BYTE

THE SMALL SYSTEMS JOURNAL

NOVEMBER 1984 VOL. 9, NO. 12

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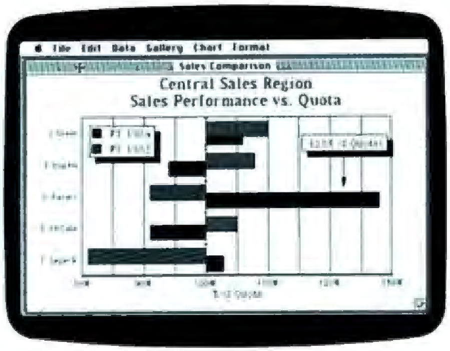
A McGRAW-HILL PUBLICATION
0360-5280

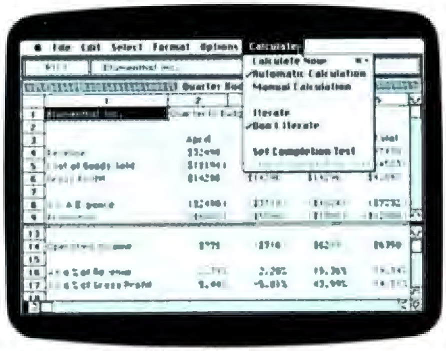
New Chips

Preview:
Data General/One

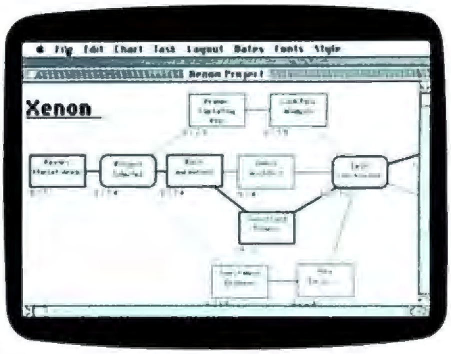
We interrupt this magazine fc



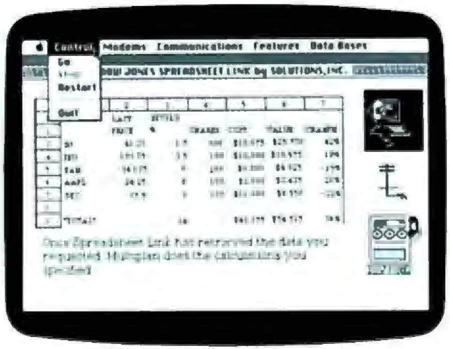
Microsoft Chart,
business graphics.



Microsoft Multiplan,
electronic spreadsheet.

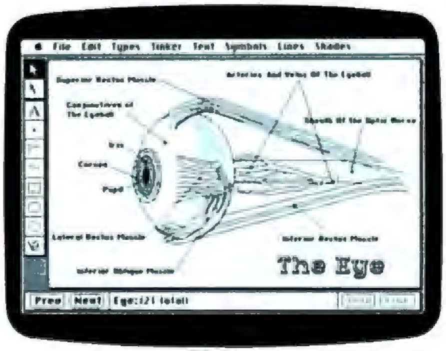


MacProject,
project management.

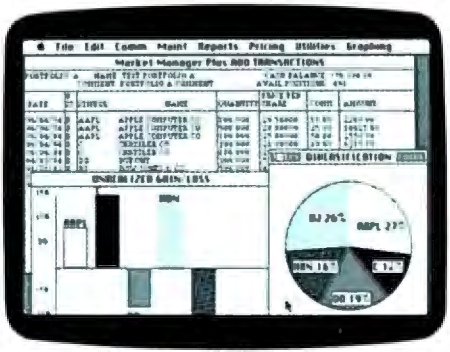


Once Spreadsheet Link has retrieved the data you requested, Multiplan does the calculations you specified.

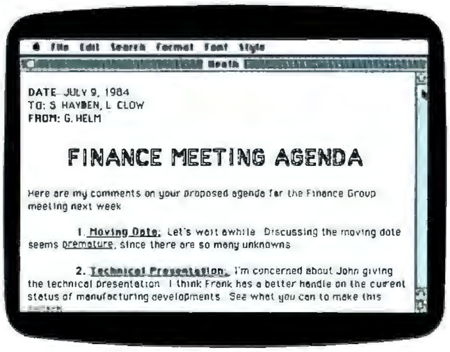
Dow Jones Spreadsheet Link,
stock analysis and communications.



FileVision,
database management.



Dow Jones Market Manager
*stock analysis.**



DATE JULY 9, 1984
TO: S HAYDEN, L CLOW
FROM: G. HELM

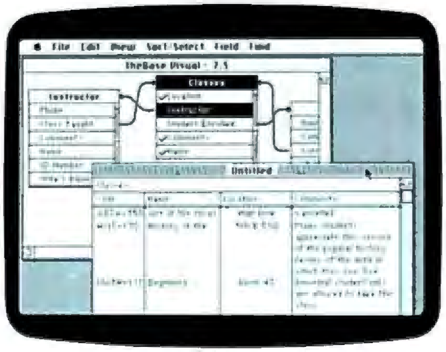
FINANCE MEETING AGENDA

Here are my comments on your proposed agenda for the Finance Group meeting next week

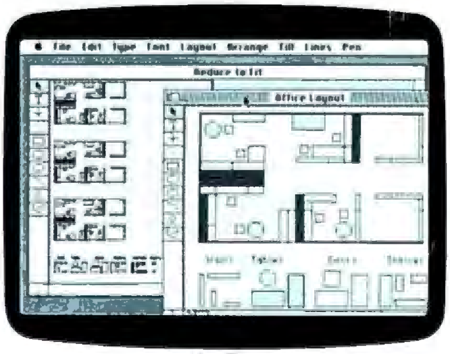
1. Moving Date: Let's wait awhile Discussing the moving date seems premature, since there are so many unknowns

2. Technical Presentation: I'm concerned about John giving the technical presentation I think Frank has a better handle on the current status of manufacturing developments See what you can to make this

MacWrite,
word processing.

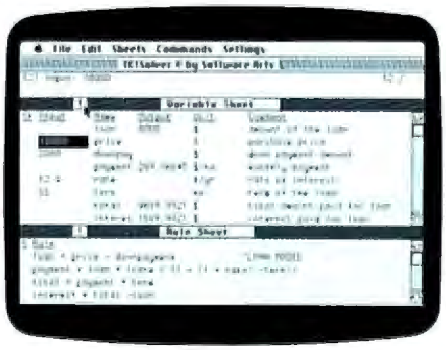


theBase,
database management.



MacDraw,
graphic illustration.

Home "Mac" Accountant,
personal finance.



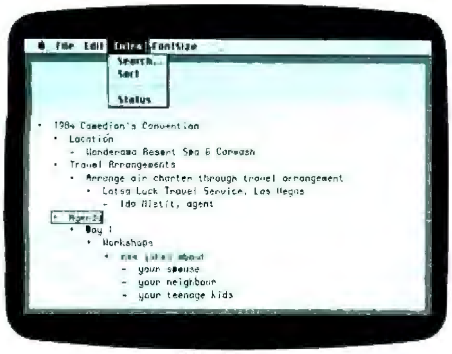
TK! Solver,
equation processor.

Habadex,
database and communications.

*The programs above are just a few examples of new software for Macintosh. Some are available now, others will be released in the coming weeks. *Available 4th quarter, 1984. **Available 1st quarter, 1985.*

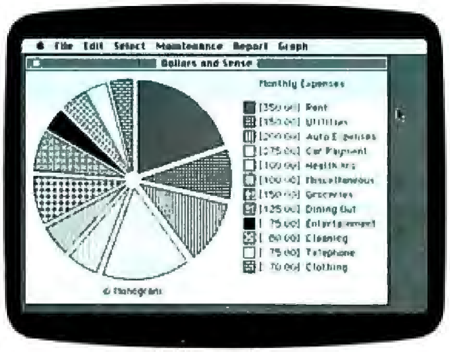
For an authorized Apple dealer nearest you call ***(800) 538-9696.*** *In Canada, call* ***(800) 268-7796*** *or* ***(800) 268-7637.***

r some important programs.

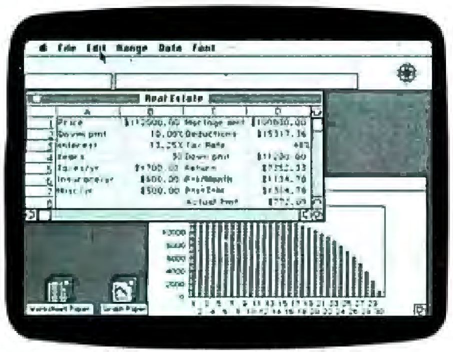


- 1984 Comedian's Convention
  - Location
    - Wonderama Resort Spa & Carwash
  - Travel Arrangements
    - Arrange air charter through travel arrangement
      - Lotsa Luck Travel Service, Los Vegas
        - Ida Nistit, agent
  - Agenda
    - Day 1
      - Workshops
        - new jokes about
          - your spouse
          - your neighbour
          - your teenage kids

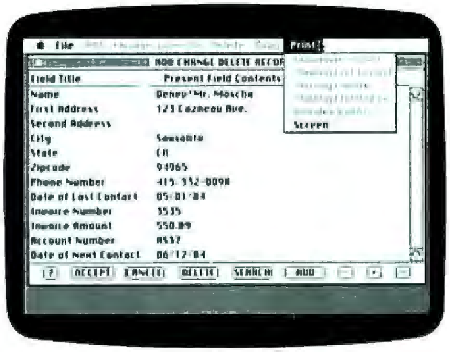
*ThinkTank,
idea processor.*



*Dollars and $ense,
personal finance.*



*The Lotus Macintosh Product,
integrated business software.***



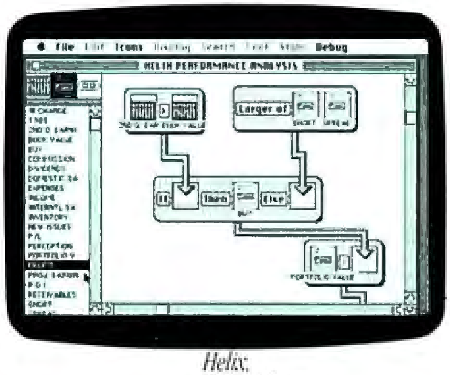
Field Title	Present Field Contents
Name	Deneu'Mr. Moscha
First Address	123 Cazneau Ave.
Second Address	
City	Sausalito
State	CA
Zipcode	94965
Phone Number	415-332-0098
Date of Last Contact	05/01/84
Invoice Number	3535
Invoice Amount	550.89
Account Number	A537
Date of Next Contact	06/12/84

*Main Street Filer,
database management.*

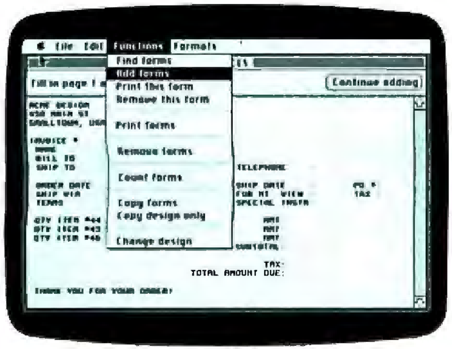
Terminal Settings

Terminal ● VT100 ○ TTY ○ IBM 3278
Compatibility ● ANSI ○ VT52
Cursor Shape ○ Block ● Underline
Character Set ● United Kingdom ● United States
Line Width ○ 132 Columns ● 80 Columns
Protocol Conv: ○ AppleLine ○ Cluster Ctlr.
☒ On Line ☐ Local Echo ☒ Show LEDs
☒ Auto Repeat ☐ Auto Wraparound ☐ New Line
☐ Rpt. Controls ☐ Transparent

*MacTerminal,
data communications.*

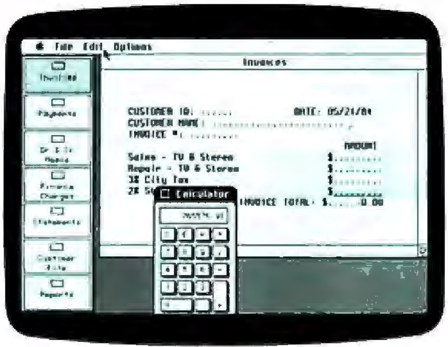


*Helix,
relational database.*



INVOICE #
NAME
BILL TO
SHIP TO
TELEPHONE
ORDER DATE
SHIP VIA
TERMS
SHIP DATE
TAX
QTY ITEM #44
QTY ITEM #45
QTY ITEM #46
AMT
AMT
AMT
SUBTOTAL
TAX:
TOTAL AMOUNT DUE:
THANK YOU FOR YOUR ORDER!

*PFS: File,
database management.*



CUSTOMER ID: DATE: 05/21/84
CUSTOMER NAME:
INVOICE #:
AMOUNT
Sales - TV & Stereo $
Repair - TV & Stereo $
3% City Tax $
INVOICE TOTAL: $ 0.00

*Peachtree's Back to Basics,
accounting package.*

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CONTENTS

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BYTE November

VOLUME 9, NUMBER 12, 1984

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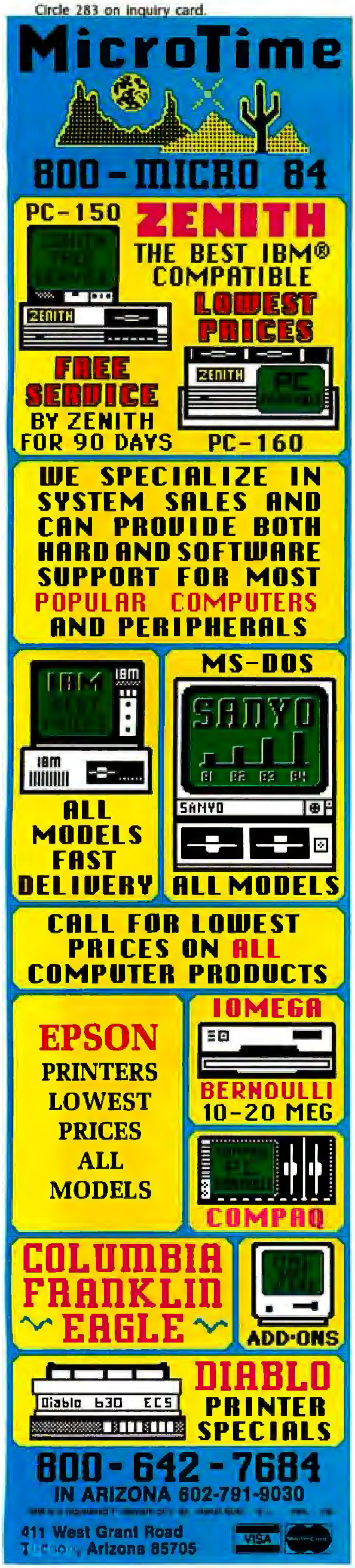

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EDITORIAL

THE MYTH OF THE ISO-TECHIE

Time and again we encounter the misconception that BYTE readers, because they have intense interests in personal computers and related technologies, have little interest in anything else. It is almost as if some people think our subscribers' technical interests isolate and disable them—prevent them from doing serious work or earning their livings. This view might be called the myth of the Iso-Techie.

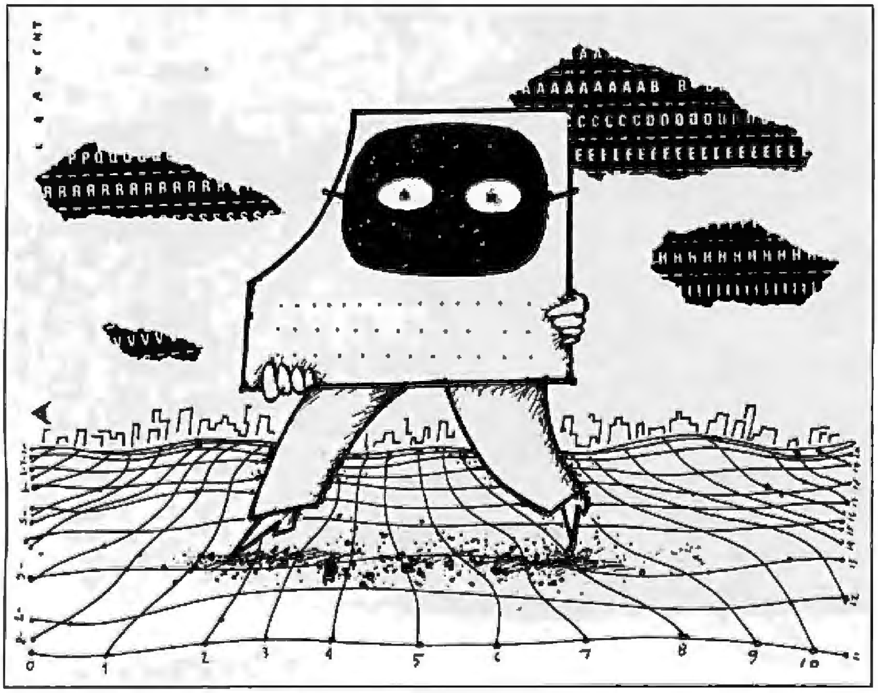
We have some new data from the 1984 BYTE Subscriber Profile Study that tells how our subscribers use their microcomputers for business purposes and for personal, nonbusiness purposes. This data is based on a survey of 1200 subscribers. It shows that Iso-Techies are as rare as Sasquatches.

Here is the breakdown of the percentages of subscribers or their companies using microcomputer software for specific business applications:

Word processing	84%
Software development	58%
Planning, forecasting, spreadsheet	54%
Graphics	45%
Accounting	45%
Engineering	44%
Math/science	44%
Telecommunications	38%
Inventory	35%
Payroll	26%
Sales/marketing	24%
Industrial control	22%
Tax management	14%
Investment management	11%

Here are the percentages of BYTE subscribers who perform specific applications when using personal computers for nonbusiness purposes:

Word processing	69%
Programming	60%
Designing/modifying hardware and software for personal use	50%
Recreation (playing games written by others)	45%
Record keeping	38%
Personal finance	35%
Learning about computers	31%
Spreadsheets	29%



In fact, most BYTE subscribers use their computers for many different purposes. They enjoy learning about computers but also apply their computers to the many different activities in their busy lives. Rather than limiting their range of activities, personal computers extend the range.

How do BYTE subscribers manage to do all these things with their microcomputers? It's both simple and amazing. They own an average of 15.5 software packages and plan to buy an average of 4.7 more in the next year.

On reflection, the versatility of the BYTE subscriber shouldn't surprise anyone. Computers are general-purpose tools that can be turned to almost any specific application. BYTE subscribers know a great deal about computers and understand their versatility. In confronting any new task, the sophisticated personal computer user first asks how a computer can make the task easier and the result better. It would be surprising if sophisticated personal computer users restricted their machines to a single use or only a few uses. Any such view is bound to be a myth.

The myth of the Iso-Techie is as wrong as some people's belief, fueled by misuse of the term in the general press, that hackers are criminals. It may be too late to dispel that misconception in the popular mind, but perhaps there's still time to stop the mythical Iso-Techie from lodging there.

—*Phil Lemmons, Editor in Chief*

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MICROBYTES

Staff-written highlights of late developments in the microcomputer industry

IBM Announces Productivity, Business Software

In late September, IBM unveiled two new integrated-software lines: the Personal Decision Series and the Business Management Series. The Personal Decision Series includes Data, a database manager; Reports+, an advanced reports generator; Plans, a spreadsheet; Plans+, which adds features to Plans; Words, a word processor; and Graphs. The Data program is required to use any of the others. Data is $250; the other programs are $150 to $300 each.

The Business Management Series includes General Ledger, Payroll, Inventory Accounting, Accounts Payable, Accounts Receivable, and Order Entry and Invoicing.

Integrated Software for UNIX

Horizon Software Systems, San Francisco, CA, announced Latitude, an integrated word-processing/spreadsheet program for UNIX. A document may contain both text and spreadsheet tables. When the cursor moves from an area of text to a numeric table, the command line changes to reflect the options available. Versions are now on sale for Altos, AT&T, Onyx, Sun, and DEC systems; Horizon plans to offer a version for XENIX on the IBM PC AT when it becomes available. The multiuser software costs $995 on small machines, including Altos, the AT&T 3B2/300, and the PC AT.

Language Standardization to Continue

In late August, the ISO (International Organization for Standardization) announced that Canada had agreed to pay for the ISO's subcommittee TC97/SC22, formed after a recent ISO reorganization to develop international standards for programming languages. For a few weeks this summer, no ISO member nation had funded the SC22 secretariat, and there was some danger that international language standardization would grind to a halt. The United States will provide funding for the parallel subcommittee TC97/SC21, which works on standards for graphics, databases, and other higher-level areas.

In domestic standards work, the American National Standards Institute technical committee X3J2 has decided to incorporate the Graphical Kernel System (GKS) as the standard way of writing graphics routines in BASIC. A conflict still remains to be resolved with the X3H3 committee, which is writing the standard for GKS, over the way BASIC will use the graphics module.

Voice Communications Added to IBM PC

Digital Pathways, Palo Alto, CA, planned to announce SoundWare, a $449 voice communications system for the IBM PC XT, at the November COMDEX show in Las Vegas. Included in the package are a half-size card and software to control the system. Software features include message playback, auto-dial capabilities, remote access, password security, voice-file transmission, Touch-Tone dialing and decoding, and provision for an audit trail.

Mutual Broadcasting Offers Data Broadcasting via Radio

The Mutual Broadcasting System plans to use spare satellite transponder capabilities to offer a data-communication service called Multicomm. Mutual has leased subcarriers from each of its 850 affiliate radio stations to broadcast data or voice information, including electronic mail and software. Each message contains a code indicating which receivers should receive the message. The receivers would cost about $200 each. Mutual says that New York state may use the service to broadcast software to schools. If the service is successful, Mutual says that its parent corporation, Amway, may use its sales force to sell receivers that could be used to download software to home computers.

(continued)

VisiCorp, Software Arts Settle Suit, Offer New Packages

VisiCorp and Software Arts settled their lawsuits in September. As part of the settlement, VisiCorp stopped selling the VisiCalc spreadsheet program and has changed the name of its Visi On Calc program to Visi On Plan. The two companies started a legal battle this spring, each accusing the other of not providing adequate support for VisiCalc.

Software Arts now sells a VisiCalc package with two versions of the program for $150. The company also recently unveiled a $249 Macintosh version of TK!Solver, an equation-processing program, and Spotlight, a set of desktop utilities for the IBM PC (see page 40).

VisiCorp offers another spreadsheet, FlashCalc, for $99. After selling most rights to its Visi On operating environment to Control Data Corp., VisiCorp announced that it would sell a complete Visi On package for $495. Included in this package are Visi On Plan, Visi On Graph, Visi On Word, and a mouse, which includes a PC Paint program and a pop-up menu system. Without the mouse, the complete Visi On package will sell for $395.

Apple Reduces IIc, Raises IIe Prices

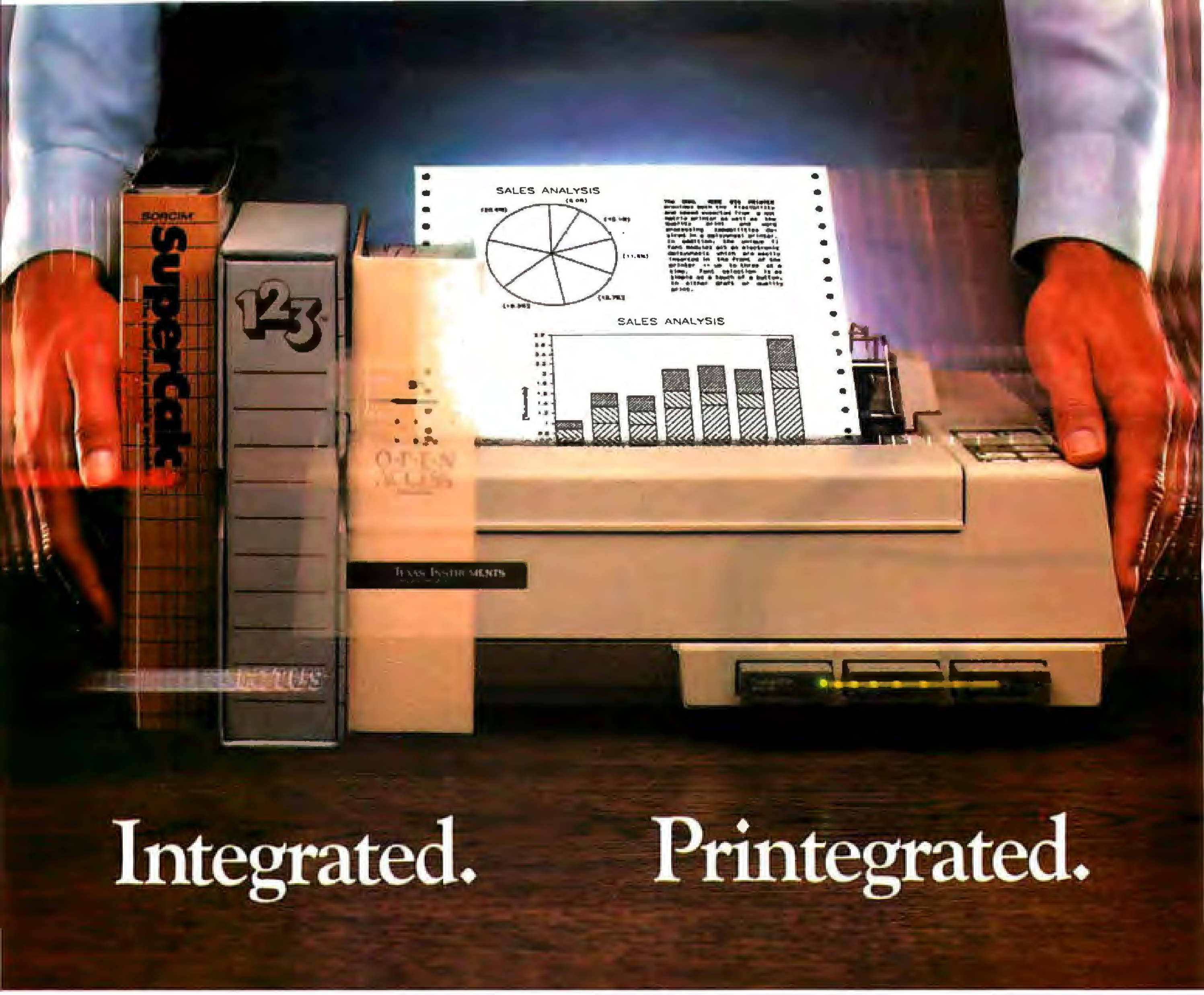
Apple Computer lowered the base price of its new Apple IIc by $100 to $1195 and announced a package that bundles the IIc, monitor, and stand for $1295. Demand for the IIc, which includes a built-in disk drive, was lower than expected, while Apple IIe sales didn't drop as planned. In an effort to reduce the backlog of orders for the IIe—more than 120,000 units were back-ordered by September—Apple eliminated a package price of $995 for the Apple IIe with a disk drive. The Apple IIe list price is still $895.

Smith-Corona Unveils Low-Cost Printer

Smith-Corona, New Canaan, CT, announced the Fastext-80, a dot-matrix printer with a list price of $259. The company says the printer features true lowercase descenders, 9 (horizontal) by 8 (vertical) dot characters, bidirectional printing at 80 characters per second, friction feed, and a parallel interface. A tractor feed and an RS-232C serial interface are optional.

NANOBYTES

Software Connections, Santa Clara, CA, announced DATASTORE:file, a $195 data-management program for the IBM PC and compatibles. . . . **AST Research** announced Advantage, a multifunction card for the IBM PC AT. The card can be extended from a $495 base version with 128K bytes to a fully equipped card with 3 megabytes of RAM, a parallel port, two serial ports, and a game port. . . . **Quadram** plans to introduce a 12-megabyte hard disk with a built-in tape drive at this month's COMDEX show in Las Vegas. Other new products will include a monitor for the IBM PCjr and a new line of QuadSoft programs. Quadram earlier announced a 2-megabyte memory board for the IBM PC. . . . **Logitech** and **Metaphor** announced an infrared mouse for Metaphor's multiuser system. Logitech also announced version 1.1 of its $495 Modula 2/86 compiler for the IBM PC. . . . **Leading Edge Products** announced that it will sell **Iquad Corporation's** 110-character-per-second daisywheel printer. Leading Edge said the price would be less than $2000. . . . **Advanced Peripheral Technology Inc.**, Columbia, MD, has announced a line of tape drives that take up only as much room as a 3½-inch disk drive. The tape units will be sold to manufacturers for as little as $300 each in quantity. . . . **Sord Computer**, New York, NY, has dropped the price of its IS-11 Consultant notebook computer to $795 and will bundle it with a thermal printer for $895. . . . **OmniTel**, Santa Clara, CA, introduced a line of 300- and 1200-bps modems for IBM and Apple computers. The Encore 1200B, an IBM expansion board, has a list price of $399, including Crosstalk software. A 300-bps modem board for the PCjr will be priced at $169 without software. An internal Apple II and stand-alone modems are also planned for early 1985. . . . **Kaypro** announced the New Kaypro 2 with one double-sided disk drive. The system includes WordStar and MBASIC for $995. A $495 upgrade adds a second disk drive and six more programs. . . . **MaxThink**, Piedmont, CA, has dropped the price of its MaxThink "thought processor" for the IBM PC from $250 to $60.



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LETTERS

MORE LETTERS ON THE MAC

I've read everything you've printed about the Macintosh, including Jerry Pournelle's criticisms in the July issue. I've been using my Mac for about a month and I think something more needs to be said about the importance of the Macintosh's graphics capabilities.

As Jerry grudgingly admits, it is a fun machine. Fun is important for learning, for thinking, and for creativity. We need fun as much as we need food, love, and sex. And the fun is in the power this machine gives people to create graphics.

Yet what people (reviewers, Apple employees) seem to focus on is the user friendliness of the icons-on-a-desktop metaphor. It is nice. I like it. It is certainly better than what I've got on my old machine. But that is not the point. MacPaint is the point. MacPaint gives people visual power. We know that one hemisphere of the brain is more or less verbal while the other hemisphere is more or less visual. This machine is for the visual brain; it is the greatest tool (other than the much more expensive Xerox Smalltalk machines) for the visual brain since Renaissance Italy gave us perspective drawing and the nineteenth century gave us the camera. But we aren't quite prepared for it.

Sure, we can do interesting, even cute, things with the Mac's typography. Sure, we can crank out bar charts, pie charts, and line graphs. We can do maps 50 ways and play with line drawings to our heart's content. We can also think visually and relate visuals to verbals with a facility not readily available before. But only if we realize that that is what this machine is about—thinking with the Macintosh.

There are many stories about great thinkers who work in images. Watson and Crick with the double-helix—why did they actually build a three-dimensional model of the helix while they were working up the basic idea? Or consider the following passages from a letter by Albert Einstein:

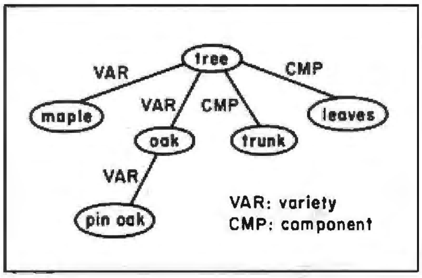

Figure 1: *Directed-graph notation.*

VAR (maple, tree)
VAR (oak, tree)
VAR (pin oak, oak)

CMP (leaves, tree)
CMP (trunk, tree)

Figure 2: *Propositional notation.*

> The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be "voluntarily" reproduced and combined . . . .The above mentioned elements are, in my case, of visual and some of muscular types. Conventional words or other signs have to be sought for laboriously only in a secondary stage, when the mentioned associative play is sufficiently established and can be reproduced at will. [*The Psychology of Invention in the Mathematical Field*, by Jacques Hadamard, New York: Dover Publications, 1954.]

I need not belabor the point. But getting at the visual brain is hard, and we all need help. The graphics capabilities of the Macintosh can provide us with that help.

Thinking is hard. It requires external support. That's why we doodle and make semicoherent jottings. That's why we write. Writing is an external support for thought; it is an instrument of thought. But writing works best for the verbal brain. Learning the mechanics of writing—how to form the letters—is relatively easy. But it's different with images.

Becoming proficient in the mechanics of freehand drawing—e.g., drawing a picture of a horse that looks more like a horse than a camel or rabbit—is much more difficult. Technical drawing is easier, but it is more difficult than writing. The Macintosh could change that.

This is particularly important as we stand on the threshold of the information age—whatever that is. The intellectual world of information, of computing, is an intensely visual one. From chip design through flowcharts to data structures—lists and trees—we think in images. If it were easier to draw good diagrams, more good diagrams would be drawn. And if more good diagrams were drawn, then more people could grasp what computing is all about.

Consider an area that is of particular interest to me, knowledge representation (a subfield of artificial intelligence). One notation that is used by many researchers is the directed graph (see figure 1). Information structure can be represented in various notations. If you want to prove theorems, you'll choose the propositional notation (see figure 2). If you want to program it into a computer, then you'll have to think in terms of a linked list. But if you want to think about how ideas fit together and teach this to others, then the graph notation is the most useful. Furthermore, if you are dealing with structures only 3 or 4 times more complex than the one I've shown—and you are typically dealing with structures 10 to 100 times more complex—then the propositional form is unreadable. You can't do any useful work with it. But the visual representation is still useful. Even if your graph covers half your desk, you can work with it.

The graph is a notation system in which the visual form can represent the structure of the information in a perspicuous

(continued)

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way. Well-drawn graphs allow you to catch important and interesting information structures in a single glance. The propositional notation doesn't allow this. A single glance at a list of propositional forms tells you nothing; you have to read each one line by line and assemble them painstakingly in your mind. The visual notation extends the range of a single mental operation (i.e., what you see in a single glance) far beyond that available with the propositional notation. It thus makes the material easier to work with.

The Mac makes it easy to use visual notations and to invent new ones. But, as I say, only if we know that is what we are looking for. Right now the Mac is being sold with a user-friendly interface and graphics capabilities that make it easy to do standard sorts of things. That's fine. But what we really need are new visual categories, images designed to convey abstract concepts, images to think with.

Those who have Macs, no matter what their graphics and artistic skills, can play with images in a way they couldn't before. The result may well be a new "cultural genetic" lottery. Somewhere in that chaotic soup of icons, graphs, images, and patterns there is going to be some important new stuff, stuff that would have been much longer in coming if it had been up to the relatively small number of people with freehand graphics skills. This possibility is what makes the Mac such an exciting machine.

Now, if only the Apple marketing people could grasp this and go with it. Then Apple might be able to live up to its pretentious 1984 TV ad. Then the company might be able to give us an intellectually significant alternative to Big Blue.

BILL BENZON
Troy, NY

The July BYTE contained several inaccurate comments about the Apple Macintosh. The first, in Phil Lemmons's editorial "Patronizing the Naive User" (page 6), misrepresents the difficulty of ejecting a disk. The method Mr. Lemmons describes to eject a disk is the most difficult of several alternatives available to a Macintosh user. Anyone—including my 4-year-old daughter—who uses the Macintosh for more than a short time quickly discovers that the command E will eject a disk when all files have been closed, and that the command Shift 1 will force an ejection even when a file is open.

I do not feel patronized by having disk ejection under software control. Rather, I

(continued)

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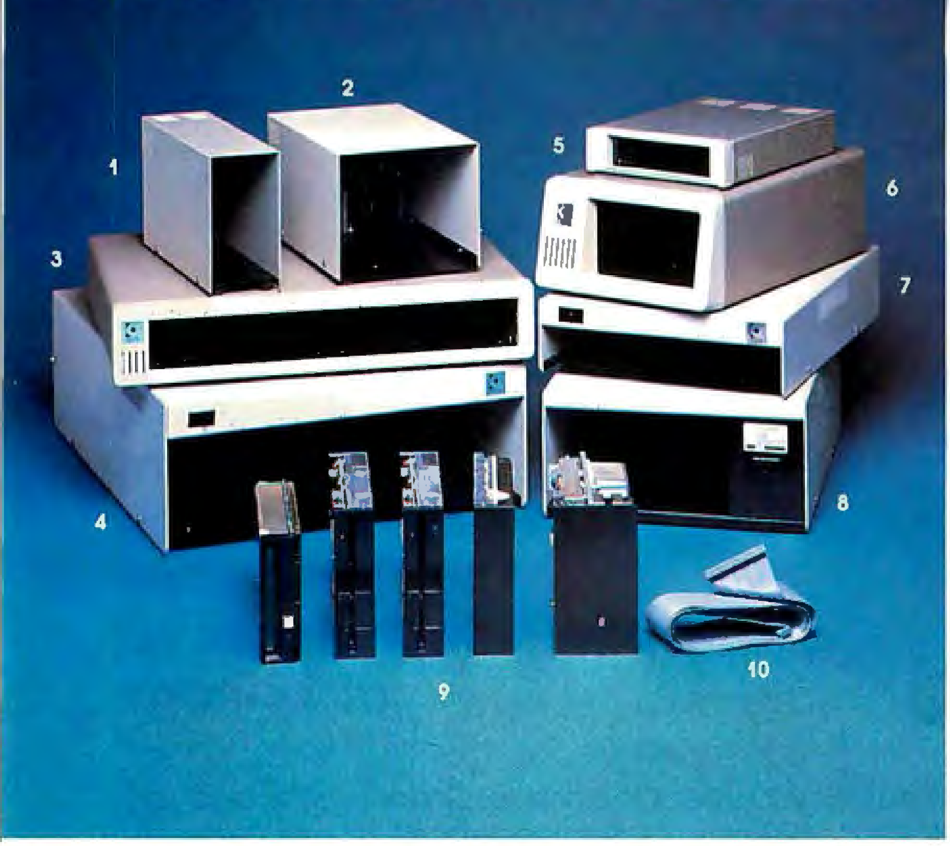

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feel this is an example of good design that makes it difficult for a user to compromise the integrity of a disk. I see little difference between this and the Safety program that a Kaypro 10 user should use to park the hard-disk head before powering down. In both cases, the software performs a useful function but can be overridden by a knowledgeable user (who should be aware of the possible consequences of his actions). The fact that a 4-year-old child has used my Macintosh for two months without supervision but has never trashed a disk is evidence enough for me of the value of this approach.

Jerry Pournelle's problems with disk copying and time to load MacWrite may simply reflect the long lead time between article submissions and BYTE's appearance on the newsstand. In mid-May Apple released revised Macintosh software that included a Disk Copy utility and a new finder with an automatic start-up option. With the Disk Copy utility, a complete disk can be copied in four passes—still not as conveniently as on a two-drive system, but enough of an improvement to make life with the Macintosh bearable. How Jerry manages to take "a couple of minutes to get the Macintosh to run a simple text editor" is beyond me. With MacWrite as the start-up application, my Mac takes exactly 20 seconds from power-on to a screen ready for writing. Since I don't like the default font and format provided by MacWrite, I generally avoid the automatic start-up and open a preformatted document. This approach takes a little longer, but in any case 45 seconds should be the outside time limit needed to get going in MacWrite.

I am not trying to say that the Macintosh is without faults, as it clearly is not. Among the worst of these is the perpetuation of a disk-drive controller that lacks direct memory access. The integrated Woz device, so hyped by Steve Jobs in Phil Lemmons's interview with the Macintosh design team (February, page 58), may be reliable and cheap to build, but the drives are maddeningly slow. Double-sided drives and hard disks will help, but the Macintosh will probably never live up to the performance of the potential of the MC68000 because of the I/O bottleneck. And while mice are nice, every so often I would love to have real cursor keys.

SELDEN S. DEEMER
Ann Arbor, MI

As Macintosh owners with 10 months of Macintosh use among us, we would like

(continued)

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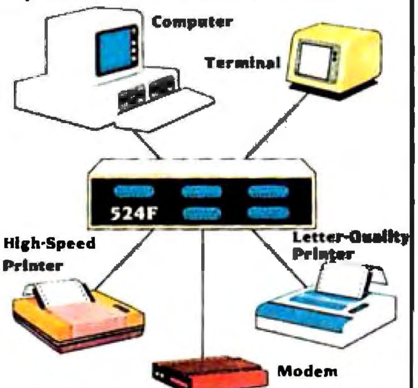

to respond to some of the criticisms of the Macintosh that appeared in your July issue.

First, Phil Lemmons's exaggerated description in his editorial of the "three-stage qualifying examination" that must be passed to eject a disk from the Mac is ludicrous. As anyone who has tried it knows, instructing the Mac to eject the disk is easy using the mouse or the keyboard. Nor can any of us recall feeling like "a humble petitioner before a mysterious and powerful computer." Come on, what kind of purple prose is this? Furthermore, all three of us are long-time computer users who hardly fall into the "naive" category; yet none of us feel the Mac is "condescending." Interacting with other computers, including some large mainframes, seems like a step back into the Stone Age after a session with the Mac.

We also found some of Jerry Pournelle's comments ("Computing at Chaos Manor: The AT&T Computers," page 305) to be inconsistent with our own experience with the Mac. One of us uses Microsoft Multiplan on a daily basis to create project-cost breakdowns, which is contrary to Jerry's implication on page 314 that Multiplan is fatally flawed. He also strongly implies on the same page that Microsoft BASIC for the Mac is so full of bugs, especially in the area of mouse utilization and graphics, that it is virtually unusable. To the contrary, one of us has developed a rather complex BASIC program (15K bytes) that is used to generate architectural perspective drawings. This program uses the mouse as the primary operator control and calls a number of the Mac's ROM-based graphics routines. Jerry also makes the claim that the "only application software for the Mac that's actually on the market is Bruce Tonkin's The Creator database." We would like to call his attention to page 413 of the same issue where he will find descriptions of three Mac programs that are on the market.

Jerry implies that the language MacFORTH is not available and that it probably won't be available any time soon (page 377). One of us already has the package. He also implies that external disk drives are not available. Two of us already own and use external Apple disk drives. Finally, Jerry states on page 312 that the ". . . Macintosh is a wonderful toy; but it's not very much more." If this is true, then the three of us have been wasting a lot of company time. Collectively, we have used MacWrite and MacPaint to generate numerous letters, technical memos with mathematical equations embedded in the text, Vugraph masters for electronic equipment layouts, organization charts, design review forms, equipment specifications up to 100 pages in length, Multiplan spreadsheets as large as 144 rows by 41 columns, and 30 pages of proposal artwork. In fact, the ease with which MacPaint can be used to rapidly create finished charts, figures, and Vugraphs represents a major reason for our decision to purchase Macs. Also, the BASIC program we mentioned earlier has been used to generate several architectural perspective drawings.

We do not wish to whitewash the Mac's flaws, the most glaring of which is the large amount of software promised but not yet delivered. However, this problem is not unusual for a genuinely new computer, and in view of the Mac's popularity we do not doubt that this will be remedied by the marketplace in time.

E. B. KNICK
D. C. MESTAYER
V. C. REYNOLDS
Melbourne Beach, FL

In regard to the July editorial "Patronizing the Naive User," I commend you. It is nice to know that there is someone out there who thinks along the same lines I do. I knew there was something that bothered me about Apple's Macintosh (beside its name) and I think you hit the nail on the head.

I do not respect people who condescend to me nor do I respect computers that do the same. I wish the designers of such computers would remember when they were computer naive and the initial excitement of discovering how computers work. Apple touts the Mac as being a "computer for the rest of us"; but the rest of us are not as dumb as the company thinks.

CHARLES P. JAZDZEWSKI
Central Point, OR

Let me remind everyone that I like the Macintosh. My critical comments were prefaced with the statement, "Macintosh will be nothing less than wonderful when it has two drives and more memory. It is without doubt the friendliest of today's computers." I have personally bought a Macintosh. I have ordered a number for the office (we also have IBM and Tandy products and have ordered some HP portables). I regard the Macintosh's user interface as largely successful. But I don't think Macintosh is perfect or that it should be treated as holy.

I do wish to confess that my frustration with Macintosh's disk procedures disap-

peared when I finally received my second drive and no longer spent half my waking hours swapping disks.

I think Bill Benzon's letter contains more insight into the Macintosh's powerful appeal than any other letter we have received.

Now, if only there were more memory and software!

PHIL LEMMONS
Editor in Chief

I was very amused by Susan Gold's remarks (June Letters, page 33) about the Macintosh not being a practical business tool. She, like so many millions of people, has not taken the time to sit down and use the Macintosh or thoughtfully analyze its potential as a business machine. I own a small business and would not purchase anything but a Macintosh. One thing that has been overlooked by all who have evaluated the computer is that when you spend several thousand dollars for a computer system, you will spend three times that amount training your employees to use it (unless you don't mind firing everyone that is not computer-literate). This is not the case with the Macintosh. The Macintosh is the least-expensive computer on the market today, when you count the cost of training your employees to use it. Not only that, I find that productivity has increased because it's so fun and easy to use.

RONALD L. LAWRENCE
Renton, WA

This is an open letter to Ms. Susan Gold:

Ms. Gold, I've read your letter given the editorial heading "Mac Flak," in the June issue of BYTE. If you check volume 6, issue 10 of *InfoWorld* you'll find that I wrote a similar letter criticizing the Apple Macintosh Computer but much more scathingly. I just hope your own letter doesn't come back to haunt you and make you feel as foolish as I feel.

You see, after sending that letter I began to visit the computer stores and "mess around" a little more with the Mac. The crazy thing began to grow on me. It was shortly thereafter that I purchased one and I find that I've been eating the words in that letter ever since.

Ms. Gold, I've learned to swallow my pride and admit I was wrong. I've learned to adapt to the future, and the future is in machines like the Macintosh. It gives the user untold power in computing and the future only looks brighter with all the additional software and hardware that is going to be coming out for the Mac. Remember, many thought the original Apple II wasn't a serious machine either. With 10,000-plus pieces of software out for it I guess *that* rumor has been dispelled. And it will go the same way with the Macintosh.

A few other points: my Mac (with external drive, numeric keypad, keyboard, and the Mac itself) takes up less room on my desk than my IBM Selectric III. And I am running it with a surface area of 6 by 8 to 8 by 8 inches for the mouse, and I don't find it clumsy at all.

Now, isn't it about time that you went out and really tried a Macintosh, to see what it can do for you? 'Cause one thing the Mac ain't . . . it ain't no toy, that's for sure!

CRAIG A. PEARCE
Berwyn, IL

In response to the letter by David Nibbelin in the June issue (page 14): Mr. Nibbelin would do better to investigate all consumer finished goods that are made with parts derived from imported steel. And remember, stay out of buildings made with imported steel beams! The bottom line for any properly run company is the quality/cost ratio. Mr. Nibbelin's efforts might be directed at those who do not make the superior product that Sony's drive is, instead of pointing an accusing finger at the way Apple conducts its business to produce a fine product at a price Americans can afford.

JULIA L. MULDAWER
Covington, LA

ON CACHING

I read with interest the very lucid article on disk caching "Maximizing Hard-Disk Performance" (May, page 307) by Roy Chaney and Brian Johnson. At Microcosm Research we have been involved in this area for some time and have had a product (MicroCache) on the market for the past three years.

We can endorse most of the authors' findings but would like to make a few observations.

With hard disks and caches of several hundred kilobytes, the algorithm used is not overly critical, as explained in the article. However, for smaller caches or floppy-disk systems, the algorithm is much more critical. As a result, we used a combination of the least-recently-used algorithm they preferred, tempered by an algorithm they did not mention—the least-frequently-used. This is further adjusted

(continued)

with regard to the physical location of the data of the disk. This has enabled us to provide significant performance improvements with caches from 16K bytes upward.

Readers may have gotten the impression from the article that the memory-addressing capabilities of 16-bit processors are necessary for effective caching. This is not so. Eight-bit systems can also employ caching. In fact, it is often more desirable on 8-bit systems because the applications software tends to use overlays extensively to overcome the limitations of a restricted address space. Caches are ideal for handling these frequently used overlays. The 8-bit version of MicroCache copes with memory addressing by accommodating whatever additional bank-switched memory is available for the machine (up to 8 megabytes).

I was surprised that they found an overall degradation in performance with small caches. This has not been our experience. Some caches we have seen (usually thrown together by a RAM-board manufacturer so that it can say it has a cache) have the opposite problem: they are okay for small caches but slow the system down when more than about 100K bytes of RAM is used. A cache-searching system that is very fast for all sizes of cache is essential.

For small caches it is worth including a facility that enables the user to "lock" time-critical files in the cache so that they are not ejected by the caching algorithm.

Printer buffers are effectively very crude caches using a first-in/first-out algorithm with background writing. Adding this facility to the disk cache is easy and can greatly improve the overall throughput of the machine. It is a much more cost-effective way of buffering printout than using add-on boxes because the RAM is dynamically shared between the disks and the printer. When the printer is the major source of delay it gets more of the RAM, releasing it for disk caching as soon as the characters are passed on to the printer.

The authors' system was primarily concerned with caching hard disks. If floppy-disk systems are to be catered to, then it is necessary to cope with the situation when disks are changed. If disks are changed without the cache knowing about the change then there will be chaos! The data on the cache from the previous disk will get mixed up with the data on the new disk. MicroCache is the only caching system that we know of that avoids this problem by automatically detecting disk changes on the IBM PC and other popular machines.

PETER CHEESEWRIGHT
London, England

ON SERVICE CONTRACTS

In your July publication, Michael W. Fitzpatrick wrote of his costly experience in having his Columbia VP portable computer repaired by Bell & Howell Service Company (Letters, page 31). I am responding to his letter in the hope that I can spare Mr. Fitzpatrick and other computer users from similar experiences in the future.

Mr. Fitzpatrick equated repairing a defective motherboard to repairing a car engine. While there is some similarity, in that eventually a defective part may be replaced, the means by which the defec-

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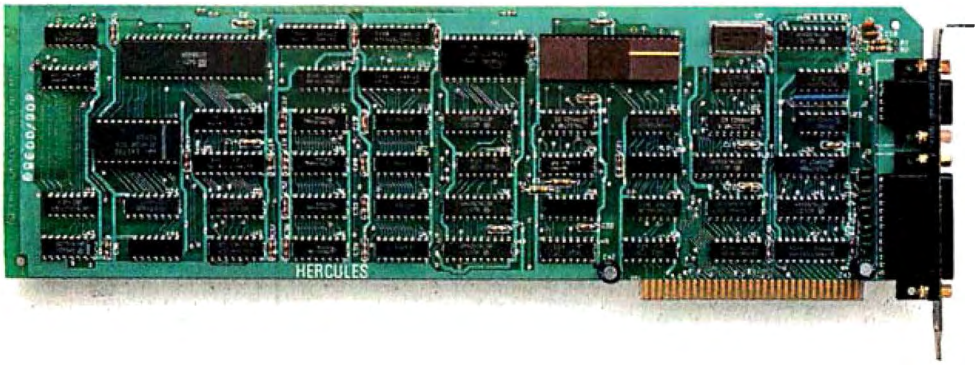

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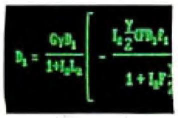

There are word processors that can produce publication quality documents with mathematical formulas.

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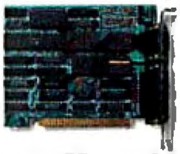

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tive part is identified is in no way similar. A board-repair system in some cases costing in excess of $500,000 does not compare in cost to a timing light and socket wrench, or even the more sophisticated equipment now in many automobile repair shops. Bell & Howell does maintain board-repair equipment but not in every location because of prohibitive cost.

While Bell & Howell Service Company welcomes all users of Columbia Data computers to place contracts on their equipment, many such as Mr. Fitzpatrick choose to take a chance that service will not be needed. The truth is that even a product as well engineered and reliable as the Columbia VP will eventually require service. To cater to the needs of noncontract customers, Bell & Howell is required to stock large spare parts inventories without prior commitment from the user, who may seek an alternative means to obtain service.

In light of this, Bell & Howell has developed contract rates that are competitive, and perhaps the lowest in the microcomputer service industry. I entirely endorse Mr. Fitzpatrick's advice to buy a service contract from a reputable service organization. If Mr. Fitzpatrick had followed his own advice, the $811.06 he paid for his motherboard would have given him three years of full parts and labor contract coverage and $16.06 change.

DAVID C. HALLQUIST
Bell & Howell Service Co.
Chicago, IL

My IBM PC developed trouble in the reverse mode, in my case black on green. It will print reverse only for the first 12 lines and 64 characters of the thirteenth line; 12 × 80 = 960 plus 64 on the thirteenth line gives 1024. That seemed significant so I ran a program to check the video system and guessed the problem might be in the attribute chip number two.

I called the 800 number and was told I could take my IBM PC to the repair depot in Tampa and I would get it back in 48 hours. The 800 number is a phone in Atlanta. I was given a repair number and then I packed up the computer and drove 36 miles through heavy traffic to the repair depot.

They had a copy of the repair ticket called in by the operator in Atlanta. However, I was told they would send the computer to Atlanta for repairs and I was given no time limit for its return. Well, at $96 an hour for labor and no guarantee of any

(continued)

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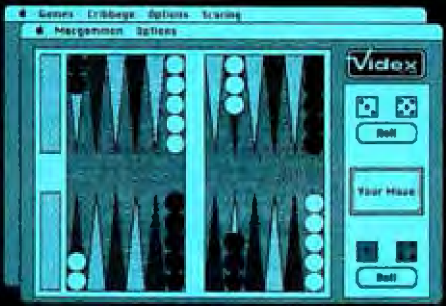

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kind as to what they might do to the machine, I decided that solution was not for me. So I packed the equipment back into the car and went home thinking about the fact that I had packed the gear up and driven all that way supposing that with a formal appointment everything would be taken care of.

I keep thinking about the advertisements that say "includes a nationwide network to help give you computer-age service support."

I have not found that to be true. I wrote Boca Raton, I called various people, and visited the local IBM showroom several times over a period of several months. Quite a few people at IBM laughed at me because, as a novice, I could not figure out how to properly use the WHILE and WHEN statements, which are explained on page 4-251 of the IBM *BASIC* manual. However, none of the IBM people who aughed at me were able to figure out how to use it either.

I would like to hear from others who have had similar problems. Please write to me at 1710 Woodbine Dr., Brandon, FL 33511.

DONALD W. PATZSCH
Brandon, FL

N DEFENSE OF BASIC

For some time now I have quietly stood by while readers, authors, and a slew of self-proclaimed "experts" have denounced BASIC for being a sloppy, unstructured anguage. These folks then go on to describe how learning BASIC inevitably leads to programming habits so horrible that its practitioners will be impaired for life. To hear them tell it, you'd be better off having a frontal lobotomy. Any day now I expect to read about some hapless soul who went prematurely bald and lost all his teeth because of exposure to BASIC.

Sure, it's possible to write programs in BASIC that go this way and that with no apparent direction—or "structure" as some people like to call it. However, it seems to me that with enough practice it should be possible to write convoluted, hard-to-follow programs in any language. I am unaware of any restrictions imposed by BASIC that would force a programmer to write poorly.

While BASIC may not be perfect, for me it is very close. I mean, what could make more sense than X = SIN(A) or L = LEN(N$)? Do you need more speed?

(continued)

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Okay, buy a compiler. If you want to declare all of a program's variables up front, then go ahead and do it. Nobody's stopping you, but then no one is forcing you, either.

If all those anti-BASIC fanatics are so opposed to something as innocuous as a GOTO, then let's all petition against assembly language with its evil BRANCH, or worse, that sinful JUMP instruction.

BASIC is the most straightforward, intuitively obvious, and easy to grasp of all the high-level languages. It has made computer programming—real programming—accessible to millions of people, and personally I am sick of snobs telling me I would be better off learning no programming language than BASIC. Phooey!

ETHAN WINER
East Norwalk, CT

COMPUTERS IN EDUCATION

As a student of behavioral psychology and a member of the Learning Processes program at the City University of New York, I would like to comment about the article "Cautions on Computers in Education" by Stephan L. Chorover (June, page 223).

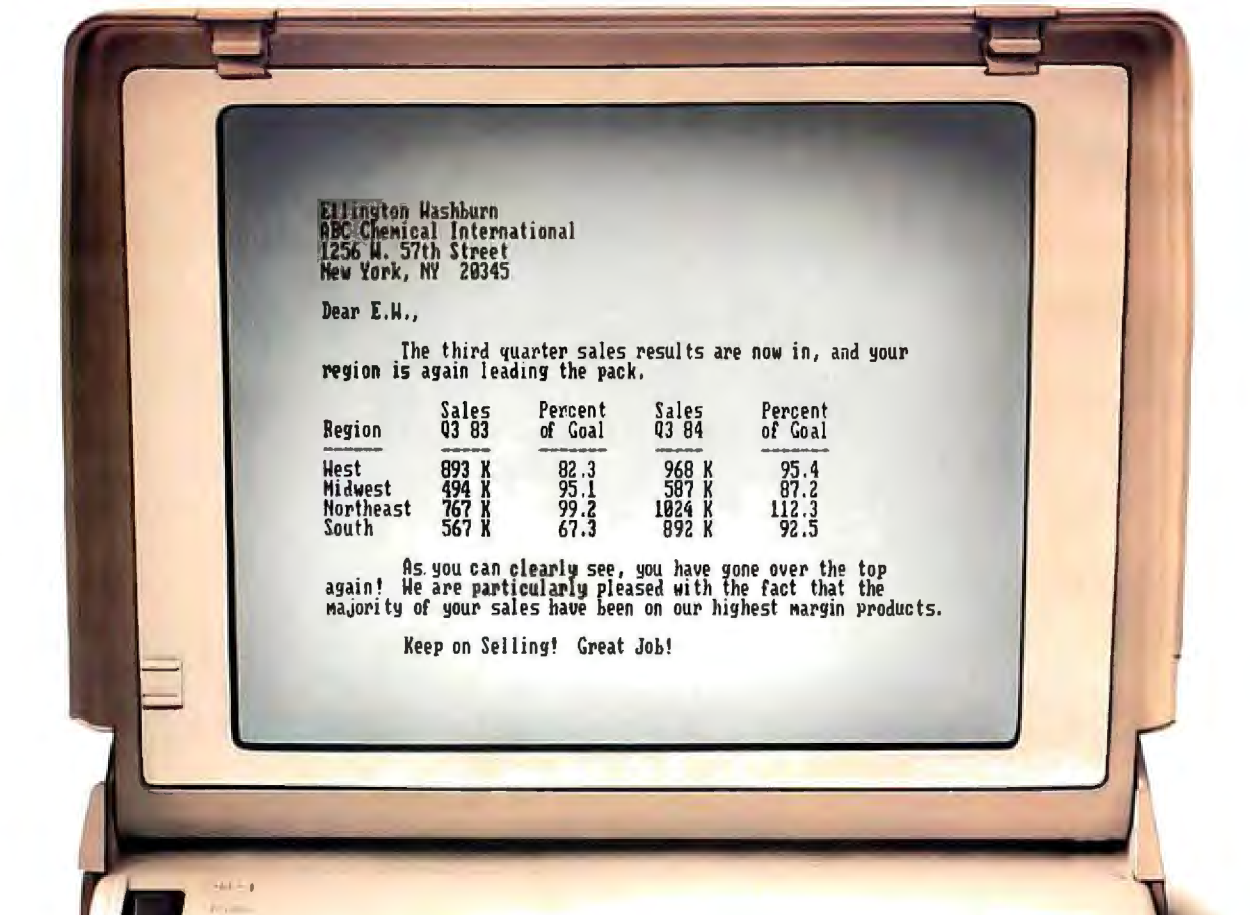
Mr. Chorover makes a number of important observations on the rush to automate the educational process. The question of who needs computers and why is not often asked and understood in learning environments. However, I would like to take issue with him on a few points.

Professor William N. Schoenfeld is as much responsible for developing the programmed approach to instruction as Professor Fred S. Keller. Some psychologists familiar with the early developments of operant conditioning argue that it was Schoenfeld who really provided the intellectual impetus.

The "Keller Plan" is an example of good teaching practices in learning environments all over the world. The intention of "Good-bye, Teacher..." was not to say teachers are useless creatures, but that they could have a more effective impact, i.e., supplying individualized care to students if they were exposed to the technology of teaching. "Good-bye, Teacher..." was an attempt to explain how aversive elements can be eliminated from the learning environment and to show how the technology of teaching can be utilized. Before Skinner, Schoenfeld, and Keller popularized the systematic methodology that stressed learning by doing and contingent reinforcement, students and teachers believed that learning was a matter of good listening.

Efficient teaching does not mean removing the concerned and dedicated teacher from the learning environment. Effective teaching does not mean sterilizing the educational environment with machines. Correct and cautious use of the computer in the educational environment means providing a stimulating and exciting environment for every individual child. The key reason for using the computer is to give every single child an opportunity to learn. Computers in the classroom means purging the classroom from the drudgery of rote learning and providing children with the opportunity to progress at their own rates. To achieve these goals both the effective teacher and the properly developed teaching machine is needed.

BARRY KATZ
Tel Aviv, Israel ■



Ellington Washburn
ABC Chemical International
1256 W. 57th Street
New York, NY 20345

Dear E.W.,

The third quarter sales results are now in, and your region is again leading the pack.

Region	Sales Q3 83	Percent of Goal	Sales Q3 84	Percent of Goal
West	893 K	82.3	968 K	95.4
Midwest	494 K	95.1	587 K	87.2
Northeast	767 K	99.2	1024 K	112.3
South	567 K	67.3	892 K	92.5

As you can clearly see, you have gone over the top again! We are particularly pleased with the fact that the majority of your sales have been on our highest margin products.

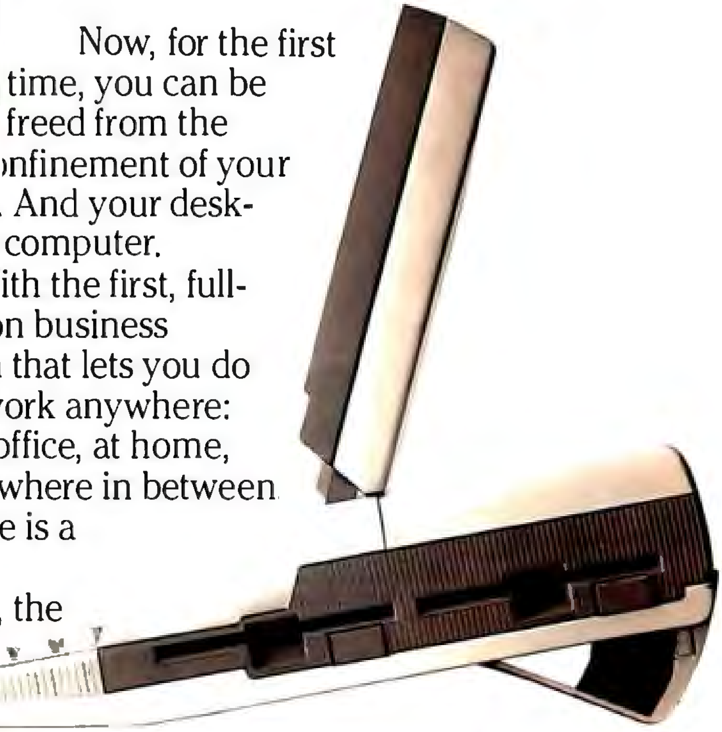
Keep on Selling! Great Job!

INTRODUCING THE DATA GENERAL/One™ PORTABLE.

Small enough to fit inside your briefcase.

Now, for the first time, you can be freed from the onfinement of your desk. And your desk-bound computer.

With the first, full-function business system that lets you do your work anywhere: at the office, at home, or anywhere in between.



IBM-PC compatible so it runs thousands of programs.

The DATA GENERAL/One portable is a computer with the capability of the leading PC: two built-in diskette drives, the same full-size screen, and full-size characters. It even runs the same programs as the leading PC.

All this in a size small enough to fit inside the average briefcase: 11.7 x 13.7 x 2.8 inches, and less than 11 pounds.

Full-size screen lets you get the whole picture.

Someday, all PCs will be like this.

It's the only portable computer to give you a full-size 80-column by 25-line screen.

Other portables give you as little as 8 lines.

It's compatible with IBM®-PC software. Which means you can run the thousands of programs available to PC users. Software like 1-2-3™ and Symphony™ from Lotus™, Wordstar®, dBase II®, Multiplan®, as well as the most popular packages from the pfs® series, like pfs: file.

The only portable offering up to two built-in diskette drives for serious business applications.

So you can do such things as word processing, database management, spreadsheet analysis, and business graphics.

The DATA GENERAL/One is the only portable computer that offers up to two built-in diskette drives. Just like the leading PC.

It's the only way to do serious work. No more aggravation swapping diskettes.

And these are state-of-the-art 3.5-inch hardcased microfloppies—with twice the storage capacity at half the size of the 5.25-inch diskettes.

Connects with Data General's CEO office automation system.

Internal memory is expandable up to 512 KB. Storage capacity is 1440 KB—nearly one-and-a-half-million characters of information.

And if you want more information, the optional built-in modem lets you communicate with other computers.

Finally, it's the only portable that can give you the benefits of integrated office automation—by connecting with Data General's CEO® system.

Other options include a portable printer, an 8-hour built-in battery pack, an external 1200-baud modem and an external 5.25-inch diskette drive unit.

The new DATA GENERAL/One portable.

It not only gives you everything the leading PC gives you. It also gives you something the leading PC doesn't give you.

Your freedom.

To find the name of your nearest Data General salesperson or authorized dealer, call 1-800-DATAGEN.

Data General
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FEEDBACK

Laserdiscs Here Today and With Us Tomorrow

A letter lauding BYTE for the July Video theme arrived the other day from Patrick Binns. Mr. Binns, the consumer-products marketing manager for Video Vision Associates, thought that our coverage was "both timely and knowledgeable," although we neglected to cover those laser videodiscs currently available.

"It is the variety and quality of laserdisc software that will make this new technology an exciting and significant advance in communications," he said in his letter.

Video Vision Associates, located in Huntington Beach, California, has been in the interactive-videodisc market for more than two years. It produces a number of topical packages for both educators and consumers and markets a peripheral, the VAI II, that interfaces Apple II+/IIe and videodisc programs. The VAI II can be used for developing interactive computer/video programs. (For more on this subject, see Stan Jarvis's article "Videodiscs and Computers" in the July BYTE on page 187.)

One of Video Vision's laserdisc software packages is called Space Disc. It's a collection of still frames, photographs, and video and movie clips that documents the American space program. It's made up of four modules that cover the Voyagers' trips around Saturn and Jupiter, the six manned lunar landings, the first four flights of the Space Shuttle, and observations of solar phenomena. Other packages address such subjects as science and art history.

Of the technology behind interactive computer/videodisc programs and where we can expect it to go, Mr. Binns said: "The creative dimensions of this technology have yet to be defined, but laserdisc software will be a critical factor in determining its full potential. Today's initiatives in laserdisc and computer programming are certain to enrich the way we will acquire knowledge and enjoy our leisure in the not-so-distant future."

Videodisc Replication Service

Stan Jarvis's article "Videodiscs and Computers" (July, page 187) inspired Larry Spangler, manager of Spectra Image Inc.'s videodisc operations to write us about a service available from his company. Spectra Image Inc. can provide single copies of standard Laservision-compatible videodiscs, using Optical Disc Corporation's technology. Individual copies of CAV-compatible single-sided discs cost $300. Turnaround time is said to be 24 hours.

Spectra Image Inc. maintains its corporate headquarters at 540 North Hollywood Way, Burbank, CA 91505, (818) 842-1111.

A Computer on (Almost) Every Desk

Entering students at Dartmouth College are *not* required to buy an Apple Macintosh or any other computer, as we erroneously reported in "A Computer on Every Desk," (June, page 162). A computer can be purchased at a discounted price through the college, but any such purchase is optional. Those electing not to buy a computer through the school can get computer experience at public clusters on campus. We thank Laura Dicovitsky, assistant director of Dartmouth's Office of News Services, for alerting us to this inaccuracy.

Call for Aid Answered

Niels J. Bjergstrøm from the Danish manufacturer E-C Data A/S has answered James R. Primm's request for help in locating an 8-inch disk controller for the TRS-80 Model 4. (See August Letters, page 23.)

E-C Data produces an 8-inch disk controller that's based on the 2793 chip. The controller is compatible with TRS-80 disk operating systems. It's available in kit form and comes with complete installation instructions, schematics, test and diagnostic software, and a sheet outlining the principles of operation. A battery-backed clock/calendar is optional.

The company also offers a range of kits for the TRS-80, including disk drives, RAM banks, and communication interfaces.

An E-C Data company representative is now located at 310 Riverside Dr., Suite 916, New York, NY 10025, (212) 678-0064. By the time this update is published, the company will have an 800 number that it can be reached at. Please call (800) 555-1212 for the correct number. The home address is E-C Data A/S, POB 116, DK-3460, Birkerød, Denmark. The company's telephone number is 45-2-818191; Telex: 37825 ec dk.

UPDATES

Database Describes 50,000 Packages, Offers All for Sale

An electronic database with descriptions of more than 50,000 software packages for every type and size of computer has gone on line. Menu, operating out of Fort Collins, Colorado, lets you identify, evaluate, and purchase software.

Menu is accessed through Dialog, the Knowledge Index, Lexis, or Euronet. Once on line, a customer can search the database and get printouts of third-party evaluations of selected software. A search costs $25 for the first 10 programs located; the fee drops to $1 for the next 40 programs, and thereafter it's $0.25 per program. (Search fees may vary depending on the network used to access the system.)

Software can be ordered through Menu. The company says that most programs can be purchased for up to 25 percent below suggested prices. If Menu cannot locate the desired package, it files the customer's needs into a database. When a suitable program is found, the customer is notified. Currently, there is no charge for this service.

A search fee is credited against the purchase price. Delivery is within 5 to 10 days.

Hard-copy printouts of the database are

(continued)

available in three categories: microcomputers, minicomputers, and science and engineering. Catalogs are produced in the spring and fall; catalog prices range between $29 and $115.

Vertical-market software and additional services are available to retail outlets. For further information, contact Menu, 1520 South College Ave., Fort Collins, CO 80524, (303) 482-5000.

Program Update for Spreadsheet

Rodolfo Cerati informs us that his original program, which appeared in the June BYTE, can be ordered in 85 different CP/M formats (see "Spreadsheet in BASIC," page 154). The program costs $25, including postage, and can be ordered directly from Placida Systems, POB 11480, Bradenton, FL 34282.

BYTE'S BUGS

Televisions As Monitors

We thank all of you who have pointed out the errors in "Televisions As Monitors" (July, page 171). We're working on a follow-up article that will provide more useful and accurate information on this interesting subject.

Logic Error Mishandles Listing

Michael Shook from Bar Harbor, Maine, spotted a logic error in the listings demonstrating concurrency in Jurg Gutknecht's "Tutorial on Modula-2" (August, page 157). He encountered the error when using the Modula Research Institute compiler on an IBM Personal Computer.

The procedure NEWPROCESS fails to begin executing the process it creates. Consequently, an initial transfer to each of the handler processes is required. This can be accomplished by placing:

```
TRANSFER(main, handler[curl])
```

after the line:

```
A : = AllocateHeap(400);NEWPROCESS
   (GenList, A 400,handler[curl])
```

in listing 11 on page 176.

In addition, when listing 10 is modified by embedding it into a LOOP. . . END and replacing GetRegistration by the call to TRANSFER, you must add a call to TRANSFER after the statement:

```
'WriteChar(out, FF)'
```

Otherwise, the first handler to terminate will terminate the entire program.

Capacitor Mislabeled

A schematic in Steve Ciarcia's article "A Musical Telephone Bell" (July, page 125) requires a few changes. In the Whimsi-Bell schematic (figure 5, page 131), the 0.22-microfarad capacitor connected to pin 8 of IC1 should be labeled C5. The explanatory text should say that potentiometer R12 controls the charge rate to capacitor C5, not C7.

Bugs Play Tricks with Listing

A number of readers noticed that a data line was missing in Michael W. Ecker's computer card trick program (see "Mathematical Recreations: Invariance," July, page 365). Add the following to listing 1 (page 367):

```
270 DATA 38,39,44,45,46,47,52,53,54,55,60,
  61,62,63
```

Alternatively, you can place 38 and 39 at the end of line 260 and begin line 270 with DATA 44,45, etc. This will maintain the structure that Mr. Ecker used.

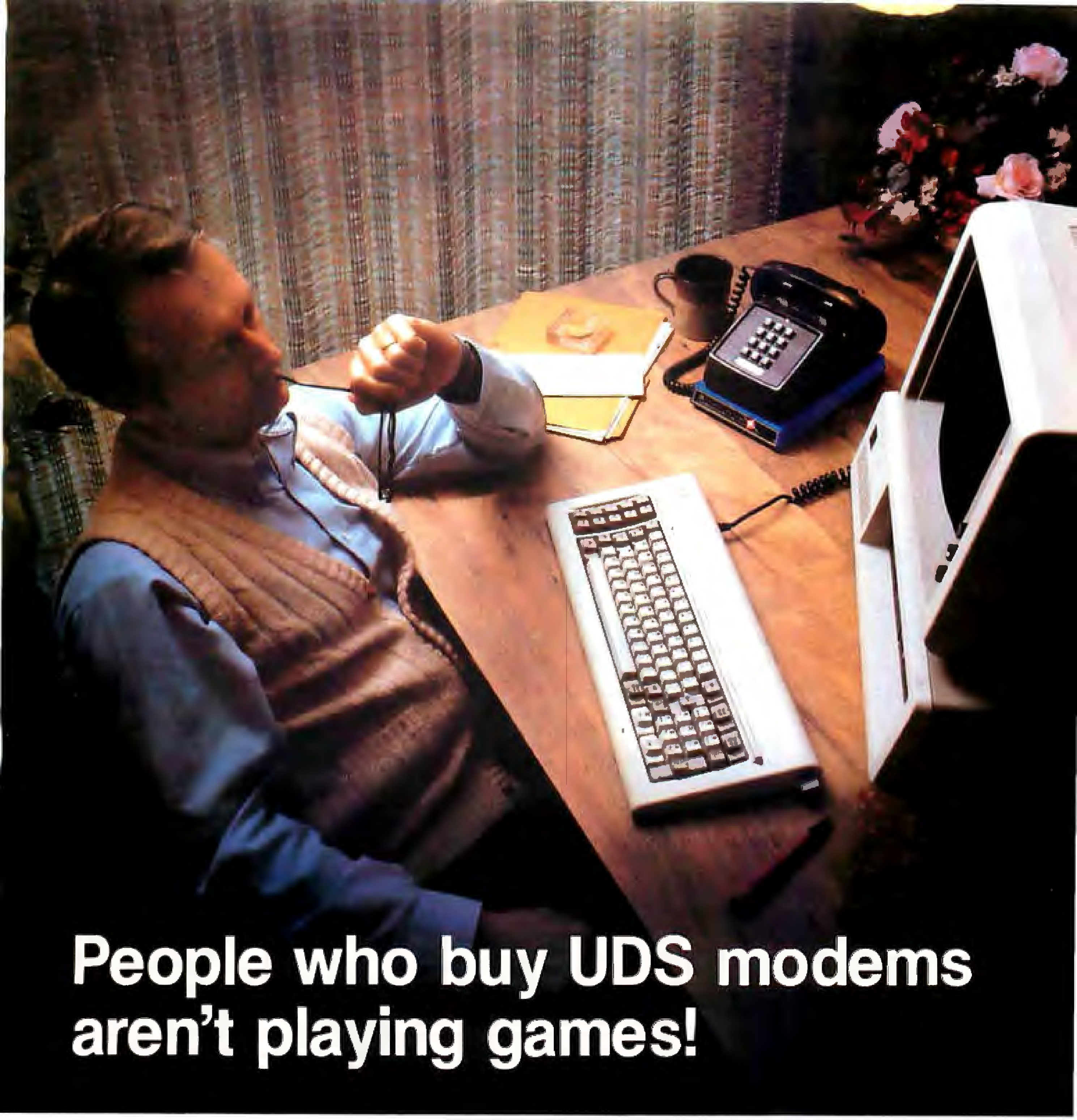
Bugs Bite Buffer

Don Gardener of San Pablo, California, and Bob Peck of Urbana, Illinois, recently reported a number of bugs in the program listing that accompanied John Bono's article "Build a Printer Buffer" (June, page 142).

Make the changes shown in listing A to listing 1, which begins on page 453. Our thanks to Mr. Gardener and Mr. Peck.■

Listing A: *The corrections to the program listing that accompanied "Build a Printer Buffer" (June, page 142).*

```
Line  22    0004  D3  01         OUT (ACKLO),A
Line  81    0040  B3             OR E
Line  82    0041  C2  47  00     JP NZ, ENDIF1
Line 100    004A  3F             CCF
Line 137    0065  C3  10  00     JP LOOP
```



You can often judge a personal computer user by the hardware he selects. If the modem comes from UDS, chances are he has a serious investment in computer and software, a serious data communications requirement and serious computer-based decisions to make.

UDS modems offer true pro-quality performance to the serious microcomputer owner. Data rates range from 0 to 9600bps. Depending on data rate, synchronous and asynchronous models may be selected for half- or full-duplex communications. Their prices put them within easy reach of the serious user.

If data communication has progressed beyond the game-playing stage in your microcomputer system, it's time to investigate UDS. The efficiency, reliability and potential for faster data transfer can add real professional capability. Contact Universal Data Systems, 5000 Bradford Drive, Huntsville, AL 35805. Telephone 205/837-8100; TWX 810-726-2100.

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Las Vegas-Booth #2436

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MOTOROLA INC.
Information Systems Group

Created by Dayner/Hall, Inc., Winter Park, Florida

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Inquiry Hotline: 800/633-2252, ext. 354.

THE END OF SOFTWARE FREEBIES.

Finally there's a foolproof way to protect software against unauthorized duplication. And the technology is all on the disk itself.

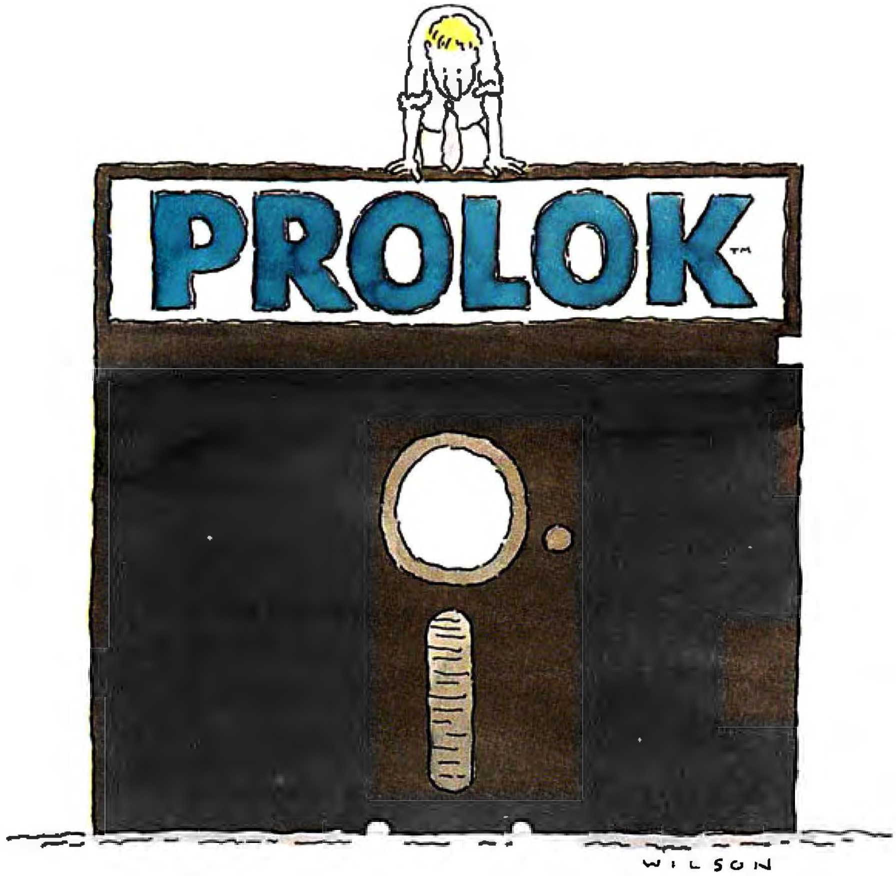
The new Prolok™ disk doesn't need add-on hardware. Instead each diskette is marked with a unique, physical "fingerprint." No two are alike. A precise description of the individual print is encoded magnetically. The fingerprint AND the description must match exactly before the software is decrypted and released to the system. No match, no access.

Its genius is its simplicity and familiarity. Prolok looks like an unprotected disk, loads like an unprotected disk, works like an unprotected disk. The user feels immediately at home and in command. It's as easy as A>PROLOK B: filename.

Backups are easily made via normal system utilities. However, to be read they must be accompanied in the system by the original Prolok disk.

Prolok puts the casual copier—and even the deliberate pirate—out of business. It barely

PROLOK. SOFTWARE



increases the price of your product, yet it makes sure your customers don't buy one program and copy ten.

Several command line slash (/) options are built into Prolok diskettes for customized security, depending on your needs.

Software can be loaded easily onto Prolok diskettes using any system from a PC to commercial mass duplication equipment.

Prolok is an engineering breakthrough of Vault Corporation, which has been successfully safeguarding software since the inception of security disk technology. Over 2000 businesses and organizations protect their valuable programs with Prolok.

Simply contact Vault Corporation at 2649 Townsgate Road, Suite 500, Westlake Village, CA 91361. Or phone us at 800 445-0193 (U.S.) or 800-821-8638 (California). And find out why software freebies are becoming a thing of the past.

PROTECTION, RIGHT ON THE DISK.

IF IT ISN'T ONE OF THOSE BRAND-NEW C. ITOH 7500 OR Y-10 PRINTERS THAT COST A MERE PITTANCE... FORGET IT.

A new C. Itoh isn't exactly a stocking stuffer. But as printers go, the new ProWriter™ 7500 dot matrix and StarWriter™ Y-10 daisy wheel go for very little money.

Yet, they're C. Itoh quality through and through. Gifts fit for a king. Tested. Proven. So doggone reliable they'll be around for many a Christmas to come.

Both printers are IBM® PC compatible. Both are perfect for your basic printing needs.

The 7500 delivers 105 characters per second, 45 lines a minute. It gives you bi-directional printing, graphics, and a 2-Kbyte buffer.

The Y-10, with its 100-character print head, gives you 20 characters per second of crisp, sharp letter quality. It has a low profile design and is engineered for quiet operation.

Like all C. Itoh printers, the 7500 and Y-10 come with a full 12-month warranty, backed by over 400 Authorized Service Centers coast to coast.

C. Itoh and your C. Itoh dealer wish you and your PC the best Christmas ever. (And you can print that.)

For more information, just write C. Itoh Digital Products, Inc., 19750 South Vermont Avenue, Suite 220, Torrance, CA 90502.

Or phone toll free 1-800-423-0300. In Massachusetts, call 1-617-769-8770.

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IBM Graphics Displays, Adapters Improve Resolution

IBM recently introduced several graphics products for its personal computers. The IBM Personal Computer Professional Graphics Display, which can only be used with IBM's Professional Graphics Controller, is a noninterlaced, high-resolution RGB monitor. It can display 640 by 480 pixels, or 67 pixels per inch, in up to 256 colors (from a palette of 4096). The display measures 15½ by 17 by 11½ inches and is priced at $1295.

The Professional Graphics Controller occupies two full IBM PC, PC XT, or PC AT expansion slots. It can emulate the IBM Color Graphics Adapter and has an expanded graphics mode that enables full use of the Professional Graphics Display capabilities. The controller includes 320K bytes of RAM: 300K for display storage and 20K for internal variables and lists. The controller has its own on-board 8088 processor and graphics firmware in a 64K-byte ROM.

The controller allows two- or three-dimensional drawing in hardware and has built-in functions to rotate, translate, or scale objects. You have access to 256 user-programmable display lists and can select either the built-in character set or define your own. The controller features vector and polygon drawing as well as polygon fill. The two-card Professional Graphics Controller has a list price of $2995.

For less demanding PC owners, IBM also announced the Enhanced Color Display and Enhanced Graphics Adapter. The display provides a resolution of up to 640 by 350 pixels in 16 colors (from a 64-color palette) and should be available by January for $849.

The Enhanced Graphics Adapter provides 640 by 200 or 320 by 200 pixel graphics in 16 colors on the IBM PC Color Display, or 640 by 350 pixels on the IBM Monochrome Display. On the Enhanced Color Display, the adapter can display the full 640 by 350 pixels in up to 4 colors with the standard 64K bytes of RAM or up to 16 colors when upgraded to 128K bytes with the optional Graphics Memory Expansion Card. An optional Graphics Memory Module Kit expands the card's memory to 256K bytes, allowing smooth scrolling and panning and additional pages of graphics data. A RAM-resident character generator can use from 256 (with 64K bytes) to 1024 (with 256K bytes) user-defined characters in sizes up to 8 by 32 pixels.

IBM warns that some PC owners may require a ROM BIOS replacement in order to use the Enhanced Graphics Adapter, which is priced at $524. The optional Graphics Memory Expansion Card, which upgrades the adapter to an 128K-byte RAM, costs $199; the Graphics Memory Module Kit is $259.

Circle 600 on inquiry card.

Graphics Software

Also announced by IBM were a number of graphics subroutine libraries for the IBM Personal Computer. All require DOS 2.1 or later, at least 256K bytes of RAM, and one of IBM's color graphics adapters. Language bindings are provided to access the routines from programs compiled by FORTRAN 2.0, Professional FORTRAN, Lattice C, and BASIC compilers.

The IBM Personal Computer Graphical Kernel System is a subroutine library of two-dimensional graphics primitives consistent with the proposed ANSI and ISO standards. The Plotting System assists programmers in generating most types of standard charts and graphs. The Graphical File System is an implementation of the proposed ANSI Metafile Standard. The Graphical Kernel System costs $295; the Plotting System, $225; and the Graphical File System, $175.

The Graphics Development Toolkit is designed for software developers writing graphics applications. By licensing the device drivers contained in the Toolkit, developers can sell device-independent software to users who need not buy the Toolkit themselves. The Graphics Terminal Emulator provides emulation of Tektronix 4010 and Lear Siegler ADM3A protocols. The Toolkit can be purchased for $350, and the Graphics Terminal Emulator costs $295.

Contact IBM Corp., Entry Systems Division, POB 1328, Boca Raton, FL 33432, (800) 447-4700.

Circle 601 on inquiry card.

(continued)

Interface Hardware

Other new items from IBM are a Data Acquisition and Control Adapter and a General Purpose Interface Bus (GPIB) Adapter.

The IBM Personal Computer Data Acquisition and Control Adapter features two 12-bit analog input channels, four 12-bit analog output channels, a 16-channel digital input port, and a 16-channel digital output port. The adapter also includes two timers: a 32-bit timer for programmable sampling rates and a 16-bit user timer/counter for use as an event counter, programmable rate generator, or for a programmable delay. The adapter can be attached to an optional Data Acquisition and Control Adapter Distribution Panel, providing easier access to its signals, voltages, and grounds. Also available is a Programming Support package including a subroutine library accessible from several high-level languages. The adapter costs $1275, the optional Distribution Panel is $245, and the Programming Support software is $160.

The IBM Personal Computer GPIB Adapter is a half-size card that provides an interface for up to 14 devices that use the ANSI/IEEE-488 standard. It is priced at $395. Optional GPIB Adapter Programming Support, which allows high-level language access to subroutines to control or monitor up to 48 devices using four adapters, costs $85.

IBM also announced a 256K-byte memory expansion on a 5-inch card, priced at $489.

For complete information, contact IBM Corp., Entry Systems Division, POB 1328, Boca Raton, FL 33432, (800) 447-4700.

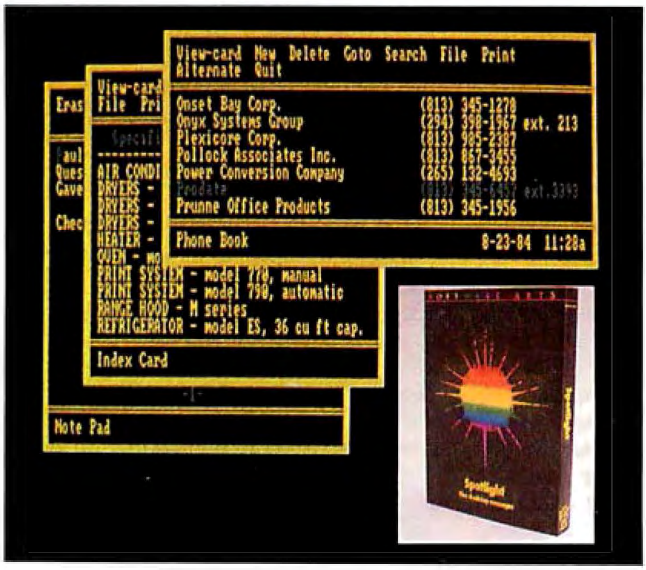
Circle 602 on inquiry card.

Desk Accessories from Software Arts

Spotlight is a memory-resident program that includes a set of six desktop management utilities for the IBM Personal Computer. The programs include a note pad, a phone list, an appointment calendar, a calculator, an index-card file, and a DOS Filer, which allows access to some DOS commands from within another program.

Each of the six utilities can be called at any time from within most PC-DOS programs, and it will appear as a pop-up window. The Appointment Book allows you to keep track of appointments in the near and distant future and to set alarms to alert you as the appointment approaches. The Calculator utility allows you to use the numeric keypad and nearby keys as a memory calculator and to paste results into an application program. The Filer can be used to view a directory, to view the contents of a text file, or to erase, copy, or rename files.

Brief notes entered in the eight-page Note Pad can be copied to a file or left in the note pad for later reference. You can use the Phone Book utility to store up to 500 names, numbers, and related information, in each of 36 possible phone lists. Each entry is a free-form index card, and text anywhere on the card can be searched for later. The Index Card File is a more general-purpose version of the Phone Book and permits 36 additional lists of 500 entries each, disk space permitting.



```
Onset Bay Corp.                  (813) 345-1278
Onyx Systems Group               (294) 398-1967 ext. 213
Plexicore Corp.                  (813) 985-2387
Pollock Associates Inc.          (813) 867-3455
Power Conversion Company         (265) 132-4693
Prodata                          (813) 345-6457 ext.3393
Prunne Office Products           (813) 345-1956
```

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AIR CONDI
DRYERS -
DRYERS -
DRYERS -
HEATER -
OVEN - mo
PRINT SYSTEM - model 770, manual
PRINT SYSTEM - model 790, automatic
RANGE HOOD - M series
REFRIGERATOR - model ES, 36 cu ft cap.
```

Each program is accessed by typing the Shift and Alternate keys simultaneously with one other key. The utility programs themselves are not copy-protected, but because Spotlight's memory-resident portion is, the master disk must be in a drive to initially install Spotlight.

Spotlight requires an IBM PC, PC XT, or Compaq computer, one disk drive, 128K bytes of RAM (the program occupies at least 72K bytes), and DOS 2.0 or higher; a second drive and more memory will improve its performance. It can be installed on a hard disk. Spotlight is priced at $149.95. For more information, contact Software Arts, 27 Mica Lane, Wellesley, MA 02181, (617) 431-6500.

Circle 603 on inquiry card.

Apple Announces 512K Macintosh, Software, Upgrade

Apple Computer recently announced a version of its Macintosh personal computer with 512K bytes of RAM. The Macintosh 512K costs $3195. The price of the first Macintosh, available with 128K bytes, was dropped from $2495 to $2195, and current owners can buy a 512K upgrade for $995 from Apple dealers. With the Macintosh 512K, MacWrite can create documents up to 80 pages long and MacPaint and MacDraw can create more complex images.

Those who purchased the 128K Macintosh before September 10, 1984, and who buy the 512K upgrade before March 31, 1985, will also receive copies of MacDraw and MacProject at no additional cost.

For more information, contact Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014, (408) 996-1010.

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(continued)

Available for the IBM PC, AT, XT, jr., and true compatibles*

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Whenever you're using your computer . . . from start to finish of your session Sidekick™ will be there . . . ready to serve. And it's as lightning-fast and compact as only Borland knows how to make it.

There's a notepad that has a full-screen editor that can time and date stamp your notes, and then save them to disk. You can even pull information into the notepad directly from the screen of your "underlying" software.

Suppose you're working in Lotus and the phone suddenly rings. Give your Sidekick a call and it pops right up over Lotus with the notepad you need. Or an appointment calendar . . . one you can never misplace.

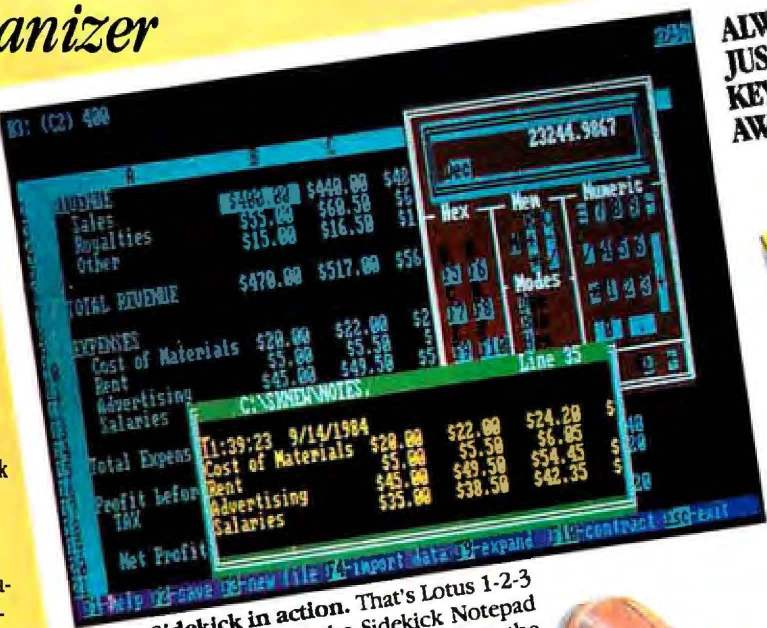
What if you need to do a quick calculation? A keystroke instantly brings up the calculator. And the results of your calculations can even be transferred to your "underlying" software.

Need to make a phone call? Up pops your personal phone directory. Type in the name you want . . . and Sidekick jumps right to the phone number. Another keystroke, and the phone is automatically dialed for you.**

There's lots more, too. You can move the Sidekick windows anywhere on the screen you like. And you can have as many on screen at a time as you need. There's even an on-line help window for each of Sidekick's features.

We designed it because we needed it. If you've ever been writing a report and needed to do a quick calculation, or jot down a note, then you need Sidekick, too.

**Only with Hayes Smartmodem and compatibles.



```
C:\SKNEW\NOTES.
11:39:23  9/14/1984  $20.00   $22.00   $24.20
Cost of Materials     $5.00    $5.50    $6.05
Rent                 $45.00   $49.50   $54.45
Advertising          $35.00   $38.50   $42.35
Salaries
```

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MacStation Organizes Macintosh and Peripherals

MicroRain's MacStation reduces the footprint of Apple's Macintosh computer and peripherals by better organizing them. The Macintosh's Imagewriter (or other) printer rests on the top of MacStation, above the Macintosh, with paper feeding from a slot in the stand. Two storage spaces, for storing manuals, a second disk drive, a modem, or disks, are included on each side of the stand. Access to the Macintosh's power, reset, and interrupt switches is provided. MicroRain says the plastic case matches the texture and color of the Macintosh and provides excellent ventilation.

MacStation is priced at $95. For complete information, contact MicroRain Corp., POB 96008, Bellevue, WA 98009, (800) 547-4000, Dept. 403; in Oregon, (503) 684-3000, Dept. 403.

Circle 605 on inquiry card.

Factfinder: Free-Form Filing on the Macintosh

Factfinder is a free-form filing system for the Apple Macintosh computer. Rather than setting up data fields, you enter data free-form in a fact-sheet window, which can be grouped with other fact sheets into a stack. Factfinder uses pull-down menus, command keys, and task-specific windows, as well as MacWrite-like text-editing features.

Information can be typed directly into a fact sheet, pasted from the clipboard, or loaded from another file. Keywords or phrases are indexed by marking them or by typing them into an "automatic keyword" list for related fact sheets. A fact-sheet stack can be locked to prevent accidental modification.

The size of each fact sheet is limited only by the computer's memory; each fact-sheet stack must be under 1 megabyte. Factfinder works with the Macintosh and the Lisa 2 with MacWorks; it also supports the Tecmar MacDrive and Davong MacDisk hard disks. It should be available this month for a list price of $150, including a free copy of the game Reversi.

Forethought plans to announce several more programs for the Macintosh soon. For more information, contact Forethought Inc., 1973 Landings Dr., Mountain View, CA 94043, (800) 622-9273; in California, (415) 961-4720.

Circle 606 on inquiry card.

Tandy 1200 Is PC XT Compatible

Tandy's newest computer, the Tandy 1200 HD Personal Computer, is compatible with IBM's PC XT system. The 1200 HD includes an 8088 processor, 256K bytes of RAM (expandable to 640K), a parallel interface port, a 360K-byte floppy-disk drive, a 10-megabyte hard-disk drive, and three additional expansion slots. The list price is $2999; the MS-DOS operating system and Microsoft BASIC are available separately for $89.95 each. The keyboard is identical to the IBM PC's except that the left Shift key and Reverse Slash key have been swapped, and LEDs are included on the Num Lock and Caps Lock keys.

Like Tandy's earlier MS-DOS computer, the Tandy 2000, the Tandy 1200 HD does not include a display adapter or monitor. A monochrome-display adapter card is available for $219; a monochrome monitor is also $219. A color-graphics display adapter, which also supports monochrome graphics, is $299, and a color display is $549.95.

Several Tecmar expansion cards can be purchased, including the $695 Graphics Master, which provides 640- by 400-pixel color graphics in 16 colors. Tecmar's Captain multifunction board, with serial and parallel ports, a 384K-byte memory, and a clock/calender, costs $795. Tandy will also offer third-party software for the 1200 HD, including WordStar, dBASE III, and Software Publishing's PFS series. For further details, contact Tandy Corp., One Tandy Center, Fort Worth, TX 76102, (817) 390-3021.

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(continued)

NEW PRODUCT NEWS FROM TELETEK

Systemaster II. Responding to market demand for speed and increased versatility, Teletek is proud to announce the availability of the next generation in 8-bit technology — the new Systemaster II! The Systemaster II will offer two CPU options, either a Z80B running at 6 MHz or a Z80H running at 8 MHz, 128K of parity checked RAM, two RS232 serial ports with on-board drivers (no paddle boards required), two parallel ports, or optional SCSI or IEEE-488 port. The WD floppy disk controller will *simultaneously* handle 8" and 5¼" drives. A Zilog Z-80 DMA controller will provide instant communications over the bus between master

sult is unprecedented performance.

Systemaster II will run under CP/M 3.0 or TurboDOS 1.3, and fully utilize the bank switching features of these operating systems.

SBC 86/87. As the name indicates, Teletek's new 16-bit slave board has an Intel 8086 CPU with an 8087 math co-processor option. This new board will provide either 128K or 512K of parity checked RAM. Two serial ports are provided with individually programmable baud rates. One Centronics-compatible parallel port is provided. When teamed up with Systemaster II under TurboDOS 1.3, this 5MHz or 8MHz multi-user, multi-processing, combination cannot be beat in speed or feature flexibility!

Teletek Z-150 MB. Teletek is the first to offer a RAM expansion board designed specifically for the Z-150/Z-160 from Zenith. The Teletek Z-150 MB is expandable from 64K to 384K. Bring your Z-150 up to its full potential by adding 320K of parity checked RAM (or your IBM PC, Columbia, Compaq, Corona, Eagle, or Seequa to their full potential). The Teletek Z-150 MB optionally provides a game port for use when your portable goes home or a clock/calendar with battery backup!

Evaluate the Systemaster II, SBC 86/87 or Teletek Z-150 MB for 30 days under Teletek's Evaluation Program. A money-back guarantee is provided if not completely satisfied! All Teletek products carry a 3-year warranty.

Specifications subject to change without

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Gould Colorwriter Plotters

The Gould Colorwriter 6300 Series color plotters have on-board software and interfaces to link them to most computers. Model 6310 is a 7-pen plotter for paper up to 8½ by 11 inches. The 10-pen Model 6320 handles paper up to 11 by 17 inches. A continuous roll is an option that eliminates the need to change paper manually. Both plotters can use any of several pen types on paper, transparencies, or foils. A self-checking facility, simple touch controls, and electrostatic paper hold-down are also standard features. Writing speed is 16 inches per second, or 20 ips with the pen up. The plotter's addressable resolution is 0.001 inch.

Built-in firmware includes Gould's own graphics language, with Hewlett-Packard graphics language-based protocols. For added flexibility, the plotter's PROM can be replaced to accommodate additional graphics standards. Three character sets, including a scientific/Greek alphabet, are stored in ROM. Other features include variable line fonts; cross-hatching, bar, and pie chart capability; arc and circle generation; character rotation and slant; and zoom and window controls.

Either Colorwriter is available with an RS-232C or IEEE-488 interface and with a 2K-, 8K-, or 16K-byte buffer. An optional digitizing sight, for feedback to the computer, is also available.

Prices for the Colorwriter 6300 series begin at $1995. Contact Marketing Services, Gould Inc., Recording Systems Division, 3631 Perkins Ave., Cleveland, OH 44114, (216) 361-3315.

Circle 608 on inquiry card.

Cermetek Modem Reduces Chance of Unauthorized Access

The Cermetek Security Modem prevents unauthorized access to your computer system by offering four levels of security. This Hayes-compatible 300-/1200-bps modem can be programmed to require all callers to enter a password. After a correct password is entered, the modem hangs up and calls the phone number associated with that password. (Up to 25 passwords and numbers can be stored.) Alternately, the modem can call back on a second phone line, allow password access without callback, or be configured to function as a Hayes-compatible modem without password security.

The Cermetek Security Modem creates an audit trail listing all valid and invalid attempts to access the computer. A dial-out password can be required to prevent unauthorized outgoing computer calls. A key is needed to change the modem's security level, passwords, or callback numbers. Standard features include auto-dial and auto-answer. It costs $695. For more details, contact Cermetek Microelectronics Inc., 1308 Borregas Ave., Sunnyvale, CA, 94088-3565, (408) 752-5055.

Circle 609 on inquiry card.

Qic-Stor-Plus Expansion Unit

Qic-Stor-Plus is an expansion unit for the IBM Personal Computer that adds a hard disk, a tape drive for backup, and five additional expansion slots. Available with 20-, 52-, or 85-megabyte hard-disk drives, the Qic-Stor-Plus can be used to expand a single PC or to create a multiuser system using Alloy's PC-Slave/16 expansion cards.

Prices for Qic-Stor-Plus start at $5595. For more information, contact Alloy Computer Products Inc., 100 Pennsylvania Ave., Framingham, MA 01701, (617) 875-6100.

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(continued on page 520)

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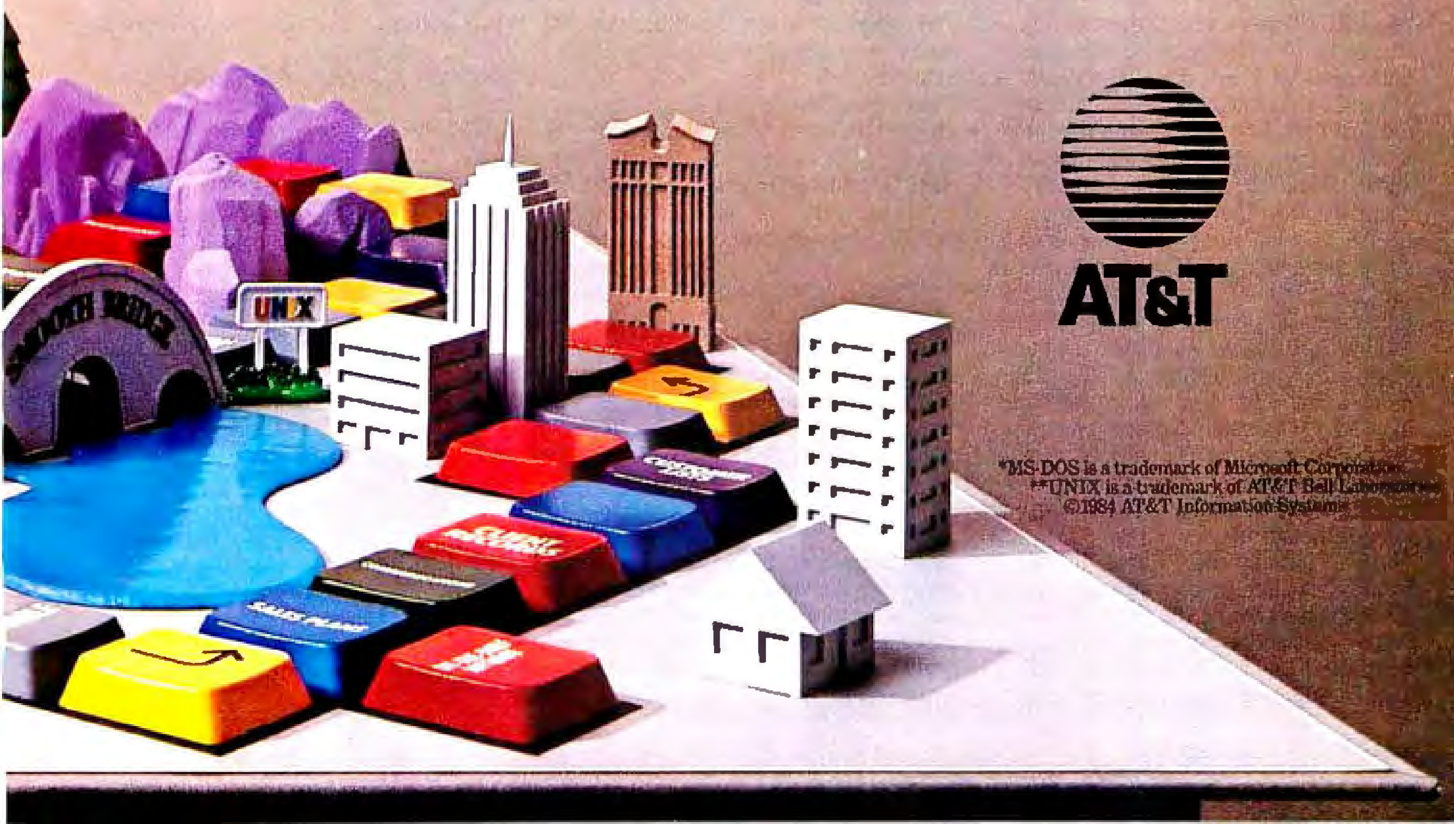

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A·S·K B·Y·T·E

Conducted by Steve Ciarcia

TRANSIENTS

Dear Steve,

Thank you for a lucid discussion of the types and consequences of power-line transients (December 1983). When my wife started using our Heath H-89 for professional word processing, the attenuation of these transients suddenly became a major concern; for us, the combination of an isolation transformer and MOVs (metal-oxide varistors) seems to have dramatically decreased the incidence of glitches, especially with respect to disk-writing operations.

Your advice regarding the installation of multiple MOVs is something most people should consider. Some computers seem to be susceptible to spikes to a lesser or greater degree than others; for most people, it isn't worth the few dollars saved to find out that their machine is among the latter.

I have one comment regarding your suggested use of MOVs: the 130-V MOV to be soldered between the neutral and ground wires will suppress only a truly major spike because the normal voltage differential between these points is 1 or 2 V at most, caused by losses across the actual house wiring. Wouldn't it be more effective to employ an MOV with the minimum value obtainable? The RCA SK Series catalog indicates that 14-V MOVs are available; although the energy absorption rating is lower, I would think their use is more appropriate. The other two MOVs should, of course, be 130-V items, and your readers should exercise special care to assure that the low-voltage MOV gets strung across the *neutral and ground lines only.*

As we are on the subject of spikes, I might add that a disruptive, if not common, source of transient voltage can come from *inside* your computer. For some time, we experienced occasional odd screen behavior, as evidenced by spurious characters or by text appearing in the wrong part of the screen.

After opening the chassis, I found strands of dirt, much like cobwebs, stretched between the flyback coil's high-voltage lead and a nearby memory-expansion board. The static charge that had accumulated made cleaning quite difficult. After cleaning, I moved the lead away from the electronics, closer to the monitor's tube. Mirabile dictu, no more screen glitches! Although the charge generated by static buildup contains little energy, the voltage levels are such that they can wreak havoc on computer electronics.

CLYDE NEWMAN
Agoura, CA

It is true that the normal voltage differential between the common and neutral lines of household wiring is small. I was concerned with the possibility of an induced voltage on this line caused by coupling of some sort. Also, one must consider Murphy's law when using devices with different voltage ratings. —Steve

CP/M 2.2

Dear Steve,

I am the proud owner of a Microstar single-board computer from the Micro V Corporation. Unfortunately, it cannot run higher application programs like MDBS or CalcStar because it uses CP/M version 1.14 and I need 2.2, which I have, but in an installed form for another hardware configuration.

How should I patch the 2.2 source to run on my hardware? Is there any book describing in more detail the alteration process? Or is there anybody selling CP/M 2.2 for a Microstar (twin 8-inch disks, single-density, double-sided)?

ROMAN SIGMUND
Vienna, Austria

I am not aware of anyone selling a version of CP/M 2.2 for the Microstar, but Digital Research has a newsletter that addresses questions of this nature. Write to Digital Research News, POB 579, Pacific Grove, CA 93950.

Installing a version of CP/M 2.2 on your system will involve techniques that are quite complicated. If you are not an experienced assembly-language programmer, attempting this installation might become very frustrating. If you are experienced in 8080 assembly language and want to attempt the installation, a good place to start is The Programmer's CP/M Handbook *by Andy Johnson-Laird (Osborne/McGraw-Hill, 1983).*—Steve

FASTER DATA PROCESSING

Dear Steve,

I have an Apple II+ and want to process data faster. Will a 3-MHz 6502B work in the Apple II+ if I cool it with a small fan—or will it only give me problems?

L. B. KIRKENDALL
Hot Springs, AR

Adding a 6502B microprocessor chip to your Apple II+ will not increase your processing speed. The chip has the capability of operating at higher clock speeds but will not do so unless the clock frequency is increased. In addition, the memory chips will have to be changed to take advantage of the faster read/write cycles, and the I/O routines in the monitor ROM will have to be rewritten.

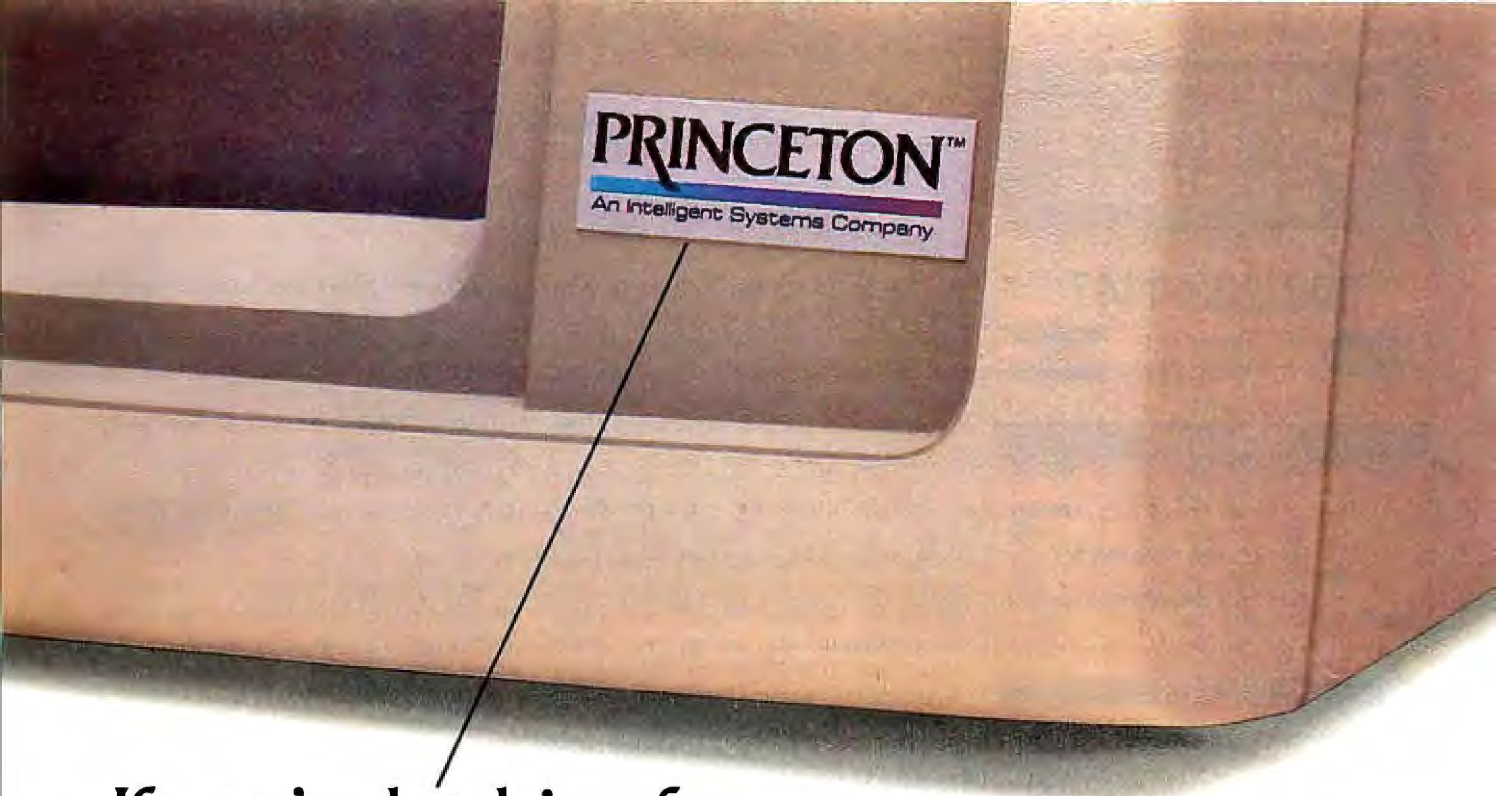
In short, it is not a simple change. Accessory boards are available that will enable your Apple II+ to run faster. They incorporate all the changes necessary and interface without problems. One such board is The Accelerator II from Titan Technologies, POB 8050, Ann Arbor, MI 48107, (313) 973-8422.—Steve

6502 PROCESSOR

Dear Steve,

While Ronnie Kelly's use of the $\overline{\text{RDY}}$ line solves the timing problems he encountered with the Z80-based Ferguson Big Board (Ask BYTE, December 1983, page 556), it is unlikely to solve Mr. Beighe's problem using the 58167 clock chip in the Apple (Ask BYTE, April 1983, page 465). The 6502 requires the $\overline{\text{RDY}}$ line to go low either during phase 1 or during the first 100 ns of phase 2. Since Mr. Beighe's circuit uses the pin 1 $\overline{\text{I/O SELECT}}$ line on the Apple bus to drive the 58167 $\overline{\text{CS}}$ pin, the clock won't be selected until well after the beginning of phase 2 (two 74LS138 decoders are chained to decode the pin 1 signals in the Apple II; they are synchronized with the system clock, and the delay through them is at least 15–25

(continued)



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ns). The 58167 can take up to 150 ns to send the $\overline{\text{RDY}}$ line low. Add the delay through the 7407 buffer, and it is unlikely that $\overline{\text{RDY}}$ on the Apple bus will get low early enough. The system may hang. Apple IIe decoding is different but the situation similar.

Another serious problem can be caused by the fact that the 6502 processor doesn't permit wait states during write cycles. This, combined with the way it executes write cycles (first reading then writing the target address) plus the fact that the output buffers on the transceivers Apple uses to drive the data bus are Tri-stated during phase 1 (transceivers in "receive" configuration), makes it extremely difficult for the 58167 to reliably latch the data written to it even if Mr. Beighe's circuit is modified by Mr. Kelly's addition. If the system doesn't hang, it will stop at the next read cycle and wait until $\overline{\text{RDY}}$ goes high—not very useful if you want to write data to the clock.

The Apple III computer has a socket on board for the 58167, but it was never offered by the company (even though routines for it were written into the SOS operating system) because it couldn't get all the functions to operate reliably. The Apple III has the 58167 D0–D7 pins tied directly to the bus and drives A0–A4, READ, WRITE, and $\overline{\text{CS}}$ with the B port of a 6522 PIA. While this arrangement allows most clock functions to operate normally, the latch and counter resets aren't completely reliable, and the GO command is inoperative. This is a good example of a half-a-loaf approach to the problem of interfacing the 58167 with a 6502 system.

All the functions of the 58167 can be reliably obtained in a 6502 system if both ports of an interface adapter such as the 6520 or 6522 are used.

Three 74LS374 latch packages and some gates can also be used to get a fully functional interface.

Frank Kuechmann
Vancouver, WA

Thank you very much for your letter. You correctly point out some of the problems with this slow chip and a way to solve them.—Steve

Dear Steve,

I've noticed at least one company that offers a plug-in enhancement board for the Apple II that makes use of the faster (3-MHz) 6502B chip.

Why don't more manufacturers of 6502-based machines offer a speed-up option, such as the so-called GT series that Ohio Scientific used to sell?

What would have to be changed (other than the processor, using faster memory chips, and altering the clock speed and possibly the I/O timing routines in the operating system) to treble the crunching speed of 6502-based machines?

How much would these changes cost if performed on one machine? How much difference in cost would there be if the manufacturers incorporated this change on the assembly line?

David T. Morse
Starkville, MS

(*continued*)

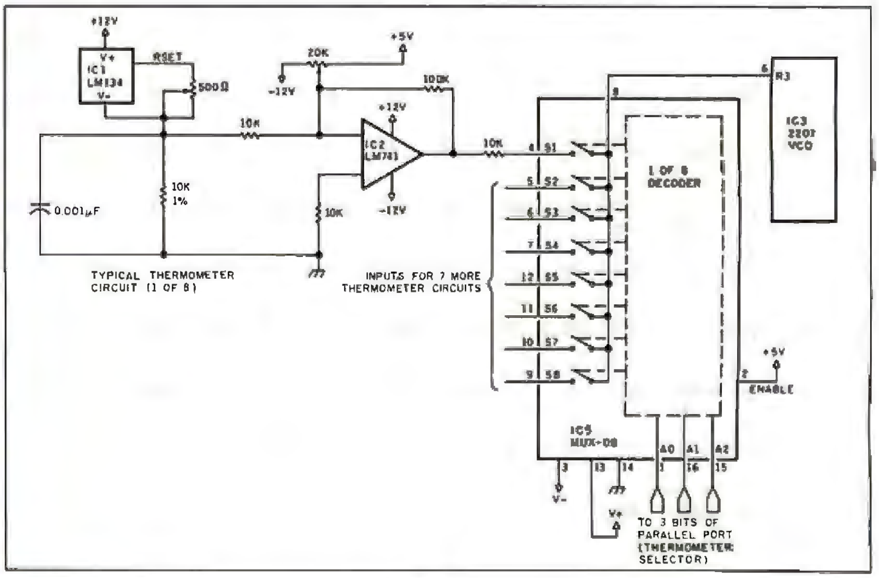

Figure 1: *Part of the original circuit with an analog multiplexer added.*

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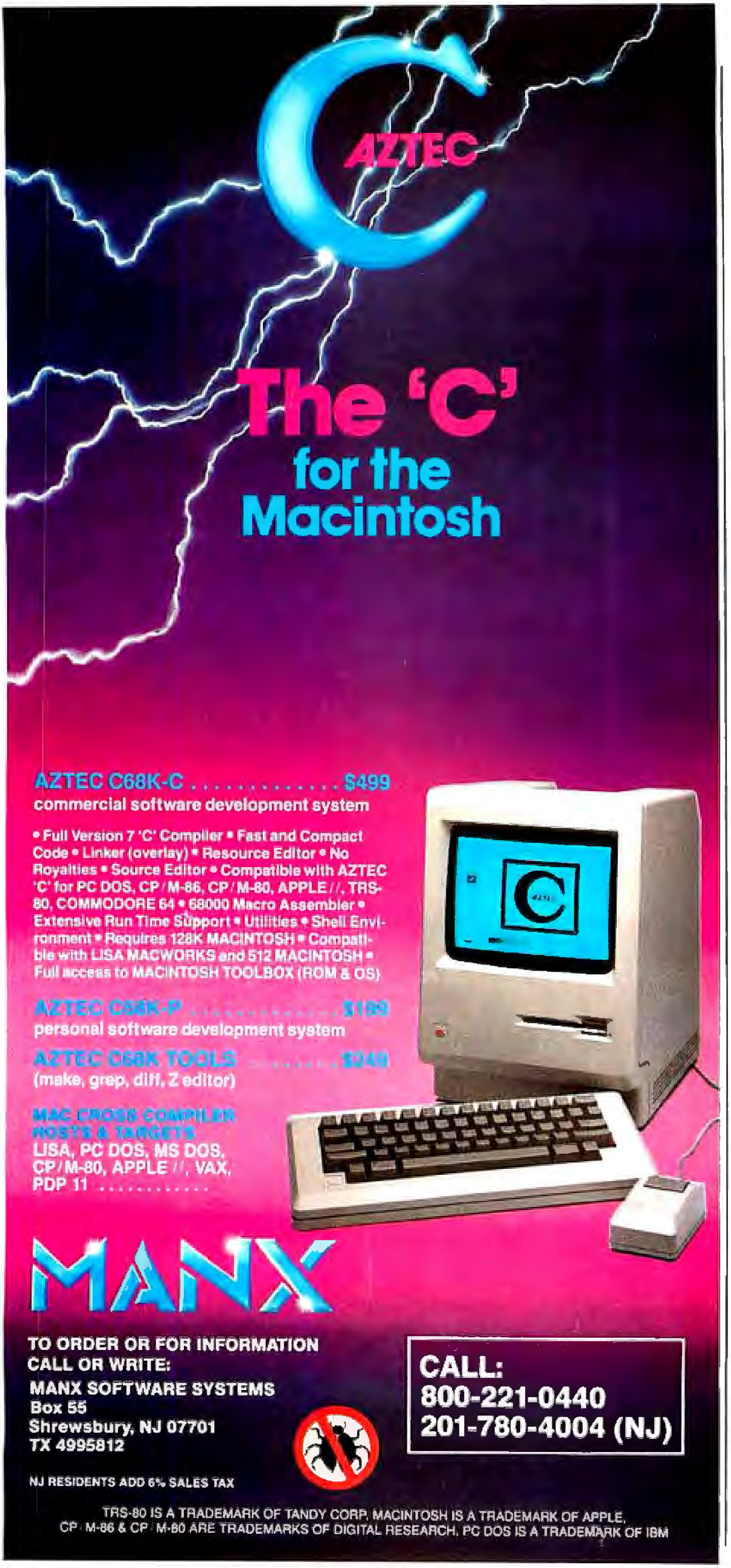

The complexity of the changes required to install a speed-up option to the 6502 (or other microprocessors) when weighed against the benefits does not make economic sense. For example, such a speed-up could be added to a VIC-20, probably at a cost greater than the computer, but it may render many commercial programs unusable because of timing problems, and the speed increase would probably not be appreciated by many users. For games and graphics, the speed of present computers is adequate. Only when significant number crunching or database searching is involved does a speed increase become important.

Isn't changing "the processor, using faster memory chips, and altering the clock speed and possibly the I/O timing routines in the operating system" to increase processor speed enough? A computer could be designed with the added speed, but it is more practical to go to a 16- or 32-bit processor.—Steve

Dear Steve,

In your article on building a computerized weather station (February 1982, page 38), you described a circuit that converts temperature to frequency in control systems.

How can this circuit be adapted so that multiple temperature inputs could be input to the system and identified and serviced, if necessary? I realize that a D/A circuit would be needed for the servicing.

I have a Big Board computer system with tiny BASIC. I feel that designing the program around this system would be similar to that of the Z8, with possibly more I/O options.

Thank you for any help.

Dace R. Smith
Huntsville, TX

Whenever signals from several different sources are to be fed into a single receiving unit, you should search for some kind of multiplexer to do the job. In the case of the digital-thermometer circuit, it is best to do the multiplexing in the analog portion of the circuit, as shown in figure 1. This figure is a redrawing of a portion of the original thermometer circuit from my article with an analog multiplexer (MUX-08) added. The MUX-08 (IC5) is an analog multiplexer made by Precision Monolithics Inc., and it is used to select one of eight different thermometer channels. The channel selected is determined

(continued)

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by the digital inputs at pins A0 through A3 of IC5.

When the circuit is connected to your Big Board, one of your output ports will be needed to select the thermometer channel, and one of your input ports will be needed to accept the frequency data from the selected thermometer. Identification of the proper thermometer is handled by the I/O program you write to select the thermometer.

If a D/A circuit is needed to service a device being monitored by the thermometer circuit, see "Analog Interfacing in the Real World" (January 1982, page 72). This article should supply you with enough information about D/A applications to assist you in your project.—Steve

MINIFILE

Dear Steve,

In the February Ask BYTE, you said that Atek NC Corporation provided the FDS-100 Minifile to interface equipment for recording 5¼-inch disks.

I would like to clarify a few points. Greco Systems is the original designer and manufacturer of the FDS-100 Minifile. Atek was our representative in the New England area. Since last April the company has discontinued marketing our products.

Last November we introduced the FDS-200 Minifile, similar to the FDS-100 Minifile, but with many enhancements. I would appreciate it if you would indicate the FDS-200 instead of the FDS-100 in future answers since our future developments will concentrate on the new product.

MICHAEL BRADBURY
Director of Marketing
Greco Systems
El Cajon, CA

Thanks for the update.—Steve ■

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

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

The "Ask BYTE" staff includes manager Harv Weiner and researchers Bill Curlew, Larry Bregoli, Dick Sawyer, and Jeannette Dojan.

A BUREAUCRAT'S GUIDE TO WORD PROCESSING

Now, if it were you or I and we wanted a word processing program for our IBM-type PC, we'd probably stop off at our local computer store and simply diddle with a few.

You and I, however, are not the U.S. Department of Agriculture.

(Nor any of its permutations of subsystems like the Economic Research Service, National Resources Economics Division, Data Services Center, etc., etc.)

So when the USDA told ERS to tell NRED and DSC to look into a truckload of w.p. programs for all their PCs, the last thing they wanted was simple diddling. Their dedicated Wangs and Lexitrons were far too few to handle their needs, their IBM® PCs weren't compatible with them anyway, and nobody really, quantifiably, knew from word processing with a personal computer.

THESE ARE THE PACKAGES THE COMMITTEE EVALUATED:

Definitely not a diddling-mode condition.

As they put it in The Exchange, an internally distributed publication of the Department of Agriculture: "A needs assessment showed that, in the long-term, a word processing system is needed that can increase word processing capability and also be compatible with ERS' Long Range Information Management goals."

Well. "Needs assessment" led swiftly to "procurement action," which galloped into an "objective review" of the eight top-rated PC programs on the market (as compiled by The Ratings Book published by Software Digest), along with Wordstar® and Display Write 2, because they had some around.

Thus armed with the names, the final evaluators (a team of secretaries from NRED who would be the primary users of the PC software) became armed with each of the programs, along with checklists to record such things as ease of use, advanced features, and similarity to their existing dedicated equipment.

The first to be eliminated from the prospect list were Office Writer™ and Samna,™ since they're copy-protected and couldn't be transferred to hard disks.

THESE WERE THE FINALISTS:

Next, IBM's Display Write 2: because it's "not compatible with other software used in ERS (like Lotus 1-2-3,™ dBASE II,® etc.)," and it's "full of confusing menu options and cryptic error messages." Au revoir IBM.

Then, three more, for a variety of reasons.

Which left the following:

Volkswriter® Deluxe™
MultiMate™
Leading Edge™

Volkswriter Deluxe? "Too complicated and confusing." Not "easy to learn or use."

MultiMate? Not bad. It actually tied the winner in a few categories.

The winner being the one that won 82% of the votes in the Ease of Use/Ease of Learning categories. The one about which they said, "The ability to store deleted text and automatic document backup features were both highly desirable." The one they thought they'd quickly "be able to use . . . for their day-to-day word processing tasks."

The whole process took some three months of work by people in DSC to support the NRED in its work with the ERS and DSC to make the world a better place for the USDA.

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● **SOLELY THE SANYO** *San*-PiC, a journal devoted exclusively to users of the Sanyo MBC-550/555, aims to provide a consolidated source of information concerning software compatibility, hardware accessories, updates, applications, reviews, and reader contributions. The subscription to the bimonthly publication is $12 for 12 issues. Contact Ambrose Barry, 1967 Defiance Ave., Las Cruces, NM 88001, or call his bulletin-board system at (505) 646-5194.

● **APPLE PIE NEWS: $10** Users of the Apple PIE and PIE Writer word-processing programs have formed a club that acts as a clearinghouse for ideas and techniques to enhance the use of the word processors. The newsletter is available for $10 a year and includes tips and modifications. Specify whether you have an Apple II or IIe, a 40- or 80-column board, and your identification numbers, if applicable. Contact Monty Lee or Mike Weasner, Apple PIE Writers, 12841 Hawthorne Blvd., POB 589, Hawthorne, CA 90250.

● **JUGFUL OF NEWS** The Jefferson State Computer Users Group (JUG), formerly the Jackson Amateur Computer Society, meets regularly in southwestern Oregon. Every month the group produces a tabloid, *The JUG Newsletter*, that prints activities of the several special-interest groups it sponsors. A subscription is included in the $5 membership fee. The Medford FORUM-80, (503) 535-6883, is available 24 hours a day. For further details, write to the Jefferson State Computer Users Group, 2355 Camp Baker Rd., Medford, OR 97501.

● **IMAGINE A CLUB FOR THE IM-1**—Owners of APF IM-1 computers seeking information and programs can subscribe to a newsletter produced by the IM-1 in a Million Club. It contains selected articles, news, reviews, questions and answers, programming hints, and more. Members receive reduced rates on hardware and software. The $20 annual membership fee includes technical assistance and all current-year back issues. Write to IM-1 in a Million Club, POB 54, Arrowsmith, IL 61722.

● **EPSON QX-10 IN AUSTIN** The Austin, Texas, QX-10 Users Group meets on the second Wednesday of each month to provide user and technical assistance for Epson owners. In addition, it distributes public-domain programs and offers member discounts. The monthly newsletter, included in the $25 annual membership fee, contains new-product reviews. For details, call Doug Jones at (512) 255-4150.

● **ATARI IN WEST L.A.** The West Los Angeles Atari Users Group (WLAAUG) meets at 7 p.m. on the first Wednesday of the month to hear speakers, witness demonstrations, and discuss items of interest to members. The club maintains a public-domain software library and produces a monthly newsletter that contains graphics, the club's bylaws and constitution, book reviews, relevant articles, and news. For meeting locations and other information, write WLAAUG, POB 84-396, Los Angeles, CA 90073.

● **COMM'PUTOY CULT IN SAN DIEGO**—The monthly newsletter of the 500-member San Diego Commodore User Group, formerly the San Diego PET User Group, is called *Comm'putoy Cult*. The group meets at 7 p.m. on the third Thursday of each month. An extensive library is maintained for the 64, VIC-20, and PET. Exchanges of library materials and newsletters are welcome. For details, contact Jane Campbell, POB 86531, San Diego, CA 92138-6531, (619) 277-7214.

● **TOO YOUNG FOR DUES** The Sanyo Users Group of Central Ohio formed recently for users of the MS-DOS 550/555 and the CP/M 1000/1050/1100/1150 series microcomputers. Monthly meetings begin at 9 a.m. on the last Saturday of the month at the Public Library (96 Grant St., Columbus, OH). The costs of producing a monthly newsletter are currently covered by contributions; dues are being established. Interested persons can contact Arnie Skurow, Sanyo Users of Central Ohio, 5760 Crawford Dr., Columbus, OH 43229, (614) 846-3330.

● **DATA WORTH ITS WEIGHT**—*GOLDATAnews*, a newsletter for users of GOLDATAbase, features articles on software enhancements, user interviews, user group meetings, and updates. For a free copy, contact *GOLDATAnews*, c/o Goldata Computer Services Inc., 2 Bryn Mawr Ave., Bryn Mawr, PA 19010.

● **SANYO CLUB FORMS IN BAY AREA**—The Sanyo PC Computer Club (SPCCC) meets at 7 p.m. on the first Wednesday of the month at

(continued)

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

Fashion Island in San Mateo, California. Members or subscribers to the *Sanyo-PC-Hackers Newsletter (International)* can keep up on the latest news about the 550 series of MS-DOS computers. A library of public-domain disks is maintained by the club and a bulletin-board service is in the works. In return for contribution of an article or program for publication, you can receive a library disk of your choice. The $15 annual fee includes access to the BBS, group-purchase discounts, and the newsletter. For details, contact the Sanyo PC Computer Club, 12155 Edgecliff, Los Altos, CA 94022.

● GEORGIA GENERAL
The Atlanta Computer Society (ACS) of Georgia welcomes people who share an interest in personal computer applications. ACS meetings begin at 7:30 p.m. on the last Wednesday of each month and offer programs of general interest. Several special-interest groups (SIGs) conduct separate meetings; many offer services that include public-domain program libraries. ACS currently houses SIGs for 8080-Z80-CP/M, 68xx, Atari, Apple, Timex/Sinclair, Epson, and robotics. A newsletter is produced monthly, and the BBS is available 24 hours a day at (404) 636-6130. For information, contact the Atlanta Computer Society, POB 888771, Atlanta, GA 30356, (404) 435-9671.

● SOLE SUPPORT FOR DATAMAC—The Datamac Computer Users Group seeks Datamac owners to interchange public-domain software, programming and repair tips, and sources of parts for the Datamac computer. For details, contact Jack Hall, POB 1179, Angels Camp, CA 95222.

● EASTER SEALS AT WORK
Computer-Disability News is a computer resource newsletter for people with disabilities. Produced quarterly by The National Easter Seal Society's Committee on Personal Computers and Disabilities, it contains information about job opportunities, technology, and publications. It also acts as a clearinghouse for people with disabilities who want to use computers. Subscriptions are free. Write to J. Minton, *Computer-Disability News*, c/o The National Easter Seal Society, 2023 West Ogden Ave., Chicago, IL 60612.

● FREE FOR ALL LOTUS USERS—All users of Lotus 1-2-3 and other integrated software are welcome to join the Lotus 1,2,3 Federal Users Group. Because the group is almost entirely composed of government employees, the applications are geared toward such needs as networking government users of sophisticated microcomputer software. Monthly general meetings also house three special-interest groups—advanced users, federal applications, and training—that meet separately. For further details, contact Cathy Robertson, D:C:H:C, BXR-1310, Washington, DC 20224, (202) 756-7453.

● BBS IN CONNECTICUT
The Switchboard Net-Works is a 300-bit-per-second bulletin-board service operating 24 hours a day on a Franklin Ace computer. Apple users can likewise benefit from the user-supported utilities downloadable from the board by dialing (203) 669-3456. Users can also use the board as a problem-solving forum. Donations are accepted. Contact Tim Sipples, 70 Glenwood Rd., Clinton, CT 06413, (203) 669-9056. ■

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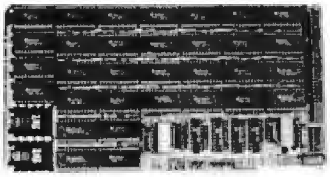

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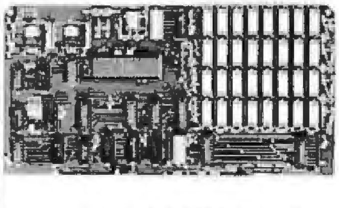

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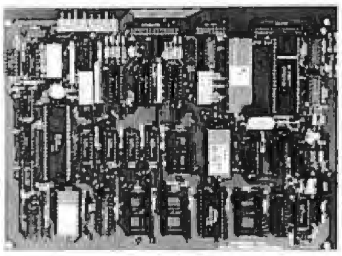

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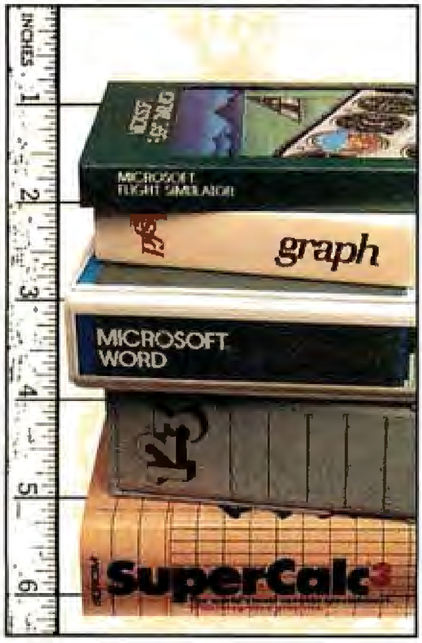

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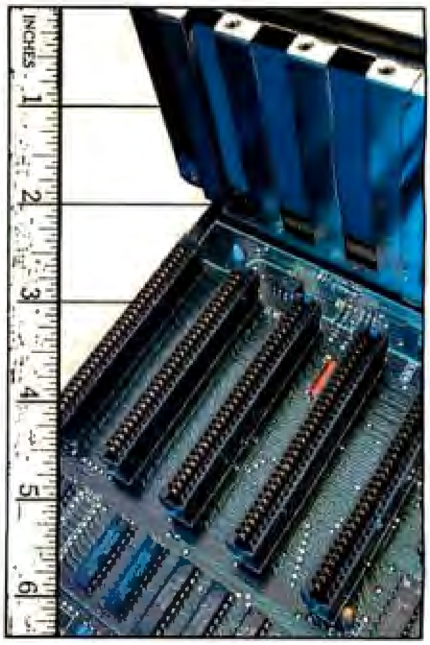

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out choosing a video card.

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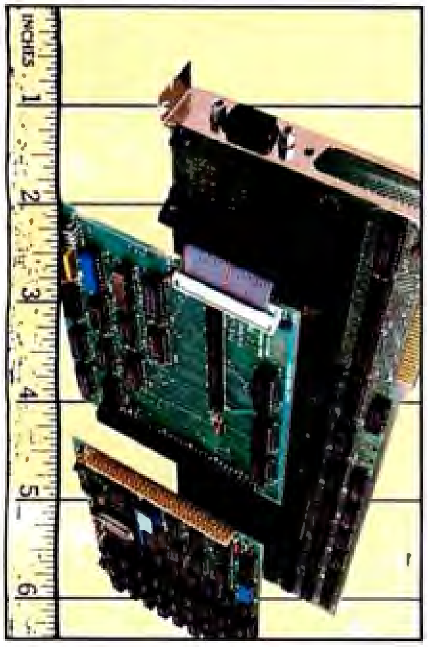

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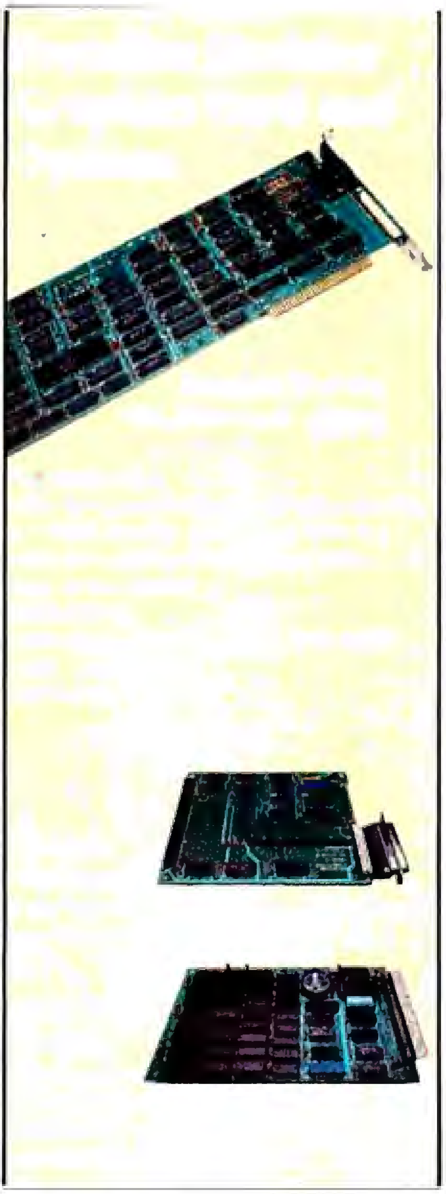

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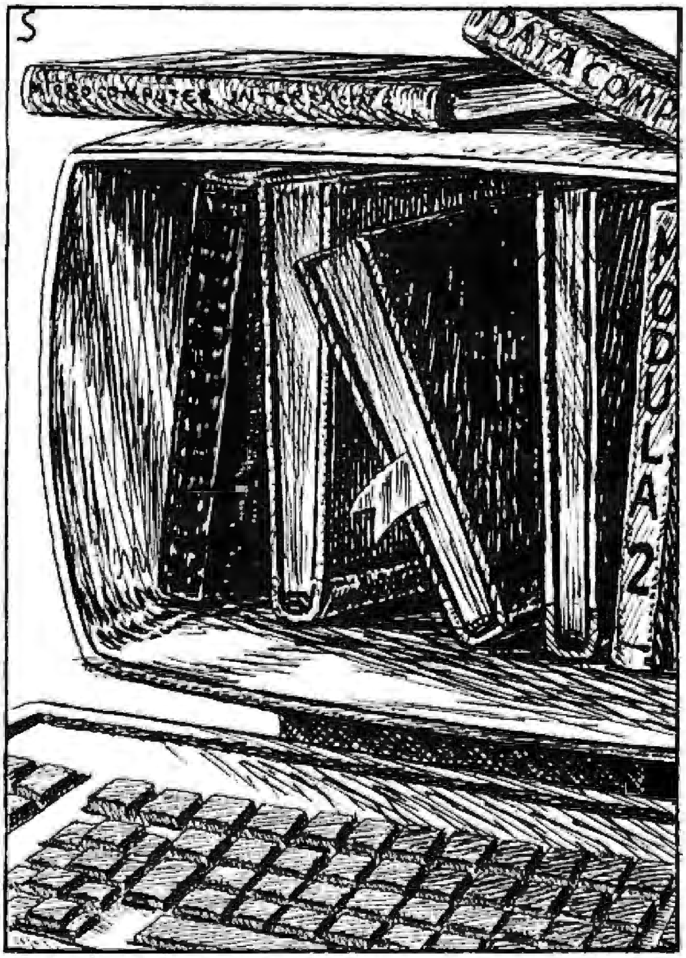
BOOK REVIEWS

MODULA-2 FOR PASCAL PROGRAMMERS
Richard Gleaves
Springer-Verlag
New York: 1984
151 pages, $16.95

DATA COMPRESSION: TECHNIQUES AND APPLICATIONS, HARDWARE AND SOFTWARE CONSIDERATIONS
Gilbert Held
John Wiley & Sons
New York: 1983
144 pages, $30.95

THE HANDBOOK OF MICROCOMPUTER INTERFACING
Steve Leibson
Tab Books
Blue Ridge Summit, PA: 1983
272 pages, $14.95

THE PROGRAMMER'S GUIDE TO LDOS/TRSDOS VERSION 6
Roy Soltoff
Misosys Inc.
Sterling, VA: 1983
208 pages, $20



MODULA-2 FOR PASCAL PROGRAMMERS

Reviewed by David D. Clark

Modula-2 for Pascal Programmers is an introduction to Niklaus Wirth's newest language and builds upon knowledge and skills already acquired by Pascal programmers. The audience for the book is well defined in the title and in the material presented. It dispenses with attempts to teach proper programming practices that might be helpful for a beginner but distracting to an experienced programmer. By drawing upon this assumed base of previous experience, Richard Gleaves is free to concentrate on differences from Pascal and features new to Modula-2. A treatment of this type will let the working programmer "come up to speed" quickly in this new language.

While a student at the University of California at San Diego (UCSD), Mr. Gleaves worked on the UCSD Pascal project, writing some of the software. He later joined SofTech Microsystems and continued work on the p-System. He now works at Volition Systems (Del Mar, California), a software company that has written a Modula-2 system for microcomputers. Volition's implementation is derived from the Apple Pascal version of the UCSD p-System and is available for several processors and operating systems. *Modula-2 for Pascal Programmers* is an extrapolation and generalization of the user manual for Volition's version of Modula-2; as such, it is a description based on a working microcomputer installation of the language. Mr. Gleaves writes with the authority of a designer and experienced user of an actual implementation of the language. He writes also with great clarity.

The book is divided into three nearly equal parts, the first of which describes the Modula-2 concepts that will be new to a Pascal programmer. The most fundamental of these is the *module*, the basic compilation unit of Modula-2. Several chapters discuss the various types of modules (local modules, separately compiled modules, and program modules). Another chapter is devoted to the module library, a crucial part of any Modula-2 programming environment. Other chapters cover new facilities for low-level programming, concurrent programming, and procedure variables.

The second main section of the text discusses the differences between Modula-2 and its predecessor, Pascal. These include changes in the interpretation of basic textual units of programs, such as identifiers, symbols, and

(continued)

ILLUSTRATED BY STEVEN SALERNO

comments; alterations to the syntax of constant, data-type, and variable declarations; and the proper formation of expressions, statements, and procedures. This section of the book also deals with some features of the language that don't really qualify as new concepts. For example, all of the structured control statements of Pascal are present in Modula-2, but in slightly altered form. Often the changes are small, but you have to learn them in order to write correct programs. There are also new structured statements like RETURN and the LOOP/EXIT construct. In addition, this section covers new standard procedures (FLOAT and VAL, for example) and other new parts of the language, including open-array parameters, cardinal numbers, set constants, and relaxed rules for the order of declaration of objects. Another important topic is the group of revised rules for type compatibility in assignment statements and expressions. The subjects covered in this section are basically extensions of Pascal, things you've always wanted but couldn't have. Some of the differences are trivial, others have profound effects, but all are presented clearly and thoroughly.

Part three of the book discusses utility modules, facilities expected to be provided with each implementation of the language on a particular computer. Since the language definition does not provide explicitly for I/O (input/output), file handling, storage management, and other functions, modules containing the required routines are included with each implementation. Some chapters describe the facilities for standard I/O, like reading and writing characters, strings, and text. Mr. Gleaves describes modules to perform storage allocation, subprogram calls, format conversions, and mathematical functions. These are not the same modules Wirth discusses in *Programming in Modula-2* (New York: Springer-Verlag, 1982), but they are more applicable to a microcomputer environment. The definition module for each is presented after a discussion of the function of each of the procedures. In many cases the discussions are short for obvious reasons. For example, just about everyone can figure out how to use the cos procedure to take a cosine. However, the construction of an interrupt-driven serial-port driver requires, and is given, a more detailed treatment.

Several appendixes follow the main text—a glossary, syntax diagrams, a list of standard identifiers, and a list of reserved words and symbols. The index also appears to be very complete.

One of the best things about *Modula-2 for Pascal Programmers* is that each important language feature is illustrated with at least one example of correct usage. These examples are often trivial, but it is refreshing to be shown explicitly how the language works rather than having to ferret out the information from obscure references scattered throughout the text. Aside from the profuse examples, Mr. Gleaves provides notes and warnings at many locations, pointing out not-so-obvious features of the operation of the language.

If pressed to find something annoying about the book, I would mention the listings. I hate to try to read a book in which all characters are equally spaced, but it is just as unpleasant to read listings of computer programs that are spaced proportionally. I know this is just a matter of personal taste, but the equal spacing of letters provides textual markers that line up vertically in a listing, making some structural features of the program easier to see. Proportional spacing can destroy that vertical format. Fortunately, care has been taken to preserve such markers in this text. For example, formal parameters for groups of procedures and comments for variable declarations are lined up vertically.

Mr. Gleaves makes a presentation that is clear and complete. Lots of concrete examples demonstrate the language facilities. Subtle technicalities and potential hazards are plainly pointed out in numerous notes and warnings. Facilities not an actual part of the language but expected to be available in any Modula-2 environment are also described.

Although I received an early proof of the book to review, all typographical errors had already been eliminated. This may be characteristic of careful work by Springer-Verlag editors. For an experienced Pascal programmer, this single volume can serve as an introduction to the similar but extended facilities of Modula-2.

DATA COMPRESSION: TECHNIQUES AND APPLICATIONS, HARDWARE AND SOFTWARE CONSIDERATIONS

Reviewed by Michael O'Neill

Judging by the several articles that BYTE has published on the subject, data compression is a topic of interest to users of personal computers. Part of this interest is intellectual, but I imagine that the major reason for concern with data-compression methods is practical. This practical interest can be attributed to two of the Laws of Universal Privation: You never have enough memory, and You never have a data channel that's fast enough.

Data Compression addresses the practical aspects of this subject. "The goal of this book," the author writes, "is to provide readers with an intimate awareness of practical and easy-to-implement data-compression techniques." Gilbert Held deals solely with the compression of digital data, primarily text or numeric data stored as characters (rather than, for example, as binary numbers). Held concentrates on applications to communications, but most of the techniques can be applied to storage reduction as well. True to his word, Mr. Held focuses on the nuts-and-bolts aspects of data compression.

Chapter 1 introduces basic definitions and areas of application. It also has a section giving you the data and formulas necessary to determine information-transfer rates for various types of commonly used data channels.

In chapter 2, the author presents methods of compression. There are methods that suppress repetitions of char-

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acters: null suppression, bit mapping, and run-length encoding. Half-byte packing compresses blocks consisting of only one type of character—for example, numeric. And there are techniques that replace frequently occurring characters or groups of characters with short codes: diatomic encoding, pattern substitution, and statistical encoding (Huffman and modified Huffman codes). Mr. Held also describes the method of relative encoding, used when successive data items vary only slightly. In this method, you encode the differences between one item and the next; if these differences are sufficiently small, compression results.

All data-compression methods require that the data to be compressed have the proper characteristics. Chapter 3 deals with this important aspect of the design of compression systems. The author describes a FORTRAN program (a complete listing is included) that will provide the statistical information necessary to choose which form of compression is appropriate for a given type of data file. Even if you choose not to use the author's program, he gives enough information to enable you to design one suitable to your needs.

In the final chapter, Mr. Held deals with problems involved in linking data-compression routines to other software in order to build a working system. He treats such matters as routine placement and timing considerations.

I have two complaints about this book: first, it is not comprehensive; second, the author is repetitious.

As to the first complaint, the author does not mention Karlgren's method (similar to, but more powerful than, half-byte coding), and his treatment of adaptive compression is sketchy. I would like to have seen some material on specialized methods, such as differential compression, as applied to reduction of storage requirements.

As to the second complaint, the expositions frequently are repetitious. This is most obvious in Mr. Held's discussion of Huffman coding; not only does he explain twice how to construct a Huffman code, but figure 2.29 is included in figure 2.30 and could have been eliminated with no loss of clarity. It's appropriate that a book on data compression is slim, and it's ironic that it is redundant. Considering the high price of this book, I feel that the gratuitous repetition ought to have been replaced with new information.

Data Compression is detailed and wide-ranging, although not comprehensive. The book should be of interest to you if you are seriously involved with data communications and have a need to know, in detail, about practical data-compression schemes.

THE HANDBOOK OF MICROCOMPUTER INTERFACING

Reviewed by Petr Beckmann

Though there are several books available on interfacing to microcomputers, they all seem to fall short when

(continued)

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explaining the practical workings. For example, why is it so difficult to connect two devices using an RS-232C connection? Many books written about interfacing tell you about the RS-232C standard interface conceptually, but they ignore the problems encountered when using it.

I am happy to report that Steve Leibson's *The Handbook of Microcomputer Interfacing* does not shortchange the reader. Based on a series of six articles that appeared in BYTE in 1982, this book does indeed answer the preceding question about RS-232C connection, as well as many more about interfacing. It is clear that the author feels at home with this subject. In the introduction to the book he writes, "Welcome to the world of microcomputer interfacing! It is a place full of mysteries much like a computerized Adventure game. . . . This book is a set of guidelines on how to play the Interfacing game." Throughout the book Mr. Leibson mixes facts, history of technology, and opinion into an easy-to-read introduction to this field.

The first chapter, "Bits, Bytes and Buses," serves as a preface for the hardware novice. It presents clearly and simply the basic concepts of Boolean mathematics, gates, flip-flops, computer number systems, and buses. Chapter 1 also includes a complete explanation of the ASCII (American Standard Code for Information Interchange) code. The author covers each ASCII control code in a short paragraph, lifting the veil on a somewhat cryptic subject.

In chapter 2, titled "Component-Level Buses," Mr. Leibson discusses the first port of access to the microprocessor. All data flows into or out of the microprocessor over its component-level bus. The chapter starts by defining the parts of a generic microprocessor bus, which is composed of address, data, and control buses. The author then progresses to specific microprocessor buses; the 6800, 8080, Z80, 8086, Z8000, and 68000 microprocessors are covered in depth. The read and write cycles of each bus are detailed, and special features of each microprocessor bus are described. Throughout this chapter, Mr. Leibson specifically calls attention to aspects he feels are particularly interesting, rather than simply reciting "the way things work."

Backplane buses are described in chapter 3. Several of the better-known buses are covered, including the STD, S-100, Multibus, and IBM Personal Computer bus. I did not find the same level of description in this chapter, which is more like a handbook of the various buses; the interesting and readable prose found in the rest of the book is missing. However, the material is still handled well technically. Some humor did find its way into the chapter: Did you ever hear about the "MOTEL" circuit?

Chapter 4 is the first to cover an actual interface, the parallel type. The author classifies parallel interfaces into zero-, one-, two-, and three-wire handshakes. I have seen several of these types before, but the classifications seemed new to me, and I found it easier to sort things out thinking of parallel interfaces in this manner. Simple latched outputs are an example of a zero-wire handshake

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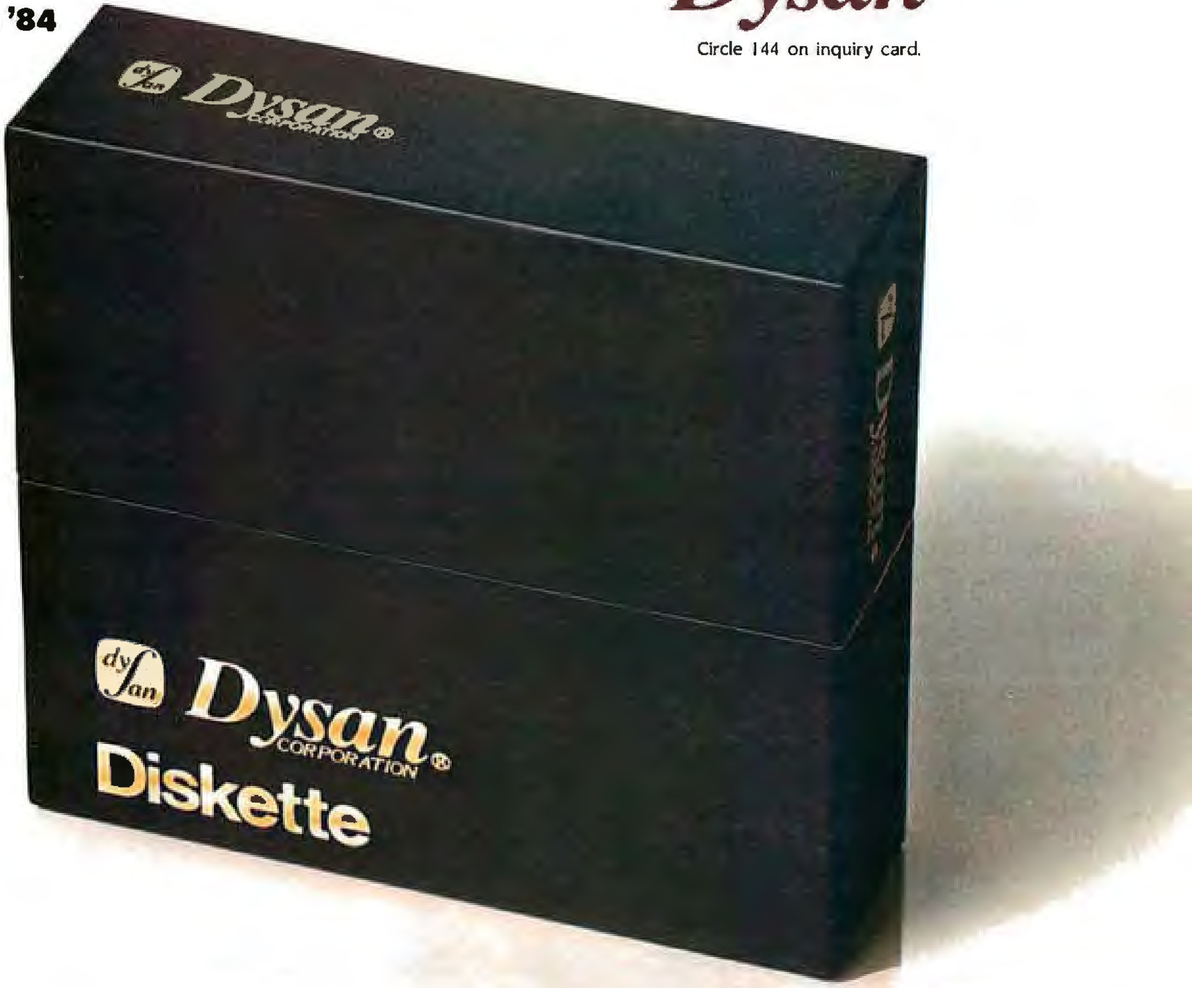

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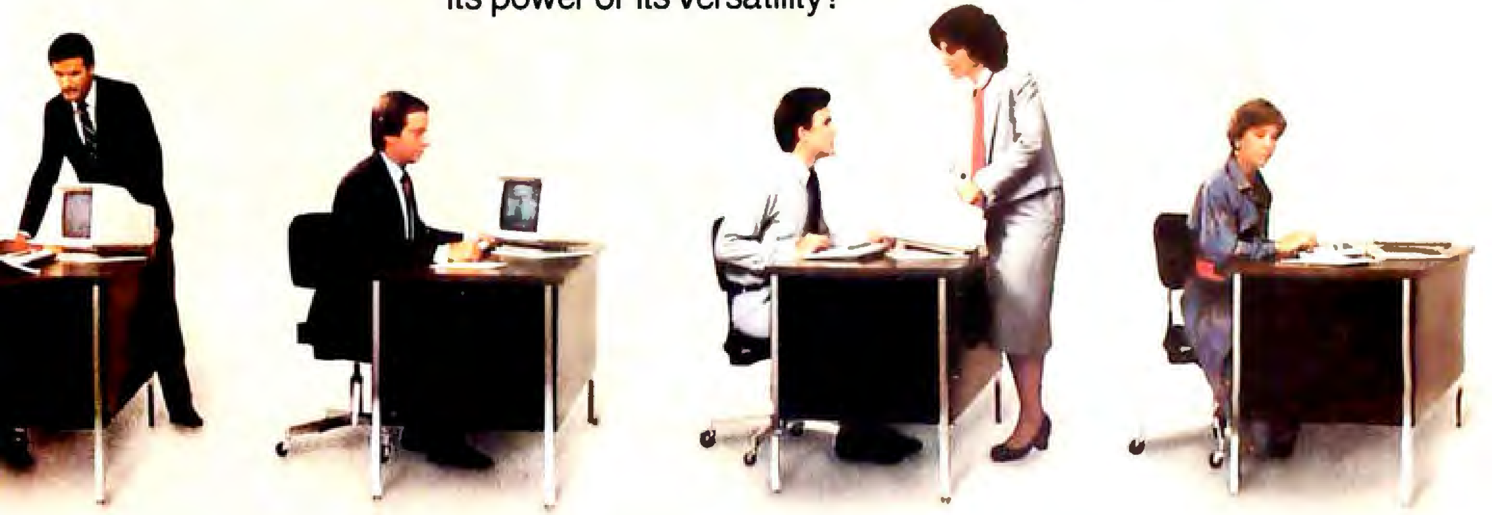

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interface, while the IEEE-488 (HPIB) is an example of a three-wire handshake interface. The author details another well-known parallel interface, the Centronics.

The last part of chapter 4 covers integrated circuits (ICs) used to implement parallel interfaces and how these ICs are applied. Many of the illustrations are apparently taken from manufacturer data sheets. I found this to be quite unusual for an interfacing book; the "real world" details are usually left as an exercise for the reader. The approach used in this chapter sets the tone for the rest of the book.

Mr. Leibson tackles serial interfaces in chapter 5. He starts out by showing how Morse code and telegraphy evolved into today's computerized serial interface, then he follows with descriptions of simplex, half-duplex, and full-duplex connections, and synchronous and asynchronous communications.

When discussing serial-interfacing standards, Mr. Leibson pays special attention to RS-232C. He has tried very hard to give the reader a personal perspective on this, the most pervasive of the interfacing standards, and he describes the "basic eight" signals in the RS-232C standard. As in the previous chapter, a substantial part of chapter 5 is devoted to the ICs used to implement a serial interface, including level translators, receiver/transmitters, and baud-rate generators.

Chapter 6 covers analog interfacing, both digital-to-analog (D/A) and analog-to-digital (A/D). This chapter includes a smattering of operational amplifier theory and the only math in the book. Many pages are used to describe resistor ladders and how they are used to convert digital signals to analog voltages. Various A/D conversion techniques are illustrated, but the author unfortunately does not mention any real devices as examples, as he did in the previous two chapters.

A unique concept, interfacing to time, is discussed in chapter 7. The author covers both interval timers and time-of-day clock circuits and provides some actual IC descriptions, which makes the chapter seem less esoteric.

Chapters 8 and 9 are not about specific interfaces but about the interfacing techniques of interrupts and direct memory access (DMA). In the chapter on interrupts, the author discusses the subject generally. He then returns to four of the microprocessors described in chapter 2 to discuss their interrupt capabilities. The chapter on DMA is quite short, and I was left feeling that there is probably a lot more to be said on the subject.

The Handbook of Microcomputer Interfacing is an excellent introduction to microcomputer hardware. It is easy to read, yet it contains a wealth of information needed by anyone working closely with microcomputers. The book seems to be targeted at hobbyists, technicians, engineers, and scientists.

If you have been a victim of books that promise a lot and deliver even more, but most of it over your head, this is the one you need for interfacing microcomputers with other devices.

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THE PROGRAMMER'S GUIDE TO LDOS/TRSDOS VERSION 6

Reviewed by Terry Kepner

LDOS/TRSDOS version 6 is a very powerful and flexible DOS (disk operating system), but it's also very complex and difficult to learn and use. Programming in machine code with LDOS is even harder; the user manual gives only a few details on how to interface your machine-language programs with the LDOS system, forcing you to waste time experimenting with code and trying to decipher just what LDOS is doing.

Roy Soltoff's *The Programmer's Guide to LDOS/TRSDOS* eliminates much of that work, providing details on the operations and procedures used by LDOS, both in memory and on disk.

The book is divided into six chapters, with an appendix and a copious index. The first chapter gives you a brief overview of LDOS and the philosophy that went into designing it. Chapter 2 describes the methods used in interfacing the various hardware devices (printer, RS-232C, keyboard, video) with a program and how to write your own device drivers and special filter modules (for example, setting up a character filter so that your printer automatically slashes zeros).

In chapter 3, Soltoff describes disk-drive interfacing protocols for sending and receiving data to and from the disk-drive controller, including the allocation schemes used for hard-disk drives. LDOS supports the Lobo Universal, Western Digital WD-1000, and Xebec S-1410 hard-disk controller, all three of which are described with the attendant service calls used and disk-drive registers. Floppy-disk and hard-disk configurations are explained, as well as the drive control tables used by LDOS to access them. A sample disk-driver routine is included.

In chapter 4, the author moves on to the DOS directory structure for 5¼- and 8-inch disks. He covers the Granule Allocation Table, the Hash Index Table, directory record structure (for 5¼- and 8-inch floppy disks and 5-inch hard disks, in single-density, double-density, single-sided, and double-sided configurations), and he provides a breakdown of 32 bytes used for an actual directory record entry.

The next chapter contains general information on a file's disk configuration, controlling disk files, accessing them, and the file control block (in memory), which tracks what's happening with a file currently in use.

THE REAL VALUE

Chapter 6 describes the DOS supervisor calls (SVCs) used to communicate with the operating system at the assembly-language level. This is where the book's value is truly revealed. These routines are vital for any programmer who wants his programs to be as powerful and short as possible, relieving you of the need to create your routines to get a character from the keyboard, send data to the video, obtain the system date, send a character to a disk file, select a disk drive, read a disk sector, or any one of the

(continued)

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94 service calls supplied by LDOS. In fact, by using only these SVCs for data manipulation between the system and your program, you can insure that a program written on one computer using LDOS 6 can be used on another computer using the LDOS 6 environment (i.e., create a program on the Lobo Max-80 that can be used on the TRS-80 Model I or Model 4). These calls are listed alphabetically, numerically, and by functional group. Calls requiring more than just a brief note (such as how to switch between different banks of memory if your computer has more than 64K bytes of RAM) are given more attention and detail at the end of this chapter.

The appendix is devoted to topics that don't fit into the other chapters. These topics include boot-up initialization interfacing (so your program can automatically be initialized during boot-up), the disk-loading formats used by the system loader, the protocols for using high-memory modules, interfacing with the interrupt task processor, using the @KITSK SVC to perform background tasks while doing disk input/output or print spooling, details on the DOS system overlays, and using the @PARAM SVC to decode complex parameter commands from the user. Soltoff includes three sample programs using the various SVCs and filtering concepts.

All of this information is explained in simple language, with a minimum of jargon. The only assumption made is that you are a machine-language programmer, or at least have more than just a vague idea of the details of such programming.

Since most programmers are in a hurry and don't want to have to read an entire book to get the answers to one or two questions, Roy Soltoff has included an index that provides a "random access" approach to the information. He has tried to make each section of the book independent of the rest. This tends to make some sections a little repetitive, but that's a small price to pay for the referencing capability it delivers.

This is one reference book every LDOS/TRSDOS version 6 programmer should have. Its cost is preferable to the amount of time you'd have to spend to discover the information yourself. ■

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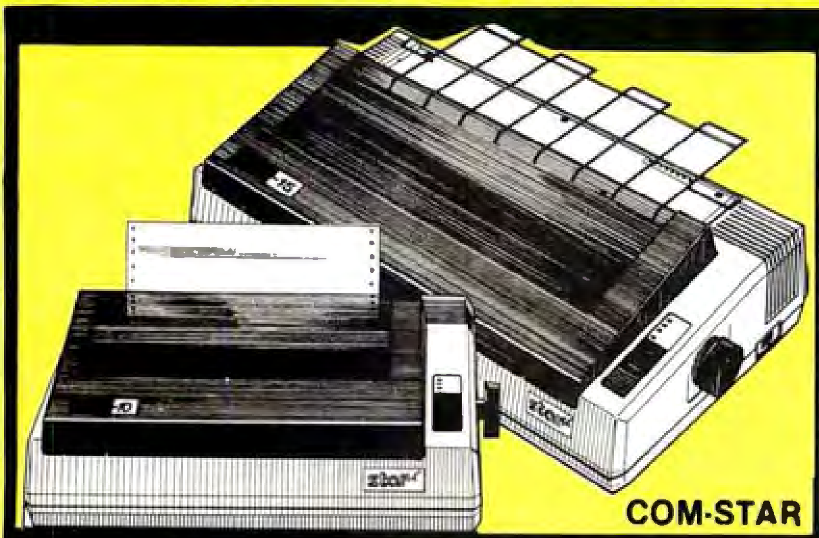

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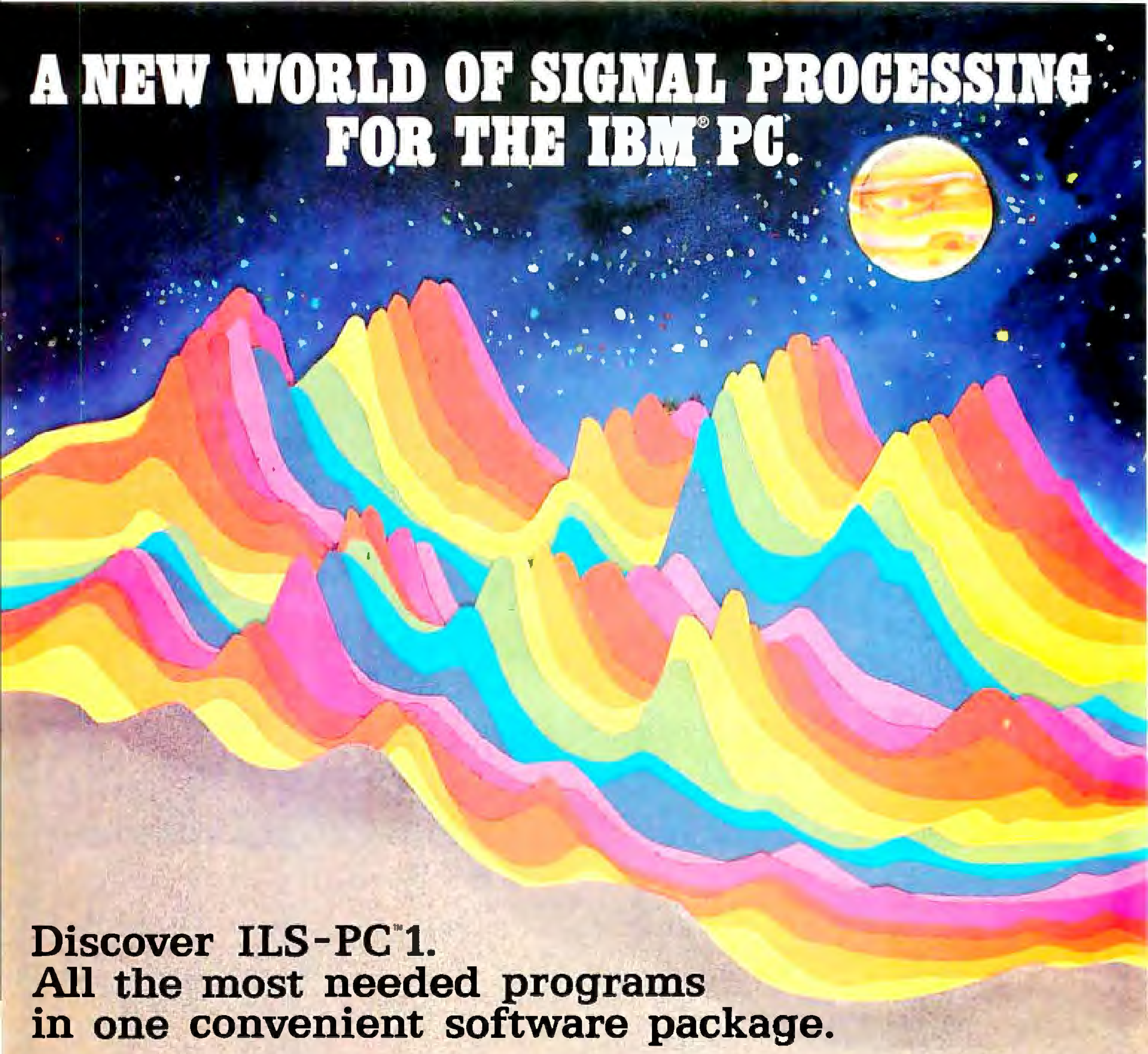

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● PROGRAM WITH dBASE—dBASE: Programming and Advanced Techniques, Hartford, CT. See November 13–14 for details. *November* 15–16

● WESTERN EDUCATORS MEET—The Eighth Annual Western Educational Computing Conference, Vacation Village, San Diego, CA. Refereed papers on computer science, humanities and the fine arts, CAI, administration, and research support. Contact Dr. Virginia S. Lashley, Glendale College, 1500 North Verdugo Rd., Glendale, CA 91208. *November* 15–16

● FORTH CONVENTION The Sixth Annual FORTH Convention and Banquet, Hyatt Palo Alto, Palo Alto, CA. Contact FORTH Interest Group, POB 1105, San Carlos, CA 94070, (415) 962-8653. *November* 16–17

● FARM COMPUTER CONFERENCE—The 1984 Purdue On-Farm Computer Use Conference and Trade Show, Purdue University, West Lafayette, IN. Workshops will complement exhibits and conference sessions. Contact Continuing Education Business Office, Stewart Center, Room 110, Purdue University, West Lafayette, IN 47907. *November* 18–20

● BRIEFING ON ADVANCED LANGUAGES Structured Techniques Using Fourth Generation Languages, Palo Alto, CA. This seminar explains how structured techniques and fourth-generation languages can be used. The fee is $795. Contact Software Institute of America Inc., 8 Windsor St., Andover, MA 01810, (617) 470-3880. *November* 19–21

● CANADIAN CONFERENCE—Annual CIPS Computer Conference, International Centre, Toronto, Ontario, Canada. Speakers will address a variety of issues. Contact Canadian Information Processing Society, Fifth Floor, 243 College St., Toronto, Ontario M5T 2Y1, Canada, (416) 593-4040. *November* 19–22

● COMPUTERS IN TORONTO—The Fifteenth Annual Canadian Computer Show and Conference, International Centre, Toronto, Ontario, Canada. Contact Industrial Trade Shows, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791. *November* 19–22

● SHOW IN GERMANY *Chip* Microcomputer Weeks, Essen, West Germany. Microcomputer products, trends, and applications will be demonstrated. Sponsored by *Chip*, a leading German computer magazine. Contact Network GmbH, An der

(continued)

Friedenseiche 10, D-3050 Wunstorf 2, Bundesrepublik Deutschland (West Germany); tel: (0 50 33) 10 56; Telex: 92 45 45. In England, Network Events Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, England; tel: (02 80) 81 52 26; Telex: 83111. *November 20–22*

● PICK PRAISED IN AUSTRALIA—International Spectrum Pacific, Centrepoint, Sydney, Australia. Exhibits by manufacturers of Pick-based systems and technical seminars. In the U.S., contact International Spectrum, Suite 210, 9740 Appaloosa Rd., San Diego, CA 92131, (619) 578-3152. In Australia, International Spectrum, POB 77, Gymea, New South Wales 2227; tel: (02) 570-5505. *November 21–23*

● SHANGHAI EXPOSITION The China International Microelectronics/Computer Exhibition and Conference, Shanghai, Peoples Republic of China. Integrated circuits, semiconductors, personal computers, minicomputers, peripherals, and software will be exhibited. Contact American Exhibition Services International Inc., POB 66373, O'Hare International Airport, Chicago, IL 60666, (312) 593-2462. *November 21–26*

● TRADE SHOW IN MOSCOW—Systemotronica '84, Sokolniki Exhibition Centre, Moscow, Union of Soviet Socialist Republics. An international trade exhibition of office systems, electronics, and components. Contact Düsseldorfer Messegesellschaft mbH-NOWEA, POB 32 02 03, D-4000 Düsseldorf 30, Federal Republic of Germany; tel: (0211) 45 60-729; Telex: 8 584 853 mes d. *November 22–30*

● CANADIAN ATLANTIC SHOW—Moncton Computer Exhibition '84, Moncton, New Brunswick, Canada. Home computers, video games, and office automation equipment will be displayed. Contact Anne LeBlanc, Commerce Building, University of Moncton, Moncton, New Brunswick E1A 3E9, Canada, (506) 858-4555. *November 23–25*

● FORTH USERS MEET FORTH Modification Laboratory Conference, Asilomar Conference Grounds, Pacific Grove, CA. Expert systems and artificial intelligence will be discussed. Registration is $250, which includes room, meals, and conference fees. Contact FORTH Interest Group, POB 1105, San Carlos, CA 94070, (415) 962-8653. *November 23–25*

● COMPUTERS IN CHINA Computer China, Xiamen Special Economic Zone, Peoples Republic of China. Contact Kallman Associates, 5 Maple Court, Ridgewood, NJ 07450, (201) 652-7070. *November 25–December 1*

● PICK PRAISED IN ENGLAND—International Spectrum Europe, Heathrow Penta Hotel, London, England. Exhibits by manufacturers of Pick-based systems and technical seminars. In the U.S., contact International Spectrum, Suite 210, 9740 Appaloosa Rd., San Diego, CA 92131, (619) 578-3152. In England, International Spectrum, POB 32, Northwood, Middlesex HA6 1HZ; tel: (04946) 71663. *November 26–27*

● BUILD BUSINESS GRAPHICS—Computer Graphics for Business, Hyatt on Union Square, San Francisco, CA. This seminar presents guidelines for selecting graphics hardware and software. Contact Technology Transfer Institute, 741 Tenth St., Santa Monica, CA

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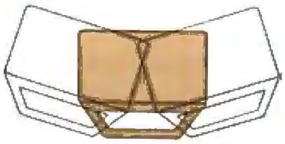

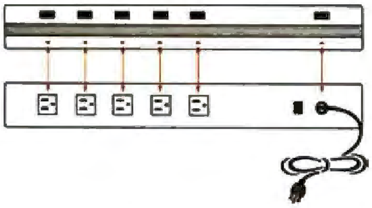

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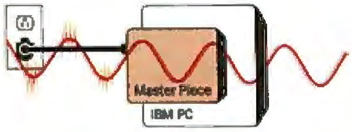

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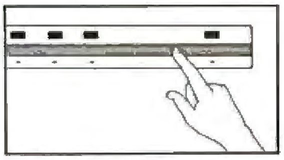

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90402, (213) 394-8305. *November 26–28*

● MEET 20 PROGRAMS Production and Allocation Applications for the Personal Computer, Atlanta, GA. More than 20 interactive management-science programs for MS-DOS-based machines will be demonstrated. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *November 26–28*

● PREDICTING RELIABILITY—The Twenty-Second Annual Reliability Engineering and Management Institute, Ramada Inn, Tucson, AZ. This institute will emphasize system reliability prediction, reliability testing, and life-cycle costing. The fee is $750. Contact Dr. Dimitri Kececioglu, Reliability Engineering and Management Institute, Aerospace and Mechanical Engineering Department, Building 16, Room 200B, University of Arizona, Tucson, AZ 85721, (602) 621-6120. *November 26–30*

● ROBOTICS IN WEST Robots-West, Anaheim Convention Center, Anaheim, CA. Robot manufacturers and component suppliers will exhibit their wares. Contact Robot Institute of America, POB 1366, Dearborn, MI 48121, (313) 271-0778. *November 27–29*

● ADMINISTER SOFTWARE PROJECTS—Managing the Development and Application of Computer Software, Atlanta, GA. Topics include establishing the need for a computer application, identifying computer software requirements, and managing the changes to established production and marketing baselines. The fee is $400. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *November 28–29*

● VERTICAL MARKETS CONFERENCE—Computer Vertical Markets, Sheraton Harbor Isle Hotel, San Diego, CA. Contact Carol Every, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080. *November 28–29*

● DEVELOP EFFECTIVE DOCUMENTATION—How to Develop Effective User Documentation, Somerset, NJ. This course covers preparation, planning, documentation design, illustrations, graphics, quality assurance, and other topics. Class size is limited. Tuition is $850. Contact Human Performance Associates Inc., 13 East Main St., POB 297, Mendham, NJ 07945, (201) 543-4333. *November 28–30*

● LOCAL NETWORK COURSE—Local Area Networks, Atlanta, GA. This course looks at the alternative technical approaches on which local-area networks are based. The fee is $795. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *November 28–30*

● SIMULATION CONFERENCE—Winter Simulation Conference, Sheraton Dallas Hotel, Dallas, TX. Papers, tutorials, sessions, and panel discussions will complement commercial exhibits. Contact Udo Pooch, Department of Computer Science, College of Engineering, Texas A&M University, College Station, TX 77843, (409) 845-5498. *November 28–30*

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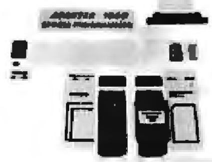

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● KIDS SHOW Bits & Bytes, Disneyland Convention Center, Anaheim, CA. This conference and exposition attempts to show educators, parents, and children how to use computers in the home and classroom. Contact Information Processing Group, Suite 113-150, 350 South Lake Ave., Pasadena, CA 91101, (818) 792-5111. *November 30–December 2*

December 1984

● dBASE, LOTUS DEMYSTIFIED—dBASE II and Lotus 1-2-3 Seminars, various sites throughout the U.S. Both seminars stress the practical applications of these two popular programs. The fee is $245 each or $450 for both. Contact Software Institute of America Inc., 8 Windsor St., Andover, MA 01810, (617) 470-3880. *December*

● REFRESHERS FOR ENGINEERS—Continuing Engineering Education, San Diego, CA, and Washington, DC. Courses include "Frequency Synthesis," "Fiber Optic Communications," and "Foundations of Modern Telecommunications Systems." Fees range from $695 to $920. Contact Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-8530. *December–January*

● TELECOMMUNICATIONS CONFERENCES—Telecommunications Programs, various sites throughout the U.S. "Finding Telecommunications Information" and "Satellite Technology for the Nontechnical Manager" will be offered. Contact Phillips Publishing Inc., Suite 1200N, 7315 Wisconsin Ave., Bethesda, MD 20814, (301) 986-0666. *December–January*

● INFO PROCESSING SEMINARS—New York University Seminars in Information Processing, various sites throughout the U.S. Seminars to be held include "Fundamentals of Information Processing for Nontechnical Executives," "The Management of Technical Personnel," and "Managing the Data Center." Contact New York University, School of Continuing Education, Seminar Center, 575 Madison Ave., New York, NY 10022, (212) 580-5200. *December–March*

● SIMULATION PROGRAM EXPLAINED—Short Course on MAP/1 Simulation Software, West Lafayette, IN. MAP/1 is a simulation-based modeling and analysis program that can be used to design and evaluate discrete manufacturing systems. Contact Pritsker & Associates Inc., POB 2413, West Lafayette, IN 47906, (317) 463-5557. *December 4–5*

● ENGINEERING CONFERENCE—The 1984 Western Design Engineering Show/ASME Western Design Engineering Conference, Moscone Center, San Francisco, CA. Exhibitors, conferences, and short courses.

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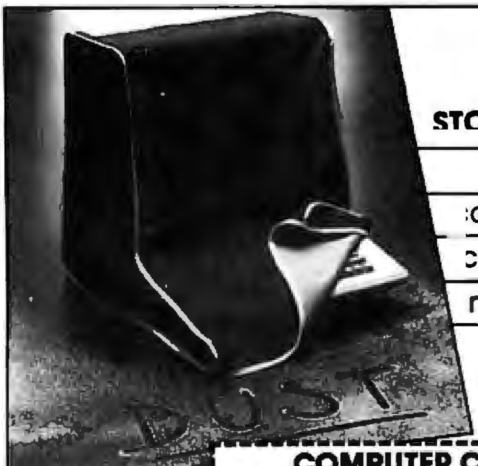

Contact Show Manager, Western Design Engineering Show, 999 Summer St., Stamford, CT 06905, (203) 964-8287. *December 4–6*

● SNA EXPLAINED
Systems Network Architecture, Atlanta, GA. Systems Network Architecture (SNA), IBM's design for an end-to-end communications network, is investigated. Course fee is $795. Contact Elaine Hadden Nicholas, Department of Continuing Education, Georgia Institute of Technology, Atlanta, GA 30332-0385, (404) 894-2547. *December 4–6*

● COMPUTER MANAGEMENT CONFERENCE—CMG XV, San Francisco, CA. Introductory and advanced tutorials, lectures, and product displays. Contact The Computer Measurement Group Inc., POB 26063, Phoenix, AZ 85068, (602) 995-0905. *December 4–7*

● BUSINESS SOFTWARE
Software Connection, Coliseum, New York City. This computer software exposition focuses on business applications. For more information, contact Conference Management Corp., 17 Washington St., Norwalk, CT 06854, (203) 852-0500. *December 5–7*

● VIDEO, OPTICAL DISKS GATHERING—The Fourth Annual Videodisc, Optical Disk, and CD-ROM Conference, Washington Hilton Hotel, Washington, DC. More than 30 sessions will delve into interactive videodiscs, digital optical disks, and CD-ROMs (compact disks). Complementary exhibits. Contact Meckler Communications, 520 Riverside Ave., Westport, CT 06880, (203) 226-6967. *December 5–7*

● GOLDEN STATE SHOW
California Computer Show, Hyatt Hotel, Palo Alto, CA. Products and technology for OEMs and sophisticated end users will be displayed by more than 65 companies. Contact Norm DeNardi Enterprises, Suite 204, 289 South San Antonio Rd., Los Altos, CA 94022, (415) 941-8440. *December 6*

● SHOW IN FLORIDA
The Great Southern Business and Computer Shows and Seminars, Leon County Civic Center, Tallahassee, FL. Computer hardware, software, peripherals, accessories, and word- and data-processing equipment will be featured. Contact Great Southern Computer Shows, POB 655, Jacksonville, FL 32201, (904) 356-1044. *December 6–8*

● STRATEGIC ISSUES CONSIDERED—The 1984/1985 Strategic Issues Conference, Americana Canyon Hotel, Palm Springs, CA. The theme for this conference is "Positioning for Success in the New Computer Market." A keynote address will be delivered by John Sculley, president and chief executive officer of Apple Computer Inc. Contact Corky Holden, Info Corp., 20833 Stevens Creek Blvd., Cupertino, CA 95014-2107, (408) 973-1010. *December 10–13*

● FIFTH GENERATION COMPUTERS—Fifth Generation and Super Computers: An International Symposium, Rotterdam, The Netherlands. Lectures and panel discussions will be featured. Prototypes of several Japanese machines are expected to be shown for the first time outside Japan. Contact Fifth Generation and Super Computers Symposium 1984, Rotterdam Tourist Office, Stadhuisplein 19, 3012 AR Rotterdam, The Netherlands; tel: (010) 14 14 00; Telex: 21228 vvvnl. *December 11–13*

(continued)

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● DEC SHOW
DEXPO West 84, The Sixth National DEC-Compatible Industry Exposition, Disneyland Hotel, Anaheim, CA. Products and services that support Digital Equipment Corporation's machines will be displayed. Contact Expoconsul International Inc., 55 Princeton-Hightstown Rd., Princeton Junction, NJ 08550, (609) 799-1661.
December 11–14

● TECHNOLOGY UPDATE—Hi-Tech Update '84, Delta Ottawa Hotel, Ottawa, Ontario, Canada. A series of presentations designed to inform senior management, engineers, and consultants. Sponsored by the Carleton University Faculty of Engineering. For further details, contact Conference Coll Inc., 1138 Sherman Dr., Ottawa, Ontario K2C 2M4, Canada, (613) 224-1741.
December 12–13

● EDUCATIONAL COMPUTING—The Second Annual International Computers in Education Conference, Queen Elizabeth Hotel, Montreal, Quebec, Canada. More than 100 exhibitors and 125 speakers will participate in conferences sponsored by the McGill University Faculty of Education. For more information, contact GEMS Conference and Consulting Services, POB 367, Snowdon, Montreal, Quebec H3X 3T6, Canada, (514) 735-1388.
December 12–14

● COMPUTERS AND SOFTWARE—The Fourth Annual Southeast Computer Show and Software Exposition, Civic Center, Atlanta, GA. Contact CompuShows, POB 3315, Annapolis, MD 21403, (800) 368-2066; in Annapolis, (301) 263-8044; in Baltimore, (301) 269-7694; in the District of Columbia, (202) 261-1047.
December 13–16

● CAD/CAM SEMINAR
Carl Machover on CAD/CAM, Cathedral Hill Hotel, San Francisco, CA. Contact Carol Every, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080.
December 17–19

● BRIEFING ON ADVANCED LANGUAGES
Structured Techniques Using Fourth Generation Languages, Dallas, TX. See November 19-21 for details.
December 18–20

● BUSINESS GRAPHICS SEMINAR—Carl Machover on Business Graphics, Cathedral Hill Hotel, San Francisco, CA. Contact Carol Every, Frost & Sullivan Inc., 106 Fulton St., New York, NY 10038, (212) 233-1080.
December 20–21

January 1985

● HANDS-ON LEARNING
Hands-On Computer Seminars, Wintergreen, VA. Seminars offered are "Introduction to Personal Computing," "Word Processing/Information Management," and "Spreadsheeting/Graphing." Each spans a four-day period and provides 14 hours of hands-on practice. Rates, which include lodging and ski-lift tickets, vary from $570 to $975, depending on accommodations. Contact Dr. M. D. Corcoran, Wintergreen Learning Institute, POB 7, Wintergreen, VA 22958, (800) 325-2200; in Virginia, (804) 325-1107.
January–March

● SYSTEM SCIENCE EXAMINED—The Eighteenth Annual Hawaii International Conference on System Sciences: HICSS-18, Honolulu, HI. A series of conferences devoted to advances in information and system sciences. Major topic areas are hardware, software, decision-support and knowledge-based systems, and medical information processing. Contact Nem B. Lau, HICSS-18 Conference Coordinator, Center for Executive Development, College of Business Administration, University of Hawaii, 2404 Maile Way, C-202, Honolulu, HI 96822, (808) 948-7396.
January 2–4

● GIZMOS GALORE
Consumer Electronics Show, Convention Center, Las Vegas, NV. One of the largest shows of consumer electronics products. Contact Consumer Electronics Office, Suite 300, 2001 Eye Street NW, Washington, DC 20006, (202) 457-8700.
January 5–8

● MANAGE RESOURCES WISELY—Managing Computer Resources, Wintergreen, VA. Focuses on networking, system design, performance evaluation, and operational difficulties encountered by managers and executives. Rates include lodging and ski-lift tickets and vary from $570 to $769 depending on accommodations. Contact Dr. M. D. Corcoran, Wintergreen Learning Institute, POB 7, Wintergreen, VA 22958, (800) 325-2200; in Virginia, (804) 325-1107. *January* 7–11

● STERLING COMPUTER SHOW—The Fourth Annual Sauk Valley Computer Club Computer Show, Northland Mall, East Lincolnway, Sterling, IL. Businesses, schools, and users groups from the area will display and dem-

onstrate computers and related services. Admission is free. Contact Sauk Valley Computer Club, POB 702, Sterling, IL 61081. *January* 12–13

● THINKING OF SOFTWARE—The Second Annual International Software Update, Kahala Hilton Hotel, Oahu, HI. Speakers from the U.S., Europe, and Pacific Rim nations will discuss trends, current difficulties, possible solutions to marketing problems, and the future of software. Attendance is limited. Contact Raging Bear Productions Inc., Suite 175, 21 Tamal Vista Dr., Corte Madera, CA 94925, (800) 732-2300; in California, (415) 924-1194. *January* 14–18

● SCSI DEVELOPMENTS Small Computer Systems Interface (SCSI) Forum, Fort Lauderdale, FL. A seminar and exhibit devoted to SCSI controllers and peripherals. Contact Mr. J. Molina, SCSI Forum Ltd., POB 2625, Pomona, CA 91768-2625, (213) 410-3952. *January* 15

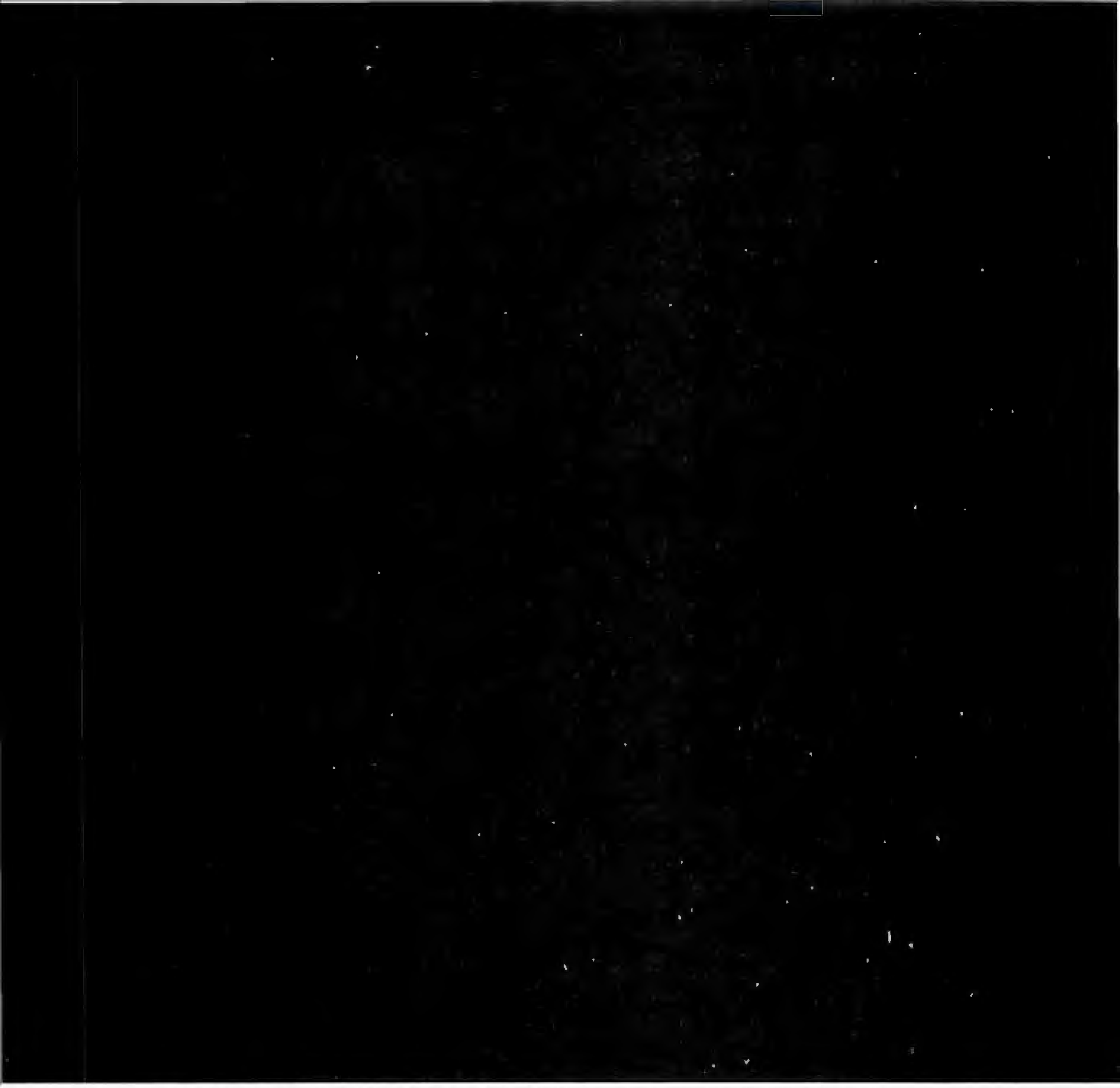
● COMMUNICATIONS INDUSTRY CONFERS COMMTEX International and The 1985 NAVA, Convention Center, Anaheim, CA. COMMTEX features audiovisual, video, and microcomputer products for business, education, and government. NAVA, the conference and convention of the International Communications Industries Association, is made up of numerous seminars, general sessions, and special-interest group meetings. Contact International Communications Industries Association, 3150 Spring St., Fairfax, VA 22031-2399, (703) 273-7200. *January* 16–21

● OPTICAL ENGINEERING SYMPOSIUM—The 1985 Symposium on Optical and Electro-Optical Engineering and Instrument Exhibit, Marriott Hotel, Los Angeles, CA. This symposium, sponsored by the International Society of Photo-Optical Instrumentation Engineers (SPIE), is made up of conferences, exhibits, and tutorial short courses. Contact SPIE, POB 10, Bellingham, WA 98227-0010. *January* 20–25

● UNIX USERS UNITE The 1985 UniForum: The International Conference of UNIX System Users, Infomart, Dallas, TX. More than 400 companies are expected to exhibit UNIX-related equipment. A conference program is planned. UniForum, sponsored by the /usr/group, will be held in conjunction with the grand opening of Dallas's International Information Processing Market Center (Infomart). Contact Professional Exposition Management Co., Suite 205, 2400 East Devon Ave., Des Plaines, IL 60018, (800) 323-5155; in Illinois, (312) 299-3131. *January* 21–25

● NETWORK CONFERENCE, EXPO—The Seventh Annual Communications Networks Conference and Exposition, Convention Center, Washington, DC. Contact Communications Networks 1985, POB 880, Framingham, MA 01701, (800) 225-4698; in Massachusetts (617) 879-0700. *January* 29–31

● PAN AMERICAN CONFERENCE—The First International Information Management Congress Pan American Conference, Caribe Hilton International Hotel, San Juan, Puerto Rico. Seminars and product exhibits on advanced micrographics and office automation. Contact IMC Pan American Conference, POB 34404, Bethesda, MD 20817, (301) 983-0604. *January* 30–31 ■



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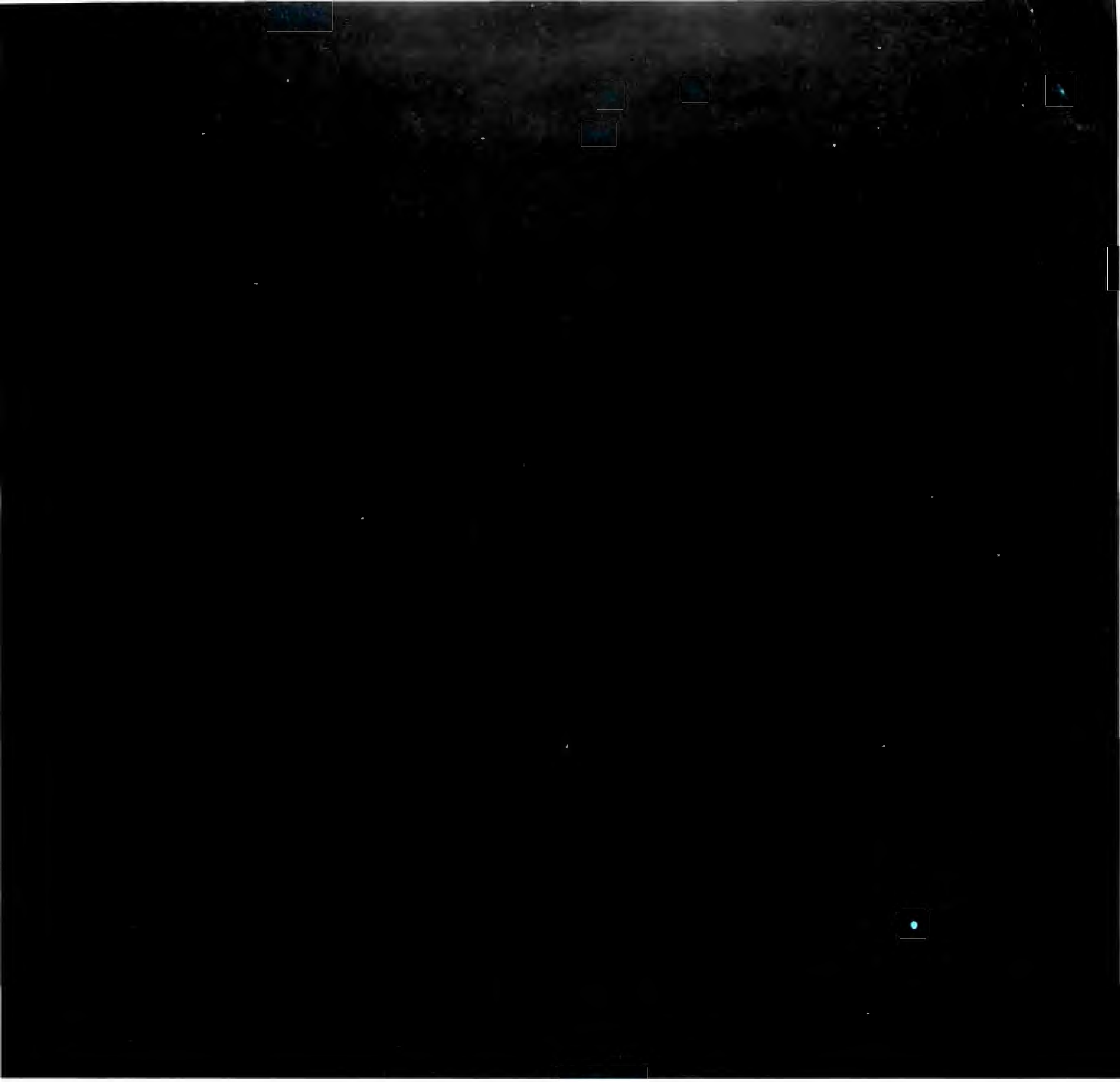

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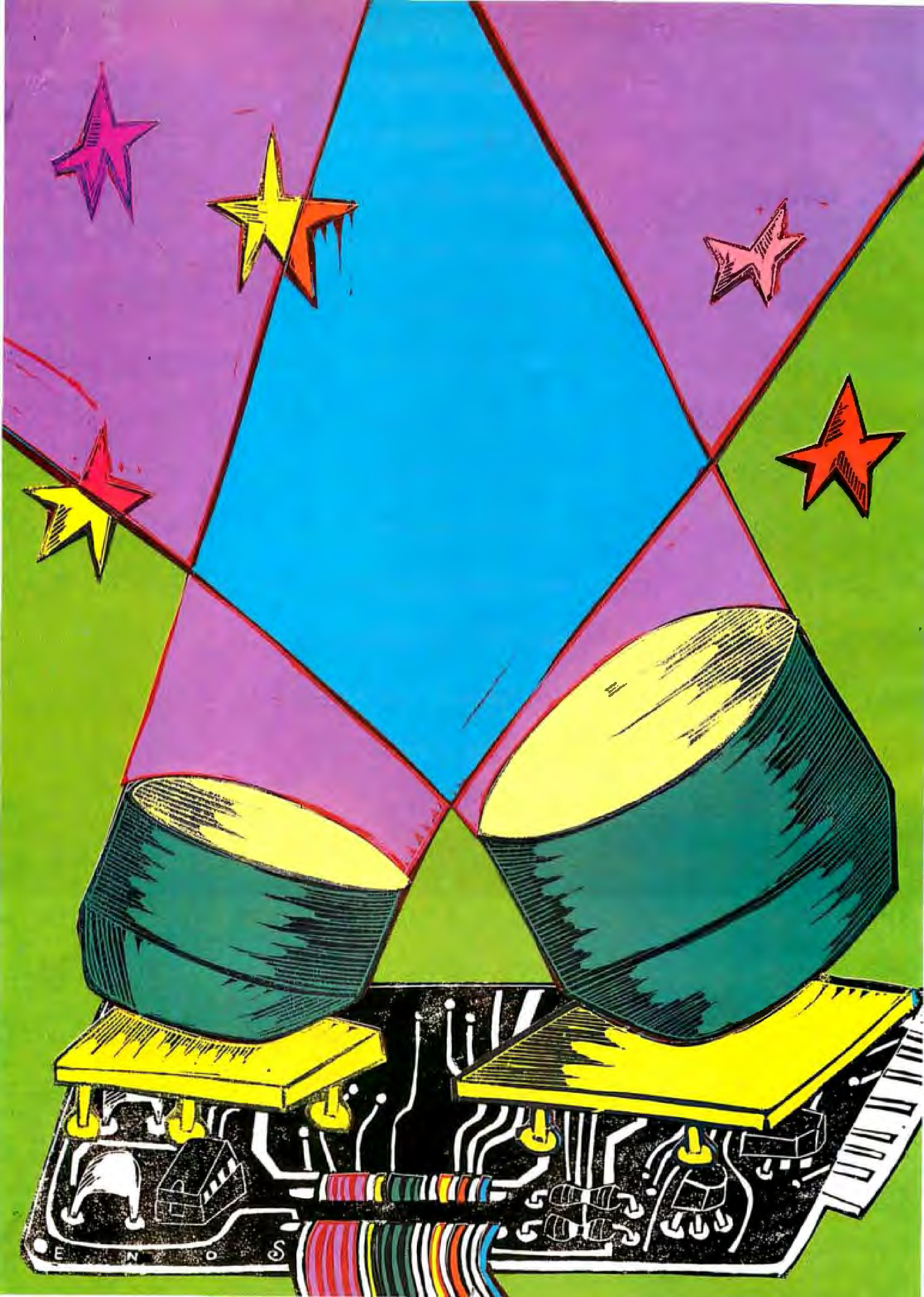


Features

A TRAVESTY IS a distorted, stylistically incongruous translation or imitation of a literary or artistic endeavor. Some puns are travesties; so is a Mark Russell musical parody. In the computer business, people sometimes think that documentation is a travesty.

A travesty is an interesting study for a linguist. Until the invention of the computer, however, analyzing the frequency of various letter combinations was tedious at best. But today even microcomputers aid the student of language in examining the frequency of letter patterns in ordinary text. It is even possible to imitate the style of a writer by generating text based on the patterns observed in a particular passage. This month's feature article by Hugh Kenner and Joseph O'Rourke describes a travesty generator written in Pascal. The program uses frequency tables and reveals that the best algorithm is slow but the faster algorithm misses certain patterns. Regardless, the possibilities for the linguist, or the entrepreneur looking for a name for his newest company, are exciting.

The big new product of the fall turns out to be small—Data General's new eight-pound, PC-compatible portable computer called the One. Technical editors Gregg Williams and Ken Sheldon report on the custom gate arrays, CMOS (complementary metal-oxide semiconductor) chips, and efficiently used printed-circuit board space (with surface-mounted ICs) that permit packaging desktop power in a true briefcase portable. A sub-$3000 price tag makes the Data General/One affordable, but imperfect LCD technology might hurt the machine's acceptance.

Steve Ciarcia travels to the cutting edge of technology again this month, building what he believes is the first speech-recognition device based on the new General Instruments SP1000 voice-recognition chip. This is a low-cost, high-performance, voice-recognition hardware project.

Contributing editor Bruce Webster recently learned the MacFORTH programming language in order to produce some software for his Macintosh. The result is a game board for the Japanese game of *go*. Webster's software doesn't play the game; it automates the board manipulations of two human opponents and might prevent that aggravating ploy known as "go-stones pick up."

Dr. Leo Bores's recent medical-research visits to the Soviet Union turned up an interesting surprise—an Apple computer clone. At $17,000, this machine is not likely to flood American shores as did the wave of Apple copies from the Far East. The existence of such a machine could add a new dimension to Soviet-American relations, however, if Jobs and Wozniak decide to sue.

November's concluding feature, the second installment in our series on the Pick operating system, examines programming, portability, and batch processing. Rick Cook and John Brandon discover that Pick is easier to use than UNIX and provides powerful BASIC program-development tools.

—G. *Michael Vose, Senior Technical Editor, Features*

THE DATA GENERAL ONE

A 10-pound battery-powered portable that's fully compatible with the IBM PC

Editor's Note: The following is a BYTE product description. It is not a review. We provide an advance look at this new product because we feel it is significant. A complete review will follow in a subsequent issue.

IMAGINE A PORTABLE COMPUTER that weighs only 10 pounds but has a full-size display screen, a standard keyboard, and two disk drives. Imagine that it can run for up to eight hours on built-in batteries or use an ordinary wall outlet. Now imagine that it is software-compatible with the IBM Personal Computer (PC) and can have up to 512K bytes of internal RAM (random-access read/write memory). Imagine two serial ports, an optional built-in modem, and an expansion bus that will let you connect the system to a monitor in your office or add on third-party hardware.

Earlier this year, David Winer, president of Living Videotext and publisher of ThinkTank, dreamed of just such a portable computer (see "Portables—1984 and Beyond," by David Winer and Peter Winer, in the January BYTE, page 243). Winer predicted that this ideal portable would take two to three years to arrive, that it would weigh up to 25 pounds, and that it would cost up to $5000.

Imagine Winer's surprise when, in June, he received a preproduction unit that included all of the above features and was told that the system would be available this fall for "well under $3000."

The system is the $2895 Data General/One, a portable computer that incorporates a number of state-of-the-art innovations in a sleek 10-pound package.

The Data General/One features a full-size, flip-up LCD (liquid-crystal display) screen that displays 25 lines of 80 characters, or 256 by 640 pixels for software that uses bit-mapped graphics. Although the display is less than an inch thick, its viewing surface is as large as that of a standard IBM monitor and much larger than the displays of other portable computers. (There are, unfortunately, some trade-offs associated with such a large LCD, as we'll explain later.) Although color graphics are not yet available, the video system will display most monochrome and color graphics in shades of gray.

The Data General/One's keyboard (see photo 1c) is a standard, full-size, low-profile QWERTY keyboard with a variety of special and function keys designed to make it compatible with the IBM PC while maintaining compatibility with the Data General line of computers. Thus, IBM's Control, Alternate, and Delete keys are present, as well as Data General's Command and Special keys and even a blank key for future use.

Ten function keys are arrayed across the top of the keyboard, and above them is a ridge for inserting plastic command cards for programs such as word processing. Four cursor-control keys are lined up along the bottom right.

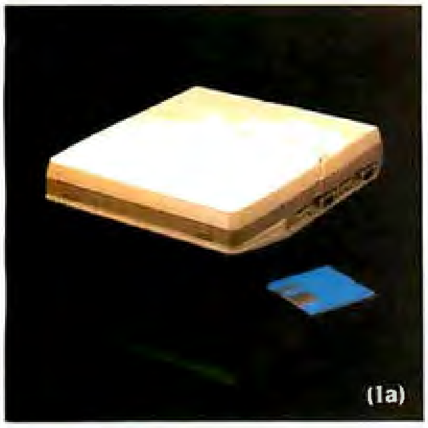
Like other PC clones—and unlike the IBM PC—the Data General/One has large Shift and Return keys in the places where a typist would hope to find them. Finally, a numeric keypad is superimposed over a group of keys on the right-hand side of the keyboard; it's activated by hitting the Num Lock key.

(continued)

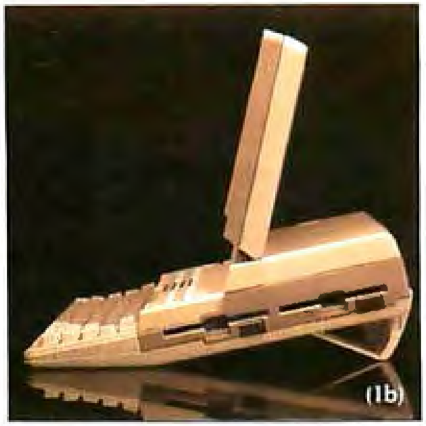
Gregg Williams is a senior technical editor and Ken Sheldon is a technical editor for BYTE. They can be contacted at POB 372, Hancock, NH 03449.

Photo 1: *The Data General/One with case closed (1a) and case open (1b). The keyboard (1c) is a full-size QWERTY unit compatible with IBM's PC and Data General's line of computers. The portable comes with a 3½-inch microfloppy-disk drive on the right-hand side (1d), and there's room for an additional drive.*

BY GREGG WILLIAMS AND KEN SHELDON



(1a)



(1b)

(1c)

(1d)

PHOTOGRAPHED BY PAUL AVIS

The Data General/One comes with a 3½-inch floppy-disk drive on the right-hand side, and there's room for an additional built-in drive (see photo 1d). These double-sided drives provide 512 bytes per sector, 8 or 9 sectors per track, and 40 or 80 tracks per side—a maximum of 720K bytes of storage per disk. An external 5¼-inch drive, with up to 360K bytes per disk, may also be attached to the unit. With this external drive, the Data General/One can run most of the software available for the IBM PC or transfer software that's not copy-protected to 3½-inch disks. At the time of this writing, 20 major software packages are already available in 3½-inch format, including Lotus 1-2-3, WordStar, dBASE II, VisiCalc, and the PFS series.

An A/C adapter, included in the base price, enables you to use the system with a wall outlet. You can also install an optional battery pack containing 10 nickel-cadmium batteries by removing a cover on top of the machine. The battery pack comes with a recharger that lets you charge the batteries from a wall outlet, even while running the system from another outlet.

On the back of the Data General/One are a bus-expansion connector and two RS-232C serial ports. One of the serial ports also doubles as an RS-422 port, thanks to a program-controllable switch.

OPTIONS

Options for the Data General/One include internal memory expansion in 128K-byte chunks (up to 512K bytes maximum), a built-in 300-bps (bits per second) modem, an external 5¼-inch drive, an external 1200-bps modem, the battery pack and charger, a carrying case, and a portable printer. The printer has a 27-pin print head that provides type that's quite readable on thermal paper or smooth sheet paper—this rules out rough-surfaced bond paper. The printer can run from the system's power supply or its own set of nickel-cadmium batteries.

SOFTWARE

The Data General/One supports MS-DOS, CP/M-86, and various programming languages. According to Data General's software team, a great deal of IBM PC software will run as is, using the external 5¼-inch drive. In addition, several software developers have signed agreements with Data General to release their software in 3½-inch format. Among these developers are Ashton-Tate, Infocom, Lotus Development Corporation, MicroPro, Microsoft, Peachtree, and Software Arts.

A few pieces of software have been built into the system's ROM (read-only memory). These programs include Notebook, a kind of scratch pad that lets you print output or send it via modem to another computer (but does not let you save it); Terminal, which enables the computer to act as a dumb terminal to the Data General line of minicomputers; and a system configurator that lets you configure the Data General/One for different monitors, keyboards, printers, and so on. Each of these programs is menu-driven and makes use of the function keys.

Data General has also announced DG Term, an advanced terminal program, and CEO Connection, which enables the Data General/One to tie into the company's CEO office-automation system.

INSIDE

The Data General/One is built around the 80C88, a CMOS (complementary metal-oxide semiconductor) version of the 8088 microprocessor used in the IBM PC and most of the PC clones. The 80C88 uses less power than the 8088—an obvious advantage in a portable system—but it is a little slower, operating at 4 MHz as compared to the 8088's 4.77 MHz.

The Data General/One comes with 128K bytes of RAM on the main printed-circuit board, 80K bytes of which is available to the user. (The system uses 48K bytes of RAM to manage screen graphics.) Also located on the main board are 32K bytes of ROM that contain the BIOS (basic input/output system), diagnostics, and built-in software.

Mounted on the main board is a small box in which up to three 128K-byte memory expansion cards may be added, providing a maximum of 512K bytes, with 464K bytes available for user programs.

The I/O (input/output) components are located on a separate card, as are the power-supply components, and the disk-controller hardware is located on top of the disk drive(s). An optional 300-bps modem card may also be installed internally.

TECHNOLOGICAL INNOVATIONS

The Data General/One could not have been built without pushing current technology to the limit—in many cases, designing the machine around parts announced but at the time not available. Three innovations stand out: technology to create an LCD panel the size of a standard monitor display, the inclusion of custom gate arrays that decrease the component count, and the use of CMOS parts to reduce heat and power consumption.

The Data General/One's LCD panel is innovative from both manufacturing and design standpoints. A liquid-crystal display consists of two glass sheets separated by a conductive liquid material. Nippon Data General engineers overcame manufacturing difficulties associated with creating an LCD of this size, the main problems being the size of the glass sheets and the evenness of the distance between the two inner surfaces.

LCDs are often criticized for being "slow"—that is, leaving a ghost image that fades slowly enough for the eye

(continued)

DEVELOPMENT OF THE DATA GENERAL/ONE

According to Kazuhiro Miyashita, head of the research and development team that designed the Data General/One, a portable computer was the last thing on his mind when he went to the National Computer Conference (NCC) in May of 1982.

"We had just finished designing a laser printer for Nippon Data General, and I went to NCC in search of a new project for our team," Miyashita says. "At the time, we had no intention of doing a portable computer."

At NCC, however, laptop portables such as the Gavilan were stealing the show, and when Miyashita returned to Japan, his list of possible projects included a proposal for a portable computer. The laptop project was approved in September of 1983.

At the time, the proposal was only a concept, with none of the hardware specified. By January of 1984, however, an initial design was presented, one that included a large LCD (liquid-crystal display) screen [illegible] emphasis on CMOS (complementary metal-oxide semiconductor) technology. In other respects, the design differed significantly from the final product. The cover of the proposed portable flipped aside to reveal an LCD, a microcassette, and a small keyboard. It looked, literally, like a three-ring notebook—thus the code name for the project, Book-1.

The microcassette was the first major element to change; it was replaced by a floppy-disk drive because, as Bob Miller, senior vice president for Data General, put it, "Nobody's going to buy a portable computer with a microcassette."

Although there were many floppy-disk options to choose from, the design team settled on 3½-inch drives (licensed by Sony and made by Epson) for three main reasons: a small size that would allow for two built-in drives, less power drain than other drives, and use of hard-shell disks that can contain increased amounts of data.

The change in storage media dictated a change in software philosophy, away from a concentration on ROM (read-only memory) software and toward mass-market applications. To the Data General software team located in North Carolina—they had struggled to convince vendors to make software for the company's Desktop Generation microcomputer—this meant only one thing: as much IBM PC compatibility as they could get. Ironically, then, it was the third-party software team that spelled out the requirements for much of the Data General/One's internal hardware, in order to make the system IBM PC compatible.

In June of 1983, Edson DeCastro, president of Data General, visited Nippon Data General to discuss the project. DeCastro wanted the portable to be compatible with his company's line of mini- and microcomputers; he pressed the team to incorporate a full 25-line by 80-column display in the design. Nippon Data General's contacts with other Japanese manufacturers quickly became invaluable.

The largest LCDs available at the time were 480 by 128 pixels, and no vendor was willing to commit to making a larger screen because the technical challenges were too great. Miyashita was able to convince two vendors, however, that to develop a full-size LCD screen would be beneficial for all involved. In September, Hitachi agreed to try and make a 640- by 256-pixel LCD that would provide 25 rows and 80 columns of 7 by 9 characters (8 by 10 with spacing). Epson followed quickly thereafter. (Interestingly, the division of Epson that makes the LCDs is distinct from its sister company that makes portable computers. The LCD maker apparently prefers to sell its parts to outside companies because it makes more money that way. As one member of Data General's third-party software team put it, "Good old capitalism strikes again.")

By October of 1983, the essential elements of the design had been finalized in spite of the fact that major parts, such as the LCD and 80C88 microprocessor, were not available yet. "We had to design to the specifications given to us by the parts designers and synchronize our design with theirs," Miyashita says. In this "design by speculation," Nippon Data General had an advantage over American laptop portable manufacturers such as Hewlett-Packard and Apple, which have had trouble getting Japanese manufacturers to commit to volume production of large LCDs.

During this time, the design of the Data General/One's ca[illegible] was taking place in Data General's Westboro, Massachusetts, division, while development of the ROM software and deals with third-party software vendors were taking place in North Carolina. The ROM software was purposely limited so as not to scare off the vendors of application software; those vendors generally found that making versions of their programs for the Data General/One consisted of simply putting the IBM PC version on a 3½-inch microfloppy disk.

In January, the "final form factor" of the project was completed—a prototype with essentially the same external appearance as the final product would have. Still, neither the 80C88 nor the commercial gate arrays were yet available; they were included in the second prototype, released in April. The third and final prototype was unveiled in June, and preproduction units began shipping to third-party software developers, like David Winer of Living Videotext.

"We were blown away," Winer says. "When we wrote the article for BYTE [see "Portables—1984 and Beyond" on page 243 of the January issue], it seemed as if we were being overambitious in our projections. Actually, we were conservative."

to catch. The challenge for the designers of the Data General/One was to create a full-size panel that would be both readable and "fast." Faster LCDs have to receive electrical pulses more often in order to retain their opacity, a doubly difficult challenge for a proposed panel with more than 2.6 times as many pixels as the largest LCDs being produced then (640 by 256 pixels versus 480 by 128 pixels).

The solution was an ingenious one. Since there was no way to pulse 163,840 pixels often enough to produce a dark image, the designers created a single physical panel divided electrically into a number of smaller panels that are driven simultaneously. Functions such as smooth scrolling from one screen to another are tricky with this kind of system, and the challenge was finding video-display drivers that could handle the task.

The engineers solved this problem by using CMOS gate arrays, which also significantly contributed to the Data General/One's compactness and portability. Two 4000-gate gate arrays control the video display and replace about 500 integrated circuits (ICs), which would use lots of space and power: one gate array controls the LCD panel's contents and contrast, based on the contents of video memory; the other mediates the processor's access to video memory and emulates a superset of the functions of the Motorola 6845 video-controller chip (the one used in the IBM PC). The computer "sees" the same character and graphics memory areas as are in the IBM PC.

REDUCING POWER CONSUMPTION

As previously stated, extensive use of CMOS parts such as the 80C88 processor and the memory chips radically decreases the power needed to run the Data General/One. (Because machines using CMOS parts also develop negligible heat, a designer can create compact designs without having to worry about heat-dissipation problems.) CMOS integrated circuits hold information with virtually no current (usually in the range of microamps) and require only milliamps of extra current when that information is being accessed or changed. Also, the 80C88 has half as many data lines as its parent chip, the 80C86. Although this means about a 20 percent decrease in processing power, it also means that the computer has eight fewer data lines to drive.

The designers also reduced power consumption by careful choice of their 64K-byte static CMOS RAM chips. Most memory designs use 64K- by 1-bit designs, thus requiring eight chips to be activated to retrieve a single byte (1 bit from each chip); by using 8K- by 8-bit chips, the designers made it possible for the processor to read or write 1 byte of data by activating only one CMOS chip.

Finally, the designers created hardware and software that automatically switch power on and off to subsystems (such as the floppy disks and communications subsystem) that normally consume large amounts of power.

MAKING IT SMALLER

The Data General/One fits in a space of 355 cubic inches—about the size of two three-ring binders. The wise choice of components (3½-inch disk drives, gate arrays, and the thin LCD panel) helps in terms of size, as does a state-of-the-art printed-circuit-board technique known as surface mounting. Surface mounting lets manufacturers put specially packaged ICs directly onto the copper traces without having to first drill holes through the board. The lack of holes means that the designers can lay more traces per board and use both sides of the board. For example, the 128K-byte memory card (see photo 2b) packs 18 ICs onto both sides of a board about the size of a playing card and only a quarter-inch thick.

OTHER INNOVATIONS

Because the Data General/One is not designed to be opened by the end user, the machine's engineers included the aforementioned configuration program in ROM. The user's choices are stored in RAM, backed up by a lithium battery that should, according to Data General, last for three years.

Another nice touch is that the Data General/One character set is downloaded from ROM to RAM at C5000 hexadecimal (see table 1). This lets software vendors and other programmers redefine the character set, a feature that often makes software more versatile.

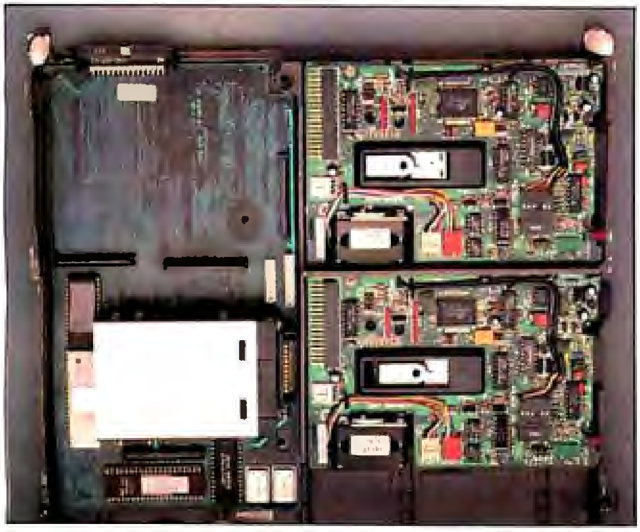
IBM PC COMPATIBILITY

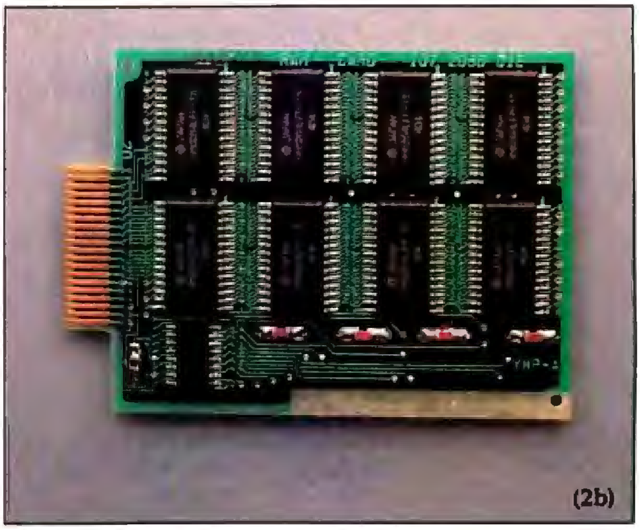
According to Data General, programs that use the documented IBM DOS and BIOS interfaces will run on the external 5¼-inch drive without modification. Although we did not conduct exhaustive tests, a fair amount of the PC software we had on hand booted up without problems, including WordStar, PeachText, PC-Talk, Turbo Pascal, and others. Some programs exhibited problems. Flight Simulator ran fine, but there were scattered pieces of graphics along the top and bottom of the screen. Lotus 1-2-3 ran well except that the printer driver did not work; the 3½-inch-disk version announced concurrently with the Data General/One does not have this problem.

On the hardware end, Data General has announced

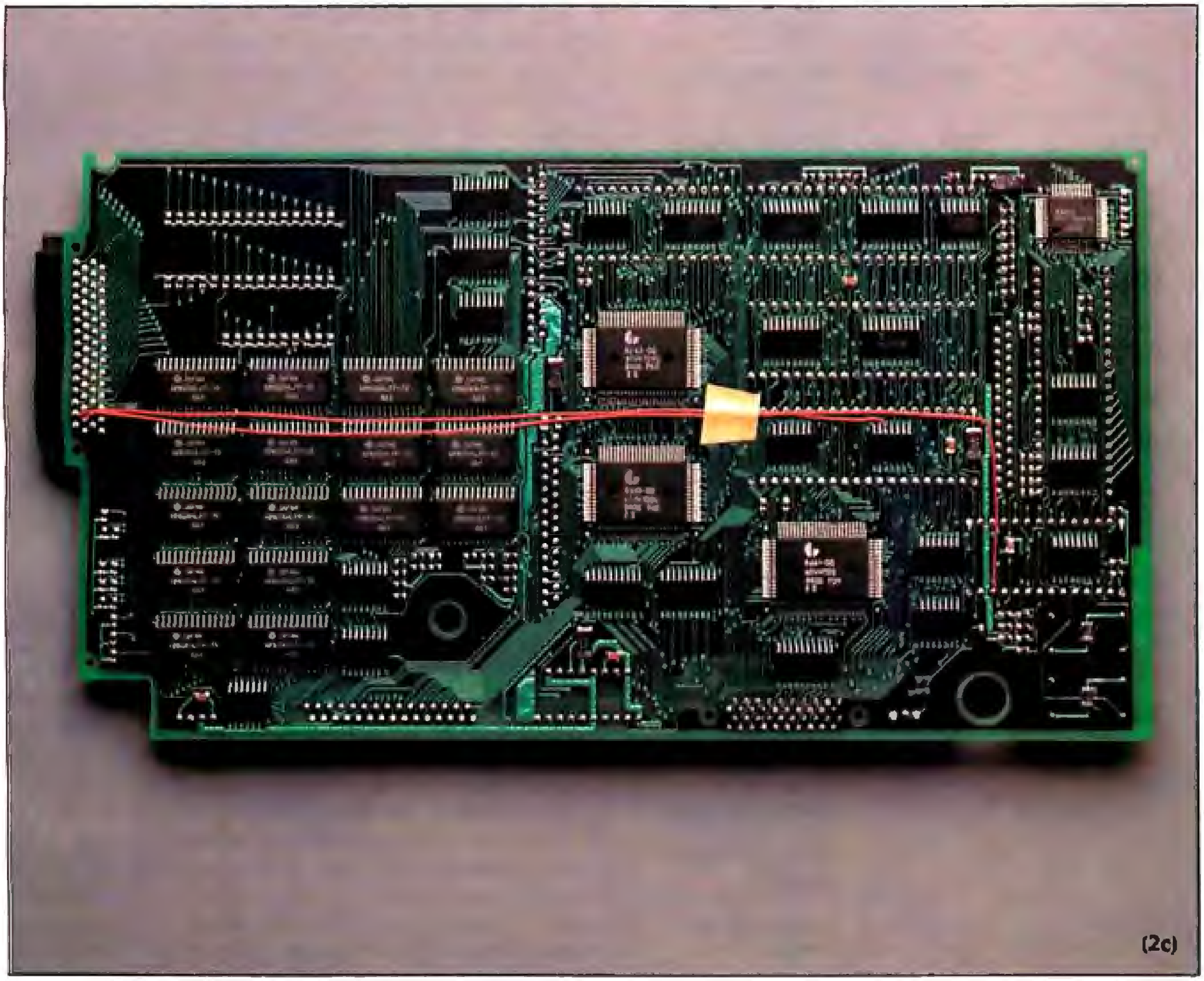
(continued)

Photo 2: A *top view (2a) of a preproduction Data General/ One shows the power-supply board at top left, the disk-drive controllers at the right, and the main board at bottom left. The I/O board is not shown. A case mounted on the motherboard holds* 128K-*byte RAM cards* (2*b*), *which are the size of playing cards. The bottom of the main board is in* 2*c.*





(2b)



(2c)

Table 1: *The Data General/One memory map. The 128K bytes of memory on the motherboard includes 80K bytes of available memory and 48K bytes of dual-ported RAM (marked with asterisks) used to support the LCD panel. (This video memory actually totals 52K bytes, not 48K bytes. This is because 4K bytes are shared by the monochrome and color-video memory areas and are mapped to the appropriate address depending on the video mode that is active at the moment.)*

BEGINNING LOCATION (HEXADECIMAL)	AMOUNT OF MEMORY	NOTES
00000	80K bytes	motherboard; user memory
14000	128K bytes	optional memory board
34000	128K bytes	optional memory board
54000	128K bytes	optional memory board
74000	240K bytes	memory space for external memory
B0000	4K bytes*	monochrome video memory
B1000	28K bytes	used by gate arrays
B8000	16K bytes*	color video memory
BC000	16K bytes	used by gate arrays
C0000	20K bytes*	image buffer that stores bit map for LCD panel
C5000	12K bytes*	font memory
C8000	32K bytes	reserved for future use by Data General
D0000	128K bytes	memory space for external memory
F0000	32K bytes	system ROM; includes BIOS, bootstrap code, Notebook and Terminal programs
FFFFF		end of address space

its intention to release an expansion chassis that will enable you to add IBM PC-compatible plug-in boards.

CAVEAT

The information in this product description is based on two days of meetings with Data General people, a telephone conversation with the design team leader in Japan, access to the Data General/One programmer's manual, and more than a week's access to a fully functional, late-preproduction machine with 512K bytes of memory, two 3½-inch disk drives, battery pack, internal modem, and external 5¼-inch floppy-disk drive. All photos and measurements in this article were taken from this preproduction machine.

INITIAL TESTS

We ran a few tests on the Data General/One in our offices. The system completes its internal memory test (with 512K bytes) in 10.3 seconds; an IBM PC at BYTE with the same amount of memory takes 43.8 seconds.

Data General claims the batteries will last 8 to 10 hours with the disk being used 20 percent of the time. With the battery fully charged, the Data General/One we tested lasted 6 hours, 51 minutes running a GW BASIC program that wrote to disk once a minute, a process that took 8 seconds, resulting in a 13.3 percent duty cycle. (The nickel-cadmium batteries are said to recharge in 6 to 8 hours; for this test, we left the recharger connected overnight.)

The infamous Gilbreath Sieve of Eratosthenes benchmark took 202 seconds to complete one iteration using Microsoft's GW BASIC; the IBM PC took 191 seconds using its BASICA.

The prototype Data General/One we had (fully configured) weighed 12 pounds, 10 ounces. The AC power adapter weighed 1 pound, 13 ounces. The battery recharger weighed 4 ounces.

STRENGTHS AND WEAKNESSES

The Data General/One's most important strength is that it is truly portable and fully functional. We've seen machines that are small, light (under 15 pounds), and useful (the Radio Shack Model 100 is the most popular example so far). But this is the first such machine that is as useful as the computer on your office desk, has 512K bytes of memory, an LCD panel the size of a standard display, two large-capacity disk drives, a comfortable keyboard, and a modem.

One of the nicest things about the LCD panel is that its low-persistence pixels make it possible for text to scroll at normal display speed without leaving behind ghost images (a problem with many LCD panels). It is also different in that it uses 2-to-1 aspect pixels (rectangular pixels twice as high as they are wide) instead of the 1-to-1 aspect pixels used in other LCD panels. Because the 2-to-1 aspect pixel most closely matches that of video displays, the Data General/One display looks like a CRT (cathode-ray tube) display, while others (the announced LCD panel for the Apple IIc, for example) give a distorted image that is compressed vertically.

The Data General/One brings us again to the inevitable adjustments to yet another keyboard layout. All in all, Data General has done a good job of creating a keyboard that is compatible with both IBM PC and Data General keyboards. The keys, though they give some audible feedback, are not as loud as those of the IBM PC or other portables. For those of us who have finally gotten used to the location of the left Shift key on the IBM PC, Data General's decision to place it in its preferred, pre-PC position means we'll have to readjust again.

One change that we like is the placement of the function keys above the number keys. This enables you to insert directly above the keys plastic templates that tell the function of each key and its function when used with Shift, Control, and Control-Shift. Because Data General computers have 15 function keys, the keyboard layout lets Data General software use the F1 through F10 keys and the five keys to their right as function keys.

Data General is to be commended for choosing a standard disk format for its 3½-inch drives. The Data General/One uses unmodified Sony 80-track, double-sided disk drives and formats each track as nine 512-byte sectors; this is the proposed standard used by Microsoft for 3½-inch-disk MS-DOS systems. Hewlett-Packard and Apple, the first major vendors to use 3½-inch drives, have both used incompatible, nonstandard disk formats. According to one engineer, Data General places a high value on industry-wide compatibility and hopes that future vendors will adopt this format. (The Data General/One can read and write disks using one or two sides and 8 or 9 sectors per track. With some limitations, it can also write sectors of 128, 256, and 1024 bytes each.)

On the negative side, we must point out that the LCD panel is difficult to read in conditions less than ideal. It looks great if you have diffuse light coming over one shoulder and you're wearing light-colored clothing; otherwise, the image is not strong enough to overcome the image reflected on the glass face of the LCD (even when you adjust the LCD's contrast). Also, because of the physics of driving rows and columns of LCD pixels, you can see faint streaks above and below and dark vertical bars in the LCD image. The LCD image is functional—good enough for an airport but not for sustained use at the office. (Fortunately, Data General claims it will fix this inadequacy with a "system expansion box"; see "Plans.")

Another disappointment is the quality of the ROM-based Notebook and Terminal programs, which are limited in that they cannot interact with the microfloppy disks. Although you can use the Notebook to write something and print it out (or transmit it to a remote computer using the Terminal program), you cannot recall and save work directly to a disk, which makes us think that we wouldn't use these programs very often. The Data General engineers explained that the two programs "came free" because of ROM space left over after the Configuration program had been written. They also didn't want to anger third-party software developers, who are less enthusiastic about writing software for a given machine if adequate programs are bundled with it (in ROM or on disk).

Finally, we must point out a simple inadequacy of some importance: the machine has no built-in handle. Granted, Data General will offer several carrying cases, but they are too inconvenient for those times when you want to carry the machine to the library downstairs. Maybe someone will invent a harness that has a handle and never needs to be removed from the machine.

PLANS

A Data General spokesperson said that a "system expansion box" would be available "60 to 90 days after product announcement" (September 20). Although he could not provide specifications for the unit, he said that it would definitely include the ability to drive a color or a monochrome monitor. With this feature (and perhaps the 5¼-inch disk drive), we can see possibly buying a Data General/One instead of an IBM PC.

On the Data General/One main board, there is an empty socket beside the 80C88 that is the same size as the empty socket beside the 8088 in the IBM PC. Since we now know that that IBM PC socket is meant to house an Intel 8087 arithmetic coprocessor chip, it is plausible to speculate that the empty Data General/One socket will house an 80C87 or some other coprocessor that will enhance the machine's performance. The Data General spokesperson would not comment, but he pointed out that the Data General/One is "not the only product in this line we intend to put out" and that Data General has plans to ensure that its products will provide state-of-the-art performance.

Another interesting possibility springs from the fact that there are four DMA (direct memory access) channels in the Data General/One, two internal and two external. Of the internal DMA channels, one is used for the 3½-inch drives, and the other is reserved "for future use." An obvious enhancement to this machine would be substitution of a 3½-inch Winchester hard disk (which might hold, say, 10 megabytes) for the second disk drive. A machine of such capacity, at less than half the weight of a suitcase-size AC-powered transportable computer, would be impressive indeed. ■

CIARCIA'S CIRCUIT CELLAR

THE LIS'NER 1000

BY STEVE CIARCIA

Build a low-cost, high-performance speech-recognition system

The concept of a computer understanding speech is not new. For years we have watched Capt. Kirk and Mr. Spock on the bridge of the *Enterprise* talking with the ship's computer or have remarked at the diabolical mind of HAL in *2001: A Space Odyssey*. These computers represent the ultimate in automatic speech recognition (ASR). Unfortunately, most of their capabilities are still science fiction.

The ultimate goal of all speech-recognition techniques is to characterize the spoken word into a recognizable pattern. Specifically, ASR is the ability that would let a computer recognize the spoken word. Exactly how the words are spoken, however, determines the hardware cost and analysis techniques employed.

SPEECH-RECOGNITION UNITS

The first type of unit is the *speaker-dependent* recognition system, which creates its recognition vocabulary by "listening" to the voice of a single speaker. It then concerns itself only with recognizing the same word as spoken by that speaker.

First, the user speaks into a microphone all the words the machine is to recognize. The acoustical characteristics of each word are analyzed and stored as templates, which are digital patterns used by a recognition algorithm to identify words. The procedure of creating templates is referred to as *training*. Depending upon the available memory and the recognition-algorithm speed, the total vocabulary can be from 4 to 100 words. Generally speaking, the more words in the vocabulary, the longer it takes to recognize a specific word and the more sophisticated the algorithm must be.

The second type of unit is the *speaker-independent* recognition system. Other than HAL or the *Enterprise* computer, few functioning speaker-independent systems exist that have more than a 10-word vocabulary. This system requires no template training by a single speaker. Its speech templates are preprogrammed, and the matching algorithm is supposed to be adaptable to the voices of a variety of speakers and accents.

The third type of unit is *unconnected speech*. Also called discrete-utterance recognition, unconnected speech is simply single words preceded and followed by pauses. This is

(continued)

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Photo 1: *The General Instrument* SP1000 *voice-recognition chip.*

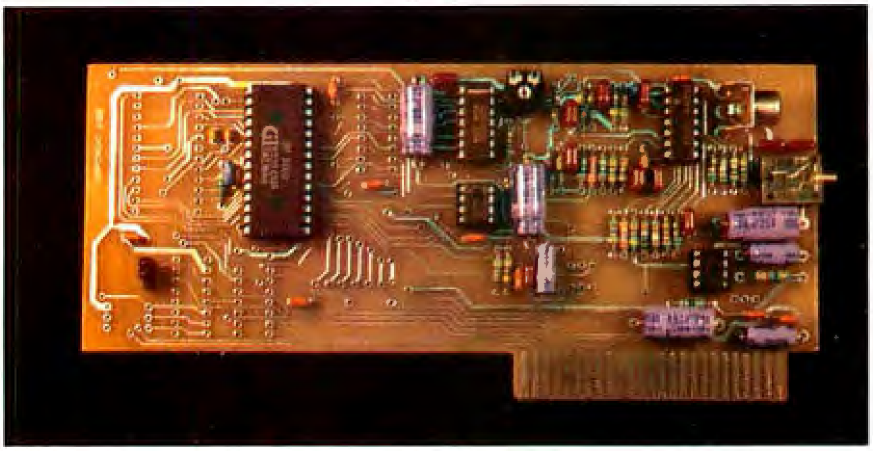

Photo 2: A *prototype printed-circuit board of the* Apple II *recognition-only* Lis'ner 1000 *circuit. The two connectors on the top right are for an external speaker* (RCA) *and the microphone* (*miniphono*). An IBM PC *version is in the works.*

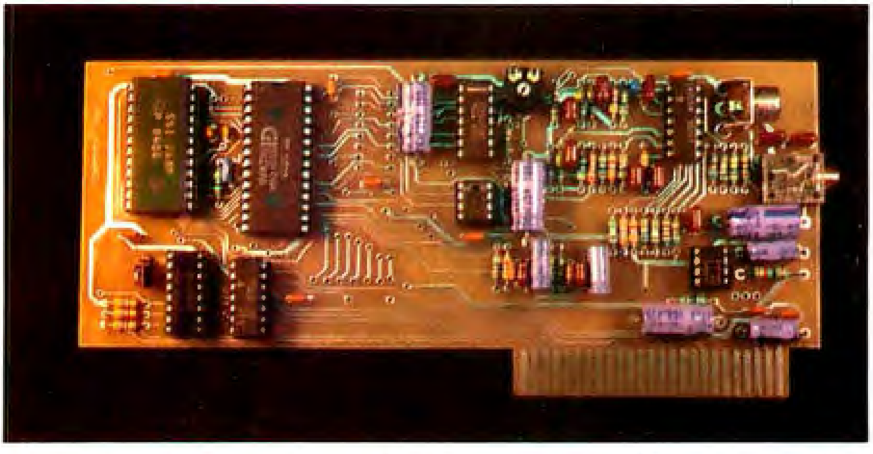

Photo 3: A *prototype printed-circuit board containing* Lis'ner 1000 *circuitry, which performs recognition, and speech-synthesis circuitry for the* Apple II. *It contains both the* SP1000 *and an* SSI-263 *speech synthesizer with a text-to-speech algorithm. Together they facilitate a functional hands-off computer with complete speech* I/O.

the easiest recognition approach and generally the technique used in most inexpensive systems. Each template is for a single utterance that must be spoken as a discrete word rather than as part of a longer word or phrase.

The final type of unit is *connected speech*. Also called continuous speech, this is the way we normally talk. Unfortunately, much of our understanding is dependent on recognizing the words in context. One major problem for the computer is coarticulation, where words are blended so that there are no distinct word boundaries for direct template matching. The result is costly computing overhead because every template must be aligned with every possible interval of the utterance. While significant advances have been made in this area, connected-speech ASR systems are expensive and generally require some monitoring of context as well.

Today, most speech-recognition systems are discrete-utterance speaker-dependent units. They may be in the form of expansion boards for existing computers or stand-alone black boxes. Ultimately, however, their purpose is singular. When the user speaks, the computer analyzes the acoustical signal, compares it to the stored templates, and decides which most closely resembles the spoken word. Once a candidate is chosen, the computer can itself respond to the user's utterance or output a control signal to another device.

Each stage of the analysis and pattern-matching procedure can be carried out by a variety of techniques. The earliest techniques used a simple zero-crossing detector to produce a pattern somewhat related to frequency. It soon became evident that speech, which is a complex combination of frequencies, could not be so easily represented. The next refinement was to break the voice frequencies out through a series of filters and separately record energy levels. While economically attractive, since it used readily available components, the massive quantities of data gathered proved ponderous and slow to compute. Many systems on the market still use this technique.

One significant advance in estimating the amplitude spectrum of speech is linear predictive coding (LPC). Also known as autoregressive analysis, this method predicts the amplitude of a speech waveform at any instant by combining the amplitudes at a number of earlier instants. The LPC coefficients that best approximate the speech waveform can be mathematically converted to approximate the amplitude spectrum. In speech applications, the LPC analyzer is basically a lattice of filters that approximate a series of resonant cavities, thus simulating the vocal tract.

A Circuit Cellar System

Up until now, it hasn't seemed worthwhile to present a speech-recognition system that merely imitated others. My article in the March 1982 BYTE ("Use Voiceprints to Analyze Speech," page 50) demonstrated the separated-filter and energy-level recording technique in the hopes that I could learn enough to quickly present an ASR system based on that principle. While feasible in theory, I ultimately scrapped the idea as having too many components, even if they were readily available. Since then, I have been watching for any new components that might improve the situation.

Fortunately, the wait has not been in vain. The new SP1000 voice-recognition chip from General Instrument allows me to demonstrate the construction of a low-cost, high-performance voice-recognition system (see photo 1). To my knowledge, this project is one of the first recognition devices using the SP1000.

The Circuit Cellar speech-recognition system, which I've called the Lis'ner 1000, is both a voice-recognition and voice-synthesizer board using the SP1000. The schematics I present are specifically for the Apple II, but they are applicable to other 6502-based systems such as the Commodore 64. The Apple II version plugs into any of the computer's expansion slots, but slot 4 is preferred. The Commodore 64 version (shown in the opening photo) plugs into the rear expansion connector. The Commodore board is configured for recognition only; the Apple II board, shown in photos 2 and 3, supports the LPC speech output from the SP1000 and has optional provision for an SSI-263 phonetic speech synthesizer with a text-to-speech algorithm.

The Lis'ner 1000 hardware forms merely the front end of a recognition system by performing feature extraction of the incoming audio signal. The host microcomputer compares these features with those of the templates stored in memory and makes the recognition decisions. Such a separation of system tasks leaves control of system performance to the system designer. You can use the Lis'ner 1000 board in speaker-dependent or speaker-independent systems with connected or unconnected speech. The designer is not locked into a specific recognition algorithm that may not be suitable for a particular application. Instead, the recognition algorithm is contained in software resident in the host microcomputer and can be easily upgraded to take advantage of advances in recognition techniques without requiring hardware redesign.

This project is one of the first recognition devices using the SP1000.

In an effort to more fully support

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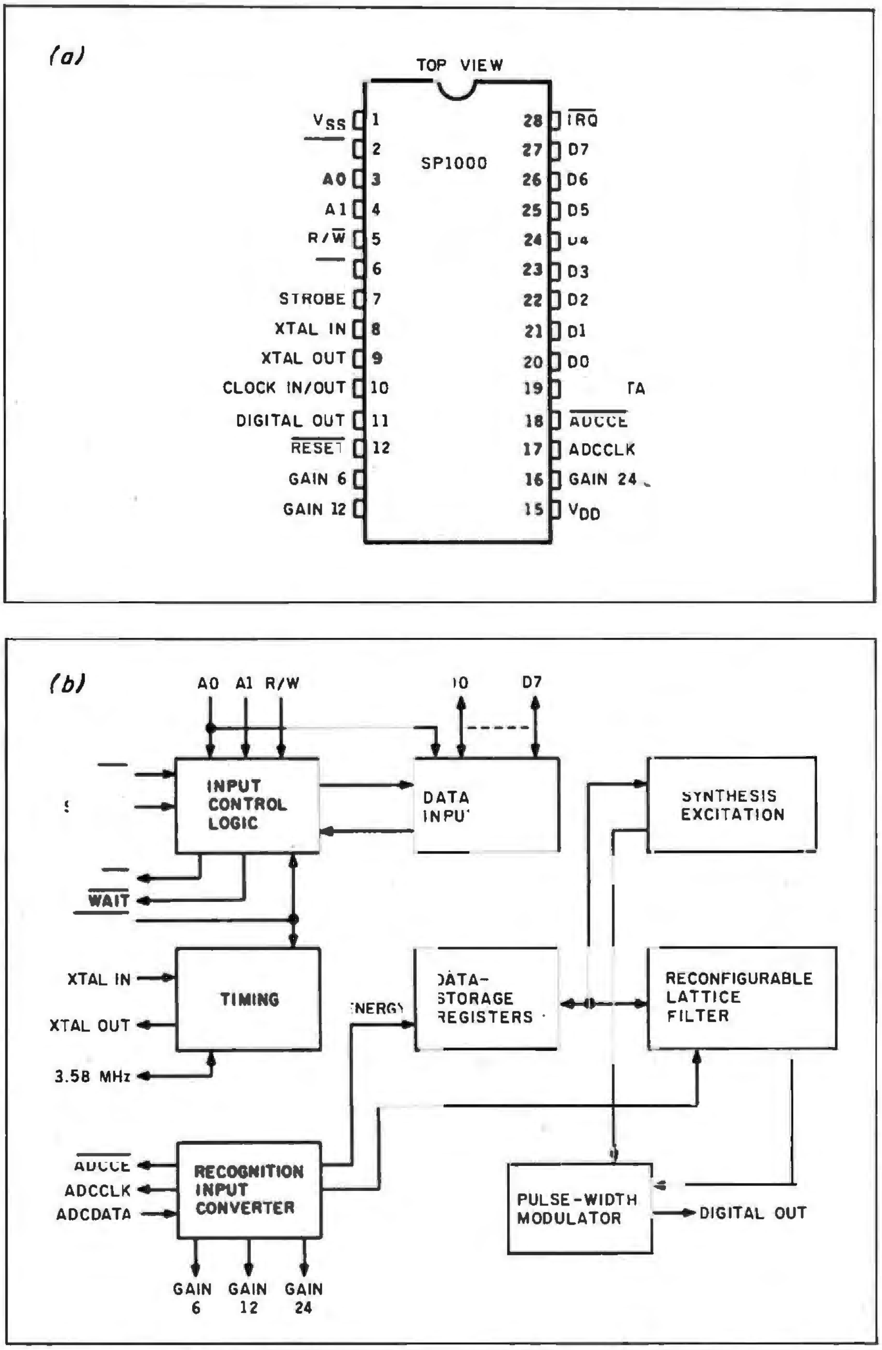

Figure 1: *The SP1000 pin configuration (a) and block diagram (b).*

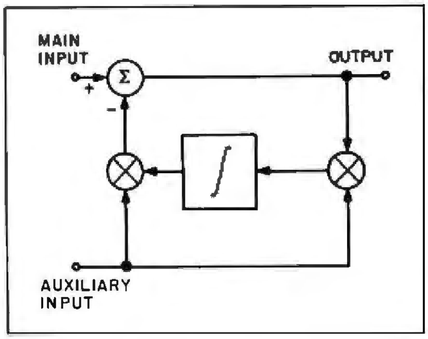

Figure 2: A CCL *loop.*

the Lis'ner 1000 and make it immediately usable, I've had developed a package of software routines that allows the board to function as a voice-operated keyboard on the Apple II and Commodore 64. Not to lose touch with true experimenters, however, the source code necessary to make the basic system function will be available to those who build the project and want to modify the software (see Experimenter Support on page 123).

The software I provide makes the Lis'ner 1000 a speaker-dependent, discrete-utterance recognition system. The present software supports 64 words in two groups of 32. You'll need a disk drive for either unit to function with the present software.

Before I get too far ahead, however, let me describe the SP1000 chip itself and what's necessary to build the Lis'ner 1000.

GENERAL INSTRUMENT SP1000

The SP1000, block-diagramed in figure 1, is a 5-volt (V) 28-pin NMOS (negative-channel metal-oxide semiconductor) microprocessor peripheral chip that can be used for both speech recognition and LPC speech synthesis. Using a bidirectional data bus and control lines, the SP1000 interfaces to most 8-bit processors as a memory-mapped peripheral device.

The unique aspect of the SP1000 is its ability to do LPC analysis in real time. LPC analysis solves for the coefficients Ai in an equation of the form:

$$X'_K = A_1X_{K-1} + A_2X_{K-2} + \ldots + A_NX_{K-N}$$

where X'_K is an approximation of X_K.

Typical techniques used to solve for the coefficients involve matrix calculations and manipulations. Such techniques, which require vast amounts of memory and extensive calculations, preclude their use on an inexpensive device at this time.

The SP1000 uses a modified form of the correlation cancellation loop (CCL) shown in figure 2 in a reconfigurable lattice structure. The CCL approach can be used to operate directly on the incoming data stream without extensive buffering of data or exorbitant processing power. The predictor coefficients (Ai) are taken from the integrator output of each stage. The stages can be cascaded for higher-order analysis and multiplexed in low-bandwidth applications.

In simpler terms, by modifying the feedback-control scheme within the filter itself, the ultimate number of computations is reduced. The CCL approach requires 300 bits of working storage versus 3 kilobits for a standard covariance or autocorrelation analysis. It also has the interesting property of being able to run backward with a minimum of reconfiguration. This property allows the SP1000 to be used as a speech synthesizer as well as an analyzer for recognition.

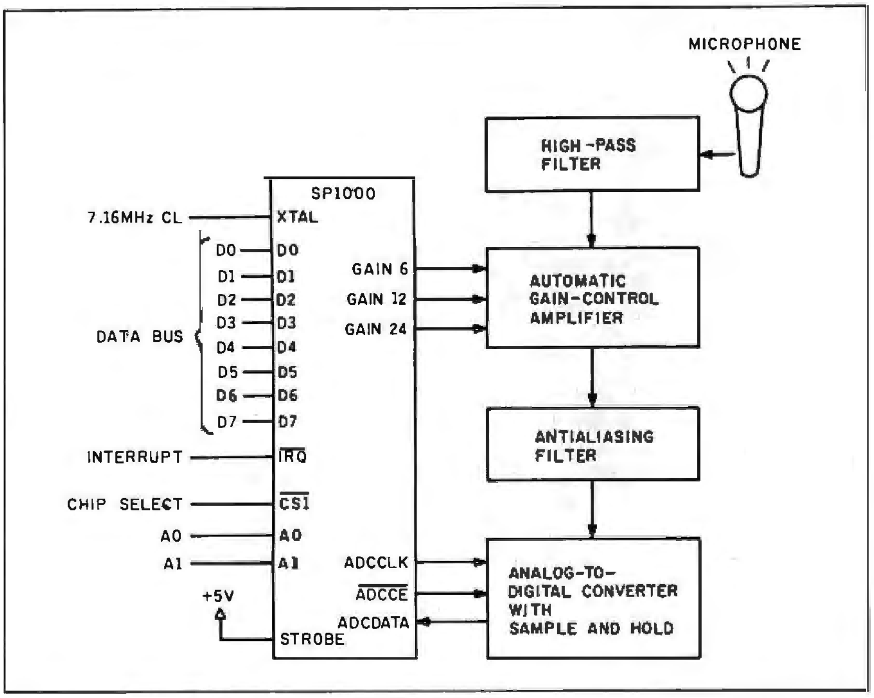

Figure 3: A *block diagram of the voice-recognition hardware.*

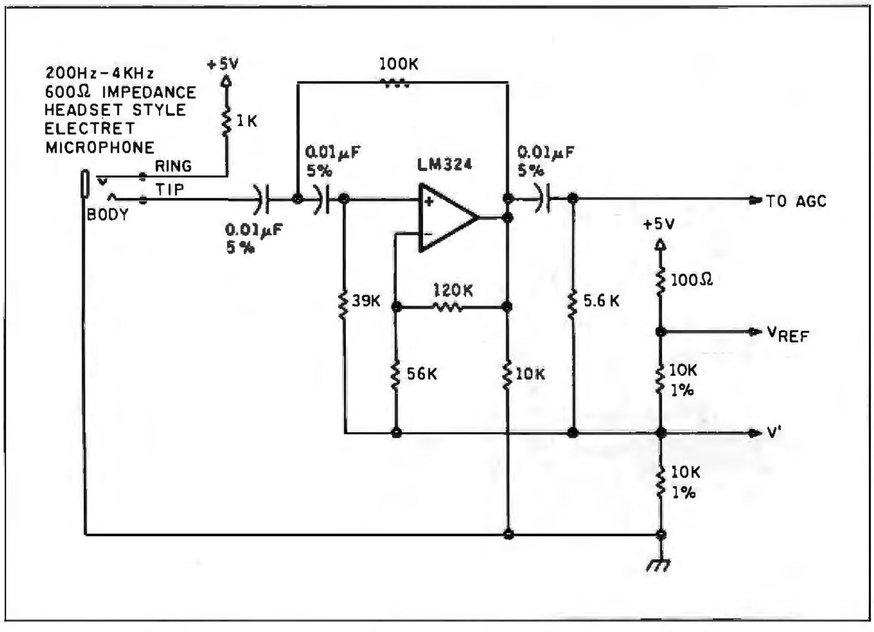

Figure 4: *The high-pass filter for the microphone.*

The SP1000 can perform useful speech analysis with a relatively inexpensive 8-bit A/D (analog-to-digital) converter. The major reason for this is the use of an on-board automatic-gain-control (AGC) algorithm. The three gain outputs from the SP1000 are used to control a variable gain amplifier. The SP1000 tests the 2 most significant bits of each incoming sample and lowers the gain if they are too high. The net effect is to keep the amplitude of the analog signal within the dynamic range of the A/D converter, preventing distortion and stabilizing the signal level entering the lattice filter.

When used as a synthesizer, the filter is presented with LPC coefficients of the speech frame to be synthesized. Typically, these coefficients are computed on a minicomputer and stored as files to be loaded into the microprocessor's memory. Eventually, General Instrument intends to supply an allophone set that will let the user synthesize any word using a text-to-speech algorithm or dictionary table. The functional use of the Lis'ner 1000 in recognition applications is not dependent on this software, which can be added when it is available.

The desire for user-programmable voice-output capability immediately did not go unnoticed, however. I anticipated the interest in a functional recognition/synthesizer board and purposely designed the Lis'ner 1000 to perform as one. While the project described is for an SP1000-only device, the Apple II printed-circuit board for this project is also etched to accommodate an SSI-263 phonetic speech-synthesizer chip (see "Build a Third-Generation Phonetic Speech Synthesizer," March, page 28). Adding the SSI-263 and the text-to-speech algorithm facilitates true voice I/O (input/output) and supports both phonetic-generated and allophone-generated (LPC) speech.

BUILDING THE LIS'NER 1000

Figure 3 is a block diagram of the recognition portion of the Lis'ner 1000, which interfaces to the Apple II and Commodore 64 through an 8-bit bidirectional bus and a few control lines. The SP1000 occupies four address locations and is written to or read from as any other peripheral device at that address. Data is transferred through the data lines whenever the chip-select line is active. The read/write line determines the direction of the transfer, and the two address lines specify the particular register within the chip. Of the four registers, three are read/write and one is write only.

The source code that is necessary to make the basic system function will be available.

A typical system consists of the SP1000 and an assortment of analog components. The analog interface consists of filters, amplifiers, switches, and an A/D converter. The purpose of the circuitry is to convert the utterances spoken by the user into a form that the chip can understand. The entire circuit is designed to run on +5 V and, except for the SP1000 connection to the host computer, is virtually the same for all applications.

The first section (see figure 4) contains the microphone input and high-pass filter. For best performance, you should use a 600-ohm-impedance, condenser-type electret microphone.

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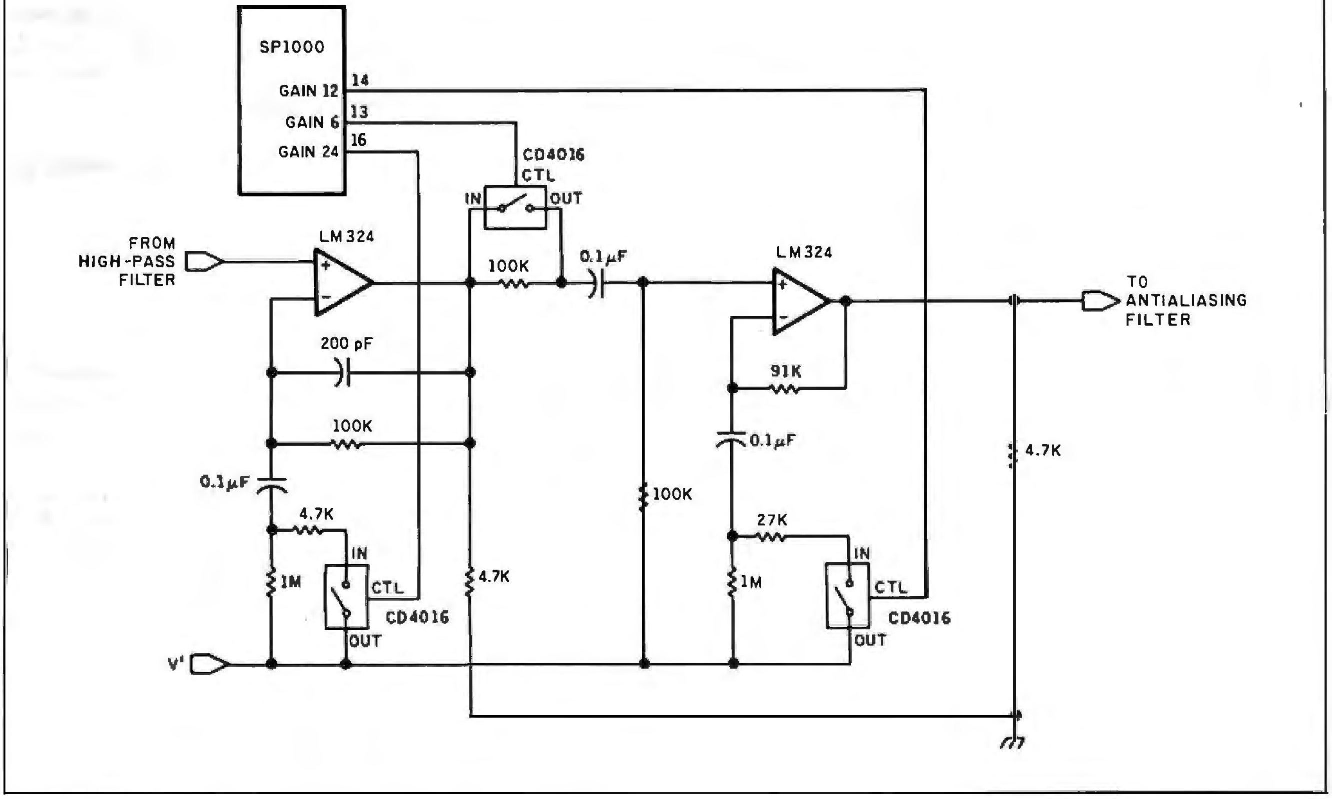


Figure 5: A *programmable automatic-gain-controlled amplifier.*

Table 1: *Signal amplifications possible with different combinations of the* SP1000 *gain pins, which are shown in figure* 5.

Gain Pins			
24	12	6	Gain
0	0	0	0 dB
0	0	1	6 dB
0	1	0	12 dB
0	1	1	18 dB
1	0	0	24 dB
1	0	1	30 dB
1	1	0	36 dB
1	1	1	42 dB

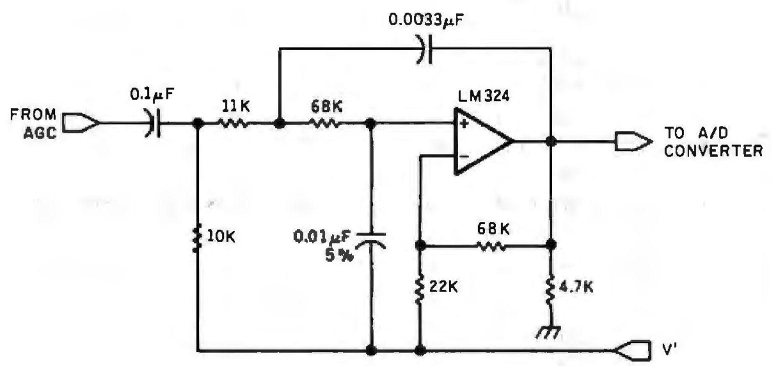


Figure 6: *An antialiasing filter.*

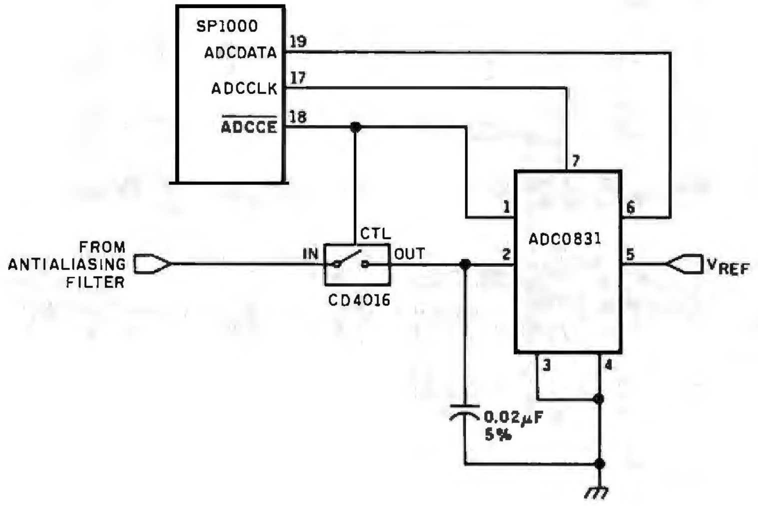


Figure 7: *The sample-and-hold 8-bit* A/D *converter.*

To avoid background noise pickup, I suggest the microphone headset combination shown in the opening photo. This keeps the microphone close to the mouth and limits interference.

The high-pass filter removes all sounds below 250 Hz.

The output from the high-pass filter is connected to an automatic-gain-controlled amplifier (see figure 5). The SP1000 provides three output lines that control switches to vary the resistor values within a circuit consisting of two noninverting operational amplifiers connected in series. These signals are GAIN 6, GAIN 12, and GAIN 24, corresponding to 6-, 12-, and 24-decibel (dB) signal levels (this is a voltage gain of 2, 4, and 15.8, if you are interested). See table 1 for the gain produced by combining these pins.

The SP1000 updates these signals at a predetermined interval, depending upon the value of the digital output from the A/D converter. The three lines create eight combinations of signal amplification from 0 dB to 42 dB in 6-dB steps. The purpose of the AGC is to monitor and modify the incoming signal amplitude so that it always stays within the range of the A/D converter.

Switching these resistors in and out in the AGC produces high-frequency transients known as *aliases*. These unwanted frequencies are removed by a two-pole, 3200-Hz, low-pass, antialiasing filter (see figure 6) before going to the A/D converter.

Once a conditioned signal with all the extraneous noise removed is obtained, it is directed to the sample-and-hold A/D converter to be read by the SP1000 (see figure 7).

The SP1000 provides two signals for controlling the A/D converter and the sample-and-hold circuit: ADCCLK and ADCCE. The ADCCE signal provides an active-low chip select that turns off the sample switch (the switch, which is normally closed, opens when the A/D converter reads the voltage level stored on the capacitor) and enables the A/D converter. I used a National Semiconductor ADC0831 8-bit serial-output converter clocked at 150 kHz provided through ADCCLK as the A/D converter. The serial-output data is read through the ADCDATA line. You can program the SP1000 to read the input data at 5k to 16k samples per second. As configured in this project, the sample rate is 6.25k samples per second.

A complete schematic showing the recognition part and LPC-synthesis portion of the Apple II Lis'ner 1000 is shown in figure 8. Figure 9 shows the circuit changes necessary to add the SSI-263 specifically for the Apple II. Figure 10 is the Commodore 64 version.

SP1000 SOFTWARE

Figure 11 is a flowchart of the basic software control of the Lis'ner 1000. The routines described assume that the SP1000 is implemented as a discrete-utterance speaker-dependent unit. The software can be segmented into two major functions: the creation of training templates and actual recognition of utterances relative to the training templates previously created.

TRAINING

The purpose of training is to create a set of patterns, each of which represents a specific utterance. (Note that an utterance may be a single word or a phrase.) When recognition is performed, these patterns are compared to a pattern created from the word to be recognized. The pattern or template from the training utterances that is closest to the word to be recognized is the one the system chooses as the recognized word.

A well-designed training process will create templates that capture the unique features of an utterance in a form simple enough to facilitate the matching process and the efficient use of a system's memory. With this in mind, let's examine the training process implemented here.

The first step is initialization of the hardware and software. The SP1000 is an extremely flexible device that allows the user to specify several parameters that govern its analysis calculations. The parameters include the sample rate (6.25 kHz), the analysis-frame duration (20 milliseconds [ms]), and the gain-update period (10 ms). Once these parameters have been specified and the software has enabled the interrupts, the SP1000 will provide the processor with a fresh analysis frame at the end of each frame period.

The software initialization consists of setting the counters for the number of templates and the number of training passes for each template. The number of templates (utterances) is variable. The system uses two training passes for each template.

After initialization, the program enters the endpoint-detection process. Since this is a discrete-utterance recognizer, it must identify the start and finish of each utterance it "hears." This applies to both training and recognition. The endpoint-detection algorithm is designed around a finite-state machine with four states: silence, rising, plateau, and falling.

The SP1000 continually analyzes the audio input and sends its analysis data to the host processor. Whenever no speech is reaching the microphone, the SP1000 will be analyzing the ambient room noise. This represents the silence state. While in this state, the processor is constantly calculating a noise level based on the average energy of the last 16 frames of silence. If an incoming frame has an energy 6 dB or more above the noise level, the machine enters the rising state. Similar energy measurements control the state transitions throughout the duration of the utterance until the machine exits back to silence, indicating that the end of the utterance has been reached.

Once the machine enters the rising state, it saves all the analysis frames generated by the SP1000 until the end of the utterance has been found. At that point, the data collected is tested with criteria pertaining to minimum duration and dynamic range to confirm its legitimacy as speech input and pinpoint the endpoints more closely. A normalization process is also performed on the energy coefficients to equalize weighting.

At the end of this process, we have captured a parametric representation of the utterance. The next step is to include that representation in a training template.

It is worth noting that the data collected for an utterance with one second of duration is calculated as follows: (8 bits/coefficient) × (9 coefficients/frame) × (50 frames/second) × (1 second) = 3600 bits of data (450 bytes). Utterances of 3 seconds in duration would generate 1350 bytes. If left in this form, a few dozen utterances would take a sizable quantity of memory just for storage.

The purpose of training is to create a set of patterns, each representing a specific utterance.

Fortunately, the system need save only the unique characteristics of an utterance in order to perform good recognition. The unique sounds that constitute a particular utterance will usually be several frames in duration. Thus, the algorithm tests the utterance data one more time, essentially to perform a type of averaging in which adjacent frames with similar coefficient values are combined to form one new frame that replaces the two old ones. This process reduces the total number of frames in an utterance to 12. Theoretically, these 12 frames are representative of the unique speech sounds that occurred in the utterance. This process also provides a time normalization for all utterances. Since all utterances are reduced to 12 frames, they all have an identical length for comparison purposes.

The resulting 12 frames constitute a template. Since different repetitions of an utterance are never exactly alike, even when spoken by the same person, the software averages two templates created from two repetitions of the utterance in order to form a more general template. This is stored as the training template for that utterance. The final size of the training template is 12 frames of 9 coefficients each (or 108 bytes of data).

RECOGNITION

Recognition is performed with the same front-end software as the training. It uses the finite-state machine and post-processing functions to identify the endpoints of the utterance and performs time normalization to create a 12-frame unknown utterance template. It then tries to find the best match among the training templates previously stored. The two key elements of the matching process are the frame-to-frame distance measure and nonlinear time alignment.

DISTANCE MEASURE

I have mentioned the closeness of templates, which is used to determine

(continued)

the best match. But just how do you determine the closeness of two templates? The answer lies in a frame-to-frame distance measure, which is used to build a template-to-template distance. The smaller the template-to-template distance, the closer the two templates are to one another.

A Chebyshev distance measure is employed as the frame-to-frame distance measure. The equation ABS VAL $(A_i - B_i)$ is summed for all i, where i is the distance from frame A to frame B, A_i is the Ith element of frame A, and B_i is the Ith element of frame B.

Thus, frame-to-frame distance measurement consists of simply summing the magnitudes of the differences of corresponding elements in the frames being compared.

To find a template-to-template distance, the frame-to-frame distance measure is applied within the context

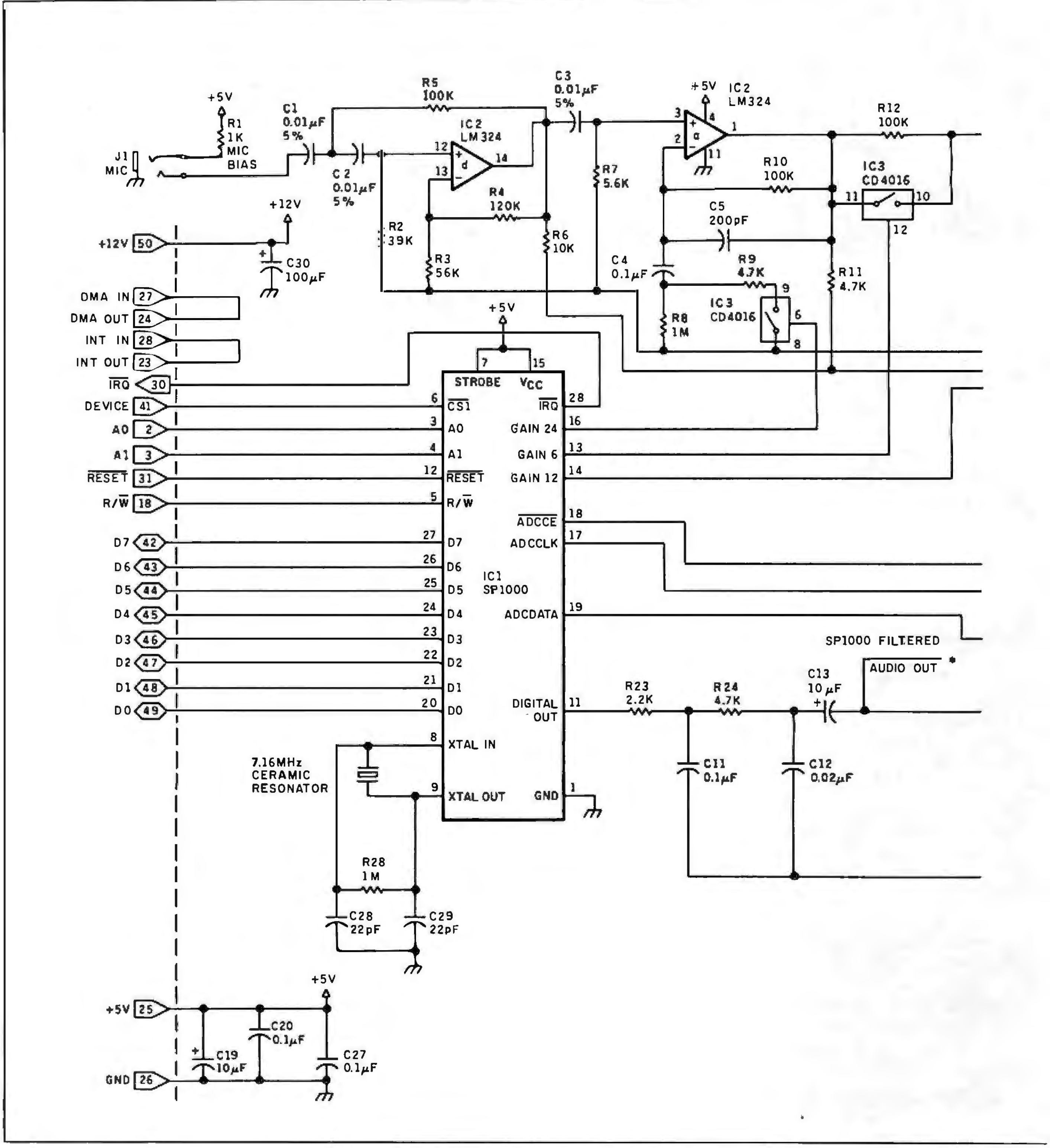


Figure 8: *The Lis'ner 1000 schematic without the SSI-263 for the Apple II.*

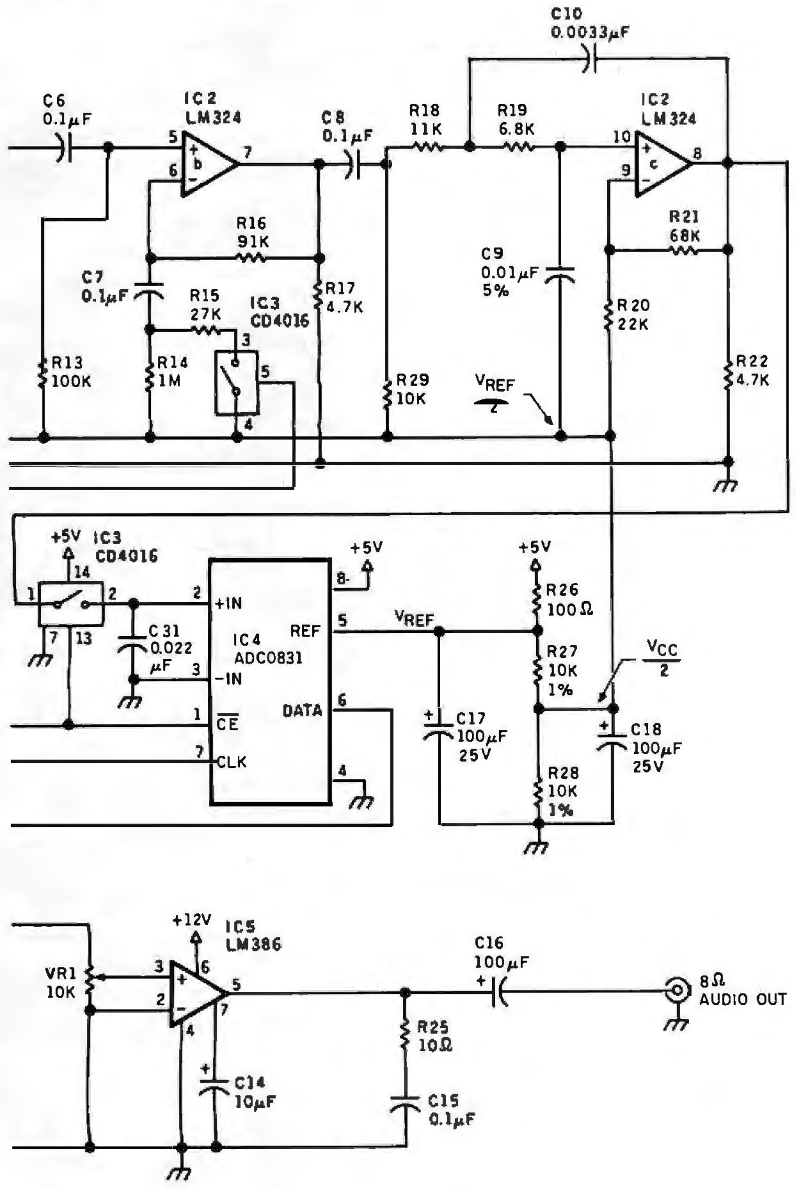
of the nonlinear time alignment of the frames.

NONLINEAR TIME ALIGNMENT

The need for nonlinear time alignment arises because human beings do not speak the same words exactly the same way each time. Volume and duration of words obviously vary, but a more subtle variation is very significant to a speech recognizer. The individual speech sounds comprising a word vary in duration relative to one another in different repetitions of the same word. This time distortion is nonlinear because simply stretching or compressing one entire repetition will not time-align the boundaries of the speech sounds with those of another repetition of the same utterance.

Consider a word with two syllables, such as table. Two repetitions of this

(continued)



word may have the same total duration, but the first syllable may constitute 50 percent of repetition one and only 30 percent of repetition two. If we created templates for the two repetitions and compared them on a frame-by-frame basis, we would not get the best match because at some point we would be comparing parts of syllable one with parts of syllable two.

On different occasions, the timing of these patterns may vary considerably, but they must all be present in the described order if the utterance is to count as a reasonable rendition of the word table. The misalignment can be corrected by stretching the template in some places and compressing it in others, so that a mathematically optimum match is found. This procedure is called dynamic time warping (DTW). (See "Speech Recognition: An Idea Whose Time Is Coming," January, page 213.)

REJECTION THRESHOLD

Once we have a best match, we have to determine if it is usable or not. One method is to qualify the match by setting a rejection threshold. This allows the recognizer to request that an input be repeated because it is not confident of a good match. With no rejection, the recognizer is forced to make a choice. The rejection threshold itself is the degree of confidence necessary to consider a match valid. The use of rejection criteria implies a trade-off between two types of error, the incorrect match versus no match at all. Rejection criteria can enhance the performance of the recognizer if they are adjusted to suit specific applications. The problems caused by the two types of error are application dependent.

As part of the recognition process, a template is made of the word just spoken, and it is compared to the templates made during training. For each comparison, a distance is computed that is used to determine the best fit to the spoken word. In order to reduce the number of false alarms (i.e., extraneous room noises being recognized as words), a method of rejection is used. Three parameters are used during rejection: the lower limit, the upper limit, and the rejection threshold.

The lower limit specifies a distance below which a word is automatically accepted and no more rejection tests are performed. This is useful in reducing recognition times and allows the

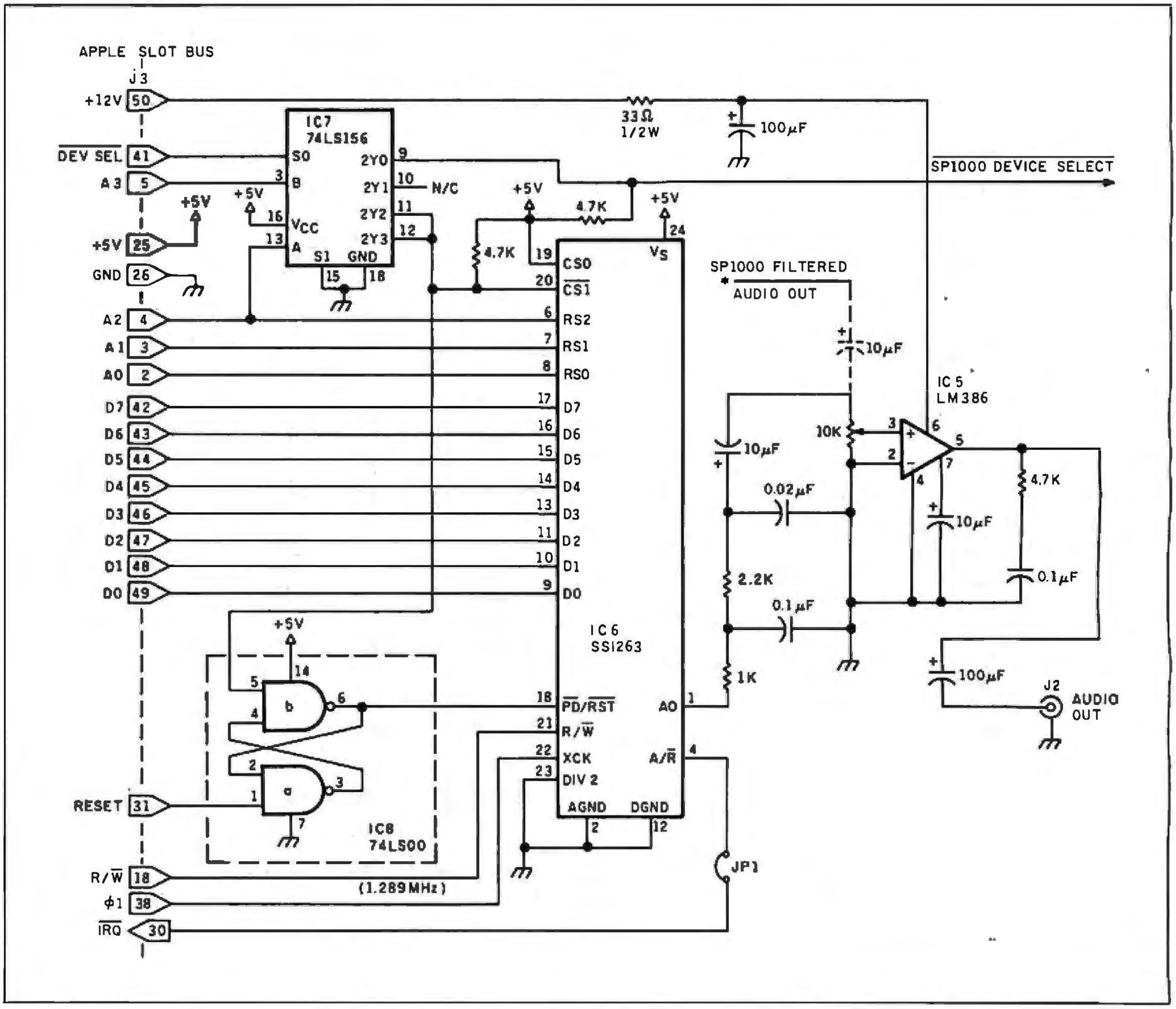


Figure 9: *The Lis'ner 1000 schematic with the SSI-263 for the Apple II.*

obvious correct matches to pass through. However, if it is set too high, many false alarms may occur.

The upper limit specifies just the opposite, the distance above which a word is automatically rejected. This too is helpful in speeding reaction times and discards obvious room noises such as clapping. If this number is set too low, a large incidence of rejecting good words will occur, resulting in a good deal of frustration for the user.

The last parameter is the rejection threshold, which is used to control just how close the spoken word may be to the two next closest reference templates. In short, a small rejection threshold results in a higher degree of rejection; a large rejection threshold is more forgiving and rejects less.

These three parameters are combined to tailor the system to the user's particular needs. If a highly speaker-dependent system is desired, a small lower limit, a small upper limit, and

(continued)

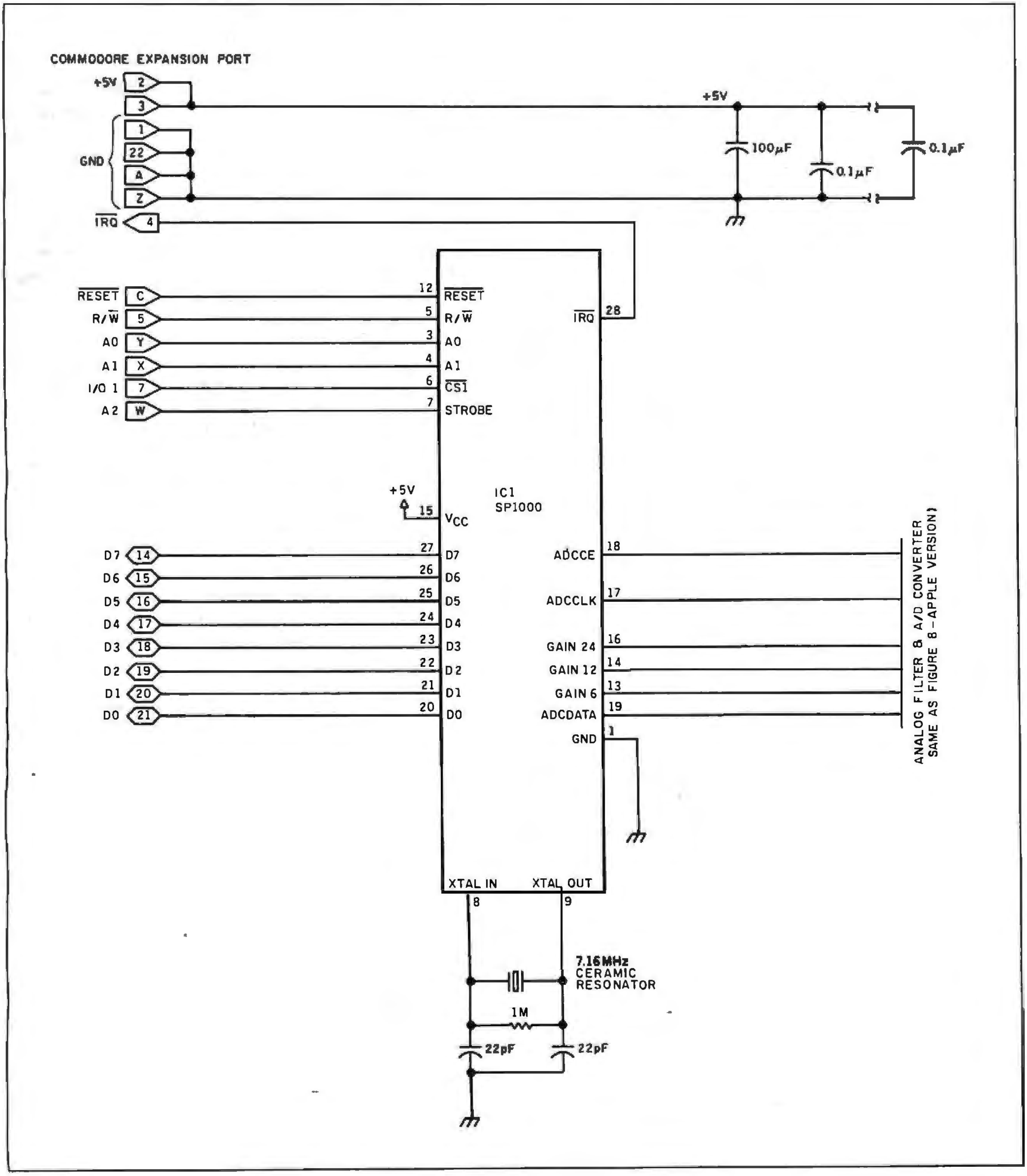


Figure 10: *The Lis'ner 1000 schematic for the Commodore 64.*

a small rejection threshold should be used. The result would be that only the person who trained the system would have good recognition results.

Lis'ner 1000 Software

The Lis'ner software consists of a combination of BASIC and assembly-language routines. The recognition algorithm and template matching are handled in assembly language to speed execution. Training and other infrequently used housekeeping functions are done in BASIC.

The purpose of the software is to function as a parallel voice input for application programs or normal operation of the computer. When first starting the system, for example, you are prompted to train a preselected vocabulary of DOS (disk operating system) and system commands. Rather than typing CATALOG and a carriage return, you merely have to say "catalog" and "return" (you can still type any part of it if you wish). In effect, the Lis'ner 1000 can be programmed to send a sequence of characters to the keyboard input handler as if they had been typed. This function can be turned on and off at will or used at specific points in application programs.

The process of selecting and training a vocabulary is prompted by a menu. You start by entering your own list of words to be recognized. Up to four groups of 8 words, or 32 words, are entered at one time, as shown in photo 4. A total of 64 words may be entered into the system. Next, you are asked for each spoken word followed by its corresponding command sequence, as shown in photo 5. The command sequence is the group of characters that the recognizer routine will respond with when it hears this particular utterance. The command sequence may contain any combination of letters, numbers, punctuation, and control characters.

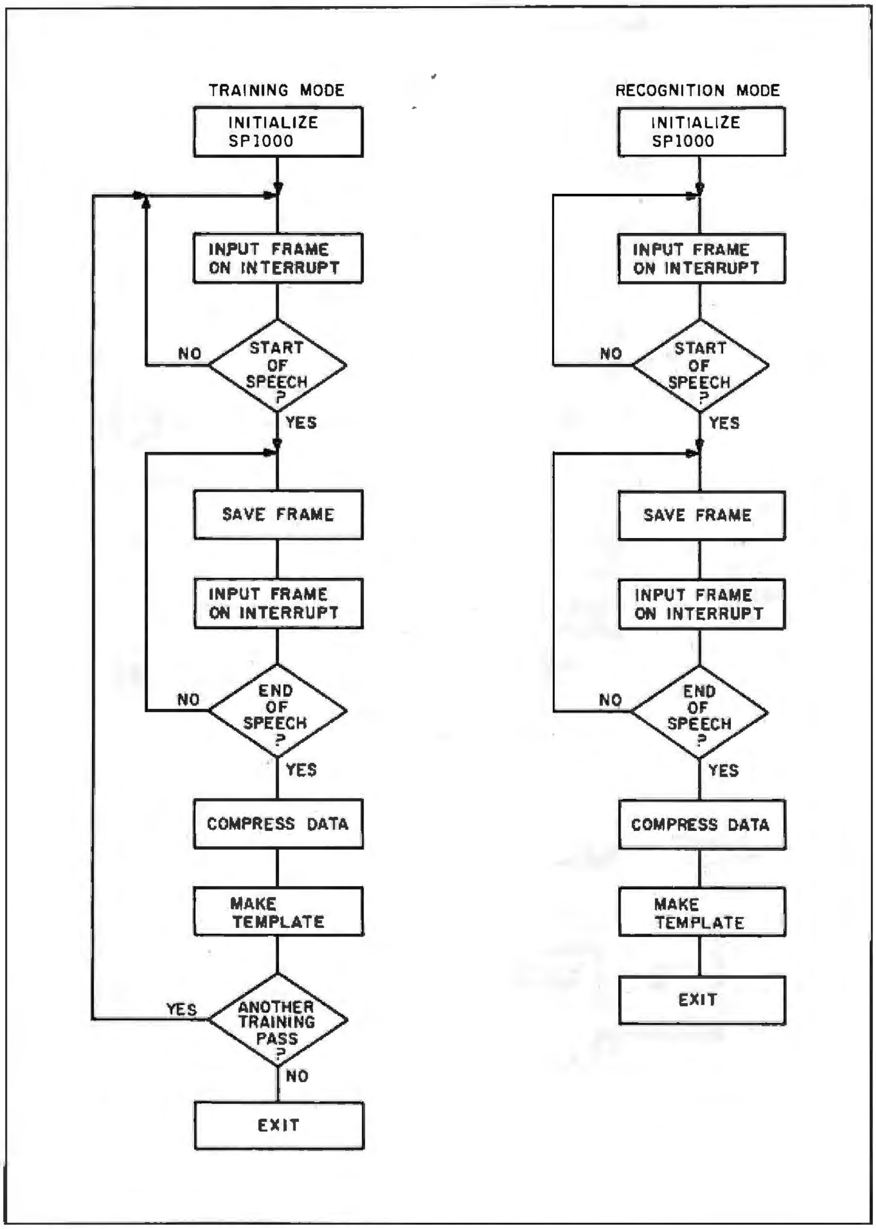


Figure 11: *The* SP1000 *recognition-software flowchart.*

The recognition software responds with the preset command sequence when it hears a particular word, regardless of whether it is appropriate. For example, you could make one of the speech commands a phrase such as "DIRECTORY, PLEASE." In response, the command sequence would print CATALOG and a carriage return for an Apple. (If you plan to use the device to simulate the direct function of discrete keyboard keys, it is best to use words such as APPLE, BAKER, CHARLIE, etc., rather than the single-syllable letters A, B, C, etc.).

Once all the words have been entered and a series of questions regarding rejection levels has been answered, you are prompted to train the system by saying each of the words two times. When this is done, the computer knows your voice and saves the templates to disk. The following is a list of editor commands, which can be spoken or typed. Their function is to aid in producing a vocabulary that approaches 100 percent recognition accuracy.

TEST—Enter test mode. This option, shown in photo 6, is useful in testing how well each word was trained. After each word is spoken, the letter "A" (accept) or "R" (reject) is displayed next to the word. If an "R" is displayed, the match between the spoken word and the word as the computer knows it is totally unacceptable. It may be due to the fact that the word that was recognized wasn't even the word spoken, or two words that sound alike may keep being confused. If any word or words consistently get low scores, that word or words should be retrained. To get back to command mode, hit any key.

EDIT—Add, delete, replace, and retrain any of the words.

LOAD—Load prestored templates so that editing and training may be performed.

SAVE—Save the templates being worked on for later use. This is used to save all the work you've done up to now. These templates may then be loaded by one of the Hello programs at some later date for use in your application programs.

QUIT—Leave the editor and return to BASIC. Once all your editing and saving are done, you may enter BASIC with the recognize routine and DOS templates still active.

Software design is of course dynamic. Some aspects of the Lis'ner software I've described here may have been modified by the time you read this.

EXPERIMENTER SUPPORT

I try to support the individual experimenter as much as I possibly can, and this project is no exception. To aid you in building the Lis'ner 1000 or an SP1000-based system, I have coordinated parts and software suppliers.

The Lis'ner software package consists of a combination of source-code and executable-only code files that are much too lengthy to print for distribution or to be published here. The Lis'ner software is supplied as BASIC source code with assembly-language executable code. Since I expect that many of you won't be happy until you've personally experimented with dynamic time warping and converted the routines to run on a different processor, I am making available demonstration source code for an SP1000 recognition algorithm for the Apple II. This code, which is less complicated than the Lis'ner software, was written by General Instrument. Also included are LPC coefficient files that will demonstrate the SP1000's synthesis capability.

Although this software is well annotated, it is unsupported and distributed for its educational value only. It contains all the necessary structure should you care to roll your own. (If you do convert these routines, I would be very interested in seeing your handiwork.)

The Experimenter Support package contains the General Instrument SP1000 demonstration software, Lis'ner software, and the *Lis'ner 1000 User's Manual*. It is available on disk for either the Apple II (except IIc) or Commodore 64 (please specify) directly from me for a $17 shipping-and-handling charge ($27 for overseas airmail). This offer is valid until March 1, 1985.

Finally, while it isn't a requirement that you include a picture this time when you write to me, I'd like to see your finished product so that I can add your picture to the many hundreds I've received on previous projects.

CONCLUSION

The toughest part about writing this article was deciding how much to say about recognition techniques. I have

(continued)

```
HIT ANY KEY TO BEGIN TRAINING...
```

Photo 4: *In this training mode, you select and train up to 32 words at a time. Multiple overlays of these template dictionaries result in potential recognition vocabularies of thousands of words. In practice, 64 concurrent-available words is a reasonable search vocabulary that maintains a high response reaction time.*

```
EPEAT EACH WORD AS IT'S HIGHLIGHTED.

1 CATALOG        1 ZERO
2 SAVE           2 ONE
3 LOAD           3 TWO
4 RUN            4 THREE
5 VERIFY         5 FOUR
6 BLOAD          6 FIVE
7 BRUN           7 SIX
8 BSAVE          8 SEVEN

1 EIGHT          1 YES
2 NINE           2 NO
3 LIST           3 QUIT
4 LOCK           4 TEST
5 DRIVE          5 EDIT
6 BACKSPACE      6 ADD
7 KILL LINE      7 REMOVE
8 RETURN         8
```

Photo 5: *These standard* DOS *commands comprise one of the vocabularies that the user is directed to train. Once trained, many keyboard entries can now be verbal.*

barely scratched the surface in my explanation.

It is equally difficult for me to list and describe the multitude of potential applications for computerized voice recognition. Besides the obvious aids for the disabled, the Lis'ner 1000 can be used in order-entry systems, voiceprint-security systems, video games, and telephone communications. Also, many people subscribe to the notion that the world needs a voice-operated typewriter. In my opinion, it will be a long time before voice entry becomes commonplace in an office environment, but there have been inroads.

I intend to apply the board to telephone communications so that I can call and correspond with my computer. Since the Apple II Lis'ner has both recognition and synthesis, it would seem natural that all conversation over the phone with the Apple should be spoken. "Hello, computer, how are you?" "Fine, Steve, your house is still here."

While this is a possibility, the quality of the telephone lines suggests that an alternate means of backup communication also be used. Some time ago I wrote an article about DTMF (dual-tone, multiple-frequency) decoders ("Build a Touch Tone Decoder for Remote Control," December 1981, page 42). In it, I suggested that one way to communicate with your computer was through an auto-answer device with a DTMF decoder. Once the computer answers, simply send your message by pressing the Touch-Tone keys on the telephone.

Your first thought might be to add a DTMF decoder in parallel with the recognition board, but it is quite unnecessary. DTMF tones and spoken words are all sounds as far as Lis'ner is concerned. It is simply a matter of pressing the telephone buttons while in the template training mode to program the Lis'ner to respond to the DTMF tones. Adding a few select words in addition will make it a truly unique answering system. Using just DTMF tones will allow invited subscribers a certain level of access to your system, but combining speaker-dependent voice recognition with DTMF tone recognition will allow you to reserve certain functions only for yourself.

CIRCUIT CELLAR FEEDBACK

Circuit Cellar Feedback is a new feature I'm starting. Every month, I'll answer letters about past projects. This month's Circuit Cellar Feedback begins on page 430.

NEXT MONTH

I'll show you how to build an AC I/O controller. ■

```
CIRCUIT CELLAR VOICE TRAINER
SAY THE WORD(S) YOU WISH TO TEST

1:UNACCEPTABLE              2:ACCEPTABLE
3:GOOD                      4:VERY GOOD
         GROUP 1                    GROUP 2
1 COMPUTER   4          1
2 COMMAND    4          2
3 SEQUENCE   4          3
4 STOP       4          4
5                       5
6                       6
7                       7
8                       8
         GROUP 3                    GROUP 4
1                       1
2                       2
3                       3
4                       4
5                       5
6                       6
7                       7
8                       8
```

Photo 6: *One of the features of the Lis'ner software is the ability to make and test a recognition vocabulary. In the modified editor program shown here, as the words are spoken, the acceptance level is noted so the user can select words with less interference. Words like "computer" and "sequence" have few differentiation problems. "Nine" and "mine" would present difficulties, as would "next" and "text."*

Special thanks to Dennis Intravia for his work on the recognition software.

Diagrams and data specific to the SP1000 are reprinted courtesy of General Instrument.

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

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

The following items are available from

The Micromint Inc.
561 Willow Ave.
Cedarhurst, NY 11516
(800) 645-3479 for orders
(203) 871-6170 for information

1. Apple II Lis'ner 1000 with SP1000 recognition/synthesis components only—includes headset-style microphone and software on disk.

VR01 assembled and tested	$189
VR02 complete kit	$149

2. Apple II Lis'ner 1000 with SP1000 recognition/synthesis components and SSI-263 phoneme synthesizer chip with text-to-speech algorithm—includes headset-style microphone and software on disk.

VR03 assembled and tested	$259
VR04 complete kit	$219

3. VR01/VR02 phoneme-synthesis upgrade to VR03. Includes SSI-263, miscellaneous components, and text-to-speech algorithm on disk.

VR05 VR01/VR02 upgrade kit	$79

4. Commodore 64 Lis'ner 1000 with SP1000 recognition/synthesis components—includes headset-style microphone and software on disk.

VR10 assembled and tested	$149
VR11 complete kit	$119

5. Apple II speech experimenter's kit—includes SP1000, 7.16-MHz ceramic resonator, ADC 0831 A/D chip, Lis'ner manual, and Lis'ner software on disk.

VR20 complete kit	$60

Please include $4 for shipping and handling in the continental United States, $10 elsewhere. New York residents please include 8 percent sales tax.

To receive a complete list of Ciarcia's Circuit Cellar project kits, circle 100 on the reader-service inquiry card at the back of the magazine.

BY BRUCE F. WEBSTER

A GO BOARD FOR THE MACINTOSH

Explore the capabilities of the Mac and MacFORTH with this computerized game

[Editor's Note: *Although Mr. Webster's program is rather straightforward, you will need some previous experience with FORTH to understand this program. His comments and descriptive word names demonstrate how these things make a FORTH program more readable and easier to understand.*]

I bought a Macintosh about three weeks after Apple announced and released it. Despite the marvelous things it can do, I felt frustrated because *I* couldn't make it do more. Two months later, though, I received a copy of MacFORTH (from Creative Solutions Inc.), which gave me substantial access to the Mac's myriad features. After writing several small programs, I decided to try something a little more ambitious: bringing up a *go* game board on the Mac.

Go is an Asian game of ancient origin (see the text box "The Ancient Game of Go" on page 434). Played with black and white stones on a wooden board, go has simple rules but subtle and complex strategies. Unlike chess, go has not readily yielded to computerization, so this program does *not* attempt to play against a human opponent. Instead, it provides a board with which two people can play a quick, friendly game.

I wrote this program for several reasons. First, the program does most of the bookkeeping for you: removing captured stones, preventing illegal moves, counting territories, and so on. Second, you can't accidentally jiggle or bump the board and send the stones flying. Third, I wanted to learn how to use MacFORTH. (By reading the code, you can learn about MacFORTH, too.) The board is 13 by 13 inches (often used instead of the usual 19 by 19 inches), which makes for a quicker game.

The program, given in listing 1, is organized into 30 screens, a division of code peculiar to FORTH (a screen is 1024 bytes of text, displayed as 16 lines of 64 characters). Table 1 shows a rough breakdown of the program by screens.

The program is not as long as it seems—I could have fitted it into fewer than 30

(continued)

Bruce F. Webster (c/o FTL *Games,* 7907 *Ostrow St., Suite F, San Diego,* CA 92111*) is a Macintosh owner,* FORTH *and go enthusiast, and contributing editor of* BYTE. *He wrote a go-playing program as his project for a class in artificial intelligence and is currently working on another go-playing program that builds on top of the listing in this article.*

screens, but this would have been bad programming practice. Instead, I commented heavily on the routines, which expanded the program's size considerably. Also, I suspect that my FORTH coding could be improved in quite a few places; I ask for patience (and suggestions) from those more experienced than I.

INSIDE THE GO PROGRAM

This go program uses many of the Macintosh's unique features: custom menus and their command-key equivalents, windows, graphics, input using the mouse, and even a custom mouse-cursor shape (while a game is in progress, the cursor becomes a round circle the color of the player whose move it is). By looking at certain parts of the program, you can see how the Macintosh and MacFORTH amplify each other's efforts. (See the text box "How the Program Works" on page 445.)

Creating the board window: Screen 2 (lines 1–5) defines the window for the go board and displays it on the screen. Screen 2 (line 8) creates the "wood-grain" pattern used to fill the go board itself. This pattern is 8 by 8 pixels and uses 8 bytes; the first byte is the top row of the pattern, and the most significant bit of each byte forms the leftmost pixel of a row.

Screen 16 (lines 6 to 14) contains the routine draw.board . This word creates the board's frame, fills it with the wood-grain pattern, puts the grid on the board, and prints the headings for tallying the stones captured by each side.

Defining custom cursors: Screen 4 (lines 1 to 12) defines the two cursors (wcurse and bcurse) used to let the players place their stones on the board. Each cursor is 68 bytes or, more logically, 34 (16-bit) words long. The first 16 words form the 16- by 16-pixel shape of the cursor itself, following the top-left convention of the wood-grain pattern (the first word is the top row, with the most significant bit of each word being the leftmost pixel in a row). The next 16 words form the 16 by 16 mask, which defines what portion of the area *under* the cursor shows through. If a bit is 0, then the area underneath shows through; if a bit is 1, then it is blocked out. The last two words specify the row and column numbers, respective-

Table 1: *Screen contents of the go program (listing 1).*

Screen	Contents
0	program information
1	load block (executed when block file is loaded)
2–4	definitions of constants, variables, and data structures
5–7	various utility routines
8	expand routine for tracing armies
9–10	more utilities
11–15	routines to handle placing and capturing stones
16–17	game save and restore routines
18–20	endgame routines (pick up stones, count territory)
21	routines to manipulate the Go menu
22–25	driving routines for major portions of the game
26–28	Go and Handicap menu routines
29	main body of program (listing captions)

Listing 1: *The MacFORTH go program. FORTH programs are split into 1024-byte units called screens, usually presented as 16 lines of 64 characters each. The parenthetical comment on the first line of most word definitions briefly describes the word. The part before the vertical bar provides a picture of the stack before and after the word is executed: for example, the notation "r/c—val" should be read, "The word takes r and c from the stack (c is on top-of-stack) and returns val."*

```
SCREEN # 0          "Go Blocks"          06/29/84          03:48:04 AM
  0 ( A simple go program for the Macintosh                 ( 062884 bfw)
  1 Version: 1.0                          Last Update:    28 June 1984
  2 Author: Bruce F. Webster
  3          FTL Games, Inc.              Language:       MacFORTH
  4          7907 Ostrow, Suite F                         Version 1.0
  5          San Diego, CA 92111                          Level 1.1
  6
  7 Allows two people to play go on a 13x13 board, using the mouse
  8 to place stones. Detects and prevents illegal moves. Detects
  9 capture and removes stones. Ends game after two consecutive
 10 passes. Allows players to remove dead stones. Counts up con-
 11 trolled territory and declares winner. Allows 2 to 9 stone
 12 handicaps. Has "undo" feature to take back last move.
 13
 14             Copyright (c) 1984 by Bruce F. Webster.
 15                  All commercial rights reserved.


SCREEN # 1          "Go Blocks"          06/29/84          03:48:10 AM
  0 ( load block for "GO" program                           ( 060984 bfw)
  1
  2 options.menu            ( put up apple, FORTH options menus )
  3 20000 resize.object     ( allocate memory for code, words )
  4 10000 resize.vocab
  5
  6 cr ." Loading GO program..."
  7 2 load
  8 sys.window board send.behind
  9 init.cursor event.loop
 10
 11
 12
 13
 14
 15


SCREEN # 2          "Go Blocks"          06/29/84          03:48:15 AM
  0 ( create board window, data structures                  ( 062884 bfw)
  1  new.window board              ( define and name window for board )
```

```
 2  " GO Version 1.0 —  © 1984 Bruce F. Webster" board w.title
 3                                                            ( set title     )
 4  40 40 330 460 board w.bounds                ( set bounds of board window )
 5  board add.window                                ( create actual window )
 6  5 constant go.menu       6 constant hand.menu         ( define menu #'s )
 7
 8  create texture hex 04000200 , 00010008 ,                  ( "wood grain" )
 9  decimal
10
11  create pstk 512 allot                     ( used for stack for army search )
12  create tmap 256 allot                        ( used for capture detection )
13  create map 256 allot                   ( set aside data structure for board )
14                                                                       -- >
15


SCREEN # 3           "Go Blocks"          06/29/84          03:48:22 AM
 0 ( variables, bmap, cmap                                     ( 060884 bfw)
 1 variable bflag               ( current player's color: 1 = black, 2 = white )
 2 variable stones    variable freedoms            ( values for a given army )
 3 variable stptr                    ( stack pointer in pstk—incremented by 2 )
 4 variable color             ( color flag: 0 = empty, 1 = black, 2 = white, 3 = edge )
 5 variable gflag                        ( game status flag — controls states )
 6 variable btaken    variable wtaken                  ( total stones captured )
 7 variable wspace    variable bspace                ( total spaces controlled )
 8 variable pflag                        ( used to detect consecutive passes )
 9 variable hlevel                ( handicap level—1 = none, 2. .9 = # of stones )
10 variable playy     variable ko                 ( stone played, single stone taken)
11 variable taken     variable tstones               ( last taken, total # taken )
12                  ( bmap, cmap automatically adjust their size to fit everything)
13  create bmap bmap map  -  allot                          ( used for backup )
14  create cmap cmap bmap  -  allot                        ( used to save game )
15                                                                       -- >


SCREEN # 4           "Go Blocks"          06/29/84          03:48:31 AM
 0 ( set up cursors for stones                                 ( 060884 bfw)
 1  hex  create wcurse                                ( cursor for white stone )
 2  03C00C30 , 10082004 , 40024002 , 80018001 ,                        ( shape)
 3  80018001 , 40024002 , 20041008 , 0C3003C0 ,
 4  03C00FF0 , 1FF83FFC , 7FFE7FFE , FFFFFFFF ,                         ( mask)
 5  FFFFFFFF , 7FFE7FFE , 3FFC1FF8 , 0FF003C0 ,
 6  00080008 ,                                                       ( offset )
 7  create bcurse                                     ( cursor for black stone )
 8  03C00FF0 , 1FF83FFC , 7FFE7FFE , FFFFFFFF ,                        ( shape)
 9  FFFFFFFF , 7FFE7FFE , 3FFC1FF8 , 0FF003C0 ,
10  03C00FF0 , 1FF83FFC , 7FFE7FFE , FFFFFFFF ,                         ( mask)
11  FFFFFFFF , 7FFE7FFE , 3FFC1FF8 , 0FF003C0 ,
12  00080008 ,                                                       ( offset )
13  create stars                               ( handicap locations on board )
14   04040A0A , 040A0A04 , 07070704 , 070A0407 , 0A070707 ,
15  decimal                                                              -->


SCREEN # 5           "Go Blocks"          06/29/84          03:48:44 AM
 0 ( bounds checking routines; draw.stone                      ( 060884 bfw)
 1 : legal ( n — n/ – 1 or 0 | checks if n in 1 . . 13 )
 2  dup 0> over 14 < and dup if ( nothing) else swap drop then ;
 3 : bounds ( n – low/high | converts row or col into bounds      )
 4  18 * 10 + dup 7 – swap 7 + ;
 5 : get.bounds ( r/c — x1/y1/x2/y2 | gets coords for spot                  )
 6  bounds rot bounds rot swap ;
 7 : stretch.bounds ( x1/y1/x2/y2 — x1/y1/x2/y2 | expands by 1              )
 8  1 + swap 1 + swap 2swap 1 – swap 1 – swap 2swap ;
 9 : at.point ( coord – loc/flag | converts x/y to c/r                      )
10  1 – 18 / legal ;
11
12 : draw.stone ( r/c/f — –| draws black stone at location                  )
13  >r get.bounds 2over 2over stretch.bounds frame oval
14  r> 1 = if black else white then pattern oval ;
15                                                                       -- >
```

(continued)

ly, of the "active point" of the cursor. This defines the point considered when the cursor's coordinates are read. Both cursors have offsets of (8, 8), meaning that the center of each cursor is where it is "pointing" at. The FORTH word set.cursor makes one of these cursors active. (In this program, line 13 of screen 10 changes the cursor shape.)

Drawing and erasing stones: Screen 5 gives us draw.stone , a routine that draws the black and white stones once they have been placed on the board. It first draws a circular frame slightly larger than the stone, then draws a white or black (solid) circle for the stone itself.

Screen 11 contains clear.stone , which removes a stone from the board. This word first erases the stone by filling the appropriate rectangular area with the wood-grain pattern (texture). Then the word redraws the intersecting lines, doing the necessary clipping for correctly drawing the intersections of an edge or corner intersection. (The word vector interprets the top four items on the stack as two points and draws a line between them.)

Controlling the program: Screens 22, 24, and 25 contain the four main driving routines of the program. Each contains a loop of the form begin do.events . . . until . The FORTH word do.events returns a value that indicates if a special event has occurred. The constant mouse.down is the value indicating that the mouse's button has been pressed; two of the driving routines (play.go and end.game , both on screen 24) use this to tell if a stone is being placed or picked up. In all four cases, this loop continues until the game state flag (gflag) changes (usually as a result of some selection on the Go menu), moving the program to another state.

Screens 21, 26, 27, and 28 set up and handle the two menus (Go and Handicap). Screen 21 contains routines to enable and disable the items in the Go menu (note that the Quit selection is never disabled). Screen 26 creates both menus, specifying the entries in each. Screen 27 defines the results of any item selected from Go, while screen 28 does the same for the Handicap menu. Screen 28 also contains init.program , which contains all the code that is executed once short-

(continued)

ly after the board window is activated. This includes graphics initialization (ginit), clearing the window (page), setting the origin to the upper-left corner of the window (upper.left), defining the pen size (2 2 pensize), and setting the text mode to "overwrite" (srccopy textmode).

Screen 29 represents the highest level of the program. The routine exit.program does the final cleanup, deletes the Go and Handicap menus (making the FORTH window the active one), and changes the mouse cursor back to the familiar arrow. The routine go.program is the main body of the program itself. Below it is the phrase board on.activate go.program , which is directly executed when this block is loaded. This phrase "attaches" go.program to the window board . Whenever board is activated, a -1 ("true") is pushed on the stack and go.program is executed. The same happens if board is deactivated except that a 0 ("false") is placed on the stack instead. This causes go.program to use the "else" branch of the if . . . else . . . then construct to make an orderly exit.

LOADING THE PROGRAM

To use this program, boot up your working MacFORTH disk and double-click the FORTH BLOCKS file (to load the editor). Then type in the following command:

```
include" Go Blocks"
```

This will create a work file named Go Blocks and enable you to enter FORTH source code with the editor. Your next step is to key in the 30 screens of text shown in listing 1. Do this one screen at a time and proofread your work very carefully. Your biggest problem will probably be accidentally omitting the right parenthesis at the end of most lines; FORTH considers everything between that point and the next right parenthesis to be a comment. You might consider leaving off the comments altogether, putting them in later.

You might get an error loading screen 6 if you have already loaded the MacFORTH editor. If this occurs, you can get the screen to load correctly by adding the following definition:

```
: 2dup    over over ;
```

(continued on page 434)

```
SCREEN # 6          "Go Blocks"          06/29/84          03:49:00 AM
( get.addr, put.on.map, get.stone, empty.spot                  ( 060884 bfw)
: get.addr ( r/c — addr | calculate address into map                        )
1 - 13 * swap 1 -  + map + ;

: put.on.map ( r/c/f  -  r/c/f | non-destructive placement on map)
3 pick 3 pick 3 pick >r                          ( duplicate parms and save f )
get.addr r> swap c! ;                            ( get loc, restore f, and store )

: get.stone ( r/c  -  stone | gets stone value at r,c                       )
legal if swap legal if swap get.addr c@ ( check if legal spot)
else drop 3 then else drop 3 then ;                         ( else off of board )

: empty.spot  ( r/c  -  r/c/flag | checks if spot is empty                 )
2dup get.stone 0= if -1 else 0 then ;


                                                                             -->

SCREEN # 7          "Go Blocks"          06/29/84          03:49:14 AM
( fill.spot, st+, push, pull, get.adj                          ( 060884 bfw)
: fill.spot ( r/c —-| sets loc to 3 = filled spot                           )
get.addr 3 swap c! ;
: st+ ( n —| adds n to stptr and stores in stptr                            )
stptr @ + stptr ! ;
: push ( r/c — -| pushes row, column onto pstk                              )
 stptr @ pstk + dup rot swap c! 1+ c! 2 st+   ;
: pop ( — -  r/c/ -1 or 0 | gets row, column from pstk                      )
stptr @ pstk + 1 - dup c@ swap 1 - c@ -2 st+   ;

: get.adj ( r/c/i — r/c | gets adjacent row/column                          )
 CASE ( 0=down, 1=up, 2=right, 3=left )
  0 OF 1 +                ENDOF 1 OF 1 -                ENDOF
  2 OF swap 1 + swap ENDOF 3 OF swap 1 - swap ENDOF
 ENDCASE ;
                                                                             —>

SCREEN # 8          "Go Blocks"          06/29/84          03:49:28 AM
( expand                                                       ( 060884 bfw)
: expand ( r/c —-  |count stones, freedom of army at r,c                     )
0 stptr ! 0 stones ! 0 freedoms !                          ( clear all values )
map tmap 256 cmove                                    ( backup map for count )
2dup fill.spot push begin                        ( fill spot, push on stack, start )
   pop 1 stones +!                  ( pop stone from stack, increment counter )
   4 0 do 2dup i get.adj                        ( check all 4 adjacent locations )
     2dup get.stone dup                        ( get color and act appropriately )
     CASE    ( 0 = space — add 1 to freedoms, fill it up                    )
       0              OF 1 freedoms +! drop fill.spot                  ENDOF
     1 2 RANGE.OF                   ( if color matches, add to army, else drop )
     color @ = if 2dup fill.spot push else                   2drop then ENDOF
       3              OF drop 2drop ( ignore edge )                    ENDOF
     ENDCASE
                    loop 2drop stptr @ 0= until ( continue until stack is empty)
tmap map 256 cmove ;  ( restore map from tmap )                             —>

SCREEN # 9          "Go Blocks"          06/29/84          03:49:49 AM
( lim, limit.bounds, blackif                                   ( 060884 bfw)

: lim ( n — n | forces n to 28..244                                         )
     244 28 rot 2dup > if drop swap drop                     ( force n >= 28 )
     else swap drop 2dup < if else
        swap then drop then ;                                ( force n <= 224 )

: limit.bounds ( x1/y1/x2/y2 — x1/y1/x2/y2 | put limits on                  )
     lim swap lim swap 2swap                       ( condition x1,y1 to 28..244 )
     lim swap lim swap 2swap ;                     ( condition x2,y2 to 28..244 )

: blackif ( — flag | checks if color = black                                )
```

(listing continued on page 438)

A TRAVESTY GENERATOR FOR MICROS

Nonsense imitation can be disconcertingly recognizable

English letter-combination frequencies can be used to generate random text that mimics the frequencies found in a sample. Though nonsensical, these pseudo-texts have a haunting plausibility, preserving as they do many recognizable mannerisms of the texts from which they are derived. For example, the following text was generated by the first sentences of this article:

> English letter-combination frequencies from text was generived. For example. Though nonsentencies from text was the text was generated to generisms of that mimics the first sentencies from text the texts have a have a sample, they article:

The nature of such texts has been little explored, in part because it's been difficult to get samples. Claude Shannon generated "approximations to English" by hand in 1948, but the laborious calculation it involved prevented extensive study. This is clearly a task for a computer, but programs have been hampered by the need for impractical amounts of memory.

We offer a Pascal program, Travesty, to fabricate pseudo-text quickly from any input text. Students of style and linguistics will see possibilities. So may programmers, since Travesty contains a feature that can greatly speed up general pattern-matching procedures. We add a special-case version that is *(continued)*

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BY HUGH KENNER AND JOSEPH O'ROURKE

ILLUSTRATED BY JOAN HALL, WITH APOLOGIES TO JAMES JOYCE AND HENRY JAMES

Each of these writers
had his own way
with trigrams, tetragrams, pentagrams,
matters to which
he surely gave no thought.

even speedier. To make clear what Travesty does, we'll first discuss language statistics and what they imply.

LANGUAGE STATISTICS

Finish typing a page of English prose, and the key you hit most often will have been the space bar. Either "e" or "t" will rank second. You did not make those decisions, the language did. In fact, the language makes three-quarters of your writing decisions for you. Not only do the letters observe preferred frequencies, they keep preferred company. A familiar example: write "Q", and (unless you are drafting a QANTAS ad or some comments on Iraq) the next character is almost sure to be "u".

If probability coerces the successor to a single letter, what follows a letter pair is even more tightly bound. Write "th", and the probability is very high that what follows will be "e". If it is, then the character after "e" is most likely to be either a space or an "r". Pairs like "th" are called digrams; triplets like "the" are trigrams. They have frequencies, like letters. The most common English digram is "he"; you will find it three times in the sentence you are reading now, 15 times in this paragraph. And you will guess correctly that as we move up from single letters to diagrams and trigrams, the probabilities that govern the next character grow ever more rigorous. By the time we've reached, say, pentagrams, has the author any choice at all?

Yes, he has; otherwise Henry James could have had no way to be Henry James, or James Joyce to be James Joyce. At a fairly low level, the statistics of English would have taken over from both of them, and neither would have been distinguishable from *The New York Times*.

But that is not what happens. True, even with a James or a Joyce holding the pen, the statistics do not lie dormant. However, they no longer derive from the undifferentiated language, i.e., from a large sample of everything we can find. The significant statistics derive from the personal habits of James, or Joyce, or Jack London, or J. D. Salinger. Each of these writers, amazingly, had his own way with trigrams, tetragrams, pentagrams, matters to which he surely gave no thought.

(continued on page 449)

PART 2: SYSTEM CONTROL

THE PICK OPERATING SYSTEM

BY RICK COOK AND JOHN BRANDON

Programming capabilities and control elements

[*Editor's Note: Last month we looked at Pick's structure and information-management facilities. This month, we'll discuss the system's control and programming capabilities and take a brief look at the IBM PC implementation of Pick (see the text box on page 133).*]

PICK BASIC

Like Access, Pick BASIC is an integral part of the Pick operating system. It is a compiled/interpreted version of Dartmouth BASIC, which makes it a rather distant cousin of the version of BASIC used on home computers. Unlike most microcomputer versions of the language, Pick BASIC contains all the constructs you need to write highly structured code. It is not, however, strongly typed like Pascal and it does not force you to declare variables before using them.

Among the commands available in Pick BASIC are CASE, COMMON, IF . . . THEN . . . ELSE, FOR . . . NEXT, FOR . . . UNTIL, FOR . . . WHILE, LOOP . . . WHILE, and LOOP . . . UNTIL. There are also a number of matrix and array commands and other commands that have no close parallels in microcomputer BASICs (SLEEP, for instance). Writing modular programs is made easier by the use of statement labels (not line numbers) for references in flow-of-control commands.

Pick BASIC supports two types of arrays. One is the conventional dimensioned array (via a DIM statement limited to about 3000 elements). However, in Pick you don't have to specify the size of each element. Elements in a dimensioned array will grow to absorb the data placed in them. Pick also supports dynamic arrays, which allow any number of elements of any size. Like a Pick item, the dynamic array will grow and shrink as elements are added and removed. An item in a Pick file is processed as an array. Pick BASIC contains a number of commands to specify and operate on elements in an array.

In Pick, subroutines are separate programs that can be compiled individually and linked into other programs as needed. This encourages, but does not force, you to write several small programs that can be linked together rather than one long program.

One of Pick's strong points is that it makes writing applications easy. Many of the chores that are time-consuming in other programming languages, such as writing I/O (input/output) routines and complex data manipulations, are either not necessary with Pick or can be done with utilities that are built into the operating system. In addition, Pick BASIC has a powerful built-in debugger and facilities to automatically generate a program map and a variable cross-reference table upon compilation.

WHY BASIC?

At this time, BASIC is the only high-level programming language available for Pick. There are several reasons for this.

One is simply historical. When Pick was evolving, in the late 1960s and early 1970s, BASIC was the most suitable high-level language available. Most of the other high-level languages familiar in the micro-

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computer world were either still under development, not yet thought of, or not widely known.

Richard Pick's original plan was to use APL as the Pick high-level language. If he had used APL, the system might be a lot more attractive to theoreticians, but it would be a lot less useful for managers and programmers.

A second reason Pick just has BASIC is that Pick BASIC fixes most of the common problems associated with microcomputer BASICs as serious programming languages. It contains the constructs needed to write structured programs, as well as the kind of I/O support and string-handling facilities lacking in Pascal. Features like the COMMON statement, the use of labels, and the ability to chain subroutines encourage you to write modular code. Because the language is closely linked to the database-management system, primitives are available for searches and sorts. Because Pick BASIC is compiled, it avoids the speed penalty of a purely interpreted BASIC.

Pick BASIC is not strongly typed—deliberately. Forcing you to declare the type of all variables may prevent certain kinds of errors, but it makes extra work and imposes some frustrating limits unless the language has facilities for crossing type boundaries when useful. However, at run time Pick checks for things like alphabetic characters where numbers were expected.

Furthermore, the Pick operating system contains a number of commands and utilities that can be used to do the equivalent of type checking and, in most cases, do it more thoroughly than strongly typed languages can. For example, Pick BASIC contains string-handling utilities that will not only check to see that numbers rather than letters are entered but can check for the form of the numbers as well. If you want to specify that only numbers in the form *NNN-NNN-NNNN* are acceptable (as in a telephone number), you can do it easily. If you choose to check data types you can do so readily, but the system doesn't force you to do so.

Many programmers who work in Pick BASIC say that it is more like Pascal than conventional BASIC.

The fact that every Pick system comes with an essentially identical high-level language ensures a high degree of applications portability. (There are, however, some relatively minor differences among the versions of Pick BASIC on various systems.) The Pick world doesn't have the kind of differences in dialect that plague even closely defined languages like C.

But perhaps the biggest reason for limiting Pick to one language is that, by tying the language into the operating system, it can directly know the data structures and other features of the system. By offering a single, tightly integrated, high-level language, Pick can use the system's abilities to full advantage from within the programs. Pick BASIC contains commands that let it operate directly on elements in the kind of three-dimensional dynamic arrays you can build with the Pick file structure.

Incidentally, Pick Systems Inc. is reportedly planning to offer a C compiler as part

(continued on page 474)

THE IBM PC IMPLEMENTATION

Recently, Pick Systems Inc. ported Pick to the IBM PC XT. The IBM PC version of Pick is a full implementation. It converts the PC XT, or the PC with the expansion chassis and a minimum of 256K bytes of RAM, into a multiuser system capable of supporting three users. The implementation will also work with some of the IBM PC-compatible computers such as the Compaq Plus, the hard-disk version of the Compaq portable computer.

On the IBM PC, Pick requires a 10-megabyte hard disk and 256K to 640K bytes of RAM. No hardware modifications are required and the system uses stock IBM PC expansion boards. The second and third users are supported via RS-232C ports and serial terminals.

The first user is supported with the computer's screen and keyboard treated as an intelligent terminal with memory-mapped video. In this mode, the IBM PC version of Pick offers underlining, half intensity, protected fields, and—if the graphics card is installed and a color monitor is used—selectable colors. All these features are supported by commands that are an integral part of the operating system.

The hard disk is required partially because the Pick operating system is big and partially because it needs the read/write speeds of a hard disk to function effectively. On the IBM PC, Pick can operate with as little as 4.5 megabytes of a hard disk. The Pick software occupies 2.5 megabytes of disk space, so this minimum configuration leaves 2 megabytes for user data.

Because Pick doesn't have to take up the entire disk, the user can keep other operating systems and their files on the disk as well and switch back and forth between them. However, only one operating system at a time can be used.

Due to the way the Pick virtual memory operates, it wasn't practical to use the ROM BIOS routines on the IBM PC for disk I/O. The expanded PC BIOS on a PC XT takes control on a disk seek and read, keeping control until it is done. This is fine for a single-user machine, but it ties things up seriously in a multiuser environment. To get around this, Pick Systems wrote its own hard-disk I/O drivers.

Like the other versions of Pick, the IBM PC Pick makes a disk I/O request and goes on to other things while the request is acted on. Once the operation has been performed, the disk controller issues an interrupt that tells the monitor the request has been serviced and the data is now in memory.

Although the performance of IBM PC Pick is limited by the 4.77-MHz clock speed of the 8088 microprocessor and the 8-bit data paths, performance is still acceptable. According to the company, testing with some simple benchmarks indicates that in a computation-intensive operation, IBM PC Pick runs about 35 percent as fast as minicomputer implementations.

ILLUSTRATED BY ROBERT TINNEY

BY LEO D. BORES, M.D.

AGAT

A SOVIET APPLE II COMPUTER

The Russians' first microcomputer is a bad copy of the Apple

THE AVERAGE SOVIET citizen would be startled to hear about personal computers. A computer? In the house? *Ne voz moshna*—impossible! In Russia, the language does not even have a word for "private," the manufacturing emphasis is definitely not on consumer goods, the thought of having a dishwasher is a flight of fancy, and the thought of having your own computer certainly is Peter Pan time. For Russians, computers conjure up images of huge buildings filled with exotic electronic gear located in the bowels of a major university guarded by platoons of soldiers in the heart of Siberia.

Things are changing slowly. Products from the West are beginning to show up in Russia (Pepsi is for sale in kiosks all over Moscow), and Russian products are appearing in the West. Still, it was a surprise when the Soviets introduced the prototype of a tabletop computer at a Moscow trade fair in July of 1983. Produced by ELORG, (Electronorgteknika) the organization responsible for the purchase, manufacturing, and sale of electronic instruments and computers in the Soviet Union, the machine represents a milestone for the Russians. Systems that ELORG has produced in

(continued)

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the past are in the minicomputer category and usually run a clumsy form of the CP/M operating system or a similar BIOS (basic input/output system). Direct copies of early model IBM 1401s and 370s are known to be in use in Russia, many controlled by old-fashioned paper-tape readers and punchers. Except for an occasional Hewlett-Packard and a rare DEC (and perhaps a VAX hidden away in the Ural Mountains), computer systems in Soviet institutions are outdated but serviceable. An Apple-compatible computer, therefore, is a definite first.

I first saw the machine called the AGAT in August of 1983 when I had an opportunity to use it for a week. After booting it and examining its operation, I dubbed it the *yablocka* (Russian for apple). The operating system and ROM (read-only memory) seemed to be a direct lift from the Apple computer, with only a few minor differences, and the case is finished in a patriotic red, so the sobriquet was a natural. (See photo 1.)

HARDWARE

The machine is definitely not in the portable category. It is, rather, a "transportable" computer (that is, you would not get a hernia or a backache, as long as you didn't carry it too far). I suppose that you could call it robust. The monitor that comes with it weighs almost as much as the computer itself. It is a standard 30-centimeter composite color SECAM (système électronique pour couleur avec mémoire) television set with an RCA connector at the back for a video signal.

The keyboard clips to the front of the computer with two light-duty metal clips. There is no provision for storing the connecting cable. The one-meter cable is permanently affixed to the keyboard and terminates in a 9-pin DIN (Deutsche Industrie Norm) type connector for insertion into the back of the main housing.

The keyboard is full size, and it is mounted so that the upper edge is elevated to tilt the keys about 15 degrees. The layout is that of a standard Russian typewriter, which resembles nothing you've ever seen; the Cyrillic alphabet has 33 characters (31 sounded). The Control key is located in the extreme upper left corner. The Return key is only slightly larger than the other keys and is located where it could easily be struck by accident. I never did find the Escape key. There is a full numeric keypad to the right, separated from the alpha keyboard by a row of presumably programmable function keys, and there is the usual row of number/miscellaneous keys at the top of the keyboard. Cyrillic, as well as English, characters are embossed into the key caps, one below the other. Auto-repeat and lowercase are implemented. The debounce circuitry is shaky, and occasionally a stray character shows up, especially during rapid data entry. The feel of the keys is very similar to that of an IBM Personal Computer (PC), and they are about as noisy. The elevation of the keyboard base (about 3.5 centimeters) and the slightly steeper-than-normal board angle would cause rapid fatigue as well as wrist pain after prolonged use.

Photo 1: *The AGAT, the Soviet Union's first microcomputer.*

One standard-height 5¼-inch disk drive is built into the right side of the machine. There does not appear to be any provision made for adding another drive, at least not internally. There is no port for adding on a drive at the rear, either. The AGAT has ports for a printer, a serial communication port, and a keyboard, but no game port. The machine is convection cooled through the top, bottom, and rear.

I did not try to open the case, but I peeked into the interior through the openings in the back and top. What I saw was not reassuring. I was confronted with a nightmarish wiring maze. The boards were a sickly brown color and looked like the old semi-glass boards of ancient renown. I could not see anything resembling a motherboard (although it's possible that there was one buried down there somewhere) and had to assume that I was looking at a variant of an old "back-plane" system, and a hard-wired one at that.

SOFTWARE

I had not expected to be examining a Russian computer—especially a Russian "Apple"—so I had not come prepared with my "hammer and tongs" with which I dissect Apple disks. However, I was able to perform a few tests and make notes of some impressions of the system. In a later visit I was able to examine the DOS (disk operating system) in greater detail.

The boot-up process seemed to be quite a bit slower than it would be on the Apple using DOS 3.3. This sluggishness is not confined to the booting process, as I found out later. The drive is noisier than I expected, both from the motor and the head-positioning mechanism. The greeting program was in Russian and turned out to be a demonstration of the three graphics modes available.

The scrolling rippled, suggesting the use of graphics mode to display text. This was verified after the demo, when I reset the computer. The computer dropped into normal text mode displaying garbled English characters.

(continued on page 486)

Hard Disk, Soft Shell

The Complete Hard Disk Solutions For Desktop & Portable PC's 10 Megabytes $794, Or 20 Meg $1288.

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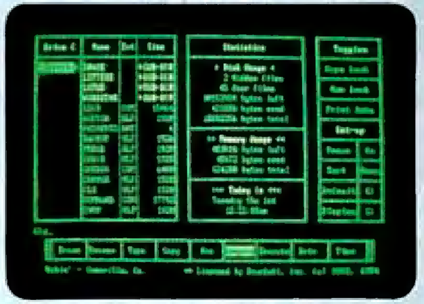

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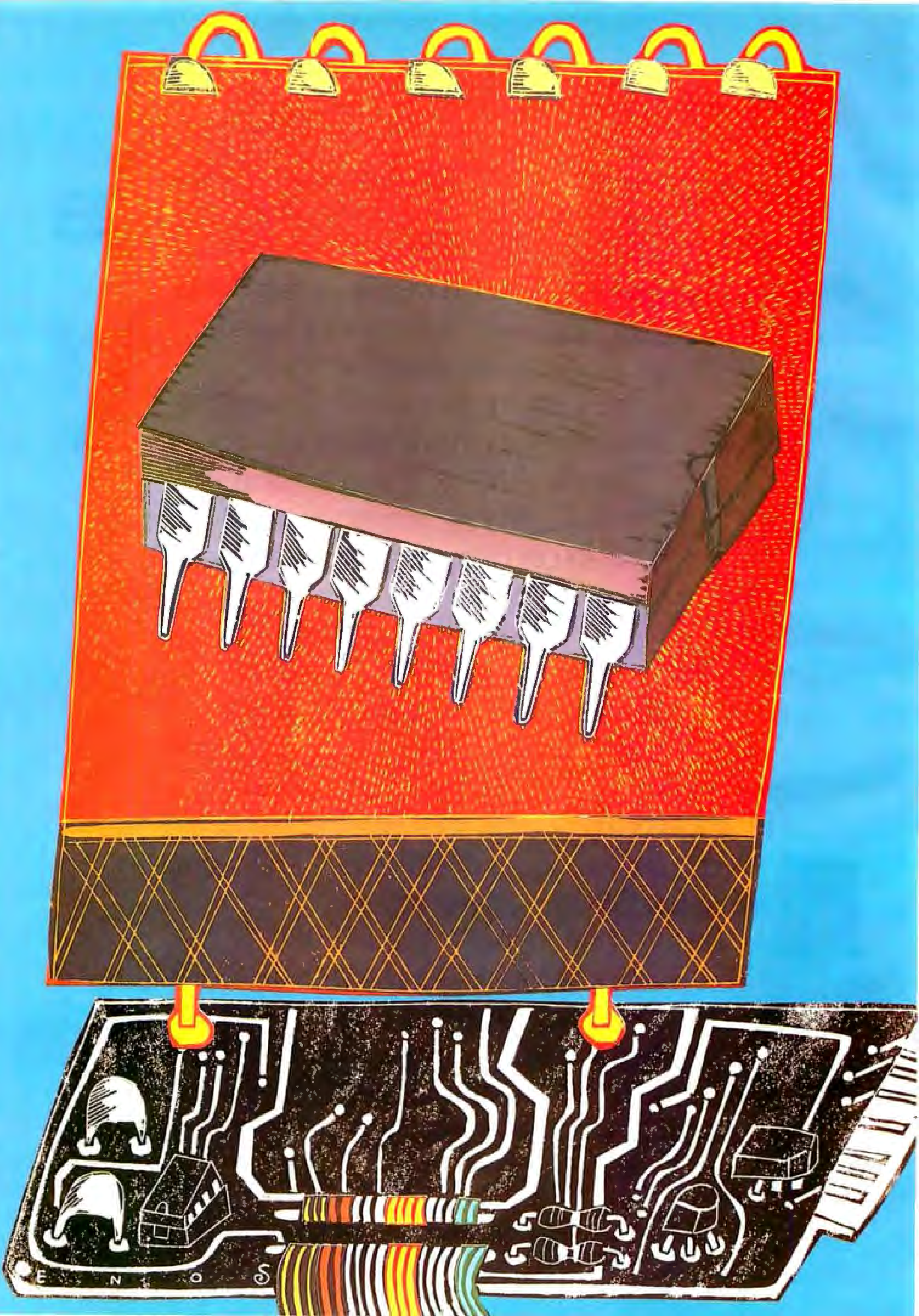
ENOS

New Chips

SEVERAL YEARS AGO a computer scientist told us, "The biggest problem presented by VLSI (very-large-scale integration) design isn't new fabrication or computer-aided design tools; our biggest problem is simply getting the designer's brain around a VLSI circuit."

Cal Tech computer scientist Carver Mead has compared the density of current-generation VLSI circuits to street maps of major U.S. cities like Los Angeles and New York. He suggests that in the future, chip densities may approach the complexity of a similar map of the entire United States.

Yet many of the obstacles facing designers are being surmounted. Computer-aided design and manufacturing tools permit microprocessor designs that equal the performance of the newest generation of super-minicomputers. And at the IEEE International Solid-State Circuits Conference held in San Francisco earlier this year, four manufacturers showed off experimental 1-megabit RAM (random-access read/write memory) designs.

This month's theme articles focus on new chip design, including an introduction to semiconductor technology, new microprocessor designs, new design technologies, and specialized semiconductor applications.

BYTE contributing editor Alan Miller opens the new-chip section by providing a general introduction to semiconductor technology. Miller explains how semiconductors function at the most basic level.

We have included articles on both the Intel 80286 and the Motorola MC68020 microprocessors. The 80286 might gain widespread acceptance because it is used in the IBM PC AT. Likewise, the MC68020 also could attract a major following; its predecessor, the MC68000, is used in Apple's Lisa and Macintosh and the emerging software is an indication that Apple could move to the MC68020 to power its future 32-bit personal computers.

BYTE editor Phil Robinson looks at gallium arsenide technology to remind us that more processing power and speed will be available in the future based on advances in material sciences. The pluses of gallium arsenide are simple: the chips are fast and they run cool. The first commercial chips are now available.

One way of dealing with the complexity of VLSI circuits is to simplify microprocessor design. This is exactly what faculty and students at Stanford and the University of California at Berkeley have done in experimental RISC (reduced instruction set computer) microprocessors. As BYTE editor John Markoff reports, using CAD (computer-aided design) tools developed on campus, the two research groups have created VLSI microprocessors that outperform commercial 16-bit and 32-bit microprocessors.

Steve Rosenthal writes about a specialized application: the PF474, a semiconductor optimized to perform fast string-search operations on text files.

Finally, Xtar Electronics explains some details of its graphics coprocessors.

—John Markoff, Senior Technical Editor, and
Ezra Shapiro, West Coast Bureau Chief

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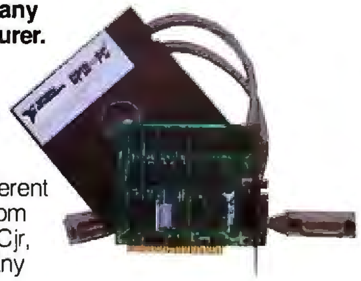

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INTRODUCTION TO SEMICONDUCTORS

BY ALAN R. MILLER

What they are and how they work

ELECTRICITY IS THE MIGRATION of charge carriers. In metals, these carriers are electrons; in ionic melts (such as sodium chloride), they are ions; and in gases (e.g., in a fluorescent lamp), ions and electrons are carriers. The charge carriers in semiconductors can be either electrons or electron holes.

This article covers the fundamental concepts behind conduction in semiconductor devices, including the thermistor, rectifier diode, zener diode, and Schottky diode. In particular, the relationship between the band gap and the Fermi level is explored for each device.

BAND THEORY

According to quantum mechanics, orbitalized electrons are restricted to certain values of energy. Some energy levels are allowed and others are not allowed. For a single atom, the allowable energy levels are discrete, while a solid material has broad ranges or bands of allowable energy.

The values of energy that are not allowed fall in an area known as the band gap, which lies between the allowable energy bands. An energy-band diagram (figure 1) shows energy increasing vertically; that is, an electron that is higher than another has more energy. In the unexcited (ground) state, bands with lower energy are completely filled with electrons. The regions of energy between filled bands are free of electrons and are the forbidden band gaps.

For a material to act as a conductor of electricity, some of its electrons must be excited above the ground state into orbitals that will allow them to roam across the material. For some materials, the top band is only partly filled with electrons; that is, energy states are available within this band. This material is an electrical conductor since very little energy is needed to raise an electron to the next level and make it into a charge carrier. Figure 1a shows the corresponding energy-band diagram. For other materials, the top band is exactly filled. Electrical conduction is not possible unless an electron is given sufficient energy to promote it across the band gap to the next available (empty) band. These two bands, the top filled band and the next empty band, are respectively known as the valence band and the conduction band. This band picture, diagrammed in figure 1b, corresponds to both semiconducting and insulating materials.

What distinguishes semiconductors from insulators? At room temperature, the normal thermal vibration of the atoms can provide sufficient energy to promote an electron across the band gap if the gap is not too large. On the other hand, materials with large band gaps will have few electrons available for conduction. A material with a large band gap is known as an insulator. However, if the band gap is small, the material is known as a semiconductor. Perhaps it should be called a semi-insulator.

THE FERMI LEVEL

At any temperature above absolute zero, energy will be available for the promotion of electrons. The higher the temperature, the more conduction

Alan R. Miller is a professor at New Mexico Institute of Mining and Technology (Socorro, NM 87801) where he has taught materials science, thermodynamics, electrical engineering, and programming methods since 1967. He holds a Ph.D. in engineering from the University of California at Berkeley, and he has written six books about computer languages and operating systems.

The variation of conductivity with temperature and light can be useful.

electrons can be found at any given energy level. The energy level where the probability of finding a conduction electron is exactly one-half is known as the Fermi level. At absolute zero, all available states below the Fermi level are filled and all states above the Fermi level are empty.

For a conductor, the Fermi level lies in the partially filled band at the top of the electrons. By contrast, the Fermi level for an insulator or semiconductor lies in the band gap midway between the valence band and the conduction band. The Fermi levels for a conductor and for an insulator or semiconductor are marked by E_f in figure 1. Notice that the Fermi level lies within a band for a conductor but it lies in the band gap for a semiconductor or insulator.

ELECTRON HOLES

When a valence electron becomes a conduction electron in a semiconductor, it leaves a space in the lower-energy bonding orbitals that is available for other electrons. This "electron hole" can carry electrical current just as an electron can, since both have an equivalent charge. (Of course the charges have opposite sign.) Clearly, for each valence electron promoted across the band gap to the conduction band, one electron hole is produced. In this case, there are an equal number of conduction electrons and electron holes, and the material is called an intrinsic semiconductor.

MOBILITY OF CHARGE CARRIERS

Electrons and holes respond to electric fields in different ways. Electrons move against the electric field while holes move with the field. (In reality, of course, bonding orbitals do not move at all. The holes only appear to move as electrons are promoted out of one bonding orbital and fall into another, just as the sequentially lit lightbulbs of a movie marquee appear to move across the sign.) Although the two types of carriers move in opposite directions, they also have opposite charge. Consequently, the resulting electrical current is the sum of the two parts.

Movement of electrons and holes is not symmetrical; they do not move at the same speed. The relative velocity of charge carriers is known as the *mobility*, the velocity relative to the electric field. The units of mobility are m/s (meters/second) divided by V/m (volts/meter), or m^2/V s. Mobility changes from one material to the next. However, the mobility of the electron is always greater than that of the corresponding hole. The ratio can be as small as three or as large as several hundred. The mobility changes with temperature and with the concentration of the carriers. If you keep in mind that the only thing that really moves is the electron, the reason why holes "move" more slowly is readily apparent. Holes would move at the same speed as electrons only if each conduction electron moved directly and unfailingly to the next available bonding orbital. Quantum mechanics tells us that the probability of this is always and necessarily less than one.

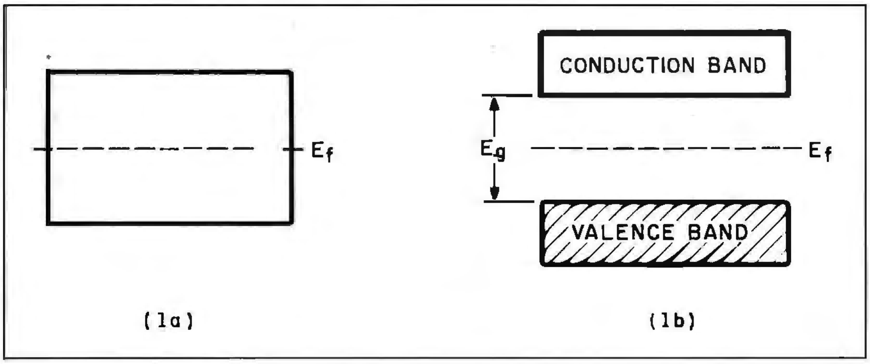

Figure 1: *Energy-band diagram for a conductor (a) and for an insulator or semiconductor (b).*

TEMPERATURE, LIGHT, AND CONDUCTIVITY

The normal thermal vibration of atoms can provide the energy needed to promote a valence electron to the conduction band. Consequently, the electrical conductivity (the reciprocal of resistivity) increases with increasing temperature. For an intrinsic material the relationship is

$$s = A \exp(-E_g/2kT)$$

where s is the conductivity, A is a constant, E_g is the band gap, k is Boltzmann's constant, and T is the absolute temperature. This expression shows that the logarithm of conductivity varies linearly with reciprocal temperature; that is, a plot of log conductivity versus $1/T$ is a straight line.

The variation of conductivity with temperature can be useful. An intrinsic semiconductor designed for measuring or controlling temperature is known as a thermistor (for thermal resistor).

The conductivity of a semiconductor also changes when exposed to light. Photons of wavelength λ (Greek letter lambda) have an energy

$$E = hc/\lambda$$

where h is Planck's constant and c the speed of light.

When a semiconductor is exposed to light, valence electrons will be promoted to the conduction band if the energy of the photons is equal to the difference in energy between a valence band orbital and a conduction band orbital. This is the principle of photodetectors. The band gaps of common semiconductors (in electron volts) are given in table 1 with the corresponding wavelengths of the band gaps. Silicon and germanium have band gaps that correspond to infrared, cadmium sulfide's band gap is in the visible region, and zinc sulfide has a gap in the ultraviolet range. Therefore, silicon and germanium can be used to detect infrared light but not visible light, which has a higher energy. Cadmium sulfide is commonly used for photographic light meters since its band gap corresponds to visible light. Zinc sulfide is used as a phosphor in fluorescent lamps, video screens, and television tubes.

N- AND P-TYPE MATERIALS

Silicon (Si) and germanium (Ge) use four valence electrons for bonding and appear as Group IV elements of the periodic table (figure 2). A semiconductor made from silicon will be a single crystal in which each silicon atom is surrounded by four other silicon atoms.

Table 1: *The band gap for selected semiconductors (eV=electron volts).*

	Band Gap (eV)	Corresponding Light
Si	1.1	infrared
Ge	0.67	infrared
GaAs	1.4	infrared
GaP	2.3	visible
CdS	2.4	visible
ZnS	3.6	ultraviolet
diamond	5.3	ultraviolet

If a small amount of a Group V element such as arsenic (As) is added to silicon, the arsenic atoms will occupy the regular silicon positions of the crystal structure. Arsenic has five valence electrons: since only four of these electrons are needed for bonding, the fifth will be loosely held. This fifth electron can readily become a charge carrier. The energy needed to promote this electron to the conduction band is only about 4 percent of the band-gap energy of silicon.

As stated earlier, when a valence electron is promoted to the conduction band of an intrinsic semiconductor, an electron hole is produced. However, when a conduction electron is created by doping a Group IV element with a Group V impurity, no corresponding hole is created. Thus silicon doped with arsenic has an excess of electron carriers. The doped silicon is therefore known as an N

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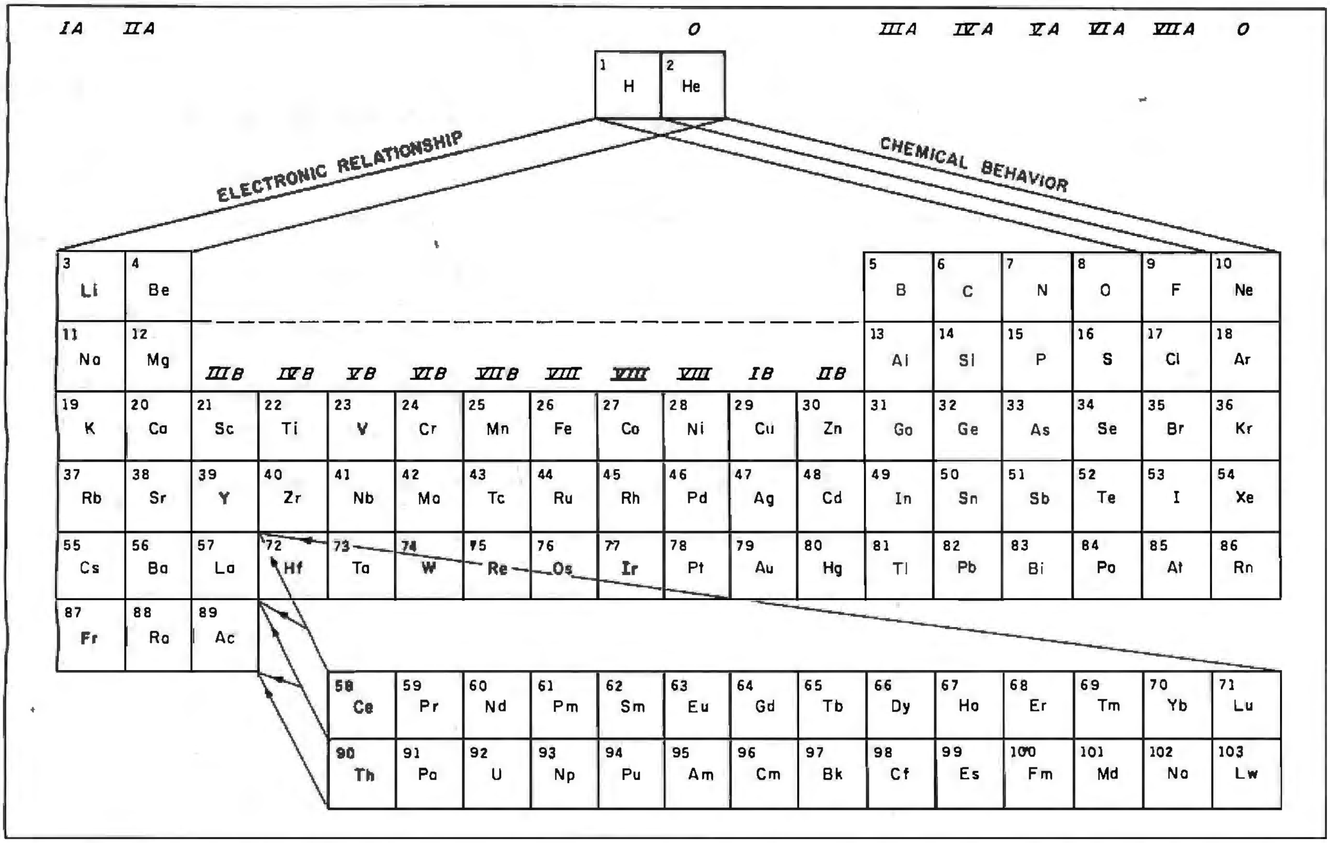

Figure 2: *The periodic chart of the elements. Customarily the A in group designations (e.g., Group IIIA) is omitted in discussing semiconductors.*

type material. This designation does not mean that the material is negatively charged; that is, there are not more electrons than protons. Rather, it means that the material has more electrons than available slots in valence orbitals.

If a small amount of a Group III element such as gallium (Ga) is added to silicon, the impurity atoms again occupy regular silicon sites. But gallium can only provide three bonding electrons. Since four valence electrons are needed for bonding, the fourth is taken from the surroundings.

Thermal energy has promoted the fourth electron into the conduction band, making it available for bonding. In the process, an electron hole was also created. Together they are known as an electron hole pair (EHP). Since the electron of this pair has been taken by a gallium atom for a bond, the electron hole is left by itself, creating an excess of electron holes. A material with excess electron holes is called a P-type material.

ENERGY BANDS FOR EXTRINSIC SEMICONDUCTORS

Semiconductors that have an excess of either conduction electrons or holes are known as extrinsic or doped semiconductors. P-type and N-type energy-band diagrams are given in figure 3. The band gap, E_g, is the same, suggesting that both are for the same substrate. However, an acceptor band is near the bottom of the band gap of the P-type material. The acceptor band is separated from the valence band by a small acceptor band gap, E_a. A similar donor band is near the top of the band gap for the N-type material. The donor band is separated from the conduction band by a small donor band gap, E_d.

Notice that the Fermi levels are not in the center of the extrinsic band gaps as for intrinsic semiconductors. The Fermi level is below the midpoint for the P-type material and above the midpoint for the N-type material. Let's look at the N-type more closely.

The relatively free fifth electron originally associated with the Group

(continued)

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V impurity can become a conduction electron by applying a small amount of energy equal to the donor band gap. This amount of energy is considerably less than the energy needed to promote a valence electron across the band gap to the conduction band. Because the donor band gap is relatively small, with a small concentration of donor atoms, the donor electrons are thermally excited to the conduction band at room temperature. But the temperature is not high enough to promote electrons from the valence band to the conduction band. Thus, the conductivity of an extrinsic semiconductor is essentially constant at room temperature, unlike the great change in conductivity with temperature that occurs in an intrinsic semiconductor.

COMPOUND SEMICONDUCTORS

I have been discussing semiconductors that are primarily one element, such as silicon or germanium. When doped with a small amount of a Group III or Group V element, the structure is still predominantly that of the Group IV element. However, another class of semiconductors, known as the compound semiconductors, combines two elements in equal proportions.

The chemical element immediately to the left of germanium on the periodic table (figure 2) is gallium, an element with an atomic diameter about the same size as that of germanium, but with one less electron. The element arsenic is immediately to the right of germanium. It too is about the same size, but has one additional electron. A compound made of equal parts of gallium and arsenic is similar in certain ways to germanium; that is, the total number of electrons will be the same. Furthermore, the bonding is similar to germanium. Each atom of gallium is surrounded by four atoms of arsenic and each atom of arsenic is surrounded by four atoms of gallium. The resulting band gap, however, is larger (table 1).

A material of this type is known as a III-V compound semiconductor. Most of the Group III and Group V elements can combine in this way. Sometimes two Group III elements are combined with a Group V element or vice versa. Gallium aluminum phosphide and gallium arsenide phosphide are examples.

A III-V compound semiconductor made with equal parts of Group III and Group V will be intrinsic. However, extrinsic compound semiconductors are possible. Adding small amounts of zinc (Zn), cadmium (Cd), or silicon to gallium arsenide produces a P-type material, while adding sulfur (S) or selenium (Se) makes it N-type.

THE P-N JUNCTION

Simple semiconductors are a single crystal throughout. If such a material is pure, the semiconductor is intrinsic. However, by adding one type of impurity to one end and another to the other, you can create a P-N junction, a device with two different regions. If a Group III impurity is added to the left end and a Group V impurity is added to the right end, then the left end will be P-type and the right end will be N-type. The resulting material is diagrammed in figure 4.

Because of the small concentration of impurities in a P-N junction device, the structure is still physically the same throughout its length; that is, despite an excess of holes on the P side and an excess of electrons on the N side, the crystal structure and band gap remain the same throughout the device.

As described above, a P-N device has an excess of holes (the majority carrier) in P-type material on the left side and an excess of electrons on the right. At some point near the center, the concentration of the two carriers is equal and the material is intrinsic. The energy-level diagram for the P-N junction (figure 4) shows the bands distorted so that the Fermi level is constant throughout. Notice that the valence band is close to the Fermi level on the P side while the conduction band is close to the Fermi level on the N side.

MOTION OF CARRIERS

The operation of a P-N junction involves two types of carrier movement. The charge carriers move from regions of high concentration to regions of lower concentration. This movement is called a diffusion current. The movement alters the local electric field, which in turn induces

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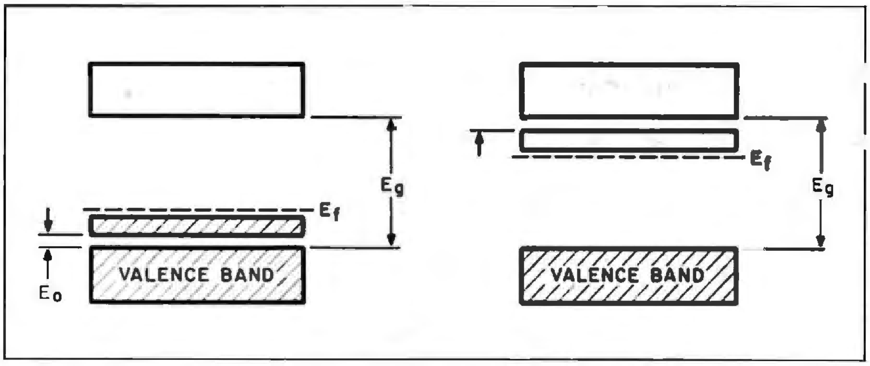

Figure 3: *Energy-band diagrams for P-type (left) and N-type (right) semiconductors.*

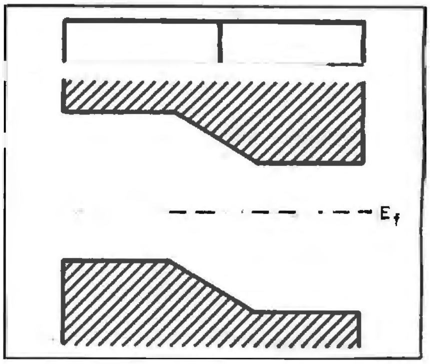

Figure 4: A P-N *junction device and the corresponding energy-level diagram.*

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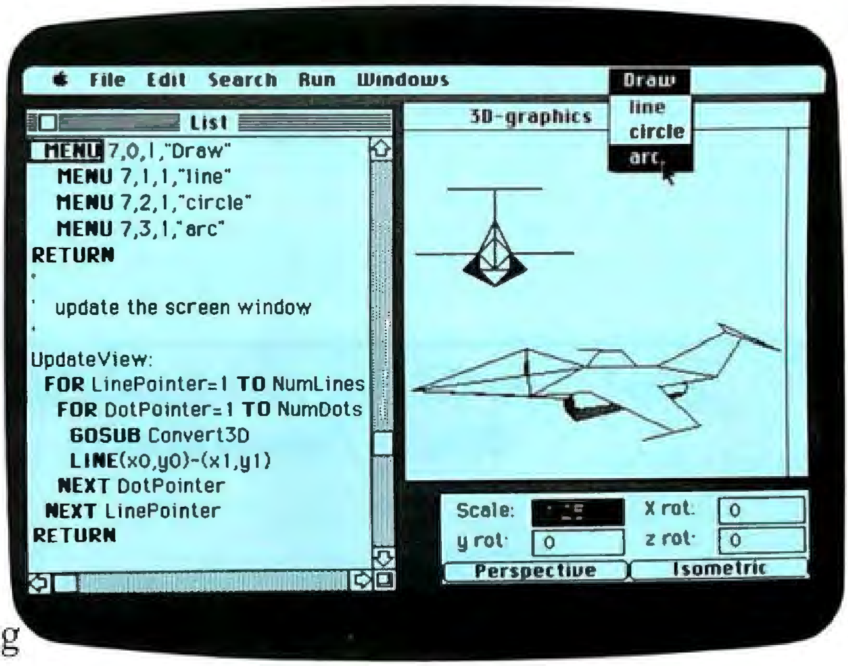

```
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  MENU 7,2,1,"circle"
  MENU 7,3,1,"arc"
RETURN
'
' update the screen window
'
UpdateView:
 FOR LinePointer=1 TO NumLines
  FOR DotPointer=1 TO NumDots
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   LINE(x0,y0)-(x1,y1)
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the charge carriers to move. This charge carrier movement in response to electric field fluctuation is called a drift current. With two types of charge carriers and two types of movement, four separate currents must be considered.

Since in the P-N junction a greater concentration of holes exists in the P-type material than in the N-type material, a diffusion current of holes occurs from the P side to the N side (from left to right in figure 4). Similarly, a greater concentration of electrons exists in the N-type material. Here a diffusion current of electrons moves from the N side to the P side (from right to left). This diffusion creates a charge imbalance and an internal electric field. The electric field, in turn, creates a drift current.

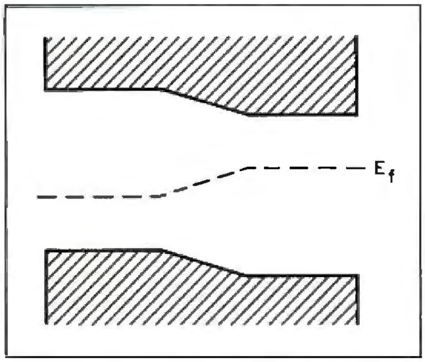

Figure 5: A *forward-biased* P-N *junction device and the corresponding energy-level diagram.*

The electric field of the P-N junction creates drift currents for both the electrons and holes. In contrast to the diffusion current, the drift current for electrons begins in the P region (where electrons are minority carriers) and moves to the N region (that is, the electron drift current moves from left to right in figure 4). The drift current for holes begins in the N region and moves from right to left. Thus the diffusion currents arise from majority carriers while the drift currents begin with minority carriers.

Since the electron diffusion current begins in the N region and ends in the P region, the electrons must climb the potential energy barrier from the conduction band on the N side to the conduction band on the P side. Hole diffusion is similar. You can visualize this process by imagining that the energy of holes increases downward in the band diagram, opposite to the energy of electrons. The diffusion currents are limited by the potential barrier they must climb at the P-N junction.

In contrast to the diffusion current, the drift currents do not have to climb an energy barrier. An electron in the P region moving to the N region falls in energy as it crosses the P-N junction. The drift current, therefore, is limited by the very low concentration of the minority carriers.

All of the above can be more clearly understood from the perspective of orbital theory. In the absence of an external field, there is no directionality to the overall motion of the electrons. Without a vectored migration of electrons, there is no ordered arrangement of the orbitals they leave behind. That is, when no electric field is externally applied, the two diffusion currents and two drift currents cancel each other and the semiconductor is at equilibrium. However, when an external electric field is applied, two situations can occur—forward bias or reverse bias.

THE FORWARD-BIASED P-N JUNCTION

If you apply an external electric field to a P-N junction so that the positive lead is attached to the P side and the negative lead to the N side, the P-N junction is forward-biased. The energy-level diagram for a forward-biased P-N junction is shown in figure 5.

By comparing figures 4 and 5, several features are apparent. The band gap is the same throughout for both examples. However, in figure 5 the

(continued)

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Fermi level is displaced at the junction by an energy $E = qV$ where q is the charge on the carrier (in coulombs) and V is the applied voltage. The energy E is in joules. The Fermi level is higher on the right or N side.

Another feature of the forward-biased P-N junction is a lowering of the potential energy barrier between the conduction band on the P side and the conduction band on the N side. As discussed earlier, this energy barrier impeded the diffusion current since the carriers must climb the barrier to cross the junction. On the other hand, the drift current falls down in energy when crossing the junction. Therefore, a forward bias applied to a P-N junction should increase the diffusion current but should not alter the drift current. Figure 6 shows the relationship between the applied external electric field and the resulting current for a P-N junction. The curve indicates that with a forward bias (positive V) the current rapidly increases with the voltage.

THE REVERSE-BIASED P-N JUNCTION

If the external electric field is reversed, that is, if the positive lead is attached to the N side and the negative lead is attached to the P side, the P-N junction is reverse-biased. The energy-level diagram for a reverse-biased junction is shown in figure 7.

A comparison of figures 4, 5, and 7 shows that a reverse bias separates the Fermi levels but in the opposite direction of a forward bias. The Fermi level is higher on the P side than on the N side. Futhermore, with reverse bias the potential energy barrier to carrier diffusion is greater than the equilibrium value, whereas a forward bias reduces the barrier.

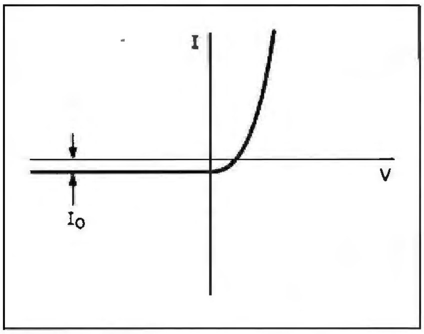

Figure 6: *The current-voltage relationship for a* P-N *junction.*

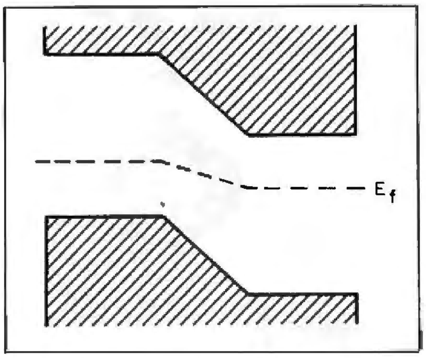

Figure 7: A *reverse-biased* P-N *junction device and the corresponding energy-level diagram.*

Diffusion current is negligible with no applied field; therefore, it is also negligible for a reverse bias because the barrier is greater. Drift current is not affected by the external field since carriers are falling down the potential. However, the drift current is not very large anyway since it depends on the concentration of minority carriers. The drift current, also known as the reverse saturation current, is shown as I_0 in figure 6.

THE P-N RECTIFYING DIODE

The current-voltage relationship shown in figure 6 indicates that current flows in a P-N device when the voltage is applied in a forward direction but not when the voltage is reversed. A rectifier is a device that requires that current flow with only one bias direction.

Alternating current periodically reverses direction and rectifying this current is sometimes necessary. The rectifying diode can perform this task. The electronic symbol and the corresponding identification of polarity are shown in figure 8. Positive current flows in the direction of the arrow, from the P side to the N side.

HIGH CARRIER CONCENTRATION

The semiconductors described above have a relatively low concentration of impurities (measured in parts per billion). The Fermi level for these semiconductors is off center but still within the band gap. As the impurity concentration in a semiconductor increases, the Fermi level moves further and further from the center position (downward for P-type and upward for N-type). If the concentration of impurities is very large, the Fermi level will move out of the band gap and will actually be located within the valence band for P-type and within the conduction band for N-type. A material with a high impurity concentration is known as a degenerate semiconductor. Since the Fermi level is located within a band, rather than in the band gap, the material exhibits the properties of a conductor rather than an insulator. Several semiconductor devices are based on degenerate semiconductors, including the zener diode.

THE ZENER DIODE

Zener diodes are used to regulate voltage. To diagram the operation of a zener diode the curve given in figure 6 must be extended. For a P-N diode, the forward current increases rapidly with the voltage, but the current for a reverse bias is negligible. However, if the reverse voltage is increased sufficiently, a point will be reached where current will flow (figure 9). The voltage where this breakdown occurs is known as the peak inverse voltage (PIV) and is one specification for a rectifying diode. Reverse breakdown can result from one of three effects: punch-through ("frying" the chip),

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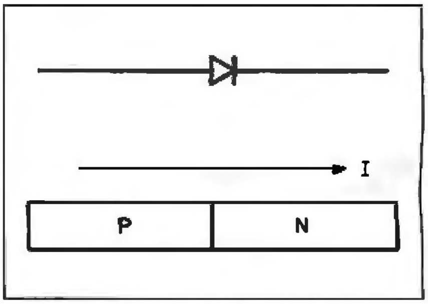

Figure 8: *The electronic symbol for the rectifying diode and the polarities of the corresponding material.*

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Schottky diodes are used in digital circuits because they can be turned on faster.

avalanche (nondestructive ionization), or zener (field effects) breakdown.

A zener diode is made by lightly doping one side of the junction (e.g., the P side) and heavily doping the other side (e.g., the N side). For such a semiconductor, the Fermi level lies in the band gap of the P side but is within the conduction band for the N side. At reverse breakdown, electrons can tunnel (another quantum mechanics concept) from the valence band of the P side to the conduction band of the N side. (Technically, tunneling is a thin-layer effect while zener is a field effect, but it is common to call any classically forbidden energy barrier penetration tunneling.) The idea here is that the applied field is opposed by the field within the chip, resulting in a deformation of the chip's orbital. At some point, the induced field will so deform the orbitals that the potential energy barrier to reverse current flow is less than the ambient thermal energy. The resulting current is constant, independent of further applied voltage. All modern voltage regulators are based on this device.

The electronic symbol and the corresponding identification of polarity for the zener diode is shown in figure 10. The symbol is similar to a rectifying junction except that the cross arms are broken to represent the letter Z. Positive current flows in the direction of the arrow, from the N side to the P side, since the zener diode is reverse-biased.

METAL-SEMICONDUCTOR JUNCTIONS

Two types of junction can form when a metal is attached to a semiconductor, depending on the work functions of the materials. (The work function is the minimum energy needed to remove an electron from a material.) For some metal-semiconductor combinations a regular ohmic junction is formed. This junction is nonrectifying, and the current is directly proportional to the voltage. For other metal-semiconductor combinations, a rectifying junction known as a Schottky-barrier diode is formed. The current-voltage curve is similar to the one shown in figure 6 for P-N junctions. A Schottky diode is not used for general rectifier applications since the reverse saturation (maximum) current is greater than that for a silicon P-N junction. The advantage of a Schottky diode is that it can be turned on faster than a P-N diode. Therefore, Schottky diodes are commonly used in digital circuits. (The S, e.g., in the designation 74S04, indicates a Schottky device.) The electronic symbol for a Schottky diode is similar to a zener diode except that the arms are bent more sharply to look like a squared-off letter S.

Every semiconductor device must be attached to at least two metal lead wires so that it can be attached to other devices. However, these leads must form ohmic rather than rectifying junctions. As discussed earlier, ohmic junctions can be formed between certain combinations of metals and semiconductors depending on the work function. However, there is another way to ensure an ohmic junction.

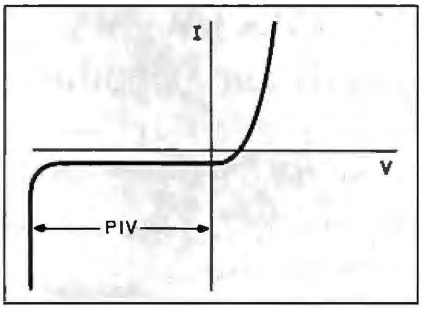

Figure 9: *The current-voltage relationship for a P-N junction extended to reverse breakdown.*

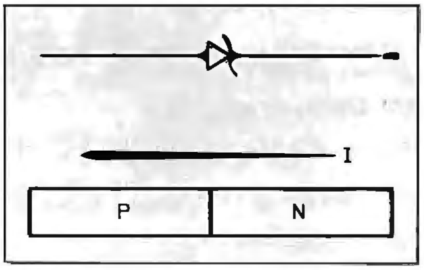

Figure 10: *The electronic symbol for the zener diode and the polarities of the corresponding material.*

Increasing the concentration of impurities in a semiconductor moves the Fermi level further from the center of the band gap. At some point, the Fermi level will enter the valence band for a P-type material or the conduction band for an N-type material. The semiconductor is degenerate and the energy-band diagram now looks like that of a metal. Consequently, a junction between a metal and a degenerate semiconductor will always create an ohmic junction. Degenerate semiconductors are indicated with a plus symbol; that is, the symbol N^+ represents a degenerate N-type material and the symbol P^+ represents a degenerate P-type material. Making a semiconductor degenerate at the point where the metal lead is attached ensures an ohmic contact.

CONCLUSION

In this article I have explored the fundamentals of electrical conduction in solids with special emphasis on semiconductors. I've considered some simple semiconductors, such as the thermistor, photodetector, rectifier diode, zener diode, and Schottky diode. You can obtain more information from the works cited below. ■

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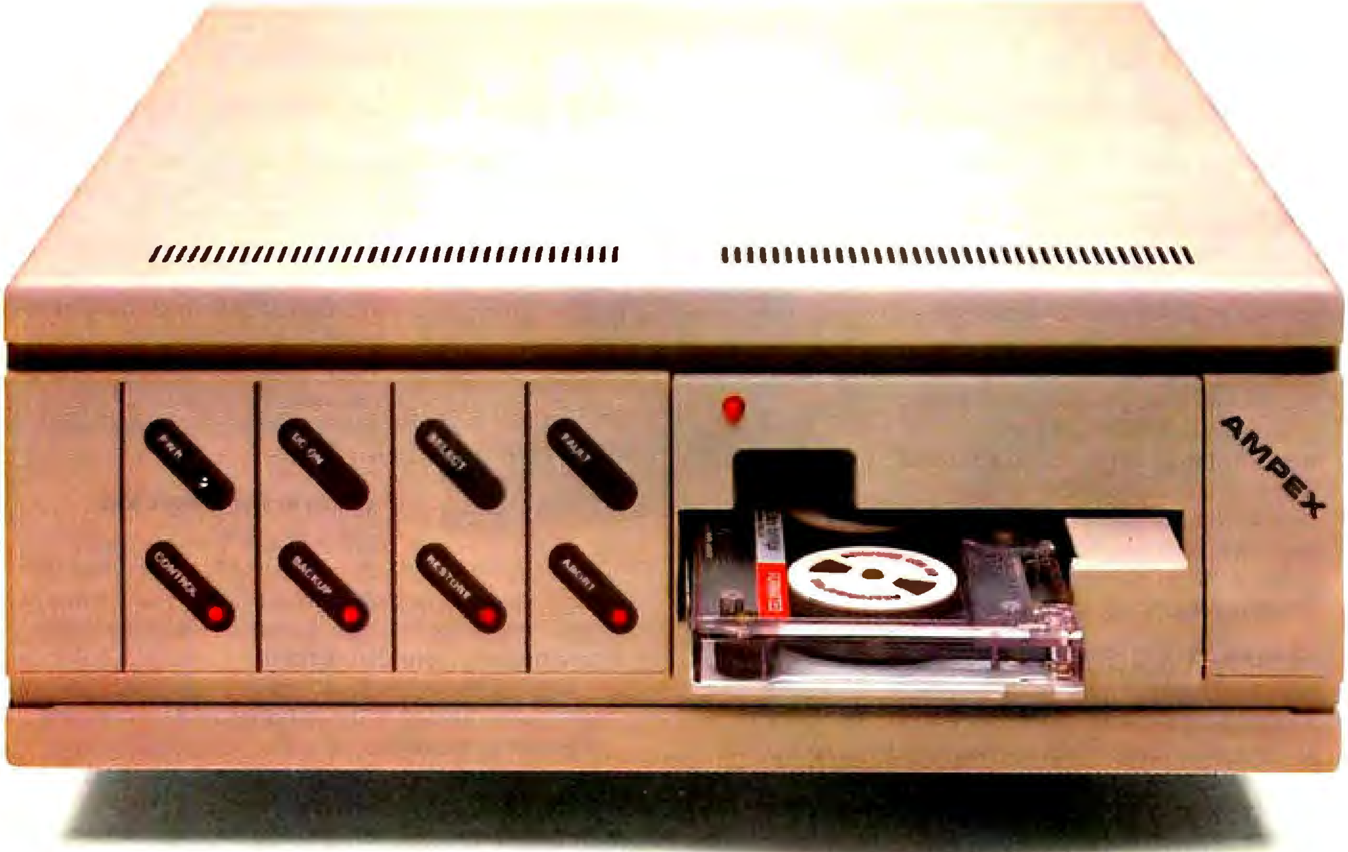

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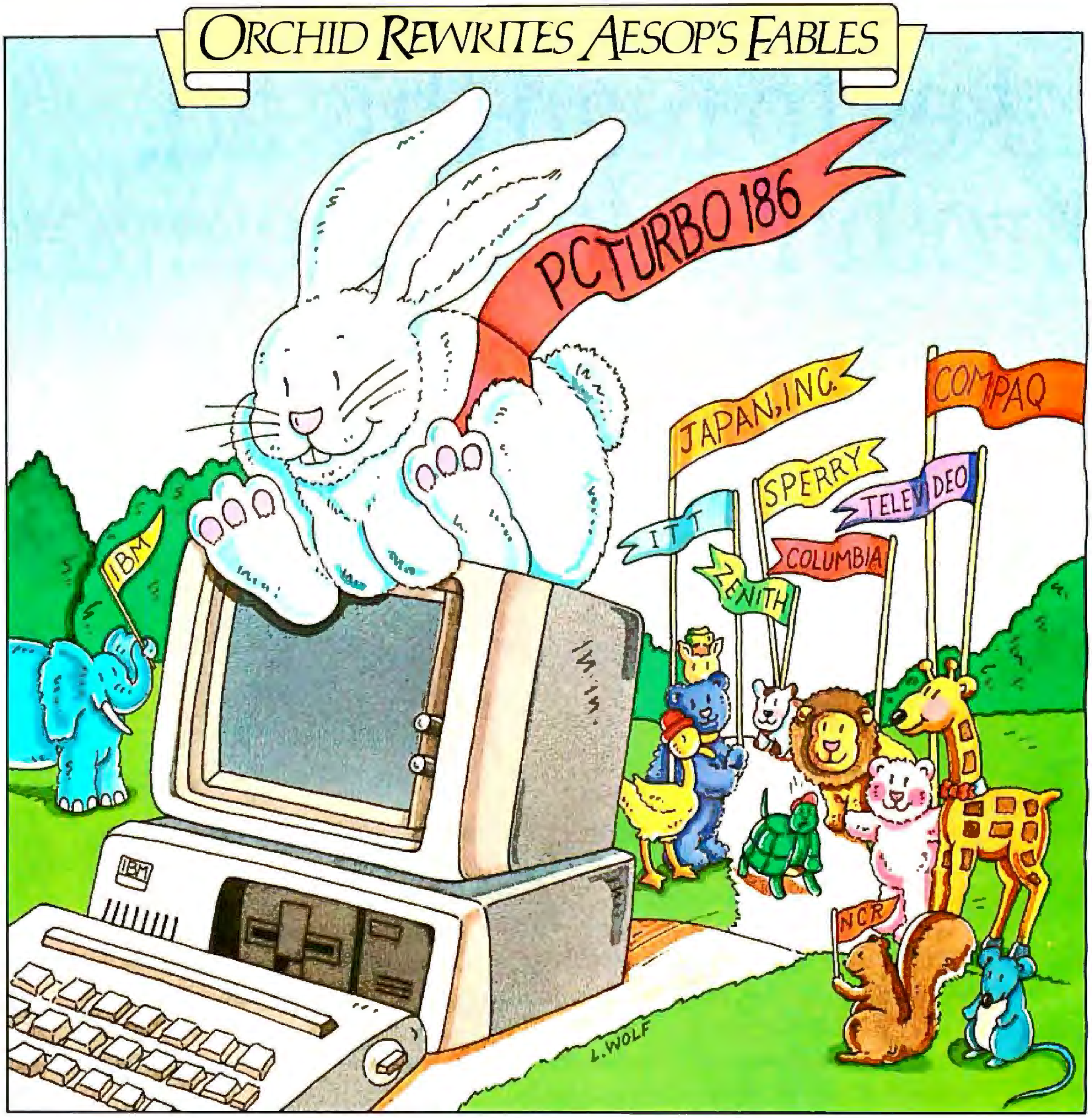

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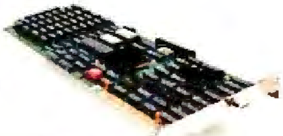

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THE MC68020 32-BIT MICROPROCESSOR

BY PAUL F. GROEPLER AND JAMES KENNEDY

The latest member of Motorola's 68000 family includes on-board cache and virtual memory

THE MC68020, the newest addition to the Motorola M68000 family of microprocessors, is a full 32-bit processor with separate 32-bit data and address buses, an on-board instruction cache, dynamic bus sizing, and a coprocessor interface. It is object-code compatible with the earlier members of the M68000 family but has new addressing modes in support of high-level languages.

The MC68020 is an HCMOS (high-speed complementary metal-oxide semiconductor) microprocessor with some 200,000 individual transistors on a 375- by 350-millimeter die, operating at a 16.67-MHz clock frequency (60-nanosecond clock period) and dissipating less than 1.5 watts of power. It can process instructions at a sustained rate of 2 to 3 million instructions per second (MIPS) and at burst rates exceeding 8 MIPS.

MC68020 PARTS

Figure 1 is a block diagram of the MC68020 with the various internal sections labeled. We'll briefly describe their functions.

The sequencer and control unit are the chip managers. They control internal buses, registers, and the execution unit.

The execution unit contains the program counter (PC), the address, and the data. The PC section calculates instruction addresses and manages pointers. The address section calculates operand addresses and stores the registers available to the user. The data section performs all data operations, such as immediate data value moves. It also contains the barrel shifter, which performs one-cycle shifts of any amount on data.

The bus controller manages cache and external memory accesses. It also provides control for the various parts of the 68020 microprocessor and interprets the nanorom information. This information is combined with decoding the instruction pipe to generate control for the micromachine.

The instruction prefetch and decode unit fetches and decodes an instruction for execution by the execution unit. The prefetch is a three-word-deep on-chip instruction store. It eliminates the need for the processor to sequentially fetch an instruction from external memory, decode and execute it, and fetch another.

Instead, because of the sequential nature of instruction accesses, the prefetch can anticipate the next access and make it before it is needed. Thus, external memory fetches are anticipated and overlapped with current processor execution.

The instruction addresses for the prefetch are calculated independently of data addresses, allowing for parallel accesses of instruction and data addresses. This simultaneous access will occur if the data access is from external memory and the instruction access is from the instruction cache. When this happens, a simultaneous instruction and data access occurs.

The 256-byte instruction cache increases performance by reducing the

(continued)

Paul F. Groepler is a systems applications designer in the High-end Applications Engineering Department at Motorola. James Kennedy is a software engineer in the MPU Design Department at Motorola. You can reach them at Motorola Inc., POB 6000, *Austin,* TX 78762.

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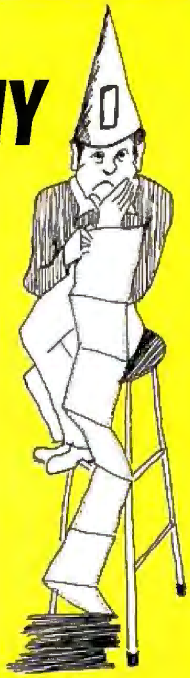

number of instruction fetches, or bus cycles, from main memory. This lets system performance increase because the processor's bus use is decreased, freeing the bus for other system bus masters. Only instructions are stored in the cache. Data accesses must still be read from main memory.

Hardware and software may control the cache. Hardware control is in the form of the cache disable ($\overline{\text{CDIS}}$ pin), which can disable the cache. The $\overline{\text{CDIS}}$ pin has priority and overrides any software setting.

Software control is in the form of two control registers: the cache control register (CACR) and the cache address register (CAAR). The CACR and CAAR are organized as shown in figures 2 and 3. Bits 4 to 31 are unused and always read as zeros. The CACR lets the systems programmer enable or freeze the cache, clear an entry, or clear the entire cache. The CAAR is a 32-bit register that provides an address for cache control functions. This register is used only for the clear entry (CE) function in conjunction with the CACR.

DYNAMIC BUS SIZING

A nice feature of the MC68020 for the designer as well as the programmer is the dynamic bus. Now a designer need not worry about excessive hardware "glue" to interface to 16- or 8-bit peripherals and a programmer need not worry about word or long-word aligned data in data space. The MC68020 allows transfers of 8-, 16-, and 32-bit data between 8-, 16-, and 32-bit ports. The only requirement for data alignment is that it occur on a byte boundary. Instructions and any associated extension words must still fall on word address boundaries, but word/long-word alignment is no longer required for program space operands.

The processor lets misaligned transfers occur by determining the data

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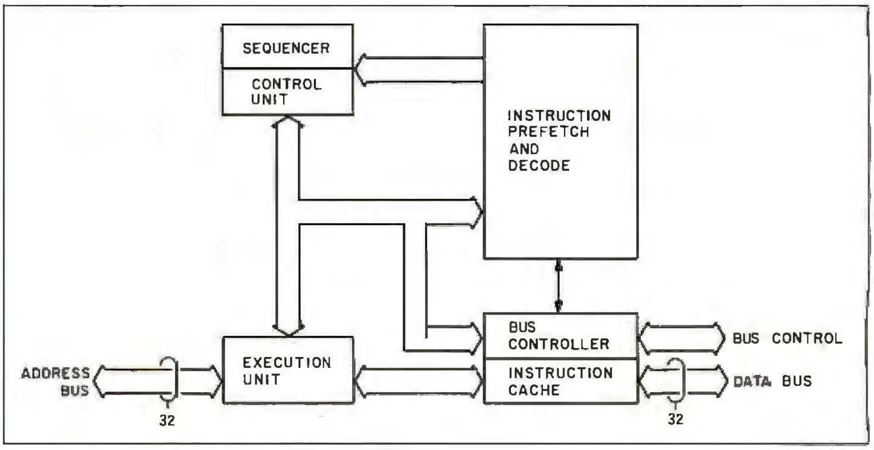

Figure 1: MC68020 *block diagram.*

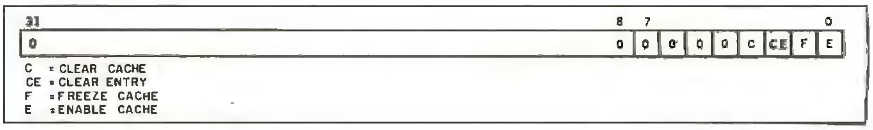

Figure 2: *The cache control register.*

Figure 3: *The cache address register.*

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port size during each bus cycle. By handshaking lines between the processor and external memory or peripherals, the MC68020 can transfer this mismatched or mis-sized data. Figure 4 illustrates the workings of the internal hardware that makes this possible and the alignment of operand bytes for an 8-, 16-, and 32-bit bus interfacing with the MC68020.

Misaligned operand transfers can lead to an increased number of bus cycles because the processor might not be able to successfully transfer the misaligned data across the port within one bus cycle. A normal transfer occurring from an aligned 32-bit operand address across a 32-bit bus to a 32-bit peripheral would take only one transfer cycle.

In a mis-sized transfer, as well as a normal transfer, the peripheral uses the DSACK0 and DSACK1 pins to signal to the processor that it has a bus width of 8, 16, or 32 bits. The processor outputs the operand transfer size using the SIZ0 and SIZ1 pins.

Notice that with an 8-bit peripheral, only data bits D31 to D24 need to be connected to the peripheral. Four bus cycles are necessary to complete this transfer with only 1 byte being moved across the bus per cycle.

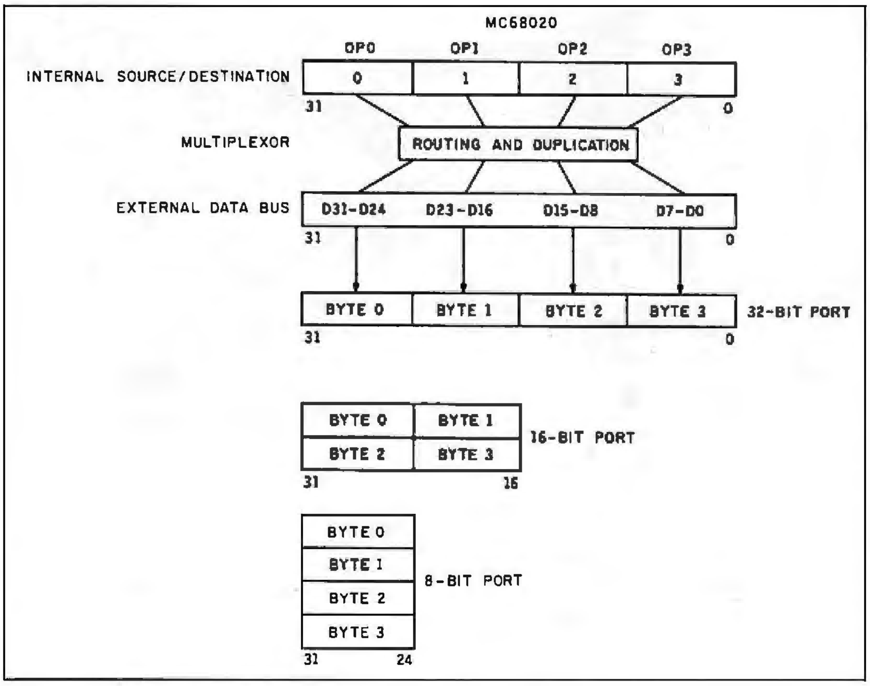
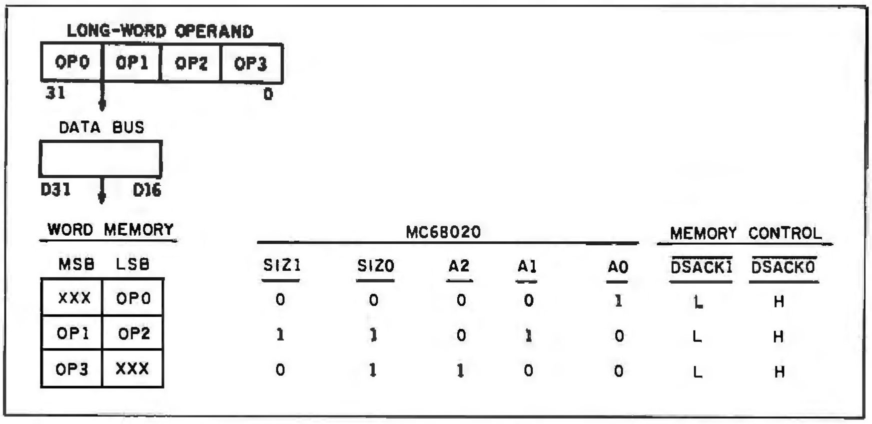


Figure 4: *The MC68020 interface to various port sizes.*



WORD MEMORY		MC68020					MEMORY CONTROL	
MSB	LSB	SIZ1	SIZ0	A2	A1	A0	$\overline{DSACK1}$	$\overline{DSACK0}$
XXX	OP0	0	0	0	0	1	L	H
OP1	OP2	1	1	0	1	0	L	H
OP3	XXX	0	1	1	0	0	L	H

Figure 5: *Example of a misaligned long-word transfer to a word-wide bus.*

The MC68020 relaxes word and long-word alignment restrictions for data. It is now possible to execute an operand transfer across a memory boundary that only needs to be byte aligned. Even and odd word restrictions are gone. Some performance degradation can occur, due to extra bus cycles needed to transfer misaligned long-word or word data across boundaries.

Figure 5 shows a misaligned long-word transfer across a word-wide bus. In the example, a byte box with "xxx" denotes that the location in memory is not overwritten and remains unchanged. As you can see from this example, it is important for the system designer to control the enabling/disabling of the appropriate data buffers to avoid overwriting or misreading nonpertinent data during a misaligned cycle.

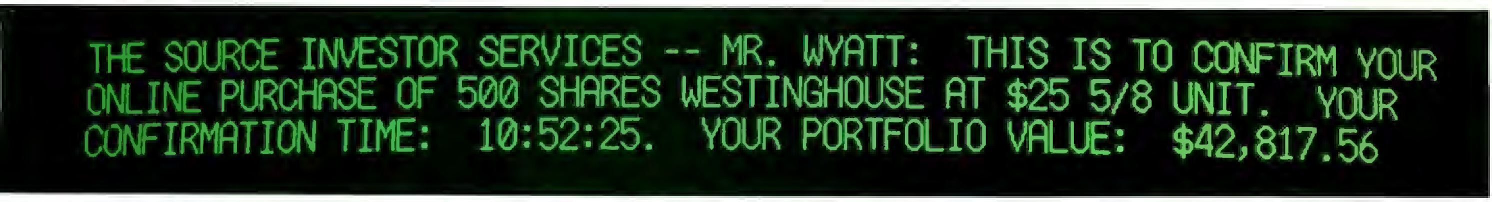
For clarity's sake, figure 5 also shows line A2 in offset of the transferred data into word memory. The first cycle runs with A2/A1/A0 being 001, showing an offset of 1 byte in memory. SIZ1/SIZ0 is 00, indicating that the processor has a long word left to transfer. The second cycle shows A2/A1/A0 with a 2-byte displacement, and SIZ1/SIZ0 showing the processor with 3 bytes left to transfer. The third cycle has no offset on the address pins and the SIZE pins indicating 1 byte left to transfer. There is a two-bus-cycle degradation here, but it is transparent to the programmer, letting him ignore the restrictions of data alignment.

COPROCESSOR INTERFACE

Though the MC68020 is powerful, it might not have all the special commands or capabilities that a designer requires. For this reason, the designers of the MC68020 incorporated a general coprocessor interface and instructions. The coprocessor interface provides a means by which Motorola

(continued)

Not Dow Jones.



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and other coprocessors (floating point, fast Fourier transform, or graphics processors) can extend the MC68020.

The coprocessor interface is designed to support synchronous operation between the MC68020 and up to eight coprocessors. With this interface, downward compatibility is possible because a coprocessor can be coupled with a main processor other than the MC68020 (e.g., 68008, 68000, 68010, 68012). All the main processor must do is provide instruction sequences that emulate the protocol of the coprocessor interface.

The coprocessor operates based on an F-line operation code, essentially the first word of a coprocessor instruction. It is so named because the hexadecimal F in the upper nybble of the instruction word causes the processor to flag the instruction during decode. The F-line indicates to the main processor that it must call the coprocessor for proper execution of the instruction. See figure 6 for the format of the F-line word.

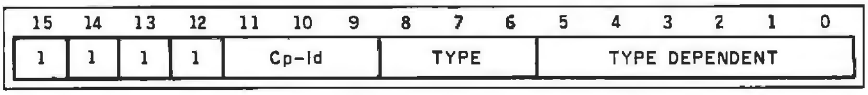

Figure 6: *F-line format.*

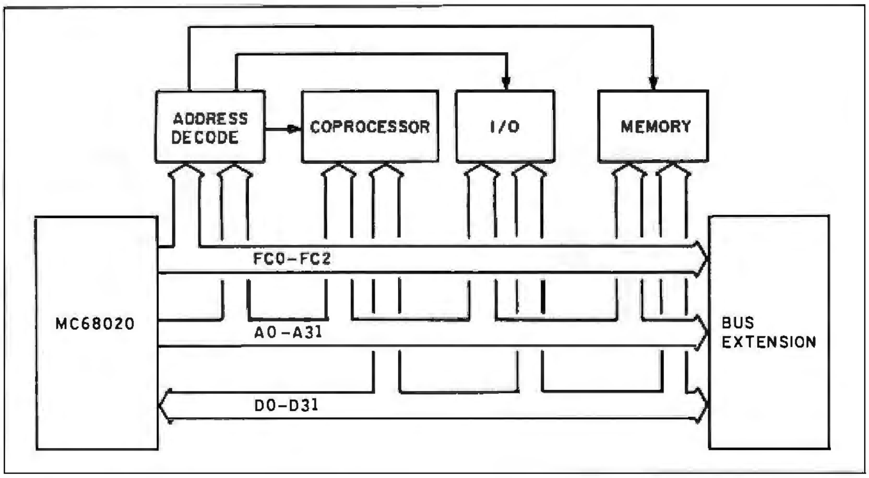

Figure 7: *Coprocessor system configuration.*

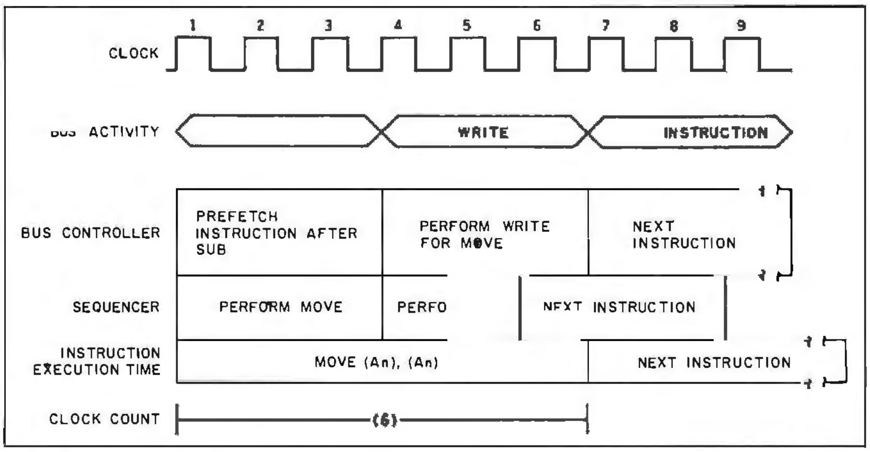

Figure 8: *Overlap example.*

The coprocessor identifier (Cp-Id) field identifies which coprocessor is to be selected. The Type field identifies which type of coprocessor operation is to be performed (branch, general, save, etc.).

Communication between the main processor and coprocessors is synchronous, but the main processor might not need to wait for the coprocessor to complete an instruction before it begins execution of its next instruction.

Hardware connection is a simple extension of the MC68000 bus interface and is shown in figure 7. The coprocessor is connected as a peripheral to the main processor and is selected based on combinations of function codes (FC2–FC0 are 111) and address bits (A19–A16 are 0010) as well as bits A15–13, described in figure 6.

OVERLAP

Overlap occurs when the sequencer and bus controller are operating on different instructions simultaneously. For example, in figure 8 a MOVE (An),(An) instruction and a SUB Dn,Dn instruction can operate concurrently for some of the total execution time. The overlap takes place during the external bus activity associated with the MOVE. Since for a certain clock time the bus controller is busy performing the write to external memory associated with the MOVE, the sequencer can continue with the next instruction, subtract (SUB). The SUB instruction does not require any external bus activity, so the sequencer alone can operate on it. This overlap time is shown from clocks 4 through 6.

Also note that part of the instruction following the SUB might have some of its execution time overlapped under the MOVE instruction. This occurs if calculations, such as effective address calculations, are needed to perform the instruction. An example of this would be if another MOVE instruction followed the SUB instruction.

Because the bus controller was performing an external bus cycle associated with the MOVE during the time the SUB was taking place internally,

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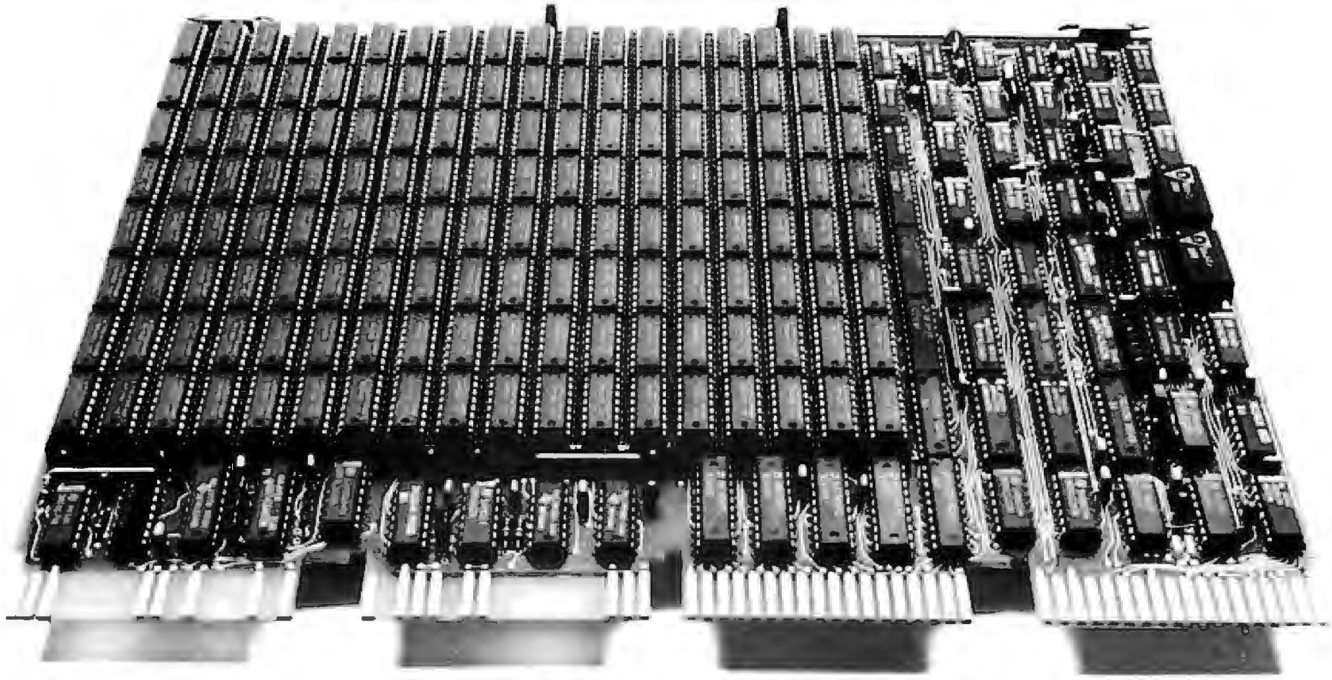

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the execution time is attributed to the MOVE instruction alone. If the pipe had been depleted and the SUB instruction had not been inside, the described overlap would not have taken place.

This example illustrates an important point about this concurrent machine. With a sequential microprocessor (no prefetch and no concurrency of operation), instruction timing is easy to calculate. It is virtually impossible with a concurrent microprocessor such as the MC68020. Each individual instruction is dependent on the instruction previous to it and is subject to the rules built into the prefetch mechanism. The best timings that can be given are in terms of best, average, and worst-case boundaries. Performance ratios and benchmarks become requisite in measuring performance.

PROGRAMMING

As shown in the programming model (figure 9), the MC68020 has eight 32-bit multifunction data registers, seven 32-bit general addressing registers, three 32-bit stack pointers (user, master, and interrupt), a 32-bit program counter, a 16-bit status register, a 32-bit vector base register, two 3-bit alternate function code registers, a 32-bit cache address register, and a 32-bit cache control register. The MC68020 is object-code compatible with the M68000 family but has several new addressing mode capabilities (table 1) and several new and enhanced instructions (table 2).

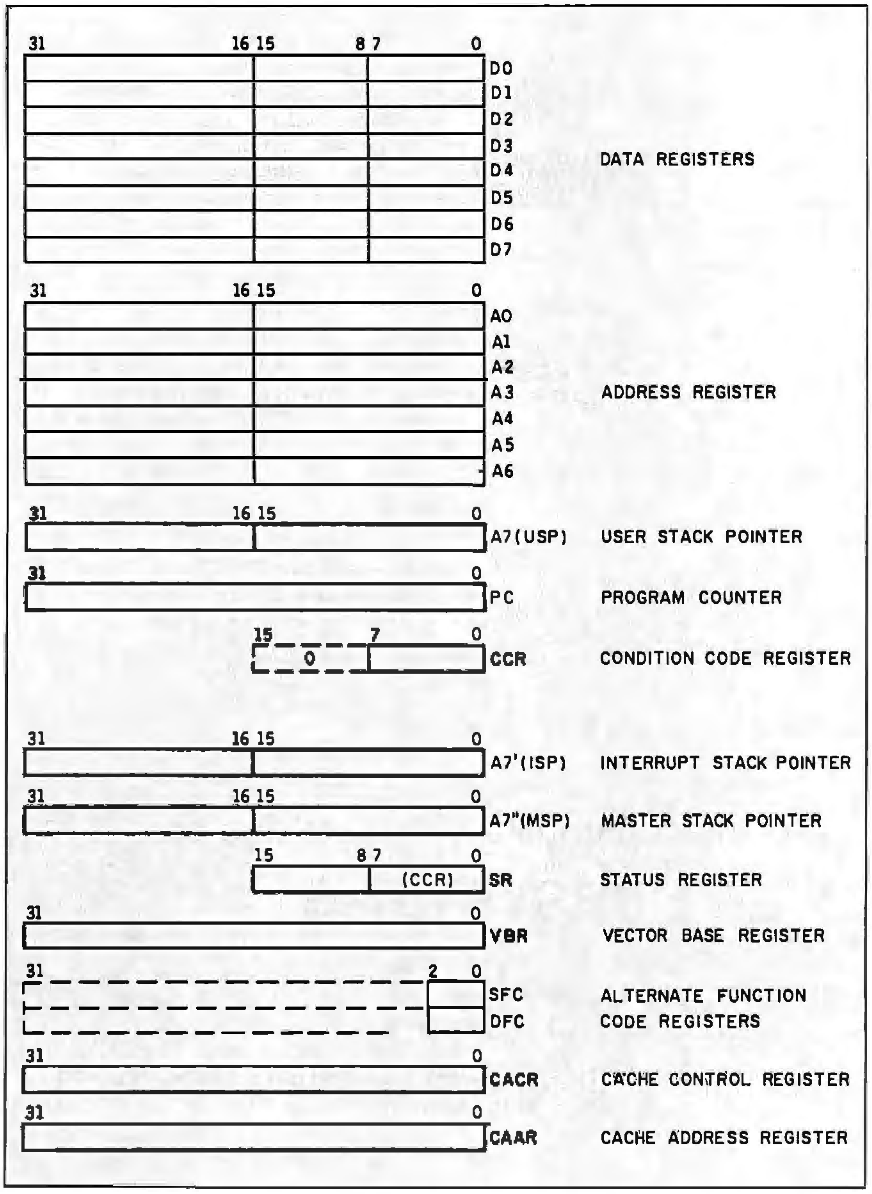

Figure 9: MC68020 *programming model.*

A principle in the MC68020 design is support for high-level language and system software implementation. This support is provided by the inclusion of special instructions that allow array bounds checking with a single instruction, safe manipulation of system queues, support for linked lists, expansion of system trap capabilities, and module support.

The MC68020 has three new 32-bit registers: the master stack pointer (MSP), cache control register (CACR), and cache address register (CAAR) (figure 8). The interrupt stack pointer is virtually the same as the M68000 family's supervisor stack pointer and therefore is not really a new register. The terminology has been changed to reflect a multiprocessing environment. The MSP was created to facilitate multiprocessing by letting each process have a small master stack area where process-specific exception data is stored, while maintaining a common large interrupt stack area among all the processes. The CACR clears the entire cache, clears a single cache entry, freezes the cache, and enables the cache. Each of these functions is controlled by simply setting a bit in the CACR. The CAAR is used with the cache clear entry function to clear a single entry in the cache.

Table 1 shows the MC68020 addressing modes. Of particular interest are the memory indirect and program counter memory indirect addressing modes.

There are two forms of memory indirect addressing and program counter memory indirect addressing: indirect pre-indexed and indirect post-

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indexed. Program counter memory indirect is similar to memory indirect addressing; however, where the address register is normally added into the calculation, the current program counter is used. The result is position-independent code where the memory pointer is accessed relative to the current program counter. In indirect pre-indexed and indirect post-indexed addressing modes, the base displacement (bd) and outer displacement (od) can be null (zero), word (16-bit), or long-word (32-bit) sizes.

Indirect pre-indexed addressing adds the index register into the address calculation before the memory indirection is performed. Indirect pre-indexed can be used to access operands through an array of pointers or through a pointer located in a record item or an array of records. The address register or program counter, index register, and base displacement are added together and used as the address of the memory pointer. The 32-bit memory pointer is fetched and the outer displacement is added to form the effective address.

Table 1: MC68020 *addressing modes.*

Addressing Modes	Syntax
Register direct	
Data register direct	Dn
Address register direct	An
Register indirect	
Address register indirect	(An)
Address register indirect with postincrement	(An) +
Address register indirect with predecrement	– (An)
Address register indirect with displacement	(d_{16},An)
Register indirect with index	
Address register indirect with index (8-bit displacement)	(d_8, An, Xn)
Address register indirect with index (base displacement)	(bd,An,Xn)
Memory indirect	
Memory indirect post-indexed	([bd,An],Xn,od)
Memory indirect pre-indexed	([bd,An,Xn],od)
Program counter indirect with displacement	(d_{16},PC)
Program counter indirect with index	
PC indirect with index (8-bit displacement)	(d_8,PC,Xn)
PC indirect with index (base displacement)	(bd,PC,Xn)
Program counter memory indirect	
PC memory indirect post-indexed	([bd,PC],Xn,od)
PC memory indirect pre-indexed	([bd,PC,Xn],od)
Absolute	
Absolute short	xxx.W
Absolute long	xxx.L
Immediate	$<data>

Notes:
Dn = Data Register, D0–D7.
An = Address Register, A0–A7.
d_8,d_{16} = A two's-complement or sign-extended displacement; added as part of the effective address calculation; size is 8 or 16 bits (d_{16} and d_8 are 16- and 8-bit displacements); when omitted, assemblers use a value of zero.
Xn = Address or data register used as an index register; form is Xn.SIZE*SCALE, where SIZE is .W or .L (indicates index register size) and SCALE is 1, 2, 4, or 8 (index register is multiplied by SCALE); use of SIZE and/or SCALE is optional.
bd = A two's-complement base displacement; when present, size can be 16 or 32 bits.
od = Outer displacement, added as part of effective address calculation after any memory indirection; use is optional with a size of 16 or 32 bits.
PC = Program Counter.
<data> = Immediate value of 8, 16, or 32 bits.
( ) = Effective address.
[ ] = Use as indirect address to long-word address.

Indirect post-indexed addressing performs the memory indirection and then adds the index register to calculate the effective address. Indirect post-indexed can be used to access an element of an array that is pointer addressed. The base displacement and address register or program counter are added to form the memory pointer address. The 32-bit quantity at the memory pointer address is fetched and added to the index register and outer displacement to form the operand's effective address.

SCALING AND SUPPRESSION

An index register can be scaled—the value in the register is read and then logically shifted (zero fill) zero, one, two, or four bit positions to the left before it is used. This has the effect of multiplying the value in the register by 1, 2, 4, or 8. The original value in the register is not affected by this operation. Using scaling, the same index value can be used to point to individual bytes, words, long words, and quad words, without disrupting the value.

Let address register A0 be used as an index and contain the value 3. The A0*1 (assuming 0 to be the first element in the array) will point to the fourth element in a byte-wide array, A0*2 will point to the fourth element in a word-wide array, A0*4 will point to the fourth element in a long-word-wide array, and A0*8 will point to the fourth element in a quad-word-wide array. This scaling takes no overhead on the MC68020.

The suppression of the base address register or program counter allows the use of any index register in place of the base register. Since data

(continued)

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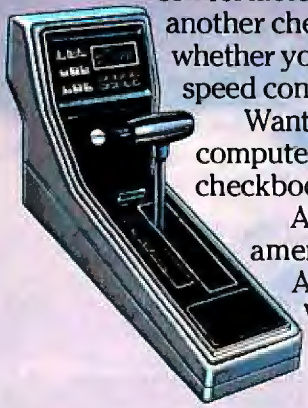

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registers can be used as index registers, this gives the MC68020 the ability to have addresses in data registers. Also, with suppression of the program counter the user has access to program space.

BIT-FIELD INSTRUCTIONS

The MC68020 has eight new bit-field manipulation instructions over the previous M68000 instruction set. These instructions can be used to manipulate individual bits in registers or memory. The bit-field instruction mnemonics are described in table 2.

A bit field is simply an array of bits. It can be small enough to be contained in a register or large enough to require millions of bytes of memory. Some examples of bit-field applications are bit-mapped graphics, communications with packed data, and assembler op-code construction.

In each bit-field instruction, the field selection is specified by a field offset and field width. The field offset denotes the starting bit of the field in bits from the base address, and the field width determines the number of bits to be included in the field. The base address is the effective address and can be in memory or a data register.

In a data register, the offset starts with the leftmost bit, bit 31, and the width determines the amount of bits to the right of the offset. Register wraparound is allowed; that is, if the combination of offset and width extend the bit field past bit 0 in the register, the field wraps back around

(continued)

Table 2: MC68020 *instruction set summary.*

Mnemonic	Description
ABCD	Add decimal with extend
ADD	Add
ADDA	Add address
ADDI	Add immediate
ADDQ	Add quick
ADDX	Add with extend
AND	Logical AND
ANDI	Logical AND immediate
ASL,ASR	Arithmetic shift left, right
Bcc	Branch conditionally
BCHG	Test bit and change
BCLR	Test bit and clear
BFCHG	Test bit field and change
BFCLR	Test bit field and clear
BFEXTS	Signed bit field extract
BFEXTU	Unsigned bit field extract
BFFFO	Bit field find first one
BFINS	Bit field insert
BFSET	Test bit field and set
BFTST	Test bit field
BRA	Branch
BSET	Test bit and set
BSR	Branch to subroutine
BTST	Test bit
CALLM	Call module
CAS	Compare and swap operands
CAS2	Compare and swap dual operands
CHK	Check register against bound
CHK2	Check register against upper and lower bounds
CLR	Clear
CMP	Compare
CMPA	Compare address
CMPI	Compare immediate
CMPM	Compare memory to memory
CMP2	Compare register against upper and lower bounds
DBcc	Test condition, decrement, and branch
DIVS,DIVSL	Signed divide
DIVU,DIVUL	Unsigned divide
EOR	Logical exclusive OR
EORI	Logical exclusive OR immediate
EXG	Exchange registers
EXT	Sign extend
JMP	Jump
JSR	Jump to subroutine
LEA	Load effective address
LINK	Link and allocate
LSL,LSR	Logical shift left, right
MOVE	Move
MOVEA	Move address
MOVE CCR	Move condition code register
MOVE SR	Move status register
MOVE USP	Move user stack pointer
MOVEC	Move control register
MOVEM	Move multiple registers
MOVEP	Move peripheral
MOVEQ	Move quick
MOVES	Move alternate address space
MULS	Signed multiply
MULU	Unsigned multiply
NBCD	Negate decimal with extend
NEG	Negate
NEGX	Negate with extend
NOP	No operation
NOT	Logical complement
OR	Logical inclusive OR
ORI	Logical OR immediate
PACK	Pack BCD
PEA	Push effective address
RESET	Reset external devices
ROL,ROR	Rotate left, right
ROXL,ROXR	Rotate with extend left, right
RTD	Return and deallocate
RTE	Return from exception
RTM	Return from module
RTR	Return and restore condition codes
RTS	Return from subroutine
SBCD	Subtract decimal with extend
Scc	Set conditionally
STOP	Stop
SUB	Subtract
SUBA	Subtract address
SUBI	Subtract immediate
SUBQ	Subtract quick
SUBX	Subtract with extend
SWAP	Swap register words
TAS	Test operand and set
TRAP	Trap
TRAPcc	Trap conditionally
TRAPV	Trap on overflow
TST	Test operand
UNLK	Unlink
UNPK	Unpack BCD
Coprocessor Instructions	
cpBcc	Branch conditionally
cpDBcc	Test coprocessor condition, decrement, and branch
cpGEN	Coprocessor general instruction
cpRESTORE	Restore internal state of coprocessor
cpSAVE	Save internal state of coprocessor
cpScc	Set conditionally
cpTRAPcc	Trap conditionally

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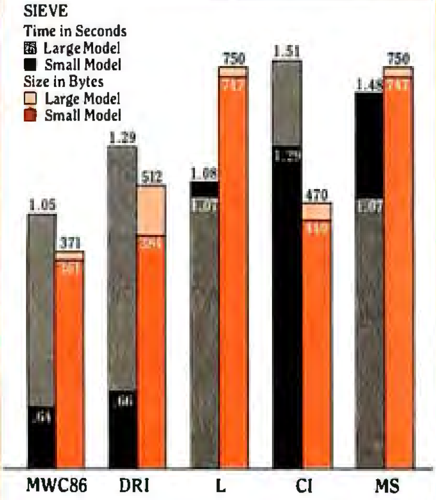

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The MC68020 is an improvement on the M68000 family.

and continues with bits 31, 30, etc. Table 3 shows the Motorola assembler syntax and examples of the bit-field instructions.

DIVISION AND MULTIPLICATION

The MC68020 has several enhancements to the original M68000 multiply and divide instructions. The most important of these enhancements is the ability to have 32-bit operands for multiplication with a 64-bit result, and a 64-bit dividend with a 32-bit divisor and quotient for division.

The MC68020 also has special multiply and divide instructions for high-level languages where the result is the same size as the operands. That is, a 32-bit operand times a 32-bit operand yields a 32-bit result. This is equivalent to multiplication in Pascal or C, where an integer times an integer results in an integer of the same size data type. If overflow occurs, it will be reflected in the setting of the condition codes after the operation. For division there is provision for a 32-bit dividend divided by a 32-bit divisor to yield a 32-bit quotient with no re-

Table 3: *Bit-field instructions, syntax, and examples.*

Instruction	Motorola Assembler Syntax	Assembler Example
BFCHG	BFCHG <EA>{offset:width}	BFCHG (AO){DO:7}
BFCLR	BFCLR <EA>{offset:width}	BFCLR D1{25:10}
BFEXTS	BFEXTS <EA>{offset:width},Dn	BFEXTS (A3){D2:5},D7
BFEXTU	BFEXTU <EA>{offset:width},Dn	BFEXTU D5{2:5},D1
BFFFO	BFFFO <EA>{offset:width},Dn	BFFFO (A6){D0:32},D7
BFINS	BFINS <EA>{offset:width},Dn	BFINS D4{6:9},D2
BFSET	BFSET <EA>{offset:width}	BFSET D3{30:9}
BFTST	BFTST <EA>{offset:width}	BFTST D1{0:32}

<EA> = effective address of the base of the bit field
offset = bit offset from base address of bit field to start to bit field
width = bit width of bit field from 1 to 32 bits
Dn = data register

Table 4: *Division and multiplication syntax and operation.*

Instruction	Motorola Assembler Syntax	Operation
DIVS.W	DIVS.W <EA>,Dn	32/16 --> 16r:16q
DIVS.L	DIVS.L <EA>,Dq	32/32 -- > 32q
DIVS.L	DIVS.L <EA>,Dr:Dq	64/32 --> 32r:32q
DIVSL.L	DIVSL.L <EA>,Dr:Dq	32/32 --> 32r:32q
DIVU.W	DIVU.W <EA>,Dn	32/16 --> 16r:16q
DIVU.L	DIVU.L <EA>,Dq	32/32 -- > 32q
DIVU.L	DIVU.L <EA>,Dr:Dq	64/32 -- > 32r:32q
DIVUL.L	DIVUL.L <EA>,Dr:Dq	32/32 --> 32r:32q
MULS.W	MULS.W <EA>,Dn	16 x 16 -- > 32
MULS.L	MULS.L <EA>,Dl	32 x 32 --> 32
MULS.L	MULS.L <EA>,Dh:Dl	32 x 32 --> 64
MULU.W	MULU.W <EA>,Dn	16 x 16 --> 32
MULU.L	MULU.L <EA>,Dl	32 x 32 --> 32
MULU.L	MULU.L <EA>,Dh:Dl	32 x 32 -- > 64

<EA> = effective address of source operand
Dn = data register
Dq = quotient in data register
Dr = remainder in data register
Dh = high 32 bits of product in data register
Dl = low 32 bits of product in data register

mainder. Several variations of syntax and operations exist for divide and multiply instructions. For more information, see the Motorola assembler syntax and operation examples shown in table 4.

BINARY-CODED DECIMAL

Two MC68020 instructions, PACK and UNPACK, can store BCD (binary-coded decimal) data in packed form (two digits per byte) and then be expanded after calculations. The PACK instruction reduces 2 bytes of numeric data into a single byte, while the UNPACK instruction reverses this operation. In both cases, a user-defined constant is added to the original value to allow conversion from or to ASCII, EBCDIC (extended binary-coded-decimal interchange code), or any other data format.

HIGH-LEVEL LANGUAGES AND SYSTEM SOFTWARE

The MC68020 has extended the bounds-checking capability of the M68000 family with the introduction of two new instructions, CHK2 and CMP2 (check 2 and compare 2). CHK2 and CMP2 perform comparisons on the upper and lower bounds and can be signed or unsigned. The CMP2 instruction sets the condition codes according to the result of the operation. The CHK2 instruction sets the condition codes and causes a system trap if either boundary condition fails.

The MC68020 also offers other new security and system-level instructions. The CAS and CAS2 instructions use the same read-modify-write cycle as the M68000's TAS (test and set). These operations are indivisible and noninterruptible, which ensures data security in single and multiprocessor systems.

The CAS (compare and swap) instruction compares the contents of a data register (the compare register) to the operand at the effective address. If the operand and the contents of the data register are equal, the contents of a second data register (the update register) are used to update the operand at the effective address. If the

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compare register and the operand are not equal, the operand is unchanged, but the value in the compare register is updated with the operand at the effective address. The CAS2 instruction is basically the same as CAS, but there are two compare registers (upper and lower bound), two update registers, and two operands at two different effective addresses. The CAS and CAS2 instructions are useful for updating system counters and for insertion and deletion from linked lists.

The MC68020 also has expanded system trap capabilities in the form of the TRAPcc instruction, where any condition code is allowed to be the trapping condition. The TRAPcc instruction can be followed by a word or long-word quantity that can be used to convey information to the trap handler, such as a high-level language statement number or other debugging information.

The MC68020 introduces module support to the M68000 family. Modules are high-level subroutines that can have different levels of protection or access. Two new instructions, CALLM and RTM, support this module implementation.

The CALLM instruction initiates the module call by referencing a module descriptor. The module descriptor contains access information, control information, and the entry point for the called module. If the module access is valid, the CALLM instruction creates a module stack frame, stores the current module state in that frame, and loads a new module state from the module descriptor.

The RTM instruction removes the module state that was stored on the module stack frame and returns to the calling module. The MC68020 module support is broken into two types: type 0 where there is no access level change and type 1 where the access level can be changed. No external hardware is necessary for type 0, but for type 1 CALLM, the MC68020 relies on external hardware (a memory management unit) to verify that calling modules possess the proper access level for the called module.

VIRTUAL MEMORY

The MC68020 supports virtual memory, the ability to make a small amount of main memory look like a large or infinite amount of memory by using secondary storage devices to swap currently executing code segments into the main memory. In a virtual memory system, the processor has access to a limited amount of fast main memory (the physical memory of the system), while the user writes programs that might require millions of bytes of memory (the virtual memory of the system).

If the processor attempts to access a memory location not currently residing in physical memory, a page fault occurs. The processor suspends the current instruction until the required memory is moved into physical memory from slower but larger secondary storage. When the required program segment is in physical memory, the instruction is allowed to complete execution. All this activity is transparent to the user, so physical memory appears to be the same size as virtual memory. Virtual memory size has been increased from a 16-megabyte direct addressing range in the MC68010 to 4 gigabytes in the MC68020.

CONCLUSION

The MC68020 is a fully compatible member of, and an improvement on, the M68000 family of processors. It is backed by the same powerful software and hardware design-support tools that back other members of the M68000 family. For more information, see the *MC68020 32-Bit Microprocessor User's Manual* (Prentice-Hall, 1984) and the three-part article by Thomas W. Starnes, "Design Philosophy Behind Motorola's MC68000" (April–June 1983 BYTE). ■

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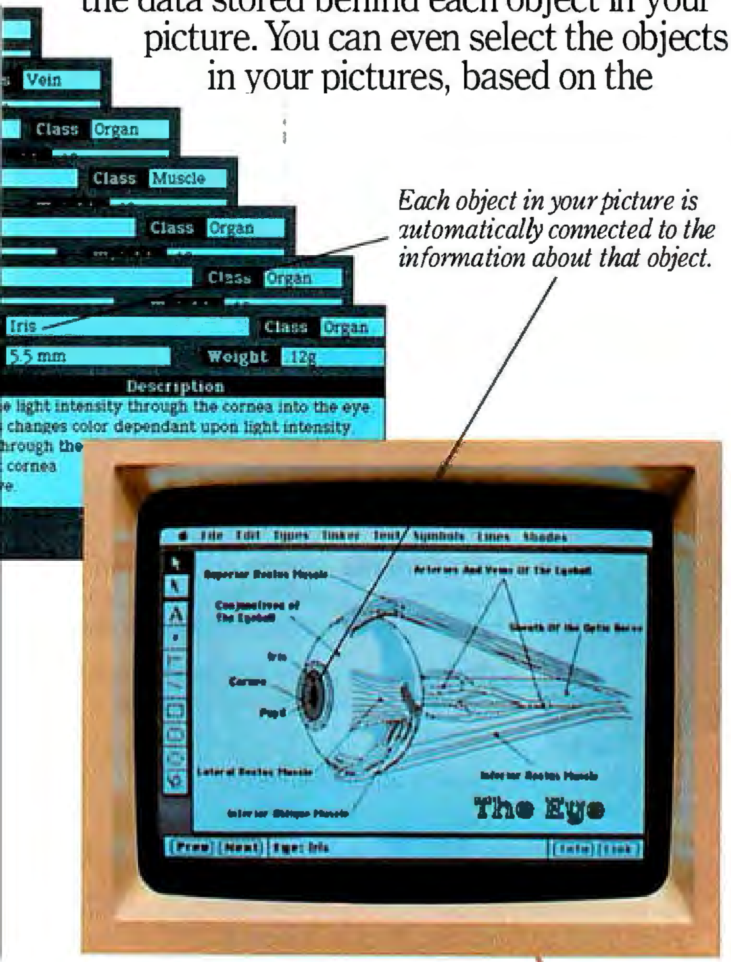

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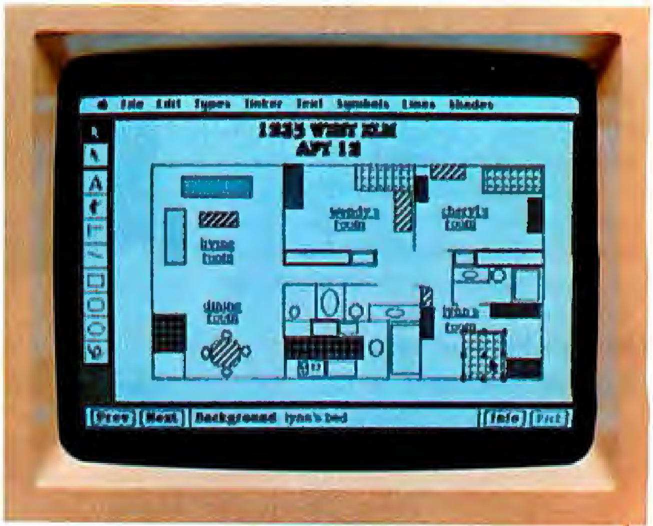

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212A Modem Comparison Chart*

STANDARD FEATURES	PRO	HAYES STACK	NOVATION SMARTCAT+	ANCHOR 1200	US ROBOTICS PASSWORD
300/1200 Baud (212A)	✓	✓	✓	✓	✓
Intelligent Microprocessor	✓	✓	✓	✓	✓
Tone and Pulse Dialing	✓	✓	✓	✓	✓
Hayes Command Compatible (Works with Smartcom™)	✓	✓	✓	✓	
Additional telephone jack with exclusion switching	✓				
Analog loop back self test	✓	✓	✓		
Self Test at Power Up	✓		✓		
Call Progress Detection (Busy, Dial Tones, Trunk Busy, etc.)	✓		✓		
Speaker and External Volume Control	✓	✓	✓		
Full Complement of Status Lights	✓	✓			
8 Switch Selectable power-up defaults	✓	✓			
Adaptive Dialing	✓		✓		
Auto Redial on Busy	✓		✓		
Ergonomically designed easy to read front display panel	✓				
Internal Stand-Alone Power Supply	✓				
Built in Real Time Clock/Calendar	✓				
Help Command	✓				
300 baud connect while maintaining 1200 baud RS-232 link	✓				
EXPANDABLE OPTIONS					
Automatic Receiver Buffer	✓				
Automatic Transmit Buffer	✓				
On-board Personal/Business Directory	✓				
Buffer, Expandable to 64K	✓				
Auto Logon Macros	✓				
Auto message transmission to groups of numbers	✓				
Records call duration	✓				
12-character Alphanumeric Display	✓				

*Comparison made by Prometheus on the basis of the best information available to Prometheus at time of printing.

THE XTAR GRAPHICS MICROPROCESSOR

BY TERRY COLEMAN AND SKIP POWERS

This graphics chip set draws filled-in polygons at superhigh speed

GENERATING COMPLEX IMAGES on a CRT (cathode-ray tube) at real-time rates of 30 or more frames per second requires the ability to draw graphical primitives (points, lines, and polygons) rapidly into a display memory or frame buffer. A standard microprocessor working alone is not nearly fast enough. CRT controller chips can draw about 10 times as fast as microprocessors but still fall far short of the speed required for real-time simulations and smooth animation. To obtain the necessary throughput for these applications, you must use a dedicated graphics coprocessor.

DRAWING SPEED SPECIFICATIONS

The key specification for a graphics chip is the drawing rate. Drawing rates are reported in two different ways. The *burst pixel-drawing rate* is obtained whenever video-refresh memory cycles are not occurring, i.e., during horizontal and vertical retrace and portions of the active display time. This is the rate usually given on manufacturers' spec sheets.

A more accurate benchmark of a system's drawing speed, the *average pixel-drawing rate*, is the total number of pixels (picture elements) that can be drawn in one frame time divided by the frame time. This rate will always be less than the burst rate.

The number of frame updates per second achievable is obtained by dividing the average pixel-drawing rate by the number of pixels in the frame buffer. This provides an excellent indication of how well the system will perform real-time animation.

THE XTAR GMP

The GMP from Xtar is a special-purpose microprocessor that executes graphics instructions contained in an external program memory. The instruction set is specifically designed for graphics applications and includes instructions for drawing points, lines, and filled polygons into a frame buffer. Because the GMP is specifically designed to draw filled polygons into a frame buffer, it can accomplish this task at extremely high speeds. Polygons can be drawn at a rate fast enough to update every pixel in the frame buffer 130 to 300 times per second. The GMP eases the implementation of real-time simulation and animation systems by drawing at speeds that are often hundreds of times faster than can be attained with a CRT controller.

Tables 1 and 2 illustrate the drawing speeds obtained by systems using the GMP. The average pixel-drawing rate increases as the resolution of the frame buffer is increased, while the number of screen updates per second remains relatively constant. This allows essentially the same level of performance to be maintained, regardless of system resolution.

SYSTEM CONFIGURATION

A typical system based on the two-chip GMP is shown in figure 1. Oper-

(continued)

Skip Powers is the chief executive officer of Xtar Electronics. Terry Coleman is Xtar's vice president of engineering and the designer of the GMP chip. They can both be reached at 2262 Landmeier Rd., Elk Grove, IL 60007 .

ating in a multiprocessing environment with a general-purpose host microprocessor, the GMP communicates with the general-purpose processor through a shared memory. The shared memory is the program memory or display list for the GMP. The general-purpose processor controls the GMP by downloading graphics instructions into the GMP's memory. While the host processor may be any general-purpose microprocessor, the system is simplified if the host has a 16-bit data bus.

As many as 64K words of program memory can be addressed by the GMP. Any combination of 16-bit wide RAM (random-access read/write memory) and ROM (read-only memory) may be used, but if animation is to be done, at least part of the memory must be RAM.

Instructions in the shared-memory display list cause the GMP to draw graphical primitives into the frame buffer. The GMP performs all calculations necessary to draw two-dimensional polygons. A separate circuit controls the Write Enable inputs of the RAMs in the frame buffer, which may be any size from 256 by 256 by 1 byte to 2048 by 2048 by 32 bytes.

The video shift register (VSR) chips, an option that is ancillary to the GMP, convert the parallel-pixel data from the frame buffer into the serial form required to drive the color-palette RAM or D/A (digital-to-analog) converters. In addition to the Shift-Register function, the VSRs allow the host processor to access the frame buffer for Read-Modify-Write operations on individual pixels. Also, a stippling feature allows the filling of polygons with two-color patterns. This feature increases the number of apparent displayable colors without increasing the depth of the frame buffer—allowing about 1800 effective colors to be displayed simultaneously while requiring only 4 memory bits per pixel.

A color-palette RAM defines the actual color displayed for each pixel value that comes from the VSRs. In a high-performance system the color-palette RAM may be as large as 4096 by 24, which allows 4096 solid colors to be displayed at one time from a palette of over 16 million colors. In low-cost systems the color-palette RAM will not exist and the output of the VSRs will feed the D/A converters directly.

Because the GMP chip set does not generate CRT sync signals or video-refresh addresses, a standard CRT controller chip is used.

Specialized Instruction Set

The GMP's instruction set allows the programmer to easily manipulate graphical primitives. There is no need for the programmer to be concerned with repetitive tasks usually required when programming graphics systems, such as calculating the actual frame-buffer addresses of pixels to be modified, calculating difference parameters defining lines to be drawn, and searching the frame buffer for polygon edges to do polygon fills. The instruction set is divided into three major categories: graphics primitive instructions, register loading instructions, and program control instructions (see table 3).

Clipping Window

Within the GMP, four 12-bit registers define the four sides of a rectangular clipping window, which can be placed anywhere on the screen. All points, lines, and polygons drawn by the GMP are automatically clipped to the current window. The registers are under software control and can be modified at any time using the LOAD instruction. The GMP can draw an image, change the clipping window to a different area of the screen, then draw a new image clipped to the new window.

Automatic Program Memory Refresh

The GMP's program memory may be designed with low-cost dynamic RAMs and the GMP will take care of RAM refresh. During noninstruction-fetch memory cycles, the GMP places the contents of its internal refresh counter on the lower 8 bits of the ad-

(continued)

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Table 1: *In systems based on the GMP, the time required to draw a line is a function of the slope of the line. The figures here present the pixel-drawing rates for drawing lines and assume a large number of lines with the slopes equally distributed between 0 and 90 degrees.*

System resolution and refresh rate	Burst pixel writes per second	Average pixel writes per second	Screen updates per second
512 x 512 30 Hz	6.7M	5.6M	21.3
512 x 512 60 Hz	6.7M	4.6M	17.4
1024 x 1024 30 Hz	9.2M	7.8M	7.4
1024 x 1024 60 Hz	9.2M	6.3M	6.0
2048 x 2048 60 Hz	11.9M	8.1M	1.9

Table 2: GMP *pixel-drawing rates for drawing filled polygons.*

System resolution and refresh rate	Burst pixel writes per second	Average pixel writes per second	Screen updates per second
512 x 512 30 Hz	50M	42M	160
512 x 512 60 Hz	50M	34M	129
1024 x 1024 30 Hz	200M	168M	160
1024 x 1024 60 Hz	200M	136M	129
2048 x 2048 60 Hz	800M	544M	129

dress bus and places zeros on the upper 8 bits of the bus. The refresh counter is incremented after each refresh cycle.

APPLICATIONS

As the increasing capabilities of personal computers bring them into use as low-cost computer-aided design systems, greater demands are being placed on the graphics proficiency of these machines. Complex, real-time images can be generated by a GMP system at a fraction of the cost normally associated with powerful graphics systems. The GMP could be the basis of a moderate-cost peripheral for personal computers that would provide graphics capability currently unavailable to small systems.

Flight simulators, devices that allow pilots to practice maneuvers that would be unsafe in a real aircraft, are

(continued)

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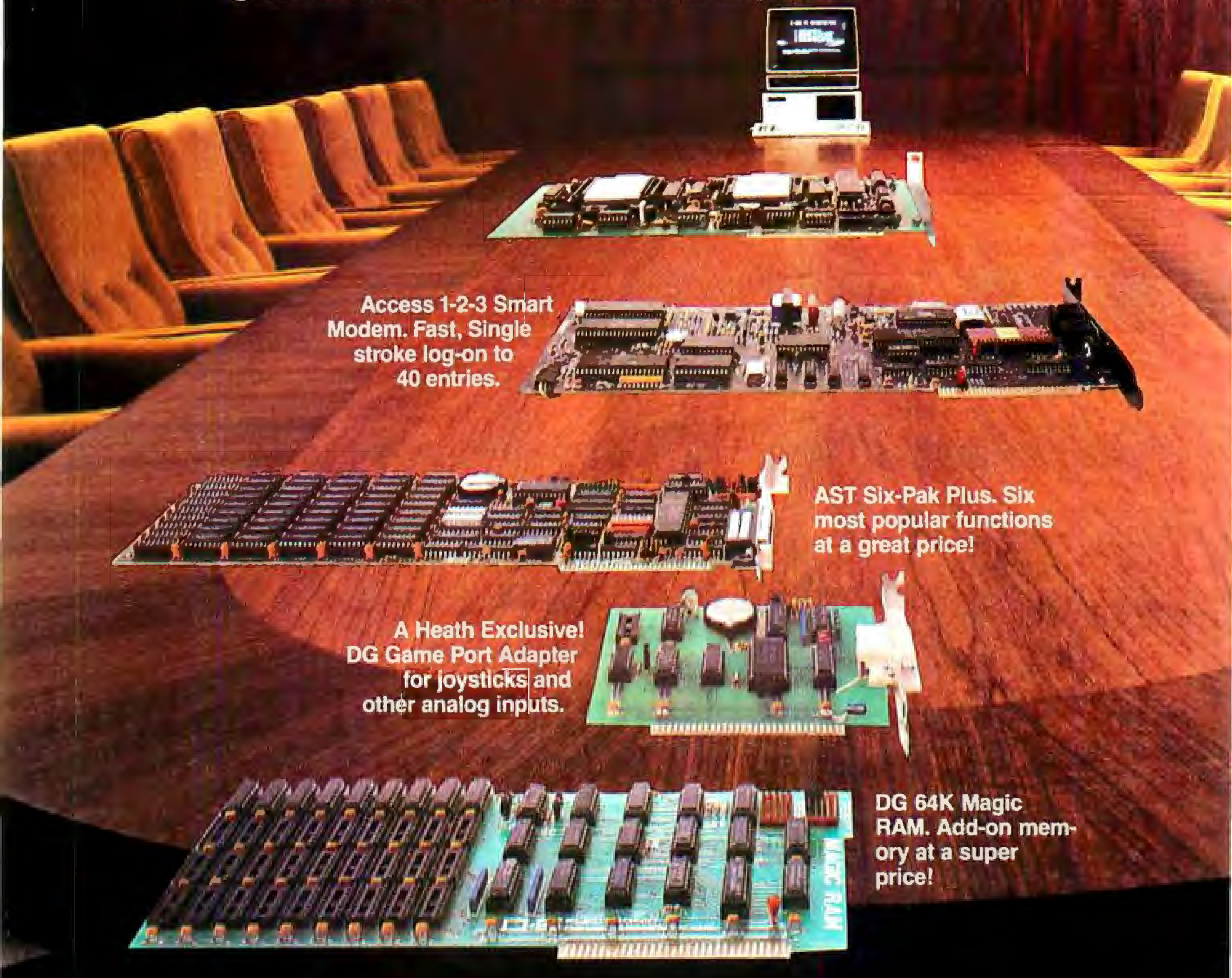

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CB-101R1

Table 3: *The GMP instruction set.*

Graphics Primitive Instructions

PNTDRW (DATA,Y,X)
This instruction causes the GMP to draw a point into the frame buffer at screen coordinate (*X*,*Y*). DATA is the actual value (color or shading value) written into the frame buffer.

LDRW (DATA,*Y*1,*X*1,*Y*2,*X*2)
Draws a line between points (*X*1,*Y*1) and (*X*2,*Y*2).

PDRW (*N*,DATA,*Y*1,*X*1, . . . *YN*,*XN*)
Draws a polygon of *N*+1 vertices, filled with DATA. *N* must be 0 to 255. The vertices must be specified in clockwise order, although any vertex can be first. All convex polygons are legal while concave polygons are legal, only if it is not possible for a horizontal line to intersect the edge of the polygon more than two times.

Register Loading Instructions

LOAD (REG#,DATA)
Loads an internal register with DATA.

Register Number	Function
0	pixel address of top clipping border
1	pixel address of bottom clipping border
2	pixel address of left clipping border
3	pixel address of right clipping border
4	MODE register; used to program the GMP for various sizes of frame buffers

S32B
Selects the 32-bit mode. When in this mode all DATA words must be 32 bits.

S16B
Selects the 16-bit mode. When in this mode all DATA words must be 16 bits.

Program Control Instructions

JUMP (ADDRESS)
Causes an unconditional branch to the specified address in the GMP's program memory.

JSR (Yrel,Xrel,ADDRESS)
A relative draw instruction. Calls a subroutine at ADDRESS and sets the *X* relative and *Y* relative registers. All primitives drawn after execution of this instruction but prior to execution of an RTS instruction are drawn at coordinates offset by Xrel and Yrel. Nesting of subroutines is not allowed, so an RTS instruction must be executed before another JSR or JSRC can be executed.

JSRC (DATA,Yrel,Xrel,ADDRESS)
Similar to the JSR instruction, except primitives drawn after execution of this instruction use the DATA specified in this instruction.

RTS
Return from subroutine. Clears the Xrel and Yrel registers.

COMP
Causes the GMP to stop executing instructions and wait for a new hardware START command.

(continued)

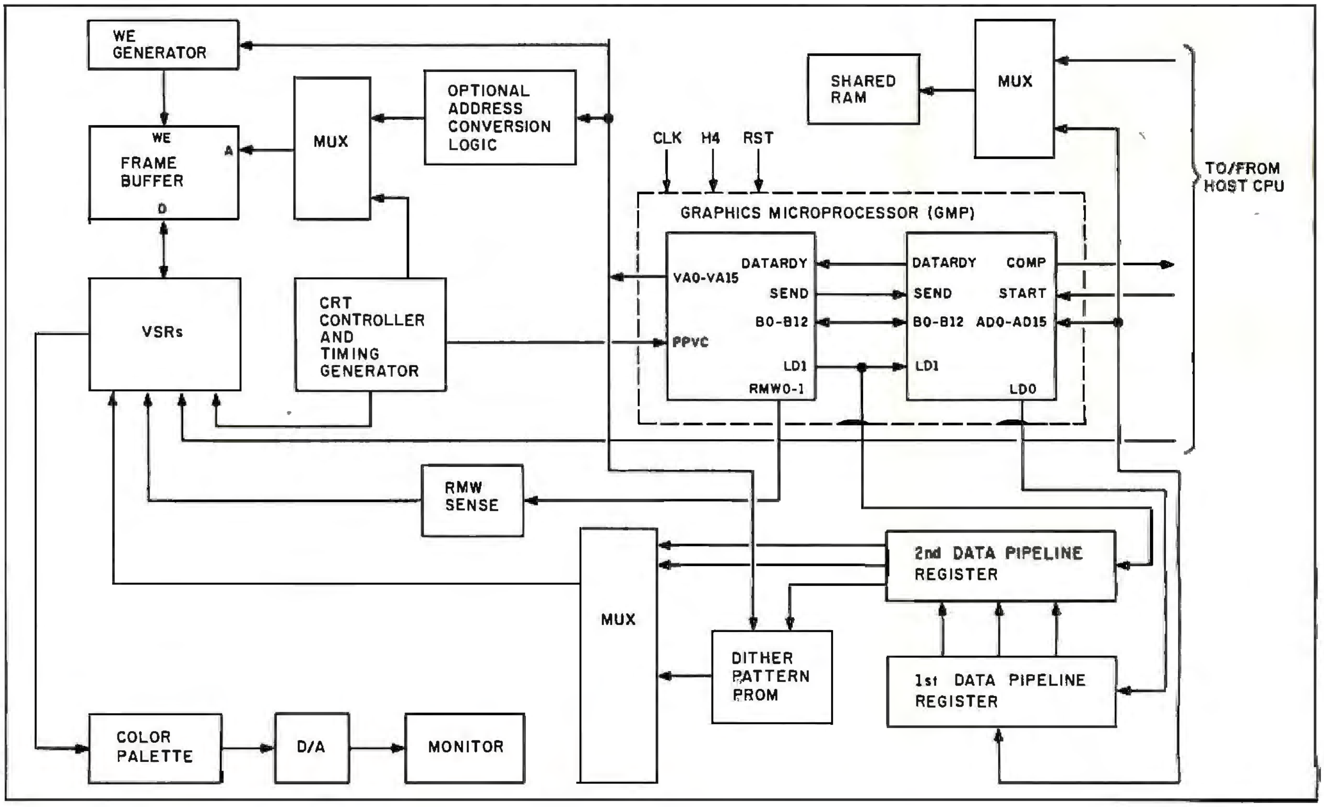

Figure 1: *Typical system block diagram.*

Photo 1: *This is a frame from a real-time flight-simulation display. A simulator based on the GMP might be affordable by small airports and flight schools. The screen is updated at 30 frames per second to provide a realistic, moving view corresponding to the plane's position in space. The objects in the scene are defined as polygons in a three-dimensional space.*

currently too expensive to be used for general aviation training. (See photo 1.) A significant part of the cost of these systems is in the display electronics that generate realistic real-time views for the pilot.

Other applications include solid modeling systems, architectural drafting systems, animation workstations for artists, and graphics systems for video production houses and cable TV stations.

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RISC CHIPS

BY JOHN MARKOFF

RISC *means longer programs but faster execution*

IF YOU PEER into a microscope at a certain VLSI (very large scale integration) microprocessor designed and fabricated recently by faculty and graduate students at the University of California at Berkeley, you will see something quite startling. There, inscribed in tiny detail next to the initials of the microprocessor designers, is a Porsche racing car.

The Porsche is intended to symbolize a radical philosophical departure from conventional thinking about microprocessor design. The departure is known as a reduced instruction set computer (RISC), and it provides an alternate solution to one of the fundamental problems facing modern computer designers: how best to support high-level languages.

Until today the general trend in computer architecture design has been to increase the complexity of hardware in an effort to more closely match high-level language constructs. Sophisticated modern computers such as the DEC (Digital Equipment Corporation) VAX-11 family of minicomputers and the Intel iAPX 432 microcomputer exemplify this trend. These systems are referred to as CISCs (complex instruction set computers) by the RISC advocates. (In one of their papers, the Berkeley RISC designers contrasted their Porsche RISC symbol with a Cadillac symbol for CISC design.)

CISCs are characterized by rich instruction sets, a variety of address modes, and extensive microcode. The iAPX 432 in particular is representative of the CISC approach in that Intel designed the system to best support one high-level language, Ada, which has been adopted as a standard by the U.S. Department of Defense. The 432 has an instruction set intended to efficiently translate Ada into machine-language programs.

By way of contrast, RISC designs offer exceedingly simple instruction sets, shortened design and fabrication cycles, and the freeing of scarce silicon real estate for other microprocessor tasks.

Therefore, as the semiconductor industry enters the era of VLSI for microprocessor design, CISC and RISC will offer conflicting avenues of approach: VLSI used to construct increasingly complex microprocessors where hardware is used extensively to do functions previously done by software, versus simplified designs optimized for speed of operation.

RISC designers argue that even in VLSI circuits, transistors available on a limited chip area constitute a scarce resource when they are used to implement an entire processor. They argue that CISC instruction sets constitute an inefficient use of these resources. In fact, detailed analyses that the RISC advocates have made of machine code generated by modern compilers indicate that complex instruction sets are frequently not fully used by compilers; therefore, much of the power supplied in silicon by hardware designers is wasted.

Furthermore, because the cost of memory continues to fall rapidly, the relatively compact code afforded by CISCs is an increasingly insignificant factor in total system cost. Occasionally, complex architectural designs even lead to "irrational" implementation of instructions. In a number of cases, special-purpose instructions are not faster than a sequence of simple instructions. David Patterson, an asso-

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ciate professor in computer science at the University of California at Berkeley and one of the principal designers of the Berkeley RISC project, has cited a number of examples (see reference 1):

> One example was discovered by Peuto and Shustek for the IBM 370; they found that a sequence of load instructions is faster than a load multiple instruction for fewer than 4 registers. This case covers 40% of the load multiple instructions in typical programs. Another comes from the VAX-11/780. The INDEX instruction is used to calculate the address of an array element while at the same time checking to see that the index fits in the array bounds. This is clearly an important function to accurately detect errors in high-level language statements. We found that for the VAX-11/780, by replacing this single "high-level" instruction by several instructions (COMPARE, JUMP LESS UNSIGNED, ADD, MULTIPLY) that we could perform the same function 45% faster! Furthermore, if the compiler took advantage of the case where the lower bound was zero, the simple instruction sequence was 60% faster. Clearly, smaller code does not always imply faster code, nor do "higher-level" instructions imply faster code.

One of the criticisms of RISC is that new instruction sets require radical revisions of existing software bases. RISC advocates respond that a performance increase by a factor of two or possibly three times is worth the time spent modifying existing software.

RISC History

A number of experimental and commercial attempts have been made to build RISCs, both as microprocessors and by using discrete logic. In this article I will focus on the experience of the Berkeley RISC project, which has built two separate RISC microprocessors and is currently planning a third.

Recent RISC history extends back to the IBM 801 project. In 1975 the 801 was originally designed as a minicomputer. It was thought of as a simple alternative to the more complex IBM 360 and 370 mainframe architectures. While no public performance figures are available on the 801, reports indicate that it could execute about 10 mips (million instructions per second). This compares quite favorably to the IBM 370/168 (2.4 mips) and the IBM 3033 (5 mips).

The design of the 801 began after an analysis of trace tapes (measurements of instructions actually executed by a computer) at the IBM Watson Research Center indicated that relatively simple instructions such as LOAD, STORE, ADD, SUB, and BRANCH are used much more frequently than complex instructions (see reference 2).

IBM is still carrying on the 801 research. Several implementations have been done in VLSI, and several reports indicate that IBM might offer a commercial product based on the technology.

A group of Stanford faculty and students is also experimenting in RISC design. The microprocessor is known as the MIPS machine (microprocessor without interlocked pipe stages). While the Berkeley RISC group has used off-the-shelf compilers, the MIPS group has focused its attention on compiler technology, using software solutions to several traditional hardware problems such as pipeline interlocks (data dependencies that force one stage of a pipeline to wait for results from another stage). See the text box for further information.

In addition to these research projects, a number of companies are reported to be carrying out their own RISC research; several have RISC-designed computers already on the market. In addition to IBM, the companies TRW, Fairchild Semiconductor, Hewlett-Packard, and DEC have research efforts under way, and Pyramid Technology and Ridge Computer already have introduced RISC minicomputers. INMOS has announced a single-chip VLSI computer with on-board memory and a RISC instruction set. In the supercomputer class, Seymour Cray's designs have consistently adhered to the RISC philosophy.

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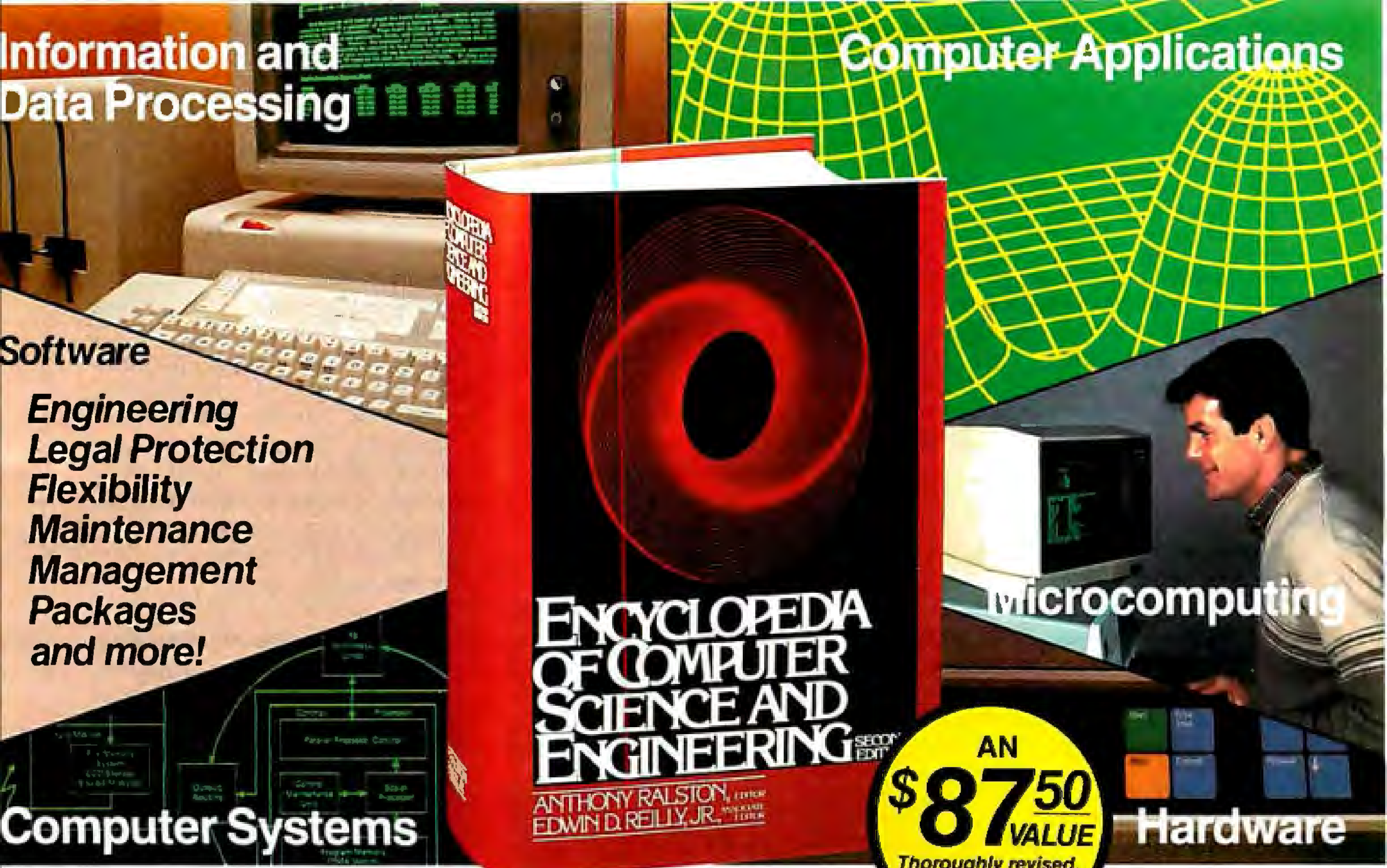

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The Berkeley and Stanford RISC groups are now working on several new designs. Students at Berkeley are completing final design work on SOAR (Smalltalk on a RISC). At Stanford, work is just beginning on MIPS-X, a microprocessor that is projected to have 10-mips performance.

ARCHITECTURAL DESIGN

The Berkeley RISC project largely grew out of the design ideas of David Patterson and Carlos Sequin. Patterson's thoughts about RISC developed after he spent a leave of absence at DEC where he gained experience with the difficulties facing VLSI computer designers. He realized that to build a computer like a VAX in VLSI, he would have to include a writable control store because of the near impossibility of perfecting the microprocessor's microcode.

Patterson recognized that most of the current 16-bit microprocessors had essentially replicated the design complexity of the PDP-11. Instead of following the DEC approach, he decided to put a point on the other end of the complexity curve.

From the first architectural studies in the spring of 1980, Berkeley faculty and graduate students began work on the design of a microprocessor known as RISC I. RISC I, a simple 32-bit NMOS (negative-channel metal-oxide semiconductor) microprocessor, was fabricated and tested by the summer of 1982. Because of a design error, it did not meet performance expectations. However, a second microprocessor, RISC II, exceeded them.

The initial design specification of the RISC project was based on the concept of a simple 32-bit architecture to both test the RISC hypothesis and allow the research group to shorten design time and reduce design errors. Shortened design time is not insignificant. Patterson estimates that it can be cut to as little as two years from the five years currently typical of a major commercial microprocessor.

The RISC architecture includes four important design constraints. The first is execution of one instruction per cycle; instructions are intended to be as simple and fast as microinstructions on computers like the VAX. (The LOAD and STORE instructions are the only operations that violate this single-cycle constraint; they take two cycles, adding an index register and an immediate offset during the first cycle and then performing the memory access during the next cycle, thereby allowing sufficient time for main-memory access.) Also, all instructions are the same size; this generally simplifies implementation. Third, system memory is accessed only with LOAD and STORE instructions; this also simplifies the system design and is well matched for a microprocessor optimized for keeping operands in internal registers. Finally, the RISC design was done with the idea of supporting high-level languages in mind.

The resulting microprocessor is a register-oriented NMOS design that has just 31 operation codes (shown in table 1) and supports 32-bit addresses and 8-, 16-, and 32-bit data. This design leaves floating-point calculations and instruction and memory caches to peripheral devices. The finished RISC II is a 41,000-transistor chip that is 25 percent smaller than RISC I, yet has 60 more registers and 39 operation codes. However, both

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THE SOFTWARE SOLUTION

The Berkeley RISC design isn't the only approach to building reduced instruction set computers. Computer scientists at the Center for Integrated Systems (CIS) at Stanford University have designed MIPS to do in software much of what RISC does in hardware.

Instead of taking up silicon area with a large bank of physical registers, MIPS attempts to keep operands in registers by using sophisticated compiler technology. This strategy leads to a smaller chip and a faster register set than in the Berkeley RISC design. John Hennessy (a Stanford professor who is one of the leaders of the MIPS design team) notes that the Berkeley and Stanford strategies are not mutually exclusive. In fact, a number of similarities exist in the two chips. Both RISC and MIPS have what is called a load/store architecture; this means that only load and store operations can access memory. Data can be operated on only when it is in a register.

What sets MIPS apart is the focus on compiler issues. "We attempt to get zero idle time in the pipeline," says Hennessy. "In practice, we get within 5 percent of that goal."

The MIPS compiler technology consists of several parts, including the relatively straightforward issue of code generation and more complex techniques such as instruction scheduling, branch scheduling, and instruction packing. A pipeline reorganizer that is part of the MIPS software system reorders sequences of MIPS instructions, packs instructions, and handles the effect of branch delays.

At the heart of the MIPS architecture is a dense five-stage pipeline composed of instruction fetch (IF), instruction decode (ID), operand decode (OD), operand store/execute (SX), and operand fetch (OF) components. MIPS allows packing of up to two instructions per 32-bit word; the combination of two operations per word and two cycles per instruction makes possible a peak rate of one operation per machine cycle.

The argument in favor of doing instruction reorganization in software instead of in hardware is that the performance price is paid for only once, at compilation time.

And what's the performance bottom line? Hennessy says that MIPS outperforms an 8-MHz Motorola 68000 by as much as a factor of five or six. What's next? Last May, work began on MIPS-X, a CMOS (complementary metal-oxide semiconductor) microprocessor projected to have 10-mips performance. MIPS-X will have an on-chip instruction cache, some support for multiprocessing, and possibly some sort of interprocessor communications facility.

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designs were fabricated at 2 microns (4 microns drawn gate length). RISC II was later resubmitted at smaller geometries of 1.5 microns. This version is reported to run at 330 nanoseconds per instruction with a 12-MHz clock and 1.8 watts power dissipation.

The RISC I microprocessor essentially consists of a large general-purpose register bank, a shifter, an ALU (arithmetic and logic unit), a set of program counter (PC) registers, data I/O (input/output) latches, the program status word (PSW) register, and the control section. The RISC I register bank has two independent buses (A and B) that are read-only and a bus C that is write-only.

The register bank bus architecture was redesigned in RISC II. The modification permits dual-port read accesses with single-bus signal sensing; however, both buses are required for a write operation. Each cell is about 2.5 times smaller than the three-bus RISC I register cell.

By visually examining a RISC microprocessor, you can see that, while the control section generally covers 50 to 60 percent of the total chip area in a commercial microprocessor like the Motorola 68000 or the Zilog Z8000, the control section covers only 6 to 10 percent of the RISC I or II chip area. Remarkably, the RISC II op-code decoder (equivalent to the microprogram memory in microcodable CPUs) occupies only 0.5 percent of the chip area, has only 7 percent of the transistors, and requires less than 2 percent of the design and layout time needed by CISCs.

Table 1: *Operating instructions for* RISC I. *Tables in this article are based on information from the Berkeley* RISC *project.*

Instruction	Definition	Operands	Comments
ADD	integer add	Rs,S2,Rd	Rd←Rs + S2
ADDC	add with carry	Rs,S2,Rd	Rd←Rs + S2 + carry
SUB	integer subtract	Rs,S2,Rd	Rd←Rs – S2
SUBC	subtract with carry	Rs,S2,Rd	Rd←Rs – S2 – carry
SUBR	subtract with carry	Rs,S2,Rd	Rd←S2 – Rs
SUBCR	subtract with carry	Rs,S2,Rd	Rd←S2 – Rs – carry
AND	logical AND	Rs,S2,Rd	Rd←Rs & S2
OR	logical OR	Rs,S2,Rd	Rd←Rs | S2
XOR	logical EXCLUSIVE OR	Rs,S2,Rd	Rd←Rs xor S2
SLL	shift left	Rs,S2,Rd	Rd←Rs shifted by S2
SRL	shift right logical	Rs,S2,Rd	Rd←Rs shifted by S2
SRA	shift right arithmetic	Rs,S2,Rd	Rd←Rs shifted by S2
LDL	load long	(Rx)S2,Rd	Rd←M[Rx + S2]
LDSU	load short unsigned	(Rx)S2,Rd	Rd←M[Rx + S2]
LDSS	load short signed	(Rx)S2,Rd	Rd←M[Rx + S2]
LDBU	load byte unsigned	(Rx)S2,Rd	Rd←M[Rx + S2]
LDBS	load byte signed	(Rx)S2,Rd	Rd←M[Rx + S2]
STL	store long	Rm,(Rx)S2	M[Rx + S2]←Rm
STS	store short	Rm,(Rx)S2	M[Rx + S2]←Rm
STB	store byte	Rm,(Rx)S2	M[Rx + S2]←Rm
JMP	conditional jump	COND,S2(Rx)	pc←Rx + S2
JMPR	conditional relative	COND,Y	pc←pc + Y
CALL	call and change window	Rd,S2(Rx)	Rd←pc, next pc←Rx + S2, CWP←CWP – 1
CALLR	call relative and change window	Rd,Y	Rd←pc, next pc←pc + Y, CWP←CWP – 1
RET	return and change window	Rm,S2	pc←Rm + S2, CWP←CWP + 1
CALLINT	disable interrupts	Rd	Rd←last pc; next CWP←CWP – 1
RETINT	enable interrupts	Rm,S2	pc←Rm + S2; next CWP←CWP + 1
LDHI	load immediate high	Rd,Y	Rd<31:13>←Y,Rd <12:0>←0
GTLPC	to restart delayed jump	Rd	Rd←last pc
GETPSW	load status word	Rd	Rd←PSW
PUTPSW	set status word	Rm	PSW←Rm

The Berkeley RISC uses the area freed by the absence of a large instruction set for a bank of 32-bit registers intended to minimize access of system memory. These registers are used in an innovative window-register scheme described below. The RISC philosophy also claims that it makes more sense to use silicon area to implement an instruction cache than the complex control circuitry necessary for a large microprogram ROM. However, the instruction cache was dealt with as a separate device to keep the scale of the first experimental RISC chips small.

RISC'S INSTRUCTION SET

While initially it seems plausible that complex instruction sets offer better support for high-level languages, RISC advocates have conducted experiments indicating that simple instructions are the most frequently executed. This statistical evidence in favor of simple instructions, coupled with the facts that sequences of simple instructions often run as fast or faster than corresponding complex instructions and that microcoded control can be slower than hard-wired control, makes it logical to consider supporting high-level languages by translating simple high-level language operations directly into machine instructions and translating more complicated high-level functions into machine-language subroutines.

Additional simplicity is gained by using only two addressing modes, in-

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dexed and PC-relative. More complicated addressing modes can be synthesized from these if desired.

Most of the Berkeley RISC II's 39 instructions are simple ALU and shift operations on registers. Instructions, data, addresses, and both RISC I and II registers are 32 bits wide. A fixed width simplifies instruction fetching and sequencing. Additionally, the instruction format is simple, with fields in fixed locations to speed instruction decoding. As a consequence, register access can take place at the same time as op-code decoding.

PIPELINE

Both RISC I and II have pipelined architectures. RISC I has a simple two-stage pipeline that overlaps the instruction fetch and execution phases. RISC II introduces a third pipeline stage. In this version the process of writing to a destination register has been delayed until that stage. The advantage of the fixed RISC instruction format is that register operands always appear in the same place in the 32-bit word. Therefore, register access can take place simultaneously with op-code decoding, effectively shortening the pipeline (see figure 1).

While pipelined architectures on commercial machines generally use complex schemes to avoid delays incurred as a result of jump instructions, the RISC goal of simplicity has led to the choice of a "delayed branch" technique. Berkeley RISC redefines jumps so they do not take effect until after the following instructions. This insures that the RISC can always prefetch the next instruction while the current one is being executed.

It is possible for a compiler to further optimize the branch by rearranging instructions so the cycle after the delayed branch can be used more than 90 percent of the time. This avoids having to insert a NOP (no operation) instruction at this point.

REGISTER WINDOWS

Although the Berkeley researchers didn't focus on compiler technology to the same degree that the Stanford MIPS designers have, they developed a hardware design intended to keep operands in registers in order to significantly increase the speed of microprocessor operations. A block of CPU registers is the fastest storage option because it is on the same chip with the CPU and because addressing is done with a shorter address than for cache or memory.

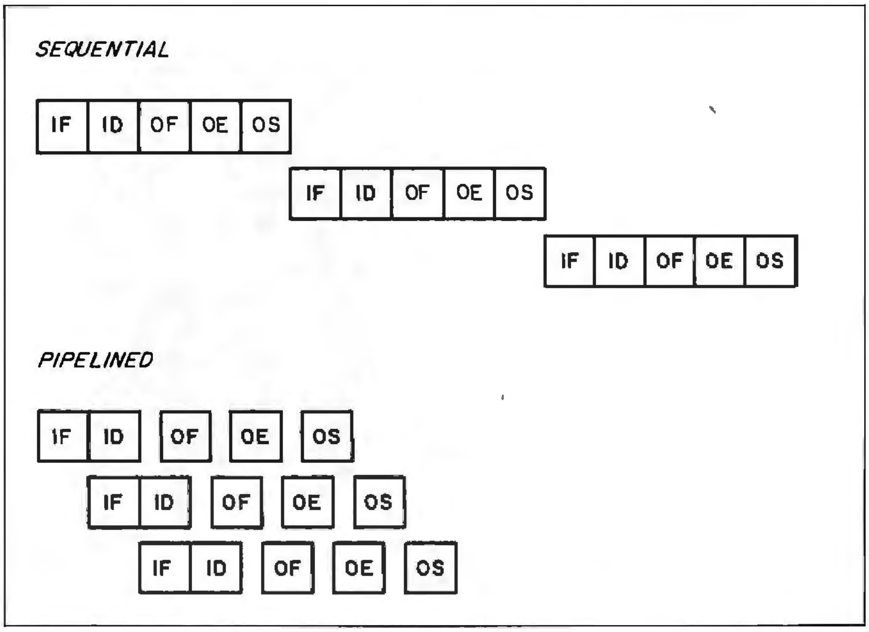

Figure 1: *Sequential versus pipelined execution. Pipelined execution gives a peak performance of one instruction per step. The five steps here refer to the steps of instruction execution: instruction fetch* (IF), *instruction decode* (ID), *operand fetch* (OF), *operand execution* (OE), *and operand store* (OS).

The Berkeley solution is to have a number of sets of registers (referred to as windows) to insure that local variables and parameters are always immediately available in registers. This solution avoids the time-consuming process of saving the state of a bank of registers to slower system memory on every procedure call and then restoring the original parameters on every return.

Thus, when a procedure call takes place in both the RISC I and II architectures, the processor is automatically switched to a new set of registers. To further optimize this architecture's performance, an overlapping window arrangement is employed (see figure 2). Because different windows overlap, operands are automatically passed, so it is not necessary for procedures to pass values between registers.

The Berkeley register-window design has already achieved at least limited commercial acceptance. Pyramid Technology's 90x processor uses register-window design architecture.

The window-based register design is vital to a RISC because procedure calls are time-consuming, and RISC designs create more procedure calls than CISCs do. This is because complex instructions are implemented as subroutines in RISC designs, rather than as single op codes as in CISCs.

One potential problem faced by the register-window scheme is nesting of procedures. If the nesting depth is large enough, the RISC architecture handles the overflow condition by creating an additional stack in system memory.

According to the Berkeley designers, the effectiveness of this idea depends on the relative frequency of register overflows and underflows. Two students did a study on the project indicating that with eight register

(continued)

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windows, overflow occurs in less than 1 percent of the calls (see reference 3). This study, done early in the RISC project, involved the dynamic measurement of the number of arguments and local scalar variables for a given procedure and similar measurement of locality property of procedure-nesting-depth. The students measured a C compiler, Pascal interpreter, UNIX troff typesetter, and six smaller nonnumeric programs written in C.

In practice, not all the physical registers are visible to the machine-language programmer at any given time. Instead, one window designated "the current window" is available. Within each window are two types of registers. Some registers belong only to a single window and are referred to as "locals." Other registers belong to two windows simultaneously and are called "overlap registers." These registers are divided into high and low sets. The high registers contain parameters passed from "above" the current procedure, while the low registers contain parameters that will be passed to procedures "below" the current procedure. Finally, RISC I and II have a set of registers called "global" that are always visible regardless of which window is current. A register window in the RISC II design contains 6 overlapping registers, 10 local registers, and 10 global registers.

In the sample RISC register window in figure 3, registers 26 to 31 contain parameters that have been passed from the calling procedure. The local registers are 16 through 25. These are used for local scalar storage. Low registers 10 through 15 are used for parameters passed to the called procedure. By changing only the pointer to the current window, it is possible to immediately pass parameters between procedures. Registers 0 through 9 are always visible regardless of which register window is current.

Overflow and underflow conditions are handled by associated circuitry and with a trap to a software routine that adjusts the procedure stack in memory.

The performance advantage of this design is impressive. Overlapped

(continued)

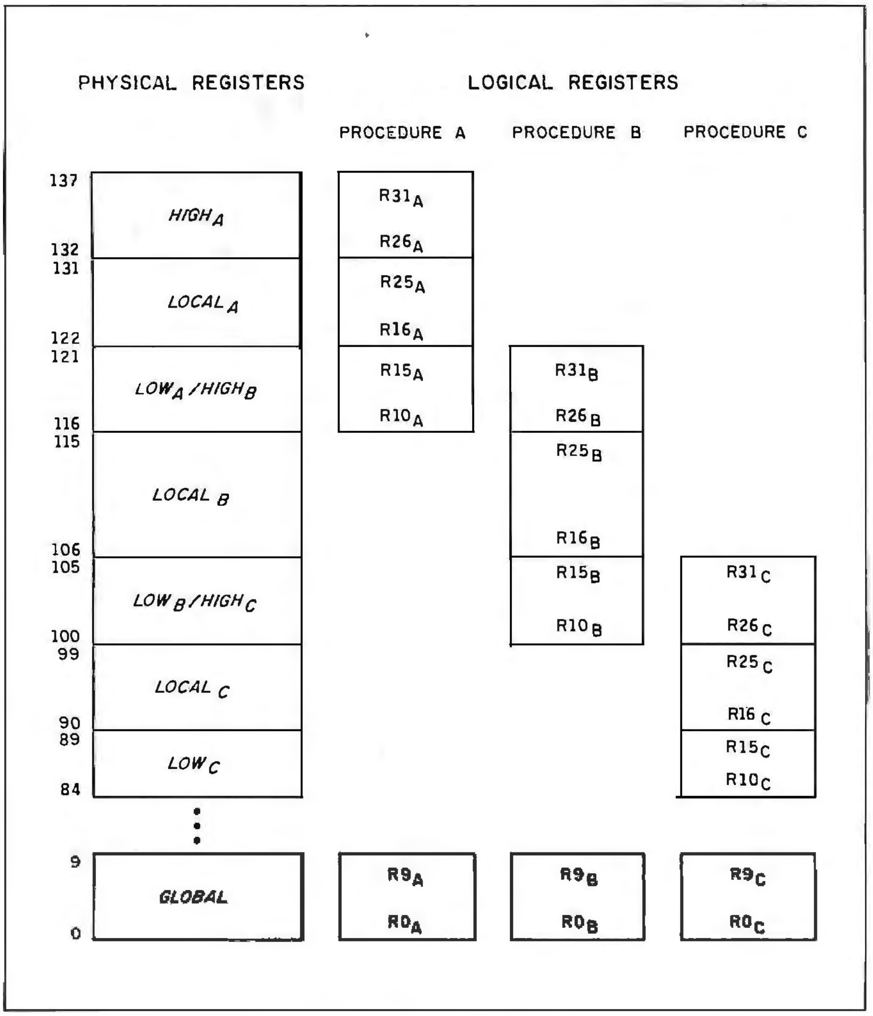

Figure 2: *Three overlapped register windows in* RISC I.

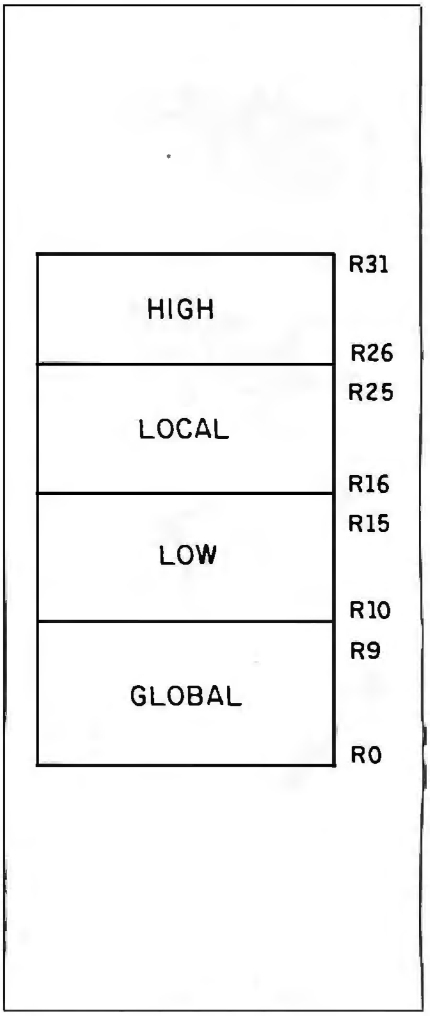

Figure 3: RISC *register windows.*

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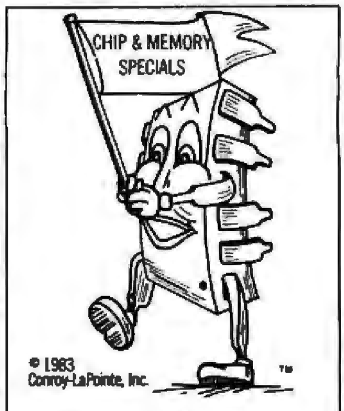

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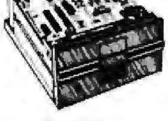

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register windows give the Berkeley RISC design a typical call time of 2 microseconds versus the 20 microseconds typical of a call on the VAX-11/780 (see reference 4). Additionally, register windows reduce the total accesses to system memory by a factor of two.

It is interesting that one of the criticisms of the Berkeley RISC project has been that RISC performance actually comes from the register-oriented basis of the RISC design rather than the RISC architecture itself. The Berkeley group has responded by agreeing that a significant portion of the speed is due to the overlapped register window. However, the group notes that critics have ignored a key point in the design—that a drop in the control logic area due to the reduced set of instructions (from 50 percent to 6 percent) created space for the expanded number of registers in the first place.

DESIGN TOOLS

In many ways, the tools created to design the Berkeley RISC microprocessors are as significant as the new design philosophy inherent in RISC. These tools have enabled a small group of faculty and graduate students, using the Mead-Conway VLSI NMOS design rules and with access to corporate silicon foundries over the ARPAnet, to construct working microprocessors that rival commercial designs in performance. Many of these tools are now available in the public domain, making VLSI design projects more readily accessible than most people realize. The Berkeley RISC project's decision to choose a simple and regular design has also led to shortened design cycles and chips that function in first silicon.

The principal design tool available to the RISC project was a color graphical layout editor called Caesar, created by Berkeley professor John Ousterhout. Caesar runs on DEC VAX computers under the Berkeley 4.1 version of UNIX and is widely in use in university and corporate research centers. Caesar is not an intelligent system. It does not understand design rules, electrical properties, or connectivity. It functions primarily as a geometry editor that lets the designer create pictures of VLSI circuits and then integrate them into more complex circuits.

A variety of tools (designed by a group that Ousterhout led) were used to check the layout after it was created, including Drc, a program that checks for layout errors; SPICE, a low-level circuit-simulation language; and Crystal, a high-level timing verifier that analyzes the performance of VLSI circuits.

Future design work at Berkeley will be done with an advanced layout editor called Magic that Ousterhout's group is now designing. This tool will permit intelligent operations such as automatic routing of connections between different devices and "plowing," or altering a portion of a design while maintaining layout rules and connectivity.

RISC PERFORMANCE

The bottom line on RISC architecture is actual performance, and this is difficult to ascertain because the Berkeley RISCs have not yet been integrated into complete microcomputer systems. However, preliminary studies and projected benchmarks indicate that RISC designs yield performance benefits as well as cost/performance benefits.

While the operating speed of RISC I was originally expected to be 7.5 MHz, its actual speed was much slower: only 1.5 MHz. The Berkeley RISC designers attributed this to their inexperience as VLSI designers; they concentrated principally on logical correctness rather than circuit speed. Subsequent tests indicated that the design errors would have limited the performance of RISC I to 4 MHz and that problems with the implementation of only a few instructions were limiting actual performance.

A RISC I test board was assembled, including memory, I/O, and memory management. Comparative performance tests measuring the first version of RISC against commercial systems (see table 2) indicate that it can run a series of programs a little faster than a series of microprocessors can.

RISC II results have been much more promising. Because of added experience and the use of more sophisticated design tools, RISC II ran much closer to original predictions. The predicted cycle time execution of a register-to-register instruction had been 480 nanoseconds (8-MHz clock). Actual RISC II performance was 500 nanoseconds per instruction. The RISC II submitted with smaller geometries runs at 330 nanoseconds per instruction (12-MHz clock).

According to Patterson, "Benchmark simulations show that even at 500 nanoseconds, RISC II runs integer C programs faster than an 8-MHz iAPX 286, 10-MHz NS 16032, 12-MHz 68000, or 18-MHz HP 9000." (See reference 5.)

C-compiler benchmarks on both the RISC II (simulated) and the VAX-11/780 have determined that the RISC II compiles faster (see table 3).

To date, the results of all the RISC experiments have been positive. During the next few years, RISC architecture should have an opportunity to

(continued)

Table 2: *Execution time of four microprocessors on four programs.*

Machine	Speed		Language	Time (milliseconds)			
	MHz	wait states		search	sieve	puzzle	acker
8086	5	0	Pascal	7.3	764	44000	11100
432	8	4	Ada	4.4	978	45700	47800
68000	8	2	C	4.7	740	37100	7800
Average				5.5	827	42300	22200
RISC I	1.5	0	C	2.5	698	23500	16000

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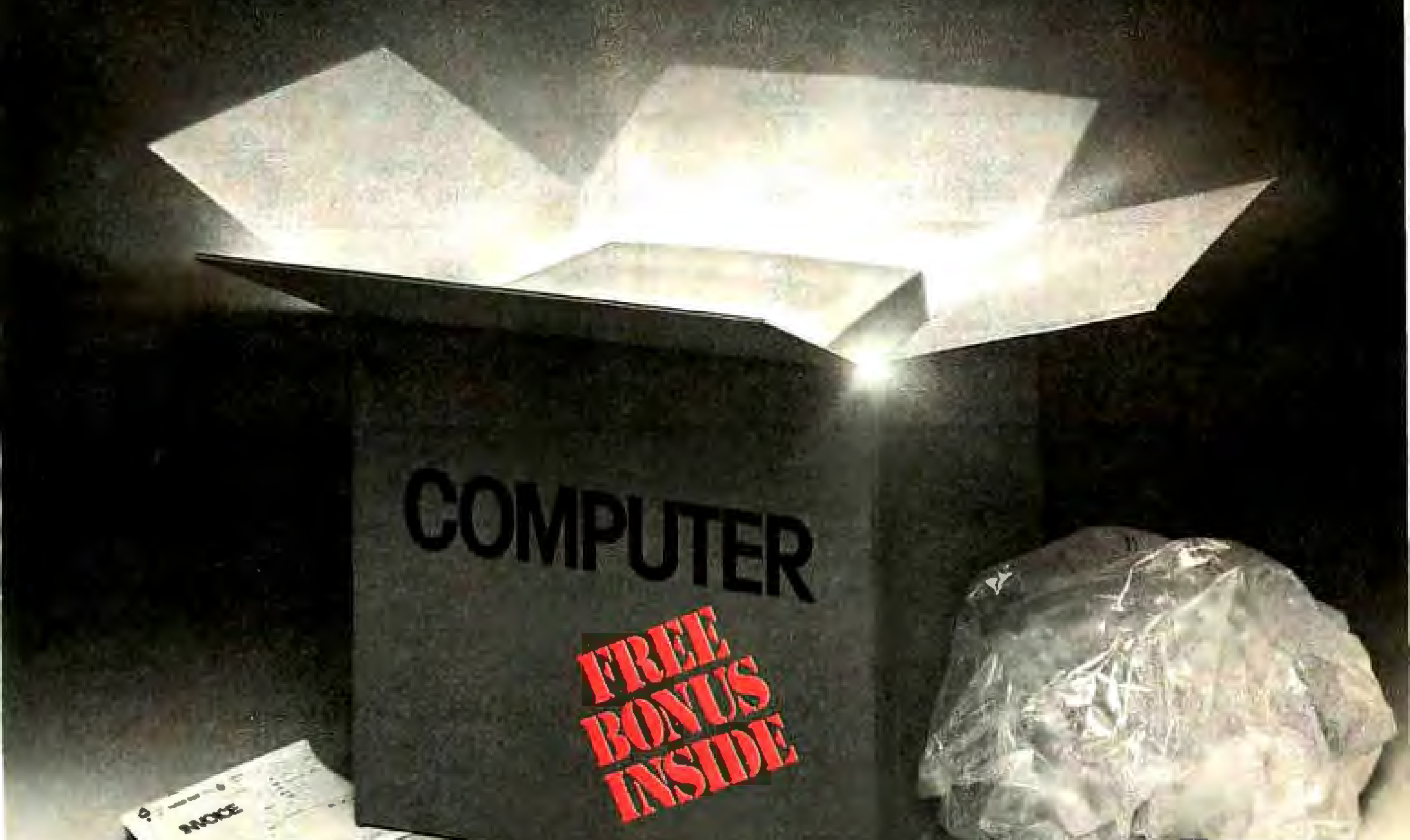

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Table 3: UNIX C *compile-time benchmarks.*

Compiled Program		VAX-11/780 C Compiler					RISC C Compiler				
					VAX					VAX	
	size	on VAX	on RISC		RISC		on VAX	on RISC		RISC	
name	(lines)	(secs)	8MHz	12MHz	8	12	(secs)	8MHz	12MHz	8	12
ld.c	1587	27.9	21.0	13.9	1.3	2.0	35.2	22.4	14.8	1.6	2.4
sort.c	873	17.4	13.2	8.7	1.3	2.0	20.0	13.2	8.7	1.5	2.3
puzzle.c	118	5.2	3.6	2.4	1.4	2.2	7.3	4.8	3.2	1.5	2.3
Total	2578	50.5	37.8	25.0	1.3	2.0	62.5	40.4	26.7	1.5	2.3

prove itself in the commercial marketplace.

SOAR

Another criticism leveled at RISC architecture is that it is appropriate only for certain high-level languages. RISC I and II and Stanford MIPS have shown that RISC does provide superior performance in C and Pascal. In order to test the applicability of RISC to other language environments, the Berkeley RISC project has begun work on microprocessors tailored for those environments.

SOAR is a 35,000-transistor 32-bit NMOS microprocessor designed to execute the Smalltalk-80 language at performance levels comparable to a Xerox Dorado, a powerful, single-user ECL (emitter coupled logic) minicomputer that sells for more than $100,000.

The SOAR design was scheduled for fabrication in September of 1984 and projected performance micro-benchmarks range from 41 percent to 580 percent of the Dorado's performance.

CONCLUSION

RISC design principles fit well with the "small is beautiful" philosophy of the personal computer industry. In fact, RISC design at Berkeley and Stanford proves that successful VLSI microprocessor design work can be done on a shoestring, without the resources of the semiconductor industry.

According to the Berkeley RISC designers (see reference 6):

> The bottom line of the RISC I effort is that students as part of the graduate curriculum designed and evaluated an architecture, learned Mead/Conway design, built new CAD tools, and tested their design. The end product, a 44,500-transistor integrated circuit, has one minor design error, worked on the first good silicon, and runs programs faster than commercial microprocessors. ■

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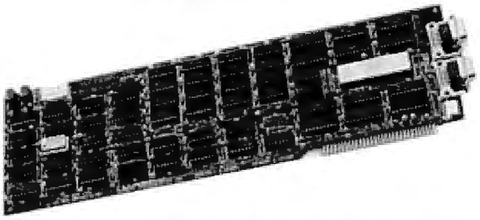

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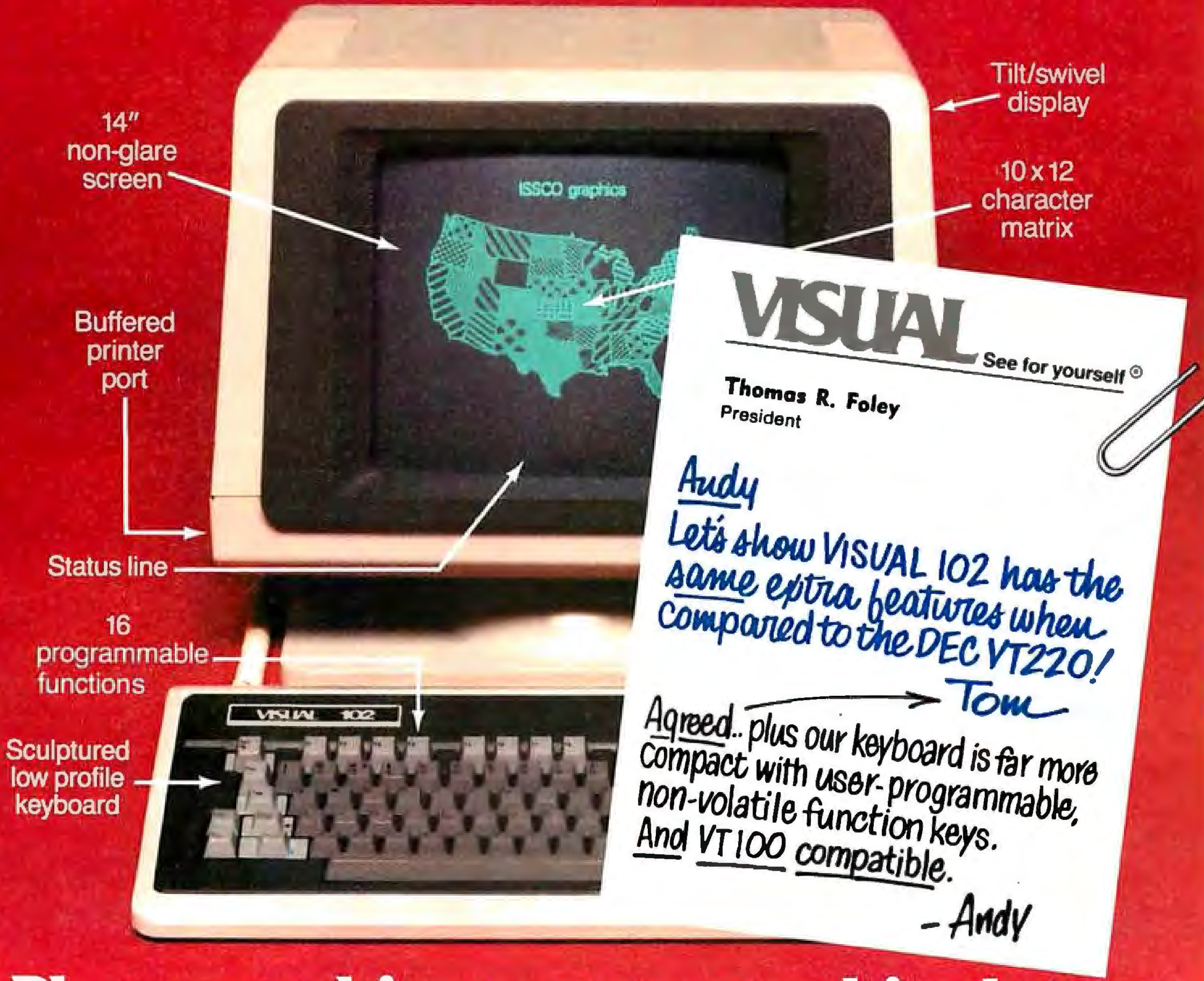

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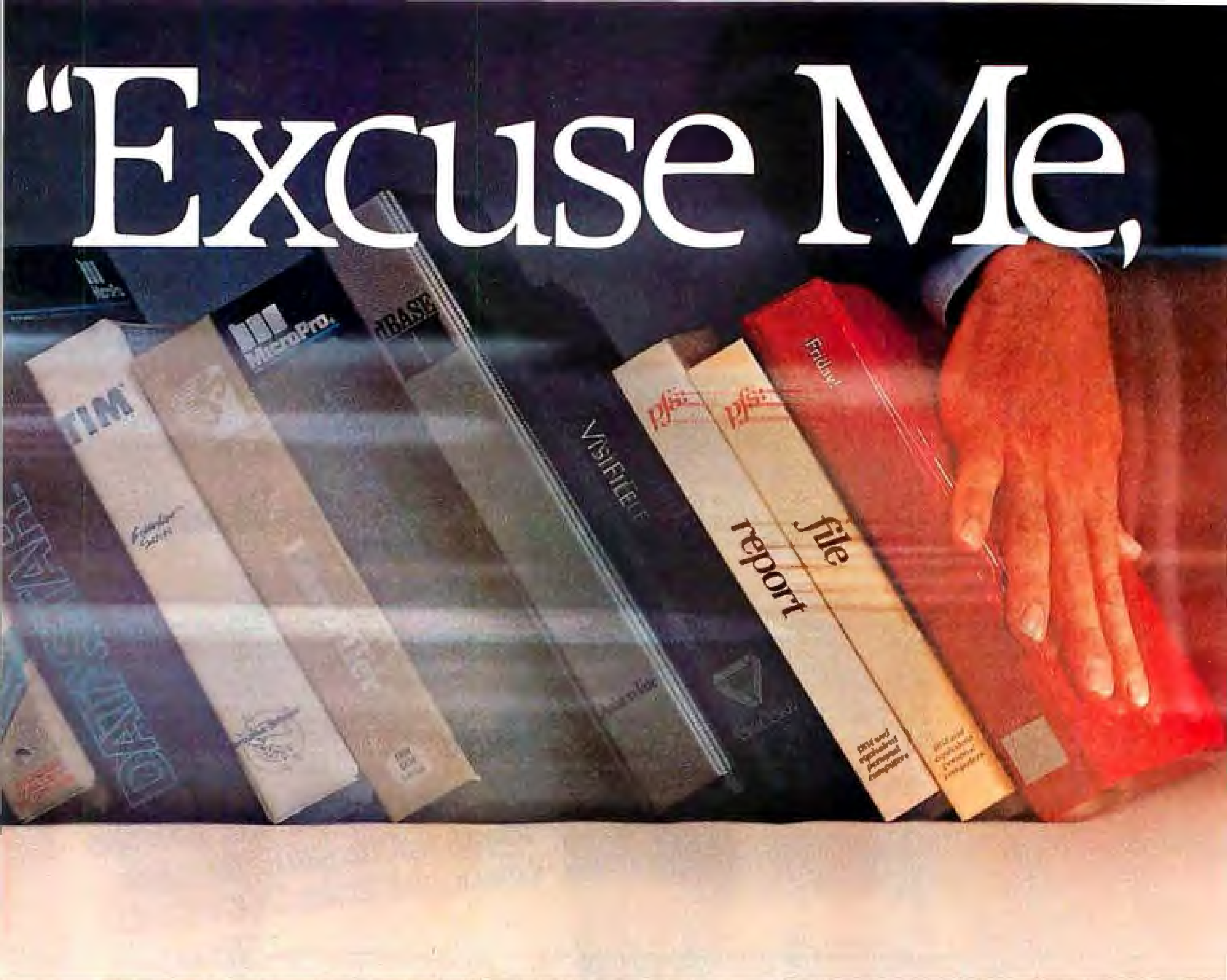

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GALLIUM ARSENIDE CHIPS

BY PHILLIP ROBINSON

A high-speed IC *material gets ready to go*

VIRTUALLY ALL microelectronics chips are based on silicon. Ever since silicon trounced germanium in the transistor market, silicon has been the only practical material for devices ranging from SSI (small-scale integration) to VLSI (very-large-scale integration).

However, silicon has a new rival—gallium arsenide (GaAs). GaAs has the physical properties to be a material that's faster and requires less power than silicon. While it has been the preferred material for a few devices, such as microwave transistors and LEDs (light-emitting diodes), it wasn't until the 1980s that GaAs became a practical foundation for ICs (integrated circuits). A recent series of events moved GaAs technology into the commercial sphere.

First, the United States military decided that signal processing and complex design computation required a leap in processing speed that silicon ICs would be hard-pressed to provide. When the engineers looked at GaAs and realized that it not only provided higher speed than silicon but also vastly improved radiation resistance, higher operating temperatures, and lower power dissipation, they knew they had to have it.

The second factor that turned the spotlight on GaAs was the telecommunications market's desire for higher-frequency devices. If GaAs was used for simple discrete devices, why couldn't complete circuits be fabricated upon it? The DBS (direct broadcast satellite) dreams of entrepreneurs played a role here. Using silicon amplifiers, a home owner would need a huge antenna (larger than a house roof, by some estimates) to receive television signals directly from a satellite. GaAs IC amplifiers, on the other hand, hold out the promise of an antenna only a meter or so wide.

Also, the telecommunications firms knew fiber optics would be invading more of their fiefdom. GaAs has been the major LED material for many years and has been the substance of choice for integrated semiconductor lasers. The idea of an integrated repeater—laser, amplifier, and digital processing circuitry all on the same chip—occurred to quite a few designers. Such a construction would be vital to a fiber-optics network: every link between fibers could use such a repeater.

The final impetus for GaAs came from the world of commercial supercomputers. GaAs offered chips that would be five to seven times faster than the best silicon devices while consuming equal or less power. Supercomputer manufacturers were all keeping an eye on the improvements in GaAs technology. And just when some of those firms made plans to include GaAs in a future system, the other shoe dropped.

That shoe was the Josephson junction. A superconducting device, the Josephson junction switches in picoseconds (ps) and uses a minute amount of power. Unfortunately, Josephson junctions operate only at supercold temperatures (only a few degrees above absolute zero). That made them very difficult to manufacture. IBM was the largest Josephson

(continued)

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

investigator, and Big Blue had openly predicted that supercomputers would be built with these devices. Then, in late 1983, IBM announced it was canceling its Josephson project. Interest in GaAs exploded.

PHYSICS AND PROCESSING OF GAAS

Silicon has dominated IC manufacture because it yields good performance devices and is easily refined and processed. An important example of that processing simplicity is the use of silicon dioxide for insulation. Many places on a chip require an insulating layer between or within devices. Silicon dioxide, an excellent insulator, grows on hot silicon without requiring intricate chemical processing. GaAs doesn't provide any simple insulating process and must rely on complicated depositions for insulation.

But GaAs lab work in the past decade has made GaAs processing practical, if not as simple as silicon processing. In fact, the same equipment that IC manufacturers use for silicon needs only slight modification to be used for GaAs. And now that GaAs is practical, designers don't have to live with silicon's disadvantages.

The first major disadvantage of silicon, in comparison to GaAs, is its speed. Silicon microprocessors accomplish their simplest tasks in microseconds. That corresponds to an operating frequency of as much as 10 or 20 megahertz (MHz). If faster, though less space-efficient, technologies are used to manufacture the transistors on the chip—such as bipolar bit-slice chips—silicon can go as fast as 100 MHz with the simplest actions taking nanoseconds (ns).

This isn't fast enough for all applications. Solutions that require huge numbers of calculations (the most famous example is weather forecasting) cannot be accomplished with current computers because those computers just aren't fast enough. Also, some real-time computing problems, such as controlling complicated machines, require answers in such a hurry that silicon chips are hard-pressed to do the job. But because of its "energy-band" structure, GaAs is nearly ideal for ICs: electrons in it are very "light" and can move very quickly. This is true of many of the compounds known as III-V materials (so called because of the position in the periodic table of the compounds' components). GaAs is the best known of the III-V semiconductors. Others, such as indium phosphide and indium antimonide, also hold great promise as foundations for microelectronic devices.

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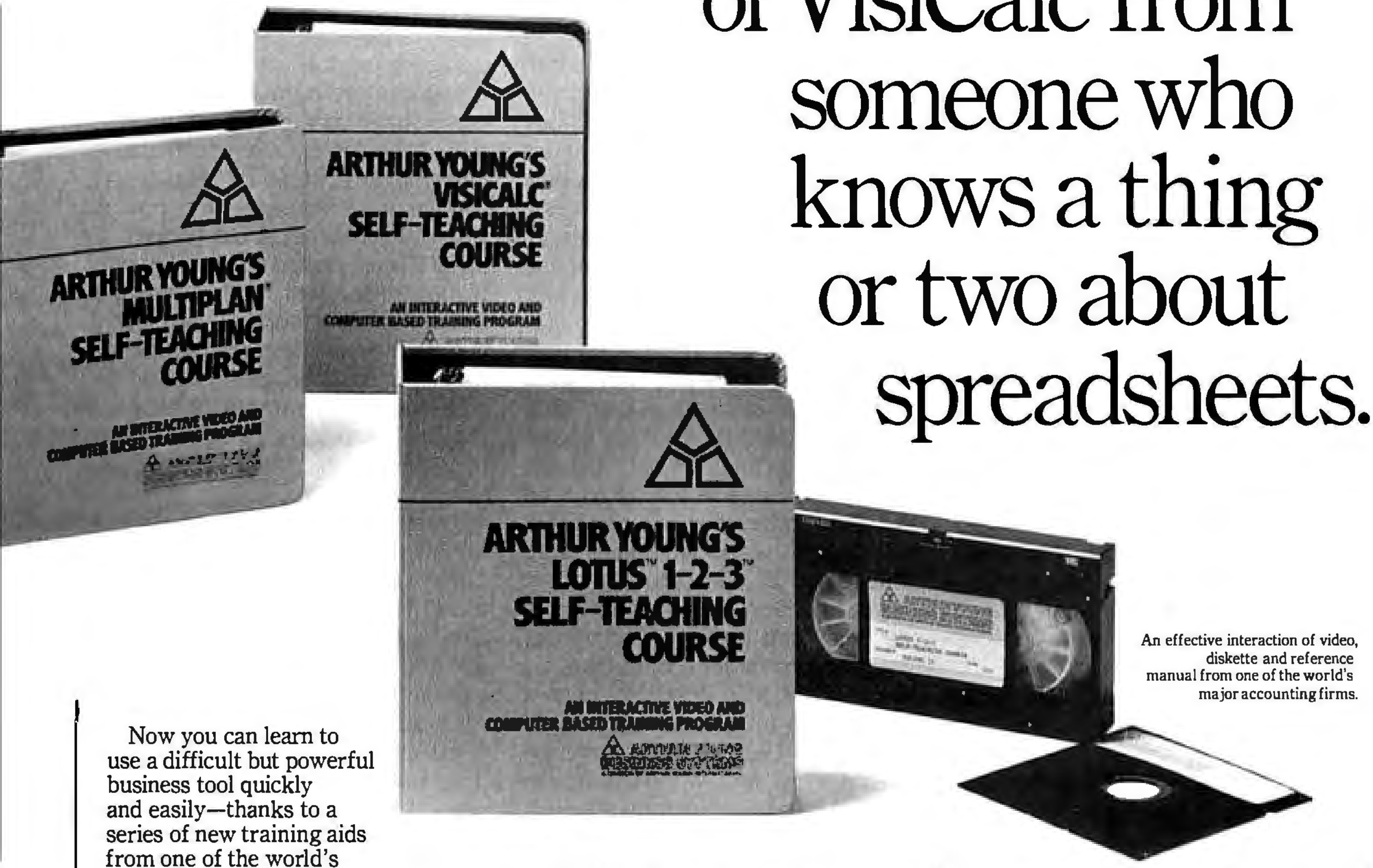

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In essence, the effective mass of the GaAs electron is only 7 percent of what it is in silicon. That means GaAs can be up to five times faster than the fastest silicon chip. GaAs electron mobility ranges from 1.4×10^7 to 5×10^7 centimeters per second (cm/s) while silicon electron mobility is approximately 6×10^6 cm/s. In the end, silicon devices struggle to run at 200 MHz, while GaAs just gets going at 2 gigahertz (GHz).

Another major advantage of GaAs is that, when properly manufactured, it is a better insulator than silicon, which helps isolate devices on the chip from each other and reduces parasitic capacitance. (Parasitic capacitance limits how close transistors can be to one another; a large amount of parasitic capacitance slows the chip down.)

Gallium arsenide is also very radiation-hard, and so it is good for military and space applications. It can withstand 10^7 to 10^8 rads; silicon takes only 10^3 to 10^4 rads. GaAs also has a wide working-temperature range (from −200 to +200 degrees Celsius) because of its wider energy band gap. Special processing techniques can be used to make GaAs chips that run as hot as 300 or 400 degrees Celsius.

Standard microprocessors, such as the 8088 used in the IBM Personal Computer, are built out of silicon NMOS (negative-channel metal-oxide semiconductor) transistors. The fastest silicon chips use ECL (emitter-coupled logic), a bipolar technology that consumes a lot of energy and is more expensive than NMOS. The heat generated by ECL chips becomes a major problem in computer design, requiring extensive cooling apparatuses and packaging innovations. Silicon CMOS (complementary metal-oxide semiconductor) became popular during the 1980s and offers much lower power dissipation than ECL. CMOS has been traditionally known as a "slow" technology, but when the devices are made very small and run at higher power, they can run faster. Still, CMOS uses about 5 times more voltage and 25 times more dynamic power than GaAs. Figure 1 compares the delay and power dissipation of several types of semiconductors.

Just as in silicon, there are quite a few ways to make a transistor on a GaAs wafer. The three most common GaAs devices are D-MESFETs (depletion-metal semiconductor field-effect transistors), E-MESFETs (enhancement-MESFETs), and HEMTs (high electron-mobility transistors). GaAs won't grow a regular planar-oxide, so standard MOSFETs (metal-oxide-semiconductor FETs) cannot be built on it.

Currently, the most mature technology is the D-MESFET. E-MESFETs and HEMTs are not yet ready for commercial markets. D-MESFETs have a depletion region (depleted of electrons) and are normally on. Positive bias voltage on the gate reduces the size of the depletion region; negative gate voltages extend it. The negative voltage may increase to the point where the channel is pinched off. E-MESFETs are doped to cut off the depletion region with no bias voltage; thus, they are normally off. That means they use less power than D-MESFETs. Positive bias voltage on the gate increases the size of the channel. D-MESFETs require two power supplies while E-MESFETs require only one.

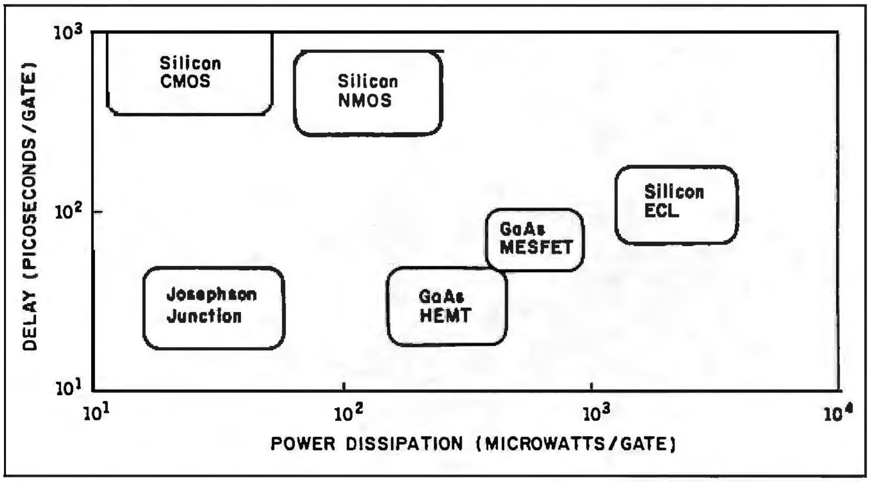

Figure 1: *A comparison of the delay and power dissipation of several semiconductor types.*

If they consume less power than D-MESFETs and need only a single power supply, why aren't E-MESFETs used? For one thing, they draw excessive gate current if gate voltage is above 0.7 volt, so the pinch-off voltage must be controlled very exactly. Also, surface depletion regions that appear between the gate, source, and drain lower the efficiency of the transistor. The gate area can be recessed, but that complicates manufacturing.

HEMTs perform better than E-MESFETs, particularly at low temperatures. HEMTs are superlattice heterojunctions—multiple, extremely thin layers of GaAs and GaAlAs (gallium aluminum arsenide, a solid solution of the three elements). The foundation of the device is an undoped GaAs channel with a GaAlAs doped layer between channel and gate. Electron mobility in the channel is higher because there are no dopant ions to scatter current carriers. HEMTs turn on very quickly because they reach full transconductance with a gate-logic voltage only slightly above the threshold voltage. HEMTs, however, are more difficult to fabricate than MESFETs, and the required processes—such as MBE (molecular beam epitaxy)—don't adapt easily to mass production.

The Supercomputer Chase

It is no secret that supercomputer makers are depending on GaAs for some of their future speed improvements. Cray Research, the premier

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supercomputer maker, plans to use GaAs for the central processing unit in a future computer. Fujitsu is also planning to use GaAs. Fujitsu, NEC, Hitachi, and Mitsubishi are making GaAs chips for the Japanese Ministry of International Trade and Industry supercomputer project.

Fujitsu has announced it will use GaAs in its own supercomputers, and, because Fujitsu owns a portion of Amdahl, the chips may turn up in Amdahl systems, too.

Fujitsu has developed two HEMT GaAs chips. HEMT structures must be cooled to 77 degrees Kelvin for best results, not as cold as Josephson junctions. At such temperatures, and with a small (0.4 volt) logic swing, HEMT gate arrays should switch in 30 ps and use only about 150 microwatts. HEMT chips with 1-micron gates and running at room temperature are about 25 percent faster than MESFET chips. Fujitsu foresees an HEMT computer running with a 2-ns clock. Today's supercomputers have clocks that run at approximately 10 ns. Still, HEMT chips are in the labs only and are hard to fabricate. The thin layers, made by MBE, are difficult to control and slow to build.

In February of 1983, Fujitsu announced an experimental HEMT 1K-bit SRAM (static random-access read/write memory), and then in February of 1984 it announced an experimental 4K-bit SRAM. The former is one of the fastest HEMT chips announced, with 0.9-ns access time at −196 degrees Celsius. The latter has been tested at 3-ns access time—twice the speed of comparable silicon chips. Typical 1K-bit silicon ECL SRAM access times are 15, 20, or 24 ns. The newest commercially available 4K-bit ECL SRAMs have about the same access times.

The 4K-bit GaAs SRAM also uses only 700 milliwatts. That is only one-third the power needed by a comparable silicon chip. In some cases the peripheral circuitry on these chips uses 85 percent of the power even though it takes up only 15 percent of the total device count.

The Fujitsu chips have all been described in conferences and journals. They are not available for purchase. The only GaAs chips Fujitsu sells are its GaAs FETs.

Cray indicates it will be using some GaAs in a supercomputer; however, it has published very little on this subject. As is true of many of the supercomputer designs, GaAs chips won't make up all or even a majority of the system. Instead, these expensive jewels will be used where they can give an economically justifiable boost to performance—namely, in the central processor as ALU (arithmetic and logic unit) chips, cache and microcode memories, clock components, and the like.

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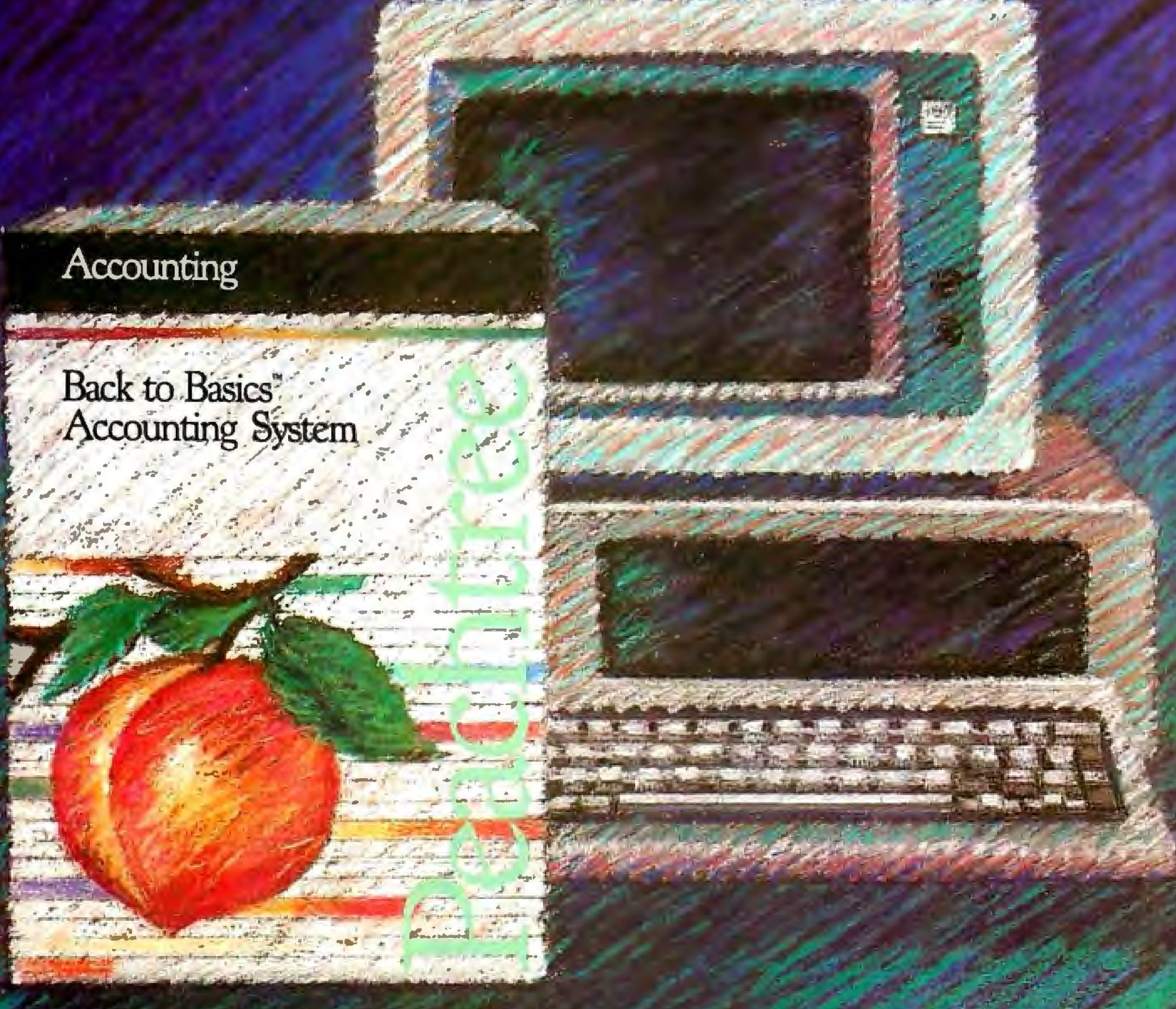

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Cray is building a GaAs research and development facility and is investing nearly $100 million in the next three years to build the Cray-3 supercomputer (which industry observers expect will use eight GaAs processors). Cray is even making its own GaAs chips to lessen its dependence on Japanese suppliers.

MILITARY APPLICATIONS

Military applications demand many of the physical advantages of GaAs. The speed is vital for everything from complex weather forecasting to real-time signal processing. The radiation resistance is crucial for satellites and for hardening electronic equipment against the threat of an electromagnetic pulse from a nuclear blast. The ability of GaAs to run at much higher temperatures than silicon is useful for many of the extreme environments military equipment must perform in.

For those reasons, the United States Department of Defense (DOD) has long been interested in GaAs and has contracted with firms such as Rockwell to develop GaAs chips. DARPA, the Department of Advanced Research Projects Agency, is also pursuing GaAs work for applications such as long-term space missions.

The military wants to use GaAs in satellites. "Just about all surveillance satellites gather tremendous amounts of data," explains Richard Reynolds, the deputy director of the Defense Science Office, "but the sensors are so good that there's no way to relay all the data to Earth. We'd like to have on-board selection of what's relevant." A very fast, radiation-resistant, low-power (able to work from solar cells) satellite computer would be just what the DOD doctor ordered. Raytheon is the prime contractor for the prototype of such a computer, expected in 1987. Rockwell and Honeywell are making production lines for GaAs digital circuits and will deliver logic and memory chips. McDonnell and Texas Instruments are working on new circuit designs. Both Rockwell and Honeywell are working on 64K-bit RAMs that will have access times of 10 to 15 ns.

According to Allen Firstenberg, of Rockwell's Microelectronics Research and Development Center, Rockwell has been active in GaAs for quite a few years. The low-power, radiation-hard GaAs RAM LSI and VLSI chips that Rockwell is developing are exemplified by a 1K-bit SRAM that uses only 100 milliwatts to achieve a 6-ns access time. Operating the same chip at higher power can yield access times approaching 1 ns.

Rockwell is also working on optronic GaAs chips: it has used ion implantation to make the FETs and multilayer epitaxy to make the GaAs-GaAlAs structure for integrating semiconductor lasers onto a chip. Rockwell apparently believes it can get 500 to 1000 gates on a chip within the next two or three years.

At the 1984 International Solid-State Circuits Conference, Rockwell representatives described a 4.5-GHz frequency-divider chip that used GaAs/GaAlAs heterojunction bipolar transistors (HBTs) in an ECL circuit configuration. This is a very high-speed configuration that has higher current drive capability, higher transconductance, and lower sensitivity to process parameters than simple GaAs FETs.

Rockwell grows its own 3-inch-diameter, low dislocation density GaAs crystals using the LEC (liquid encapsulated Czochralski) technique. Each crystal provides between 75 and 150 wafers, and each wafer can yield 880 256-bit SRAMs.

DO IT YOURSELF

According to Al Patz, general manager of Tektronix Gallium Arsenide Integrated Technologies, "Our involvement in gallium arsenide began in 1978, from our people trying to guess what the future needs of our customers would be." Looking for high-speed parts to improve their own instrumentation performance, the Tektronix designers decided to use

(continued)

SAFETY CONCERNS

The tag "arsenide" in GaAs worries quite a few people who know that arsenic is dangerous. It is important to remember that once GaAs chips are packaged, they are no more dangerous than any other chips.

However, processing GaAs wafers—forming the circuits on them—involves toxic gases, solvents, high temperatures and voltages, radio-frequency fields, acids, and just about every dangerous condition found in the field of materials science. But those same conditions are found in the processing of silicon wafers. While the semiconductor industry may be comparatively "clean" when seen from the outside, it can be anything but clean for those who work on the processing line. Companies need to carefully isolate workers from fumes, splashes, and particulates. At this stage, GaAs and silicon work pose the same fundamental dangers. (In fact, silicon processing sometimes involves arsine gases.)

In the first step of making a GaAs chip—growing, cutting, and polishing the GaAs wafer—solid arsenic, called the *charge*, is used. This stage of chip preparation is the most dangerous.

The people at Harris Microwave Semiconductor, one of the companies that grows its own crystals, take efforts to keep things as safe as possible. Their position, as they explained it to me, is that the need for safety applies mainly to the growing and processing of the crystals. Once the gallium and arsenic are locked into a crystal, processed, and sealed in a hermetic package, they are completely nontoxic. But in the growing process, keeping in mind that arsenic is a carcinogen, the people making the charges must be protected. Proper clothing and a clean processing environment help insulate workers from the materials. In addition, the arsenic is stored in jars in inert gas. Tests of both the area and the workers' blood help monitor toxic elements. According to Harris, no dangerous levels have been detected.

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GaAs. By 1985, GaAs chips will be part of many of the company's instruments. Tektronix, however, has decided to use its knowledge to also build circuits for others because, Patz said, "We recognized we had a technology with applications beyond our product line."

Tektronix's current chips are only medium-scale integration (around 100 to 500 gates). Patz sees GaAs as "about seven years behind silicon in terms of the level of integration, which means that GaAs LSI devices are still a year or more away from production." Tektronix is working on an LSI process that will use combined enhancement and depletion-mode circuits to keep dissipation to 250 microwatts per gate. Those chips will run at twice the rate of ECL while using only one-tenth to one-fifteenth the power.

Tektronix is making depletion-mode MESFETs with 1-micron gates, gate delays of 65 ps, and power dissipation of 15 milliwatts per gate. The company's line and processes aren't limited to digital chips; Tektronix also makes GaAs analog chips with transistors that run at 12 GHz.

OTHER GAAS PRODUCERS

Harris Microwave Semiconductor was the first to bring GaAs digital ICs to the commercial market. In February of this year, Harris introduced its first two GaAs chips: a shift register and a binary counter. Harris says both of these chips can operate five times faster than the fastest silicon equivalent and are completely ECL compatible.

Bruce Hoffman, Harris's manager of product marketing, admits that GaAs is "not cheap." In fact, the shift register and the binary counter now cost $393 apiece in quantities of 100. ECL chips, which are gallium arsenide's main competition, cost far less. For instance, an off-the-shelf ECL binary counter costs approximately $6 in the same quantities (100 pieces) as the Harris GaAs HMD-11016-1 binary counter. But it muddles along at a mere 150 MHz, or an even slower 125 MHz when the temperature reaches +85 degrees Celsius. Harris's GaAs binary counter cruises at 2.0 GHz. So, although the Harris binary counter costs more than 60 times as much as an ECL binary counter, it runs more than 13 times faster. While the price is sure to come down for GaAs, the chip is even now worth the price if speed is critical and beyond the capability of ECL.

Similarly, a standard ECL universal shift register costs about $7 and runs at 250 MHz; the Harris GaAs HMD-11141-1 equivalent costs $393 and runs at 1.4 GHz.

Harris says that testing these new high-speed ICs is not as easy as testing simple silicon TTL ICs. It disputes,

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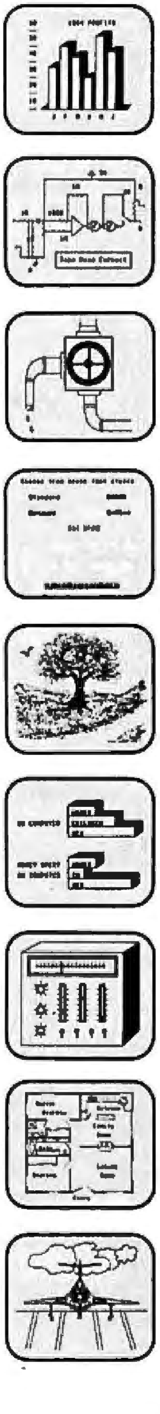

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however, that the testing problem is unique. Testing can be done, Harris says, with other digital circuits that are that fast. In fact, testing GaAs digital ICs may mean building GaAs ICs into the test instruments.

Other GaAs products planned at Harris are SSI logic elements such as D flip-flops, divide-by-two prescalers, five-input NAND/AND gates, five-input NOR/OR gates, exclusive NOR/OR gates, differential amplifiers, and variable-modulus dividers. Harris says all of these parts will run at 3 to 4 GHz and will be available by the end of this year. In addition, the firm is working on cell arrays and on GaAs FETs.

Gigabit Logic, a Rockwell spin-off started in 1982, makes only GaAs ICs. The firm offers a series of 12 chips and an evaluation board to simplify the task of designing with the chips.

According to Tony Livingston, marketing vice-president of Gigabit, "There is a learning curve on parts complexity that builds with time and the maturity of the technology. We could physically make at least 16K-bit SRAMs, but we don't have the yield experience to do it economically." Livingston adds, "We'll be pushing up the level of integration very rapidly, but we are purposefully starting out with things that are easy".

"Everything we're making is 1-micron design rule," according to Richard Eden, Gigabit's vice-president of research and development. Gigabit sees GaAs as "a tool to a system designer for high performance" just as CMOS is used for low power and bipolar for speed. Having GaAs digital chips on the commercial market lets people "use it where it makes the most sense." Furthermore, Gigabit says that all of its parts are ECL compatible and can also be easily interfaced to TTL and CMOS.

Gigabit's 12 products fall into three categories: diode arrays and FET arrays, high-speed counter/prescalers, and logic devices.

The dual-gate and single-gate FETs and diodes are useful in analog work and in testing the characteristics of the fundamental components of GaAs technology. The four high-speed counter/prescalers are useful in clocks and high-frequency systems running up to 3 GHz.

The four logic devices include a quad three-input NOR chip, a dual high-speed comparator, a dual-precision D flip-flop, and a dual fan-out buffer. The NOR gate has a mere 75-ps/gate delay in the die form. That is 10 times faster than ECL at the same power. It would run even faster and use less power if it didn't have to drive a 50-ohm line. Most of the power is used in the buffering. The

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dual high-speed comparator and the dual-precision D flip-flop run at 3 GHz.

Livingston explains that Gigabit expects GaAs digital chips to be strategically used to gain system performance. For instance, in clock distribution, GaAs might be used as a comparator and a fan-out buffer to eliminate the skew time that forces other system parts to wait for the clock signal to become steady. In such a position, Livingston sees GaAs making a 20 to 25 percent improvement in system performance. GaAs memory products will be used for microcode, fast registers, and cache.

Livingston says, "In the next few years we will see complete GaAs computers. Within a year to 18 months the Japanese will have something. By 1988 we will see complete GaAs systems."

Gigabit's chips have up to 80 gates now. But according to Livingston, you'll see "16- and 32-bit microprocessors running a couple of hundred megahertz by 1990 or sooner. Imagine a 68000 microprocessor at 200 MHz on your desk and you get an idea of the promise this holds."

When asked about the economics of digital GaAs, Livingston points out that Gigabit is using fewer masking steps than are required in most CMOS processes. Initial material for the GaAs chips is more expensive (wafers cost approximately $175, 20 times the cost of a similar silicon wafer), but Gigabit apparently believes that after all costs (testing, packaging, and so on) are considered, the price of those chips can be very competitive when their performance is taken into account. Eden says that wafer costs add only 15 to 30 cents to the price of each chip. He further asserts that on the basis of cost, GaAs will compete head to head with silicon. "And in the long run," Eden says, "we hope to match high-performance silicon on an absolute-cost basis."

Gigabit's chips cost from $59 for the NOR gate to $399 for the 4-GHz seven-stage ripple counter. Those prices are for 100-piece lots. If you want to buy single chips, you'll shell out from two to three times that much; however, if you think you can work with the naked dice, you can cut those prices by as much as a third. These prices are between 10 and 100 times those of ECL chips, but the GaAs chip performance is also significantly higher.

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According to Livingston, "Gallium arsenide is fundamentally attacking emitter-coupled logic, which cannot make the jump into the gigabit speed range. Only gallium arsenide can do that."

HOW BIG THE MARKET?

Yves Blanchard of Strategic Inc., a market-research firm, thinks GaAs will cost three to five times what ECL costs but will fit in special applications where high speed, low power, or radiation resistance is important. Strategic indicated it also believes that GaAs will remain at 3 percent of the semiconductor market; that is, even though it will grow enormously over the next decade, the entire semiconductor market will grow just as fast.

Strategic Inc. estimates that the 1983 market for GaAs was $48 million. It further subdivides the GaAs chips into types and estimates that, of the chips sold in 1983, 75 percent were analog and 14 percent were digital, with optoelectronic representing the rest. By 1992, it sees a market where 47 percent of the GaAs chips will be digital, 28 percent analog, and 25 percent optoelectronic.

According to Strategic, chips used in supercomputers and voice-recognition systems will represent $6 million of business in 1985, $56 million in 1987, and $865 million in 1992.

Unfortunately, all of these estimates, including the general estimate that many people working in GaAs will quote—that the market will be $5.6 billion in 1992—are from a study that has become dated. No one is really sure where the market will be.

Companies should be able to sell to DOD and communications firms and thus have a source of cash while moving down the learning curve. "We are still at the top of the learning curve," according to Blanchard. He sees the industry moving from a level of 200 devices per chip in 1980 to 16,000 in 1984 and 600,000 in 1990.

A study by Mackintosh International

(continued)

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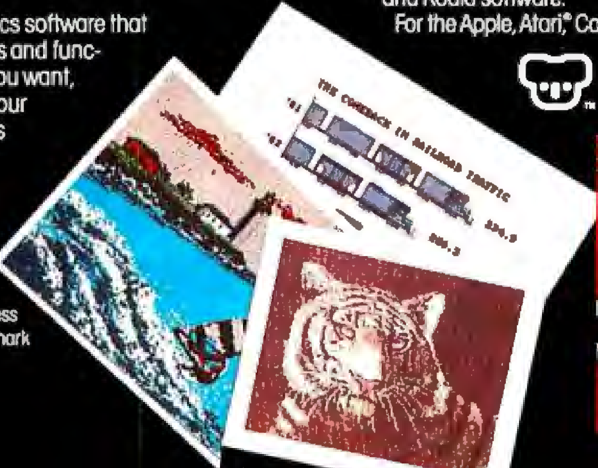
[1] *Lotus Development* [2] *Ashton-Tate* [3] *MicroPro* [4] *IBM Corporation*


C. Weiner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Don't expect to see GaAs chips in your micro for quite a while.

(a technology consulting company in London), directed by Tony Pyne, indicated that 2 percent was a more realistic figure for the portion of the IC market that GaAs would capture. That means a market one-third smaller than Strategic expects (at least on the basis of the first Strategic report). There are several reasons the GaAs market may not take off. For one thing, it is a high-capital start-up business terribly short of experienced people. One major reason Mackintosh sees a smaller market for GaAs is that it is hard to get a high processing yield using the GaAs material. According to Pyne, the processing problems "are so severe that yields can be a fraction of 1 percent, requiring the processing of many wafers to obtain one good die site." So with high yields and complex new VLSI architectures, silicon technology is presenting a moving target to GaAs makers.

FINAL NOTE

Don't expect to see GaAs chips in your microcomputer for quite a while. They will first turn up in advanced telecommunications systems, supercomputers, and on-board aerospace processors.

GaAs won't be the final winner of the high-speed race. Many other materials are waiting out there. Some are just wild shots in the dark. But there is at least one material that has even greater mobility than GaAs and could surpass it for all the same reasons GaAs surpasses silicon. Indium phosphide is another III-V compound semiconductor that is still found only in labs. It is harder to process than GaAs, but it is already the material of choice for some very special applications such as millimeter wave devices. GaAs holds everyone's attention now; but remember, just four years ago, Josephson junctions were the odds-on favorites over GaAs and GaAs was in second place. ■

← Circle 237 on inquiry card.

7400

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Part No.	**Pins	Price
SN7400N	14	.29
SN7401N	14	.29
SN7402N	14	.29
SN7403N	14	.29
SN7404N	14	.35
SN7405N	14	.49
SN7406N	14	59
SN7407N	14	.59
SN7408N	14	.29
SN7409N	14	.35
SN7410N	14	.29
SN7411N	14	29
SN7412N	14	.49
SN7413N	14	.39
SN7414N	14	.49
SN7416N	14	.49
SN7417N	14	.59
SN7420N	14	.19
SN7421N	14	.59
SN7422N	14	.59
SN7423N	16	.69
SN7425N	14	.39
SN7426N	14	39
SN7427N	14	.25
SN7428N	14	59
SN7430N	14	.35
SN7432N	14	.39
SN7437N	14	.25
SN7438N	14	.49
SN7439N	14	.79
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.75
SN7447N	16	.75
SN7448N	16	.75
SN7450N	14	.19
SN7451N	14	.19
SN7453N	14	19
SN7454N	14	.19
SN7459N	14	.35
SN7460N	14	.39
SN7470N	14	.39
SN7472N	14	[illegible]
SN7473N	14	[illegible]
SN7474N	14	[illegible]
SN7475N	16	[illegible]
SN7476N	16	[illegible]
SN7479N	16	4.95
SN7480N	14	[illegible]
SN7482N	14	1.49
SN7483N	16	55
SN7485N	16	.59
SN7486N	14	.39
SN7489N	16	2.25
SN7490N	14	49
SN7491N	14	79
SN7492N	14	.45
SN7493N	14	.45
SN7494N	14	.89
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74104N	14	1.19
SN74105N	14	1.19
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.45
SN74122N	14	.69
SN74123N	16	.55
SN74125N	14	.49
SN74126N	14	.49
SN74132N	14	.59
SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.65
SN74147N	16	1.29
SN74148N	16	.69
SN74150N	24	1.49
SN74151N	16	.49
SN74152N	14	.49
SN74153N	16	99
SN74154N	24	1.49
SN74155N	16	.49
SN74156N	16	.59
SN74157N	16	.49
SN74160N	16	.59
SN74161N	16	.59
SN74162N	16	.59
SN74163N	16	.59
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.69
SN74167N	16	2.95
SN74170N	16	1.59
SN74172N	24	4.95
SN74173N	16	85
SN74174N	16	.59
SN74175N	16	59
SN74176N	14	.79
SN74177N	14	.79
SN74179N	16	1.49
SN74180N	14	69
SN74181N	24	1.95
SN74182N	16	1.05
SN74184N	16	2.29
SN74185N	16	2.29
SN74190N	16	.69
SN74191N	16	69
SN74192N	16	.69
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SN74194N	16	69
SN74195N	16	.49
SN74196N	14	.75
SN74197N	14	.75
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	2.49
SN74279N	16	.79
SN74283N	16	1.39
SN74284N	16	2.85
SN74285N	16	2.85
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

Part No.	**Pins	Price
74LS00	14	.29
74LS01	14	.29
74LS02	14	.35
74LS03	14	.29
74LS04	14	.39
74LS05	14	.35
74LS08	14	.35
74LS09	14	.35
74LS10	14	.35
74LS11	14	.35
74LS12	14	35
74LS13	14	39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.35
74LS22	14	.19
74LS26	14	.29
74LS27	14	35
74LS28	14	.39
74LS30	14	.39
74LS32	14	.39
74LS33	14	.49
74LS37	14	.35
74LS38	14	.39
74LS40	14	.29
74LS42	16	.49
74LS47	16	.89
74LS48	16	.75
74LS49	14	.75
74LS51	14	.29
74LS54	14	.29
74LS55	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.45
74LS76	16	.39
74LS78	14	45
74LS83	16	.59
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.59
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.45
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.79
74LS125	14	59
74LS126	14	.59
74LS132	14	.65
74LS133	16	.59
74LS136	14	.39
74LS138	16	59
74LS139	16	.59
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.49
74LS155	16	.69
74LS156	16	69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.89
74LS165	16	89
74LS168	16	1.19
74LS169	16	1.49
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.49
74LS190	16	.79
74LS191	16	89
74LS192	16	.79
74LS193	16	.89
74LS194	16	.69
74LS195	16	.59
74LS197	14	.89
74LS221	16	1.09
74LS240	20	1.09
74LS241	20	.99
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.29
74LS245	20	1.49
74LS247	16	.89
74LS248	16	.89
74LS249	16	.69
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.49
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.89
74LS298	16	.89
74LS352	16	1.09
74LS353	16	1.09
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.39
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

74S/PROMS*

Part No.	**Pins	Price
74S00	14	.35
74S02	14	.35
74S03	14	35
74S04	14	.45
74S05	14	45
74S08	14	45
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	45
74S38	14	.89
74S40	14	35
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	55
74S85	16	1.99
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55
74S133	16	.45
74S134	16	.39
74S135	16	.89
74S136	14	1.39
74S138	16	89
74S139	16	.89
74S140	14	.69
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.29
74S174	16	1.09
74S175	16	1.09
74S188*	16	1.75
74S194	16	1.49
74S195	16	1.49
74S196	14	149
74S240	20	1.95
74S241	20	1.95
74S242	14	2.19
74S243	14	2.19
74S244	20	2.19
74S251	16	.99
74S253	16	.99
74S257	16	99
74S258	16	.99
74S260	14	79
74S280	14	1.89
74S287*	16	1.79
74S288*	16	1.79
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	4.95
74S472*	20	4.95
74S473*	20	4.95
74S474*	24	4.95
74S475*	24	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95
74S940	20	2.49
74S941	20	2.49

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CA3010H		1.09
CA3039H		1.25
CA3046N	14	.99
CA3059N	14	2.95
CA3060N	16	2.95
CA3065E	14	1.49
CA3080E	8	.99
CA3081N	16	1.15
CA3082N	16	1.15
CA3083N	16	1.15
CA3086N	14	85
CA3089N	16	1.95
CA3096N	16	1.75
CA3130E	8	1.19
CA3140E	8	85
CA3160H		1.79
CA3161E	16	1.79
CA3162E	16	6.95
CA3189E	16	2.79
CA3401N	14	.59

CD—CMOS

Part No.	**Pins	Price
CD4000	14	.29
CD4001	14	.29
CD4002	14	29
CD4006	14	.89
CD4007	14	.29
CD4009	16	.59
CD4010	16	49
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	.89
CD4015	16	.39
CD4016	14	.49
CD4017	16	.79
CD4018	16	.79
CD4019	16	.49
CD4020	16	.75
CD4021	16	.75
CD4022	16	.75
CD4023	14	29
CD4024	14	69
CD4025	14	.29
CD4026	16	1.59
CD4027	16	.45
CD4028	16	69
CD4029	16	.79
CD4030	14	.39
CD4034	24	1.79
CD4035	16	.79
CD4040	16	.75
CD4041	14	69
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.59
CD4049	16	.39
CD4050	16	.39
CD4051	16	.79
CD4052	16	.89
CD4053	16	.79
CD4056	16	2.95
CD4059	24	3.95
CD4060	16	.89
CD4066	14	.45
CD4068	14	.39
CD4069	14	.35
CD4070	14	.29
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	.89
CD4078	14	49
CD4081	14	.29
CD4082	14	.29
CD4093	14	.49
CD4098	16	1.95
CD4506	16	1.29
CD4507	14	1.19
CD4508	24	1.95
CD4510	16	.85
CD4511	16	85
CD4512	16	.85
CD4514	24	1.49
CD4515	24	1.49
CD4516	16	89
CD4518	16	.89
CD4519	16	.59
CD4520	16	.89
CD4526	16	1.19
CD4528	16	1.19
CD4529	16	1.69
CD4543	16	1.19
CD4562	14	6.95
CD4566	16	2.95
CD4583	16	2.49
CD4584	14	59
CD4723	16	1.19
CD4724	16	1.19
MC14409	16	16.95
MC14410	16	8.95
MC14411	24	11.95
MC14412	16	7.95
MC14419	16	12.95
MC14433	24	17.95
MC14538	16	1.49
MC14541	14	1.49

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MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	**Pins	Function	Price
D765AC	40	Floppy Disk Controller	19.95
2650	40	MPU (2MHz)	9.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
MCS6502	40	MPU w/Clock (1 MHz)	4.95
MCS6502A	40	MPU with Clock and RAM (2Mhz)	6.49
MCS6502B	40	MPU w/Clock at 3MHz	8.95
6809	40	CPU—8-bit (Internal Clock) 1MHz	8.95
6809E	40	CPU—8-bit (External Clock) 1MHz	9.95
8031	40	Control Oriented CPU w/RAM & I/O	14.95
INS8035N	40	MPU—8-bit	5.95
INS8039N	40	CPU-Sgl. chip 8-bit (128bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU (64 bytes RAM)	19.95
INS8073N	40	CPU w/Basic Microinterpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	19.95
8155	40	HMOS RAM I/O Port-Timer	6.95
8237	40	High Performance Prog DMA Cont.	15.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	19.95
8748	40	HMOS EPROM MPU	39.95

Z80, Z80A, Z80B, Z8000 SERIES

Part No.	**Pins	Function	Price
Z80	40	CPU (MK3880N)(780C) 2MHz	2.95
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Z80-DART	40	Dual Asynchronous Rec./Trans	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-P10	40	Parallel I/O Interface Controller	3.49
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-S10/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-S10/9	40	Serial I/O	11.49
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	3.49
Z80A-CTC	28	Counter Timer Circuit	4.49
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB bonded)	11.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-S10/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynch. Receiver/Transmitter	19.95
Z80B-P10	40	Parallel I/O Interface Controller	10.95
Z8001	48	CPU Segmented	44.95

6500/6800/68000 SERIES

Part No.	**Pins	Function	Price
[illegible]	40	MPU with clock and RAM (2MHz)	4.95
MC6520	40	Peripheral Inter Adapter	3.95
MC6800	40	MPU	2.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6809E	40	CPU (1MHz) External (Locking)	9.95
MC6821	40	Peripheral Inter Adapt (MC6820)	2.95
MC6828	24	Priority Interrupt Controller	15.95
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MC68652P2	40	Multi. Protocol Comm. Controller	14.95
MC68661P	28	Enhanced Prog Comm Int.	8.95
MC68764	24	64K EPROM (450ns)	24.95
SY6522	40	Peripheral Inter Adapter	5.49

8000 SERIES

Part No.	**Pins	Function	Price
INS8080A	40	CPU	3.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	8.95
DP8212	24	8-bit Input/Output (74S412)	2.95
DP8214	24	Priority Interrupt Control	3.79
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.95
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	4.95
DP8238	28	System Controller (74S438)	4.95
INS8243	24	I/O Expander for 48 Series	4.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm Element	10.95
DP8251	28	Prog. Comm I/O (USART)	4.95
DP8253	24	Prog Interval Timer	6.95
DP8255	40	Prog Peripheral I/O (PPI)	4.95
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	5.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	6.95
8284	18	Clock Generator/Driver	6.95
8288	20	Bus Controller	19.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans	3.49
DP8304	20	8-bit Bi-Directional Receiver	3.49
DP8307	20	8-bit Bi-Directional Receiver	3.49
DP8308	20	8-bit Bi-Directional Receiver	3.49
DP8310	20	Octal Latched Peripheral Driver	3.95
8741	40	8-bit Univ Peripheral Interface	29.95

DISK CONTROLLERS

Part No.	**Pins	Function	Price
INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	24.95
FD1793	40	Single/Double Density (True)	26.95
FD1795	40	Dual Density/Side Select (Inv.)	26.95
FD1797	40	Dual Density/Side Select True	29.95

SPECIAL FUNCTION

Part No.	**Pins	Function	Price
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	7.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5424ON	24	Asynchronous Transmitter/Receiver	5.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	8.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.79
CDP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int	5.95
CDP470N	20	32-seg VAC Fluor Drvr (20-pin pkg)	3.25
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	**Pins			Price
1103	18	1024x1	(300ns)	.95
4027	16	4096x1	(250ns)	1.49
4116N-2	16	16,384x1	(150ns)	1.39 - 8/10.95
4116N-3	16	16,384x1	(200ns)	1.15 - 8/8.95
4116N-4	16	16,384x1	(250ns)	.89 - 8/6.95
4164N-150	16	65,536x1	(150ns)	5.95 - 8/40.95
4164N-200	16	65,536x1	(200ns)	4.95 - 8/38.95
MM5261	18	1024x1	(300ns)	.35 - 8/1.95
MM5262	22	2048x1	(385ns)	.10
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95

NEW 256K DYNAMIC RAM

41256 16 262,144x1 (200ns)...31.95

MM5298-3	16	8192x1	(200ns)	.59

STATIC RAMS

Part No.	**Pins			Price
1101	16	256x1	(650ns)	1.49
2101	22	256x4	(450ns) 8101	1.95
2102	16	1024x1	(350ns)	.89
21L02	16	1024x1	(450ns) L.P	1.49
2111	18	256x4	(450ns) 8111	2.49
2112	16	256x4	(450ns) MOS	2.49
2114	18	1024x4	(450ns)	1.29 - 8/9.95
2114L	18	1024x4	(450ns) L.P	1.95 - 8/13.95
2114-2	18	1024x4	(200ns)	1.39 - 8/10.95
2114L-2	18	1024x4	(200ns) L.P	1.69 - 8/13.49
2147	18	4096x1	(70ns)	4.49
2148	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	1.95
5101	22	256x4	(450ns) CMOS	3.95
MM5257	18	4096x1	(450ns) 4044	3.95
HM6116P-3	24	2048x8	(150ns) CMOS	4.95
HM6116P-4	24	2048x8	(200ns) CMOS	4.75
HM6116LP-4	24	2048x8	(200ns) L.P CMOS	5.49
HM6264P-15	28	8192x8	(150ns) CMOS	34.95
HM6264LP-15	28	8192x8	(150ns) L.P CMOS	37.95
27LS00	16	256x1	(80ns) L.P	3.95
7489	16	16x4	(50ns) 3101	2.25
74C920	22	256x4	(250ns)	5.95
74C921	18	256x4	(250ns) CMOS	5.95
74C929	16	1024x1	(250ns) CMOS (6501)	3.95
74C930	18	1024x1	(250ns) CMOS (6518)	5.95
74S189	16	16x4	(35ns) 93405	2.95
74S200	16	256x1	(80ns) 93410	3.95
74S206	16	256x1	(60ns) 93411	3.95
74S289	16	16x4	(35ns) 3101	2.95
82S10	16	1024x1	(50ns) O.C (93415)	3.95
82S25	16	16x4	(50ns) O.C (74S289)	2.25

PROMS / EPROMS

Part No.	**Pins			Price
1702A	24	256x8	(1us)	3.95
2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00246	3.49
TMS2516	24	2048x8	(450ns) 2716	4.95
TMS2532	24	4096x8	(450ns) MMC2532	5.49
TMS2564	28	8192x8	(450ns)	10.95
TMS2716	24	2048x8	(450ns) 3 voltage	7.95
2716	24	2048x8	(450ns)	3.95
27C16	24	2048x8	CMOS	14.95
2716-1	24	2048x8	(350ns)	5.49
27160-5	24	2048x8	(550ns)	3.75
2732	24	4096x8	(450ns)	4.95
2732A-3	24	4096x8	(300ns)	7.95
2732A-4	24	4096x8	(450ns) 21V	6.49
27320-4	24	4096x8	(550ns) 21V	5.95
27580-A	24	1024x8	(450ns)	2.95
2764-4	28	8192x8	(450ns)	6.49
2764-3	28	8192x8	(300ns)	7.19
27C64	28	8192x8	CMOS	22.95
MCM68764	24	8192x8	(450ns)	24.95
27128	28	16,384x8	(450ns) 128K EPROM	21.95
74S188	16	32x8	PROM O.C (6330-1)	1.75
74S287	16	256x4	PROM T.S (6301-1)	1.79
74S288	16	32x8	PROM T.S (6331-1)	1.79
74S387	16	256x4	PROM O.C (6300-1)	1.95
74S471	20	256x8	PROM T.S (6309-1)	4.95
74S472	20	512x8	PROM T.S (6349-1)	4.95
74S473	20	512x8	PROM O.C (6348)	4.95
74S474	24	512x8	PROM T.S (DM87S296N)	4.95
74S475	24	512x8	PROM O.C (6340)	4.95
74S476	18	1024x4	PROM T.S	6.95
74S478	24	1024x8	PROM T.S	9.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S (6306)	2.95
74S572	18	1024x4	PROM O.C (6352)	4.95
74S573	18	1024x4	PROM T.S (82S137)	4.95
82S23	16	32x8	PROM O.C (27S18)	2.95
82S115	24	512x8	PROM T.S (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C (27S20)	2.95
82S129	16	256x4	PROM T.S (27S21)	2.95
82S130	16	512x4	PROM O.C (27S12)	3.95
82S185	18	2048x4	PROM T.S (TBP24S81)	9.95
82S191	24	2048x8	(80ns)	14.95
DM87S180N	24	1024x8	PROM O.C (82S180)	9.95
DM87S181N	24	1024x8	PROM T.S (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S (82S185)	9.95
DM87S190N	24	2048x4	PROM O.C (82S190)	14.95
DM87S191N	24	2048x8	PROM T.S (82S191)	14.95

DATA ACQUISITION

Part No.	**Pins	Function	Price
DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	1.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.25
ADC0803LCN	20	8-bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-bit A/D Converter (1LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch Multi.)	9.49
DAC1000	24	10 bit D/A Conv Micro Comp (0.05%)	7.95
DAC1008	20	10 bit D/A Conv Micro. Comp (0.20%)	6.95
DAC1020	16	10 bit D/A Conv (0.05% Lin.)	7.95
DAC1022	16	10 bit D/A Conv (0.20% Lin.)	5.95
DAC1222	18	12 bit D/A Conv (0.20% Lin.)	6.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.29
LM399H		Temp Comp Prec Ref (.5ppm/C°)	5.95
AY-5-1013A	40	30K Baud Uart (TR1602)	3.95

LOW PROFILE (TIN) SOCKETS

	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.46	.42	.39
40 pin LP	.49	.46	.43

LP

SOLDERTAIL (GOLD) STANDARD

	1-9	10-99	100-up
8 pin SG	.39	.35	[illegible]
14 pin SG	.49	.45	[illegible]
16 pin SG	.55	.49	[illegible]
18 pin SG	.65	.59	[illegible]
24 pin SG	.79	.69	[illegible]
28 pin SG	.95	.85	[illegible]
36 pin SG	1.25	1.15	[illegible]
40 pin SG	1.39	1.25	1.15

SO

ST

WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
14 pin ST	.29	.27	.25
16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
40 pin ST	.99	.95	.89

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-9	10-99	100-up
8 pin WW	[illegible]	.49	.45
10 pin WW	[illegible]	.65	.59
14 pin WW	[illegible]	[illegible]	.65
16 pin WW	[illegible]	[illegible]	.65
18 pin WW	[illegible]	[illegible]	.75
20 pin WW	1.19	[illegible]	.95
22 pin WW	[illegible]	[illegible]	1.05
24 pin WW	[illegible]	[illegible]	1.09
28 pin WW	[illegible]	[illegible]	1.39
36 pin WW	[illegible]	[illegible]	1.69
40 pin WW	[illegible]	[illegible]	1.79

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Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc.

The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ . . . . $34.95 ea.
MM54104 Processor Chip . . . . $14.95 ea.

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INTERSIL

*Evaluation Kits

Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
FE0203D		3½ Digit LCD Display for 7106 & 7116	14.95
7106EV/Kit*	40	IC, Circuit Board, Display	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit*	40	IC, Circuit Board, Display	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD.	10.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit*	24	Stopwatch Chip, XTL	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq Counter Chip, XTL	8.49
7215IPG	24	4 Func CMOS Stopwatch CKT	16.95
7215EV/Kit*	24	4 Func Stopwatch Chip, XTL	19.49
7216AIJI	28	8 Digit Univ Counter C.A	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	9.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	99.95

30009 1983 INTERSIL Data Book (1356p.) $9.95

NEW PRODUCT! 74HC High Speed CMOS

Part No.	**Pins	Price
74HC00	14	.59
74HC02	14	.59
74HC03	14	.69
74HC04	14	.59
74HCU04	14	.69
74HC08	14	.59
74HC10	14	.59
74HC11	14	.69
74HC14	14	.89
74HC20	14	.59
74HC27	14	.59
74HC30	14	.69
74HC32	14	.79
74HC42	16	1.09
74HC51	14	.69
74HC58	14	.89
74HC73	14	.79
74HC74	14	.79
74HC75	16	.99
74HC76	16	.79
74HC85	16	1.69
74HC86	14	.75
74HC107	14	.79
74HC109	16	.79
74HC112	16	.79
74HC113	14	.79
74HC125	14	1.75
74HC132	14	1.29
74HC137	16	1.59
74HC138	16	1.19
74HC139	16	1.05
74HC147	16	1.79
74HC151	16	.99
74HC153	16	1.09
74HC154	24	3.65
74HC157	16	.99
74HC158	16	.99
74HC160	16	1.39
74HC161	16	1.39
74HC162	16	1.39
74HC163	16	1.39
74HC164	14	1.25
74HC165	16	2.15
74HC166	16	2.49
74HC173	16	1.29
74HC174	16	1.09
74HC175	16	1.09
74HC192	16	1.49
74HC193	16	1.49
74HC194	16	1.19
74HC195	16	1.09
74HC237	16	1.49
74HC240	20	2.29
74HC241	20	2.29
74HC242	14	2.15
74HC243	14	2.15
74HC244	20	2.79
74HC245	20	2.59
74HC251	16	.99
74HC253	16	1.29
74HC257	16	.89
74HC259	16	1.69
74HC266	14	.89
74HC273	20	2.79
74HC280	14	4.59
74HC299	20	3.59
74HC366	16	2.59
74HC367	16	2.59
74HC373	20	2.69
74HC374	20	2.69
74HC390	16	1.59
74HC393	14	1.59
74HC533	20	2.69
74HC534	20	2.69
74HC595	16	3.59
74HC688	20	3.99
74HC4002	14	.59
74HC4017	16	1.49
74HC4020	16	1.49
74HC4024	14	1.75
74HC4040	16	1.49
74HC4060	16	1.49
74HC4075	14	.59
74HC4078	14	.59
74HC4511	16	1.95
74HC4514	24	4.19
74HC4538	16	2.59
74HC4543	16	3.75

74HCU04 is unbuffered All others are buffered

74C—C/MOS

Part No.	**Pins	Price
74C00	14	.39
74C02	14	.35
74C04	14	.35
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.19
74C48	16	1.79
74C73	14	.69
74C74	14	.59
74C85	16	1.39
74C86	14	.39
74C89	16	5.95
74C90	14	1.09
74C93	14	1.09
74C95	14	1.19
74C107	14	.79
74C151	16	2.19
74C154	24	3.25
74C157	16	1.75
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.29
74C173	16	.89
74C174	16	1.19
74C175	16	1.19
74C192	16	1.39
74C193	16	1.39
74C195	16	1.29
74C221	16	1.75
74C240	20	1.95
74C244	20	1.95
74C373	20	2.29
74C374	20	2.29
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	4.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

LINEAR

Part No.	**Pins	Price
TL071CP	8	.79
TL072CP	8	1.09
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.39
LM302H		2.49
LM304H		1.95
LM305H		.99
LM307CN	8	.49
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.95
LM311CN	8	.59
LM312H		2.79
LM317T		1.19
LM317K		3.49
LM318CN	8	1.59
LM319N	14	1.49
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320K-24		1.35
LM320T-5		.85
LM320T-12		85
LM320T-15		.85
LM320T-24		85
LM322N	14	1.49
LM323K		4.95
LM324N	14	59
LM329DZ		65
LM331N	8	3.95
LM334Z		1.19
LM335Z		1.29
LM336Z		1.09
LM337MP		1.15
LM337T		1.89
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340K-24		1.35
LM340T-5		.75
LM340T-12		.75
LM340T-15		.75
LM340T-24		.75
LM341P-5		69
LM341P-12		69
LM341P-15		69
LM342P-5		65
LM342P-12		65
LM342P-15		.65
LF347N	14	1.49
LM348N	14	.89
LM350K		4.79
LF351N	8	59
LF353N	8	.89
LF355N	8	1.09
LF356N	8	1.09
LM358N	8	.59
LM359N	14	1.79
LM370N	14	4.95
LM373N	14	4.95
LM377N	14	1.95
LM380CN	8	1.09
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.49
LM384N	14	1.95
LM386N-3	8	89
LM387N	8	1.39
LM389N	18	1.19
LM391N-80	16	1.19
LM392N	8	.59
LM398N	8	3.95
LM399H		5.95
TL494CN	16	2.79
TL496CP	8	1.59
NE531V	8	1.79
NE544N	14	1.95
NE550A	14	1.95
NE555V	8	.35
XR-L555	8	.69
LM556N	14	.79
NE564N	16	1.95
LM565N	14	.99
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	2.95
NE571N	16	2.49
LM703CN	8	1.49
LM709N	14	.59
LM710N	14	.69
LM711N	14	.79
LM723N	14	.49
LM733N	14	.89
LM739N	14	1.95
LM741CN	8	.39
LM747N	14	[illegible]
LM748N	8	.59
LM1310N	14	1.49
MC1330AI	8	1.69
MC1349	8	1.69
MC1350	8	1.19
MC1358	14	1.49
LM1456V	8	1.95
LM1458CN	8	.59
LM1488N	14	.69
LM1489N	14	69
LM1496N	14	99
LH1605CK		9.95
LM1800N	16	2.49
LM1871N	18	2.95
LM1872N	18	3.25
LM1877N-9	14	2.95
LM1889N	18	1.95
LM1896N	14	1.59
LM2002T		1.95
ULN2003A	16	1.49
XR2206	16	3.95
XR2207	14	2.49
XR2208	16	1.79
XR2211	14	2.95
LM2877P		1.95
LM2878P		2.95
LM2901N	14	.79
LM2902N	14	89
LM2907N	14	2.49
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.89
LM3914N	18	2.39
LM3915N	18	2.39
LM3916N	18	2.39
RC4136N	14	1.25
RC4151NB	8	1.95
RC4194TK		4.49
RC4195TK		5.95
LM4250CN	8	1.49
LM4500A	16	2.95
NE5532	8	1.69
NE5534	8	1.39
79M05AH		1.29
ICL8038B	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19
76477	28	3.95

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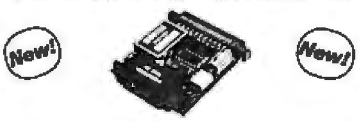
Commodore

RS232 ADAPTER FOR VIC-20 AND COMMODORE 64



The JE232CM allows connection of standard serial RS232 printers, modems, etc. to your VIC-20 and C-64. A 4-pole switch allows the inversion of the 4 control lines. Complete installation and operation instructions included.

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JE232CM $39.95

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- Instrumentation
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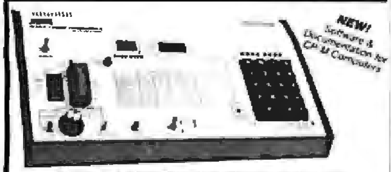
Part No.	Description	Price
JE520CM	For Commodore 64 & VIC-20	$114.95
JE520AP	For Apple II, II+, and //e	$149.95



JE664 EPROM PROGRAMMER

8K to 64K EPROMS — 24 & 28 Pin Packages

Completely Self-Contained — Requires No Additional Systems for Operation

• Programs and validates EPROMs • Checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing and program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, less than 10W power consumption • Enclosure: Color-coordinated, light tan panels with molded end pieces in mocha brown • Size: 15⅜"L x 8¾"D x 3⅛"H • Weight: 5¾ lbs.

The JE664 EPROM Programmer emulates and programs various 8-Bit Word EPROMs from 8K to 64K-Bit memory capacity. Data can be entered into the JE664's internal 8K x 8-Bit RAM in three ways: (1) from a ROM or EPROM; (2) from an external computer via the optional JE665 RS232C BUS; (3) from its panel keyboard. The JE664's RAMs may be accessed for emulation purposes from the panel's test socket to an external microprocessor. In programming and emulation, the JE664 allows for examination, change and validation of program content. The JE664's RAMs can be programmed quickly to all "1"s (or any value), allowing unused addresses in the EPROM to be programmed later without necessity of "UV" erasing. The JE664 displays DATA and ADDRESS in convenient hexadecimal (alphanumeric) format. A "DISPLAY EPROM DATA" button changes the DATA readout from RAM word to EPROM word and is displayed in both hexadecimal and binary code. The front panel features a convenient operating guide. The JE664 Programmer includes one JM16A Jumper Module (as listed below).

JE664-A EPROM Programmer. $995.00
Assembled & Tested (Includes JM16A Module)

JE665 — RS232C INTERFACE OPTION — The RS232C Interface Option implements computer access to the JE664's RAM. This allows the computer to manipulate, store and transfer EPROM data to and from the JE664. A sample program listing is supplied in MBASIC for CP/M computers. Documentation is provided to adapt the software to other computers with an RS232 port 9600 Baud, 8-bit word, odd parity and 2 stop bits.

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JM32A	[illegible]	[illegible]	Motorola, TI, Hitachi, OKI	[illegible]
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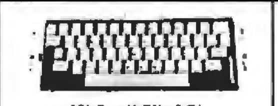

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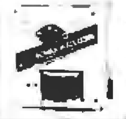

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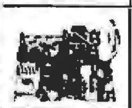

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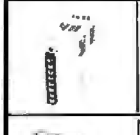

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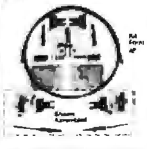

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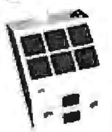

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Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

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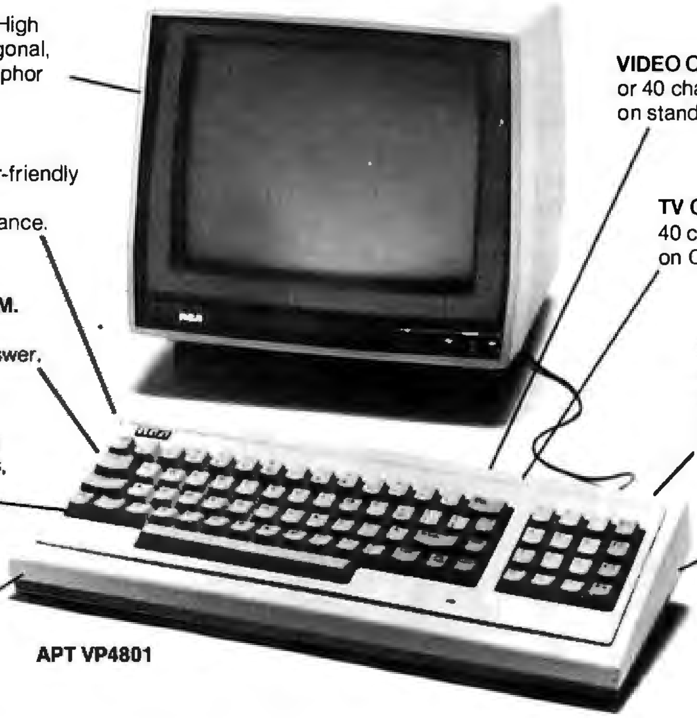
Circle 225 on inquiry card.

You don't need a computer to talk to another computer.



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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.

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OTHER FEATURES

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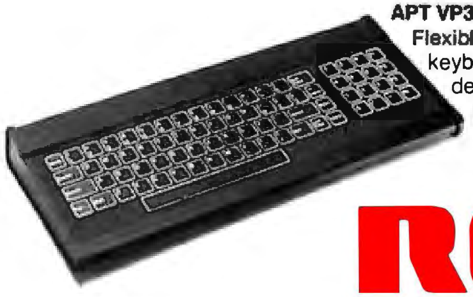
Quite simply, matching features with price, there is no other professional quality terminal available today that can do as much at such low cost.

APT terminals list for $498, in your choice of full stroke or membrane keyboard versions. Either style is also available with a display monitor for $697 list. The data display monitor alone, VP3012D, $199 list.

For more information—or to order—call 800-722-0094. In Penna., call 717-295-6922. Or write for fully descriptive brochure to RCA Data Communications Products, New Holland Avenue, Lancaster, PA 17604. OEM and dealer pricing available. The new RCA APT. Expansive. Not expensive.



APT VP3801. Flexible membrane keyboard version designed for travel and hostile environments.

RCA

Circle 356 on inquiry card.

THE 80286 MICROPROCESSOR

BY PAUL WELLS

A close look at Intel's 32-bit iAPX 286 chip

DURING THE PLANNING phase for a processor to follow the 8086, we at Intel realized that two distinct markets had emerged. One market required the power of the 8086 but was primarily driven by the customers' need for cost-sensitive solutions. To satisfy this market, we defined a processor with a significant performance increase over the 8086 that also included such common peripheral functions as software-controlled wait state and chip select logic, three timers, priority interrupt controller, and two channels of DMA (direct memory access). This processor, the 80186, could replace up to 22 separate VLSI (very large scale integration) and TTL (transistor-transistor logic) packages and sell for less than the cost of the parts it replaced.

80286 FUNDAMENTALS

For the second market, driven by performance, address space, and complex system-level requirements such as sophisticated OS (operating system) support and protection, Intel developed the 16-/16-bit 80286 microprocessor.

To allow designers committed to the 8086 to take advantage of the next-generation technology, the 80286 design uses the 8086/88 instruction set and is capable of executing binary-level 8086 code. Like the 8086, the 80286 operates at TTL levels and supports the use of coprocessors. Among these coprocessors are the 80287, the iAPX 286 version of the 8087, the 802586 Ethernet coprocessor, and the 802730 text and graphics coprocessor (iAPX 286 refers to the family of chips that includes the 80286 microprocessor; iAPX 186 refers to the 80186 family, and so on). The 8086 instruction set has been extended on the 286, and a new design employing a high degree of parallelism and pipelining to improve processor performance has been implemented.

Finally, the 80286 was designed to be more "aware" of the complex problems it has to solve. For example, multitasking is a software-intensive solution to many types of problems but represents significant overhead to a CPU (central processing unit) that has no knowledge of what a task is and no way to support it. The 80286 provides an implementation in hardware of task switching and a protection model that recognizes attempts to violate protection criteria and monitors the transfer of control within the system. Virtual memory support was also fully integrated within the 80286 to avoid reliance on external devices.

To provide additional flexibility, the 80286 operates in two modes. Following power-up or a system reset, the 80286 is in real address mode, supporting a 1-megabyte real address space. The real mode operates as an 8086 except that it is up to six times faster, based on internal improvements and increased clock frequency. When you run the processors at the same clock speed and do not take advantage of any 80286 capabilities, the 80286 achieves 250 percent of the 8086's performance. |*Editor's Note: For one example of how the 80286 performed in a system environment, see* "The IBM PC AT," *October* 1984 BYTE, *page* 108.| The pro-

(continued)

Paul Wells has been employed by Intel Corporation (3065 Bowers Ave., Santa Clara, CA 95051) for the past 11 years. He has spent five years in engineering, two years in sales, and four years in marketing. He is currently the Marketing Manager of Special Programs within the microprocessor operation.

cessor can continue to execute in the real mode or it can be switched to protected mode by setting a bit in a status register. In protected mode, the 80286 supports a 16-megabyte real address space (24-bit address) and a virtual address space (32-bit address) of up to 1 gigabyte (one billion bytes).

80286 Memory Management

Memory management makes programs and data independent of physical memory location.

In the 80286 protected mode, application programs deal exclusively with virtual address and have no access to the actual physical addresses that the processor generates. A program specifies an address in terms of two components: an effective address offset that determines the displacement in bytes of a location within a segment, and a 16-bit segment selector that uniquely references a particular segment. Jointly, these two components constitute a complete 32-bit virtual address pointer data type.

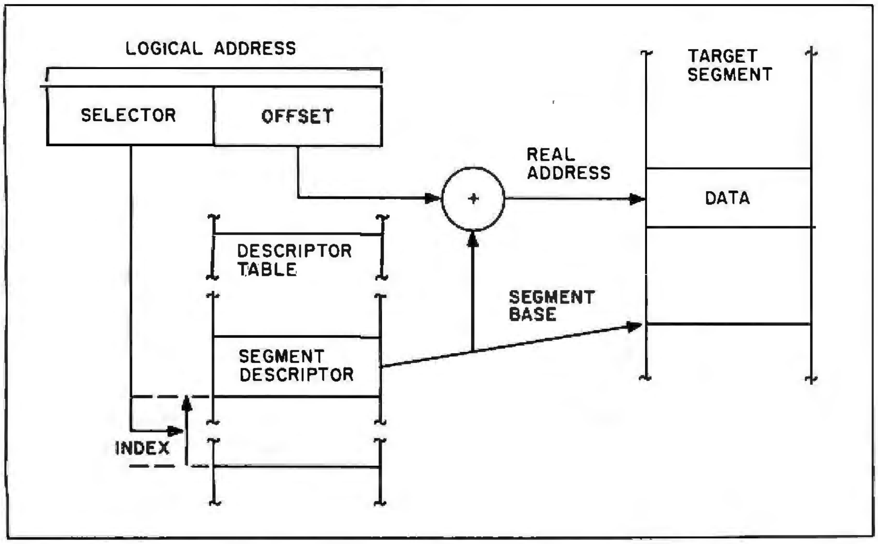


Figure 1: 80286 *address translation model.*

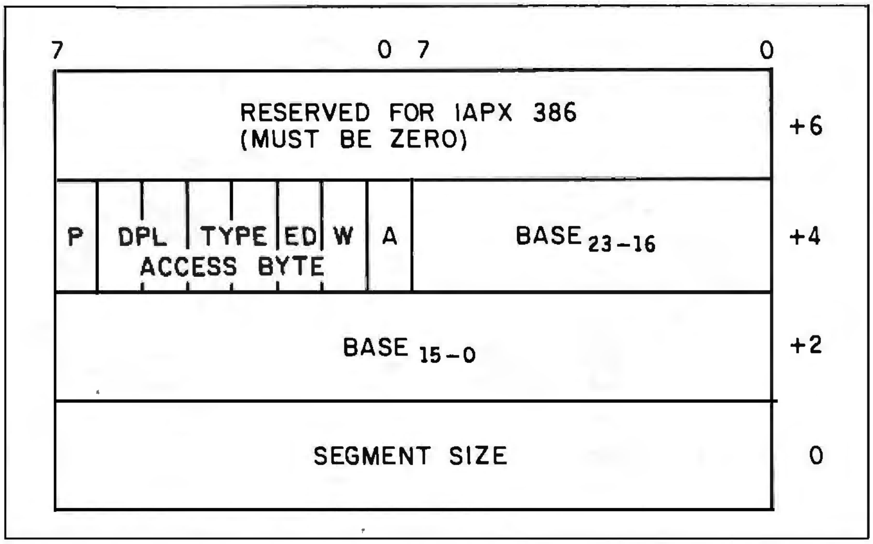


Figure 2: *Descriptor data type. The meanings of the access byte abbreviations are* P=*present bit;* DPL=*privilege level;* TYPE=*type of descriptor;* ED=*expand down (stack);* W=*write protect bit;* A=*access bit (segment has been read/written).*

Programs manipulate these 32-bit virtual addresses in exactly the same way as the two-component addresses of real address mode. After a program loads the segment selector component of an address into a segment register, each subsequent reference to locations within the selected segment requires only specification of an offset; this improves speed.

The important difference between real address mode and protected mode is the format and information content of segment selectors. The protected mode alters the interpretation of the value in a segment register from a 16-bit real address to a table index (figure 1). In addition, protected mode extends the 16-bit segment registers by 48 bits to hold the addressing protection, access write, access bit, and privilege information.

Selector loading in protected mode parallels the loading of a segment base in real address mode. By retaining the basic addressing procedures of real address mode in protected mode, the 80286 eliminates rewriting application programs to use virtual memory.

80286 Address Translation

The 48-bit segment register cache contains a segment descriptor that defines the properties of the segment being addressed, such as the base address in physical memory, segment size (from 1 byte to 64K bytes), and protection parameters for a single segment of memory (see figure 2). All the descriptors needed to define a program space are collected in a descriptor table.

The 80286 uses this cache descriptor information in a segment register to translate a program's virtual addresses to real addresses. As long as a program remains within the boundaries of a single segment, the processor obtains all address-translation information from the descriptor field in the segment register. This normally takes one processor clock cycle (which is 125 nanoseconds at 8 MHz).

(continued)

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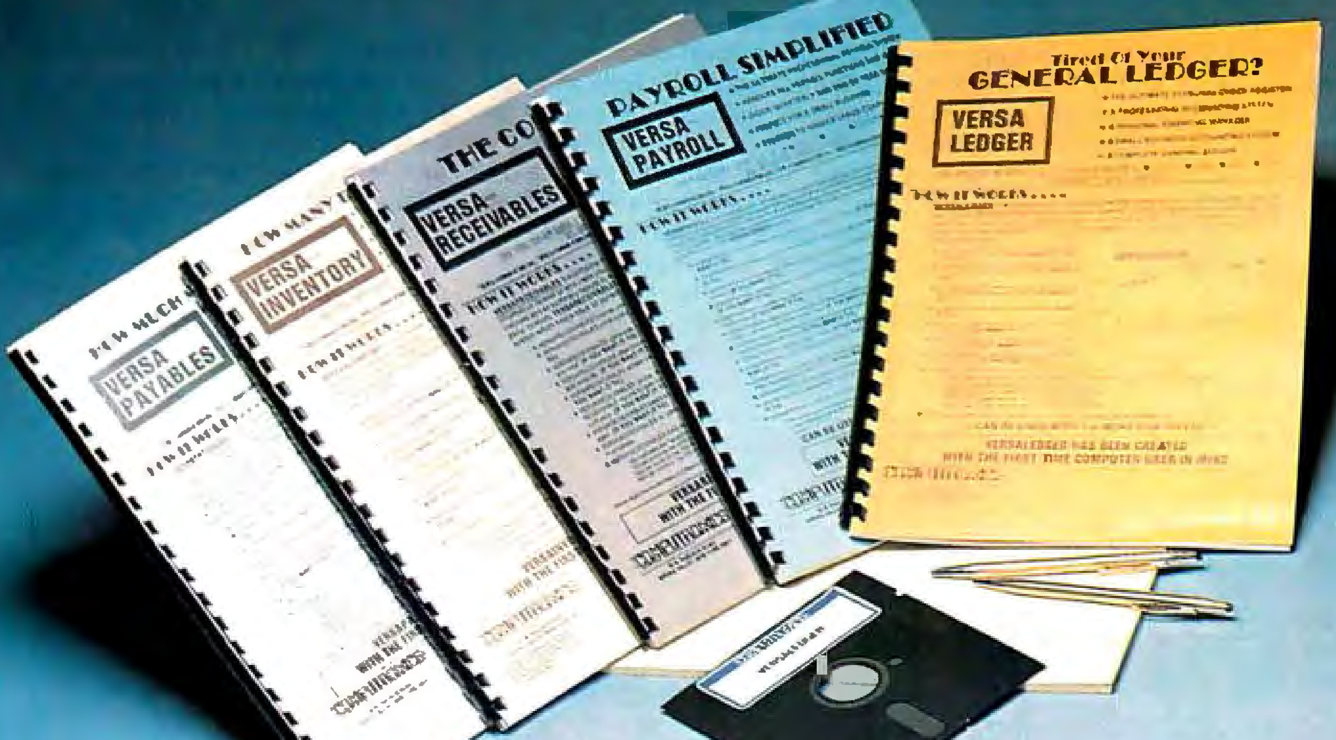

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Whenever a program loads a new selector into a segment register, the CPU automatically copies the descriptor from main memory into an on-board cache within the 80286 (figure 3). Once the hardware has copied the segment-addressing information from memory to the cache, the CPU does not refer to a descriptor table again until the program requires access to another segment.

DESCRIPTOR TABLES

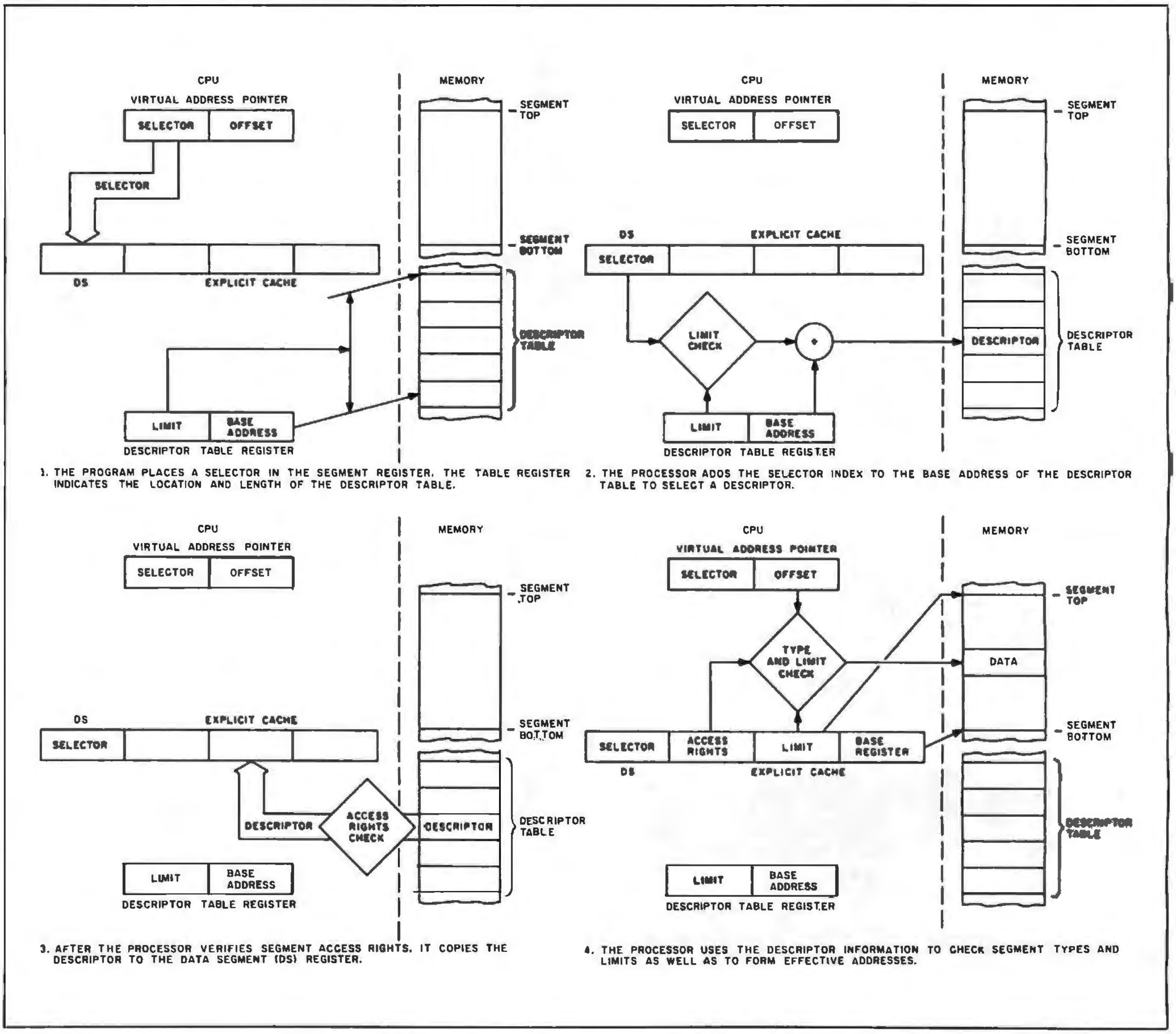
At any one time, a user's address space is defined by three descriptor tables: a global descriptor table (GDT) for code and data common to all tasks, an interrupt descriptor table (IDT), and a local descriptor table (LDT) that defines the code and data private to each task. There are as many LDTs as tasks in the system.

These tables form the interface between the OS software and the 80286 virtual addressing hardware. The address of each table is automatically maintained by the 80286 through three on-chip registers: GDTR, IDTR, and LDTR. Switching from one user's local address space to another's only requires changing the LDT register in the CPU.

PROTECTION

The hardware-enforced protection of the 80286 improves the reliability of an entire system (by confining software errors) and keeps the system running even when a user program attempts an invalid or prohibited operation. The 80286's protection mechanism can locate and isolate a large number of program errors during development and prevent the propaga-

(continued)



1. THE PROGRAM PLACES A SELECTOR IN THE SEGMENT REGISTER. THE TABLE REGISTER INDICATES THE LOCATION AND LENGTH OF THE DESCRIPTOR TABLE.

2. THE PROCESSOR ADDS THE SELECTOR INDEX TO THE BASE ADDRESS OF THE DESCRIPTOR TABLE TO SELECT A DESCRIPTOR.

3. AFTER THE PROCESSOR VERIFIES SEGMENT ACCESS RIGHTS, IT COPIES THE DESCRIPTOR TO THE DATA SEGMENT (DS) REGISTER.

4. THE PROCESSOR USES THE DESCRIPTOR INFORMATION TO CHECK SEGMENT TYPES AND LIMITS AS WELL AS TO FORM EFFECTIVE ADDRESSES.

Figure 3: *Virtual memory addressing procedure on the* 80286.

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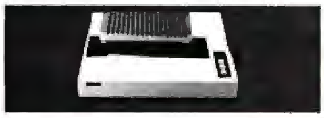

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tion of errors in other tasks or programs once the system is installed. Protection in the 80286 has three basic aspects: data-type checking, system software isolation, and task isolation.

DATA-TYPE CHECKING

The foundation of the 80286 protection mechanism is the segment, the smallest region of memory that has unique protection attributes. Modular programming automatically produces separate segments whose contents reflect the natural construction of a program, e.g., code for module A, data for module A, stack for the task, etc. The 80286 was designed to optimally execute code for software composed of independent modules.

The attributes of each segment are contained in the memory-resident descriptors I discussed earlier. During address translation, the 80286 protection mechanism compares the segment's attributes against the operation requested. Thus, with no software intervention, it is possible to guard against executing data or writing into a write-protected area. All checks are made for each instruction the CPU executes and take one-half of a processor clock cycle. Since the checks are performed concurrently with address formation, there is no performance penalty.

The hardware performs several checks while loading a segment register. These checks enforce the protection rules before any memory reference is generated. The hardware verifies that the selected segment is valid (is in memory and is accessible from the privilege level in which the program is executing) and that the type is consistent with the target usage (code, data, stack). For example, a code segment or read-only data segment cannot be written.

All these checks are made before the memory cycle starts; any violation prevents that cycle from starting and causes an exception to occur. This prevents the machine state from being partially changed due to an exception detected halfway through an

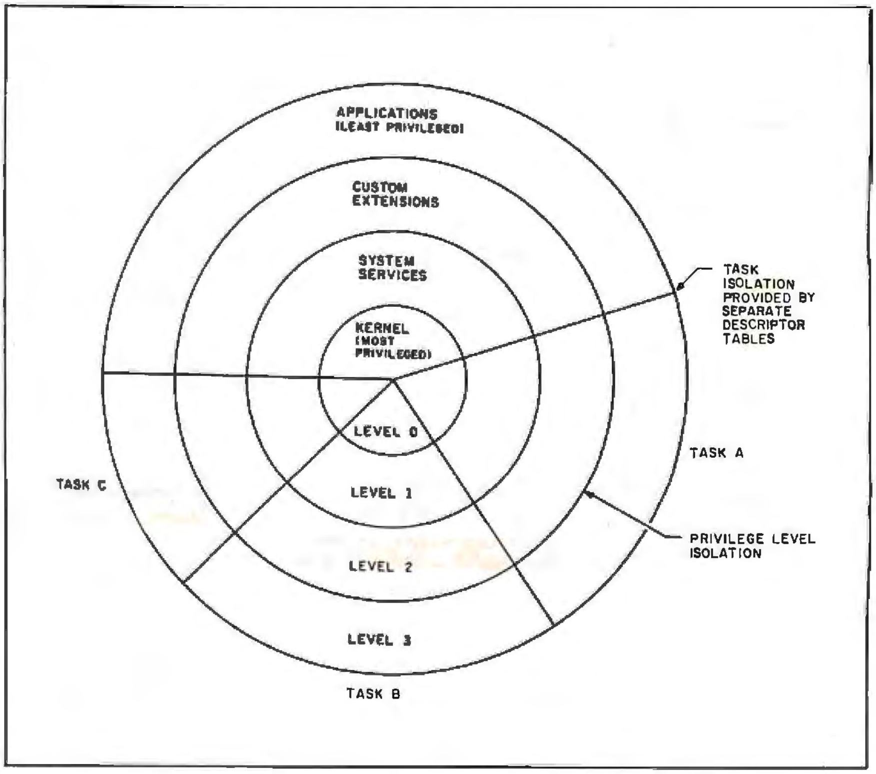

Figure 4: *The four-ring protection model showing tasking.*

Four privilege levels provide the isolation necessary.

operation and streamlines exception handlers.

ISOLATING SYSTEM SOFTWARE

The 80286 provides a four-level, ring-type protection mechanism to isolate application software from various layers of system software (figure 4). Software modules at the operating-system level are protected from modules in the application level. Within the OS, the kernel can be isolated from the more dynamic operating extensions such as device drivers, standard libraries, and other services. This is especially important in an environment that supports multiple, concurrent instruction streams.

The four privilege levels provide the isolation necessary for the system's various layers. Privilege on the 80286 is hierarchical with the levels numbered from 0 to 3, where 0 is the most trusted level and 3 the least. Programs at a given privilege level can access data and code at the same or a numerically higher privilege level.

The 80286 controls access in the opposite direction through a mechanism called a gate. A gate is a 48-bit data type residing in a user's descriptor table that points to (contains the address of) the procedures in a more privileged ring accessible to the calling procedure. The referencing procedure uses a standard CALL instruction with the operand containing the gate's address. The 80286 recognizes that a level transition is in progress and performs the necessary access checks automatically. If the checks are passed, access is allowed to the target procedure (figure 5).

The gate for a more privileged procedure must reside at the calling procedure's privilege level. If the privilege levels do not agree, the processor will fault the operation. It is impossible for a procedure to access a procedure at

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another level unless it has access to the gate. It is also impossible for a user to manufacture a gate or manipulate its descriptor table. Operations on descriptor table contents are allowed only at level 0.

The multiringed mechanism of the 80286 has simplified the view that application programs have of the operating system. Each request for system resources passes directly to the OS via the gate structure. The application has access to the OS through as many different paths (gates) as the system designer allows. Since no operating system intervention is necessary to pass into a "supervisor" state, the 80286 also provides a performance enhancement over the software-based user/supervisor approach.

The most important aspect of the ring model and gate mechanism is that it is transparent to the application programmer. For the user, a CALL instruction acts as if a system service were locally defined.

FOUR PRIVILEGE LEVELS

Four privilege levels allow the development of more reliable, flexible system software. For example, an operating system is normally composed of two parts: a kernel and system services. The system kernel is responsible for supporting key system-level mechanisms such as memory allocation, task scheduling, and dispatching. The kernel represents the most static code in the system. The services portion supports more dynamic aspects such as file access scheduling, data communication, and device control. Normally, these two parts are physically placed together in a supervisor space. A major problem arises when the operating system is updated with a new device driver or data communication protocol. Changes compromise overall system integrity.

The 80286 lets an operating system be physically separated with controlled access, monitored by the hardware, between the two parts. The kernel could be placed at level 0, isolated and unaffected by any changes to the system services at level 1. The kernel's integrity is maintained and the kernel can be smaller due to the hardware assistance supplied for task and memory management.

Privilege level 2 could contain the custom operating-system extensions. Such customizing can be kept isolated from errors in application programs and cannot affect the basic integrity of the system software. Examples of customized software are the database manager and logical file access services.

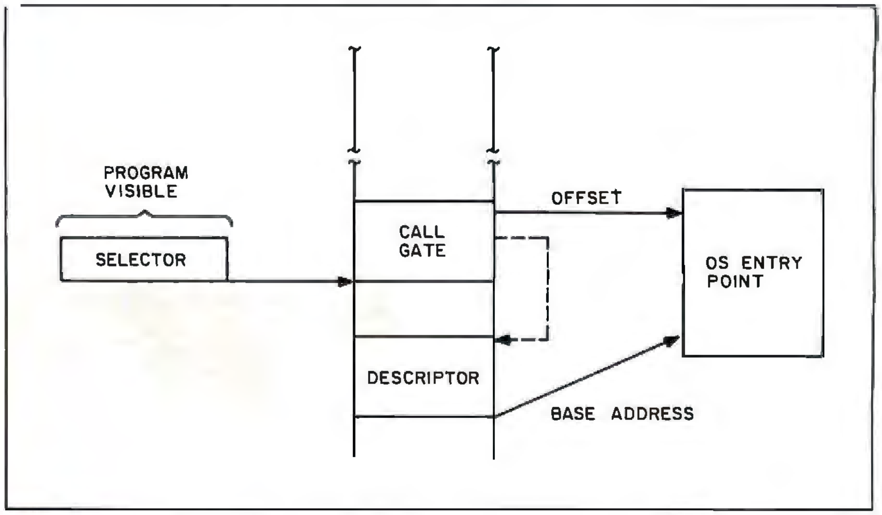

Figure 5: 80286 *operating system* CALL *model. Because the offsets are taken only from the* OS *table, applications can only access elements at the prescribed point.*

Tasks are dynamic and execute one or more programs.

This is just one example of protection mechanism usage. The four protection levels can be used in many different ways or, in the case of some implementations, not at all. The usage (or nonusage) is up to the system designer.

TASK ISOLATION

An important distinction exists between tasks and programs. Programs (instruction in code segments) are static and consist of fixed sets of code and data, each with an associated privilege level. The privilege assigned to a program determines what the program may do when a task executes it. Privilege is assigned to a program when the system is built or when the program is loaded.

On the other hand, tasks are dynamic and execute one or more programs. Task privilege changes with time according to the privilege level of the program being executed. Each task has a unique set of attributes that define it, such as address space, register values, stack, and data. A task may execute a program if that program appears in the task's address space.

Multitasking partitions a problem into separate instruction streams that the central processor executes in rapid succession. To an observer, the tasks appear to be operating in parallel. From a physical standpoint, multitasking provides an efficient way to share a scarce resource—the CPU; while one task is waiting for I/O (input/output), another task can be executing. Logically, multitasking affords a system designer a natural partitioning of large problems into smaller, more manageable functions or the ability to support multiple users/tasks at one time.

An example of an implementation is a workstation on a network supporting an advanced word processor. At

(continued)

least one task would handle data shipped over the local-area network. At the same time, the word processor would be using multiple tasks to perform user I/O, formatting, spelling checks, and disk access.

The 80286 provides a high-performance task-switch operation with complete isolation between tasks. A full task-switch operation takes 21 microseconds at 8 MHz.

Performance and system design advantages arise from the 80286 task switch. First, a task switch performed by hardware is faster. A task switch is a single instruction performed by hardware. Such a scheme is more than five times faster than an explicit task-switch code sequence.

Second, a task switch performed by hardware creates more reliable, flexible systems. The high-speed task switch lets interrupts be handled by separate tasks rather than within the currently interrupted task. This isolation of interrupt handling code from normal programs prevents undesirable interactions. The interrupt system can be more flexible since adding an interrupt handler is as safe and easy as adding a new task.

Third, every task is protected from all others via the separation of address spaces, unless explicit sharing is planned in advance. If the address spaces of two tasks include no shared data, one task cannot affect the data of another (figure 4).

A data type called a task state segment (TSS) defines tasks in the 80286. The definition of a task includes its address space and execution state. A task is invoked (made active) by intersegment JMP or CALL instructions whose destination address refers to a TSS. Such TSS has a unique selector value that provides an unambiguous identifier for each task. This lets an operating system manipulate tasks through a single pointer.

A TSS contains 44 bytes that define the contents of all registers and flags, the initial stacks for privilege levels 0 through 2, the LDT selector, and a link to the TSS of the previously executing task. The descriptor used for task state segments must be accessible at all times; therefore, it can appear only in the global descriptor table.

A task switch can occur in one of four ways. The destination selector of a long JMP or CALL instruction can refer to a TSS descriptor. An IRET (return from interrupt) instruction can be executed when the NT (nested task) bit in the flag word is set. The destination selector of a long JMP or CALL instruction can refer to a task gate. Or an interrupt can occur whose vector refers to a task gate in the interrupt descriptor table.

(continued)

```
05  GRACE DRAKE                   555-5644                   V
06  GEORGE T. SMYTHE              408-555-2333          A    V
07  GEORGE T. SMYTHE (AT WORK)    408-555-5689          A    V
08  ICON CORPORATION              415-555-1000               D 1200 N 8 1
09  RAND SYSTEMS                  555-2389                10 D  300 E 8 1
10  *LOGON SEQUENCE               *LOG ON                 16 D

12  DOROTHY SMYTHE                408-555-4545          A    V
13  OSLO COMPUTER CENTER          011-47-2-455260            D  110 O 7 2
14  ELMER S. BRYAN                914-555-5588          B 21 D 1200 N 8 2
15  ELMER                         914-555-5589          B 21 D 1200 N 8 2
16  *PASSWORD FOR RAND            *                          D
17  E. F. HUTTON & CO.            555-5611              Z    V
18  DOW JONES                     415-555-7777          D    D 1200 E 7 1
19  E. F. HUTTON & CO.            555-5600              D    D  300 O 8 1
20  INVESTMENT BANKING, INC.      415-555-5522          Z    V
21  *USERID                       ELMERID                    D
```

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No new instructions are required for a task-switch operation. The standard 8086/80286 JMP, CALL, IRET, or interrupt operations perform this function. The processor makes the distinction between the standard instruction and a task switch through the type of descriptor referenced. The choice of task-switching technique depends on the system designer.

I want to consider the steps necessary for an operating system to dispatch a task.

TASK INVOCATION

After the operating system makes the policy decisions as to which task is to run, the task is dispatched with a standard JMP instruction whose effective address is a task gate. From this point on, hardware handles the task switch.

The CPU checks the task gate against the protection rules. If the request is valid, access to the TSS is allowed. Once access to the TSS has been granted, the task-switch operation involves six steps in the CPU that were formerly required of the operating system. The processor then applies data access privilege rules and the current task becomes the outgoing task. If the new task is present (in memory), the new task becomes the incoming task.

Then the state of the outgoing task is saved by the processor. The dynamic portion of the outgoing TSS is written with the corresponding CPU register values (e.g., AX, BX, CX, DX, SI, DI, BP, SP, ES, DS, SS, CS, IP, and flag register). The IP (instruction pointer) value points at the instruction following the one that caused the task switch. All errors up to this point are handled in the context of the outgoing task. The errors are restartable and error handling is transparent to the application program. (A restartable error occurs when an executable line of code cannot be executed at this time. For example, a virtual memory fetch to disk might not have the data available when the line of code requires it.) The task register is then loaded with the incoming task selector, and the incoming task's descriptor is marked "busy." Finally, the incoming task state is loaded and execution resumes. The following registers are loaded: LDT, AX, BX, CX, DX, SI, DI, BP, SP, ES, DS, SS, CS, IP, and flag register. Any errors detected in this step are handled in the context of the incoming task. The operating-system software is not involved with the task-switch mechanism, but is only concerned with identifying which task runs next.

Note that the state of the outgoing task is always saved. If execution of that task is resumed, it will start the instruction that caused the task switch. The value of the registers will be the same as when the task stopped running. ■

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Object Code Size (bytes)	128	255	329	181	415	
Program Load Time (secs.)	3.2	3.8	6.3	11.2	23.5	
Compile Time (secs.)	8.5	—	—	3.9	108	

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THE PF474

BY STEVE ROSENTHAL

A coprocessor for string comparison

FINDING THE CLOSEST match for a string of symbols is important in database searches, speech recognition, artificial intelligence, and computer vision. Yet, even with the fastest 16- and 32-bit processor chips, computing a closest-match function is relatively slow and complex. However, there is no reason why this operation must be left entirely to the central processing unit. Just as a numeric coprocessor can greatly accelerate complex calculations, a string-search chip can make fast work of finding the closest string value.

Proximity Technology Inc. makes the PF474, a VLSI (very-large-scale integration) string comparator and ranker, which is the first chip of this type to become generally available. This chip is available in single quantities for $250. Running at up to several thousand string comparisons per second, this chip compiles a ranked list of the 16 best matches for a test string from a selection of possible candidates.

The rankings, as I'll explain at length later, are based strictly on a mathematical function of symbol counts. This means the chip can be used for much more than checking English text. The PF474 will rank any information that can be expressed in strings of 8-bit characters up to 127 bytes long.

On the negative side, however, the PF474 is *only* a symbol comparator, not a linguistic processor. Each symbol is treated as entirely unconstrained by the preceding and following symbols, a situation quite unlike the workings of English and all other natural languages. (See the text box "Different Conceptions of Order" on page 248 for more information.) As a result, unless supplemented by complex processing done by the host, in some circumstances the PF474 can produce closeness rankings of words and phrases that are far different than most native speakers would produce.

The PF474 is logically composed of two semi-independent subsections: a proximity (closeness) computer and a ranker (see figure 1). Additional supporting circuits include a DMA (direct memory access) controller to rapidly load the strings, parameter storage for saving selected characteristics for each symbol, and a number of control and status registers.

The proximity computer finds the closeness of two strings and computes a 32-bit fraction that expresses their closeness. A value of all zeros indicates two entirely different strings, all ones indicate two identical strings. In between, higher values indicate closer matches.

The algorithm used to compute closeness is basically a counting function. (See the text box "PF474 Math Deciphered" on page 252 for the actual formulas.) Searching forward, the chip counts the number of matched symbols in the strings, considering in sequence the first symbol of each, then the first two, then the first three, etc. The chip then does the same computation going backward from the end of the strings.

Although conceptually simple, this method accords with many of our intuitive measures of closeness. Transpositions (where two letters are in reversed order) detract less from the proximity value than omissions.

(continued)

Steve Rosenthal (POB 9291, *Berkeley*, CA 94709) *is a writer and lexicographer. He writes seven regular columns for computer publications and is working on two computer-related dictionaries to be published by* Prentice-Hall.

Single-letter deletions or additions do not completely negate matches in letters that follow. Matches at the beginning and end are more significant than those in the middle.

The basic algorithm is fixed in silicon, but you can customize the operation of the proximity-matching function by choosing the appropriate value for the three parameters (weight, compensation, and bias) that you must supply for each of the 256 possible 8-bit symbols.

The weight (a number from 0 to 7) specifies the relative importance of the symbol during the matching process. A match of a symbol with weight 0 does not count toward the proximity value, while a match of a symbol with weight 6 counts three times as much as one with weight 2.

The compensation only enters into the result for symbols that are not matched. This parameter also ranges from 0 to 7. A high compensation value lessens the effect of a symbol that occurs in only one of the two strings. Compensation is a sort of "consolation prize" that the strings get for having those symbols individually, even though the symbols don't match between the strings.

The last symbol parameter, the bias, alters the relative importance of finding a match during a forward-comparison or a reverse-comparison scan. If the bias is 0, each direction is equally important. The bias is added to the weight during the reverse comparison, so a positive bias increases the importance of a reverse match, a negative bias decreases it. The bias for each character can be set to −2, −1, 1, or 2.

In theory, you could use just the proximity section of the chip because it is possible to read out from the chip the proximity value obtained during each comparison. Similarly, you could compute the proximity indexes for pairs of independent strings rather than comparing one constant string to a series of possible matches. However, in most applications you'll want to use the proximity section to compute an index for the closeness of a number of strings to a single reference string and then send the resulting values to the ranker to find out which ones are the closest.

THE RANKER

After the proximity section has evaluated the closeness of two strings, it passes the value on to the PF474's ranker section. The ranker tests the new value against its current 16 best values and throws the result away if the new value is less than any of the 16.

If the new value does rank more highly, the ranker section adjusts the list by eliminating the bottom value and inserting the new one in the appropriate position. Along with each proximity value, the ranker stores a 32-bit record number showing which proximity comparison produced that value. Note that the PF474 does not store the 16 best strings themselves but saves the pointer values instead.

If you want a list of more than the 16 best matches, you can set the ranker to *next-best* mode. During next-best mode, the ranker saves the 15 proximity values (and their pointers) that are less than or equal to the proximity value in the highest ranking slot. If you make the highest ranking slot equal to the lowest value from a first normal ranking and do a next-best match, you will extend your rank to the top 31 values.

The proximity computer section and the ranker operate independently, but in a pipelined arrangement. That means that while the ranker is figuring out where a new proximity

(continued)

DIFFERENT CONCEPTIONS OF ORDER

Determining how similar two strings of symbols are to each other involves philosophical as well as practical questions. A brief diversion into types of ordering seems appropriate here.

Mathematicians and metrologists (measurements specialists) generally group measurements into four different categories: nominal, ordinal, integral, and ratio.

With nominal measurements values can be classified, but you can't specify a mathematical relationship about the relations between classes. For example, you might divide computer programs into those written in BASIC, COBOL, Pascal, and C.

Ordinal measurements have a sequence but no specified magnitude. For example, you might argue that you could rank three popular operating systems for user friendliness, with UNIX being the least user friendly, CP/M being the next to least, and MS-DOS being the most. But we would not have any mathematical way of expressing how different CP/M is from UNIX, or whether that was more or less than the difference between CP/M and MS-DOS.

Integral measures let you make that judgment. In an integral scale, you can specify both direction (sequence) and distance between items, but you don't necessarily know what the true zero point is on the scale. For example, you can measure the increase in the incidence of cancer due to radiation exposure, but you won't have a good fix on what the baseline value would be with no exposure at all (including natural exposure).

Ratio measurements are the most specific. A ratio measurement lets you specify both amount and proportion. For example, you can say that one computer has 128K bytes of memory, which is twice as much memory as another machine has.

The question is: what kind of measure can you hope to apply to symbol strings? If you're comparing the closeness of characters, are you going to say that vowels are closer to each other than consonants? Are Ks more like Cs than Os? One difference between the way people operate and the way the PF474 does is that people can make those judgments (often unconsciously). The PF474, however, treats all symbols as equally distant, or as integral measurements located in a 256-dimensional space with a 1-unit separation between any two members.

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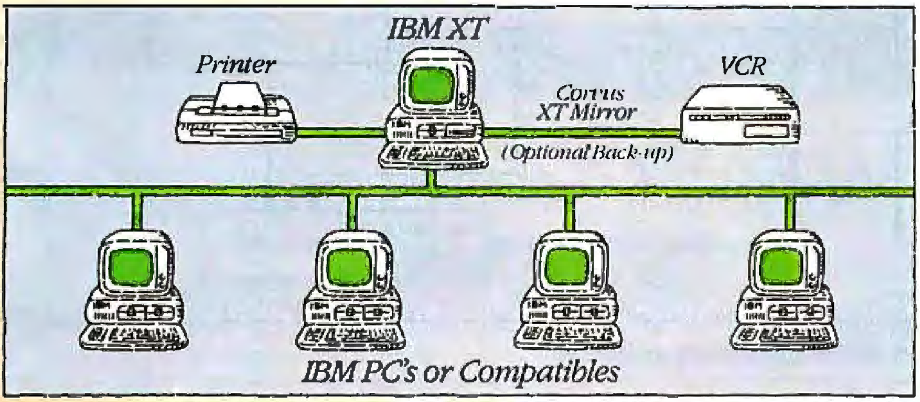

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value fits it, the proximity section can be busy loading another string and computing a new closeness value.

THE DMA

With string comparison and ranking working at speeds of thousands of strings per second, the PF474 has a voracious appetite for input data. To speed up the transfer process, the chip includes its own DMA controller to regulate the flow of data from memory to chip.

In DMA mode, the main processor writes the required control words to set up the PF474, plus a starting address for data transfer. The main processor then halts, relinquishing control of the bus to the PF474.

When the PF474's DMA section receives both bytes of the starting address, it takes control of the bus, stepping through 16-bit addresses and reading data from memory into the chip. The PF474 continues reading data until it finds a 00 byte or reaches the maximum 127 characters.

For systems that don't provide for DMA control, or where the data to be compared doesn't exist in memory but is computed during processing, the PF474 can also accept data in non-DMA mode. With a little bit of external logic, such as on Proximity's PF-PC board for the IBM PC, the PF474 can also accept data from an existing system DMA controller.

DMA loading on the PF474 provides one other capability. Prior to a DMA transfer, the PF474 can be set to use the upper 128 of the 256 possible 1-byte symbol codes as special editing symbols. According to the settings loaded from the host into the PF474's command registers, the DMA transfer will then drop all of certain specified special symbols or sequential duplicates, or add codes to emphasize transitions from one symbol to another.

USING THE CHIP

Producing a ranking with the PF474 requires four steps: initial parameter loading, search **initialization**, a transfer operation, and a final reading of the results.

The first initialization step sets values that are indeterminate when the PF474 is powered up but must be specified before the chip is used. The main task here is to set initial values for the symbol parameters. For ranker control, the size of the comparison list must be set to 16 or some smaller value (using smaller values slightly speeds processing when 16 closest matches aren't required). The ranker must also be set to start with the normal, rather than the next-best mode, so it will find the 16 highest proximity values.

For each search, the reference string must be loaded into the proximity portion of the PF474, normally into slot A (the two comparison slots are symmetric, but the software and examples that Proximity Technology provides assume this arrangement). To get the ranker section ready, the

(continued)

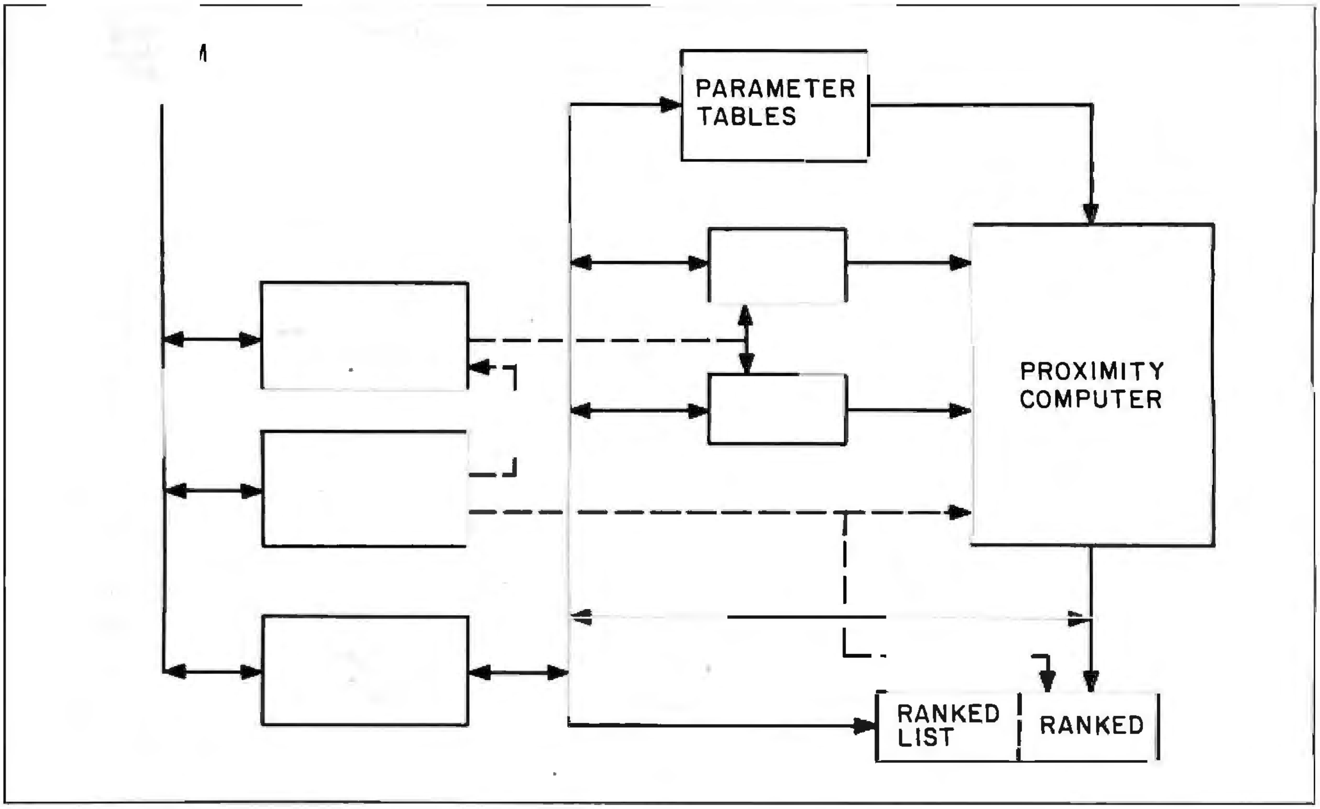

Figure 1: A *block diagram of the* Proximity Devices PF474 *string-proximity computer chip.*

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PF474 MATH DECIPHERED

I've translated the algorithm used to compute the proximity (string closeness value) in the PF474. First I'll present the formula Proximity Technology presents in its manual, then my translation.

$$Wf(a) = W(a)$$
$$Wr(a) = W(a) + B(a)$$

[illegible] Wf is the forward weight, W is the weight function, Wr is th[illegible] weight. B is the bias function, and a is a symbol.

For each symbol, assign a weight value saying how important a match of this symbol is. When comparing forward matches, use this weight. When matching the strings going backward, however, use a reverse weight composed of [illegible] sum of the forward weight and a factor called the bias. Because the bias varies from −2 to +1, it can increase or decrease the weight for the reverse scan compared to the forward scan.

$$C(a) <= min(Wf(a),Wr(a)) \text{ for all } a \text{ in } A.$$

where C is the compensation function, and A [illegible] set of all symbols [illegible] can be.

Assign each symbol a compensation value, to be taken into account as a sort of consolation value if the symbol occurs in one string but not in the other. The compensation value for each symbol can't be larger than the forward weight or reverse weight for that symbol.

$$Mf(S,T) = \Sigma_{n=0}^{\infty} \Sigma_{a\epsilon A} 2 \times Wf(a) \times min(CNT(a,suf(S',n)), CNT(a,suf(T',n)))$$

where Mf(S,T) is the forward matching value of strings S and T; CNT is the number of occurrences of a in suf(S',n) or a in suf(T',n); suf is the string ***obtained*** *[illegible]ving the first elements from S' or T'. S[illegible] T' are the revers[illegible] original string and the searched string.*

The first item you have to compute is the forward matching value. Conceptually, this is the weighted sum of the number of symbols shared by both strings, considering just the first symbol of each string, then the first two, the [illegible] three, and so on through the complete length of the strings.

Because of the way the chip works, it can handle parts of the string running from somewhere in the middle to the end better than from the beginning to

Then look at the resulting string if you remove in turn none, one, two, three, etc., characters, leaving the rest of the string from there to the end. That the order within the fragment is backward from normal doesn't matter, nor does it matter that you're starting from the full string and working down rather than from a null string and working up. So the result [illegible] working with the string fragments counted from the end of the reversed string is the same as working on a portion of the string counting from the beginning.

For each set of string subsets, look at each symbol (*a*) that belongs to the total symbol set (*A*) in turn. Count how many times the symbol appears in each string [illegible] take the minimum of the two counts, which is the same as checking how many times the symbol is shared by the two substrings.

Take that minimum count for each symbol, multiply it by the forward weight [illegible]h is the symbol weight itself), and multiply the result by two. This gives you the weighted value of that particular symbol for that size string fragment. Sum the product for each symbol in turn for the current string fragment size. Then add together the sums for all the fragment sizes, giving us the matching value for the two strings. Note that the symbols at the start [illegible] string (tested as the end of the reversed strings) are checked for match during each possible string fragment. Those that would be at the end of the string in their normal order are checked only once. Therefore, matches at the beginning have an implicitly greater weight, one that grows proportionately with the length of the strings being compared.

$$Mr(S,T) = \Sigma_{n=0}^{\infty} \Sigma_{a\epsilon A} 2 \times Wr(z) \times min(CNT(a,suf(S,n)), CNT(a,suf(T,n)))$$

where Mr(S,T) is the reverse matching value of S and T

[illegible] reverse m[illegible] works much like the for[illegible]ch. This time, you don't have to [illegible] strings around to work from the back end. And this time, instead of using the forward weight as you count matches in each string fragment and multiplying by the weight, use the reverse weight (made up of the for-

$$COMP(X,Y) = [|X|+1] \times \Sigma_{a\epsilon A} [C(a) \times max(CNT(a,X)-CNT(a,Y),0)]$$

where COMP(X,Y) is the comparison compensation value for strings X and Y, and |X| is the length of string X.

For symbols that are not matched, you can also compute a comparison compensation value for the comparison of two strings. As shown below, you do this as two partial sums, one finding the comparison compensation of *X* compared with *Y* and the other finding the compensation of *Y* compared to *X*.

Compute each sum by looking at each symbol that belo[illegible] the symbol set. For each symbol, [illegible] how many times it appears in the first string and subtract from that how many times it appears in the second. This gives you the number of times the symbol has appeared but not been matched. If it is a negative number, ignore the counts for now by using a 0 instead of the counts.

Then multiply the resulting count by the symbol compensation value for that symbol. Repeating this procedure for each symbol in the symbol set and summing the results gives you a raw compensation value, which you then have to multiply by the length of the first string plus one (to make up for the fact that all the other values in the overall proximity function have the length factored in).

The result of this process is the comparison compensation value of the two strings. When you compute this function as the second string compared to the first, however, you may get a different value. The length of the strings may differ or there may be a difference between the weighted value of how many symbols are in the first string but not in the second, and how many are in the second but not in the first.

$$TOTM(X) = \Sigma_{n=0}^{\infty} \Sigma_{i=0} Wr(X[i]) + Wf(X'[i])$$

where TOTM(X) is the self-similarity matching function on X, and X[i] is the ith character in X.

The last two elements in the proximity equation are the self-similarity scores of the two strings in the comparison (that is, each string's similarity with itself). You could compute this with the matching function, but since you know that each by that symbol in a comparison with itself, you can use this simpler formula.

You can compute the forward and reverse self-similarity matching values at the same time. Again, reverse the string to compute the forward matching value and look at the values for a series of substrings starting from within the string and running to the end. Take in turn a series of substrings, starting with the first character through the last, then the second through the last, the third through the last, etc. For each substring, look at each symbol position in the substring. For each position, add the reverse symbol weight for the character you find in the string at that position plus the forward weight you find in the reversed string at that position (that's the same as adding the forward weights and the reverse weights for all symbols in the substring). Summing the weights for each substring gives you a total matching weight for the comparison of a string with itself.

$$M(S,T) = Mr(S,T) + Mf(S,T) + COMP(S,T) + COMP(S,T)$$

where M(S,T) is the adjusted matching value for S and T.

From all of the above equations, you're now ready to compute the adjusted matching value for these two strings. Add the reverse matching value of the strings plus the forward matching value, plus the compensation for first string compared to the second string, plus the compensation of second string compared to first. Since this is a sum of positive values, increasing any of these factors increases the resulting adjusted matching value.

$$\theta(S,T) = \frac{M(S,T)}{TOTM(S) + TOTM(T)}$$

Finally, the *proximity value is equal to the adjusted matching value of the first string compared to the second, divided by the sum of the matching value of the first string with itself, plus the matching value of the second string with itself. Put another way, the proximity value is the actual adjusted matching value compared to the maximum possible matching value. The result is a single unsigned number ranging from* 0_{16} *through* 11111111_{16}.

[The following is reprinted from the PF474 *manual. Copyright* 1984 *by Proximity Technology Inc.,* 3511 *NE 22nd Ave., Fort Lauderdale, FL* 33308*. Used with permission.]*

AN INTUITIVE DESCRIPTION OF THE PROMIXITY FUNCTION

The following is an intuitive method for manually calculating proximity values that is mathematically simple, yet completely accurate. For the first few examples, all characters have a weight of one, and bias and compensation are set to zero.

The proximity value that appears in the ranker after a comparison of word *A* with Word *B* is the result of:

$$\text{PROXIMITY VALUE} = \frac{2 \times (A \text{ compared with } B)}{(A \text{ compared with } A) + (B \text{ compared with } B)}$$

The comparison of word *A* with word *B* is calculated as follows:
Let word *A* be *TOO* and word *B* be *TWO*.

Write the words above one another:	T O O T W O	
Look at the first column:	T T	
Comparing the letters in the first word, first column, and second word, first column: how many pairs of matching letters are there?		matches = 1
Look at the first 2 columns:	T O T W	
How many matching pairs are there?		matches = 1
Look at all 3 columns:	T O O T W O	
How many matching pairs are there? (there is only one pair of Os)		matches = 2
		forward total = 4
Now look at the two words with the order of the letters in each word reversed:	O O T O W T	
First column:	•	matches = 1
First 2 columns:	* *	matches = 1
All 3 columns:	* * *	matches = 2 reverse total = 4
Now, add up the matches found:		total = 8
This is the comparison value for *TOO* with *TWO*.		

Now, calculate the value for *TOO* with itself:

	T O O T O O	
First column:	•	matches = 1
First two columns:	* *	matches = 2
All three columns:	* * *	matches = 3
For the reverse words, the same results will be found: 1 + 2 + 3 = 6 for a total of:		reverse total = 6 total matches = 12
Comparing *TWO* with itself also totals 12.		

$$\text{Proximity Value} = \frac{2 \times 8}{12 + 12} = \frac{16}{24} = \frac{2}{3} = .666666666$$

The first thing you notice about pBASE is how fast it searches.

main processor must load all zeros into the ranker's list space. The ranker IRN (internal record number, which is the pointer used to keep track of which comparison produced which proximity value) must also be set to an initial value, normally 0. If DMA will be used, the main processor must also load the PF474 with the correct DMA command word.

Now the chip is ready to start searching. Each string to be compared is loaded into slot B in the proximity section either by using the main processor to write data into the PF474 in programmed mode or by direct loading by DMA. In DMA mode, loading a complete string can automatically start the proximity calculation. In programmed mode, the host must send a GO command to the PF474.

When this process has been repeated for all the match candidates in the data set, it's time to read out the results. Using the processor to read the ranker section like a section of memory, the program can find a ranked list of the top proximity values and pointers for those records. Using the pointers, the application program can then find the actual strings themselves.

THE PF-PC CARD AND pBASE

The PF474 manual gives you complete information about how to hook up the chip as a component and program its operation. But to make it easier to explore the workings of the chip without designing a whole circuit board around it, Proximity is also offering potential OEM (original equipment manufacturer) customers complete hardware implementations on IBM PC and Apple II cards ($1295 and $695, respectively). I borrowed one of the PF-PC (IBM PC-style) cards for this article.

The board comes with a manual (complete with schematic), programming information, and a 5¼-inch disk containing test programs, a monitor/debug program, and a simple example database program (pBASE) with data files.

Working with pBASE, the database program, is a good way to explore the strengths and weaknesses of the PF474 approach. Essentially, the database loads a set of strings up to 67 characters long from disk to memory and lets you search for any string using the PF474. The two sample data files Proximity supplies on the disk are a list of government officials by name, title, and phone, and a list of cities along with their state and area codes.

The first thing you notice about pBASE is how fast it searches. As you type each letter of the search string, the PF474 searches for the best 16 matches considering the information you've entered thus far. For a search of the 800 or so records in the database, the response is less than the interval between keystrokes. Then, as you provide the next letter, the program updates the list if necessary.

For example, using the government database, if you start with the letter P, you'll get a list headed with PAT SCHROEDER, but when you add an E, the head item on the list becomes PETER RODINO. Further letters may result in additional changes in the list, until the effect of added letters becomes too small to affect the result.

On the other hand, when you've only provided a small part of the reference string, the rankings the chip makes are often quite different from the rankings you and I might make. For example, using the pBASE program on the sample file of government officials with the input string PAT, THOMAS P. O'NEILL, JR. and THOMAS E. PETRI were both judged more similar than PETER H. KOSTMAYER. That's because the PF474 spots the A in THOMAS as a match for the A in PAT before it spots the A in KOSTMAYER.

pBASE also lets you alter the weight, bias, and compensation for any or all of the ASCII (American Standard Code for Information Inter-

(continued)

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change) codes. You can try, for example, to give greater weight to consonants than vowels, or vice versa. For matches closer to the ones people would make, you can emphasize the start of each string with a negative bias.

When you've explored pBASE sufficiently to get a feel for the chip, you can move on to DEX, the "Diagnostic Executive." Besides checking the operating of the PF-PC board and PF474, this program allows you to set each register on the chip, load and change memory directly, and operate the chip at the single-byte level.

APPLICATIONS

Proximity Technology claims that the potential applications for the PF474 are vast, but it has not been out long enough to start showing up in any products you can examine.

The earliest customers for Proximity's string-search chip are reluctant to say anything about their application—military buyers were among the first to spot the potential of the chip. Other commercial users are similarly closemouthed; the companies are waiting until their products using the chip hit the market. However, I was able to learn that one of the larger computer companies has been one of Proximity's best customers for the evaluation units.

Database searching is the most obvious direct use of the PF474. If multiple PF474s were used in parallel, it would be possible to search very large databases for a matching pattern quickly. Proximity points out that the speed and successive-approximation nature of the matching process would let users get immediate feedback on their search strategy, allowing the searchers to refine their strategy as they go.

The PF474 should start appearing soon in dedicated spelling-checking systems or subsystems for word processors. Proximity is already a major OEM software supplier of these routines, with its spelling-checker code used as an OEM product by several major software houses and computer companies.

Speech recognition and robot vision are two other areas targeted for the chip. Using the PF474 to search for template matches would speed processing and allow wider latitude, because the chip could more quickly look through larger sets of possible matches.

As with all chips, however, the most imaginative uses often appear after the chip has been on the market a long time. And often it is the reader of an article like this, rather than the chip's designers, who ultimately shape the destiny of the product. ■

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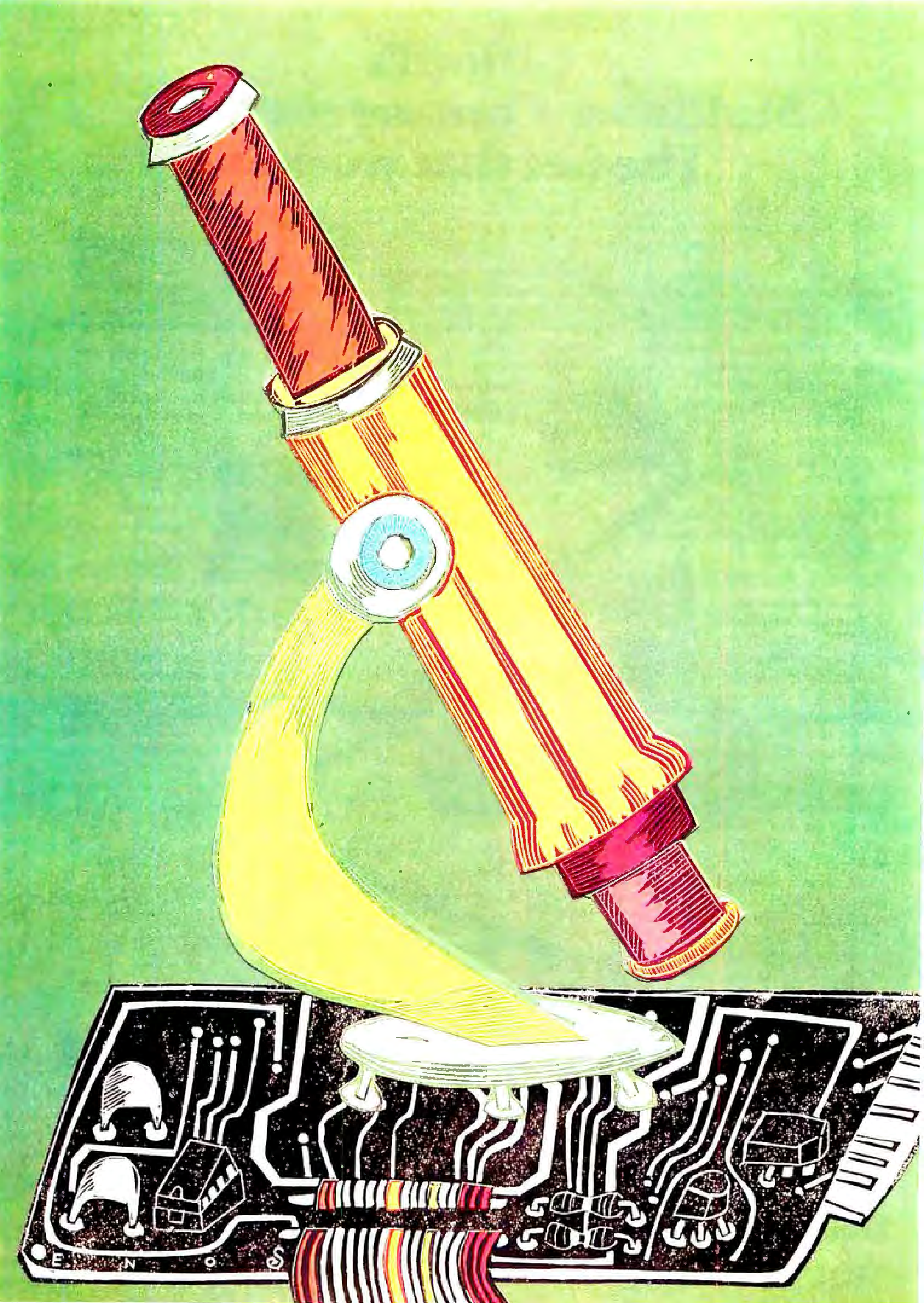
E N O S

Reviews

IN JULY OF LAST YEAR we met with Columbia Data Products and learned about the VP, its new IBM PC-compatible transportable computer. At that time we asked to borrow an evaluation unit for review in the magazine. And we asked again. And we asked again. Finally, as frequently happens, one of our veteran reviewers—Peter Callamaras—bought one for personal use and agreed to review it. Halfway through the review, Columbia sent us one of our own for a month. This helped enormously with our benchmark tests and photographs. Was the Columbia Portable worth the wait? Pete answers this and many more questions in his review.

Next we have the HP 150. More than a year ago, we published a product preview of a new computer from Hewlett-Packard. This 8088-based desktop machine with a revolutionary touch panel caused a bit of a stir. Now that the dust has settled, the initial bugs have been fixed, and some more useful software has become available, it is time to ask what this machine can really do. We engaged one of our top reviewers, Mark Haas, to put this diminutive desktop through its paces. The results are pretty interesting.

Of course, all computers—even the two mentioned above—are useless without software. So next we look at two word-processor programs for the IBM PC: Leading Edge and MultiMate. One of them has been billed as the most powerful word-processing package ever for the IBM PC. The other is recommended by many top consultants. C J Puotinen, who has written two books on word processors, gives a detailed look at these word processors and compares them to that reliable standby—WordStar. If you are thinking about serious word processing on the IBM PC, this is a "must read" article.

But wait—that's not all. Another relatively recent arrival on the IBM word-processor scene is Samna. In its fairly short time on the market, Samna has attracted a lot of attention. We recently received Samna Word III, the top-of-the-line version, which has some very advanced features. We gave this package to a veteran wordsmith, Rubin Rabinovitz. Later in this issue, Rubin gives Samna Word III a detailed examination.

For those more interested in writing programs than letters, we have a comparison of two FORTH systems for the IBM PC: polyFORTH and PC/FORTH. Ernie Tello compares these two packages and gives his recommendations.

And whether you are writing programs, letters, or shopping lists—whether you are using an IBM, Apple II, or Kaypro—you need a printer to see what you've written. This month we offer a look at two printers: one an inexpensive dot-matrix machine and the other an inexpensive daisy-wheel model. First, the Mannesmann Tally Spirit 80 is a low-cost printer that competes directly with the Epson RX-80. Mark Welch, our resident news writer, gives this machine a close look. Finally, the Brother HR-15 is a popular low-cost daisy-wheel printer that has a number of interesting options. In fact, one of the options is a keyboard that turns the printer into a typewriter. For this product review, we again enlist the efforts of Pete Callamaras. Pete examines whether this printer can do what everyone claims it can, and how well.

—Rich Malloy, Product-Revew Editor

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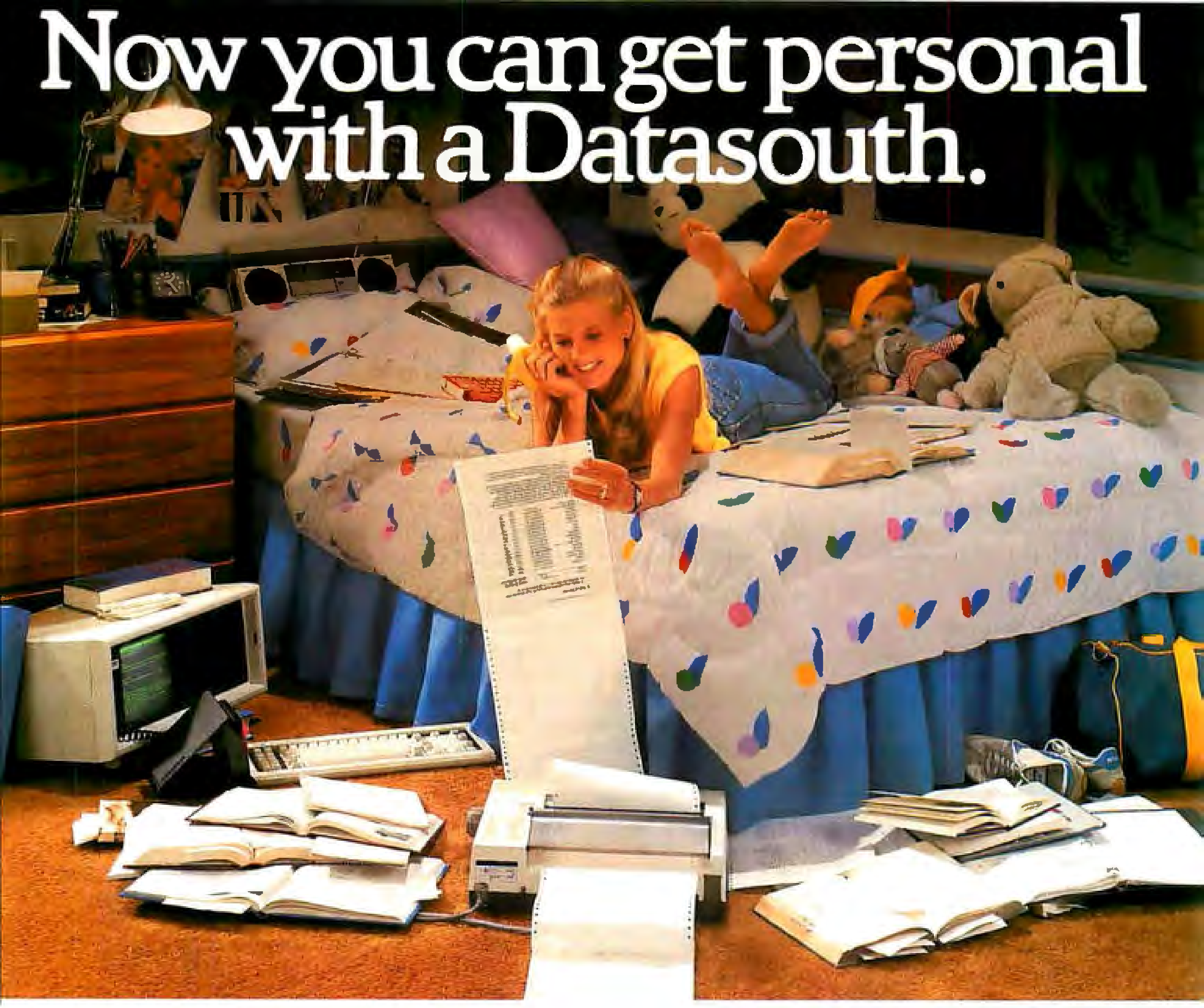

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Technically speaking, the Personal Printer is "Epson compatible." But it's better than the competing Epson because it also does near-letter-quality printing.

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REVIEWER'S NOTEBOOK

WITH ALL THE ATTENTION being paid to the IBM Personal Computer (PC) AT, another powerful machine may be overlooked: the Compaq DeskPro. This machine offers performance that is just a mite slower than the AT, a 10-megabyte hard disk, and even a tape cartridge for safe backup of the hard-disk data. Also, unlike the AT, it seems to be very compatible with the PC hardware and software. And at $7200 for a full configuration, it is quite competitive with the AT.

In our tests, we found the DeskPro to be just 25 percent slower than the AT. (The IBM PC is, by comparison, 150 percent slower than the AT.) As for compatibility, the DeskPro seems to run rings around the AT. Every IBM PC software package we tested so far works, even Microsoft's Flight Simulator. The IBM PC expansion boards that may not work with the AT apparently do work with the DeskPro. The top-of-the-line DeskPro also comes with 640K bytes of memory and serial and parallel ports. But the most important advantage of the DeskPro is its integral tape-cartridge drive for backing up data on the hard disk. The DeskPro is the first major desktop system to feature this important device.

Of course, the AT remains a potent competitor. The AT has a fast 20-megabyte hard-disk drive (as opposed to the DeskPro's 10 megabyte), a 1200K-byte floppy drive, and the ability to address (in XENIX) up to 3 megabytes of memory. But a fully equipped AT with a third-party tape-cartridge unit will cost about $8200. The DeskPro is only about $7200.

Compaq, by the way, was one of the first companies to come out with a reliable, well-cushioned hard disk in a transportable computer. Of course, I refer to the Compaq Plus, which was reviewed here last July.

Another IBM PC-clone manufacturer, Corona Data Systems from Thousand Oaks, California, has come out with a similar transportable: the Corona Portable PC XT. The Corona features the same high-resolution display and the same IBM PC compatibility as its desktop version (see November 1983 BYTE, page 308). This machine, which costs $4340 in a complete configuration (with added color graphics capability), worked very well here for a few weeks, but unfortunately, the computer's display suddenly died two weeks ago. Corona, however, quickly sent us a replacement.

We should note that the failure rate among evaluation computers is relatively high, probably even higher than that among computers bought by the general public. Computers from all manufacturers—including the Big Guys—are subject to failure at one time or another. Part of the problem is that the machine that is sent to us is usually one of the first units off the assembly line, before the early bugs have been worked out. Another factor may be just the luck of the draw: a faulty chip or a damaging voltage surge on the power line. Ideally, we would like to purchase 10 units of each type and perform comprehensive stress testing on each, but this would be prohibitively expensive. The most we can do is mention cautiously if a given machine has failed or not, and what the manufacturer has done to replace the unit. We then hope that the reader will evaluate such information in the proper statistical light. That is, the results of a statistical test of one unit are fairly meaningless by themselves but may be useful in a larger sample. The focus of our reviews is therefore on factors that will not vary from one machine to another, e.g., the speed of the operating system. For statistical tests, we hope that our Review Feedback section will give information based on large samples, and we hope our readers will relay to us their particular experiences, both positive and negative.

And with that disclaimer, let me mention another IBM PC clone that recently had problems in our testing. The ITT Xtra PC, which I mentioned here last month and which had been working here flawlessly for the past few weeks, suddenly stopped working. To its credit, ITT quickly sent us a replacement.

As for software, not a week seems to go by without our hearing some more good news about Borland International, a software house in Scotts Valley, California. Most of the time we have been hearing rave reviews about its Turbo Pascal, the $50 Pascal compiler for CP/M and MS-DOS machines that runs loops around the higher-priced compilers. Well, two weeks ago we received Sidekick, a $50 accessory program for the IBM PC that runs under your regular application programs and can be called into action at any time. Sidekick includes several Macintosh-like features, such as a notepad and calculator, but Sidekick's version of these products is really spiffy. The calculator can do calculations in octal, hexadecimal, and binary. And the "notepad" is actually a proficient word processor. However, this product is copy-protected and thus cannot be loaded on a hard disk or on all floppy disks.

What was the good news about Borland last week you ask? Well, they have come out with an unprotected version of Sidekick for a little more money ($80). Companies like Borland could put us reviewers out of business. They give us almost nothing to complain about. I can't wait to see what this week brings.

—*Rich Malloy, Product-Review Editor*

SYSTEM REVIEW

The HP 150 Computer

Easy to use but difficult to program

BY MARK HAAS

Mark Haas is technical director of Osborne/McGraw-Hill, a Berkeley, California, publisher of computer books. He may be contacted at 2600 Tenth St., Berkeley, CA 94710.

Hewlett-Packard, a company that is probably best known for its scientific and engineering products—programmable calculators, plotters of exceptional quality, and minicomputers—is now making its presence known in the lucrative business market with its latest creation, the HP 150. Using a design employing a unique software enhancement to the popular MS-DOS operating system (called PAM, which I will discuss in detail later) and a touch-sensitive screen, HP hopes to cash in on the feature most business users are demanding—ease of use.

The basic HP 150 is composed of only two units: the system processor/display unit and the keyboard. However, most of the HP 150s sold also include a 9121 disk-drive unit housing two 3½-inch Sony microfloppy-disk drives (see photo 1). Other disk-drive systems, including hard-disk systems, are also available. The HP 150, like other HP computers, uses the Hewlett-Packard Interface Bus (HPIB), also known as the IEEE-488 bus, to expand the system. The HPIB is used to connect the 9121 disk-drive unit to the system unit.

The system processor/display unit measures about 12 by 11 by 13 inches. It contains the system processor board, the 9-inch CRT (cathode-ray tube) and associated video circuitry, the touchscreen, and, on the system I tested, an optional thermal printer. The system board contains a 16-/8-bit 8088 microprocessor (16-bit internal data bus, 8-bit external data bus) operating at 8 MHz, 256K bytes of dynamic RAM (random-access read/write memory), and 160K bytes of ROM (read-only memory). Up to 384K bytes of RAM can be added through the use of a plug-in memory board, bringing the total RAM to 640K bytes. Also contained on the system board are two RS-232C ports, an HPIB port, and two expansion slots.

THE DISPLAY SCREEN

Without the disk drives, the HP 150 can be thought of as a terminal. All the characteristics of the display screen can also be thought of in that sense. The display screen on the HP 150 is actually composed of two independent screens: a 27-line by 80-character text screen and an optional 512- by 390-dot graphics display. These displays can be set up as windows into even larger areas.

The normal virtual-text screen comprises 48 lines, or two physical screens. The screen always displays the current line. The first 24 lines of text may scroll off the top of the display, but they are not lost. The computer reserves the bottom three lines of the physical display for a status line and the softkeys (touchscreen versions of function keys), leaving 24 lines available for text on the screen. The status line provides information on the state of various functions. It displays the time, lets you know when the Caps Lock is on, indicates whether the keypad is numeric or graphic, and gives you other information.

Characters are very well formed and easy to read, even on this smaller-than-average display screen. A variety of attributes are available, including half intensity, underline, inverse, blinking, security (where nothing shows on the screen—used for passwords), and something called background inverse. Several alternate character sets are provided for line drawing (useful in designing forms) and math symbols, as well as foreign-character sets that include umlauts, tildes, and other diacritical marks.

The HP 150's graphics capabilities are impressive. Included in the large ROM are a number of routines for plotting on the graphics screen. In the graphics mode, the numeric keypad to the right of the QWERTY keyboard assumes the role of a graphics keypad. It can be used to selectively turn on or off the text and graphics screens. Four keys become graphics cursor-control keys, allowing the graphics cursor easy movement to any point on the screen.

Most of the graphics capabilities, however, are accessed through escape sequences. These can be entered directly from the keyboard but are most useful when generated from a program. For example, the sequence ESC *m 0,0,100,100E will draw a box from the lower left-hand corner of the screen (0,0) 100 dots wide and 100 dots high and will fill it with the current pattern (which can be changed with another escape sequence). There are other sequences for line (vector) drawing, character-graphic definition, line-pattern definition, drawing modes, and setting of a relocatable origin.

Text can also be generated on the graphics screen. Eight different text sizes, from about 1/32 inch to about 7/16 inch, can be produced and rotated 90, 180, and 270 degrees. The text can also be slanted about 30 degrees. Escape sequences are provided to control graphics text.

SYSTEM CONFIGURATION

The HP 150 is a "soft" machine. That is, many of the operating characteristics can be changed through software control. In fact, just about everything the machine does can be controlled from the touchscreen. There are four main configuration screens built into the HP 150, and a fifth MS-DOS configuration program is supplied with the operating system. The system is a bit overwhelming at first, but the manual takes you through the initial configuration one step at a time and makes it seem easy.

The Global Configuration screen (see photo 2) allows you to set such items as the type of keyboard being used (ASCII, Swedish, French, German, etc.), the keyboard click on or off, and where the HP 150 looks for the operating system (seven HPIB addresses and two accessory slots) when booting up. At power-up you can also decide whether the HP 150 will act like a terminal or a computer.

Two more screens allow you to configure the two serial ports. Here things really get complicated. You can set the usual characteristics such as bps (bits-per-second) rate, word length, parity, and stop bits, but then there is an additional assortment of items that most people have never dealt with before, shown in photos 3 and 4. If you have never had to decide whether the Terminal Ready line should be high or low, or whether the Receiver Ready or Secondary Carrier Detect control line is detected as − 12 V instead of + 12 V, you should leave these in their default state. If you understand these terms, this type of control can be very useful.

I had no trouble using the configuration screens to connect the HP 150 as a terminal to a Radio Shack Model 100. I set the bps rate, etc., as usual, and left all the other settings alone. It worked fine except when I transmitted a file from the HP 150 to the Model 100 using XON/XOFF flow control. The HP 150 expects to see an XON charac-

(continued)

Photo 1: *The* HP 150 *with a* 9121 *disk-drive unit.*

Photo 2: *The Global Configuration screen allows you to set up the basic functions of the* HP 150.

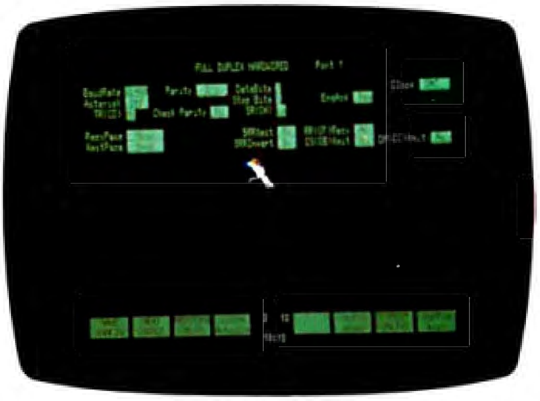


Photo 3: *The configuration screens that allow you to configure ports* 1 *and* 2 *are identical, and each can be configured as either full-duplex hard-wired, shown here, or full-duplex modem.*

Photo 4: *The full-duplex modem configuration, which is slightly less complicated than the full-duplex hard-wired configuration and has the receive and transmit signals reversed.*

ter from the external device after every line is transmitted. The Model 100 will send an XON character only after it has sent an XOFF character and has had a chance to catch up. The HP 150 would send the first line of a file to the Model 100 and then wait for an XON character. I had to manually send one from the Model 100 so the next line of text would be sent, and so on. Transmission going the other way, from the Model 100 to the HP 150, was no problem.

The last built-in configuration screen, shown in photo 5, sets a variety of terminal options. Most of the options on this screen deal with functions that are important when using the HP 150 as a terminal connected to a larger computer. Hewlett-Packard has designed the HP 150 to be compatible with its line of communications terminals. All of these can communicate with larger systems, in this case an HP 3000. From this screen you can control the cursor type (line or box), the bell (on or off), the definition of the Return key, and more exotic things concerning block-mode transmission, graphics-emulation modes, etc.

In an abstract sense, the configuration screens are easy to use. That is, changing the values of the various functions is easy; knowing what they mean is another thing. The screens often present you with somewhat cryptic abbreviations for the functions, such as InhDcTst(W), Xmitfnctn (A), and RR(CF)Recv. Unfortunately, these functions are not always clearly explained in the manual. But, to be fair, if you need to change these functions you probably already know what they mean. Otherwise, leaving them in their default states will usually suffice.

The touchscreen is also used to configure MS-DOS. The configuration screen is divided into two parts, System Devices (such as printers and plotters) and Disc Drives (see photo 6). Using these utilities, you can specify where your peripherals are physically connected and relate these locations to the logical devices MS-DOS understands. Do you want COM1: on port 1? Okay. Do you want your printer (PTR1:) on port 1 too? No problem. Do you have a plotter on the HPIB? Just say so. Are you adding a hard disk you want to boot from? These can be done in straightforward procedures.

DISK DRIVES

Without some sort of mass-storage device connected to it, the HP 150 is really no more than a fancy terminal. Adding disk drives allows you to load programs and store data. The disk drives supplied with the machine I tested were contained in the 9121 unit. This device contains two Sony 3½-inch microfloppy-disk drives. Each single-sided drive can hold a disk containing up to 258K bytes of data, although a significant portion of this space is taken up by system files.

Many other disk-drive combinations are available, including hard-disk and 5¼-inch drives, and most of these connect via the HPIB in daisy-chain form. The drive box is normally placed under the system processor/

Photo 5: *The terminal configuration screen controls the basic keyboard and display functions of the* HP 150.

Photo 6: *Hewlett-Packard has further developed* MS-DOS *by providing the user with this handy configuration screen. Here the user can relate* MS-DOS's *logical device names* (PRN:, COM2:, *etc.) to the actual physical devices and where they are connected to the computer (port* 1, HPIB, *etc.).*

Photo 7: *The keyboard of the* HP 150 *contains* 107 *keys arranged in seven groups. It connects to the back of the system processor/display unit with an* RJ-11 *plug.*

display unit. With this placement, however, the keyboard must be located some distance in front of the machine, otherwise it interferes with disk insertion and removal. In all, you need about 24 inches of depth on your desktop to situate the machine properly. More space is recommended because if you don't have enough room you might find the keyboard falling into your lap.

Having used a Macintosh for some time, this was not my first experience with 3½-inch disks. I like them very much. The rigid cases are more protective than the flexible jackets on 5¼-inch floppy disks—you can even use a ballpoint pen to write directly on them. The automatic shutter keeps misplaced fingers off the media surface and also helps keep dust off the disk. Disk storage is more convenient because the 3½-inch disks take up less space.

THE KEYBOARD

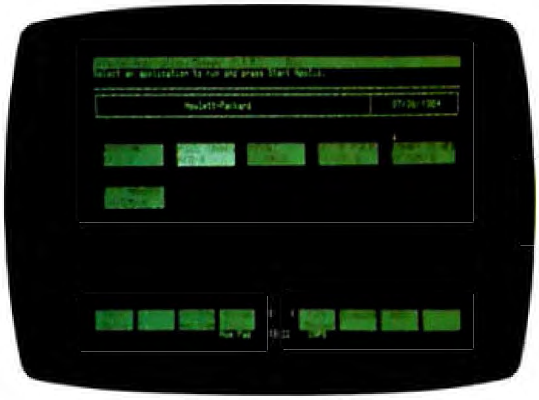
The keyboard on the HP 150 is divided into seven sections, as shown in photo 7. The character-set group is the main keyboard, including the normal QWERTY keyset. Above that are the terminal-control group (the Reset/Break and Stop keys), the function-control group (Menu and User/System keys), and eight function keys. The edit group includes keys for inserting and deleting characters and lines, and the display-control group includes the cursor keys. The numeric/graphics group is at the right of the main keyboard; it serves the dual role of numeric pad and graphics-control pad.

The keyboard is meant to be tilted up toward the back when in use; a flap along the bottom of the unit swings down to accomplish this. The keys have a nice feel and are arranged in stepped rows. The Shift keys and the Return key are in the customary positions, although I found the Control key a bit too close to the A key. Also, the Control and Caps keys on the HP 150 keyboard are in the opposite position of the same keys on a terminal I use in the office. This led to some adjustment problems, but this is no fault of Hewlett-Packard's. It only points out the unfortunate lack of standards in the computer industry.

LIVING WITH PAM

PAM, short for Personal Applications Manager, is Hewlett-Packard's idea of ease of use. Technically speaking, PAM is an MS-DOS shell installed using the CONFIG.SYS file at boot time. PAM replaces the normal MS-DOS COMMAND.COM console-com-

(continued)



Select an application to run and press Start Applic.

Hewlett-Packard

Photo 8: *The PAM screen. The highlighted box is the currently selected application. The small arrow over these boxes is controlled by the cursor keys and points to a new application. Touching the leftmost softkey would start the selected application.*

Select a function

Photo 9: *The file manager can be accessed from PAM or from most applications. It relieves the user of having to enter MS-DOS comands to perform file and directory functions.*

mand processor and presents the user with the screen shown in photo 8.

Together with the touchscreen, PAM lets novice users deal with the operating system in a more friendly way. No command lines need to be entered. You merely have to point to your desired application and then to the box in the lower left-hand corner of the screen labeled Start Application (or press the F1 key or the Return key). PAM then starts the application. Alternatively, you could point to the application with the cursor keys, moving the small arrow over the application choice boxes, and then press the Select key and then the Return key to start an application. There's no need to be concerned with default drives and the like because the drive containing the application to be run becomes the default drive automatically.

Applications appear with expanded titles of up to 13 characters, which makes it a little easier to determine what an application does.

Besides running an application, PAM lets you set the time and date, log in new disks, perform a number of file-related operations, and turn your HP 150 into a dumb terminal. A simple help facility is also provided.

You can access file-related commands by touching the File Manager box or by pressing the F5 key. The file manager (see photo 9) allows you to list the files in a directory, choose a different directory (including subdirectories), print the contents of a file or directory, delete a file or directory from a disk, view the contents of a file on the screen, and copy and rename files. Throughout these procedures, you are guided by a combination of menus, prompt lines, and screens. Of course, regular MS-DOS rules still apply; for example, you cannot delete a subdirectory if it is not empty (i.e., containing no files). As with other PAM functions, you can select files for whatever operation you are about to perform by pointing to the filename on the screen. Alternatively, you can use the cursor keys to point to a file and press the Select key to select it.

The dumb terminal is just that. It would be useful if you could run an application while simultaneously being connected to another system. But on this system, switching between the two is cumbersome; you have to end the application, return to PAM, select the terminal, press the Shift/Stop key to get back to PAM, and then reselect the application. From the terminal mode you can journey through a labyrinth of menus that will enable you to configure the communications capabilities of the HP 150. You can select bps rates and determine protocols and many other parameters. However, I doubt anyone could do it without the manual sitting beside the machine. In fact, a separate manual is devoted to explaining all this in detail.

When the PAM screen appears, it displays "installed" applications. Only installed applications can be accessed or run from PAM. This holds true even for MS-DOS. Installing an application is an interesting process that makes use of a utility program named, appropriately enough, Install. Install reads a special file associated with the application you want to be installed and then creates another file that tells PAM your application has been installed. A number of files are moved around, and a number of disks may have to be swapped in and out as well. The installation procedure also ensures that the user is not running a program from the master copy of the disk. You are forced to move a program from one disk drive to another (either A to B or B to A), usually by placing the master copy in drive A and a blank formatted disk in B. You can't install a program on the disk it resides on. Although there is definitely merit to this feature, it can be cumbersome when you are putting in your own application.

Applications sold by Hewlett-Packard come ready to install. If you create your own application, for example a BASIC program, you must install it manually. The documentation clearly explains this process. It involves creating an installation file—using EDLIN, WordStar, or some other

(continued)

AT A GLANCE

Name
HP 150

Manufacturer
Hewlett-Packard
3000 Hanover St.
Palo Alto, CA 94304

Components
Size: System unit, 12 by 11 by 13 inches; disk drives, 12¾ by 3 by 11¼ inches; keyboard, 18 by 8¾ by 1½ inches
Processor: 8-MHz 8088
Memory: 256K bytes RAM
Display: 9-inch diagonal cathode-ray tube, 27 lines by 80 characters, monochrome
Keyboard: 107 keys, detached
Mass storage: Two Sony 3½-inch microfloppy disks, single sided, 258K bytes total disk space each drive
Expansion capability: Two expansion slots
I/O interfaces: Two RS-232C ports, one Hewlett-Packard Interface Bus (HPIB), i.e., IEEE-488 parallel bus

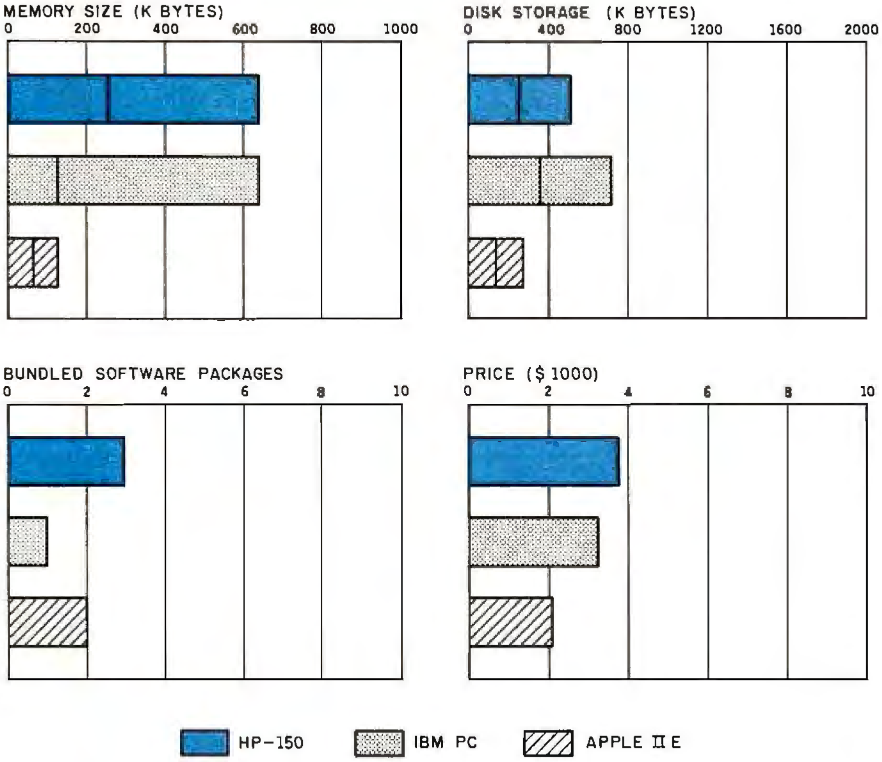
Operating System
MS-DOS 2.01

Software
1-2-3, Memo-Maker

Optional Hardware
5¼-inch floppy-disk drives and 5- and 15-megabyte hard disks, thermal printer, 384K-byte plug-in RAM board

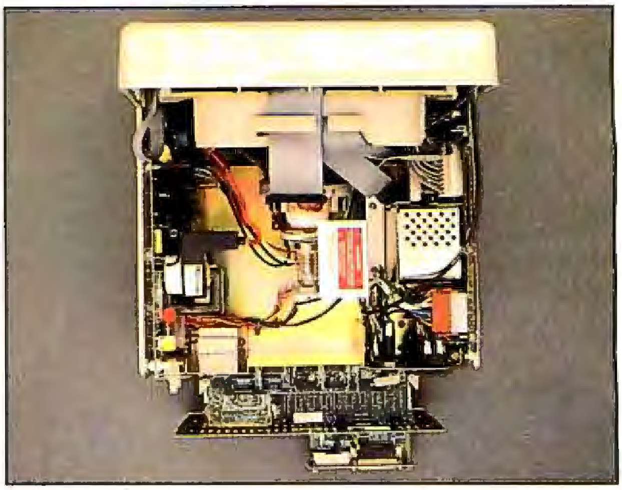
Documentation
Users manual, terminal users guide

Price
$3495 with dual microfloppy-disk drives, $3795 with BASIC, $5850 with 5-megabyte hard-disk drive and one microfloppy-disk drive, $6450 with 15-megabyte hard-disk drive and one microfloppy-disk drive

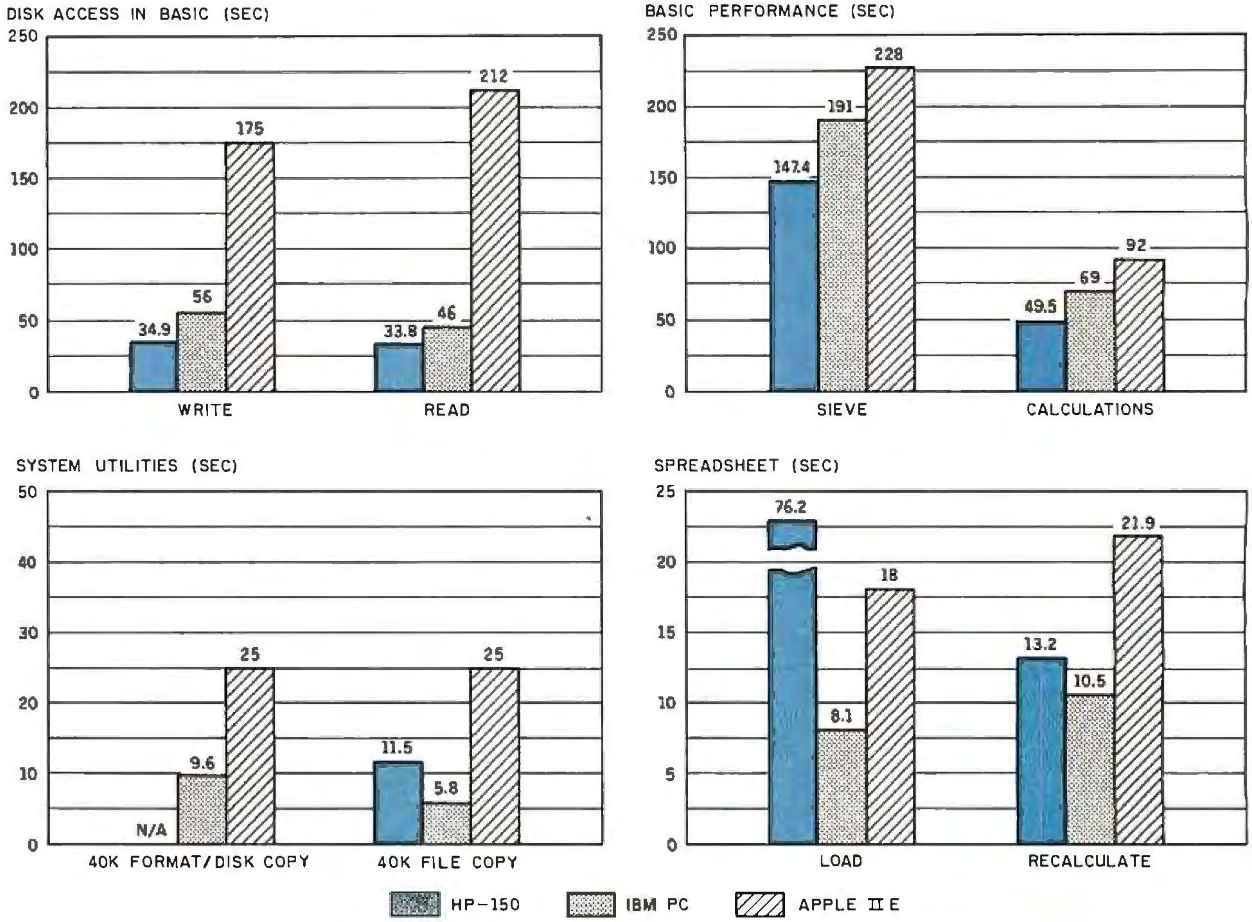


The Memory Size graph shows the standard and optional memory available for the computers under comparison. The graph of Disk Storage capacity shows the highest capacity of a single and dual floppy-disk drive for each system. The Bundled Software Packages graph shows the number of software packages included with each system. The Price graph shows the list price of a system with two high-capacity floppy-disk drives, a monochrome monitor, graphics and color-display capability, a printer port and a serial port; 256K bytes of memory (64K bytes for 8-bit systems), the standard operating system for each system, and the standard BASIC interpreter for each system.

The rear view shows two RS-232C ports and an IEEE-488 bus interface for expanding the system.



The overhead view of the HP-150 system unit, which includes the display units as an integral component.



The graph for Disk Access in BASIC shows how long it takes to write a 64K-byte sequential text file to a blank floppy disk and how long it takes to read this file. (For the program listings see June BYTE, page 327 and October BYTE, page 33.) The BASIC Performance graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. In the same graph, the Calculations results show how long it takes to do 10,000 multiplication and division operations using single-precision numbers. In the System Utilities graph, the Format/Disk Copy results could not be obtained because the MS-DOS utility Disk Copy is not included with MS-DOS for the HP 150. Formatting and copying files are two distinct operations on the HP 150. The File Copy results show how long it takes to transfer a 40K-byte file using the system utilities. The Spreadsheet graph shows how long the computers take to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. The spreadsheet benchmark program is Microsoft Multiplan, but the HP 150's spreadsheet program is VisiCalc. DOS 3.3 was used with the Apple II.

program—containing information about the application such as the names of all files needed by the application and their total size, and the title you want to appear on the PAM screen. Once this file is created, which takes about two minutes, you are ready to use the Install utility. The application program and the special installation file must reside on the same disk. If the application needs other files, such as overlays, they can be installed from other disks, but you must allow for this when creating the installation file. Since you cannot install the program back on the same disk, you must either install it onto another disk or first copy all your files onto another disk and write them back onto the first one. Once the application is installed it cannot be copied onto another disk and run from PAM. It must be reinstalled from the master disk. Also, once you have installed an application, you cannot delete it from MS-DOS. You must again use the Install utility. Otherwise, PAM will think the application still exists even though all visible files associated with it have been deleted.

Another utility, called Set Up PAM, lets you retitle applications and rearrange their placement on the screen. It also lets you auto-start an application when booting the system.

PAM's ease-of-use features do not come cheaply, however. The MS-DOS system files, plus the PAM files, leave you only 178K bytes of a blank formatted disk's 258K-byte capacity. If you want to have MS-DOS installed as an application under PAM, subtract another 17K bytes.

Despite its benefits, PAM is tremendously frustrating for experienced users. It makes everything take longer because you have to tell it to look at the new disk each time one is inserted. And with only 178K bytes on a disk, you change them often. Fortunately, PAM can be bypassed, leaving you to deal directly with the operating system.

Novice users (who would surely benefit from most of PAM's features) may have problems when PAM hands them over to the application and they no longer are protected from the operating system.

THE TOUCHSCREEN

Together with PAM, the HP 150's touchscreen provides you with an alternative form of data entry. Physically, the touchscreen is composed of a 9-inch screen surrounded by a 14 by 21 (vertical by horizontal) element array of infrared LEDs (light-emitting diodes) and matching photodiodes, similar in many ways to the touchscreen designed by Steve Ciarcia (see "Let Your Fingers Do the Talking: Add a Noncontact Touch Scanner to Your Video Display," August 1978 BYTE, page 156). The operating system can detect a finger or pointing device interrupting the infrared beams and determine the location of the interruption.

The touchscreen has a resolution of 1 line by 2 characters for a total of 40 points horizontally and 24 points vertically. This means that when you are using WordStar you will be able to place the cursor on any line by touching the screen, but only on alternate characters in a line. How does a 14 by 21 array of LEDs distinguish a 24 by 40 array of points on the screen? When your finger touches the HP 150's screen, it may interrupt one or two of the beams on each axis. Essentially, this doubles the number of points that would be available if you could detect only single-beam interruptions. However, if you have thin fingers, you may find that placing the cursor on one of the in-between points is difficult to accomplish because the space within which your finger will interrupt two beams may be very small indeed. This is especially true in the vertical axis where the LEDs are placed farther apart. Using the eraser end of a pencil will interrupt only one beam at a time on each axis and result in half the resolution (i.e., only every other line and every fourth character on a WordStar screen).

Together with PAM, *the* HP 150*'s touchscreen provides you with an alternative form of data entry.*

I found the touchscreen to be moderately sensitive to the way I lifted my finger from the screen after touching it, especially when it was working at its full resolution (for example, when using WordStar). To assure accurate cursor placement, you must withdraw your finger from the screen perpendicularly. In most, but not all cases, touching the screen lets you select an item or point, and removing your finger initiates an action or sets a point. Thus, it is possible to touch the screen and then, without lifting the finger, drag the cursor to the proper location. Too much skew when releasing your finger from the screen results in additional cursor movement.

The touchscreen also senses eight softkeys along the bottom of the screen. These correspond to the eight functions keys across the top of the keyboard, and the two may be used

(continued)

Table 1: *The benchmark results for word-processing tests run on the* HP 150 *using* WordStar. *The comparison was with the* IBM PC *only, unlike the* At A Glance *tests which measured the* HP 150 *against the* PC *and the* Apple II. *All times are in seconds.*

Word Processing with WordStar	HP 150	IBM PC
Document load	11.1	9.9
Document save	25.4	24.2
Search	13.0	10.5
Scroll	71.7	41.2

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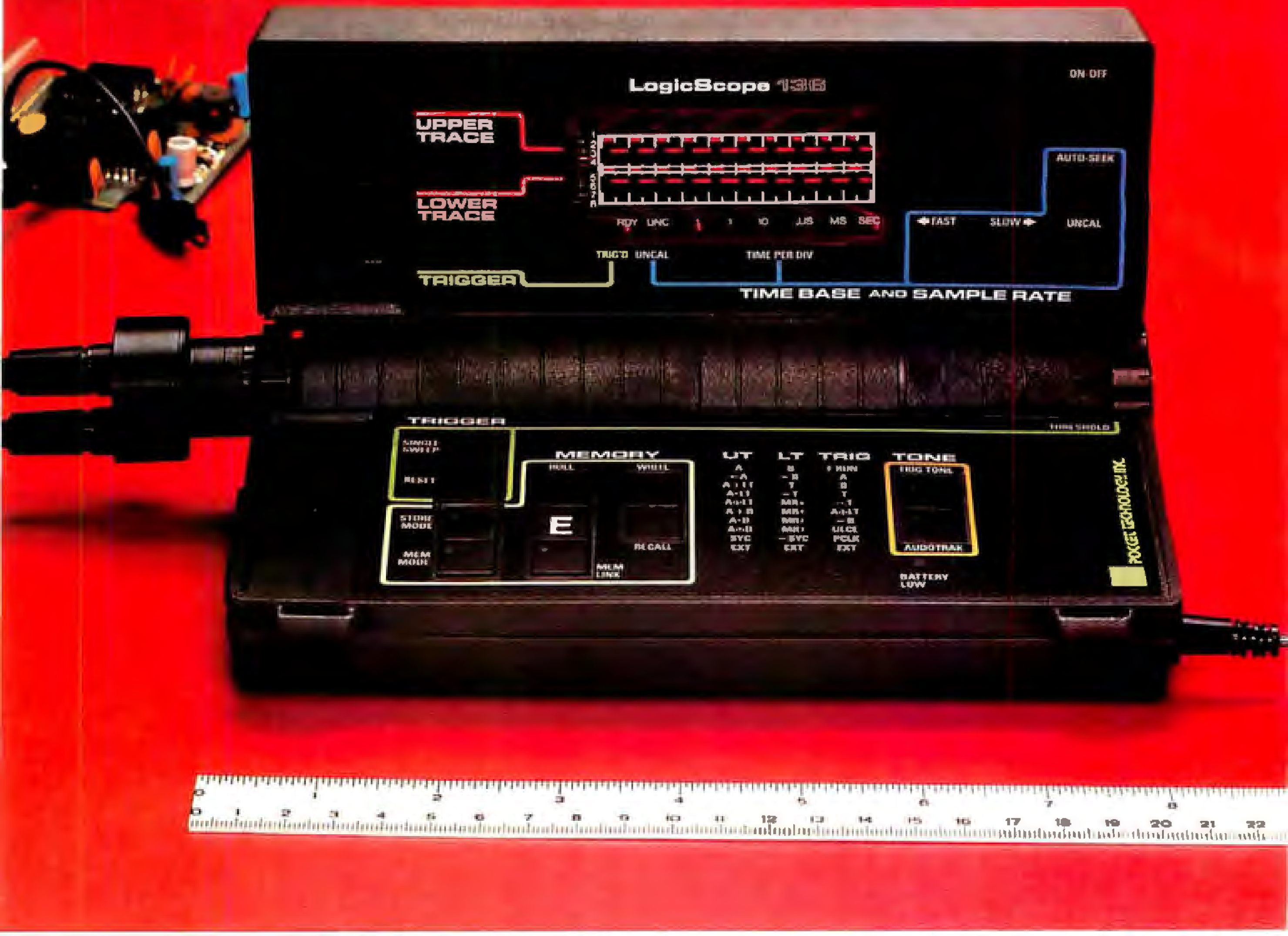

True Dual Trace • 10 MHz Real Time Bandwidth • 3 Input Channels • I/O Port
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■ The LogicScope 136 is the next logical step in test instrumentation for you. It combines many of the features and capabilities of sophisticated logic analyzers and oscilloscopes . . . and it fits in your hand. Never before has so much technology been available in so small an instrument, at such a low price.

■ The pocket-sized LogicScope 136 is made possible by a patented breakthrough in display technology. The conventional cathode ray tube has been replaced by a unique array of 400 LED's that permits simultaneous display of two digital waveforms.

■ The 136 can be used for viewing single shot events, or repetitive waveforms. It can be operated in real time mode, or in memory mode which permits acquisition and storage of up to 24 128-bit waveforms. These can be recalled, logically compared (AND, OR, EXCLUSIVE OR) to other stored/input waveforms, or output to an external device via an RS 232 port.

■ Its very low cost, convenience and ease-of-use make the LogicScope the ideal instrument, for designing, troubleshooting or repairing digital systems.

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interchangeably. The softkeys are programmed by the running application, and they take on different meanings for each application. The softkeys can be thought of as a menu. Some keys perform functions; their legends appear in uppercase letters. Others lead to other menus; their legends appear in lowercase letters.

As with most menu systems, the softkeys are helpful at first, but they tend to slow you down as you gain experience. They can also get in the way. When using the touchscreen with WordStar I inadvertently activated one of the softkeys when I wanted to point to a spot on the bottom line of text. Fortunately, none of the softkeys selected in this manner resulted in anything more than another level of menu appearing. It was annoying but not disastrous.

Overall, I found cursor positioning via the touchscreen of limited use. I also found that using the touchscreen to select items has limitations as well as benefits. For instance, when using VisiCalc adapted for the HP 150, a help menu lets you select from a full screen of items. All you have to do is touch one of about 20 lines on the screen. But touching one line exactly, not the line above or below, is almost impossible. When using VisiCalc, merely touching the screen usually sends you off to the wrong help screen. This is a problem with VisiCalc, because the selection and activation should be two steps instead of one, as with other Hewlett-Packard software.

It is nice to be able to select the file you want to edit by pointing at it. When selecting other functions in WordStar, however, I suspect most users will prefer to use keyboard commands. For example, a common WordStar sequence is Control-B Control-Q P, which re-forms a paragraph and returns the cursor to its previous location. This is a fairly fast, simple keyboard sequence. The same procedure using the softkeys or function keys requires selecting the following sequence: format and find (F4), re-form paragraph (F7), main menu (F8), cursor movement (F6), other keys (F1), previous cursor (F4), main menu (F8).

SOFTWARE

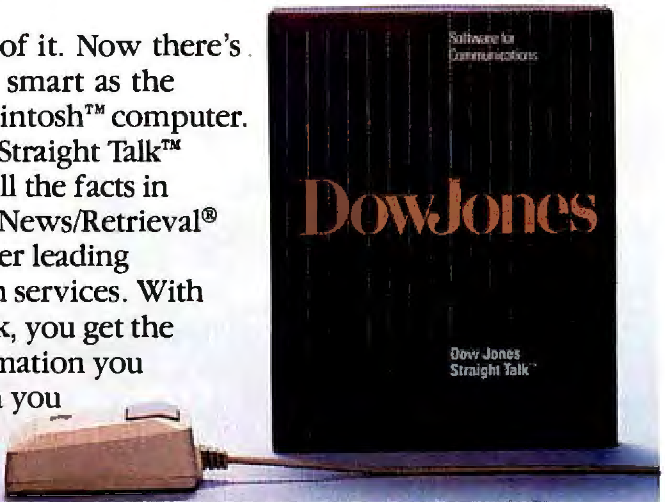
Along with the HP 150, I received several optional software packages including the WordStar and VisiCalc programs I've mentioned. I also received a communications package called DSN/Link, a version of Microsoft BASIC, a program called Text Charts, and, of course, MS-DOS. Using these packages I was able to run the standard BYTE benchmarks.

The BASIC that Hewlett-Packard offers is Microsoft BASIC-86. It is essentially the same as MBASIC, the 8-bit CP/M version. As a result, there are no commands to access the graphics capabilities (i.e., LINE, CIRCLE, PSET, etc.), perform screen operations (LOCATE, CLS, etc.), or communicate through any of the operating system's logical devices (OPEN COM1:, etc.): all things I've come to expect with 16-bit BASICs. You can only access the HP 150's graphics capabilities through escape sequences. The manual tells you how to use these escapes; for example, it tells you how to use the DEF FN command to create your own graphics commands. However, this process is a bit clumsy. [*Editor's Note: Hewlett-Packard was in the process of introducing* GW BASIC *for both the* HP 150 *and the* HP 110 *when this review was written. If all has gone as planned, the new* BASIC *should be available now.*]

The BASIC *that Hewlett-Packard offers is Microsoft* BASIC-86.

BYTE has established a set of benchmarks for testing a variety of system functions. These tests combine

(continued)



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the abilities of both the hardware and software. The complete results of these benchmarks are shown in the "At a Glance" graphs, with additional benchmarks for word processing shown in table 1.

I was unable to run the Format/Disk Copy test in the System Utilities benchmark because the Disk Copy utility is not included with MS-DOS for the HP 150. Formatting and copying files are two distinct operations in the standard HP 150 world.

VisiCalc on the HP 150 has the added feature of being able to let you select cells by pointing to them. Of course, if a cell is off screen, you have to use keyboard commands to select it. The softkeys make it easier to learn to use VisiCalc, but as I've stated, once you become familiar with the program's functions, you'll probably want to use keyboard commands, rather than the touchscreen, to evoke them.

I performed two benchmark tests with VisiCalc: I loaded a standard spreadsheet and recalculated it (the results are shown in the Spreadsheet graph). The standard spreadsheet is a 25- by 25-cell array where each cell is equal to 1.001 times the cell to its left. The first cell in rows 2 through 25 is equal to 1.001 times the last cell in the preceding row. Multiplan on the IBM PC is significantly faster than VisiCalc on the HP 150.

The word-processing benchmarks in table 1 were performed using Hewlett-Packard's latest release of WordStar, version 3.3B, which replaced the significantly slower version 3.30. I have already commented on some of WordStar's features as adapted to the HP 150. Two of the nicer ones are its ability to let you select the file you want to edit by pointing at the filename, and to let you move the cursor on the screen by pointing. As the figures in table 1 show, this new version of WordStar on the HP 150 holds its own against the IBM in all but one of the tests.

With the exception of the scroll benchmark, the times clocked for the HP 150 were fairly close to the times for the IBM. The document-load time of 11.1 seconds is only 12 percent slower than that of the IBM, the document-save time of 25.4 seconds is only 5 percent slower, the search time of 13 seconds is 24 percent slower, and the scroll time of 71.7 seconds is 74 percent slower. The benchmark times are based on loading a document immediately after starting WordStar, saving the document immediately after loading it, searching immediately after loading, and scrolling immediately after loading. Subsequent times for the same operations, however, improved substantially. Loading the document after saving it (not directly after starting WordStar) provided a load time of only 7.5 seconds. Repeated saving of the document resulted in a time of 18 seconds. Jumping back to the beginning of the document after the search test and repeating the search resulted in a time of only 4.6 seconds. But nothing improved the scrolling time. I think the subsequent times more closely represent the times you can expect when working with a document. The benchmarks don't show the superior times the HP 150 provides when you move the cursor to a random point or move it horizontally or vertically within a screen, or when you enter the name of the file to edit. But I still wonder why a processor identical to the one in the IBM PC, running nearly 80 percent faster, runs an application more slowly than the IBM PC does.

As the slow times of the benchmarks show, the 8-MHz processor is busy doing things other than running the application. Pure processing times were good, as shown by the single-precision Calculations and Sieve results. But screen-oriented tasks are particularly slow, probably because of some sort of overhead. At first I

(continued)

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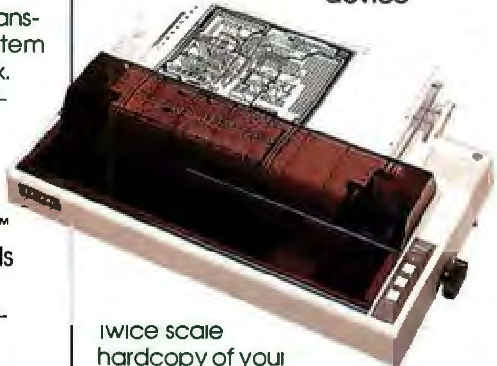

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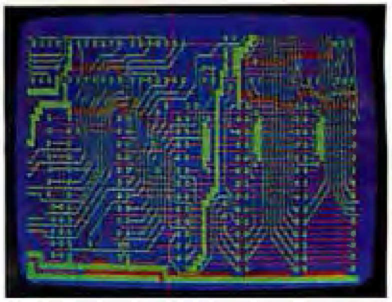

Dual-layer color display of a 2" by 4" section of a 10" by 16" circuit board

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System Requirements

- ☐ IBM PC or XT with 192K RAM, 2 disk drives and DOS Version 2.0
- ☐ IBM Color/Graphics Adapter with RGB color or b&w monitor
- ☐ Epson MX-80/MX-100 or FX-80/FX-100 dot-matrix printer
- ☐ Houston Instrument DMP-41 pen-and-ink plotter (optional)
- ☐ Microsoft Mouse (optional)

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thought it might be because of the touchscreen, but apparently the touchscreen is interrupt driven and does not affect the timings simply by being on or off. Whatever the cause of these delays, it seems ease of use has its price.

DSN/Link is a communications package designed to allow the HP 150 to communicate with an HP 3000 or another HP 150. It can be used for general-purpose communications, too. I found it to be of limited use in my situation. If I had an HP 3000, I could have used DSN/Link to access it automatically and perform a number of wonderful tasks. DSN/Link can be controlled by command files created with any text processor. The commands allow the program to carry on a dialogue with the host computer to enable automatic log-on sequences and other automatic procedures. But programming DSN/Link is not easy, and the control it gives you is limited.

Text Chart is a nice little graphics package that shows off the HP 150's graphics capabilities, but its performance is a little slow, mainly because of constant disk accesses.

|*Editor's Note: After this review was written, Hewlett-Packard began bundling Lotus Development Corporation's* 1-2-3 *and Hewlett-Packard's Memo-Maker word processor with the* HP 150.|

DOCUMENTATION

The manuals accompanying the HP 150 do a good job of explaining a fairly complex system. They are well written and provide necessary background information—telling you why things are being done, not just how to do them. The directions on setting up your computer and installing the peripherals are excellent.

Some of the software manuals were not as good as the system documentation. The BASIC manual may be a good introduction to BASIC, but it fails as a reference guide. Commands are scattered about and arranged by function rather than alphabetically; this manual is even worse than the original Microsoft manual. There is an index, which is the best way to find anything. The VisiCalc manual is rather cryptic and could have included more examples. The new WordStar manual is a big improvement over previous editions.

CONCLUSIONS

A fellow I spoke with who has been programming HP 150s for some time summed up the system nicely when he said that the HP 150 is a good "application engine" but difficult to program. If all you intend to do is buy an application and run it, this machine will make life easy for you. If you want to use all of the HP 150's features, there's a lot there to play with, but you may find it's not as accessible as you'd like. |*Editor's Note: This may change when the new* GW BASIC *is available*|.

The HP 150 is an extremely flexible machine that can become part of a much larger system of computers. Direct links with HP 3000s, links to other peripherals through the HPIB and through the Hewlett-Packard Interface Loop (HPIL), a wide assortment of sophisticated peripherals including the new Laserjet printer and the famous HP plotters, and the ability to emulate a number of graphics terminals assure the HP 150 a share in Hewlett-Packard's traditional market. Whether Hewlett-Packard's concept of ease of use will help it to penetrate the business market remains to be seen. ■

If you want to use all of the HP 150's *features, there's a lot there to play with, but you may find it's not as accessible as you would like.*

SYSTEM REVIEW

The Columbia Multipersonal Computer-VP

IBM PC compatibility on a budget

BY PETER V. CALLAMARAS

Peter V. Callamaras (POB 408, Scott AFB, IL 62225) is an officer in the Air Force. The recipient of degrees in computer technology and biological sciences, he recently received his master's degree in systems management. He has been interested in computers since 1966 and used to be the service-department manager of a computer store.

For me, choosing a computer system depends largely on the amount of software available for it. Thus, when I decided to buy a second computer, I wanted one that was either Apple or IBM compatible. Since I already had an Apple it seemed reasonable to add the IBM capability.

Because I needed a system I could use both at work and home, I decided to get a transportable machine.

Money was also a large consideration. The cost of an IBM system consisting of what I considered a minimum configuration—128K bytes of RAM (random-access read/write memory), two floppy-disk drives, graphics, and both serial- and parallel-output ports—was too high, so I decided to look at IBM PC clones.

I wanted to buy from a manufacturer I felt would be around for a while—that narrowed the field a bit. Additionally, I wanted to find out how much it was going to cost to get suitable software for my new system and what sort of software compatibility I could expect between my Apple and the IBM PC-compatible.

I eventually decided to buy a Columbia Data Products' Multipersonal Computer-VP portable (see photo 1). The VP not only met all my hardware criteria, but it came with all the software I needed to handle almost any task. And at $2495, it was priced well below any other similar system without software.

HARDWARE

The VP is housed in a metal cabinet with a built-in handle. Since the computer weighs 32 pounds, you are not going to want to move it often. However, I plan to leave it at work most of the time and take it home only on weekends or evenings when I have work to do at home.

The system unit measures 18 by 16 by 8 inches with the cover on, or 18 by 14 by 8 inches with the cover off. It comes with 128K bytes of RAM (expandable to 256K bytes) resident on the motherboard, two floppy-disk drives with 360K bytes of storage capacity each, a detachable IBM PC-compatible keyboard, a 9-inch monochrome monitor, and two I/O (input/output) ports. There are two storage slots in the front of the unit; the power switch, reset button, and a built-in fan are on the back. During transport, the keyboard is stored in the removable front cover of the VP. You have to be careful when arranging the keyboard's cable in the top cover because you run the risk of pinching the cord and possibly breaking some wires when you lock the cover down.

SOFTWARE

The VP comes with an impressive array of software that lets you do just about anything you need to—word processing, file management, spreadsheets, graphics, communications, and personal financial management. An arcade-type game is also provided with the system. (See the "At a Glance" page for more information.) Additionally, you get the CP/M-86 and MS-DOS version 2.0 operating systems, Microsoft BASIC (GW BASIC/BASICA), and Macro/86 assembler.

THE DISPLAY

The VP's 9-inch monitor (see photo 2) can be ordered with either a green or an amber phosphor (I prefer to use an amber monitor—the fact that I could get one with the VP was a major factor in my decision to buy it.)

As is the case with the IBM PC, there are four display modes: two for text or characters and two for graphics. The text-display modes are 5 by 7 matrix character, either 40 columns by 25 lines or 80 columns by 25 lines. The monochrome graphics display modes are either 320 by 200 pixels (low resolution) or 640 by 200 pixels (high resolution).

The video-graphics display is supported by a separate 16K-byte RAM storage buffer that can hold eight pages in the 40 by 25 mode and four pages in the 80 by 25 mode. The video logic is directed by a separate Motorola 6845 CRT (cathode-ray tube) Controller. I found the display sharp and the graphics pleasing.

KEYBOARD

The keyboard is an 83-key unit separated into three general areas with auto-repeat on all keys (see photo 3). On the left side are 10 function keys, in the middle is the QWERTY keyboard, and on the right side is a numeric keypad.

The keyboard is essentially the same as that found on the IBM PC, except the Caps Lock and Num Lock keys have LEDs (light-emitting diodes) built into them. The LEDs light up when you have either of these features selected. As on the IBM PC keyboard, the Return, Shift, and Tab keys have the international symbols on them. The function keys and the numeric keypad are also essentially the same as those found on the IBM machine.

The feel of the keyboard takes some getting used to. The IBM PC has "breakaway" keys that offer your finger some initial resistance and then, at a certain point, release and give you a response. The VP, on the other hand, does not have breakaway keys and has a very light touch. Since I switch among computers often, I find the VP's light touch disconcerting. I have to get used to it all over again when I've been using other computers. With the auto-repeat feature on each key, I often get a line of characters instead of the single character I wanted.

Overall, the keyboard is solid and performs satisfactorily, but it is unfortunate that Columbia didn't improve on the IBM PC keyboard by making its own more like the Selectric.

MASS STORAGE

The standard VP comes with two half-height, 5¼-inch floppy-disk drives. The double-sided double-density drives each hold 360K bytes of data. I have no problems with the drives and find them much quieter than the IBM PC drives.

The disk-drive doors will not close unless you have inserted either a disk or a cardboard protector first. I have heard that on some drives the two heads can hit each other if jarred during transit; thus it is a good idea to save the cardboard protectors to use when you move the computer.

One unhandy aspect to the drives is that, although you can check the drive speed, you can't adjust it yourself. I haven't noticed any speed problems, but I wish the drive-speed adjustment were accessible to the user, since I have found that I have to adjust the drive speed on my Apple periodically.

THE MOTHERBOARD

The motherboard is located on the underside of the metal plate that holds the CRT video-drive circuitry and the two disk drives. There are access holes cut into the plate for

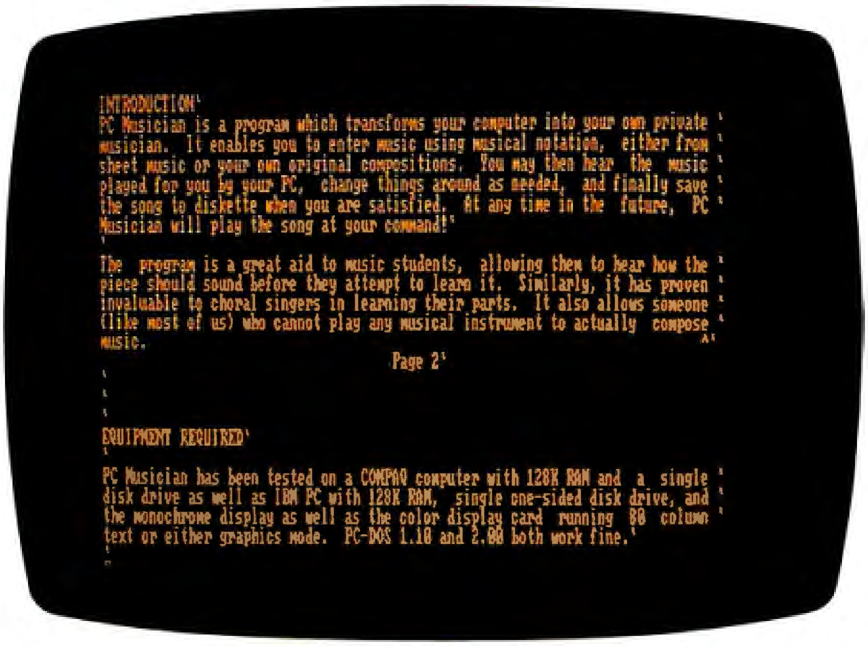
(continued)

Photo 1: *The Columbia Multipersonal Computer-VP.*

the single expansion slot and the video connectors. The disk-drive cable slides around the front of the plate. This arrangement protects the motherboard if you happen to remove the top of the computer to work inside. There is also a place in the motherboard to plug in an additional 128K-byte memory-expansion piggyback board.

THE PROCESSOR

The VP comes with a standard 16-/8-bit 8088 microprocessor (16-bit internal data bus, 8-bit external data bus) running at 4.77 MHz. You can also plug an 8087 arithmetic coprocessor into the premounted socket that is wired in parallel with the 8088. Unfortunately, you have to completely disassemble the computer to do so.



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INTRODUCTION
PC Musician is a program which transforms your computer into your own private
musician.  It enables you to enter music using musical notation,  either from
sheet music or your own original compositions.  You may then hear  the  music
played for you by your PC,  change things around as needed,  and finally save
the song to diskette when you are satisfied.  At any time in the  future,  PC
Musician will play the song at your command!

The  program is a great aid to music students,  allowing them to hear how the
piece should sound before they attempt to learn it.  Similarly, it has proven
invaluable to choral singers in learning their parts.  It also allows someone
(like most of us) who cannot play any musical instrument to actually  compose
music.
                                   Page 2



EQUIPMENT REQUIRED

PC Musician has been tested on a COMPAQ computer with 128K RAM and  a  single
disk drive as well as IBM PC with 128K RAM,  single one-sided disk drive, and
the monochrome display as well as the color display card  running  80  column
text or either graphics mode.  PC-DOS 1.10 and 2.00 both work fine.
```

Photo 2: *The VP's display showing the 80-column text mode.*

Photo 3: *The VP's keyboard. Except for the Shift Lock and Num Lock key LEDs, the keyboard is laid out like the IBM PC's.*

MEMORY

The VP's RAM chips are standard 4164s, which are automatically refreshed every 2 microseconds. The chips are soldered onto the motherboard to prevent their being dislodged in transit. If you have trouble with a RAM chip, a service center will have to replace it. When you boot the system, you are offered the option of testing the memory. If you choose to do so, pressing the S key during the test lets you listen to a series of tones that indicate whether the specific location under test is okay. If you hear a steady tone during the test, that memory location is bad.

You may want to increase the motherboard memory to its full 256K-byte capacity. The process is relatively simple. Disassemble the computer, plug in the piggyback circuit board, change a couple of jumpers, and then button it up.

INTERFACES

Both the parallel and serial interfaces use DB-25 connectors and are located on the rear of the unit with the power and reset switches. The parallel interface is Centronics compatible. The serial port is a standard asynchronous RS-232C interface with a 110- to 19,200-bps (bits per second) range. The combination of the two built-in interfaces lets you plug in a variety of peripherals without adding any other hardware to the basic system.

The VP also has one IBM PC-compatible expansion slot. With only a single slot available, choosing what to put into it can be very difficult. I chose a Quadlink board from Quadram.

You can now get the necessary cable and speaker extension wires from Quadram to put a Quadlink in the VP. However, the Quadlink is primarily intended for use with Columbia desktop units. Because of the difference in the internal arrangement

(continued)

AT A GLANCE

Name
Columbia Multipersonal Computer-VP

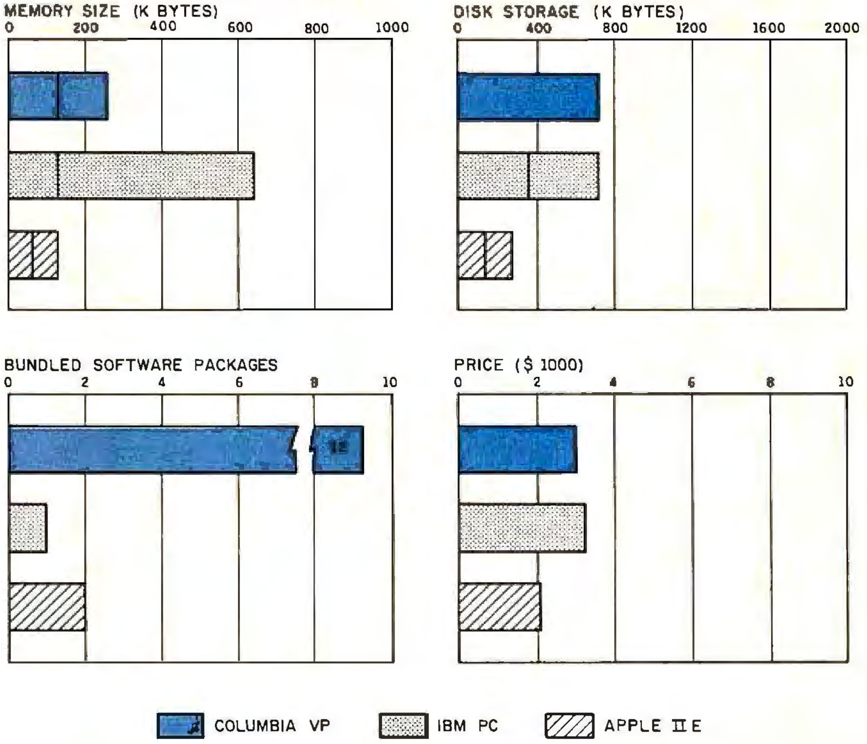
Manufacturer
Columbia Data Products
9150 Rumsey Rd.
Columbia, MD 21045
(301) 992-3400

Components
Size: 18 by 16 by 8 inches, 32 pounds with cover, 18 by 14 by 8 inches with cover removed
Processor: 4.77 MHz, 16-/8-bit 8088, socket for 8087 coprocessor
Memory: 128K bytes of system memory expandable to 256K bytes
Display: 9-inch green or amber cathode-ray tube; 80 columns by 25 rows or 40 columns by 25 rows of 5- by 7-pixel characters; 320- by 200-pixel or 640- by 200-pixel graphics
Keyboard: 83 keys, IBM PC-compatible; 10 function keys and 10-key numeric/cursor-control keypad; auto-repeat on all keys
Mass storage: two internal 5¼-inch floppy-disk drives, double-sided, double-density, 360K bytes, IBM PC-compatible
I/O: asynchronous serial interface, RS-232C, 110- to 19,200-bps Centronics-compatible parallel printer port
Expansion: one IBM PC-compatible expansion slot, 128K-byte piggyback memory board ($295)

Software
MS-DOS 2.1, GW BASIC, TIM IV, Perfect Writer, Speller, Calc, Filer, Fast Graphs, Asynchronous Communications, Space Commanders, and an A.T.I. tutorials package

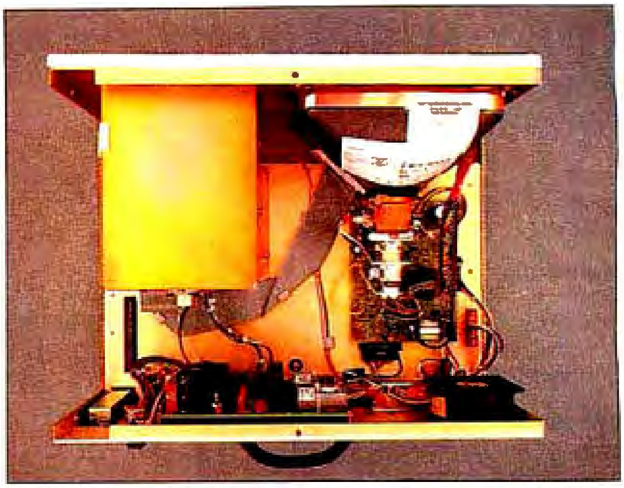
Documentation
All software manuals, 117-page *MPC-VP Operations Guide*, tutorial

Price
$2495
VP plus (with an additional 256K bytes of RAM storage) available for $2695

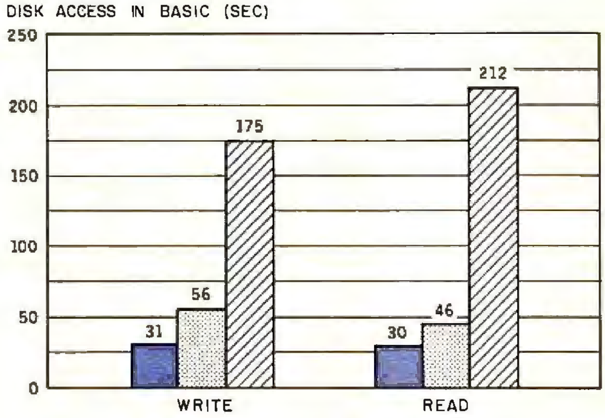


The Memory Size graph shows the standard and optional memory available for the computers under comparison. The Disk Storage graph shows the highest capacity of a single floppy-disk drive for each system. The Bundled Software graph shows the number of packages included with each system. The Price graph shows the list price of a system with two high-capacity floppy-disk drives, a monochrome monitor, graphics and color-display capability, a printer port and a serial port, 256K bytes of memory (64K bytes for 8-bit systems), the standard operating systems for the computers being compared, and the standard BASIC interpreter for each system. Note that the VP comes with graphics capability as standard but does not support color capabilities.

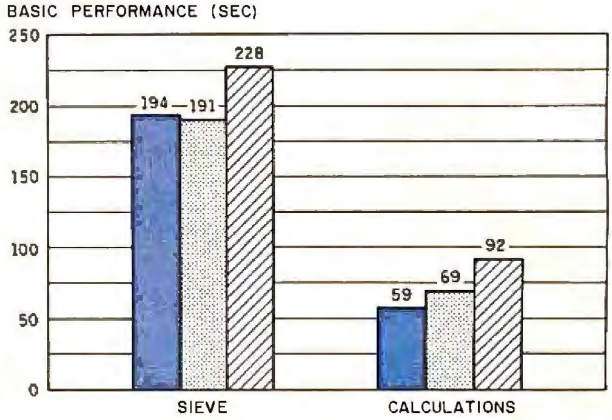
The rear panel. The parallel and serial ports are at the lower right. The expansion slot protector plate is at the far left.



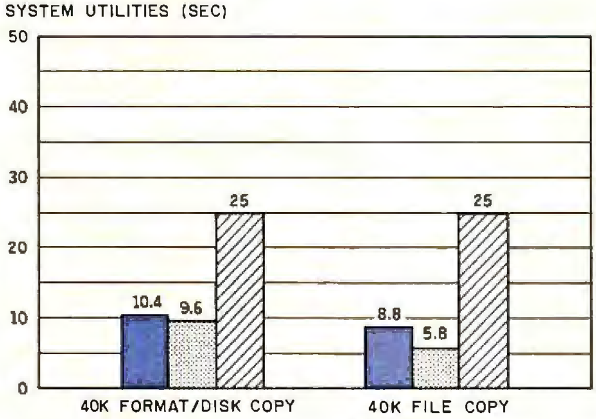
The top view. The disk drive housing is at the top left. The expansion slot is below and to the left of the disk drive.



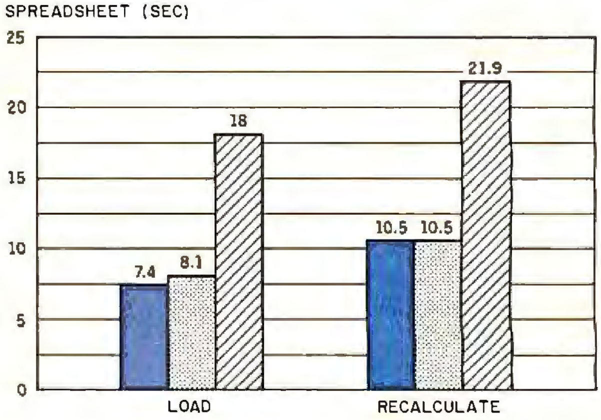
DISK ACCESS IN BASIC (SEC)



BASIC PERFORMANCE (SEC)



SYSTEM UTILITIES (SEC)



SPREADSHEET (SEC)

▦ COLUMBIA VP ░ IBM PC ▨ APPLE IIE

The Disk Access in BASIC graph shows how long it takes to write a 64K-byte sequential text file to a blank floppy disk and how long it takes to read this file. (For the program listings, see June, page 327 and October, page 33.) The Sieve bar in the BASIC Performance graph shows how long it takes to run one iteration of the Sieve of Eratosthenes prime-number benchmark. The Calculations bar shows how long it takes to do 10,000 multiplication and division operations using single-precision numbers. The System Utilities graph shows how long it takes to format and copy a disk (adjusted time for 49K bytes of disk data) and to transfer a 40K-byte file using the system utilities. The Spreadsheet graph shows how long the computers take to load and recalculate a 25- by 25-cell spreadsheet where each cell equals 1.001 times the cell to its left. The spreadsheet program used was Microsoft Multiplan. DOS 3.3 was used for the Apple tests.

I have found very few programs for the IBM PC *that the* VP *can't run.*

of the portable. I ran into a problem getting the speaker extensions to reach far enough. Once the Quadlink was installed, the computer worked fine as a Columbia, but I was not able to get it to recognize Apple disks. Apparently this was common with the early software—Quadram has since revised its emulator software to fix the problem.

COMPATIBILITY

How compatible is the VP with the IBM PC? Happily, I have found very few programs written for the IBM PC that the VP can't run. If the program does not depend on specific IBM PC ROM (read-only memory) locations, there should be little problem in running the program on the VP.

Flight Simulator (FS) from Microsoft is often used to check the level of IBM compatibility. The FS program ran fine on the VP, and the graphics the program generated were crisp and easy to see on the screen. I had no trouble flying the simulator (except that I crashed the plane a lot). The VP seems as close to 100 percent compatible as it could be without using the IBM PC ROMs. Columbia has made available a list of over 500 programs it has tested for compatibility with the VP.

I often use MicroPro products (WordStar, InfoStar, CalcStar, etc.), the PFS series from Software Publishing, Ashton-Tate's dBASE II, and 1-2-3 from Lotus Development. They all run fine on the VP, but 1-2-3 requires a memory upgrade. If you have a specific application you need to use, you might want to try it on a VP at your dealer's first.

DOCUMENTATION

You get two kinds of documentation with the VP: manuals accompanying

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> *The fact that the* VP *can run* MS-DOS *and* CP/M-86 *makes it a very versatile system.*

the software and manuals that are devoted to the system itself. The software manuals are, for the most part, well done. Essentially, they are the standard commercial manuals that accompany software packages with a Columbia Data Products cover and copyright notice. I didn't have any problem using any of them and I think even a novice user would be able to use them effectively.

The documentation dedicated to the system consists of a short introductory-type manual to get you up and running and a thicker *MPC-VP Operations Guide*. The tutorial is a short "follow these instructions exactly" manual that teaches you how to back up all the disks that accompany the system and describes the differences between the MS-DOS and CP/M-86 operating systems. Due to serialization requirements, you do not get the CP/M-86 operating system with the rest of the computer system at the time of purchase. To get your copy of CP/M-86 you have to send a card to Columbia, which will then send you a disk containing the operating system and a small booklet (which was being rewritten at the time I was writing this review) describing the Columbia implementation of CP/M-86.

The *MPC-VP Operations Guide* contains all the information you need to get the system up and running, plus sections on the company's theory of operation, troubleshooting, and maintenance. There are also indexes detailing specifications, pin-outs, ROM listings, peripherals, keyboard-code generation, and a guide to the software accompanying the system.

For those of you who want more detailed information, there is a technical reference manual under development. It will cost approximately $200. I looked at selected portions of the draft documentation and it is complete but probably unnecessary for most users. Overall, the documentation accompanying the VP is more than adequate for all levels of users.

TECHNICAL SUPPORT

Technical support for the VP includes standard dealer support, a customer-support division at Columbia, and system-maintenance support provided by Bell & Howell Service Company.

Bell & Howell provides on-site or depot (you bring it in) maintenance for Columbia products for an annual fee. This service is available nationwide. For more information contact Bell & Howell at 6800 McCormick Rd., Chicago, IL 60645.

CONCLUSIONS

The Columbia Multipersonal Computer-VP is one of the best overall bargains on the market today. It is a transportable, albeit heavy, computer that you can use wherever there is a wall plug. Included in the purchase price is all the software you will probably ever need. The Perfect Software set of applications is good, if not flashy.

The VP is compatible with most software designed for the IBM PC. I was able to run all of the popular business software I had for the IBM PC on it and had no problems. Although the software that comes with the system should meet the needs of the majority of users, if you have an IBM-format application package you would prefer to use, you should be able to run it on the VP.

The fact that the VP can run MS-DOS and CP/M-86 makes it a very versatile system.

Admittedly, parts of the system could be better—the keyboard could be improved upon, another expansion slot could be added, and the unit as a whole could be lighter. But, considering the VP's modest price, these are minor problems.

If you need a second, or even a first, computer system that gives you portability and IBM PC compatibility, the VP is an exceptionally good value. ■

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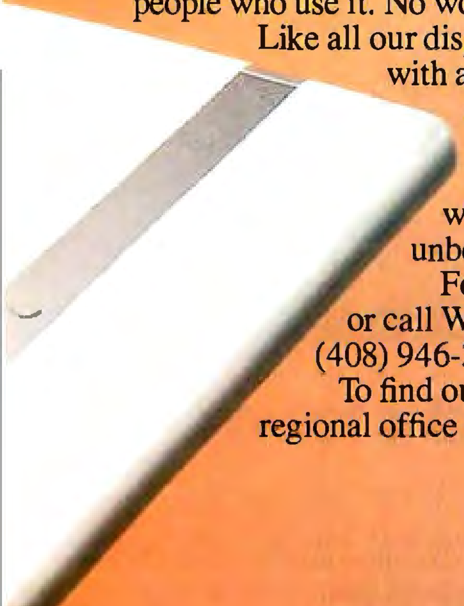

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SOFTWARE REVIEW

Leading Edge and MultiMate

Dedicated word processor programs might not be for everyone

BY C J PUOTINEN

A few short years ago, which is a long time in the world of computers, there were two approaches to word processing. You could use an office word processor, a single-purpose computer whose keys were clearly labeled according to function, or you could use a microcomputer with a program like WordStar, which meant learning a confusing array of letter-key commands.

The dedicated machines left little to chance. Unlike their microcomputer counterparts, they stored text automatically and used a logical if restrictive approach to move, copy, and delete commands. The microcomputer programs made more demands on new users, but their commands could be more flexible and, in some cases, their execution times faster.

The IBM Personal Computer's success offered software companies an opportunity to design programs for a microcomputer widely used in business offices. Developers could take advantage of special-purpose keys in combination with the Control, Shift, and Alternate keys, practically eliminating the need for letter-key commands.

Now a microcomputer could act like a dedicated word processor. Before you could say Wang Writer, dedication became a buzzword. Are the dedicated word processor programs the answer to a secretary's prayer? Are they fast, efficient, and easy to learn? In this review I will examine MultiMate and Leading Edge Word Processing, two programs riding the dedicated wave.

THE TRAILING EDGE

When the Leading Edge package appeared in late 1983, full-page, full-color advertisements hailed it as "the most powerful word processing package ever created for the IBM Personal Computer" and a model of sophistication and simplicity. Embracing the latest fads in word processing, Leading Edge splits the screen into two windows, uses layered menus, and emulates a dedicated word processor so successfully that a typist need never encounter a DOS (disk operating system) command, even during installation.

Its slick, colorful manual is the most graphically interesting I've seen, and so are its stand-up cue card, 91-page training guide and disk, quick-reference card, and keyboard template.

I spent months looking forward to trying the Leading Edge word processor. Alas, the program offers little more than a pretty face. In a competitive market where speed and efficiency matter, it uses an awkward command structure and confusing procedures. Worst of all, it's slow. Fortunately, its price has been lowered from $295 to $100.

LEARNING THE PROGRAM

The Leading Edge tutorial disk provides short, simple memos that you correct as instructed in five embarrassingly worded lessons. I can only wonder at the intended audience.

"Congratulations. Your mild-mannered computer has emerged from the phone booth..." "Wow! My typing's on TV!" "Congratulations. Your typing is a television hit." "Congratulations. You're now a licensed return key operator." "When you want somebody to read what you've written on Leading Edge Word Processing, don't mail them the computer. Here's a much easier way." There's more, but I'll spare you.

Color-coded cardboard dividers separate and label the manual's three main sections: essentials, functions, and etceteras. "Each section," says the introduction, "is an independent unit. The manual is not meant to be read from cover to cover. It is designed so that you can find exactly what you want—when you want it."

Well, that depends. There's no index, so reading the manual from cover to cover is the only way to locate most commands. You could spend a long time searching for the procedure for justifying the right margin (it's

(continued)

C J Puotinen (POB M-525, Hoboken, NJ 07030) is the author of The Last Word on WordStar *and* Using the IBM Personal Computer: MultiMate.

MultiMate's manual has been rated superior to most . . .

in the Format Line section), deleting more than a single character (see Cut commands), entering boldface type (Fancy Print), and moving blocks of text (Paste commands). You don't move or copy document files; you "archive" them. You don't copy text from one place to another; you "name paste" or "super name paste" it.

The manual provides no narrative description or overview and its explanations are so curt and cryptic that deciphering commands can be a major task, especially for new users.

EDITOR AT WORK

Where most microcomputer programs refer to disk drives, Leading Edge refers to Drawer A and Drawer B. Each drawer can hold up to 32 folders and each folder up to 32 documents.

When you first open a folder, the program creates a standard document. Here's how the manual describes it:

> The LE Standard Document is automatically created by Leading Edge Word Processing. There is one standard document per folder. It consists of a format line with a left margin of 0 and a right margin of 80. You may choose to use this format as is or to assist you in establishing new formats for the creation of new documents. Establishing new formats may be useful for creating standard memos, letters, reports, etc.

What the manual doesn't explain is that you can never erase a standard document, that you can edit this file any way you like, and that whatever you store in a standard document (text and/or format lines) will appear automatically in every new file you create within its folder.

The filing system offers certain advantages. Filenames can be a full 30 characters long, including spaces. Folders can be treated as single units and copied from one disk to another, moved, or erased; their contents can be rearranged as well. But clear disk labels are essential, for the DOS directory command reveals nothing about a disk's contents; to review filenames, you have to load the program and consult its folder directories, a procedure that involves menu changes.

LOOKING AT MULTIMATE

In 1982, after adding IBM PCs to its collection of Wang word processors, Connecticut Mutual Life Insurance Co. hired a software-development company to transform its microcomputers into Wang Writers. The development company, W.H. Jones & Associates, agreed on the condition that it retain marketing rights to the program. In December 1982, WordMate made its debut. For trademark reasons and to reflect future enhancements, WordMate became MultiMate; the development company, which changed its name to SoftWord Systems, recently became Multimate International.

Though MultiMate cannot do everything the Wang does, it comes as close as can be expected for a program requiring 256K bytes of RAM. As a result, it is easy for novice users to learn, especially those who have Wang experience. In fact, MultiMate owes much of its success to the wide base of office workers already trained on that equipment.

COMMAND STRUCTURE

MultiMate comes with a color-coded keyboard chart and matching template. Stick-on labels used in previous releases have been discontinued.

On the color charts, the Control key is orange and the Alternate key is green. Keys are labeled on the charts with both color and function.

For example, the F2 key carries four labels. On the top of the key it says PgComb above the F2 and PgBrk below it. On the front side, it says Repag on an orange stripe and PgLgth on a green one. Initiates can decipher this key at a glance: F2 by itself sets a page break; Shift-F2 combines the page you're on with the next page, assuming you enter the command from the page's last line; Ctrl-F2 starts automatic repagination to adjust the length of edited pages; and Alt-F2 lets you change a document's lines-per-page setting.

DOCUMENTATION

MultiMate's manual is easy to use, with instructions at left, explanations at right, and a built-in easel that positions the book for easy reading. An introduction offers basic information and definitions; a chapter called "Getting Started" explains the keyboard, command structure, and start-up procedures; and four training lessons introduce the program. A reference section takes up most of the manual and provides more detailed instructions. These are necessary for those commands described briefly in the training lessons or not at all on the tutorial disk accompanying version 3.22, MultiMate's latest release. A glossary and index complete the manual.

MultiMate's documentation has been well received and rated superior to most, but that has more to do with the sorry state of computer documentation than writing talent. There are irritating inconsistencies in this program and its documentation, and some procedures aren't adequately described.

You enter some commands with the Return key, others with the F10 key, and some with either. The Escape key cancels most but not all commands. For example, to cancel a replacement command, you type the number 3; the program ignores the Escape key.

Practically every command that requires user input displays the previously typed entry, and MultiMate continues to display the old name as you type the new one. This creates confusion because in some but not all cases, you must erase surviving characters from the old name before entering the command. If the two entries are so similar that you need to change only a single character, you must remember that search/replace commands ignore displayed characters to the right of the cursor, while nearly every other command includes

(continued)

AT A GLANCE

Product
Leading Edge Word Processing

Manufacturer
Leading Edge Products
21 Highland Circle
Needham, MA 02194
(617) 449-6762

Computer
IBM PC, XT, or compatible; 256K bytes RAM

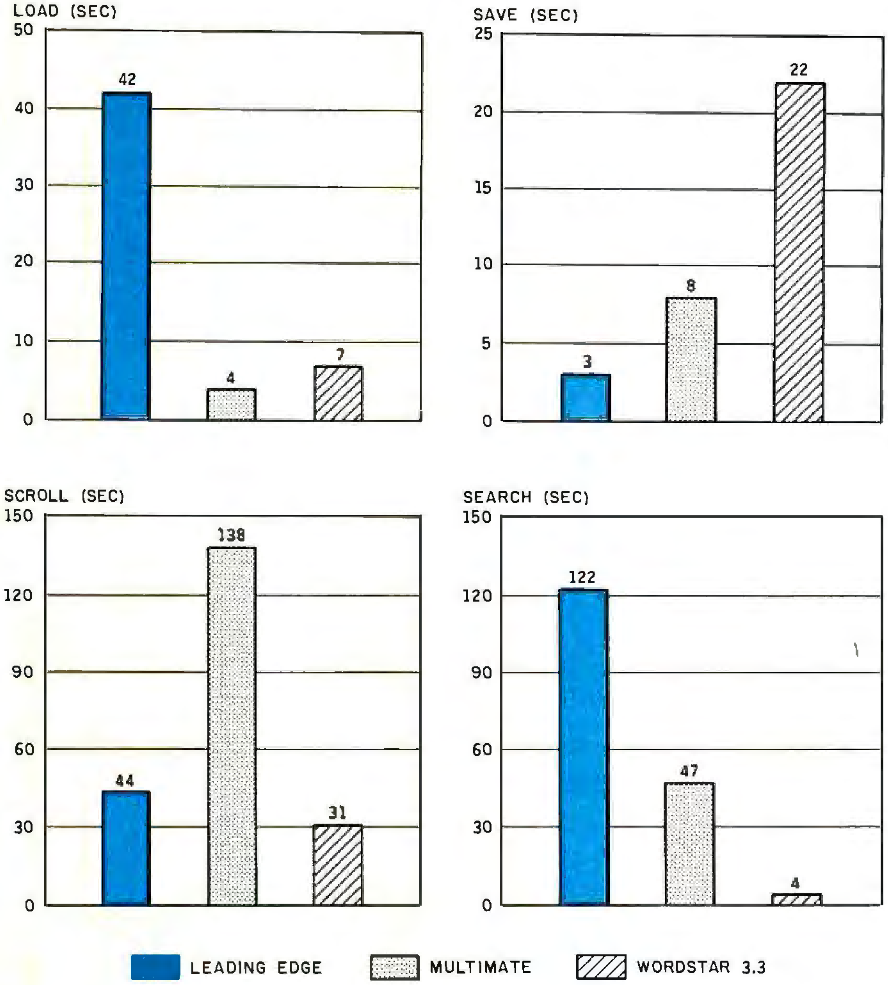
Price
$100; $150 with mail-merge program

Product
MultiMate Professional Word Processor 3.22

Manufacturer
Multimate International Corporation
52 Oakland Ave. N
East Hartford, CT 06108
(203) 522-2116

Computer
IBM PC, XT, or compatible; 256K bytes RAM

Price
$495, includes spelling checker and tutorial disk



The graphs show the results, in seconds, of performing various standard word-processing functions using a 4000-word text file. The Load graph shows the time required to load the file from disk to memory. The Save graph shows the time required to save the file on disk. The Scroll graph illustrates the time required to scroll manually from the file's first line to its last line. The Search graph shows the timing results for a search starting at the beginning of the file and looking for its last word. The times are for Leading Edge Word Processing, MultiMate 3.2, and WordStar 3.3 running on an IBM PC with dual disk drives and PC-DOS 2.0.

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them. Several of the help screens suffer from typographical errors, and some, written for previous releases, are no longer accurate.

The documentation is strongest when it describes routine commands, such as those used in short reports and correspondence; it's weakest in descriptions of complicated commands and procedures, and it makes no mention of program inconsistencies. Worse, it doesn't mention bugs, and MultiMate suffers from several. Some are harmless or merely irritating. One can wreck your files.

REPAGINATION

When you add new **material** or erase old material, pages change length. To correct imbalances and let you reformat material for legal-sized paper or short forms, MultiMate has an automatic repagination command.

It works without a hitch if the file contains heading or footing commands on the first page only or none at all, if the document uses the same format throughout, and if the page length hasn't been shortened.

I set a wide, single-spaced format at the beginning of a file and a narrow, double-spaced format in the middle of the first page. Before using the automatic repagination command, I typed and edited several additional pages, all using the double-spaced format. During automatic repagination, MultiMate inserted spurious format lines on every page, sometimes the wide format line, sometimes the narrow one. Nearly every unauthorized format line divided a sentence or paragraph. Each inserted a hard carriage-return symbol at the end of the text line preceding it, and in some cases these symbols were impossible to erase.

I developed a tedious routine for removing the symbols; if the delete command worked, I saved the page and returned to try another one. But sometimes the program refused to let me back in. "Cannot load this page," said the screen. Once this message appeared instead: "Out of record space—press any key to continue." This happened in a short file on a disk with 124K bytes available. When I did as instructed, part of the format line at the top of page 1 disappeared and the screen filled with upside-down question marks. The Escape key brought no relief, and the program ignored my reboot command. To resume the edit session, I had to shut the power off and start over.

The repagination command doesn't like headings or footings, either. Each heading occupies at least three lines (one for the "start heading" symbol, one for the heading's text, and one for the "end heading" symbol). The same is true for footings, and either can be up to five lines long. But MultiMate can't tell the difference between a heading/footing command and regular text, so when automatic repagination encounters these commands on any page but page 1, it rearranges them. Your page 3 footing might appear near the top of page 4, or a page break might separate its parts.

Changing the lines-per-page setting generates a different problem. Experimenting with a long file of alphabetical entries, I shortened the page length from 55 lines of text to 40. Automatic repagination sent text from page 1 to the end of the file, material from the middle came to the front, and several paragraphs from what had been the end were scattered through the file.

Because MultiMate saves every page as you leave it, the results of automatic repagination are permanent. If my file doesn't pass the three-part checklist (one format setting only, no headings or footings after page 1, and no revised page length), I repaginate by hand. It's a slow procedure, but it doesn't have any bugs.

By the time this article appears, Multimate International might have repaired the repagination command in version 3.3, scheduled for late summer release—but this defect was a problem in version 3.11 and should have been solved in version 3.2.

As disturbing as I found some of MultiMate's tendencies, they inconvenience few of the program's users, most of whom type only routine cor-

(continued)

respondence and short reports. It's when you deal with long or complicated files that you run risks.

INSIDE DOCUMENT FILES

Both MultiMate and Leading Edge make extensive use of the IBM PC's function keys, reconfigure text automatically, and store material continuously. Both provide merge print programs, but MultiMate supplies a spelling checker as well.

Leading Edge uses more menus and more layers of menus than MultiMate, and it ignores the Return key in favor of the Execute key, Leading Edge's name for the gray plus (+) key on the IBM's numeric keypad.

To give credit where it's due, Leading Edge outperforms MultiMate in a number of categories. The approach to onscreen formatting is similar, but MultiMate uses more embedded commands and does not display a justified right margin. Because Leading Edge recognizes the difference between alphanumeric characters and format symbols such as hard return or tab indent characters, it preserves the format symbols as you overtype old screen text. MultiMate can't tell the difference, so it's easy to erase format symbols accidentally, a situation made more confusing by the immediate reconfiguration of surviving screen text. Leading Edge is a refreshing change from MultiMate and a hundred other programs because it sends the cursor straight up and down the screen instead of zigzagging, even when it moves to an empty line.

Both programs store text continuously, a feature I find inconvenient for creative projects or manuscripts requiring extensive revision. If you like a file's previous version better, you can't restore it by canceling your edit session. Since MultiMate saves each page as you leave it, you can cancel a single page if desired. Leading Edge saves to disk 10 seconds after you stop typing, which can be disconcerting, and it interrupts a busy typing session frequently.

MultiMate is the more page-oriented program; it sets pages automatically and treats each page as a separate subfile. To see a new page, you must leave the old one. Leading Edge displays page-break lines and lets you see more than one page at a time. No page-break lines appear until you return to the beginning of a document and enter the repagination command, and the program does not update page breaks as you add or remove text. In general, Leading Edge's pagination is more convenient than MultiMate's because it doesn't have page-length limitations, it can display individual headings and footings after repagination, and it doesn't make a production out of moving from one page to another.

Even considering these advantages, however, Leading Edge is harder to understand, slower, and less convenient than MultiMate.

Table 1: *Summary of search/replace command options.*

Search/Replace Commands	Leading Edge	MultiMate	WordStar
Display search string before executing command	no	yes	yes
Search forward	yes	yes	yes
Search backward	no	no	yes
Single search/replace (does not repeat automatically)	no	no	yes
Automatic global replace (repeats automatically)	forward only	forward only	yes
Discretionary global replace (repeats automatically)	no	forward only	yes
Ignore case, match case	yes	yes	yes
Find *n*th appearance	no	no	yes
Make replacement *n* times	no	no	yes
Match whole words only	no	no	yes

PRINTING ATTRIBUTES

Leading Edge's fancy print category includes underlining, double underlining, boldface type, wide boldface, double wide print, subscripts, superscripts, italics, strike-through, color monitor selections, and color printing.

You can enter the appropriate command before typing text or type first and apply attributes later in a block procedure. Automatic underlining is the only single-keystroke attribute command; the others require seven keystrokes and two menus. Though the underline appears on monochrome monitors, underlined characters display on color monitors in inverse video. The advantage to this escapes me because all other attributes display on either monitor as inverse video. You can request a screen notation defining attributes, but only one message can appear at a time. If you use a variety of attributes, you must visit each word separately and enter two or more commands to determine which words are boldface subscripts, for example, and which are italicized superscripts.

Though automatic attributes sound convenient, the screen can't keep up as you type. When I attempted to enter three lines of italic text, I filled the keyboard buffer, which made the screen beep, and then waited while the characters appeared at the rate of two per second. It takes less time to type the material first, then mark it as a block and apply the desired attributes. WordStar and MultiMate don't handicap the user, and MultiMate offers more versatile underline commands.

MYSTERY SEARCH COMMAND

WordStar and MultiMate display your search string as you type. The string

(continued)

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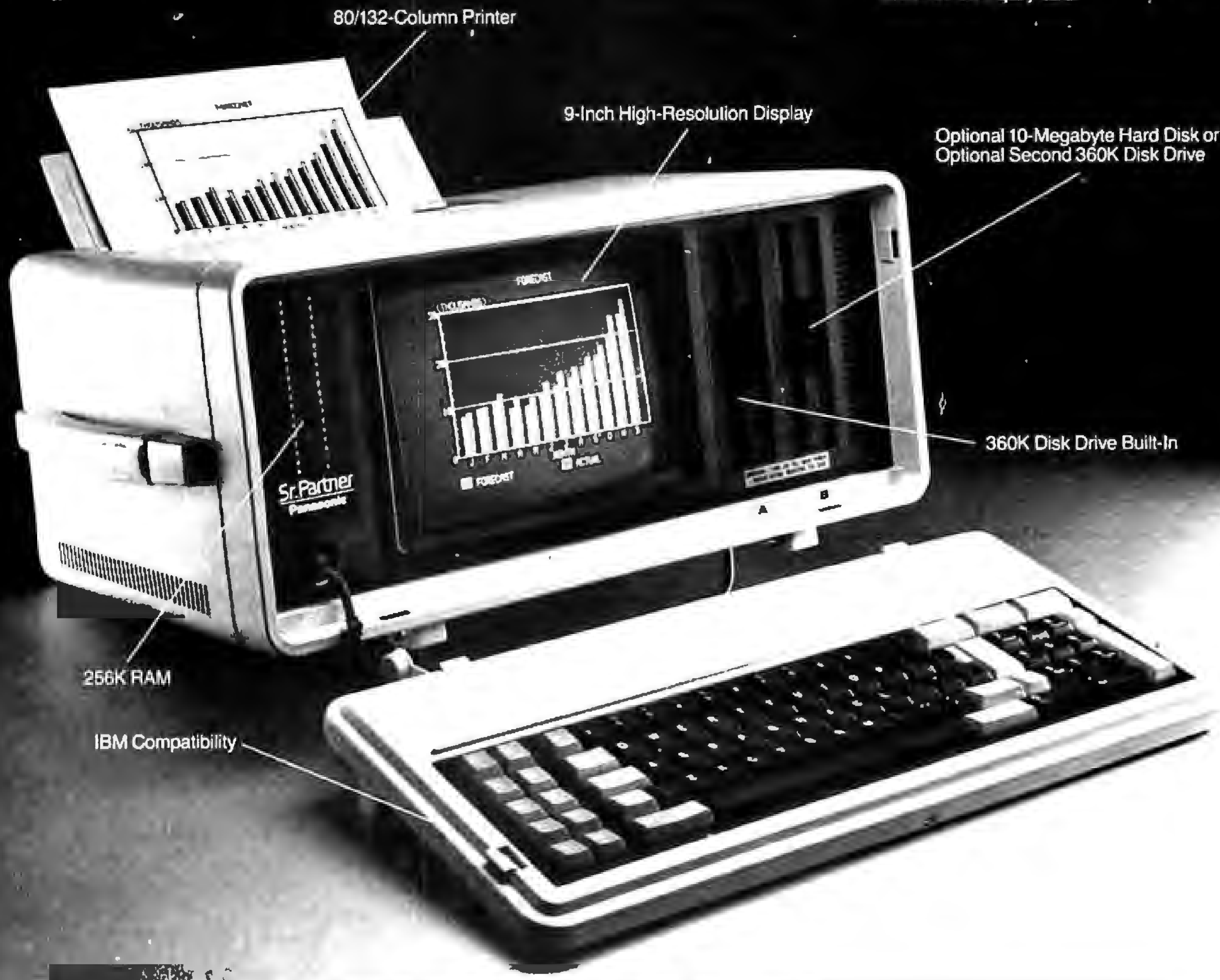

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remains on the screen until you cancel or execute the command, giving you plenty of time to verify it and make changes. Leading Edge doesn't subscribe to this user-friendly philosophy.

Whether you press the Execute key or not, the program starts its search as soon as you type the string's first character. As if this weren't confusing enough, it displays only the string's first character until it matches that character, then it displays the next character as well, and so on. Not until the cursor stops at an exact match does the entire string display on the search line. If the program can't find an exact match, it never does display the string; instead, a "Cancel search/replace" message appears. You can't tell whether you typed the string correctly.

Both programs offer automatic global replacements (see table 1), though Leading Edge's command sequence is by far the more awkward. WordStar and MultiMate provide discretionary (yes/no) global commands; Leading Edge requires you to press a key each time you want to repeat the command.

Unlike Leading Edge, WordStar and MultiMate provide numerous screen prompts and yes/no verification messages at possible replacements. Unless the Leading Edge manual or cue card is beside you, it's hard to remember the commands for special wild cards, ignoring case, and global replacements. Even a simple search/replace command requires several steps: position the cursor at the beginning of the file or where you want the search to begin; press the F7 (search) key; type the word or phrase to be replaced; when the cursor stops at the first match, press Shift-F7; type the replacement word or phrase; press the Execute key.

The command repeats automatically. To confirm the offered replacement and go to the next appearance, press the Execute key again. To go to the next appearance without making the offered replacement, press F7.

If Leading Edge's search/replace commands are confusing and awkward, their speed adds injury to insult. In a 4000-word benchmark file, Leading Edge needed 1 minute and 2 seconds to find a word that WordStar located in 4 seconds. But more stunning (I ran the test twice to confirm this) was its automatic global replacement of a word that appeared 400 times. WordStar completed the task in 21 seconds with its screen display suppressed. I thought MultiMate was slow at 6 minutes 25 seconds. Leading Edge took 30 minutes 40 seconds.

CUT AND PASTE

Leading Edge doesn't use the familiar nomenclature of block commands, such as move, copy, and delete. The cut command erases a block of highlighted text. The paste command inserts previously cut text at the cursor. A named cut is given a one-letter label as it's erased; a named paste inserts the specified named cut. To copy a block of text, you must erase it first, then restore it at the original position and insert it at the new location.

The super name paste command moves text from one window to the other.

BOILERPLATE

Like many new programs, and unlike WordStar, MultiMate and Leading Edge provide special commands for storing and inserting boilerplate text and for entering frequently used keystroke sequences automatically.

The library is MultiMate's boilerplate mechanism, and its key procedures store keystrokes. Leading Edge includes both functions in its glossary command.

Both programs name their entries: MultiMate allows up to three characters and Leading Edge limits the name to a single letter.

The programs are similar in keystroke execution but worlds apart in handling of text—and the automatic insertion of text is what word processing is all about. When called for, MultiMate's library entries appear all at once. Leading Edge, which goes out of its way to do things differently, brings the text in one line at a time. I prepared the same 500-word page of text as a MultiMate library entry and a Leading Edge glossary file. It took MultiMate less than 4 seconds to execute the command and insert the text, but Leading Edge needed 1 minute 27 seconds.

BENCHMARK TESTS

Using the same 4000-word benchmark file for each program, I tested WordStar 3.3, MultiMate 3.2, and Leading Edge 1.1 with standard BYTE procedures plus a few of my own (see table 2). I ran the tests on an IBM Personal Computer with dual disk drives and 256K bytes of RAM.

In the move-to-end-of-file test, Leading Edge took 5 seconds to go from the first line of the benchmark file to the last, WordStar required 7 seconds,

(continued)

Table 2: *Benchmark results for Leading Edge Word Processing and MultiMate 3.2 compared to WordStar 3.3. All times are in seconds.*

Procedure	Leading Edge	MultiMate	WordStar
Load a file	42	4	7
Save a file	3	8	22
Scroll from top to bottom of file	44	138	31
Search for last word in a file	62	49	4
Load program from DOS	20	16	8
Move to end of file	5	6	7
Move to beginning of file	1	6	1

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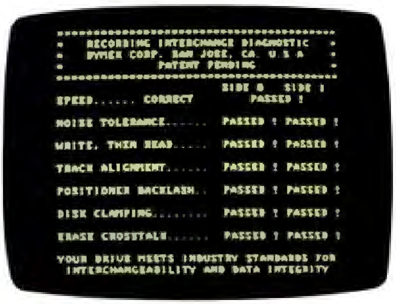

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and MultiMate used 6 seconds. Moving from the file's last line to its first took Leading Edge 1.5 seconds, WordStar 1 second, and MultiMate 6 seconds. In this category, the performance differences are negligible.

Document saving times are hard to compute for Leading Edge and MultiMate because they save text automatically. MultiMate saves every page as you leave it, a procedure that takes 5 to 7 seconds. Leading Edge saves text when you stop typing and at frequent intervals throughout a busy edit session. I timed the programs as they closed the benchmark file and returned to the main menu. Leading Edge needed 3 seconds and MultiMate 8. WordStar saved the file and returned to the main menu in 22 seconds.

For program loading, WordStar loads from disk in 8 seconds. MultiMate and Leading Edge take longer and the loading procedure includes an extra keystroke; both display copyright messages and "Press any key to continue." MultiMate's minimum loading time was 16 seconds, Leading Edge's 20 seconds.

Loading times for the benchmark file varied dramatically. It took WordStar 7 seconds to load the benchmark file, MultiMate 4 seconds (3 to display the document summary screen and 1 to display the file), and Leading Edge took 42 seconds. Leading Edge makes a backup copy not when you leave a file but when you enter it again, and the procedure makes a real racket. The longer the file, the more the disk drive sounds like a demented mechanical calculator.

Using the down-arrow key to scroll manually through the document is another benchmark test. WordStar was the fastest program, going from first to last lines in 31 seconds. Leading Edge's 44 seconds might be slower, but MultiMate needed 2 minutes 18 seconds to complete the test.

The last BYTE benchmark test is a search command; it begins at the file's first line and looks for the file's last word, which appears only once. WordStar found the word in 4 seconds, MultiMate in 49, and Leading Edge in 1 minute 2 seconds. As mentioned, the global replacement comparison is even more dramatic.

To show that Leading Edge's pace isn't my imagination, I ran some additional tests. For example, WordStar deletes a line instantaneously; Leading Edge leaves the line onscreen for a full 2 seconds after you enter the appropriate cut command, and it spends another second updating the screen.

No matter where you are in a WordStar file, you can enter the "go to end of file" command, and the cursor moves directly to the file's last line. Enter this command in a Leading Edge file and the cursor moves to the top of the last page, pauses, and continues to the end. If you're already on the last page, this program scrolls up to the top of the page and pauses before moving down to the end, a procedure that consumes half a minute on long pages.

Table 3: *Summary of save/store command options.*

Functions	Leading Edge	MultiMate	WordStar
Saves file on disk	saves text continuously	saves each page as you leave it	on command
Makes backup file	when loading file (used only to overwrite current version if damaged)	no	yes, when saving; user can rename and edit file
Abandon edit command lets you cancel edit session, restore original version of file	no	no	yes
Program can generate, edit ASCII files	no (conversion programs provided)	no	yes

MERGE AND PRINT

MultiMate's built-in merge program might not be the fastest in town, but compared to Leading Edge's, it's a model of simplicity. Someone already familiar with records, fields, delimiters, nonhyphenated field specifiers, and hyphenated field specifiers might be able to follow the Leading Edge procedure, but its documentation seems designed to confuse novice users.

MultiMate's merge program is easy to understand and use, and it doesn't require file conversion. Leading Edge merge files must be converted to ASCII format before printing.

Printing is a straightforward operation once you decipher the Leading Edge print menu. Each line is a menu item. To change a value, you move the highlighting up or down, press the Execute key, type the correction, and press Execute again. Printing begins when you move highlighting back to the top line (or the second line for merge printing) and press the Execute key.

Dedicated word processors were designed for busy offices, and it's in the printing department, where time is money, that MultiMate leaves both Leading Edge and WordStar behind. WordStar and Leading Edge let you print one file while editing another, but MultiMate uses a printer queue/spooler that frees the operator from waiting for one file to finish printing before entering the next file's print command.

With MultiMate you can delay the print session to a specific time, enter the commands for printing a dozen files one after another, rearrange files in the queue, and go out to lunch while the printer carries out your com-

(continued)

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mands. MultiMate supports sheet feeders in addition to a wide range of printers (40 at last count), making it a more practical and office-oriented program.

Leading Edge supports a number of printers: the Leading Edge Letter Quality, Leading Edge Dot Matrix, IBM Matrix, NEC 3550, Prism, PrismPro, and PrismRGB. By the time this review appears, Leading Edge users will be able to call the company to request support programs for specific printers in addition to those listed here.

Disk Recovery

As you enter a Leading Edge file, the screen displays available disk space as a percentage figure, and if the disk is nearly full, a warning message tells you to erase unnecessary files. But there is no recovery from a full disk, and you can damage files in other ways as well. In one of my practice files, the program froze as soon as the cursor reached the second page, and I still don't know why. Substituting the backup copy for the current version didn't help.

Although the program beeps and flashes warning messages when you approach a full disk while editing, it's possible to fill the disk while entering text with gallery or paste commands and receive the warnings too late. There's no mistaking a too-full-to-save document; the screen fills with small arrows and if you try to reload the file a message says, "Document truncated, please restore it from backup." Using the backup procedure doesn't necessarily rescue the file, so a full disk is a serious matter.

MultiMate's save-every-page procedure protects all but the page you're working on when the disk fills. The exception to this rule is important. MultiMate's external copy command lets you insert text of any length, and the program doesn't check for sufficient room on the disk or in the file (maximum file length: 128,000 bytes). MultiMate inserts the text and reconfigures the file. If you don't have sufficient room for your old text, it disappears. Because MultiMate saves text automatically (making it impossible to cancel an edit session and return to the file's previous version) and because the program doesn't provide backup copies, this command can be dangerous.

For more information, see the comparison of save/store command options shown in table 3.

The Bottom Line

Leading Edge has no shortage of bells and whistles, from its "Gee Whiz" keys that transpose letters and reverse upper- and lowercase letters to its special commands for generating solid lines, international and U.S. decimal tabs, reverse indent, dot leader tabs, right flush tabs, alternate page headings and footings, archive procedures, "hot print," and a dozen more. It looks very, very nice. Also, it costs only $100.

But Leading Edge is poorly documented, slow, and inefficient. It doesn't hold a candle to WordStar when it comes to standard word processing, and when you compare the commands that matter, it doesn't threaten MultiMate.

A Final Thought

"There's someone for everyone," promises the old saying, and there's a word-processing program for everyone, too. In an office setting, where users have little or no computer experience, programs like MultiMate and Leading Edge might be easy to teach because they are designed for correspondence and short reports, projects that require few commands. Many novice users fear the loss of documents and find the save-as-you-go feature reassuring.

Relatively few office workers use the procedures needed in complex projects, procedures that, in both programs, are hard to decipher, awkward, and sometimes dangerous. Novice users tolerate restrictive command procedures because they have nothing to contrast them with and because constant screen prompts are reassuring.

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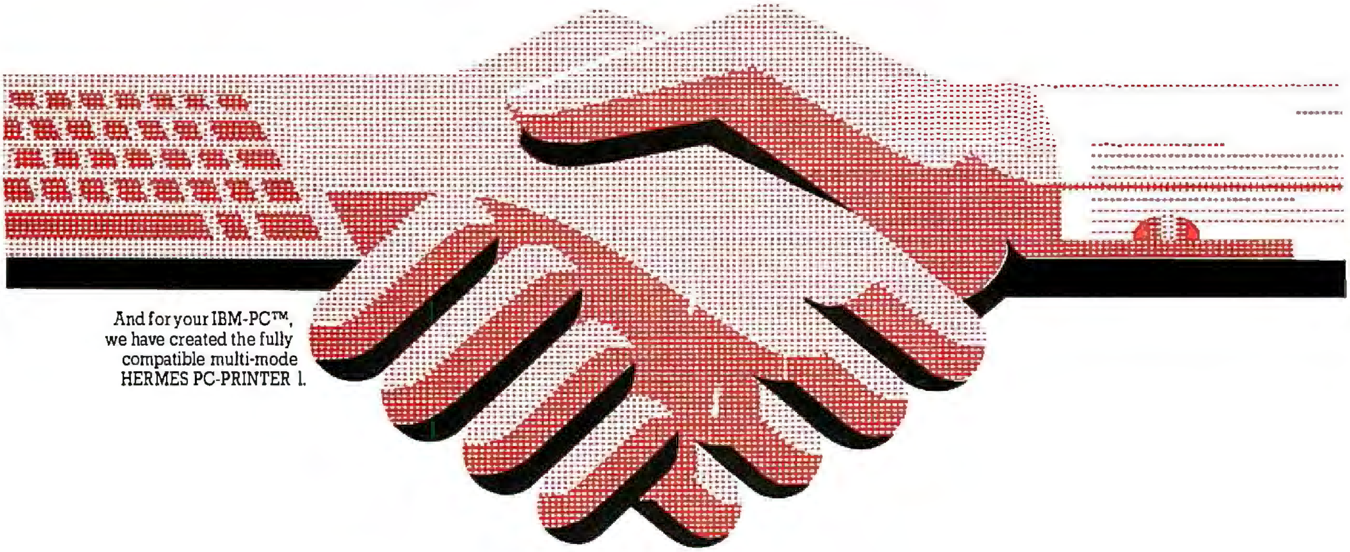

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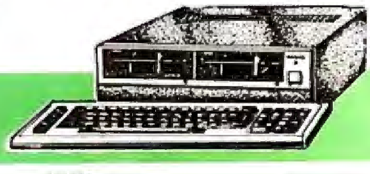

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SOFTWARE REVIEW

*poly*FORTH *and* PC/FORTH

Two FORTH development systems for the IBM PC

BY ERNIE TELLO

In this review, I will discuss some of the capabilities made possible by the FORTH language and review two excellent implementations of it for the IBM Personal Computer (PC): polyFORTH II Level 3, from FORTH Inc., and PC/FORTH, from Laboratory Microsystems.

Long the programming language favored by scientists, hardware vendors, and process-control experts, FORTH has also been a favorite in-house development tool for a surprising number of large corporations. FORTH is now coming into the spotlight as a powerful language for commercial programming. A flood of new and innovative products written in FORTH has hit the market. Some of the better-known packages written in FORTH include EasyWriter, the original version from Cap'n Software; Easel, from Time Arts; Answer, from North American Business Systems; SAVVY, from Excalibur Technologies; Mastertype, from Lightning Software; and the integrated software system for the Gavilan computer. The adaptability and flexibility of FORTH lets it fit in the most diverse applications while remaining intrinsically modular.

FORTH is a threaded interpretive language. For a moment, forget the technical side of what this means. Consider a string of pearls or beads that can be threaded in various ways to create larger pieces from the same set of originals, suiting different needs and occasions. A FORTH programmer uses the basic precompiled words of FORTH to thread together other words that will be useful again and again for an application; the programmer then orchestrates them together into still higher-level words that may be used to create programs.

While defining functions and procedures in C and Pascal is in some ways comparable to this, the difference lies in the unrestricted ease and abandon with which it is done in FORTH.

But equally important to the programmer is FORTH's interactive environment, which helps the programmer by supplying, on request, information to help him program. You enter the word that asks for information about something in the system, and FORTH will immediately display the answer on the monitor. I will cite specific examples of this later on.

Another attribute of FORTH is the often startlingly small size of itself and the programs produced under it. FORTH packs an amazing number of powerful words into a very small space. For this reason it has long been favored by vendors of small dedicated hardware packages and by producers of coin-operated video games. FORTH programs fit in places too small for programs in just about any other language. Producing compact, efficient programs has been a keynote of the FORTH philosophy since its invention in 1970 by Charles Moore, who designed it for use in controlling radio telescopes.

Naturally, FORTH has its darker sides. The most frequent complaints are that it is unreadable and that you cannot produce stand-alone executable files, as you can with compiled languages. Another common criticism is that FORTH has no real standard dialect, that there are as many dialects of FORTH as there are FORTH users. And sometimes, too, there are complaints about the postfix notation.

There are three main reasons why FORTH is difficult to read for those new to it: its use of postfix or reverse Polish notation; its stack orientation, with various apparent "sleight of hand" tricks in manipulating the stack; and its total extensibility, which lets a programmer create the language as he goes, extending it toward its applications.

Experienced FORTH programmers readily admit it is harder to become accomplished in this language than in other higher-level languages. But the reward for learning FORTH is greater control over the size and speed of the programs you produce. Because of its friendly interactive environment, it is relatively easy to get started writing pro-

(continued)

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grams in FORTH. What is far more difficult is writing powerful and efficient high-level programs. Let's take a brief look at some of the more technical details of FORTH.

THREADED CODE

There are three common kinds of threaded code interpreters: direct threaded, indirect threaded, and token threaded. What they have in common is that programs consist of linked lists of addresses. At the very heart of FORTH is the address interpreter, a short routine (typically 10 bytes or less of machine code) that looks up the addresses of machine-code instructions to be executed.

Usually the FORTH language interpreter uses the instruction pointer (IP) to point to executable machine-code routines. The direct-threaded interpreter, the fastest of the three types, uses the contents of the IP to point directly to the executable code.

Most of the popular FORTH interpreters, such as FIG (from the FORTH Interest Group), use the indirect-threaded approach. The IP points to a code field address (CFA) in system memory, which in turn points to the executable code routine. Although this extra address fetch costs more time, the routines for the FORTH interpreter are made less machine-dependent by using the indirect-threaded approach.

The token-threaded interpreter uses still another indirect address fetch, but because of the further loss in speed, this type has not found many implementations yet. One important new implementation using token-threading is MacFORTH.

PROGRAMMING ENVIRONMENT

A good deal of FORTH programming involves handling the parameter stack for all parameter passing; when used properly, FORTH naturally recycles its own programming environment without a need for periodic garbage collection. To do this effectively, a FORTH programmer has a number of interactive tools at his disposal.

Most FORTH systems include the word .S , which nondestructively displays the current contents of the stack on the screen. For example, if you first enter the numbers 1 through 5 separated by spaces, .S shows

```
1 2 3 4 5 ok
```

It should be noted that the FORTH stack is last in/first out, so 5 is on the top of the stack. With .S or its equivalent, you can use the standard FORTH words for stack manipulation and see the results of your change at each step. Here is a sample session, as it would appear on the monitor, that illustrates the effect of all the main FORTH stack operators. (User input is set in triumvirate type; the computer's response is set in italics. The entries affected by the succeeding manipulation are underlined.)

```
1 2 3 4 5 ok
.S
1 2 3 4 5 ok
SWAP .S
1 2 3 5 4 ok
DUP .S
1 2 3 5 4 4 ok
ROT .S
1 2 3 4 4 5 ok
OVER .S
1 2 3 4 4 5 4 ok
3 PICK .S
1 2 3 4 4 5 4 4 ok
DROP .S
1 2 3 4 4 5 4 ok
DROP SWAP DROP .S
1 2 3 4 5 ok
4DROP DROP .S
0 ok
```

It can be very useful to have a word like .S in the FORTH interactive environment. It is very important in FORTH that routines do not leave anything on the stack. .S can be included for debugging purposes at the end of a new routine to show what, if anything, is left on the stack. Then, when the word is finished executing, it is usually simple to DROP as many things as you do not want to appear on the stack.

The adaptability of FORTH lends itself very well for use as a systems language for the implementation of other languages. At least two implementations of BASIC are written in FORTH (one is by **Charles Moore**), as is a Tiny Pascal interpreter. There are also at least two implementations of LISP in FORTH, including a complete implementation at the University of Utrecht in Holland and a partial implementation in the United States.

POLYFORTH II LEVEL 3

FORTH Inc., started by Charles Moore to satisfy the demand for FORTH systems, has been in business for a long time. Its current system is available for several microcomputers and minicomputers. polyFORTH is offered in a series of ascending levels with increasing software capability and support for increasing levels. This ranges from Level 2, a minimal system that lacks multiuser capability but has a "turnkey compiler," to Level 6, which includes all the bells and whistles and an on-site introductory course for companies. I've evaluated polyFORTH Level 3, with the powerful interactive graphics options.

polyFORTH Level 3 comes on two double-sided disks, one of which contains all the source screens. The other contains the "shadow block" documentation; each block of source code in the A drive is "shadowed" by the disk in the B drive. Hitting the Q key gives you an immediate help screen for the current screen block in A.

One of the main features of polyFORTH Level 3 is its stand-alone multiuser operating system. Instead of running under MS-DOS, polyFORTH does its own file and disk operations and has a multiprogrammer as an essential part of its interpreter. Two kinds of tasks are supported: terminal (or foreground) tasks and control (or background) tasks. Every task has a parameter stack, return stack, and user variables. Terminal tasks have everything a control task has plus text I/O (input/output) facilities, serial line support, and their own user dictionary of commands. The minimum size for a terminal task is 2048 bytes, while that for a control task is 250 bytes.

In polyFORTH, concurrent tasks are inserted onto a "round robin" loop implemented by the word PAUSE .

(continued)

AT A GLANCE

Name
polyFORTH II Level 3

Type
FORTH programming language interpreter and multitasking development system

Manufacturer
FORTH Inc.
2309 Pacific Coast Highway
Hermosa Beach, CA 90254
(213) 372-8493

Price
$600

Format
Two 5¼-inch double-density double-sided floppy disks

Computer System
IBM PC with two double-sided floppy-disk drives or one double-sided floppy-disk drive and a 10-megabyte hard disk, optional color graphics card, 8087 coprocessor, and second monitor

Documentation
500-page polyFORTH II reference manual, 250-page Intel 8086 supplement, pocket reference guide, electives source code, *Starting FORTH* by Leo Brodie

Name
PC/FORTH 2.0

Type
FORTH programming language interpreter

Manufacturer
Laboratory Microsystems Inc.
4147 Beethoven St.
Los Angeles, CA 90066
(213) 306-7412

Price
$100

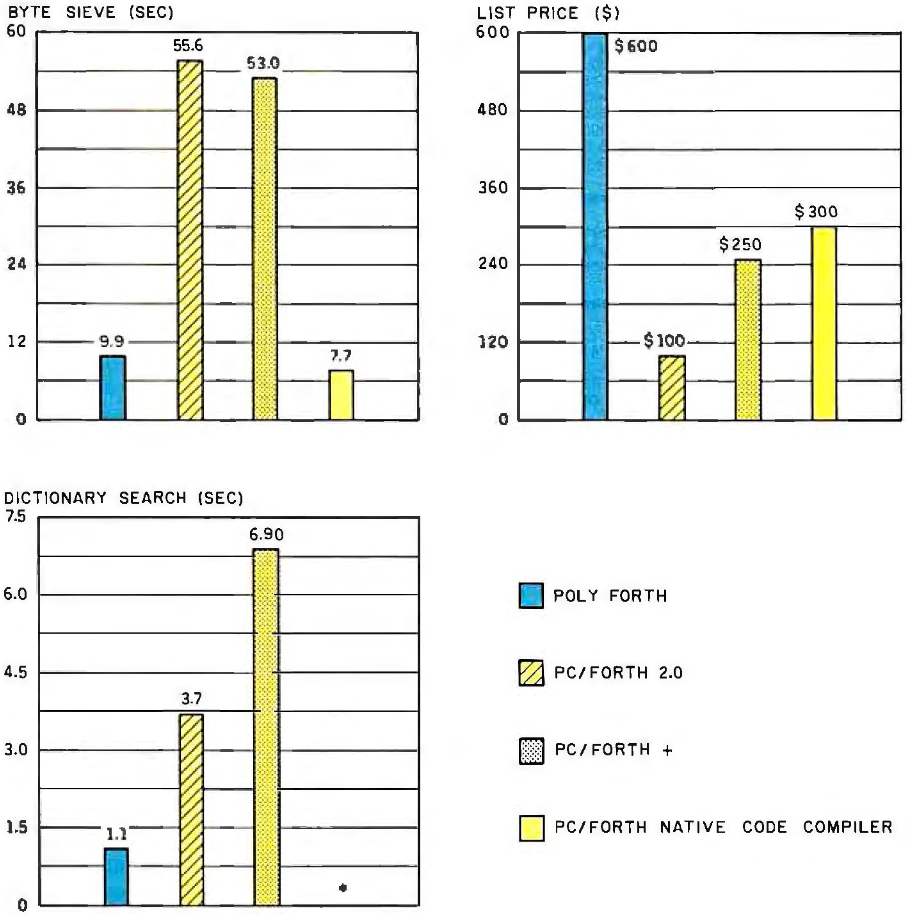
Format
5¼-inch single-sided floppy disks

Computer System
IBM PC with one floppy-disk drive, 48K RAM, MS-DOS or CP/M-86

Documentation
250-page user's manual, reference card, FORTH glossary, FORTH-83 reference document

Options

PC/FORTH +	$250
Intel 8087 package	$100
Floating-point software	$100
Interactive symbolic debugger	$100
Native code compiler	$200



A comparison of polyFORTH and three implementations of PC/FORTH. The BYTE Sieve of Eratosthenes prime-number benchmark was translated into FORTH by the author. The source code is reprinted in listing 1. All times are given in seconds. The list price for the PC/FORTH native code compiler is $200, but it requires PC/FORTH 2.0 to run. The dictionary search is not applicable to the native code compiler.

When the system is ready for use, it is cycling the PAUSE loop searching for a task. The total number of simultaneous tasks is a function of available system memory. The multiuser capability is available in the polyFORTH programming environment and for applications written with it.

POLYFORTH EDITORS

An interesting way of handling the editing problem in a FORTH environment is implemented in the IBM PC polyFORTH. Actually, there are two editors: a customized full-screen editor and a powerful line and string-manipulation editor that can be used while remaining in the FORTH vocabulary.

The line and string editor is used in conjunction with the LIST function. By listing a screen, it becomes the current screen for a large number of line and string operators. For example, T followed by a number makes that the current line and sets the cursor at the beginning of it. M takes two parameters, the block (or screen) number and the line number, and moves a copy of the current line under the specified line on the specified block. P places a string that you type on the current line, while U inserts it under the current line, shifting the others down. The advantage of this editor is that it is available right in the FORTH vocabulary and doesn't require loading a new vocabulary that takes up dictionary space.

All of the find-and-replace functions are available from this editor. When an error message comes up after you have just loaded a screen or program, simply typing L lists the delinquent screen with the cursor positioned at the objectionable line.

A full-screen editor is loaded when needed. This editor includes many useful conveniences and details. It makes effective use of the IBM PC function keys and uses the other editing keys as you would expect them to be used.

DOCUMENTATION

Two loose-leaf binders accompany polyFORTH Level 3. The first is a 500-page polyFORTH II reference manual, and the second is a supplement about the Intel 8086. In addition, *Starting FORTH* by Leo Brodie (Englewood Cliffs, NJ: Prentice-Hall, 1982) is included. Between this and the on-line shadow-screen documentation you'd think that here at last is all the documentation anyone could ever hope for. Strangely, though, there are some things absent that I would have hoped for. One of them is an alphabetical glossary of all the words in the polyFORTH system. True, there is the interactive LOCATE function, which takes you to the source screen for any word not in the protected kernel. But the glossary has become virtually standard for most FORTH systems. It is the best single tool for getting a working overview of a given FORTH implementation, and it is also an essential reference tool for actual programming.

DATABASE SUPPORT SYSTEM

Available with Level 3 and up, the database support system gives the programmer a set of tools for defining customized databases optimized for efficiency rather than providing a preset format for filing and indexing. The main database defining function is the word FILE , which is used to specify the name of the file, the number of bytes for each record, the maximum number of records, the number of 1024-byte blocks the file will occupy, and the beginning block number. Unfortunately, record lengths are limited to only one block (1024 bytes), an inflexibility that seems unnecessary.

Since the database handler is implemented in the multiuser environment, files can be declared as either shared or unshared. Fields within records accept five permissible data types: 1-byte, numeric, double, multiple-byte, and filler. Routines for controlling the allocation of records in direct-access files enable you to allocate records in such a way that relinquished space can be reallocated as needed. There are provisions for using hashed files, a report generator with variable page formats, and a documentor tool for maintaining a fully documented glossary of all FORTH words used in an application.

INTERACTIVE GRAPHICS

The graphics option is the newest addition to the IBM PC implementation of polyFORTH; it is extremely impressive, as is the included graphics demo. In addition to the usual line-drawing primitives, the new graphics package offers special text fonts in the graphics mode with the ability to set the size and spacing of the characters. There are also line-drawing and "brush" words, resembling software capabilities of the Apple Macintosh, that enable you to choose different widths and textures for line drawing, including circles and other graphics shapes. So far, however, there is no mouse support. Instead, function keys control a graphics cursor and support the placement of graphics and text or leave a trace on the screen that may be used either in the layout of screens or to draw figures.

Another plus for the polyFORTH interactive graphics package is its support of both a monochrome and a graphics monitor at the same time; code is edited and listed on one screen and graphics on the other.

polyFORTH is FORTH taken to its logical conclusion. It is an extremely powerful tool, but only in the hands of a knowledgeable user, and that knowledge doesn't come easy. The basic kernel, together with all the functions FORTH Inc. considers most proprietary, occupies only nine screens (9K bytes). When you learn all of the powerful things that are in that small space, you will have a direct acquaintance with what FORTH at its best is all about.

However, polyFORTH is not for everyone. It is the closest version to Charles Moore's implementation of FORTH and the closest to his characterization of it as a programmer amplifier. An expert can really display expertise and, conversely, a weak programmer displays his ineptness. On the other hand, in spite of the DOS (disk operating system) file transfer

(continued)

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SoftCraft, Inc., 222 State St. #400, Madison, WI 53703 orders: (800) 351-0500
(We've moved from California) from Wisc: (608) 257-3300
Fancy Font System $180 ______
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Calif. and Wisc. residents add sales tax 6.5% or 5% ______
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Diskette Format: (IBM PC, Epson QX10, Osborne DD, Kaypro, 8" CP/M, Apple CP/M, Victor) ______
Printer: (Epson FX, Epson MX, etc.; see box at left) ______
$7.50 of demo cost is applicable towards Fancy Font purchase.
CP/M requires 64K, MSDOS 128K memory.
Fully transparent 8-bit printer interface required on Apple and CP/M.

The editor always presents a special problem in a FORTH system. On the one hand, you don't want to exit the FORTH interpreter, and on the other hand, you don't want it to use too much dictionary space.

ability, it can be a disadvantage for some applications to use a system that does not run under MS-DOS. However, this could be an advantage if stand-alone multitasking is what you're looking for.

Stand-alone applications implemented in ROM (read-only memory) with a customized dictionary containing only the FORTH words needed to run the application are a specialty of FORTH systems that do not run under a separate operating system. However, it should be noted that the target compiler and source code needed for such applications are available only with polyFORTH Level 4 and up, and the price for this starts at $3200.

For those who are willing to surmount the rather steep learning curve, polyFORTH may be just what your programming needs require.

PC/FORTH

Laboratory Microsystems is one of the most progressive companies producing a fully equipped professional FORTH development system for the IBM PC. What sets this system apart from others is that it runs under MS-DOS with a full set of MS-DOS file and record interface functions. A similar version is available for CP/M-86. Another distinguishing feature of PC/FORTH is that it is the first to conform fully to the latest standard, FORTH-83. (See "FORTH-83: Evolution Continues," by C. Kevin McCabe, in the August BYTE, page 137.) A broad set of optional tools includes a high-level debugger, a new native code compiler, a cross compiler, and a database handler.

Laboratory Microsystems offers two FORTH systems for the IBM PC: PC/FORTH ($100), which is for applications only as large as 63K bytes, and PC/FORTH+ ($250), which can handle programs up to 1 megabyte. With both systems, a nucleus and elective screen file are provided for developing a customized version that lets you choose the words you want permanently in the dictionary. It is relatively easy to provide various versions of the system both to serve in the development process and for providing a compact run-time environment for the applications.

PC/FORTH Editor

In version 2.0, the full-screen editor has been redone and now takes up even more space than before, 13K bytes. This editor, while more streamlined than the earlier one, is still a potential trouble spot. The editor always presents a special problem in a FORTH system. On the one hand, you don't want to have to exit the FORTH interpreter to use it, and on the other hand, you don't want it to use up too much dictionary space, (which you will need for compiling your application).

The PC/FORTH editor is configured so that you must enter it by a two-step process. First, the EDIT command brings you to a screen from which a number of commands may be issued; these commands perform editing and various screen-moving and copying functions. You first enter E (for edit) and then the screen number you wish to edit. A certain amount of time is needed, therefore, to move back and forth between the normal FORTH vocabulary and the editor. This situation leads to problems at times because there is no way to immediately flush screens to the disk while within the editor. This, coupled with the fact that there is not a foolproof mechanism to save all current screens, means that considerable care is needed to ensure that screens are not lost. Part of the routine of developing an application is loading and testing code that has just been entered. Often code that is not yet fully debugged causes the system to crash. It is my opinion that the PC/FORTH system is not sufficiently equipped with secure protection for screens when this happens. Occasionally, and unpredictably, screens are just not there as they should be.

Table 1: *Benchmark results for the reviewed systems. All times are in seconds.*

	polyFORTH	PC/FORTH 2.0	PC/FORTH+	Native Code Compiler
Sieve of Eratosthenes	9.93	55.63	52.98	7.68
Sieve (Colburn)	28.62	34.54	10.30	7.41
Sieve (array)	1:06.25	1:05.47	2:19.56	7.36
Sieve (optimized)	1:07.50	1:04.75	2:06.71	7.03
Sieve (optimized array)	1:08.24	1:12.77	2:29.39	7.41
LOOPTEST	1.12	0.76	1.26	0.38
–TEST	3.64	3.40	5.65	0.60
*TEST	4.47	4.28	19.55	1.48
/TEST	4.72	4.72	42.95	1.75
MOVETEST	3.68	3.40	6.20	0.49
COMPTEST	4.46	4.06	6.26	0.76
Dictionary search	1.08	3.68	6.90	n.a.

PC/FORTH ADVANCED GRAPHICS EXTENSION

PC/FORTH's graphics package ($100) has words for plotting various graphics figures. The graphics program also has a set of powerful turtle graphics functions, as well as support for all types of state-of-the-art input devices such as light pens, joysticks, the Microsoft Mouse, and the Mouse Systems Mouse. Other features include words for transferring graphics images to and from a disk or a printer, full window-management support, an intersegment memory-dump utility, and several demos with source code for illustrating the use of all these features.

The graphics functions are fast and powerful. The window-management routines let you operate even in graphics mode. The documentation for the graphics extension, however, is a minor weak spot. Some functions are too scantily explained, leaving it up to you to figure out how to use them. This is an unfortunate inconvenience in a package that is otherwise very easy to use.

NATIVE CODE COMPILER

A new option from Laboratory Microsystems is the handy compiler ($200) by Tom Almy that lets you selectively compile time-consuming words without an assembler. It is intended mainly for low-level FORTH words, such as those used in hardware interface drivers, and for the inner segments of iterative loops that are particularly costly in time. The compiler is designed to work only with PC/FORTH version 2.0, the FORTH-83 model.

The native code compiler works by replacing the colon defining word at the beginning of a selected word with the special defining word COMPILE: and then loading the compiler and the application program. The two main options in the compiler enable you to either generate a development system in which the compiler is permanently present or compile selected words in application programs. There is optional support for both byte and word arrays, which must be defined prior to loading the compiler. Another special defining word, INTR:, is included for compiling new intrinsic functions. At first, only COMPILE: is used. Later, as words can be accessed solely from within words already compiled into native code, they can be changed to begin with INTR:, which invokes direct machine-language calls rather than the time-consuming interpreter.

The native code compiler provides an additional resource for FORTH programmers who want to optimize their programs for speed but, for various reasons, do not want to recode sections of their programs with an assembler. There are very definite limits within which the compiler must operate, but its use seems promising for routines in many types of applica-

(continued)

Listing 1: *Source code for the benchmark programs.*

```
Screen # 16
  0 ( Eratosthenes sieve benchmark program )
  1 FORTH DEFINITIONS DECIMAL
  2 8190 CONSTANT SIZE
  3 0 VARIABLE FLAGS  SIZE ALLOT
  4 : DO-PRIME      FLAGS SIZE 1 FILL
  5                 0 SIZE 0
  6                 DO  FLAGS I + C@
  7                     IF     I DUP + 3 + DUP I +
  8                            BEGIN    DUP SIZE<
  9                            WHILE    0 OVER FLAGS + C! OVER +
 10                            REPEAT   DROP DROP 1+
 11                            THEN
 12                 LOOP
 13         .  ." Primes " ;
 14  : 10-TIMES 0 0 !TIME CR 10 0 DO  DO-PRIME  LOOP   .T CR ;
 15

Screen # 31
  0 ( IMPROVED ERATOSTHENES SIEVE by Don Colburn              01/01/80 )
  1
  2  : DO-PRIME.HI  ( faster algorithm in high-level FORTH             )
  3         FLAGS  SIZE     01      FILL
  4         0       ( prime counter )        SIZE        0       ( range)
  5         DO     I     FLAGS    +             C@         ( prime ? )
  6           IF    3    I    +    I    +    DUP    I    +    SIZE <
  7             IF    SIZE   FLAGS    +    OVER    I    +    FLAGS    +
  8               DO   O    I    C!   DUP    +LOOP
  9                                              ( flick down modulo I flags )
 10             THEN                DROP    1+   ( bump prime counter  )
 11           THEN
 12         LOOP      .           ." Primes "  ;
 13
 14  ; 10-TIMES 0 0 !TIME CR    10 0 DO-PRIME.HI  LOOP .T CR  ;
 15
ok

Screen # 41
  0 ( SIEVE BENCHMARK W. ARRAYS                            01/01/80 )
  1
  2  : CARRAY CREATE ALLOT DOES> + ;
  3  8190 CONSTANT SIZE    SIZE CARRAY FLAGS
  4  : DO-PRIME    0   FLAGS   SIZE   1 FILL
  5         0 SIZE 0
  6         DO I FLAGS C@
  7                IF I 2*   3   +   DUP I +
  8                     BEGIN  DUP  SIZE<
  9                     WHILE  DUP  FLAGS 0 SWAP C! OVER + REPEAT
 10                     DROP DROP 1+
 11                THEN
 12         LOOP
 13      .
 14  ;
 15  : 10-TIMES 0 0 !TIME CR 10 0 DO  DO-PRIME  LOOP   .T CR ;
```

(continued

tions. Code produced by it runs extremely fast, as a glance at the benchmarks will show (see table 1). Once the FORTH routine has been compiled, the entire image of the FORTH system can be saved to disk as an executable COM file. This environment is kept from becoming excessively large by a routine that enables the system to forget the compiler vocabulary after the application has been loaded and compiled without disturbing the resulting high-speed code. This compiler is an important step in

(continued)

```
Screen # 39
  0 ( SIEVE BENCHMARK —MAX SPEED  :  NO ARRAYS        01/01/80 )
  1  8190 CONSTANT SIZE    0 VARIABLE FLAGS  SIZE ALLOT
  2
  3  : DO-PRIME    FLAGS    SIZE  1  FILL
  4                  0  0
  5                  BEGIN DUP FLAGS + C@
  6                    IF DUP 2*  3  +  2DUP  +
  7                           BEGIN  DUP  SIZE<
  8                           WHILE  DUP  FLAGS + 0 SWAP C! OVER + REPEAT
  9                           DROP DROP SWAP 1+ SWAP
 10                    THEN
 11           1+ DUP SIZE = UNTIL  DROP
 12       .
 13  ;
 14
 15  : 10-TIMES 0 0 !TIME CR 10 0 DO  DO-PRIME  LOOP   .T CR ;

Screen # 40
  0 ( SIEVE BENCHMARK MAX SPEED    W. ARRAYS                01/01/80 )
  1
  2  : CARRAY CREATE ALLOT DOES> + ;
  3  8190 CONSTANT SIZE    SIZE CARRAY FLAGS
  4  : DO-PRIME    0    FLAGS    SIZE   1  FILL
  5         0  0
  6         BEGIN DUP FLAGS C@
  7                  IF DUP 2*   3   +    2DUP +
  8                          BEGIN  DUP  SIZE<
  9                          WHILE  DUP  FLAGS 0 SWAP C! OVER + REPEAT
 10                          DROP DROP SWAP 1+ SWAP
 11                  THEN
 12         1+  DUP  SIZE  =  UNTIL DROP
 13       .
 14  ;
 15  : 10-TIMES 0 0 !TIME CR 10 0 DO  DO-PRIME  LOOP   .T CR ;
ok

Screen # 79
  0 ( BENCHMARKS FROM FORTH DIMENSIONS III/1, PAGE 11-   INTERPRET )
  1 HEX
  2 : LOOPTEST 0 0 !TIME  7FFF 0 DO LOOP .T CR ;
  3 :  -TEST 0 0 !TIME 7FFF 0 DO I DUP  -  DROP LOOP .T CR ;
  4 : *TEST 0 0 !TIME 7FFF 0 DO I DUP  *  DROP LOOP .T CR ;
  5 : /TEST 0 0 !TIME 7FFF 1 DO 7FFF I / DROP LOOP .T CR ;
  6  ( DIVIDE BY ZERO CAUSES INTERRUPT IN NCC )
  7 : MOVETEST 0 0 !TIME 7FFF 0 DO 2 @ 2 ! LOOP .T CR ;
  8 : COMPTEST 0 0 !TIME 7FFF 0 DO I 4000 < IF  ELSE  THEN  LOOP .T ;
  9  : TIMES   0 0 !TIME '  SWAP 0 DO DUP EXECUTE
 10            LOOP  DROP .T CR ;
 11 DECIMAL  ;S
 12
 13 ( EXAMPLE: TYPE " 10 TIMES /TEST "  TO EXECUTE /TEST TEN TIMES )
 14
 15
ok
```

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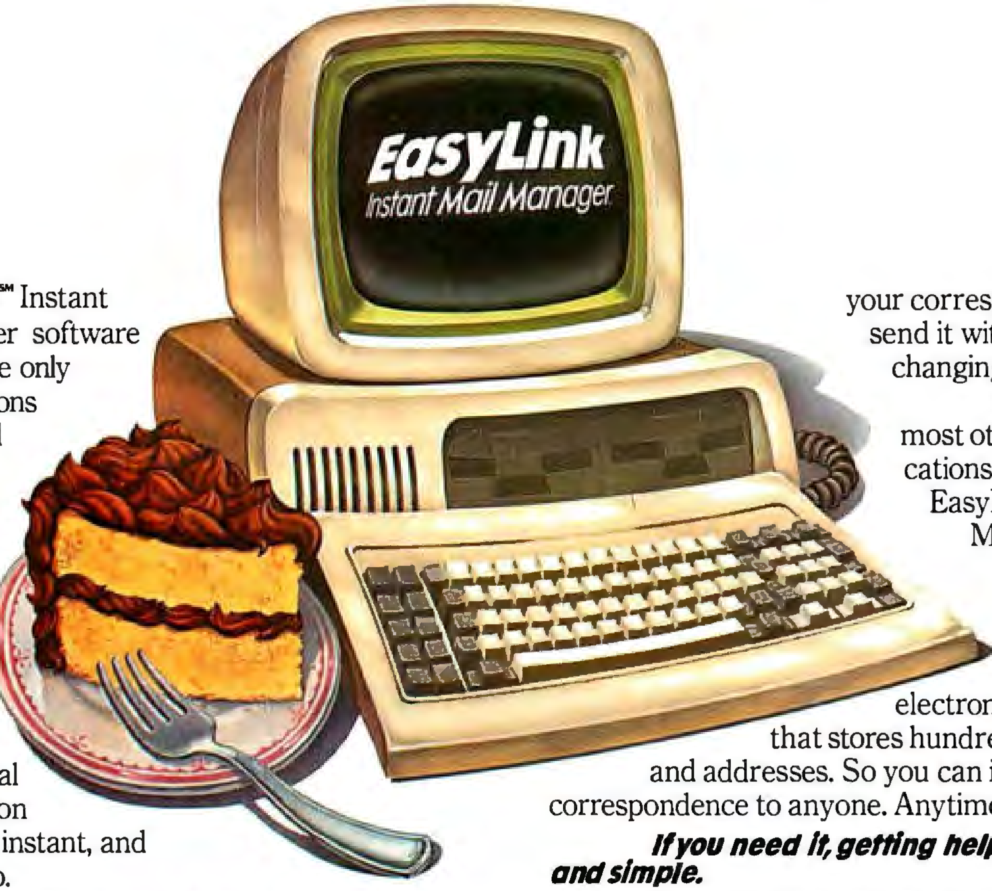

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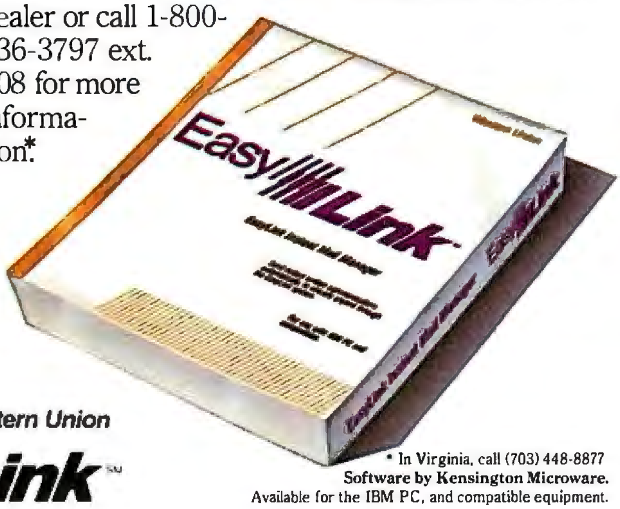

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Both polyFORTH and PC/FORTH are current and complete FORTH implementations.

the right direction for providing the FORTH language with the inherent speed and power that is normally associated with compiled languages. Also available for PC/FORTH is the Nautilus Cross Compiler, which costs $300 and can produce code for Z80s, 68000s, LSI-11s, and many other chips.

THE BENCHMARKS

I have run some benchmark tests that can provide a basis for comparison of the various FORTH implementations. polyFORTH II Level 3, a stable implementation of the FORTH Inc. system, is one entry in the tests. PC/FORTH, on the other hand, has changed a number of times. Accordingly, I have run the benchmarks in various implementations of that system: the FORTH-83 version, the current PC/FORTH+, and the results when the native code compiler is used.

The benchmarks I chose for execution time were adapted from the standard ones appearing in recent tests and from their variations. There have been attempts to rewrite the Sieve of Eratosthenes algorithm, which appeared in the September 1981 BYTE, for optimization in FORTH. Accordingly, I have selected five versions of this algorithm, including one optimized by Don Colburn for the 68000 (see Don Colburn's article in the September 1983 *Dr. Dobb's Journal*) and other versions, with and without arrays and certain optimization approaches. I've also used a set of tests that originally appeared in *FORTH Dimensions* (see issue III/1, page 11). Finally, I've used a test suggested by Bill Midge for measuring compile time by forcing the FORTH interpreter to search its entire dictionary repeatedly for a whole screen of numbers and then print the elapsed time. The source code for each of these benchmarks is included in listing 1.

In all honesty, I have to caution you against assigning too much importance to the benchmarks. FORTH by its very nature lends itself to customizing. The standard way of adding in-line assembly-language routines in the middle of higher-level code routines means that the various implementations of FORTH feature different choices of even standard FORTH words that have been implemented in code definitions.

One thing these benchmarks show clearly is how programs that are optimized for one system may run particularly slowly on other implementations for the same microprocessor. FORTH provides many ways for getting the job done. Finding the fastest way to implement routines in a given system is an ongoing process, and there doesn't appear to be any end to the opportunities for creatively improving the efficiency of FORTH programs.

SUMMARY

Although the two implementations of FORTH for the IBM PC evaluated here are extremely different in their overall features, it was not an extraordinarily complicated matter to take benchmarks, some of them written for other processors, and get them running on both systems. In spite of their many differences, both are current and complete implementations of FORTH.

polyFORTH is particularly well suited for stand-alone applications, especially in scientific and research and development categories. The multiuser and database-handling capabilities make it suitable also for dedicated business applications in which program size is an important

(continued)


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issue. Finally, the superb graphics functions open up many other possibilities, including multiuser computer-aided design and computer-aided drafting systems.

PC/FORTH, with its ability to produce programs that run under either MS-DOS or CP/M-86, its advanced turtle graphics, its low price, its support of many interface devices and user-friendly practices, and its speedy native code compiler, can be considered a major option for developing virtually any type of microcomputer application on the IBM PC and its compatibles. With the trend toward multiple program shells and integrated software, PC/ FORTH can be essential for a development environment that produces relocatable code configured to run under a major operating system. This interpreter is also relatively easy to handle for programmers new to FORTH.

Features of FORTH make it especially suited for an adaptable microcomputer system such as the IBM PC, and the products reviewed here are two of the powerful systems available for it. Clearly there are outstanding resources available for FORTH that can suit a variety of programming requirements, whether the IBM PC is the target system or is to be used as a host to develop programs for other target applications. ■

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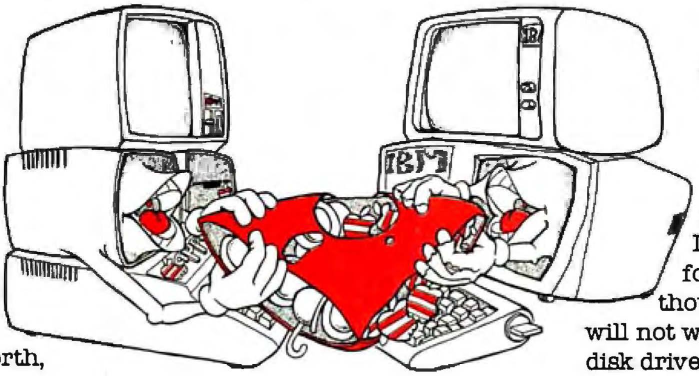

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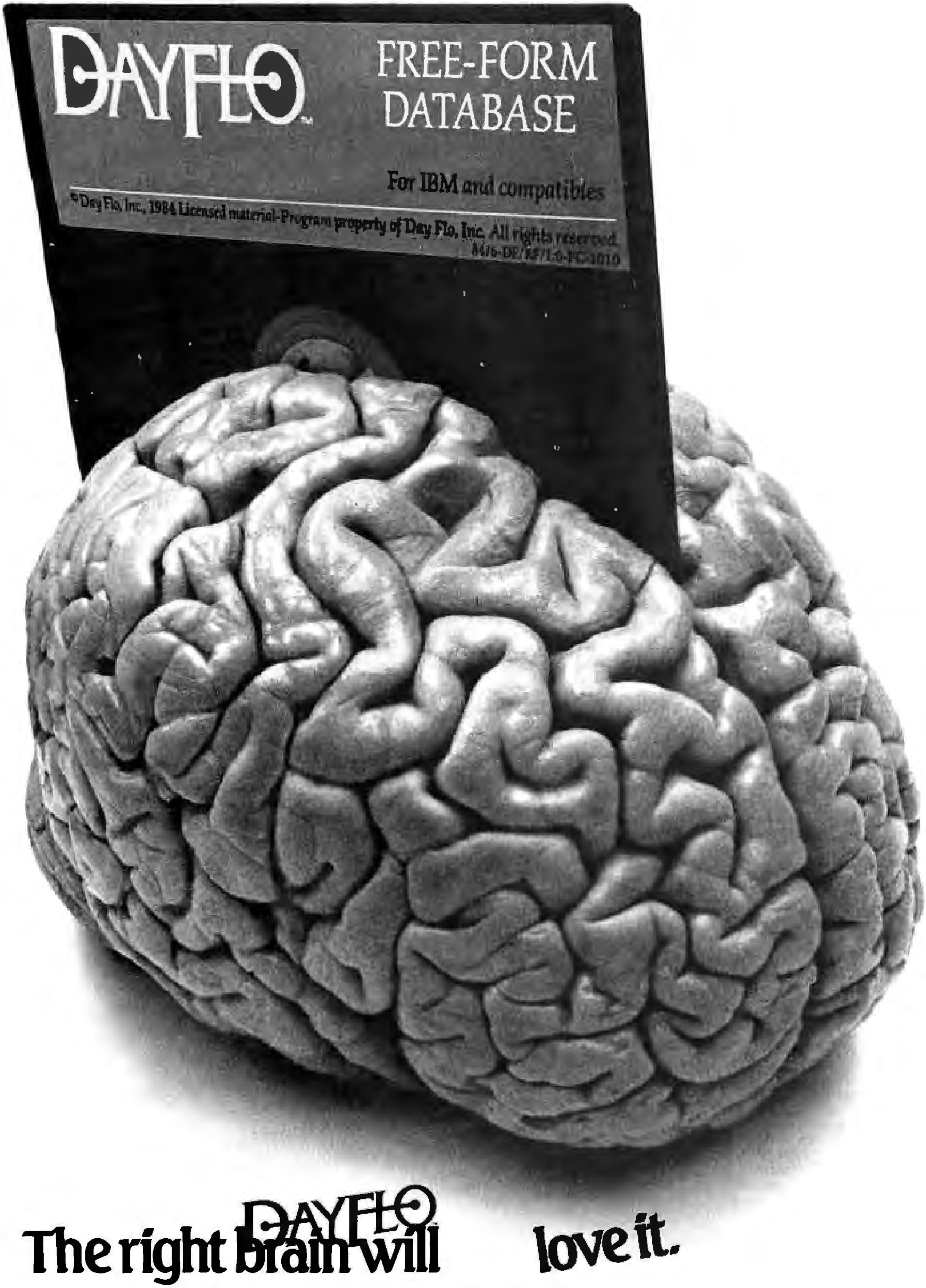

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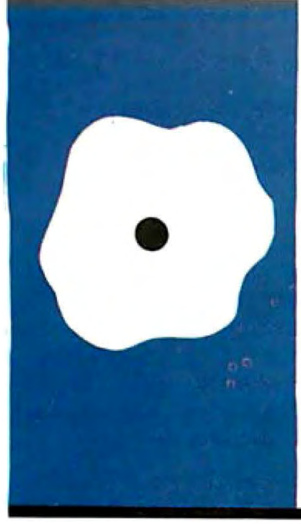
SOFTWARE REVIEW



Samna Word III

Taking on the dedicated word processors

BY RUBIN RABINOVITZ

A few years ago, word-processing programs were designed to run on personal computers with a maximum machine memory of 64K bytes. A lot could be packed into such programs, but they were no match for dedicated word processors. Recently, however, users began buying machines with more memory, and programs requiring 128K bytes of memory—like Microsoft Word and Volkswriter Deluxe—have become popular.

Samna Word III is part of the next wave: programs that have doubled the memory requirement once again. Samna Word II, released in the fall of 1983, needed 256K bytes for the DOS 2.0 version of the program. Samna Word III was introduced last April; it also runs on 256K bytes, but it's a tight squeeze, and the program will take advantage of extra machine memory up to 320K bytes. Samna Word III comes with five double-sided, double-density disks. Two disks, booted sequentially, hold the operating program. The third disk is used to customize the program for a specific printer. The fourth disk contains the training program, and the fifth, the dictionary.

Samna Word III is a large program. But is larger necessarily better? People who have worked with dedicated word processors will find that many of Samna's features are comparable or superior to dedicated processors. But the program does have limitations, as we shall see.

CURSOR CONTROL

Many features of Samna Word III resemble those of dedicated word processors; this is especially evident in its keyboard assignments. People familiar with Wang and other popular word processors will recognize the cross-shaped configuration of the main cursor-control keys. At the center of the cross is a Go To key, surrounded by the cursor-direction keys. This configuration places the cursor keys in logical positions, and it is easily adapted to the IBM Personal Computer (PC) keyboard, which has arrows on the cursor-direction keys. Manufacturers like Wang and Digital Equipment Corporation (DEC) limit the cursor pad to the five keys just described. But on some dedicated word processors (the Phillips Micom, for example), cursor quantity keys (such as Word, Sentence, Paragraph) are added to the five central keys. The Samna configuration is something like Micom's, although Samna has added one more cursor quantity key, the File key (see figure 1).

Mylar labels redefining the keys are included with the program. The new key names fit on the keys in such a way that the original key names aren't obscured. This is useful when you want to use the computer for other programs. Samna provides a chart of the keyboard for people who dislike labels; it's possible to learn the program using only the chart.

Samna's key assignments make for very efficient cursor control. With one keystroke the cursor can be advanced by a word, sentence, line, paragraph, or page. By itself the Page key scrolls through the pages of a file; in combination with the Go To key, Page takes you directly to a specified page without scrolling. The File key similarly moves the cursor to the end of a file without scrolling through intermediary pages. Using the Shift key in combination with the cursor-control keys reverses these movements: Shift plus Word moves the cursor to the previous word, Shift plus File moves the cursor to the beginning of a file, and so forth.

FUNCTION KEYS

Many word-processing programs assign an equal number of tasks to each of the IBM PC's function keys (F1 through F10). Samna's approach is different (see photo 1). While eight of the function keys have only one function, two of them have many functions. The Scroll Lock key is also assigned numerous functions.

I first found this arrangement strange. But, as I eventually understood, there are some

(continued)

Rubin Rabinovitz (Department of English, Campus Box 226, University of Colorado, Boulder, CO 80309) is a professor of English. He received his Ph.D. at Columbia University. He has reviewed books for journals and magazines, including the New York Times Book Review *and* New York *magazine.*

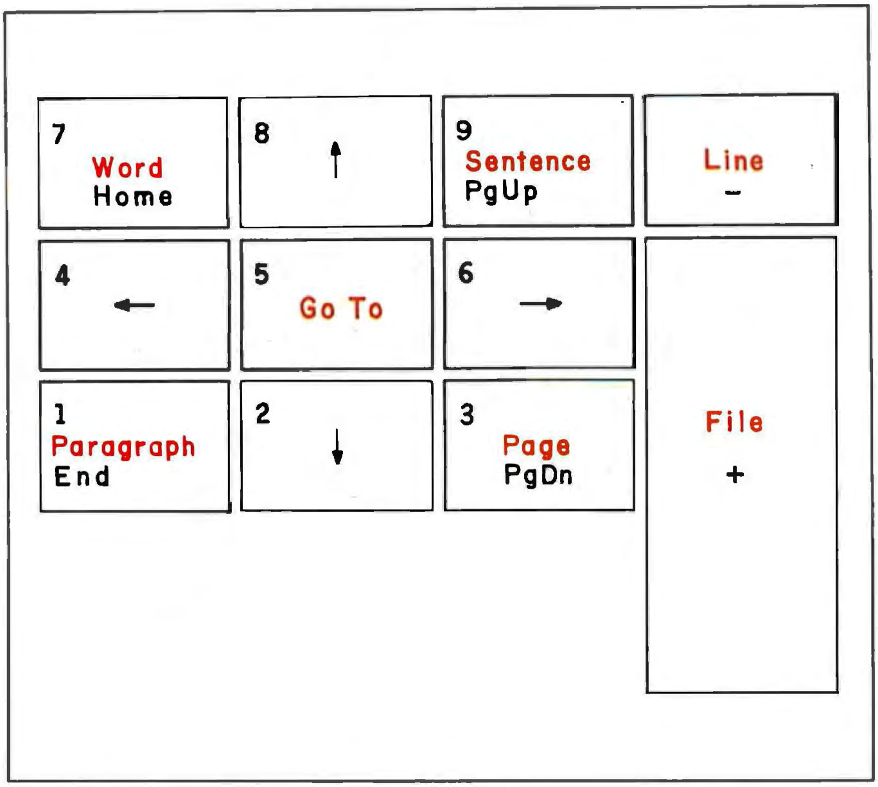


Figure 1: *The IBM Personal Computer's cursor-control keys, as defined by Samna Word III. Mylar labels with Samna's definitions (shown in color) fit on the keys without hiding the original definitions.*

```
BOLD WHAT?
                                   Col  1 Ln  1 Pg  1 File do

If you press any of the function keys as
defined by Samna Word III, the program will
ask you which text you wish to manipulate.

If you forget how to use a function, press
the function key and HELP; the program will
provide a list of available options.

Two of the function keys, DO and SELECT,
initiate a number of functions. If you
press one of these keys and HELP, the
program will list the available functions.

This diagram of Samna Word III's function
key assignments was produced using the
CONTROL key and cursor arrow keys.
```

Photo 1: *The IBM PC function keys as redefined by Samna Word III.*

good reasons for it. The keys with only one function don't have to be memorized since their labels make it clear what tasks they perform. The keys with multiple functions are used to initiate commands that—because they are both mnemonic and redundant—are easy to remember. For example, F9, defined by Samna as the Do key, appears at the beginning of a number of repetitive command sequences. Similarly, F5, defined as Select, initiates a number of functions. If you forget a command sequence, pressing the appropriate function key and then Help (the Escape key) displays a list of the functions initiated by that key. In addition, Samna provides labels listing the commands that use the multiple-function keys; these labels can be attached to the margins of the keyboard. This makes it easier to learn the keyboard than when every function key has a few diverse functions.

Just as the Shift key is used to reverse the motion of the cursor, in combination with the function keys it becomes an Undo key. For example, to remove boldface text, you press Shift and Bold; to restore a deleted item, you press Shift and Delete. Here again the combination of redundant command sequences and labeled keys facilitates learning the program.

Many of the other command sequences are equally logical: Delete plus any of the cursor quantity keys (Word, Sentence, Line, etc.) removes the amount of text specified. The commands for copying and moving use the cursor quantity keys to define the amount of text to be adjusted. This consistency makes it easy to use the program; even when I forgot commands I usually was able to guess.

Other nice touches include two that compensate for weaknesses of the IBM PC keyboard. When you are typing uppercase letters on the IBM, the proximity of Alt and Ctrl to the Shift key often leads to errors. In some programs (WordStar, for example) these errors can take some time to correct. In Samna Word III, striking Alt or Ctrl in combination with an alphabetic key never leads to disasters. Samna also makes up for the IBM PC's lack of LED (light-emitting diode) indicators on the locking keys by displaying the messages NUM and CAPS in the status line when those two keys are toggled.

LEARNING TO USE SAMNA WORD III

Samna Word III is a big program and can't be learned as quickly as word processors with fewer functions. But the program is not inherently difficult: a given series of operations in Samna Word III is no harder to learn than an equal portion of Easywriter II.

First-time users should have no special problems learning Samna Word III. People who know another word-processing program may initially be impatient with the program because many command sequences have to be relearned; but once the logical structure of the program emerges, things go more quickly. People familiar with dedicated word processors will make the transition to Samna Word III quickly.

Samna Word III has good help screens, and the help levels are adjustable. If you make a mistake, a help screen with a remedy is automatically displayed. The manual is clear and comprehensive. But I don't like the training disk very much—the exercises are at times confusing.

Most operations can be completed by initiating an operation and then pressing Help. This displays the remaining commands in the sequence. A reference card that comes with the program lists the opening commands of every operation. You can learn almost any function by using the reference card in conjunction with the help screens.

MAJOR WORD-PROCESSING FUNCTIONS

Samna Word III uses very few visible control characters (though these can be displayed when you need them). What you see on the screen is close to what the printed page will look like. Samna Word III contains all the word-processing functions I expect in a good program, including automatic

(continued)

AT A GLANCE

Name
Samna Word III

Type
Word-processing package

Manufacturer
Samna Corporation
Suite C-700
2700 Northeast Expressway
Atlanta, GA 30345
(404) 321-5006
(800) 241-2065

Computer System
IBM PC, PC XT, and compatibles with at least 256K memory; also DEC Rainbow and Texas Instruments Professional

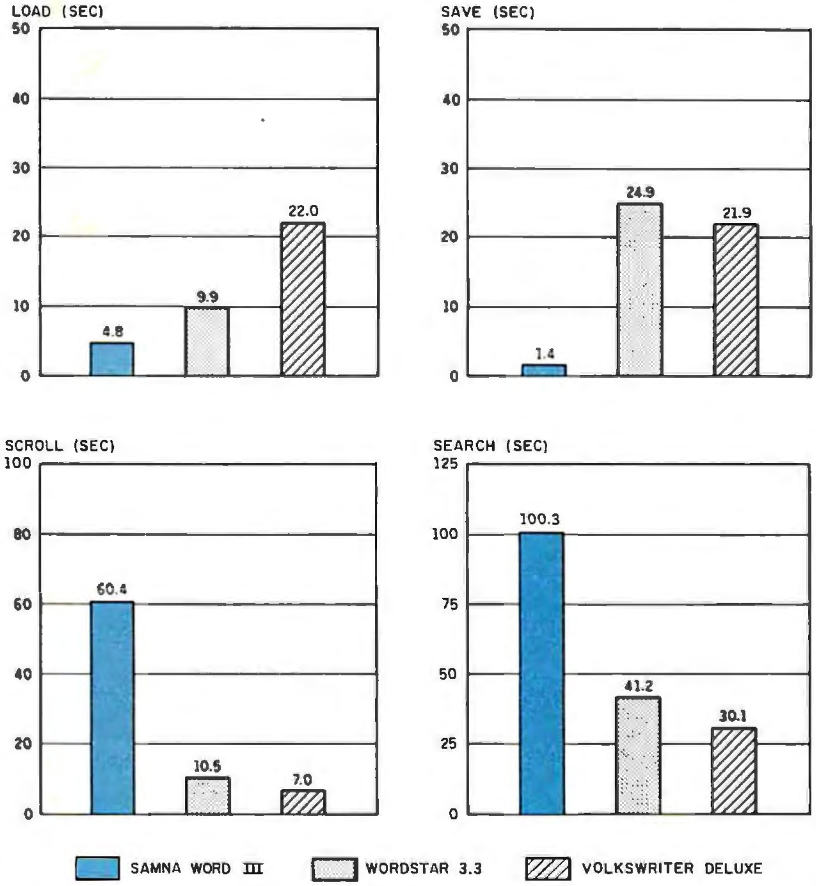
Format
Five 5¼-inch double-sided floppy disks (two for operating system, one each for dictionary, printer, and training program)

Software Required
PC-DOS, MS-DOS, or similar

Documentation
400-page indexed manual, training disk, command and keyboard chart, key labels

Price
$550

Audience
People who do a good deal of writing



A comparison of Samna Word III with WordStar 3.3 and Volkswriter Deluxe. The graphs show the results of performing various standard word-processing functions using a 4000-word text file. The Load graph shows the time required to load the file from disk to memory. The Save graph shows the time required to save the file on disk. The Scroll graph illustrates the time required to scroll manually from the file's first line to its last line. The Search graph shows the timing results for a search starting at the beginning of the file and looking for its last word.

word wrap, global search and replace, and right-margin justification. But even the common word-processing functions go beyond the usual: many have convenience features that enable various modes of operation. Underlining, for example, can be done in numerous ways: during or after typing text; with solid, broken, or double underlining; or with the shifted hyphen key, as on a typewriter. Similar options are available for printing in boldface, converting text to capital letters, and centering text. On a color-equipped system, you can specify different colors for different types of text (see photo 2).

```
READY!
                                        Col  1 Ln  1 Pg  1 File samples3

    With a color/graphics adapter and color monitor, Samna Word III allows you
to change the default values and assign up to eight different colors to
different types of text:

               regular

               underlined

               superscripts, as in ....................footnotes1

               subscripts, as in chemical equations...H20

               underlined superscripts.................footnotes1

               underlined subscripts...................H20

    While underlines, superscripts and subscripts will not appear on the color
screen, using different colors allows you to distinguish them before printing
the text.
```

Photo 2: *With a color graphics adapter and a color monitor, Samna Word III can mark underlined, superscript, and subscript text in different colors.*

```
READY!
                                        Col 44 Ln  3 Pg  1 File sample2
Samna Word III allows you to work in two windows and to move from
one window...

...to another, with two keystrokes. The two
windows may have different margins, which may
be visible or invisible._
```

Photo 3: *Samna Word III's split-screen capability.*

ADVANCED FEATURES

What makes Samna Word III superior to many competitive programs is its unusual number of advanced features. Some of these, like mail-merge or dictionary programs, are often sold as extras; but they're part of Samna Word III. The following are some important advanced features.

Windows: Samna's windows divide the screen horizontally (see photo 3). With two keystrokes you can move from one window to the other. It's easy to display a new file or another portion of the same file in the window, and to copy or move text from one window into the other.

Automatic Update: This is one of Samna's best features. As you revise or enter text, the new material is automatically recorded on the data disk. It takes little time to save a document, since most of it is written on the disk as you type. More important, it's almost impossible to lose material inadvertently. Even with a power failure you never lose more than about three lines, and since they're the last ones you typed, you can usually reconstruct them.

Automatic Merge: Samna's automatic merge works well but is difficult to learn; the instructions are confusing. As with other merge programs, you create a standard (or "boilerplate") letter and a mailing list. Then the two are merged: a copy of the standard letter, addressed to each person on the mailing list, is generated automatically.

Foreign-Language Keyboards: Many programs can generate foreign characters, usually by using special key sequences. In Volkswriter, for example, you press Alt and an alphabetic key. In Samna Word III, you can reprogram the keyboard so that it emulates a foreign keyboard. When you press the

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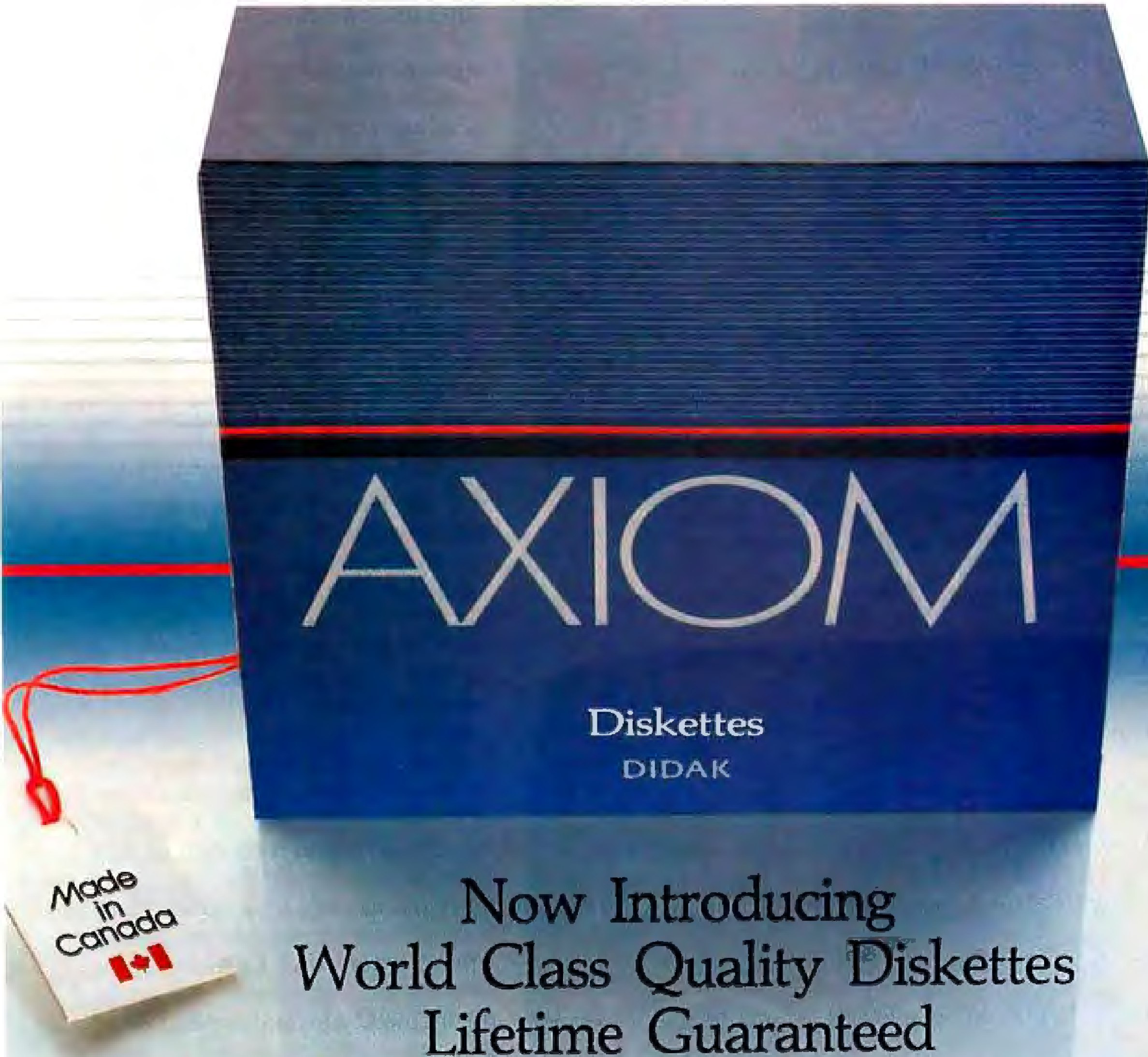

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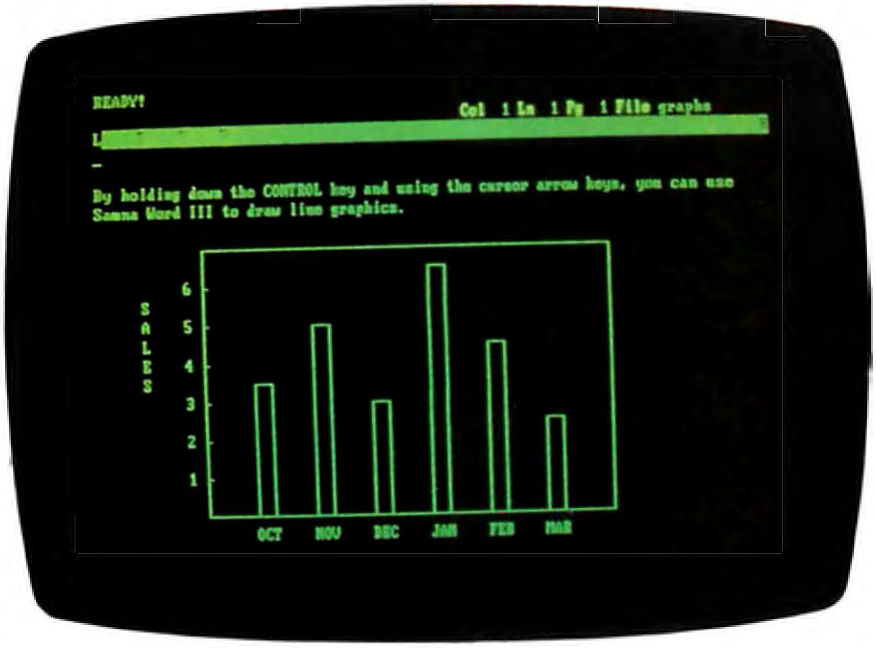
™Registered trademark of Didak Manufacturing Limited key for a particular character in the new configuration, the corresponding character appears on the screen and the same character is printed, so long as you use the proper print wheel. Samna Word III includes the following keyboard configurations: English (American and British versions), French, Canadian, Spanish, Math/Greek, German, Italian, Swiss/French, and one with alternate symbols, including many of the IBM Personal Computer's special characters that don't appear in the other configurations.



READY!   Col 1 Ln 1 Pg 1 File graphs

By holding down the CONTROL key and using the cursor arrow keys, you can use Samna Word III to draw line graphics.

Photo 4: A *bar chart drawn with* Samna Word III, *using the* Control *and cursor-arrow keys.*

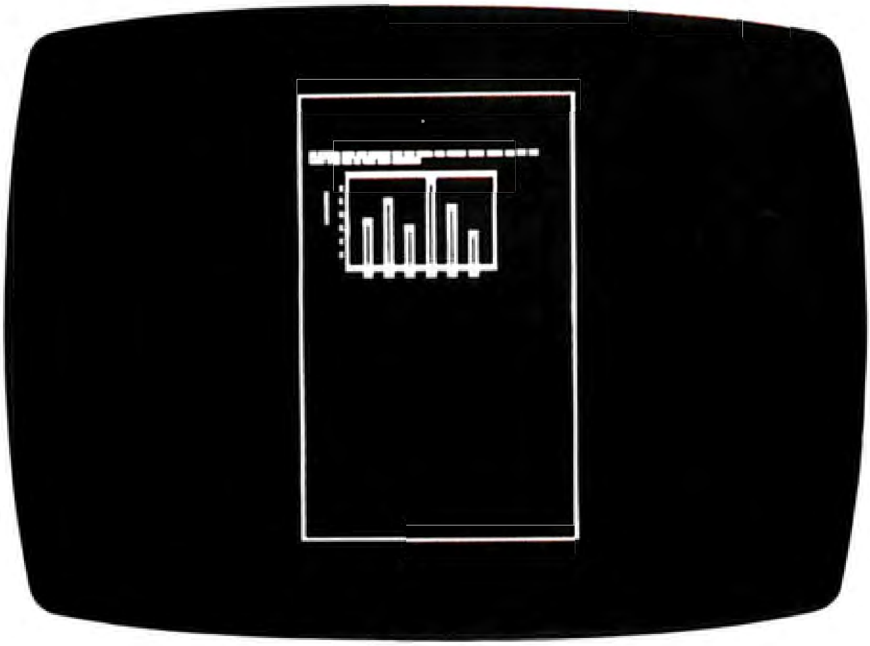


Photo 5: *Samna's* Zoom *function lets you see the layout of the material on the screen as it will appear on the printed page.*

Dictionary: Samna uses the *Merriam-Webster Dictionary* for its spelling checker. When the dictionary does not recognize a word, it flashes alternatives in the status line. You can then substitute one of the suggested alternatives, revise the misspelled word without retyping it, or add the word to the dictionary. The spelling checker is slower than some rival programs, such as Spellix. The dictionary disk provides automatic hyphenation at syllable breaks. The disk isn't copy-protected, so you can customize your own dictionary by adding new words to it.

Math Mode: In math mode you can perform five operations: addition, subtraction, multiplication, division, and calculation of percentages. Two memory registers and a total register retain the results of the calculations; you can then transfer these from the registers into the text without retyping. You can add a row of numbers across a line and columns of numbers. But it isn't possible in this mode to work on the text of a document; to do that, you have to exit to normal operating mode.

Recording of Keystrokes: This is a macro-type operation: a series of keystrokes is recorded and played back later. Both alphanumeric and command keystrokes can be recorded. To play them back, you press the Control key and a number key. It's a feature that's invaluable for repetitious jobs, such as writing letters that have the same heading and signature. You could record the keystrokes for the close of one letter, the commands for a page break, and the heading of the next letter. Samna lets you record 10 different operations using up to 500 keystrokes—an average of 50 keystrokes per operation.

Glossary: Glossaries are lists of phrases or sentences that are often repeated; with a few keystrokes you can insert these passages into the

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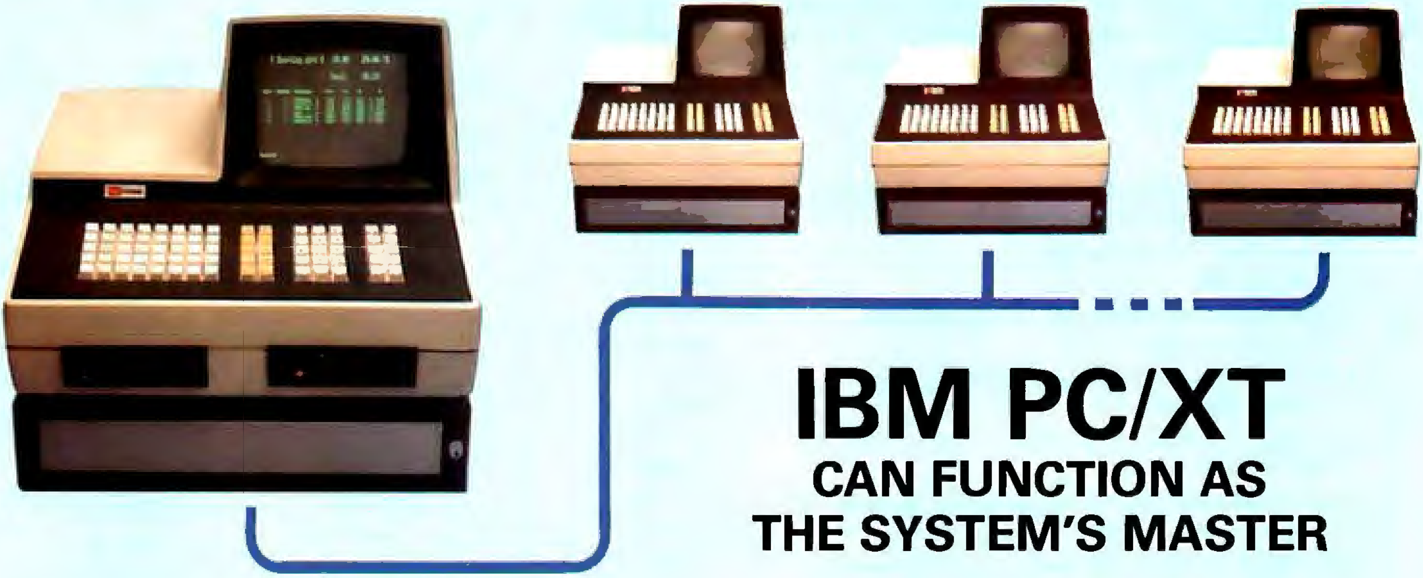

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Table 1: *Benchmark tests using Samna Word III on the IBM PC with 256K bytes and a monochrome-monitor adapter and a document of 40 paragraphs of 100 words (a total of 4000 words). Results are the average of three trials. Note that Samna Word III formats slowly (tests 6,7, and 8); however, because the program automatically saves material as it is written to the screen, Document Save time is good.*

Test	Minutes:Seconds
Document Load: time to retrieve standard document from disk and display it on the screen	0:04.82
Document Save: time to save the standard document on the data disk	0:01.42
Search: time to find the last word (the 4000th) of the standard document	1:40.26
Scroll: time to scroll from the beginning to the end of the standard document	1:00.40
End of File: time to go to the end of the file by pushing the File key	0:12.09
Delete: time to delete the first five words of a 100-word paragraph and reformat	0:04.25
Insert: time to restore the five deleted words and reformat	0:05.26
Format Changes: time to reformat the standard document from single to double space; margins from 10–75 to 15–70; top and bottom margins from 1 inch to 1.5 inches; pitch from 10 to 12	6:53.60
Print File: time from last command to print a file to start of printing	0:28.24
Print Page: time from last command to print a page to start of printing	0:04.43

Table 2: *Comparative speeds of some Samna Word III functions on the IBM PC and compatible computers. Times, in seconds and hundredths of seconds, are the averaged results of three tests: the time it took to scroll to the end of a 1000-word document, to use the Go To function to find the last word in a document, and to find the same word using the Search function. "Repaints" means the screen flickers (is being erased and reconfigured during scrolling), an undesirable characteristic.*

Computer	Scrolling	Go To Word	Search	Repaints
IBM PC with monochrome card	12.40	22.86	23.06	no
IBM PC with color card	33.84	42.79	40.71	yes
Eagle PC Plus	33.40	54.05	50.65	yes
Seequa Chameleon	33.02	43.35	41.51	yes
Zenith Z-150	35.85	45.87	42.53	yes
Sperry PC in normal mode	13.87	23.18	23.18	no
Sperry PC in Turbo mode (microprocessor clock speed about 40 percent faster than in normal mode)	9.57	17.36	17.21	no

You can use Samna to draw charts and simple house plans. No graphics card or dot-matrix printer is necessary.

text. You can use combinations of boilerplate text or insert long book titles in the text with relatively little typing. Unlike some other programs, Samna makes it possible to create and use more than one glossary at a time.

Index Compiling: With this feature you can create an index from any document written with Samna Word III. First, you prepare a list of entries you want included in the index. The program then searches through the text looking for these entries, arranges them alphabetically, and lists page references for them. The index compiler works well, but it's very slow.

Table of Contents: By introducing special marks for chapter headings and subheadings, you can have Samna create a table of contents. Subheadings, when properly marked, are indented to the right of chapter headings.

Outline Generation: If you're creating an outline, you can use special marks for each entry; these marks are used to indent the entry (up to six levels of indentation are possible) and to number it. The program automatically renumbers the entries if you make additions or deletions.

Line Graphics: Samna Word III can draw horizontal and vertical lines, useful for organizational charts, bar charts, and even simple house plans (see photo 4). You don't need a graphics card or a dot-matrix printer to take advantage of this feature; all you need is a daisy wheel that can print vertical and horizontal lines.

Samna's other features include a Zoom function (see photo 5) that lets you view a reduced image of an en-

(continued)

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KEITHLEY das

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Samna Word III's main problem is a lack of speed.

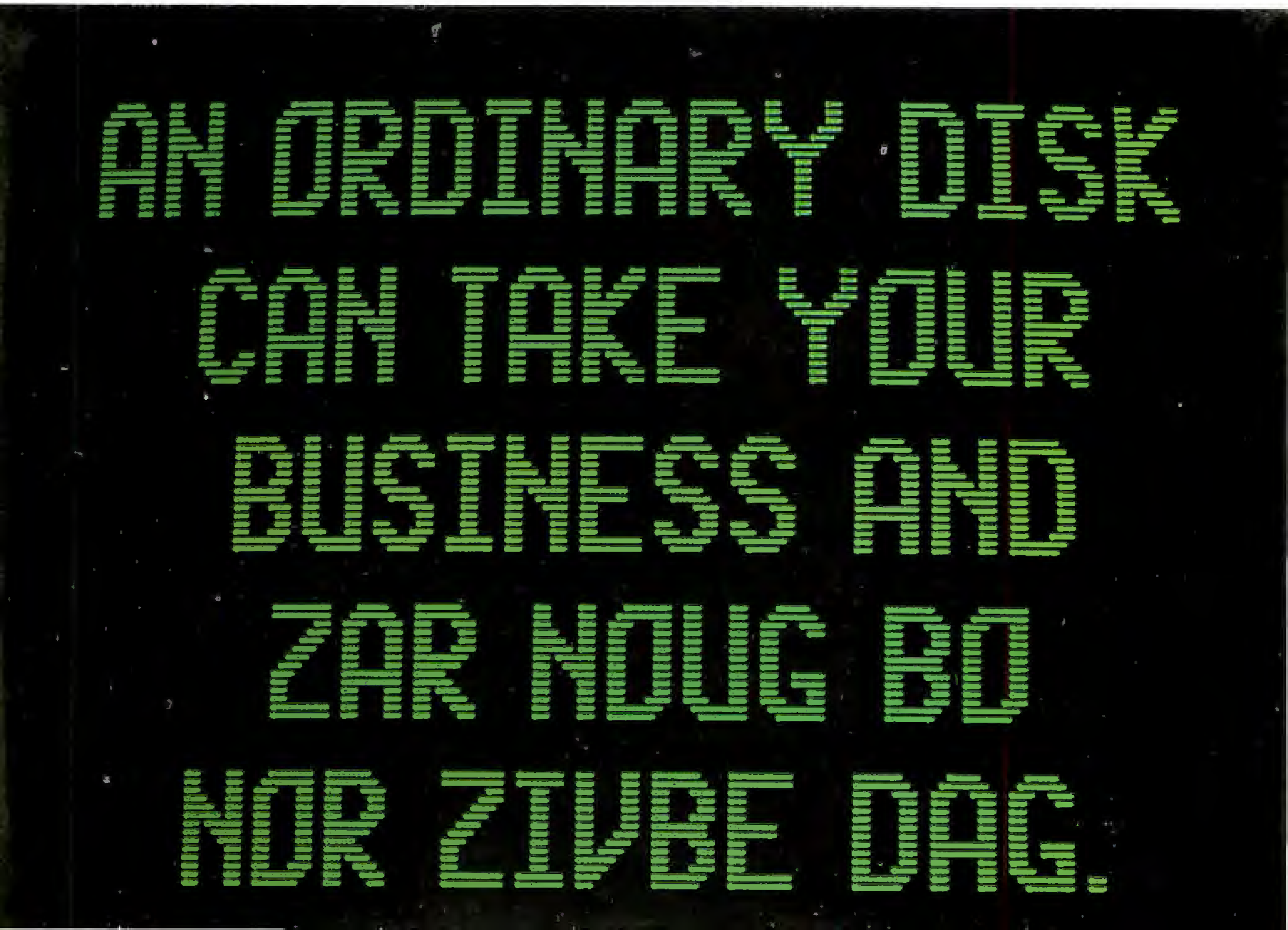
tire page on the screen (this requires a color graphics card); wild-card characters that can be used for file functions; a typewriter mode that permits you to type directly on the printer; automatic backup; support for 26 printers; the ability to create very wide pages and then to fold them on screen so you can compare various columns on a spreadsheet; and "control tabs" that let you mark and return to a specified place in a file.

WEAKNESSES

Samna Word III's main problem is lack of speed. Reformatting a 4000-word file takes almost 7 minutes (see table 1). Deleting and inserting material can be time-consuming with long paragraphs: you have to wait for the automatic reformatting to end before you can resume editing.

Like most word processors for the IBM PC, Samna Word III is even slower when you run it on a system with a color graphics adapter. As shown in table 2, the program runs between two and three times slower on an IBM PC with a color graphics adapter (or similarly equipped PC-compatibles) than on an IBM PC with monochrome adapter. In addition, the displays of the color systems are continually repainted during scrolling; the repainting produces an annoying flicker that makes the moving text almost illegible. A friend with a Zenith Z-150 had this problem until he added an IBM monochrome adapter and suitable monitor; the speed doubled and the repainting disappeared. The flicker problem is caused by the way IBM designed its color graphics adapter board. The monochrome monitor/adapter does not flicker during scrolling. Unfortunately, if you have to buy a monochrome adapter and monitor to fix the speed problem, it will cost you at least $500.

These tests were conducted on systems with two floppy-disk drives; many results would be faster with a hard disk. Samna recently announced it was removing the copy protection from all of its word-processing products, which will enable the programs to be run from a RAM (random-access read/write memory) disk or a hard disk and should speed things up quite a bit. According to Charlotte Hixson, Samna's customer-support manager, the speed problem is a result of the



program being written in C rather than in assembly language (this was done to make the program easier to debug). "As soon as the software is stabilized," says Ms. Hixson, "the screen and line-handler blocks will be written in assembly language and will be much faster."

Samna Word III is sensitive to fluctuations in power-line current, even with a surge protector; the resulting crash usually freezes the screen. But this happens infrequently and sounds worse than it really is: since Samna automatically records text as it is written, you seldom lose more than a few lines, and these can be copied from the frozen screen.

After a lot of editing, the page counter sometimes loses track of the proper page number. The spelling checker doesn't recognize words linked by dashes. The automatic-hyphenation features sometimes miss one or two words that should be hyphenated. File size is not listed in the directory, nor is there any indication of how close you are to filling a disk. However, I've never lost text because of a full disk: you're given a chance to use a new disk or delete material from the one that's full.

USER SUPPORT

Samna Corporation seems to have a positive attitude toward its customers. The people who answer the toll-free information hotline are friendly and helpful; they've provided assistance at no charge after the 30-day support period had expired. Customers who install their programs incorrectly are given new copies.

> *Samna seems to have a positive attitude toward customers. Users who install programs incorrectly are given new copies.*

When version 1.1 of Samna Word II was released, free updates were provided to purchasers of the original program, with no requirement that the old program be shipped back to the company. Owners of Samna Word II can buy Samna Word III updates for the difference in price between the programs. Samna said it is planning to release a new program, Samna+, that will include spreadsheet functions. Owners of Samna Word II and Samna Word III will be able to update

(continued)

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Samna Word III costs more than some programs, but if it can outperform a dedicated word processor, then the price is justified.

their programs for the price difference.

CONCLUSION

Samna Word III is one of the most powerful word-processing programs available for IBM PCs. In recent advertisements, Samna Corporation has claimed that a number of dedicated-word-processor operators who tested the program agreed that Samna Word III was superior to the systems they were using. Samna Word III costs $550, which is more than some other programs, but if it can outperform a dedicated word processor, the price is justified—what you pay for the software you'll save on hardware.

Who should buy Samna Word III? Anyone who spends a good deal of time writing. Samna's main strength is its assortment of automated operations and convenience features; many aren't available in other programs or on dedicated word processors. But this isn't a program for casual users: it doesn't make sense to pay for advanced functions if you'll never use them.

Samna Word III is the best of several word-processing programs I've tested, including WordStar, Easywriter II, Volkswriter, Volkswriter Deluxe, and MultiMate. I use Samna at home on my PC and a Micom word processor at work. I like the speed of the Micom, and this makes me fidgety when Samna takes too long to complete an operation, but Samna Word III's many special features more than compensate for this problem. Like the people in the advertisement, I've been won over. I'd rather work with Samna Word III than with a dedicated word processor. ■

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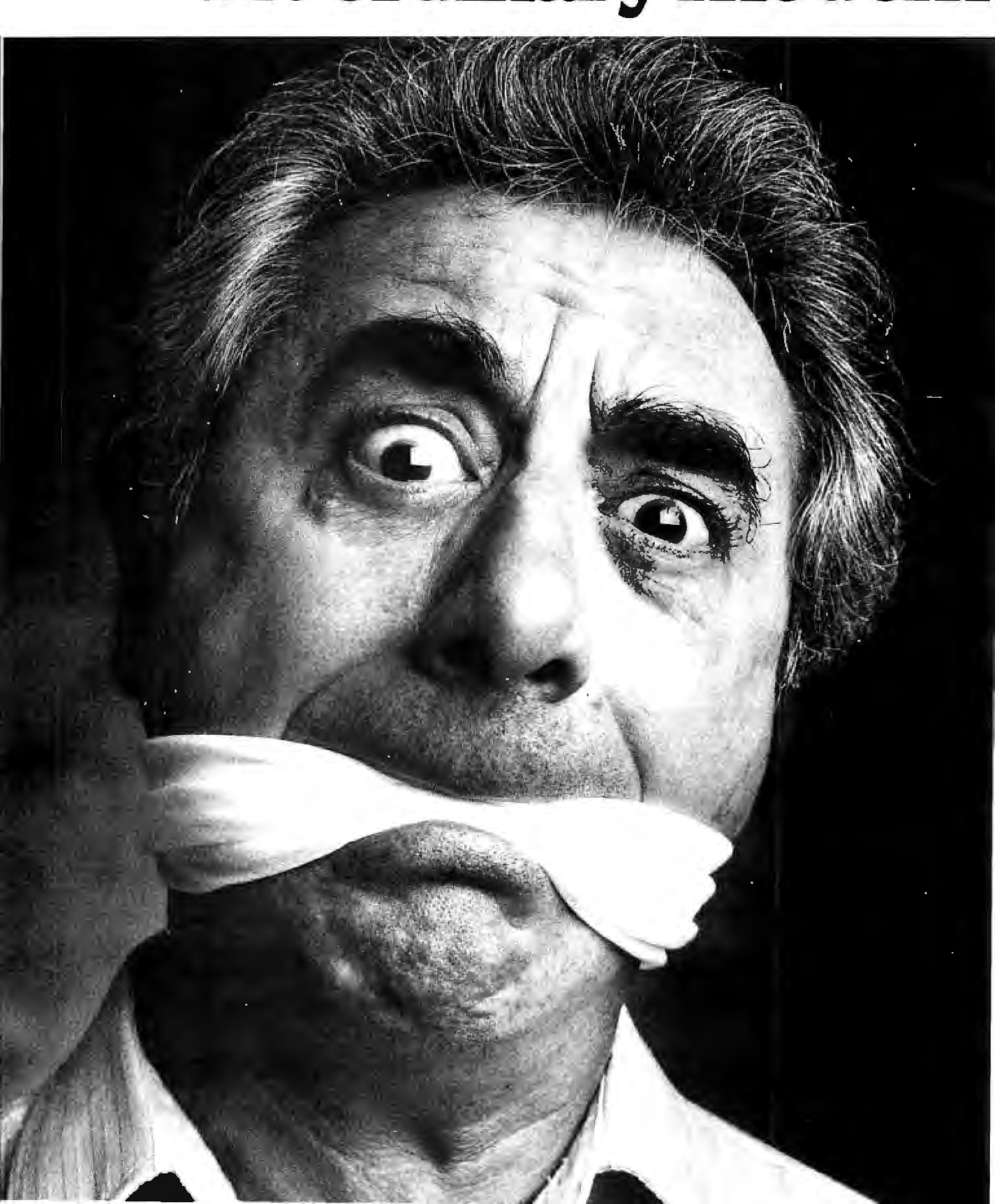

and data simultaneously, leaves a lot to be desired.

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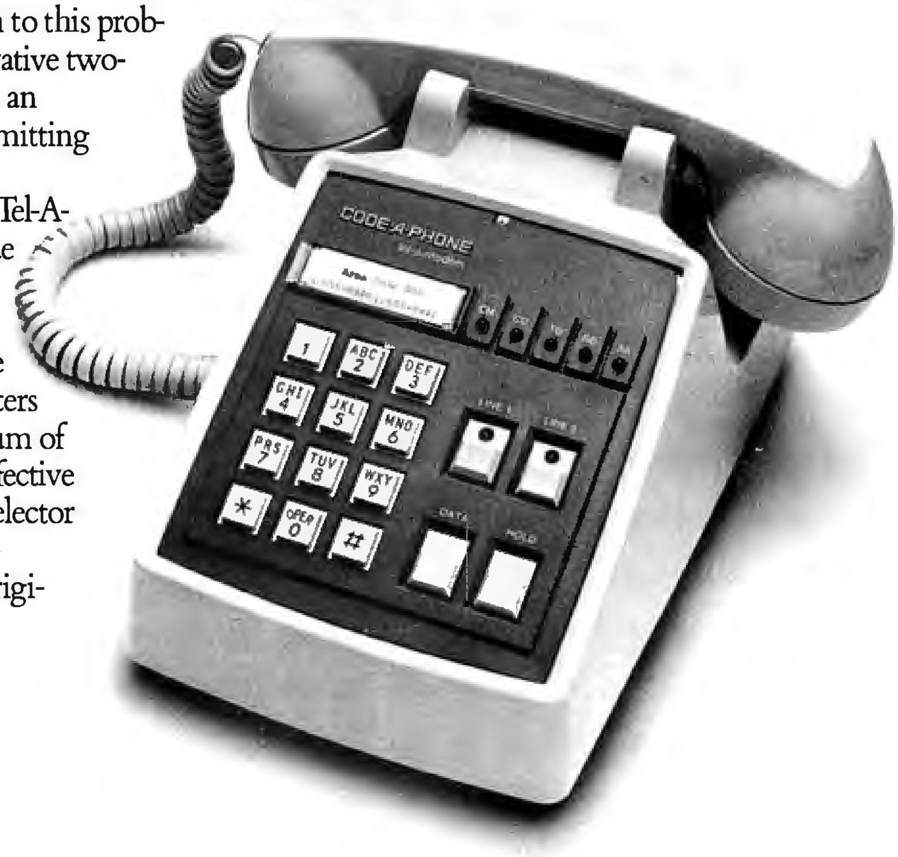

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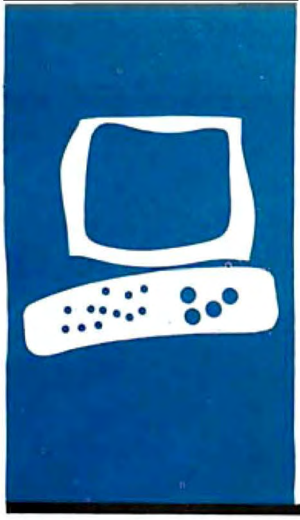


HARDWARE REVIEW

The Mannesmann Tally Spirit 80 Printer

A low-cost dot-matrix printer that's Epson-compatible

BY MARK J. WELCH

Mannesmann Tally's Spirit 80 printer doesn't represent any breakthrough in technology, performance, or price, but it follows the gradual improvement of price and performance that's been occurring over the past few years.

To some extent, the Spirit 80 is a "clone" of the Epson MX-80 or RX-80 in that it uses Epson-type control codes. The Spirit 80 takes up more desk space, but it is more attractive, quieter, slightly faster, and it has a slightly better print quality than the Epson MX-80. A parallel interface is standard; a serial interface is optional.

The Spirit 80's best selling point, however, is its price: though it has a list price of $399, it is advertised by discounters for less than $300. The Epson RX-80 FT—Epson's replacement for the MX-80—is discounted to about $400 (from a list price of $499), making the Mannesmann Tally a better bargain for similar performance.

SPEED

The Spirit 80 compares favorably with the Epson RX-80 in printer benchmarks (see "The Art of Benchmarking Printers" by Sergio Mello-Grand, in the February BYTE, page 193). The RX-80 is slightly faster in some tests but slower in others. It should be noted, however, that the RX-80 is advertised as a 100-character-per-second (cps) printer, while the Spirit 80 is advertised at 80 cps. (Interestingly, the Star Micronics Gemini-10X printer, advertised at 80 cps, beats them both in all but one test.)

PRINT MODES AND SPEED

The Spirit 80 prints 10 characters per inch (cpi) normally, 5 cpi in double-width mode, and 18 cpi in compressed mode, and it supports emphasized (bold), underlined, italicized, superscript, and subscript printing.

The printer's manual doesn't mention some commands supported by the Epson, but the Spirit 80 seems very compatible with the MX-80. Despite some differences, the printer seems to respond to most Epson commands; WordStar text, for example, was printed accurately, and, though the graphics format is slightly different, Lotus 1-2-3 graphs were also printed using Epson control codes.

The Spirit 80 uses squared print hammers, unlike the Epson or the Gemini, which use more rounded "dots." As a result, spaces between the printed pixels are less visible and characters are clearer on the Spirit. Like the Epson MX-80, the Spirit 80 prints each character as a 7 by 9 matrix; uppercase characters use the top 7 by 7, while lowercase descenders drop into the bottom two pixels. The Spirit 80 characters come closer to those of a typewriter, though not close enough to fool anyone.

Graphics are available with a resolution of 50, 67, 100, or 133 dots per inch. However, an image printed using Epson control codes won't look quite the same on the Spirit 80 because the Spirit has a finer horizontal resolution. The same number of horizontal pixels in a Spirit 80 graph are only about three-quarters as wide as on the Epson. A pie chart printed as a circle by the Epson is oval-shaped when printed on the Spirit 80.

Although software could compensate for the difference in horizontal resolution, one major flaw in the Spirit 80 can't be eliminated. Below each graphics line is a small space, probably one pixel high. This results in horizontal white lines through the graph, which detracts from the visual appeal. The Epson doesn't have these spaces.

Like the Epson, Mannesmann Tally's Spirit 80 has just three top panel buttons: on-line, linefeed, and formfeed. To get the test mode, you must hold down the linefeed button while turning the printer on.

PROBLEMS

If you don't like loud, obnoxious fault alarms, you won't like the Spirit 80. When

(continued)

Mark J. Welch is a BYTE staff writer. He can be contacted at POB 372, Hancock, NH 03449.

AT A GLANCE

Name
Spirit 80

Manufacturer
Mannesmann Tally
8301 South 180th St.
Kent, WA 98032
(206) 251-5500

Type
Dot-matrix printer

Size
15½ inches wide, 13 inches deep, 5 inches high; 11 pounds

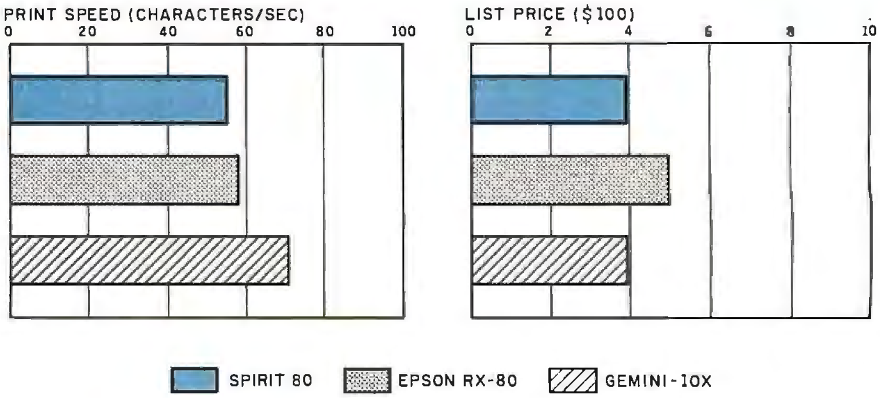
Equipment Needed
Computer with parallel interface; cable; serial printer interface optional

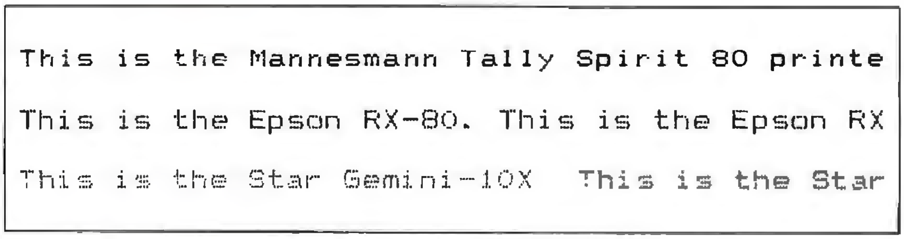
Features
Most control codes are Epson compatible; all common print modes and graphics

Documentation
Operator's manual, 57 pages

List Price
$399

Mannesmann Tally's Spirit 80 printer.





This is the Mannesmann Tally Spirit 80 printe

This is the Epson RX-80. This is the Epson RX

This is the Star Gemini-10X This is the Star

The Spirit 80 printer is compared with the Epson RX-80 and the Gemini-10X (all in draft mode). The pitch for all printers is 10 characters per inch. The print speeds in draft mode were determined by timing how long it took the printers to print 50 lines of 80 *A*s each (see "The Art of Benchmarking Printers" by Sergio Mello-Grand, in the February BYTE, page 193). The prices shown are list prices, including tractor-feed mechanism.

it runs out of paper, it whines until you turn it off or add paper. A few short beeps would be enough. Overall, however, if you hate loud printers, you'll be pleased to know that the Spirit 80 is noticeably quieter than the Epson MX-80 in its normal operation.

Another aspect of this printer I don't like is that the tractor feed pushes the paper, rather than pulling it. The paper jammed several times during page feeds when I first put it in. Though it didn't jam again, the sprockets sounded as if they were tearing into the paper during page feeds and might jam again at any time. However, because the paper exits through a slot on the removable plastic cover, it doesn't jam under the cover, which happens occasionally with the Epson.

With some printers, the paper feeding out can feed right back in again—a situation I never notice until the printer is completely jammed with three layers of paper. You'd have to work at it to get the Spirit 80 to do this.

DOCUMENTATION

The Spirit 80 manual is short, but it contains all the information a programmer or novice will want. It also includes a complete BASIC program to demonstrate each print mode and command. The appendix is compact and carries a great deal of information.

CONCLUSIONS

The Spirit 80 isn't a giant leap forward—but it is a step in the right direction. While it has a few drawbacks, such as the tractor feed that occasionally jams, unwanted white spaces in graphics modes, and an unreasonably loud fault alarm, its advantages far outweigh any problems. It has better print quality than both the Epson RX-80 and the Gemini-10X. Although it is slower than the Gemini, it seems more reliable.

Until a company announces a step down in price or a step up in performance, you should consider the Mannesmann Tally Spirit 80 an ideal alternative in dot-matrix printers. ■

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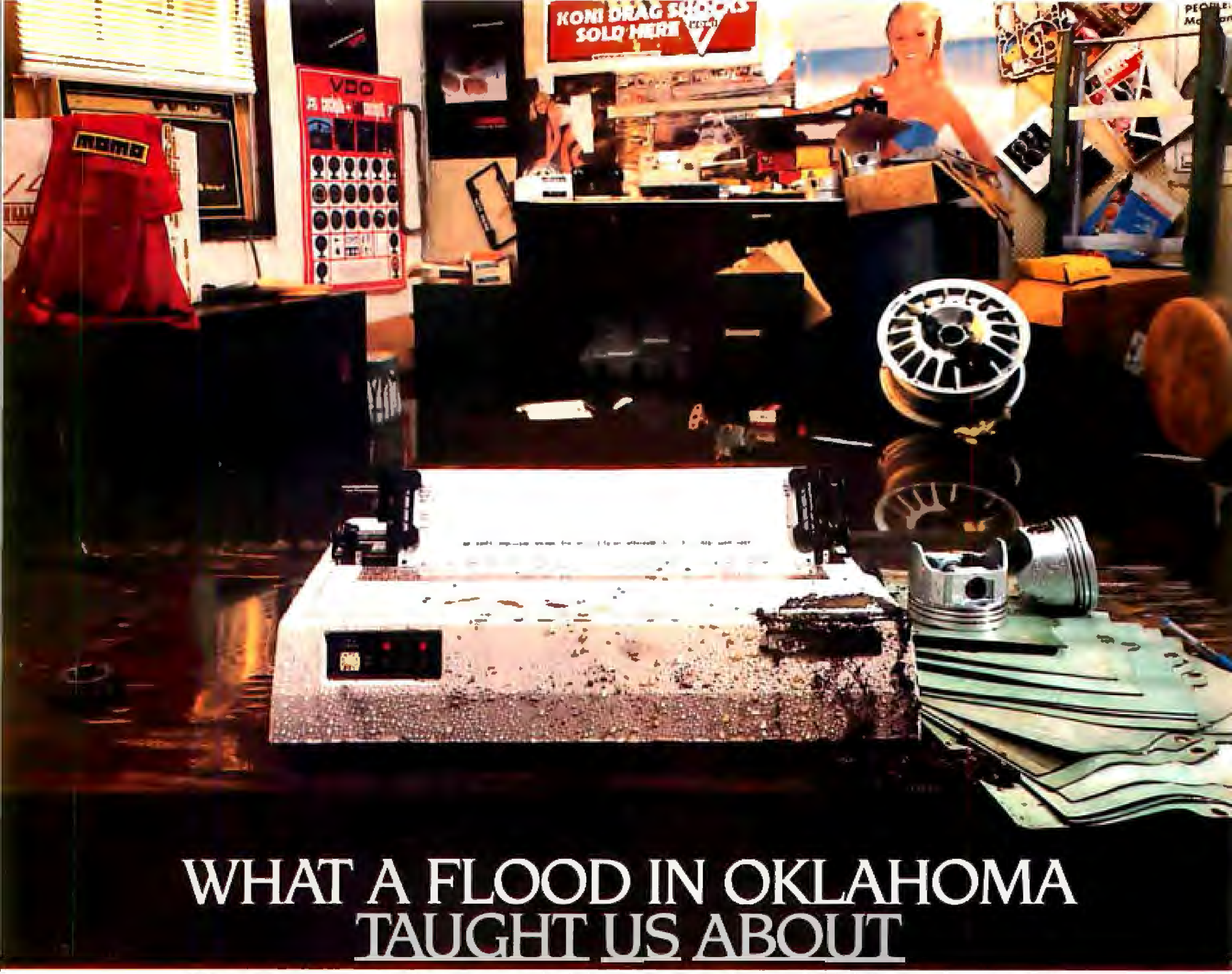

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H·A·R·D·W·A·R·E R·E·V·I·E·W

The Brother HR-15 Letter-Quality Printer

The basic print mechanism is simple, yet solid

BY PETER V. CALLAMARAS

Choosing a printer is a big decision. Until recently, most of us opted for dot-matrix printers for two reasons: price and graphics capabilities. But most of us really want a letter-quality printer. After all, a word processor lets you produce professional-looking documents in a short amount of time, right? And a dot-matrix printout is, well, not that professional looking.

But technology has once again come to the rescue. Brother International Corporation's HR-15 printer is a reasonably priced ($599 suggested list) daisy-wheel printer with a respectable speed (13 characters per second).

DESCRIPTION

The HR-15 is a well-designed, well-packaged, and rugged printer. The basic print mechanism is simple, yet solid. The design of the print hammer and daisy-wheel portion of the printer is based on that of the popular Brother electronic typewriter line. The printer is encased in relatively thick, sturdy plastic.

There are six membrane keys on the front panel of the printer labeled Pitch, Line Feeds, Top of Form, Line Spacing, Select/Deselect, and Copy. You select options by pressing the corresponding key. The Pitch key gives you a choice of 10, 12, or 15 characters per inch plus proportional spacing. If you need an extended printout, you can get 225 characters on a single line of 8½-inch-wide paper by using the 15 pitch and the optional Quadro 15 print wheel. Line spacing can be set at single, one and a half, or double spacing. The other print options are self-explanatory.

You can use the Copy key to reprint material stored in the HR-15's 3K-byte buffer (8K-byte buffer optional). The buffer stores approximately a page of text. This page will be reprinted until you stop the copy function with the Select/Deselect key.

I had no trouble using the membrane keys, and they seem relatively impervious to damage from spilled liquids, etc.

Brother International offers a wide variety of ribbons and daisy wheels for the HR-15. They are standard Brother typewriter supplies, both plentiful and affordable.

The ribbons are encased in plastic plug-in cartridges; they come in single-strike film, multistrike film, and reinkable fabric. When you get to the end of a ribbon a buzzer sounds and an alarm light goes on.

Daisy print wheels are available in most standard fonts, including Prestige, italics, script, optical-character reader (OCR), and others (see figure 1 for examples). There is also a proportional daisy wheel that can be used in conjunction with the proportional-spacing setting on the pitch selector.

The HR-15 has standard typewriter controls such as the paper-bail lift bar, platen roller knob, and paper-release arm. It functions like an electronic typewriter converted for use as a computer printer.

To use the basic printer all you have to do is insert a sheet of paper, roll the paper to the start position, and press the Select/Deselect key. You can buy the printer with either a parallel or serial connector on the back. If you buy an HR-15 with a serial-port connector, you will have to set the serial parameters via the DIP (dual-inline pin) switch on the back panel of the printer.

OPTIONS

You can add three options to the basic HR-15 to enhance its capabilities. The most useful of these options, in my opinion, is the tractor-feed mechanism, which retails for $150. It fits into a set of guides built into the printer. Slide it into the guides, plug the paper-out sensor plug into a socket on the back of the printer, and it's set up (see photo 1). The unit works well with microperforated fanfold printer paper. Your final product will look like it came from a dedicated typewriter.

Included with the tractor-feed mechanism is a large plastic noise-reduction cover that

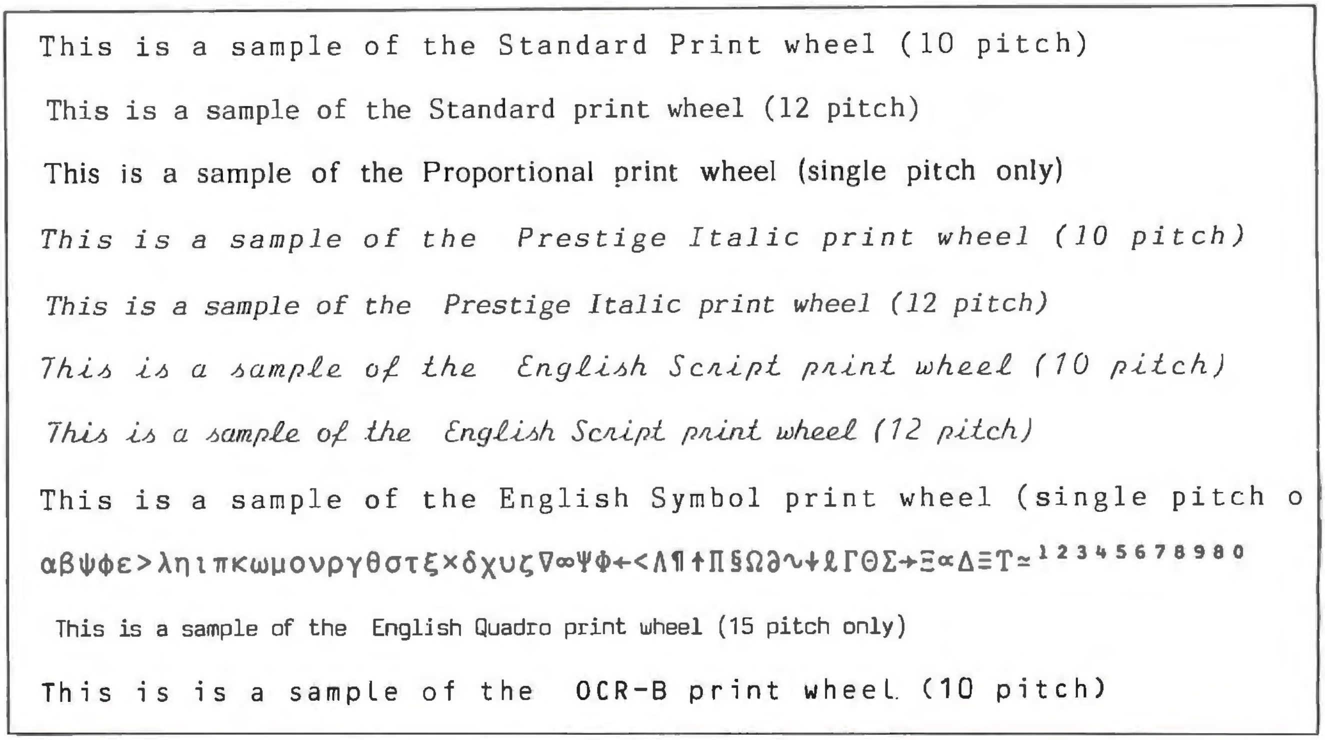
(continued)

Peter V. Callamaras (POB 408, Scott AFB, IL 62225) is an officer in the Air Force. The recipient of degrees in computer technology and biological sciences, he recently received his master's degree in systems management. He has been interested in computers since 1966 and used to be the service-department manager of a computer store.

replaces the unit's standard noise-reduction cover. Although either cover reduces the noise level somewhat, I prefer to put the printer in a noise-reduction enclosure because even when covered the printer is loud.

The cut-sheet feeder option, priced at $259.95, is an alternative to the tractor-feed unit (see photo 2). This feeder is designed to mate with preformed installation holes and guides on the back of the printer. With this option you can insert a stack of letterhead stationery into the mecha-

(continued)



This is a sample of the Standard Print wheel (10 pitch)

This is a sample of the Standard print wheel (12 pitch)

This is a sample of the Proportional print wheel (single pitch only)

This is a sample of the Prestige Italic print wheel (10 pitch)

This is a sample of the Prestige Italic print wheel (12 pitch)

This is a sample of the English Script print wheel (10 pitch)

This is a sample of the English Script print wheel (12 pitch)

This is a sample of the English Symbol print wheel (single pitch o

αβψφε>ληιπκωμονργθστξ×δχυζ∇∞ΨΦ←<Λ¶↑Π§Ω∂∿↓ℓΓΘΣ→Ξ∝Δ≡T≃^{12345678980}

This is a sample of the English Quadro print wheel (15 pitch only)

This is is a sample of the OCR-B print wheel (10 pitch)

Figure 1: *Samples of printout from the Brother* HR-15 *printer using a variety of print wheels.*

Photo 1: *The Brother* HR-15 *printer with the optional tractor-feed mechanism attached.*

Photo 2: *The Brother* HR-15 *printer with the optional cut-sheet feeder attached.*

Name
Brother HR-15

Manufacturer
Brother International
Corporation
8 Corporate Place
Piscataway, NJ 08854
(201) 981-0300

Type
Letter-quality printer

Size
18 by 6 by 13 inches

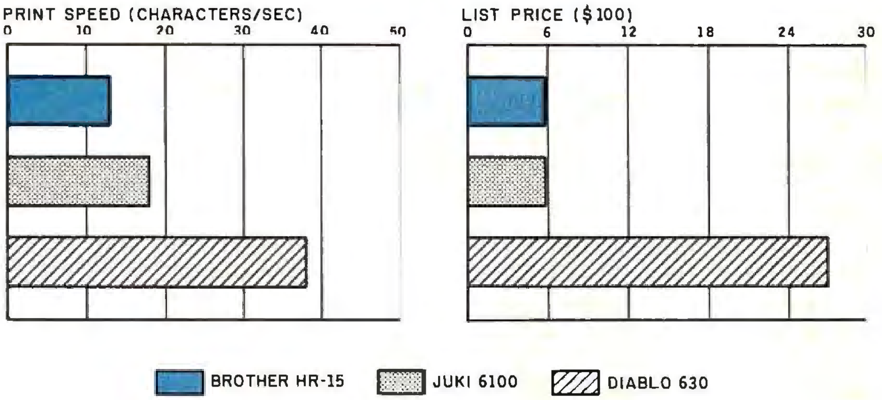
Features
3K-byte printer buffer, interchangeable daisy print wheels, cartridge ribbons (80,000- to 210,000-character print capacity), multicolor printing, boldface, subscripts and superscripts, automatic underlining, double strike, and proportional spacing. Centronics parallel or serial interface with single, one and a half, and double spacing, and 10, 12, and 15 pitch on a 13.5-inch carriage width

Cost
$599

Options
Tractor-feed mechanism, $150
Cut-sheet feeder, $259.95
Keyboard, $200

Documentation
45-page user's manual

Audience
Any computer user desiring a medium-speed letter-quality printer with adequate throughput for small business use



This is the Brother HR-15. This the Brother

This is the Juki 6100 This is the Juki 6100

This is the Diablo 630 This is the Diablo 6

The Brother HR-15 printer (using a Prestige 10/12 daisy wheel) is compared with the Juki 6100 (using a Courier 10 daisy wheel) and the Diablo 630 (using a Courier Legal 10 daisy wheel). The pitch for all printers is 10 characters per inch. The print speeds were determined by timing how long it took the printers to print the Shannon test (573 characters, see figure 1 on page 207 of "The Art of Benchmarking Printers" by Sergio Mello-Grand, February BYTE, page 193). The prices shown are the list prices, including tractor-feed mechanism.

Photo 3: *The Brother* HR-15's *optional keyboard.*

nism and it will automatically feed the sheets to the printer. This is handy if you send a lot of form letters or if you do a lot of single-page revisions. When I tested the cut-sheet feeder I had no significant jamming problems.

The last HR-15 option is a $200 plug-in typewriter keyboard. This keyboard changes your HR-15 printer into a fully correctable typewriter (see photo 3). It has 96 standard character keys and some special controls. All the print functions are controlled from the keyboard when the Select switch is on. You can set the keyboard to operate in three different formats, depending on the print wheels you are using. For example, if you are using the international print wheel, you can use the English symbol for pound sterling (£) to denote currency. All the alternate symbols (as many as four on a key) are printed on the appropriate keys.

The keyboard has three different resting angles so you can adjust it to your most comfortable typing position. Overall, the keyboard's feel, layout, and switch locations are excellent. I had little difficulty switching between it and an IBM Selectric typewriter, despite the HR-15 keyboard's extra function keys and switches.

OTHER FEATURES

The HR-15 has a second ribbon holder that can hold a correction ribbon when the optional keyboard is installed. (Unfortunately, the keyboard manual does not tell you what type or size of correction ribbon to use.) You can also use a different colored ribbon in the second ribbon holder for two-color printing capability (when using WordStar, for example).

The HR-15 prints at a rate of 13 characters per second (I did some tests that confirmed this measure). I don't think this speed is objectionable, even when printing long documents. However, I recommend that you use either an onboard or outboard printer buffer to free up the computer when you are printing long documents.

I used WordStar versions 3.1 and 3.3 on my Columbia PC and the printer did not disable any WordStar features that I usually use. I did not, however, run exhaustive tests on the HR-15/WordStar combination because I did not have access to some of the other popular word-processing programs to use for comparison. I did use the HR-15 and WordStar on an Apple II (as well as on the Columbia running the IBM version of WordStar) and again I had no problems.

When combined with WordStar, the printer let me easily change print wheels whenever I wanted a different typeface. The Brother daisy wheels come in plastic carriers that are designed to slip in and out of the print mechanism. It takes about four seconds to change daisy wheels. Open the print unit's cover, press the printwheel release, pull out the original daisy wheel by the built-in finger tab, insert the new wheel, and close the cover. One thing about this procedure did bother me: there is a chance you might damage the unit's cover when you open it to access the print mechanism. The cover is supported on either end by two hinges and the distance between them prevents the cover from being as sturdy as I would like it to be because I might change print wheels several times when printing a single document.

The printer and the optional hardware come with instruction manuals. On the whole, the manuals provide good installation directions, but inexperienced users may find them somewhat difficult to understand. My impression is that they were written primarily for installation technicians and experienced users.

CONCLUSIONS

The HR-15 currently is very popular in the marketplace: original equipment manufacturers are buying the Brother unit and repackaging it under their own label. The Comrex CR-II and Dynax DX-15 are examples.

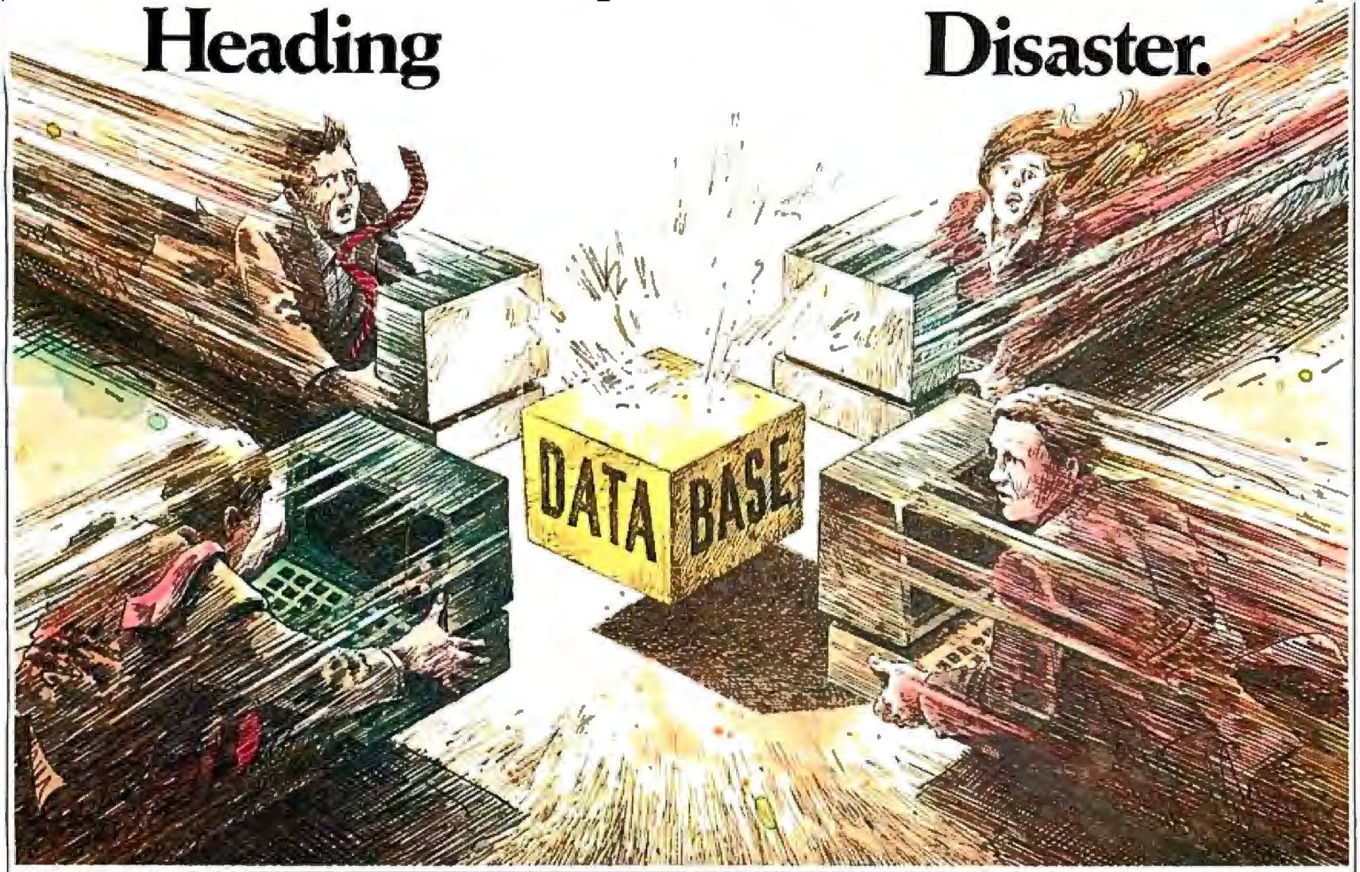
The Brother HR-15 is one of the best low-cost daisy-wheel printers you can buy today. It is sturdy and easy to use. It has a set of six controls that you would expect to find only on much more expensive printers.

The HR-15 is a medium-speed printer that should meet the needs of most personal computer and small-business computer users who want to produce letter-quality documents.

The keyboard option for the HR-15 turns the printer into a fully correctable typewriter, but for most people the tractor-feed unit will probably be the most popular option. The cut-sheet feeder is also useful if you use letterhead stationery often.

The Brother HR-15 gives you exceptional value for your dollar. It could very well become the standard for letter-quality printers in the same way the Epson MX series has become the standard for dot-matrix printers. ■

Personal Computer Networks Are Heading Disaster.



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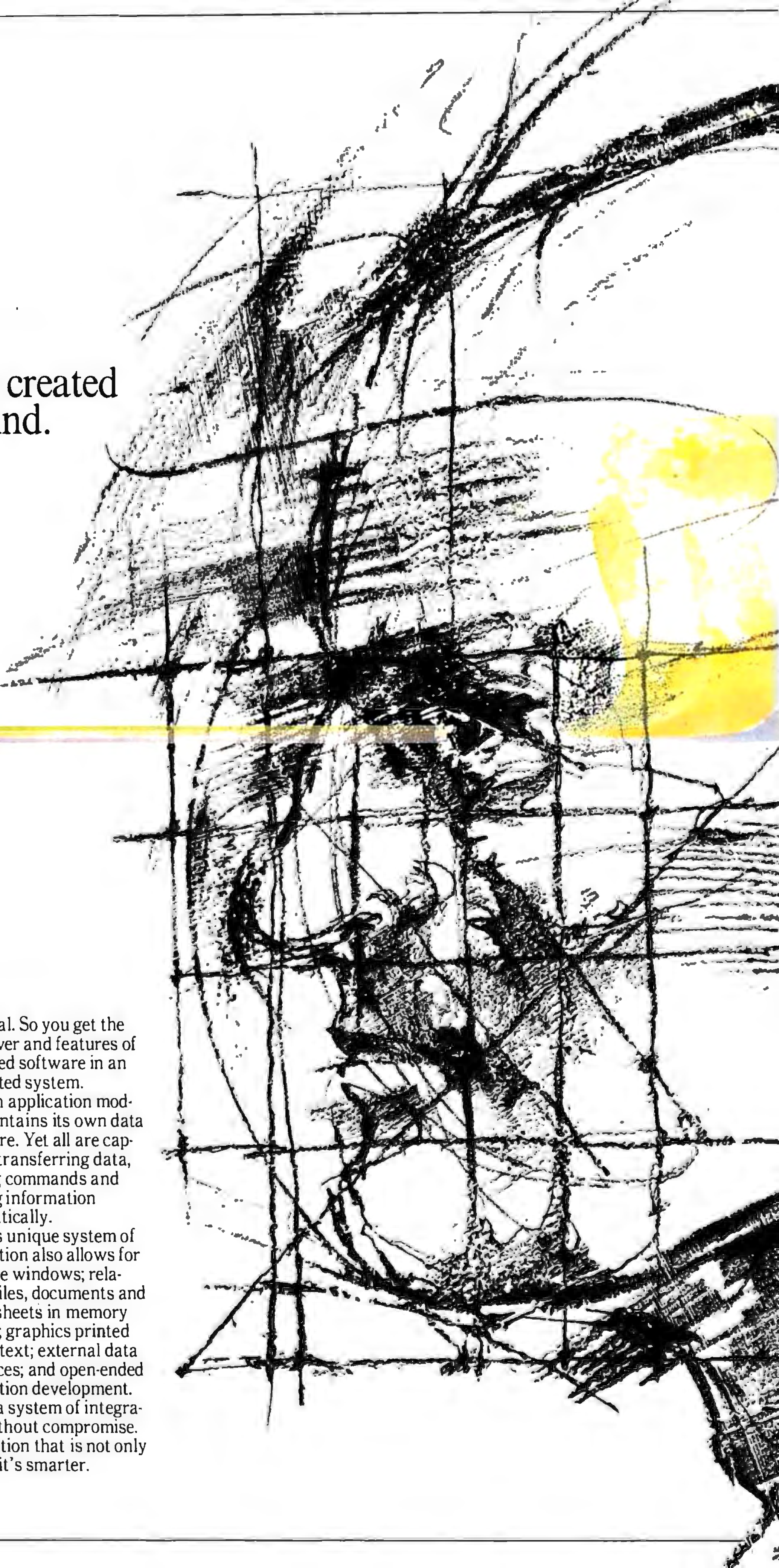

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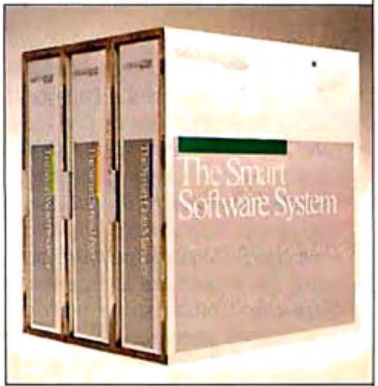

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REVIEW FEEDBACK

ANALYSIS OF SAM

I am amazed that you should publish an article comparing statistical analysis packages ("Statistical Software for Microcomputers," by James Carpenter, Dennis Deloria, and David Morganstein, April, page 234) without allowing the software authors to check it before publication. In particular, the details and comments on the SAM package were quite misleading, perhaps reflecting bias against the only non-American system.

For example, one of the unique features of SAM is its cluster-analysis option—yet this form of analysis is nowhere mentioned in the article. Table 10 is printed over two pages in such a way that it gives the impression that SAM does not include multivariate analysis. In fact SAM is one of the very few packages that features both discriminant analysis and factor analysis, etc.

The comments on SAM claim that it was one of the "weaker" packages yet fail to point out that it was the most accurate system when compared with others running on the same hardware. SAM will also read DIF and dBASE II files as well as creating correlation files and frequency table files—again this wasn't mentioned in the article.

The inaccuracies are numerous and the subjective commentary highly partial.

R.E. DOWNES
International Software
Welwyn Garden City, Hertfordshire
England

No doubt Mr. Downes has forgotten that, in fact, we sent him a copy of the original draft in September of 1983. Subsequently, Jim Carpenter spoke to Mr. Downes by telephone and received several suggested changes to the tables. Mr. Downes suggests that the details and comments on the SAM package were quite misleading. We would like to examine each of his specific points, since we do not agree with that remark.

First, we should observe that Mr. Downes sent us, as we noted in the article, only an Apple version of the SAM package.

Mr. Downes indicates that SAM was "the most accurate system when compared with others running on the same hardware." Table II does not confirm this. Microstat was the most accurate program run on the Apple with the six independent variables test, and TWG ELF was the most accurate run on the Apple with the three independent variables test.

Mr. Downes says that SAM reads both dBASE II and DIF files. Neither the documentation nor the program he sent us indicates this. We would be very pleased to examine newer documentation or program versions that have this capability. Why did Mr. Downes not tell us this discrepancy when we spoke to him on the phone?

We agree fully with Mr. Downes that SAM's cluster-analysis capability is unique and we would have served readers better by commenting on it in the review. To be candid, none of us have ever used this method but know that it is of value to some researchers.

To say that SAM was among the weaker packages does not imply that it is weak. It is far easier for us to write a review of the excellent work of all the developers, Mr. Downes's group included, than it is to prepare and document a complex statistical analysis program. We applaud International Software and the other developers for their truly valuable contributions but remain unchanged in our comments regarding comparisons of the various programs.

DAVID MORGANSTEIN
Germantown, MD

Editor's Note: *It is not BYTE's policy to send copies of reviews to manufacturers before publication.* —Rich Malloy

LISP

As I've recently started learning LISP on an Apple II+, I was very interested in your article comparing muLISP and IQLISP ("LISP for the IBM Personal Computer," by Jordan Bortz and John Diamant, July, page 281). I have a question and a couple of observations.

First the question: I bought muLISP in March 1984. As my dealer didn't keep it in stock, it was ordered from Microsoft and I received muLISP-80 version 2.15. I see that the version you were using was muLISP version 4.05. Even allowing that you were using a different implementation, the jump from 80-2.15 to 83-4.05 in under six months seems rather large. Question: have I been ripped off?

Bortz and Diamant pointed out that muLISP didn't report an error on unbound atoms and allowed you to take the CAR and CDR of atoms. MuLISP has a feature called auto-quoting: if a muLISP atom is imagined as having two pointers, then, when muLISP encounters a name it doesn't recognize, it creates an atom with the first pointer (the atom's value) pointing to itself and the second pointer (the atom's property list) pointing to NIL. This means that all atoms are bound (to themselves, at least) and that they do have a CAR (the value pointer) and a CDR (the property pointer pointing to NIL). An advantage of auto-quoting is that a sequence like

```
(SET A B)
(SET A C)
```

will always work in muLISP and involves a lot less typing than the QUOTE-ful alternative. A big disadvantage is that typing errors produce completely valid atoms that you can't get rid of; on a 56K-byte system like mine, this can get pretty annoying. I think your reviewers should have explained auto-quoting rather than simply dismiss it as poor error-checking.

I couldn't persuade your benchmark factorial function to work with my version of muLISP, as your function doesn't include the magic word LAMBDA. As muLISP doesn't require COND or T in a function like this, my version looked like this:

```
(DEFUN FACT (LAMBDA (X)
((LESSP X 2) 1)
(TIMES X (FACT (SUB1 X))) ))
```

and this ran about 2 percent–3 percent faster than a similar definition that included COND and T.

Finally, your reviewers complained that there was no documentation to cover the compatibility packages that came with their version of muLISP (I didn't get them with mine). As the only reason for including a MacLISP emulation would seem to

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be to allow LISP novices to work through Winston & Horn's "LISP," presumably the Soft Warehouse felt that any attempt at more than minimal documentation might be a little superfluous. Perhaps they should include the Winston & Horn book as part of the muLISP package—after all, doesn't everyone who gets a LISP package go out and buy it?

MICHAEL M. MASON
Worksop, Nottinghamshire
England

PRODOS

Haven't you folks at BYTE heard of the new Apple II operating system, ProDOS? You must have, since it has been available since early this year and you published a fine article by Rob Moore describing the new system in your February issue.

In recent months you have published a number of reviews of various computers and compared their respective performances versus the IBM PC and the Apple II. Why do you continue to use the old operating system (DOS 3.3) for these various tests rather than the new ProDOS system?

I would hope that in the future a fine, objective magazine like BYTE would strive to provide its readers with the most up-to-date test results so that fair comparisons can be made.

MARTIN KALMAN
Friday Harbor, WA

We agree. ProDOS is a big improvement. Many application programs, however, are not yet available for it. Multiplan, for one, will not be available for ProDOS until early next year. Despite this, we will upgrade our Apple IIe BASIC and system benchmarks shortly. —Rich Malloy

JUKI 6100 PRINTER

I was interested in the review by G. Michael Vose of the Juki 6100 printer (August, page 305). I've been using the 6100 with my Zenith 110 and Peachtree's 5000 programs for about three months and I'd like to offer my views on these products.

The Juki user's manual is far better than the Peachtree manual.

The Juki isn't kind to ribbons. If you let the ribbon-loading lever snap into position, it may cut or cause other problems for the ribbon. It must be eased ever so gently into position. The lift/lower actions of the ribbon transport/guide mechanism

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cause ribbon mispositioning/folding at the takeup area, causing the ribbon to be caught in the takeup winding spindle at the right, most often under the ribbon cartridge, which breaks or binds the ribbon. Sometimes I can salvage the ribbon by freeing the ribbon, then winding more onto the takeup reel, straightening as I go, but it's annoying and messy. I'd like to be able to stop that vertical movement, for when I find a better fabric ribbon, but I can find no instructions in the manual for doing so. The metal shield in front of the ribbon is too easily bent, which prevents full vertical travel of the ribbon, which causes underline misses when the shield scrapes the carbon from the film. The vertical movement caused constant misalignment of the only fabric ribbon in a Selectric II cartridge I have been able to find—the IBM Tech III, IBM part #1136391. That ribbon twisted almost immediately each time printing started, so I just had to replace it; $15 wasted. The ribbon guides let the ribbon slip out too easily given the constant vertical movement; what good is easy loading if the ribbon won't stay in place? The clear plastic shield between ribbon and paper accumulates flake too easily, obscuring the point at which the top of the paper must be placed to get full use of the sheets, and there's no apparent way to easily remove that shield for cleaning.

The power supply failed on my first machine three days after I got it. My dealer, ICS, replaced it without question. The metal ribbon shield started interfering with the print wheel this week, so the serviceman will have to replace that, he said. My warranty runs out next week, so I'm starting to get nervous. The external clip that holds the cable plug in place will cut your fingers as you try to remove the plug; a less-hostile clip method would cost no more.

My questions are: Do you know of other fabric ribbons available for the Juki? And what is required to make the Juki print out a chess position graphically using Mychess running under ZDOS?

JAY H. BECKERMAN
Ft. Lauderdale, FL

Having read Mr. Vose's excellent review of the Juki 6100 printer, I thought your readers might find these additional observations useful.

Juki has prepared a very user-friendly 164-page owner's manual that is available without charge to qualified Juki owners through their dealers. This overcomes the problems encountered with the supplied 44-page documentation.

In addition to the Courier 10 print wheel provided with the printer, Juki sells two others: Prestige Elite 12 and Roman PS. I paid $7.95 each for these at my Juki dealer. The mechanically (but not typographically) compatible Triumph/Adler print wheels from a Triumph/Adler dealer are available.in a wide range of type styles including 15 pitch. These cost about three times as much as the Juki wheels and, as a comparative self-test will quickly reveal, differ from the Juki wheels in 8 positions used by infrequent accent marks.

The Juki wheels' lack of a true apostrophe can be extremely disconcerting. The character that Juki has assigned to the hexadecimal 27 position is more of an acute accent. Presumably it is intended

(continued)

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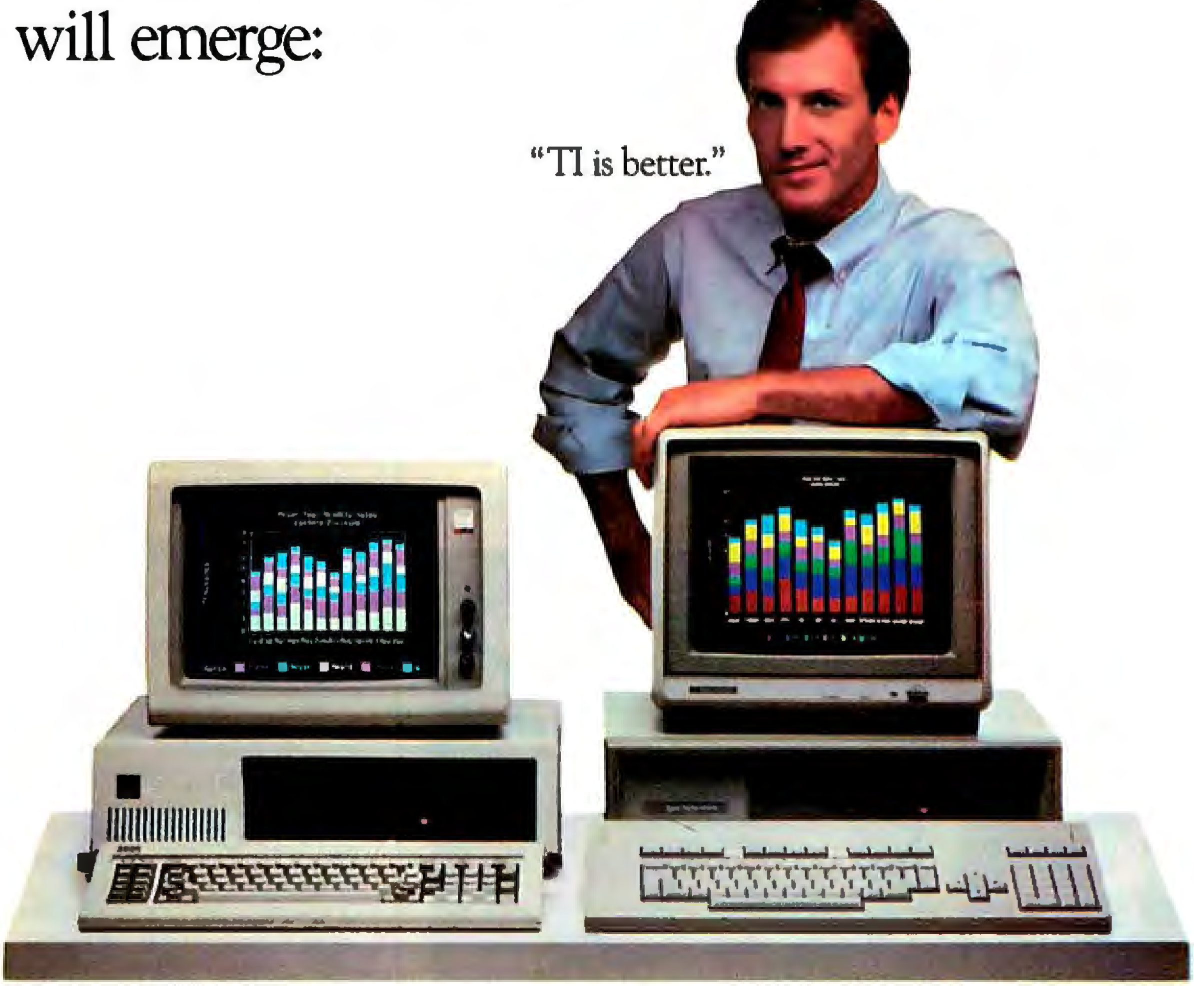

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to serve both needs, but it looks terrible as an apostrophe, particularly if you are doing quotes within quotes. It just looks wrong. For this reason, a Triumph/Adler wheel is best if you are preparing English-language text where appearance is important. The Triumph/Adler wheels can also get you in trouble at times, such as when printing out a SuperCalc 2 spreadsheet with borders. What you get instead of vertical bars for column separators are paragraph signs. It looks very awkward.

Being able to use standard IBM typewriter ribbons is a great convenience. I have found that the Tech III multistrike ribbon is of sufficiently high quality for nearly all uses—including correspondence—and its long life lessens the likelihood of running out of ribbon in the middle of a page. When preparing originals for offset printing, however, a single-strike ribbon such as Tech II will markedly improve the quality of the end product, and it is easy enough to switch ribbons back again.

STUART C. DOBSON
Irvington, NY

TOOLWORKS C/80

It was gratifying to see our Toolworks C/80 used as one of the comparison compilers in the review of three CP/M-80 C compilers (June, page 303). It's nice to see that our $49.95 compiler still matches up well with those costing much more.

But Toolworks C/80 would have done ever better if Christopher Kern had used version 3, which has been the current version since August 1983. It generates better object code and comes with an expanded library of over 45 functions. The library includes the string functions that Mr. Kern noted were missing in C/80 2.0, coded in fast machine language, which greatly speeds up the sort benchmark.

The most important improvement in version 3 is the optional C/80 Mathpak, which adds true float and long data types (not just subroutines) to the language. We sell that Mathpak separately at $29.95 to keep the price of the compiler down.

We compliment BYTE for its new review format, with graphs clearly showing differences in performance. As a leader in low-priced software since 1980, The Software Toolworks depends greatly on objective reviews to point up the differences (or lack of them) between our products and more expensive ones.

WALT BILOFSKY
The Software Toolworks
Sherman Oaks, CA

NEW PLASTIC CHIPS

In regard to Harry J. Kuhman's letter in Review Feedback (June, page 374) about hangs and crashes while using Pinball Construction Set, Commodore has started using plastic-package video controller chips instead of the ceramic-package chips. These plastic chips run hotter than the ceramic ones and after using the C64 with some games that have a lot of screen activity the chip will overheat and lock up. This can also occur when scrolling through a file with a text editor. Pulling the reset pin low with an external reset switch will not reset the chip; the only cure is to power down and let the machine cool off.

A very helpful service technician at a

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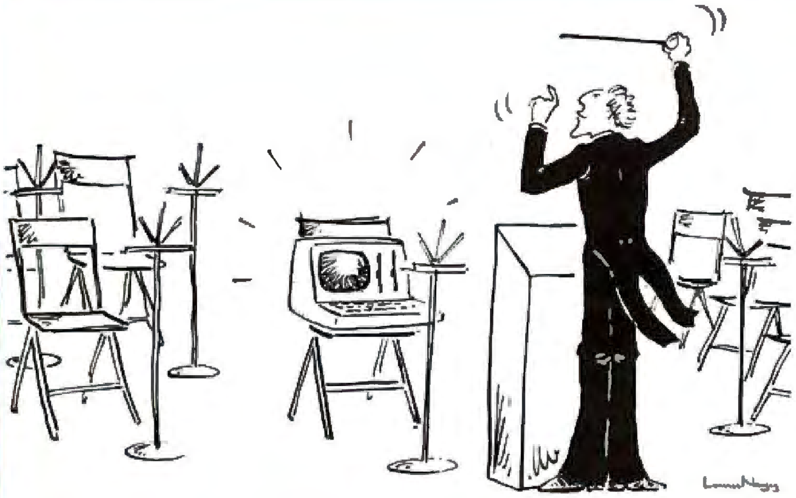

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XASM68		6800/01, 6301	200.00	250.00
XASM75		NEC 7500	500.00	500.00
XASM85		8085	250.00	250.00
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Circle 32 on inquiry card.

local dealer helped to find the problem and replaced the plastic video chip with a ceramic one; the problem disappeared.

I hope this information will help Mr. Kuhman and other BYTE readers with similar lockup or hang problems.

R. SUNLEY
Winnipeg, Manitoba
Canada

FOUR LOGOS

I liked the review "Four Logos for the IBM PC" by Mark Bridger (August, page 287). It was a well-written, in-depth, and fair review.

I was especially pleased with the text box "Recursion: Therein Lies a Tail" (page 300), because Mark Bridger realizes the importance of optimizing tail recursion and making the best use of stack space.

IBM Logo (from Logo Computer Systems Inc.) was written in machine code by people who were determined to get performance. Tail recursion and list processing are optimized.

I could not resist the temptation to rewrite the recursive version of your Sieve program (listing 6, page 301) to make it more efficient (by making it tail recursive and by building up the lists with FPUT).

The new version can find all of the prime numbers between 1 and 1500 on an IBM PC with only 128K.

```
TO SIEVE :N
PR SIEVE2 BF IOTA :N [ ]
END

TO SIEVE2 :LIST :RESULT
IF EMPTYP :LIST [OP REV :RESULT [ ] ]
OP SIEVE2 (SHRINKIT (FIRST :LIST)
 :LIST [ ] ) FPUT FIRST :LIST :RESULT
END

TO REV :LIST :RESULT
IF EMPTYP :LIST [OP :RESULT]
OP REV (BUTFIRST :LIST)
 (FPUT (FIRST :LIST) :RESULT)
END

TO SHRINKIT :N :LIST :RESULT
IF EMPTYP :LIST [OP REV :RESULT [ ] ]
LOCAL "T MAKE "T (FIRST :LIST) / :N
IF NOT :T = INT :T
[MAKE "RESULT FPUT (FIRST :LIST)
 :RESULT]
OP SHRINKIT :N (BF:LIST) :RESULT
END

TO IOTA :N
LOCAL "T MAKE "T LIST :N
REPEAT :N - 1
 [MAKE "T FPUT ((FIRST :T) - 1) :T]
OUTPUT :T
END
```

IAN MACMILLAN
Logo Computer Systems Inc.
Lachine, Quebec
Canada

COMPAQ PLUS

Mark Dahmke's review of the Compaq Plus (July, page 247) was very informative except for one small bit of misinformation.

Mark was pleased to see that Compaq was now supplying technical information with its machine, such as how to open the cabinet, how to install add-ons, set memory switches, etc. This is not entirely correct.

This information is not supplied, it must

be sought out. Compaq will try to answer questions, but it publishes no technical information of any kind. No instructions for any modifications to the Compaq, such as adding an 8087, are provided.

One is referred to the IBM technical manual for memory and I/O maps, and since Compaqs are sold on the basis of their compatibility to the IBM PC, one can only hope that the technical information contained in this volume is valid for the Compaq.

DAVID KORST
Canoga Park, CA

SANYO 550/555

I'd like to take this opportunity to tell you how much I enjoyed Bill Sudbrink's review of the Sanyo MBC-550/555 computers (August, page 270). This system certainly deserves the kind of attention your magazine offers. I think it is fair to say that no other MS-DOS computer on the market today offers as much value and performance for the money as the Sanyo. I have been using my 555 for nine months now and have few complaints. About the only thing that would make it a better machine is if software developers would do the little work needed to rewrite certain IBM-specific programs so that they would run on the many Sanyos out there.

There were a few minor errors in Mr. Sudbrink's article that I'd like to correct also. First, the 550 comes with WordStar 3.3—not the earlier 2.4 version stated in his review. Also, Sanyo now offers purchasers the choice of receiving either a bundle of IUS's "Easy" software packages or the MicroPro "Star" bundle at their option.

BRAD SCHOLZ
Norwalk, CT

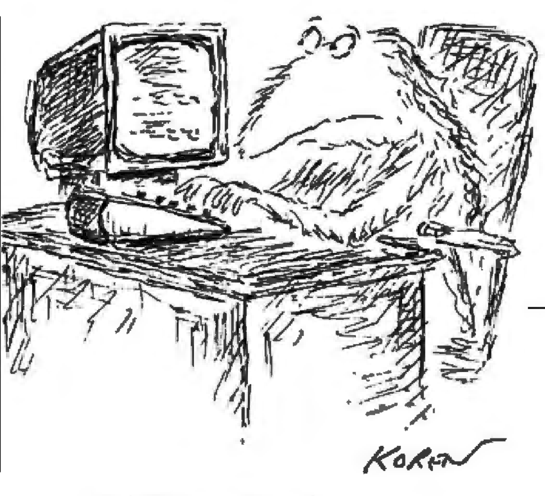
I read with interest Bill Sudbrink's review of the Sanyo MBC-555. I purchased the Sanyo as an expensive way to back up my Columbia 1600-4, which we use at the office. There was a curious problem in the WordStar program that was bundled with the machine. When I installed WordStar and attempted to set the function keys similar to the way we had set them at the office, I discovered that, while I was able to redefine the function keys, the install program did not allow me to change the message that appeared at the bottom of the screen. I was able to take the program into the office and use the WordStar install program, which we had purchased for the Columbia, to install that particular feature and had no difficulty doing so.

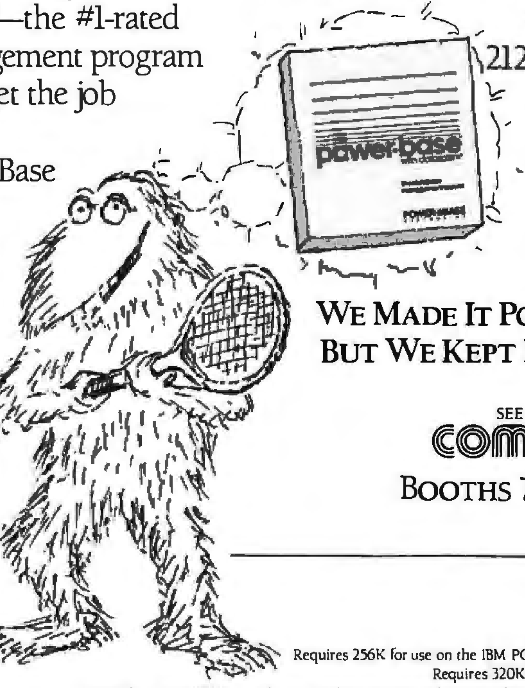
I enjoyed the review and enjoy the magazine considerably.

ROBERT C. SACKS
Lilburn, GA

I bought a Sanyo 4050 and have tried to get the Sanyo company to answer a number of questions about upgrading the memory, recommended communication packages, disk formats, etc., with absolutely no success. Three phone calls have been ignored as well as three letters; the last one having been sent by registered mail on June 28. Perhaps you or your readers can tell me how to get this company to respond?

HARVEY J. COOPERSMITH
Elmhurst, NY ■





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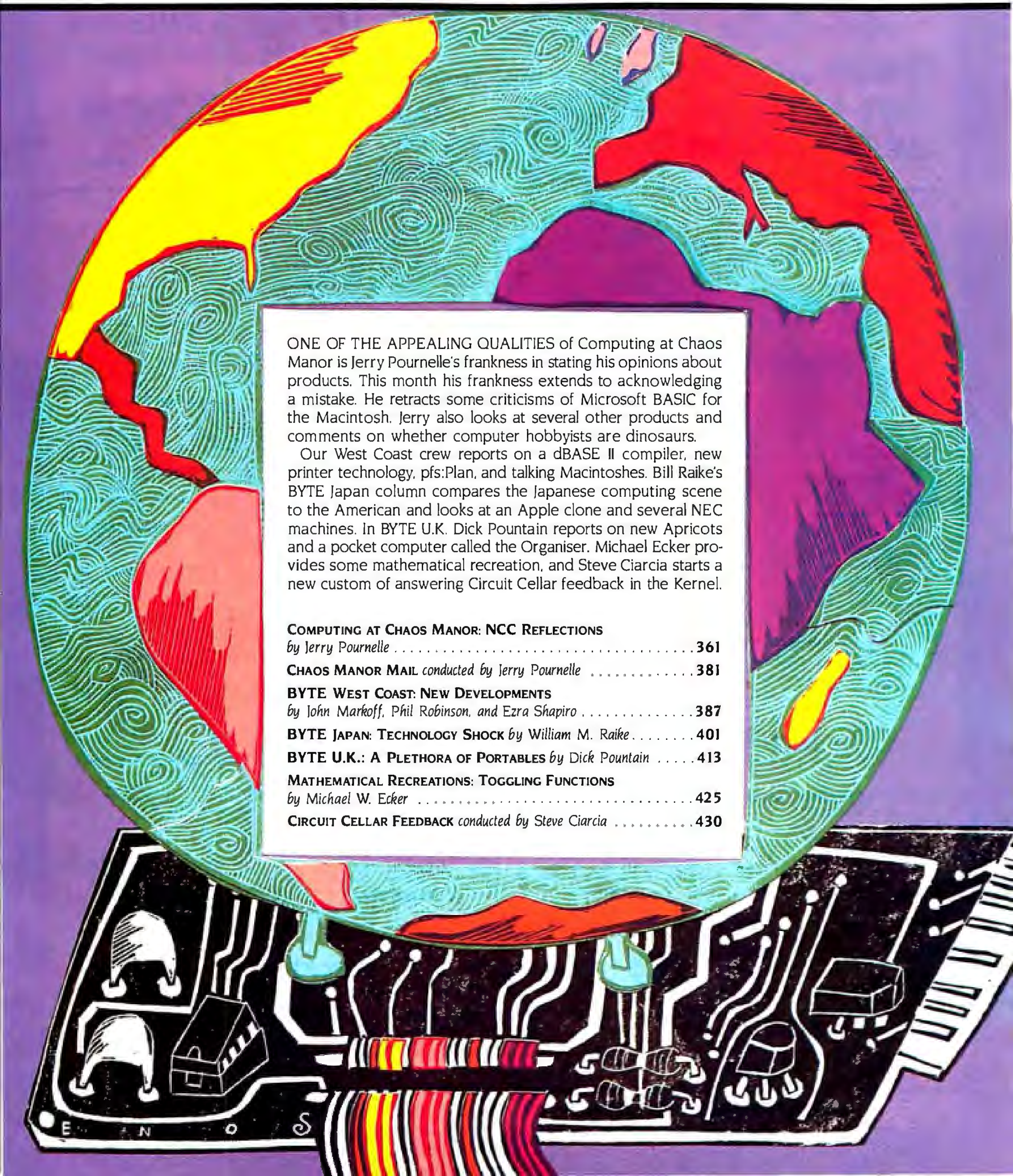

ONE OF THE APPEALING QUALITIES of Computing at Chaos Manor is Jerry Pournelle's frankness in stating his opinions about products. This month his frankness extends to acknowledging a mistake. He retracts some criticisms of Microsoft BASIC for the Macintosh. Jerry also looks at several other products and comments on whether computer hobbyists are dinosaurs.

Our West Coast crew reports on a dBASE II compiler, new printer technology, pfs:Plan, and talking Macintoshes. Bill Raike's BYTE Japan column compares the Japanese computing scene to the American and looks at an Apple clone and several NEC machines. In BYTE U.K. Dick Pountain reports on new Apricots and a pocket computer called the Organiser. Michael Ecker provides some mathematical recreation, and Steve Ciarcia starts a new custom of answering Circuit Cellar feedback in the Kernel.

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COMPUTING AT CHAOS MANOR

NCC Reflections

BY JERRY POURNELLE

Jerry Pournelle holds a doctorate in psychology and is a science-fiction writer who also earns a comfortable living writing about computers present and future.

I don't usually write about software that isn't running at Chaos Manor. Once in a while I may take someone's word for something, but when I do, I find I often regret it. There's no substitute for personal experience.

Case in point: I reported in the July issue that Bruce Tonkin had found a number of bugs in Microsoft BASIC for the Macintosh.

I shouldn't have.

What I said was true: the version Bruce was using, 1.0, did not implement mouse functions; and he did report some problems. Alas, some of those "problems" turn out to be rumors he'd heard, and even as we were speaking, Microsoft had replaced 1.0 with 1.1, which does hook into the Macmouse.

I routinely send manuscript copies of my reviews to affected companies so that they can complain about errors. (I don't pay any attention to other kinds of complaints.) Somehow, though, the copy sent to Microsoft went astray.

The best news, though, is that Microsoft is now bringing out Microsoft BASIC 2.0, which has graphics, the ability to use pull-down menus, and lots of other goodies. Note: as I write this, I have only 1.1, which works fine. I've been promised 2.0, which I should have long before you read this. More when I know more. Meanwhile, my apologies.

INVASION OF THE PRODUCT SNATCHERS

I sometimes think this industry is going to dissolve in hype.

Case in point: at NCC I made contact with some people at a major hardware house, which I'll call the Glubnautz Company to protect the innocent. They asked me why I never reviewed their products.

"I only write about what I'm using, and I've already got a good thingummy."

"Would you try one of ours if we sent it? We think you'll like it better than the Brand X you're using."

"Sure. Love to."

"Fine. We're also introducing Finkleduddy, a revolutionary new software product. Can we get you to try that?"

"Yeah, sure, it sounds interesting. You do know that I'm not BYTE, and stuff you send me doesn't get to the BYTE product-review editor, and stuff you send to BYTE doesn't get to me."

"Yeah, sure, we read your column all the time. Can we have your card?"

So I gave them a card. In fact, I gave them two: one with the BYTE address and phone and one giving the real address and phone for Dr. J. E. Pournelle at Chaos Manor. Alas.

Two weeks later, the phone rang at 8:30 a.m. My staff doesn't get here before 9:00, so I got out of bed and staggered into the office. A voice with a cultured accent asked for Dr. J. E. Pournelle. I reluctantly admitted that was me.

"Hi, J. E. I'm Joe Gland, media relations specialist for the Glubnautz Company. How're you doing? Hey, J. E., I see you're with BYTE. Great magazine. We were just up to New Hampshire. Must have missed you when we were there."

"Yeah, well, I don't get to New Hampshire very often. I live in California."

"Oh? Hey, yeah, that's right, it says so on the card here. Look, J. E., you gave your card to one of our people at the booth at NCC, right? You want some information on our new Finkleduddy software. Great product. Really great. Revolutionary."

"That's not quite the way it was." Patiently I tried to explain that it was his people who had approached me and wanted me to evaluate his company's products.

"Well, we sent a copy of the Finkleduddy program to BYTE already."

Sigh. I tried once more. "As I explained to the people at your booth, I am not BYTE."

"Your card says here you're with BYTE."

"I write a column."

"Oh, do you? Hey, J. E., that's great! If I

(continued)

send you Finkleduddy, when will you send it back?"

"I don't usually return software."

"Oh. Well, J. E., it's a pretty valuable program. Look, I'll send you our press kit on the Finkleduddy program."

"Please don't bother," I said. "I have 12 cubic feet of unreviewed software already. I certainly don't need any product descriptions."

The conversation dwindled downward from there. It was obvious that Joe Gland, the "media relations specialist," had never read a copy of BYTE in his life. I found out later from the New Hampshire staff that when he'd visited the BYTE offices, it had become obvious that Mr. Gland had never read *any* computer magazine, nor had he ever used a microcomputer. He'd come straight out of a consumer products environment, probably something to do with selling soap. He apparently used my initials because he didn't know my first name, and the Gladhander Association rescinds the membership of anyone using honorifics like "Mister" or "Doctor."

Whatever he'd been trying to do, he has certainly undone the relationship his engineering people tried to build while I was at NCC. I have to cope with a mountain of software and hardware that I feel some obligation to review. I'm always looking for good stuff, advertised or not, but let's face it, there's no real shortage; yet Mr. Gland wanted me to beg for his sacred products, which he would grudgingly send on 30-day loan, doling out the precious gold to media peasants who in his imagination must be panting with anticipation.

In other words, he didn't know the territory.

The horrible part is that he's not unusual. These "product representatives" from the consumer products outfits have descended in force; dozens of companies, including some old-line outfits, have employed them. It's as if the micro community were the victims of a curse. It's the invasion of the product snatchers, creatures determined to sell computers and software the same way you'd hype Procter & Gamble soap.

It has to stop. Look: how can it possibly benefit a company to employ "media relations specialists" who haven't read any of the media they "specialize" in relating to?

Are We Dinosaurs?

The product snatchers think computer hobbyists are out-of-date crumb balls, aged hackers dreaming of the days when we owned this field. We are, they think, obsolete fools unwilling to move aside and let the common people have their day. Query: do the common people deserve "media relations specialists"?

Is the world better off when computers and computer programs are thought of as "the product"? I would have thought that good programs, like good books, have authors who have poured something of themselves into their work, and that it's demeaning to refer to such efforts as "product" as if it were no more than yet another bar of soap.

Leave that, though: is the hacker a dinosaur? Is BYTE doomed, as computers become more and more popular? Must all computer magazines become business oriented or vanish?

No.

First, let's look at some data. Alas, this is the year of the computer book. There are so many of them, and bookstore managers are so unfamiliar with computer books, that almost no single title—including my own—will do very well. Oh, mine are making money for both me and the publisher, but less than we'd expected. Fortunately, I didn't insist on one of those truly monstrous advances, so my publisher—Jim Baen—will still be in the computer-book business two years hence.

Individual books aren't doing well—but the total sales of computer books this year is expected to exceed total sales of fiction.

There's a huge market out there. True, the book salespeople, and the public, don't yet know who to trust and what to buy, and it's going to take

(continued)

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a while for them to learn; but learn they will. Just as science-fiction readers have learned to trust certain authors, and editors, and publishing houses, so those interested in computers will learn to recognize certain names and publications. Many readers already have; it's the bookstore managers who haven't yet. They will; and it will be the hobbyists who show the way, as well as write many of the books.

Meanwhile, the computer field moves fast: today's miracle is tomorrow's old hat. It's much easier to get stung buying a computer than buying a car. The only defense is either to learn more about the machines—or find people you trust who do know about them. Pournelle's Law: if you don't know what you're doing, find people who do. As long as the field keeps moving, there'll be a need for BYTE.

Not everyone interested in computers will want to really get their hands dirty studying them—but quite a few will. After all, most people who read books don't try to write them, but there are still a vast number of writers, potential writers, and would-be writers out there. It will be the same for programs and programmers. Just as most books are not written by salaried writers, within a few years most commercially successful programs will not be written by salaried programmers. They will be published by software houses but not written by staff writers.

When BYTE first began, hobbyists were the entire micro community. This column was an unusual feature in BYTE because it dealt with *using* these little beasts, not just playing about with them or hacking their insides. Indeed, it was originally called the User's Column to distinguish it from the rest of the magazine, which largely appealed to true hackers.

Things have changed a bit now. For one thing, I've learned a bit of hacking. For another, there are millions of small computers out there, most used by people who pay so little attention to what's in the machines that they make me look like an expert. Once we BYTE types, hobbyists and hackers and users alike, were the whole of the micro community. Now we're only a small part of it.

We're still an important part. Far from being a bunch of old dinosaurs, we're the cutting edge of a real micro revolution. Part of our job is to protect "the rest of us" from the invasion of the product snatchers.

We have our work cut out.

NCC

The National Computer Convention was dull this year. The most exciting thing I saw had nothing to do with micros: it was an Intergraph design-automation system, and it was pretty wonderful. A big computer has a complex mouse that controls a large drafting table. You can draw extremely complex circuits, using conventional symbols, and specify the characteristics of all the components, such as the various chips you've sketched in.

When you're finished, the Intergraph will simulate the circuit. It analyzes waveforms, does fault simulation, shows you the circumstances under which each logic gate is activated, and in general does about everything you'd do if you'd actually built the hardware.

Computer-assisted-design (CAD) systems aren't all that new, but I've never seen one as complex, yet easy to use, as the Intergraph.

I wonder when I can get that for a micro?

AN AUDIENCE WITH MA BELL

AT&T had a big display at NCC, with the 3B2/300 tabletop computer, as well as the new Olivetti-manufactured PClone. The clone didn't interest me very much; from the specs it's Yet Another, with no special features. I do

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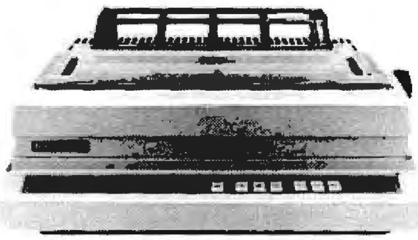

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remain interested in the 3B2/300, which runs UNIX. The 3B2/300 in combination with the Teletype 5620 "Blit" bit-mapped terminal looks like a really wonderful programming environment.

Incidentally, the Pyramid Technology Corporation thinks so, too. The company makes fairly expensive multiuser minicomputers and has done some pretty impressive things with them. Pyramid's people had to sweat blood to adapt the Teletype 5620 to their machine, but they've done it.

One thing I didn't know: just what are the practical limits of the 3B2/300? That is, how many jobs can it be doing before it slows down to a crawl? It seemed an interesting question, so I devised an experiment: keep adding tasks, each task simulating a user, until the text editor slows down enough to be annoying to a fast typist such as me. That's no exact measure, but it will give a ballpark figure. Since my son Alex, who's been studying UNIX at UCSD, was along with the camera, we headed for the AT&T booth at a time when they didn't have many visitors.

The booth was big, and it was crowded with AT&T people in three-piece suits despite the 105-degree Las Vegas weather. AT&T people at shows have a badge system. Lowest in hierarchy have paper badges in plastic holders. Then come short white plastic badges. Then wider white badges. Then (I am *not* making this up) short gold badges. The senior officer present wore a wide gold badge.

He'd never heard of Pournelle and had barely heard of BYTE (even though nearly everyone at the show was carrying the July BYTE with my AT&T comments in it). One thing he was sure of: he hadn't the authority to authorize that kind of test, and he was pretty sure there was no one in Las Vegas who could. (Technology Division Vice-President Jack Scanlon was at the show as a speaker, but one presumes he was off duty or something; or maybe *he* hasn't the authority?)

"Alas," said I. "That's too bad. I guess I'll have to concentrate on your clone. Okay, Alex, get some pictures—"

"Oh no, no, we can't authorize you to do that. You're not supposed to take pictures on the show floor," said the Wide Gold Badge.

Nobody else in the show objected to Alex taking photographs, and the Apple people even moved their crowds around so we could get better shots. I don't think AT&T knows the territory. Anyway, that's why I have nothing to report on the new AT&T machines.

MAN, THAT'S COMPATIBLE!

The Zenith display was just down the aisle from AT&T. The Zenith account reps aren't product snatchers. They normally know the machines, and when they don't know, they have people who do.

One of them, Mark Foster, a senior systems engineer from the St. Joseph, Missouri, plant, had been waiting for me. He writes most of the firmware (the code in the read-only memory or ROM) and wanted to show me just how compatible the Zenith Z-150 really is. While he was at it, we went over some of the built-in debugging features of the Z-150. It has a lot of them, all impressive. The Z-150 isn't just a PClone; it's a distinct improvement.

It is also compatible. Mark Foster is compulsive about that. For instance, there's one public-domain program that wouldn't run on the Z-150. It was driving everyone nuts until Mark found that it was actually doing a comparison with the checksum on the IBM copyright notice. No one knows why the programmer went to all that trouble—but the program will run on the Zenith Z-150 now.

Foster has gone to extreme lengths

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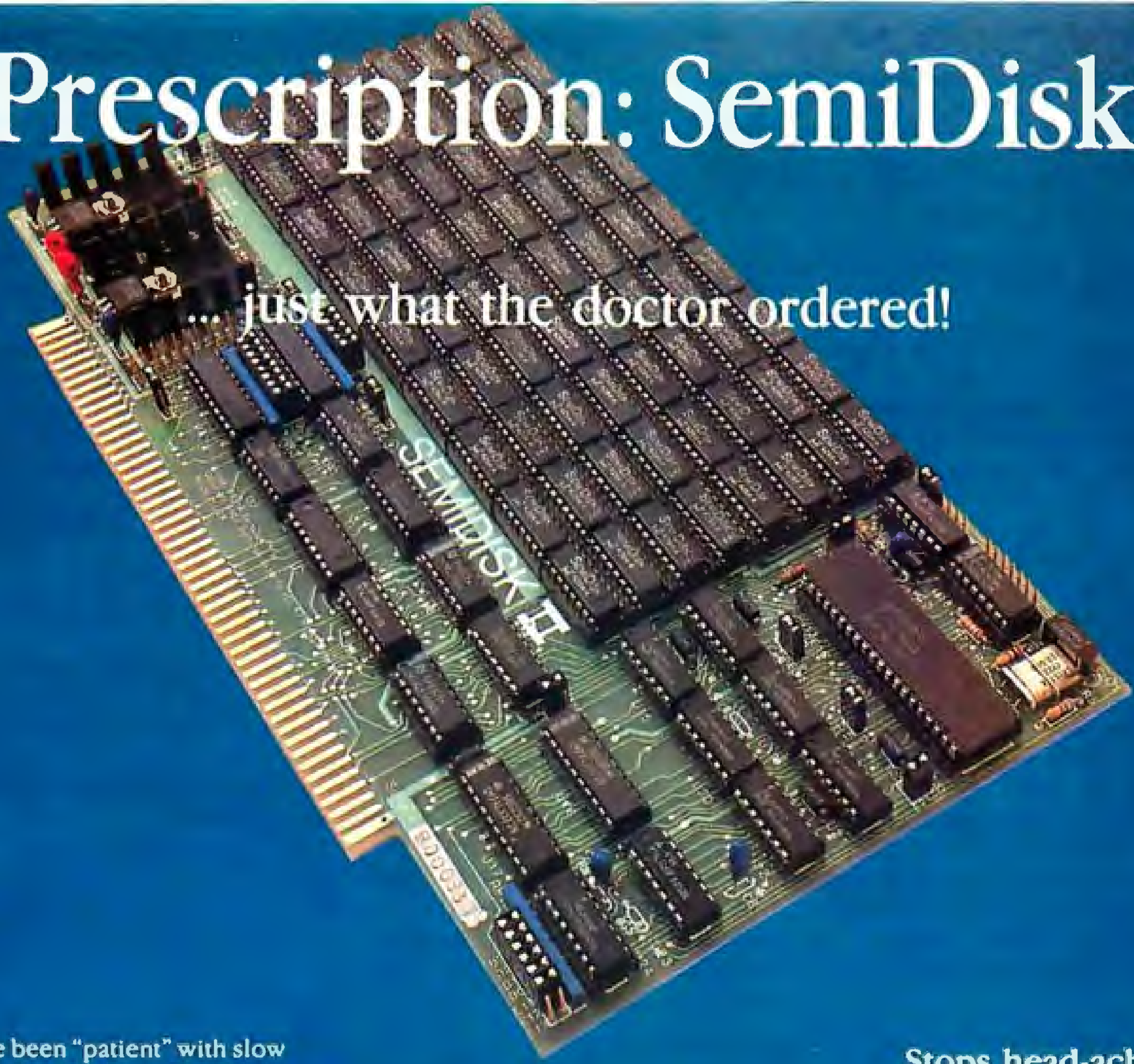

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to make the Z-150 compatible and knows of no program that will run on the PC and won't run on the Zenith. Even as he was telling me this, Philippe Kahn, president of Borland International, came around to test his new Sidekick program on the Z-150. If you read last month's column, you'll know I'm quite fond of Sidekick (except for the name). Naturally I stuck around.

It works fine. There is one oddity. When run in the color mode, one of the windows generated by Sidekick appears to be the wrong color, or at least a different color from what it displays on the PC itself. Neither Kahn nor Foster knew why. I last saw Foster muttering to himself, and I wouldn't be at all surprised if the next iteration of the Z-150 ROM changed that color.

Shortly after we returned from NCC, I received a new set of ROMs for our own Z-150. Since I was going to be inside the machine anyway, I figured I might as well fill it up with memory.

Neither operation is particularly difficult. The Zenith Z-150, unlike the IBM PC, doesn't have a motherboard; *every* board, including the one holding the central processing unit, is a plug-in. Getting the main board out of the machine takes a little effort; not much, but you do have to bend it somewhat, since it's just a millimeter or so too long. Once out, installing the new ROMs was simple enough. There are also plenty of sockets for new memory. As usual, we used 4164-type 64K-bit dynamic-memory chips, which we obtained from California Digital; they're currently advertised for $5.95 each and install in sets of nine. Each set adds 64K bytes of memory (eight chips for the memory itself and one chip to store the parity check).

The Z-150 does parity generation and checking for reliability. So does the IBM PC, of course, but there's a difference. With the Zenith Z-100 series (Z-100 through Z-161), the machine performs a register dump on finding a parity error and then exits to the system monitor (DOS). If you want to continue the program, type "G" and the machine will try to pick up where it left off. At least that's what Mark Foster tells me; I've never had a parity error, so I've never used the feature. It seems a reasonable thing to do, though.

The Z-150 is well made, quiet, and free of glitches. I have only one problem with it. Mrs. Pournelle, weary of being switched from machine to machine, has claimed the Z-150 as her own to use until she finishes her reading-instruction book/program. Since the Z-150 has far and away the best color display I've ever seen for any PClone—it scrolls smoothly, without

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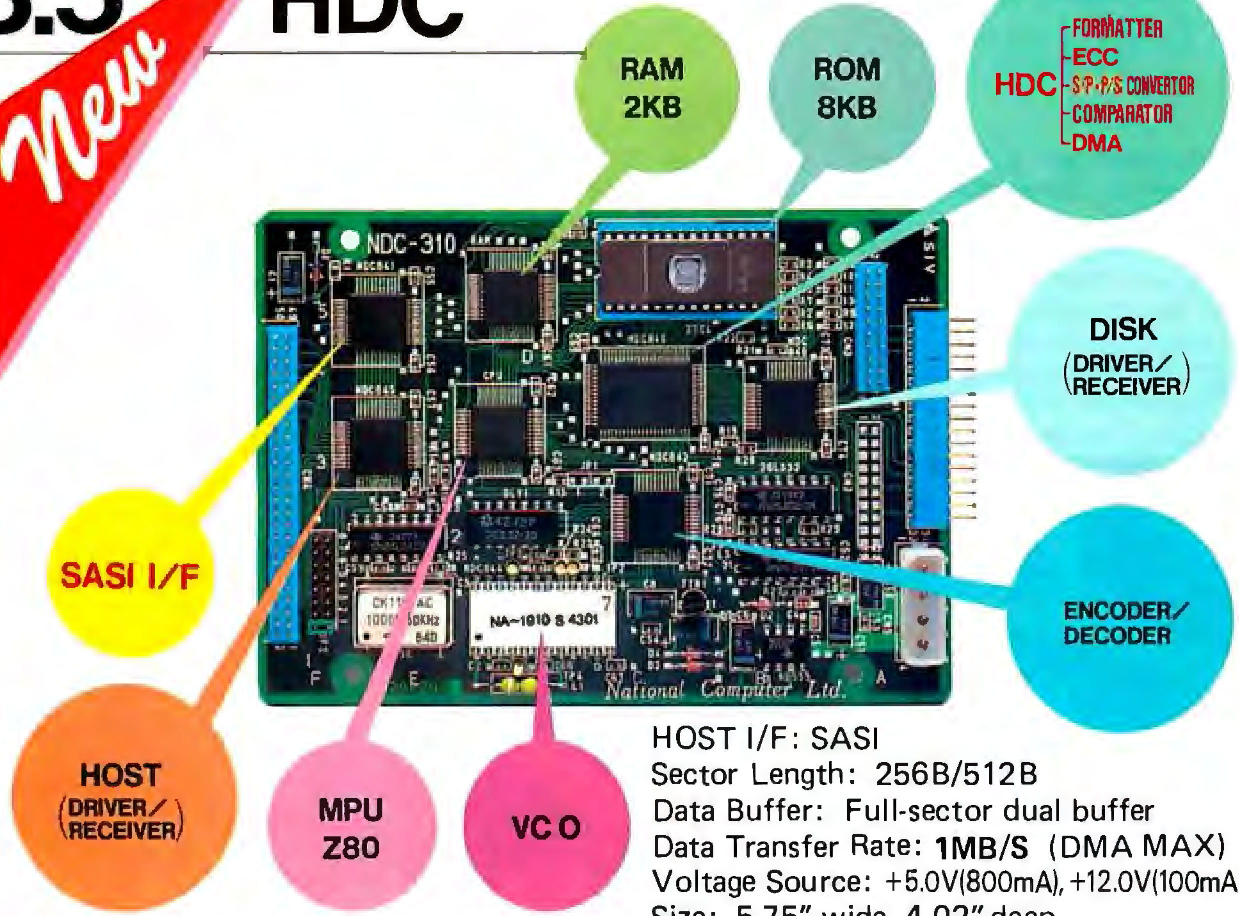

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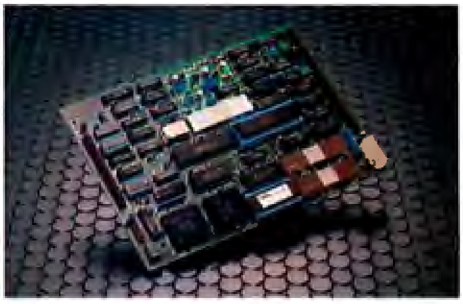

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flashing—I don't get to play Cygnus's Star Fleet I in color as often as I like.

COLOR VERSUS MONOCHROME

There's one other problem with the Z-150, but it's generic to nearly all PClones and, for that matter, to most of the microcomputers I've yet seen.

If you use the Z-150 with its color screen for word processing, the letters are just a bit fuzzy. It's not too noticeable at first, but it's enough to tire the eyes after working several hours. The 150 comes with both composite and RGB (red-green-blue) color output as standard, so it's only necessary to plug in a high-resolution monochrome monitor to clear up the situation. True, that involves having two monitors if you want color as well, and it's a nontrivial exercise finding a place to keep two monitors; but with the Z-150 you have that choice. When you buy an IBM PC, you have to choose one or the other (or buy an extra board).

Mrs. Pournelle has been using the color monitor. This was mostly because the only good monochrome monitor I have (other than the one that came with the IBM, and that has the wrong kind of plug) is the 9-inch amber-screen monitor that belongs to Adeline, my Otrona. Today, though, we plugged in the Otrona monitor to the Z-150, and it's a great improvement for word processing, which is what she's doing to get her book out; so I fear I've lost the Otrona screen.

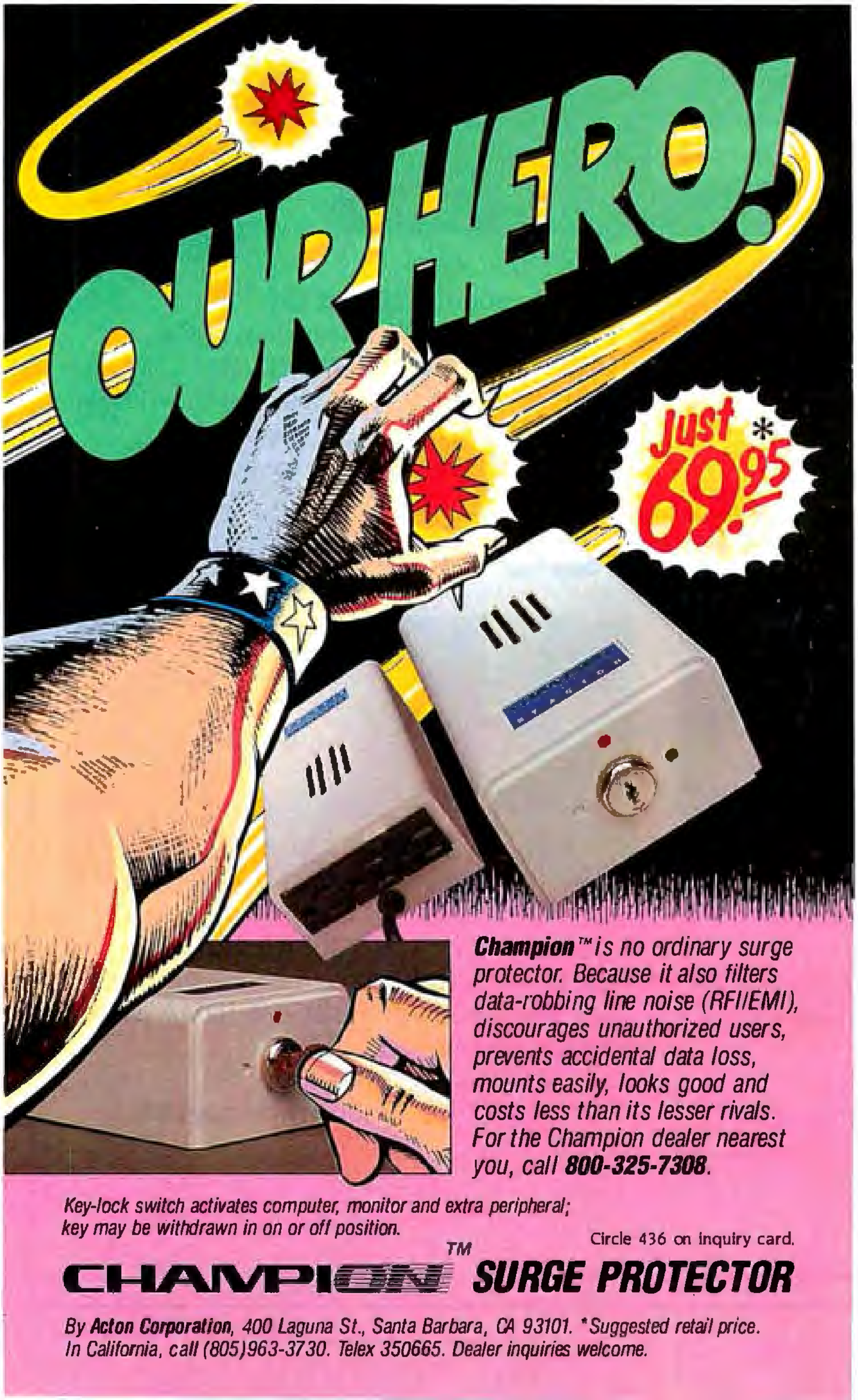
The "fuzzy image" problem is hardly unique to the Z-150. It's at least as bad for both the Z-100 and the IBM PC. Indeed, I have yet to see a color-monitor system I could write books with. High-resolution monochrome works fine, though, on both Zeniths (100 and 150) and the IBM PC itself. Incidentally, since Adeline mostly gets used on trips (I wrote some of this column with her in my Las Vegas hotel room), we have generally used Adeline's amber screen with Zorro the Z-100. She doesn't seem to mind.

THE EXCEPTIONAL TI

The one machine that has good monochrome letters displayed on its color screen is the TI Professional, which has great color *and* well-shaped letters. Nothing comes up to my standards: I use a memory-mapped video board into a high-resolution 15-inch Hitachi black-and-white monitor, which gives pleasing letters I can see from five feet away. I sure wish somebody would make something that good for new machines. The TI Professional, though, is plenty good enough, even for people with eye problems.

It has one problem: there's a rapidly blinking cursor that's optimally designed to drive you mad. Peter Flynn thinks there's a way to turn that off.

(continued)



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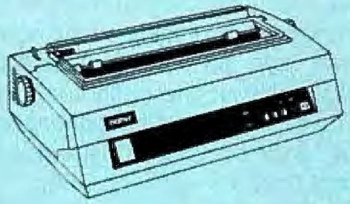

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> *The Zenith Z-150 has quite the nicest keyboard of any computer I know, including the Archive keyboard I'm using to write this with.*

I sure hope that he's right.

There's a lot to like about the TI. I was going to review it for this column, but today the TI technicians came out and did things to Big Tex. He got a new motherboard, a new processor, and a whole mess of other stuff. Alas, one of the new boards is so thick that the TI people had to remove the speech board, which is a pity; I was just getting used to the idea of using the TI as my telephone. It will dial numbers and let you talk through its headset (as well as accept voice commands).

There's much software for the TI, although not as much as for the PC or the Z-150. Alas, alas, Sidekick, Borland's nearly indispensable notebook/calculator utility, won't work with Big Tex. The good news is that I'm trying to put the TI people and Borland's Philippe Kahn in touch with each other; Philippe thinks it wouldn't be much trouble to get Sidekick working with the Professional if TI will send him a machine and the information he needs.

With Sidekick and the voice capability restored (and I'm betting TI will figure out how to get all that working at the same time before you can read this), Big Tex may just become the "master machine" to control a lot of the others here, provided that I can get that blinking cursor under control. I would like a good color/monochrome combination, and the TI has both, as well as an excellent keyboard. I may even use it as a terminal to control a genuine IBM PC.

At the moment, though, it won't even read the directory of standard IBM PC disks, so I can't even play Star Fleet I with it. I suppose there's some kind of conversion routine, but I'll never get it implemented before I have to send this off. More when I know more.

THE KEYBOARD MYSTERY

The IBM PC comes with an infuriatingly excellent keyboard.

That is: I find the sculpting, touch, and feel of the genuine IBM PC keyboard highly acceptable; excellent, in fact. On the other hand, the key layout, with that extra key between the Z and Shift, and the tilde (~) between the quotation marks and Return, is enough to make a saint weep, especially when you remember that IBM manufactures the Selectric with its wonderful keyboard.

Practically nobody likes the IBM keyboard: so what did I see all over NCC?

Why, I saw PClones with key layouts identical to the IBM but without the excellent touch and feel of the IBM. Worse, there's a plethora of keyboards that have the same goofy layout, in that there are extra keys between the Shift and the Z, and between the quotes and Return—but they aren't even the same keys that IBM put there! This is insanity cubed. The extra key near the Z is bad enough; but putting that extra key on the Return row makes it physically impossible, for me at least, to reach Return when I have my fingers on the normal home keys. Yet, having sacrificed a sane key layout, these silly companies go on to assert their independence by making their keyboard just a little different from the genuine IBM.

For instance, there's a great little Australian lap-sized computer, but I'll probably never be able to use it because my little finger's not long enough to reach Return when my index finger is on the "J" home key. Dumb.

I know why this happens: there's some kind of regulation, perhaps a union rule, that forbids anyone involved with keyboard and display design to be a touch-typist. The design engineers are pecking about with two fingers; what does it matter to them how the keys are laid out? More: because they are staring at the keyboard and not looking at the screen, they don't notice ugly scrolling, screen flashing, flickering cursor, and other distractions.

Fortunately, there are exceptions as well as remedies.

The simplest remedy is to learn to live with the IBM PC keyboard. This you can do if you buy one of those programs that rearrange the IBM PC's keyboard. There are a number of them. I use Magic Keyboard, which is run as part of my PC's start-up procedure. Magic Keyboard is a small demon that sits at the top of memory and turns those badly placed keys into about what you'd like them to be. It toggles on and off with Control-1, while Control-3 toggles the PC in and out of graphics mode, making it easy to draw figures on the PC screen.

Another remedy is to buy a Zenith Z-150 instead of a PC. The Z-150 has quite the nicest keyboard of any computer I know, *including* the Archive keyboard I'm using to write this with. For that matter, the TI Professional's keyboard is really excellent, laid out like a Selectric.

You can also buy a Key Tronic KB 5151. We've installed one on the IBM PC ("installed" = unplug old, plug in new keyboard) and it works fine. The 5151 has all the keys of the IBM PC keyboard plus some extras; and they're *much* better laid out. It's not quite a Selectric, but it's close enough. There's even a stiff-springed Reset key set where you can't possibly hit it by accident. It accomplishes the same result as the "Control-Alternate-Delete" kludge the PC wants.

The Key Tronic layout is good, it looks nice, and the keys are well shaped. Alas, I find I like the feel of the genuine PC keyboard far better than I do the 5151's. This is, of course, a matter of personal taste, and there's nothing *wrong* with the Key Tronic's feel; indeed, I'm sure that many typists will prefer the 5151, which has a soft inaudible mechanical click and good travel.

The Key Tronic 5151 keyboard measures 8½ by 20 inches, as opposed to

(continued)

the IBM's 7¾ by 18 inches. The size difference isn't really noticeable unless you have space problems. It has nice little lights to tell you if the Caps Lock and Num Lock keys are on or off, something the IBM keyboard badly needs. The cursor control keys are much more sensibly arranged, too. It may be just what you're looking for. Recommended, but try it first to be sure you like the feel.

MORE MACTHOUGHTS

Apple had a new two-story booth at NCC. The upper story was filled with minibooths, about as small as the library carrels they assign you in graduate school. Developers of Apple software were given use of these minibooths in shifts.

There are a lot of them, with some pretty impressive stuff. Probably the most impressive was a package that attaches to the print head on the Macintosh's Imagewriter (printer). Once the device, which contains a light source and an electric eye, is in place, the software package causes the print head to scan across whatever document is in the Imagewriter. The scanner sends a stream of data back to the Mac, and Hey Presto!, your document, whether words or pictures, is digitized into a MacPaint file.

There was also a program to produce poetry, namely rhymed couplets. I was reminded of the public poet in *Kismet* and his introduction song, "Fine Rhymes Have I."

There was a C compiler, said to be full Whitesmiths C.

There was a program to generate musical scores.

There were several database programs.

With the exception of the digitizer, all these programs and many more had certain things in common:

1. They were demonstrated by their owners, and audience suggestions were in general not implemented.
2. The developers said they were ready "now."
3. They promised review copies within

(continued)

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I've developed a definite love/hate relationship with my own Mac.

a few days but had none I could take home.

4. The review copies haven't come as of September 5, two months after NCC.

As I said, the digitizer was an exception: its owner said he couldn't possibly ship a review copy before September. I have a recent letter confirming that. For the rest, the software will be ready Real Soon Now; at least we can all hope so. The C compiler would be especially important, since it might enable us to write some new Mactools and utilities.

Meanwhile, I've developed a definite love/hate relationship with my own Mac. On the one hand, it writes *wonderful* letters. I find that I like doing illustrated manuscripts, printing a fried egg in the middle of a line, and simply being silly with boldface, shadow, etc.

On the other hand, it's painfully slow, and sometimes its limits are just silly. For example, after you create and store a document of any length at all, you may not be able to print it. Attempts to print produce quite a lot of disk activity lasting a minute or more, followed by the message, "Disk Full. Please Try Again."

Trying again produces the same result, and indeed you can probably stay there trying until you starve. Eventually you get the picture: this is no temporary problem. You have to do something, like erase stuff off your disk. Indeed, it turns out that you can't have very much at all on the MacWrite system disk if you want documents more than a page long. Okay. Query: why does it try to save the document for so very long before it discovers there's not enough room? Surely it could check that first.

FALLING IN LOVE WITH LOVE

What I find interesting is that everyone loves the *idea* of the Macintosh; but when pressed they don't care for the actual implementation. Everything is going to be fixed when we get hard disks and the 512K-byte memory "Fat Mac," and meantime we ought to be grateful that there's a machine to rival the IBM PC.

Macintosh is the machine for "the rest of us," the nonhackers of this world. What's interesting is that it's the hacker types who are the most passionate defenders of Mac. They don't *use* it much if they have one at all. They do their work on something else. After all, it's the machine for the naive user. Since the naive user doesn't know what small computers can do, he's not going to notice the Mac's problems; he's too busy getting his work done.

That view may even be correct. Certainly the Mac is easier to learn than the IBM PC. Whether it's easier to *use* is a different story.

I keep hoping. I really do. I don't want to see an IBM-dominated world. I have more faith in American technology than the "we must save the Mac at all costs because it's the only alternative to Big Blue" school, but I don't want to see Apple and the Mac fail. On the other hand, I'm getting very weary of the promises and hype. There was a full-page ad in the *Wall Street Journal* weeks ago showing Macscreen after Macscreen, each with a new and different application program up and running. In the real world, though, those programs will be available Real Soon Now.

Progress is happening. Dr. Michael Hyson has a new version of MacFORTH that doesn't crash unless he does something egregiously wrong. As I said earlier, there's a good Microsoft BASIC. At NCC I saw a C compiler, even though I don't have it weeks after it was promised.

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Even Philippe Kahn is getting in the act: he intends to have a Macintosh version of Turbo Pascal (for $49.95!) before the end of the year.

It could well be that the Mac will become all it was supposed to be. What bothers me is that the early purchasers were made unwitting venture capitalists when they thought they were buying "the computer for the rest of us."

SUCCESS STORY

Philippe Kahn's Borland International has done it again: this time it's a bundle of Pascal software tools called the Turbo Toolbox. I have a test version. By the time you read this, the programs will be for sale. As usual, the price is reasonable. The tools include a B-tree search and a sorting system; I've seen stuff like this, but not as well thought out, sell for hundreds of dollars.

Borland is, nearly single-handedly, transforming the micro industry, largely by doing things right. For example, the indispensable Sidekick utility has already been updated (if you run a PC or PClone without Sidekick, you don't know what you're missing). Borland keeps doing new and better versions of Turbo Pascal. A Modula-2 compiler is already in alpha test, and now Kahn's people are doing a BASIC compiler that will, of course, sell for $49.95.

Meanwhile, the people at Borland pay attention to user complaints. They keep revising their products to make them better, and they keep their prices low.

Philippe Kahn tells the story of how a bunch of venture capitalists visited his company. "We don't need venture capital," he says, "but I thought it would be fun to hear what they had to say."

What they found horrified them. Here was a company started on a shoestring. Most of the furniture comes from secondhand stores, and they use banquet tables for desks. They started out in offices above a garage and took out their first advertisements on credit secured largely by some favorable reviews (including one of mine).

They don't have any Harvard or Stanford MBAs. They do have computers, and most of the marketing decisions are modeled on spreadsheets—in fact, on the spreadsheet whose source they give you with Turbo Pascal. If the activity looks profitable they do it. It's an old Wall Street adage: "Nobody ever went broke making a profit." In these days of "profitability maximization," it's an adage often forgotten to the peril of the maximizers.

Borland sells decent products at good prices, and if you don't like what you get, you can get your money back.

That's the kind of attitude the micro community needs.

TUTSIM

It ain't easy to use, the documentation is terrible, and the user interface leaves a lot to be desired: but if you want to solve differential equations or do really complex numerical analysis on an IBM PC or PClone, Tutsim is what you need.

Tutsim is a very advanced computational program "analog computer," complete with "feedback resistors" and "condensers"; only instead of wires and walls of operational amplifiers and other hardware, you use an IBM PC and this program.

If Tutsim sold at a more reasonable price, I'd say buy it for the learning experience; I've had a lot of fun figuring out how high tennis balls rise on the fifteenth bounce and solving complex meeting engagements. It is possible, given the Tutsim program and documents and an elementary knowledge of calculus, to make your PC or PClone do some pretty amazing simulations, nothing like the big CAD simulators, but still more than worthwhile; stuff like shock absorbers, electronic systems, etc. I even managed to simulate a Richardson arms race. (Lewis F. Richardson tried to model a two-nation arms race using a series of differential equations; more on that in *Strategy of Technology* by Stefan Possony and Jerry Pournelle and "Microcomputers in the Study of Politics: Predicting Wars with the Richardson Arms-Race Model" by Philip A. Schrodt in the July 1982 BYTE, page 108.)

Tutsim has the potential to be one of the best educational tools I've ever seen. If the documents were improved and the price lowered, Applied i could really do well by doing good. A recent letter from Applied i says they're doing all that. Meanwhile, if you need Tutsim, you need it bad. It would be a really super program for the Macintosh.

EAGLE FLIES!

Two months ago I detailed the problems we'd had getting our programs out of the Eagle 1600 and over to an IBM PC. All's well that ends well. The interesting part is that our programmers, now that they know there's a way to get stuff out of the Eagle and into a PC, insist they want to work with the Eagle; it's fast, convenient, and just easier to work with.

On the other hand, fair warning: the Eagle company has problems. There's a creditor committee and a new president. The original founding president is dead, one of the major software designers is dead, and Mr. Kappenman, the Eagle founder I worked most closely with, has left the company. Rumors fly about the long-term survivability of the company.

That's a subject I know little about. I've taken a number of courses in economics and finance, and I'm supposed to know a lot about political economy; but I preserve my reputation as a financial wizard by not making predictions.

I do like Eagle machinery. I'm not fond of the documents. Eagle people have been helpful to me on the phone, but my correspondents give mixed reports, depending on when they called.

Eagle has more or less discontinued the 1600 series. At least, orders are not being taken. The Spirit XL is a very nice portable PClone about 98 percent PCompatible.

My troops like Eagles. So do I. More than that I can't say.

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lems were solved in a number of parallel ways. First, Dave Sturgiss of Eagle took copies of our disks and had the Eagle engineers transform them to standard IBM PC format. That worked fine. (Understand: our data-transport problems were with the 1600; there is no such problem with the Eagle Spirit XL or the Turbo PC.)

At the same time, Dave Butterfield of Locus Computing, the Santa Monica outfit that designed much of the AT&T 3B2/300 networking software, managed to read the Eagle disks into a VAX and use the Locus networking system to download onto an IBM PC. That worked fine, too. Thanks, Dave.

The Disk Maker I people are solving the problem generically by teaching Disk Maker I to read Eagle 96-tpi disks.

Finally, the Eagle engineering people swear blind that if your Eagle disks are aligned *just right* they're able to write to an IBM PC format just fine. You may recall that I'd thought it was alignment and sent the troops out to buy a new disk drive rather than try to align the old one. It turns out my idea was right, but the alignment is *really* critical. Anyway, Dave Sturgiss is arranging to have Eagle align both my drives. We'll see how that works.

ITEMS DISCUSSED

Design Automation System . . . Not Available
Intergraph
One Madison Industrial Park
Huntsville, AL 35807
(205) 772-2000

Macintosh $2495
Apple Computer
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

Microsoft BASIC for the Macintosh $150
Microsoft Corporation
10700 Northup Way
Bellevue, WA 98004
(206) 826-8080

M.U.L.E. $40
Electronic Arts
2755 Campus Dr.
San Mateo, CA 94403
(415) 571-7171

Sidekick $49.95
Turbo Toolbox $49.95
Borland International
4113 Scotts Valley Dr.
Scotts Valley, CA 95066
(408) 438-8400

Spirit XL $4795
Turbo PC $4995
Eagle Computer
983 University Ave.
Los Gatos, CA 95030
(408) 395-5005

Star Fleet I $49.95
postage and handling $2
Cygnus
POB 57825
Webster, TX 77589
(713) 486-4163

TI Professional . . . . from $2495
Texas Instruments
POB 402430
Department DCA232BY
Dallas, TX 75240
(800) 527-3500

Tutsim . . . . $350–$2000
Applied i
200 California Ave.
Palo Alto, CA 94306
(415) 325-4800

Zenith Z-150 . . . . from $2199
Zenith Data Systems
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Glenview, IL 60025
(800) 842-9000 ext. 1

5151 Keyboard $255
Key Tronic Corporation
POB 14687
Spokane, WA 99214
(509) 928-8000

3B2/300 . . . . $9950
AT&T
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New York, NY 10038
(212) 669-2584

I have seen and worked with the wonderful Eagle Turbo PC. The company keeps promising me my own copy, but every time one is available a new wave of orders comes in. Sturgiss says he can't even keep one on his desk; the salespeople roam the halls looking for machines to ship. The Turbo PC is about 98 percent IBM PC compatible (Lotus 1-2-3 and Flight Simulator, including the World War I mode, run right out of the box), but in keeping with Eagle's philosophy it does more than that. It has an 8086 (rather than IBM's 8088) and runs faster than the IBM even when the Eagle is in its "slow" or "compatible" mode. It also has a "Turbo" mode that goes like sin.

The Eagle Turbo PC is apparently a souped-up 1600 with added features to make it as nearly IBM PC compatible as Eagle can manage. It has more slots than an IBM; it's faster; and it has a better keyboard arrangement. I would be very glad to hear that Eagle is alive and well.

It's a real dilemma for columnists: if we don't recommend good companies, they may very well die. If we do, and they die anyway, we deservedly get letters from those who bought machines only to find they have orphans.

Eagle has contracted with Bell & Howell to provide servicing, including warranty service, through 1989, so that removes one worry.

Use your own judgment on this one.

WRAP-UP

Once again, I'm out of space before I've finished my list.

There are two games of the month: Star Fleet I, which is likely to drive me crazy but I keep coming back for more, and M.U.L.E. from Electronic Arts. M.U.L.E. is a cross between Hammurabi, Diplomacy, and an arcade game, with lots of subtle strategic decisions—provided that you're skillful enough with a joystick to implement what you've decided to do. The kids love it. I like it well enough except for the arcade aspects; I've never been very good at hand-eye coordination. I managed to beat two boys and the computer, though; strategy experience will tell . . .

The PClone of the month is still the Z-150; it's full of surprises, all good ones.

The book of the month is *The Recursive Universe* by William Poundstone (William Morrow & Co.). This is a thought-provoking series of essays on thermodynamics, Maxwell's Demon, the Game of Life, and Fifty Million Monkeys. I read it off and on during lulls in the Olympic modern pentathlon competition. Recommended.

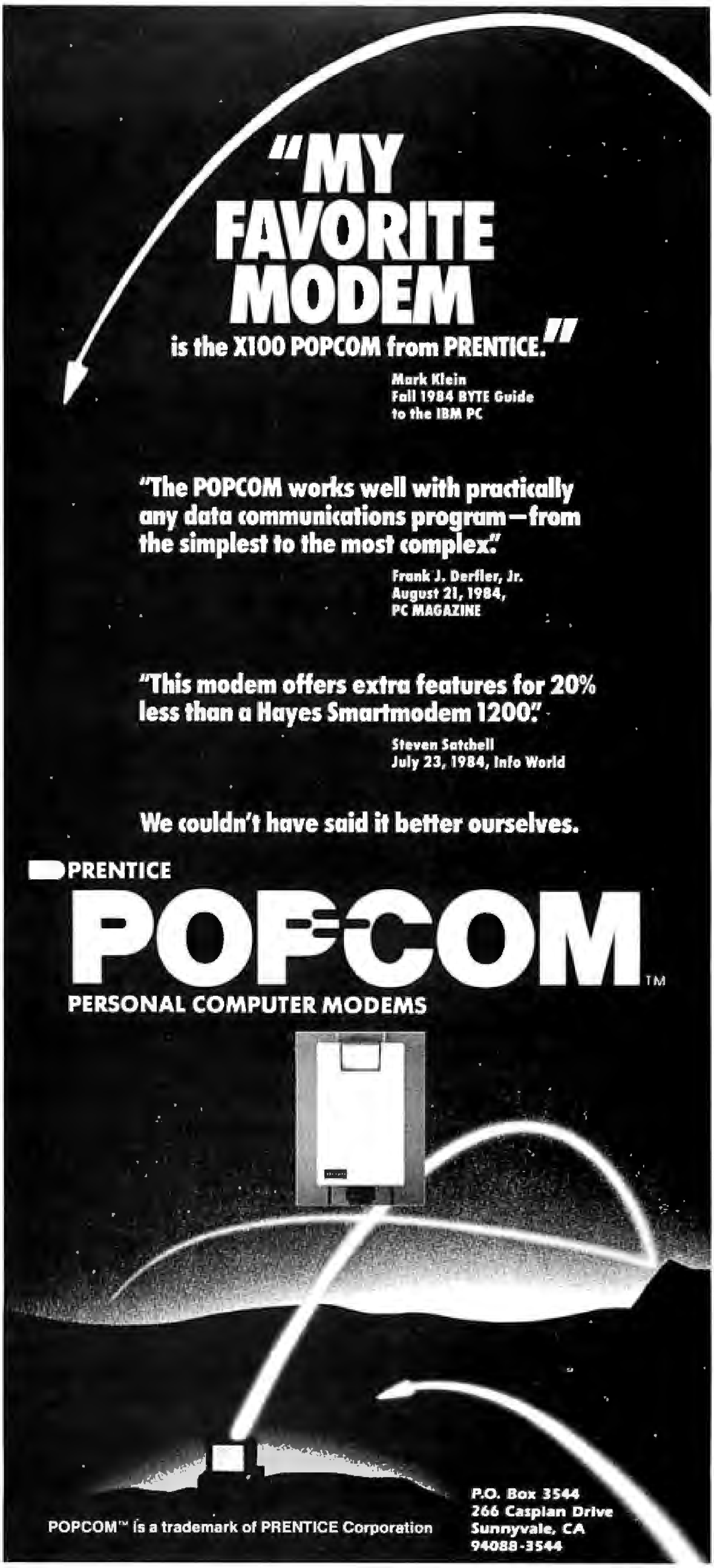
Next month, with any luck, I'll be done with *Footfall* and can clean up some of that threatening pile of unreviewed software. ■

Editor's Note: Rejoice. Footfall *is finally finished. For those who don't know,* Footfall *is the latest Niven/Pournelle science-fiction novel spectacular. Look for it from Ballantine Books next spring.*

More good news. You don't have to go to a computer show to get a signed copy of the Pournelle Users Guide poster. This is a wonderful thing, done by Robert Tinney, showing Pournelle astride a stack of dead computers, ready to do battle with yet another. You can get one free at the BYTE booth at most computer shows. If it's one either Jerry or Robert are at, they'll be glad to sign it.

For those who can't go to shows, Workman and Associates (112 Marion Ave., Pasadena, CA 91106, (818) 796-4401) is selling 25 numbered copies signed by Tinney and Pournelle and 1000 signed or inscribed by Jerry alone. If you'd like it inscribed to a certain person, make that clear in the letter ordering the poster. It's sent in a mailing tube, postpaid. Inscribed posters will take a couple of weeks longer, since Jerry does these in batches.

Jerry Pournelle welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE Publications, POB 372, Hancock, NH 03449. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply.



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C·H·A·O·S M·A·N·O·R M·A·I·L

PANCHO? TONTO MAYBE?

Dear Jerry,

I found Borland's Sidekick to be generally well designed and implemented except for two inconvenient features.

First, it is copy-protected, meaning it can't be copied onto a hard disk or RAM disk for faster operation. The whole utility doesn't reside in memory; it reads from help text files and notepad document files on the disk. Since the whole idea of Sidekick is that it be available at the poke of a key, that means it has to occupy a disk drive all the time or you wind up changing disks very often.

Second, when you try to run GW BASIC with Sidekick in the background, the computer hangs up. You can't break out of it; you can only turn the computer off and on again. This is *extremely* hazardous for computers with integral hard disks. It means a guaranteed head crash unless your particular model of hard disk automatically retracts to a landing track after a certain period of inactivity. Before you can run GW BASIC, you have to reboot to get rid of Sidekick. Again, this is quite time-consuming and therefore inconvenient for a hard-disk user. I was told that Borland is working on that bug and that a GW BASIC-compatible Sidekick is in the works.

These two faults combine to make Sidekick much less useful than it could be. In a machine with one hard disk and one floppy disk, it's more of a kick in the side than a sidekick. In all fairness, I was told that a hard-disk version will probably be offered at a higher cost Real Soon Now.

If your machine has a hard disk, wait for the hard-disk version. If you use GW BASIC a lot, wait for the friendly version to come. If you have only one floppy-disk drive, Sidekick may not be worth the additional disk changing.

Changing subjects, as president of SAPASSLA (the Society of American Programmers Against Silly Software License Agreements) it is my privilege to inform you that at our last meeting you were named honorary chairman for the courageous way in which you have championed the cause of common sense in our young industry. We all owe you a debt of gratitude.

DAVE HAMNER
Hudson, OH

Actually, both you and I have read the documents wrong: you can put Sidekick on a hard disk very easily. All you have to do is copy all the files over (except SK.EXE). Then, when you turn the machine on, you do SK from the A drive. You can then remove the Sidekick disk until the next time you turn the machine off. I'm no fan of copy protection, but I have to admit this is the least harmful kind. Incidentally, Philippe Kahn tells me he's starting a new policy to make life even easier for Sidekick purchasers.

In the fine print of the Sidekick documents, it tells you there's a configuration program that lets you tell it that the notepad and help files are on a drive other than A, and once you've done that configuration you never have to do it again. Thus, the hard-disk version works already—and at no extra cost. I do agree: if you have only one disk drive, Sidekick is probably not worth the effort.

I asked Kahn about GW BASIC. He's never tried it. If you really have problems, Borland will refund your money. Oh—and there's a new version of Sidekick that will even work with the Pro-Key keyboard rearranger. I don't myself care for Pro-Key because it messes about with the machine's registers; I prefer Magic Keyboard. However, for Pro-Key fans, there's a new Sidekick that works with it; maybe it will work with GW BASIC.

Thanks for the election. I'll try to live up to the office.—Jerry

IS TURBO THAT GOOD?

Dear Jerry,

I happen to have a copy of Turbo Pascal version 2.0 for my personal computer and think that it's really the best Pascal available, especially considering the price. However, I am getting a little tired of people's unbounded praise for it. Look—it's very good, but it's not perfect. What really prompted this letter was your remark in June that you haven't heard one complaint about Turbo Pascal. Here are a few.

As part of its ultraefficient operation, Turbo has some compiler-directive defaults that can be extremely frustrating to the novice who doesn't yet know how to set them. For instance, recursion is not allowed, there is no way to stop program execution (e.g., endless loops) without turning the computer off, and subscript checking is not performed. In case the problems of no subscript checking have never occurred to you, consider what would happen if you tried to read a string of length 132 into a variable declared to be of length 5. That's right—it gets read in and possibly writes over the operating system. I've never seen a Pascal (or any other language for that matter) that lets something like that happen!

As those who have Turbo know, when you first get it you have to "install" it. You supposedly have the opportunity to define whatever keys you wish to operate the editor with, including the programmable function keys. Problem is, some programmable function keys (depending on the specific ASCII code they generate) just won't program in; that is, the editor ignores them. Borland promises to fix this in version 3.0. Also (at least on CP/M-80 versions), you must first install the editor commands, then install the terminal; any other sequence used to install the editor commands will not work. The result would be that the default WordStar editor commands are used instead.

I'd also like to point out what I feel is an outright design mistake on the part of Borland. First, a little background. During my upbringing on Pascal, I've learned what I feel to be a rather effective method of inputting sets of data: use the end-of-line (EOLN) function to test for the end of a particular data element (it's set true by a carriage return) and use the end-of-file (EOF) function to test for the end of a data set (this is set true by the end-of-file character Control-Z). If this isn't real clear, imagine reading in several names to several groups. The end of each name is indicated with a carriage return, and the end of each group is indicated by a Control-Z. Every other version of Pascal I've used has al-

(continued)

lowed this sort of control scheme without any hitches, but not Turbo.

The folks at Borland found an obscure paragraph in the manual to justify this. It states that in the special case of reading in strings from the CON: device, if a string read in is terminated prior to its defined length (i.e., entering eight characters for a string defined to be length 10), then a Control-Z is appended to the string. Of course, this Control-Z sets EOF to true even though one has only hit a carriage return.

The Turbo manual (along with every other Pascal book) states that EOLN is set true by either a carriage return or an end-of-file character and EOF is set true only by the end-of-file character. The only justification Borland can offer for this obvious contradiction is that the manual says it's supposed to work that way. There is no sensible explanation for it. One way around this is to change the default I/O device to TRM:, but this can create other problems I don't feel like elaborating on.

I'm not *down* on Turbo, but I am just a little tired of people claiming it's absolutely perfect. Let's face it folks, nothing's perfect or above criticism.

RION T. CASSIDY
San Luis Obispo, CA

Gee, did I go overboard in my first appraisal of Turbo? Possibly. On the other hand, I was so pleasantly shocked to see a good product, marketed intelligently, priced reasonably, and put out by really nice people—

Your points are well taken. Thanks.
—Jerry

NETWORKS AND BULLETIN BOARDS

Dear Jerry,

I want you to consider coverage in your column of the telecommunications resources, from local bulletin boards to networks like CompuServe. I'm sure you have had at least some experience with these. Why don't you join in message exchanges on CompuServe's IBM PC Special Interest Group subsystem (just type GO PCS131). By the way, that SIG is not affiliated with nor supported by IBM.

Also, we would like to hear more about your experiences with public-domain software. There are some great programs out there for the IBM PC, like PC-Talk, Newkey, PC-File, and dozens of utilities to browse through files, look at directory contents, and selectively delete files.

These are generally available through CompuServe's SIG databases and also from the local boards. Boards are great sources of info and gossip. Come join in! You'll spend more time than you probably have to spare, but you'll have fun. And just think of the expansion of the effectiveness of your efforts to promote sanity in this industry. Some of the principals of some companies are participating now on CompuServe. For example, Philippe Kahn gets instant give and take about his products there.

LARRY WEISS
Garland, TX

Agreed: now that Footfall *is done I can devote more time to playing about with small computers, and I'd love to. Learning more about what's available from networks and bulletin boards will be one of my first tasks. I'd appreciate tips on where to begin. I've been out of touch too long.*—Jerry

BELIEVE IT OR NOT

Dear Jerry,

In the April BYTE (page 64), you mentioned some things about telephone customer software support. Because I work in customer support for a good-sized OEM I was intrigued. You were right on most aspects of the game. It is difficult, boring, and tends to drive the best people out fast.

To show you what the other side of the picture looks like, I transcribed one half of a telephone conversation that is very close to what a real customer-support person finds himself doing for several hours per day. In reading this, you must imagine the poor man (or woman) speaking into a telephone handset, hunched over a pile of mostly out-of-date manuals, in a small room with at least four other people doing the same thing. The name, of course, has been changed to protect the guilty.

"Hey, this is Rupert with Enisoft, what's up?"

"You can't get anything on the screen?"

"Well, is it plugged in?"

"No, look in the back of the terminal."

"No, the back—the side opposite to the side with the screen on it."

"Okay, good."

"Can you see the black cord coming out? Yeah? Okay, is it plugged into the wall?"

"It's lying on the ground? Okay, so you can see the cord part of it. What's the end of the cord doing—I mean, where can you see the end of the cord?"

"It's lying on the ground, too? Okay, well there's our problem. You need to plug it into the wall."

"No, there's a hole in the wall. Can you see it?"

"Okay, now the prongs on the plug—see them, they're on the other side from the cord—no, no, on the plug, not the terminal—they go into the hole."

"It won't go in? Okay, are you sure it's right side up? The single prong should go into the bottom hole . . . No, it sounds like you have it sideways . . . Look, it plugs in just like a vacuum cleaner."

"There is no third hole?"

"Okay, so on that one socket you're looking at there are only two holes, then the screw below that."

"And the plug definitely has three prongs on it. Okay, I'm going to have to get back to you on this."

CHARLES SHAPIRO
Atlanta, GA

Ye gods!

Actually, I think Digital Research has made a ghastly mistake with its new technical-support policy. The other day Jim Hudson told me he spent three weeks *trying to get hold of someone there to tell him why his Digital Research C compiler kept blowing up when he tried to use 8087 math-chip routines.*

Eventually, after DR people continually refused to talk to him until he paid his $250/year technical-support fees, he got hold of someone there who wanted to buy one of his Zenith Z-100 8087 support boards—and told them he wouldn't sell until they answered his question.

The answer was that the compiler, or at least the version he had, didn't support the 8087 math chip although the advertisements said it did.

I don't think anyone should have to pay $250 a year to find out that a product doesn't do what the advertisements say it does.

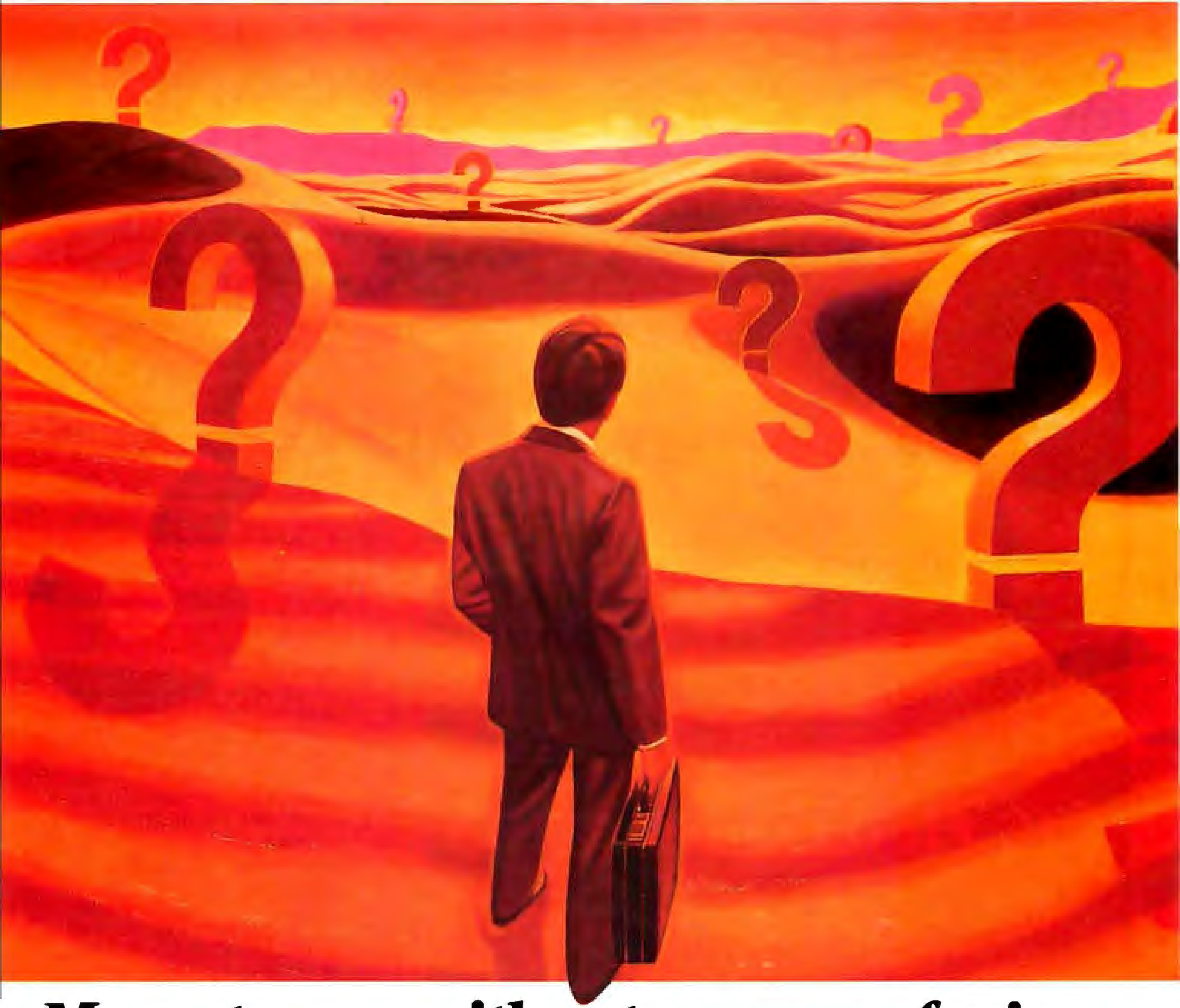
Last minute note: DR people say they agree with me and that they are retraining some telephone receptionists. We'll see. They also say the newest version of the compiler can use the 8087. I haven't seen it.—Jerry

SCIENTIFIC LANGUAGES

Dear Jerry,

I read with great interest Jay Pasachoff's

(continued)



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letter to you (April, page 404). Although my current position is that of director of a computing center, my background is in astronomy, which qualifies me to comment on his views.

To begin with, Mr. Pasachoff overstates the case when he writes that ". . . it seems unlikely that scientists will change to Pascal, Modula-2, or whatever." *Some* scientists will undoubtedly never abandon FORTRAN until they are forced to. But many of us adopted better languages a long time ago. When I worked at the U.S. Naval Observatory, a large part of the programming was done in PL/I. Languages such as BASIC, C, and Pascal also are widely used among scientists.

It is simply not true that ". . . physics and astronomy students simply have to learn FORTRAN." Like students of any other disciplines, those in physics and astronomy should be introduced to programming by use of a structured language, such as Pascal. Although a student whose first introduction to programming is by way of FORTRAN may not be permanently brain damaged, as some computing professionals feel, Niklaus Wirth's observation that it is difficult to find a language that incorporates structuring principles to a lesser degree than FORTRAN is certainly relevant. Even FORTRAN-77, which provides some of the control structures so lacking in FORTRAN-IV, still fails to include a number of necessary features, such as recursive subroutines, and remains, in my opinion, an inferior language.

After they have mastered a structured language, physics and astronomy students may want to learn a little FORTRAN to be able to interpret FORTRAN programs written by others or to incorporate FORTRAN subroutines into their own programs. Such needed subroutines can always be linked with a main program written in a structured language. With our VAX-11/780 it is simple, as long as you are careful when passing parameters, to link a main program written in, for example, Pascal, with a FORTRAN subroutine.

Three cheers to you for being unrepentant about FORTRAN and for your pertinent comments. Perhaps with the development of new languages such as Ada and Modula-2 many scientists will finally give up their obsession with FORTRAN and realize that more suitable languages exist for their programming tasks.

RICHARD BRANHAM
Mendoza, Argentina

Thanks for the kind words.
I haven't repented yet!—Jerry ■

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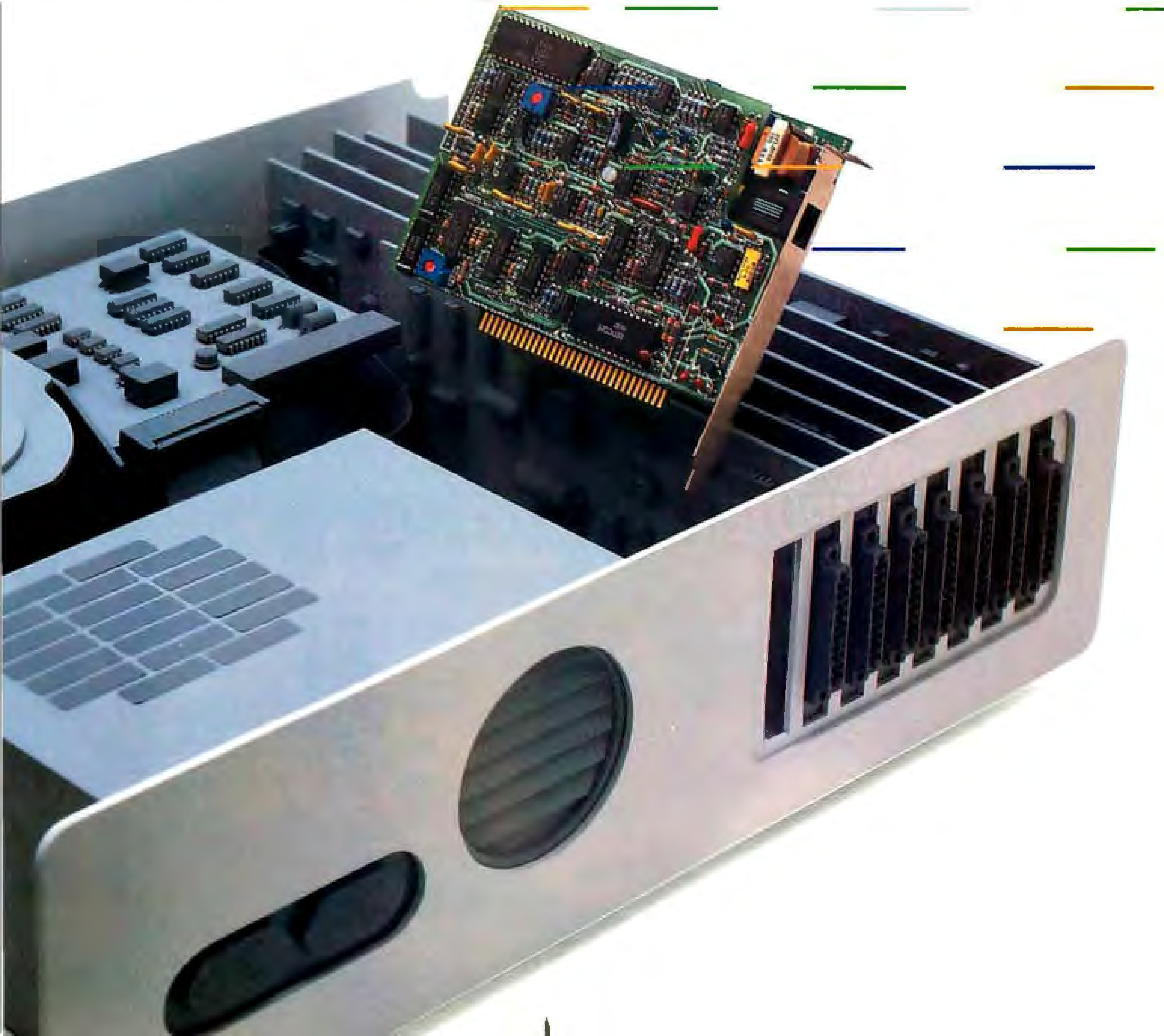

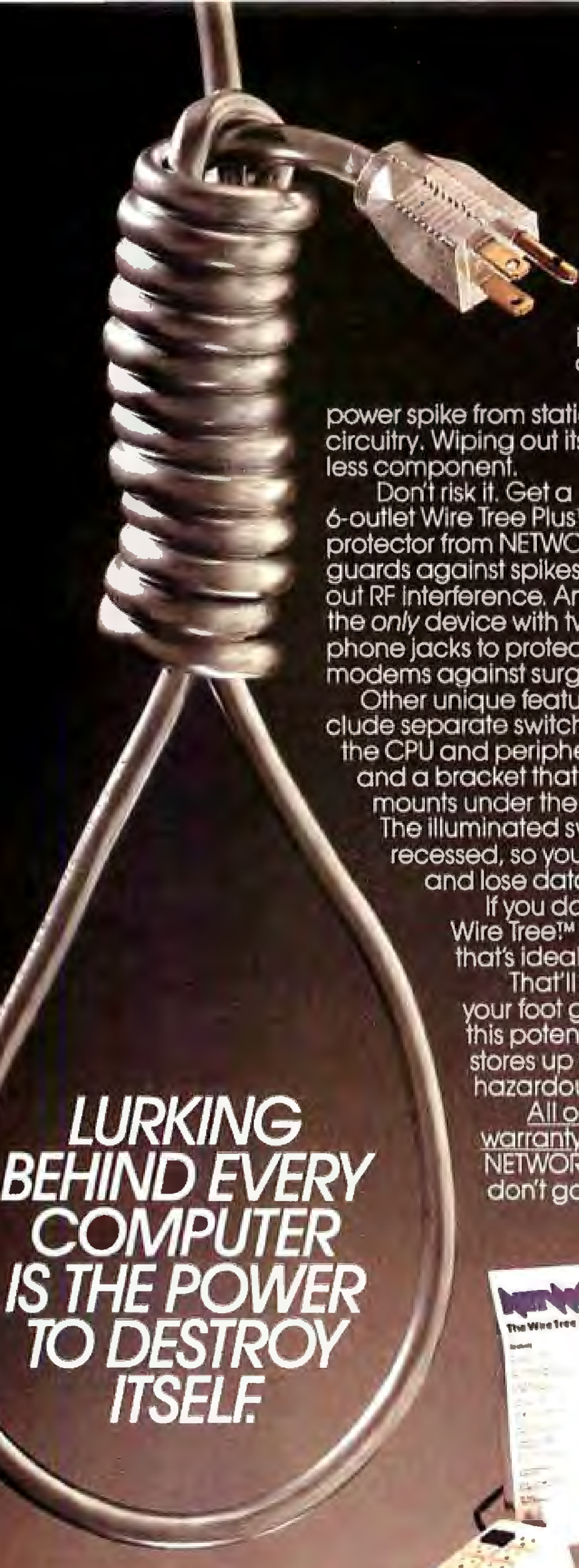

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New Developments

The dBASE Compiler package, new printer technology, pfs:Plan, and talking Macintoshes

BY JOHN MARKOFF, PHIL ROBINSON, AND EZRA SHAPIRO

Ezra Shapiro (McGraw-Hill, 425 Battery St., San Francisco, CA 94111) is BYTE's West Coast bureau chief. John Markoff and Phil Robinson (1000 Elwell Ct., Palo Alto, CA 94303) are BYTE senior technical editors.

Two of the most widespread database-management programs ever marketed are dBASE II and dBASE III from Ashton-Tate. A key to their success is their programmability. Although the programs themselves are fully functional, their cryptic command structures are a source of frustration for many users. As a result, consultants and programmers have built a lucrative profession out of manipulating the products' built-in programming language to produce menu-driven database packages in which the end user is completely protected from dBASE.

However, it has not all been gravy for dBASE programmers. In order to market an application for dBASE, a developer either had to purchase one copy of Ashton-Tate's RunTime module for each copy of the package he wished to sell, or distribute original, unprotected source code that could easily be pirated.

Today, a package called dB Compiler from Wordtech Systems of Orinda, California, may be the answer to many dBASE programmers' dreams. The program, which consists of a compiler and a linker, is similar in operation to many Pascal compilers. It takes source code written for Ashton-Tate's dBASE products and compiles it into low-level intermediate code (so much like Pascal's p-code, in fact, that authors Richard Sheng, San San Sheng, and Charles Chou refer to it as "d-code"). The dB Compiler program then builds a command file and several overlays (PC-DOS and MS-DOS versions produce an .EXE file and two overlays; the CP/M-80 version yields a .COM file and three overlays) that incorporate emulation of most major dBASE functions and the application programmer's material. A word processor can create original source code for dB Compiler; actual dBASE is required only for interactive program debugging and for database file creation, which dB Compiler does not support.

The dB Compiler package is essentially a self-contained new program that parses dBASE syntax. It handles all dBASE commands and functions except those interactive commands that would drop the user back into dBASE when finished. The program's authors decided that dB Compiler would use interpreted d-code, rather than compile all the way down to assembly language, in order to support the dBASE macro substitution facility.

As Wordtech doesn't impose any license fees for the programs produced with dB Compiler, a developer is freed from the RunTime requirement and can market dBASE applications at a much lower cost than before. In addition, compilation represents an effective form of encryption that protects the author's original source code.

Furthermore, dB Compiler is a handy tool for businesses. A firm that wished to develop a complex dBASE application to be used by a large number of employees on separate microcomputers would have to purchase one copy of dB Compiler and one copy of dBASE—period. The application programs created by dB Compiler could be distributed in unlimited quantities.

Wordtech's principals, Dave Miller and Mike Gardner, are quick to point out that dB Compiler may not offer the same speed increases that other programming language compilers do. Some operations are much faster than they were, while others are a bit slower, depending on the size of the database, the type of data being handled, and the nature and complexity of the manipulations performed. In general, they predict a 20 to 25 percent increase in speed under most conditions.

The current price of the dB Compiler package is $750. A CP/M-80 version was shipped around June 15, generic MS-DOS on July 8, PC-DOS on August 8, and a CP/M-86 version was planned for the end of August. Cross-compilers (to compile source under one operating system for use under another) are available for $350 each. These are all compilers for use with dBASE

(continued)

II. Wordtech plans to develop a 16-bit version for dBASE III and intends to announce a trade-in policy in the near future. The purchase price includes free bug fixes forever and free upgrades for one full year from the date of purchase.

MAGNETIC PRINTING RIVALS LASERS

Recently a number of U.S. companies, including Hewlett-Packard, have introduced their own versions of the Canon laser printer, and Apple Computer is set to use the Canon as a print-server in its promised network of Macintoshes and Lisas. But as soon as it appeared that the personal computer industry had settled on laser printing as office automation's technology of the future, a new rival appeared on the horizon.

Ferix, a start-up company from Fremont, California, has introduced a novel magnetic printing technology that may potentially undercut low-cost laser printing before it gets off the ground. The first Ferix product, the Model 800 Magnetic Printer, looks like a desktop copier. However, it has an 8085 microprocessor, contains both serial and parallel interfaces, and has both ROM (read-only memory) and RAM (random-access read/write memory) cartridges to allow you to alter fonts. With the addition of a graphics controller, the Model 800 can function as a bit-map printer.

The Model 800 is targeted at almost exactly the same market as the Canon laser printer. It prints 10 pages per minute (14 pages in duplication mode) and is designed for applications that print between 2000 and 10,000 pages per month. The cost of supplies (not including paper) may fall as low as one cent per page. Ferix plans to sell the model to OEM (original equipment manufacturer) distributors for between $2000 and $3000, depending upon the quantity ordered and the features desired.

Ferix uses a semiconductor-like process to produce a thin-film magnetic printing head that differs significantly from traditional ring/core heads that employ wire coils wrapped around a soft magnetic material. Instead, the Ferix technology incorporates an "inside-out" architecture that focuses magnetic flux patterns to produce distinct magnetic boundaries in an array of magnetic heads. Inside-out in this case means that each individual magnetic coil (which is lithographically deposited on a substrate) is actually embedded in a magnetic material shaped like a half doughnut. This approach results in a flux pattern that generates less interference, or crosstalk, between individual heads and produces sharper characters with higher definition. The Ferix head projects the flux pattern through the plane of the substrate instead of off an edge as in traditional recording techniques. Although the manufacturing process of the flexible thin-film head is similar to that of semiconductors, it uses an entirely wet chemistry and 7-micron technology—a much larger scale.

The head array is embedded in a flexible strip that slides across a rotating drum. The heads deposit a magnetic bit-map image on the drum material that is similar to the magnetic material used in conventional floppy disks. After the image is recorded, toner is transferred from the drum to the paper and fused in a manner somewhat akin to a traditional xerographic process.

One of the intriguing aspects of the Ferix process is that once the image is written to the drum, it stays indefinitely, allowing the device to easily function as a copier. The magnetic image is deposited on the drum as if it were an 8½- by 11-inch sheet of paper (three lines at a time in the daisy-wheel emulation mode).

Ferix President Pete Wilson claims that the printer is currently capable of

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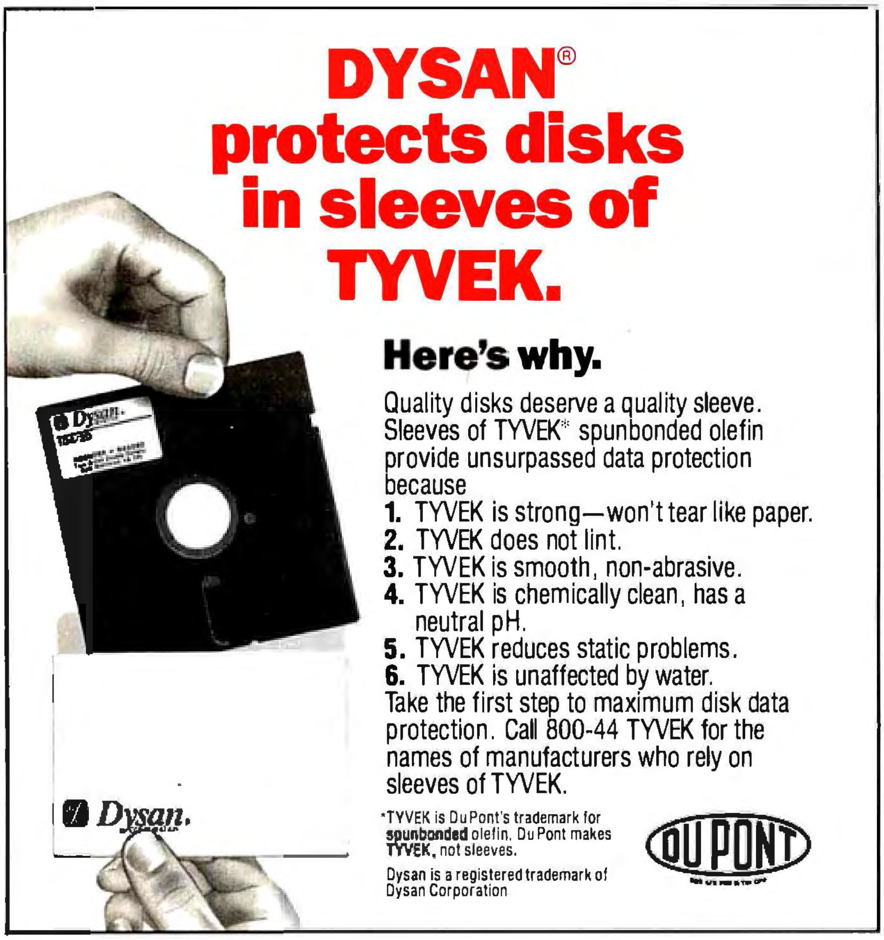

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The Model 800 produces excellent gray scales and sharp images.

densities up to 240 by 240 dots per inch, but adds that this is conservative in terms of the potential of thin-film magnetic technology. The current pixel size is 6.5 mils. The speed of the current model is also nowhere near potential; much higher-speed printing should be possible in the near future.

Wilson also says that the printing-head technology is generic enough that Ferix could place it in both higher-performance, more expensive printers and less expensive desktop models that could compete with the high end of the daisy-wheel market.

We are impressed with the printing samples that Ferix showed us, although the one graphics sample was slightly less dense than the output we've seen from laser printers. However, the Model 800 produces excellent gray scales and sharp images.

So far, Ferix is the only U.S. company that has introduced a thin-film magnetic printing technology. Both a French and a Japanese company are currently selling printers based on more expensive magnetic technologies.

YET ANOTHER SPREADSHEET

Does the world need another electronic spreadsheet? With a personal computer software market flooded with the likes of Multiplan, SuperCalc, Lotus 1-2-3, and even two VisiCalcs, how can yet another program be added to the deluge? With the introduction of pfs:Plan, Software Publishing of Mountain View, California, is betting that there's room for another contender—at the low end of the market. The company has already scored with this strategy; the success of the PFS family (pfs:Write, pfs:File, pfs:Report, and so on) has firmly established Software Publishing as a leading money-maker in an overcrowded software industry.

They've also been eyeing statistics from Future Computing, the market-research firm, about the purchasers of new personal computers; something like 23 percent of all microcomputer buyers get spreadsheet software at the same time they purchase their machines. That's a hefty market, and with a $140 list price for pfs:Plan, the company hopes to attract a significant chunk of it.

The program represents one of Software Publishing's biggest product-development efforts to date; it

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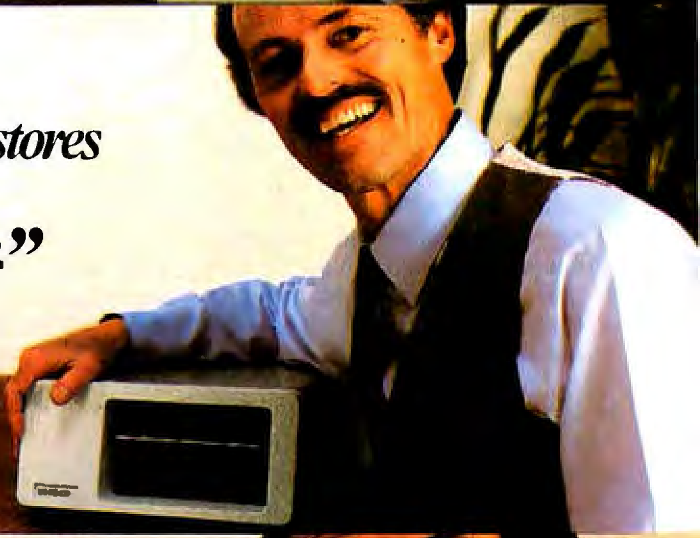

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Perhaps pfs:Plan's nicest touch is that it can read values from data files written by other programs.

took two years to bring pfs:Plan, developed mostly in Pascal, to market.

The version we saw recently wasn't quite ready to go out the door, but it had a number of interesting aspects. Like other third-generation programs, formulas in pfs:Plan use a very English-like syntax. They are built around user-defined column and row headings, rather than numbers. A typical formula might look like "Profit = Sales − Expenses."

Construction of worksheets as large as those allowed by programs like Lotus 1-2-3 is not permitted by pfs:Plan. However, it is big enough for models based on five-year projections with quarterly columns and summaries. It also includes automatic consolidation, the ability to add in numbers from other spreadsheets, and the ability to clear values from a spreadsheet without destroying headings and formulas (similar to the Zap command in Microsoft Multiplan). And there's an additional feature that isn't seen in other spreadsheets: pfs:Plan allows *targeting*—the ability to constrain one variable in an equation embedded in the spreadsheet. With this feature, for example, you can set gross margin goals and then compute the required sales. The only thing we found that was obviously missing from pfs:Plan was a set of statistical functions, though there is a series of financial functions that can be built into equations.

Perhaps pfs:Plan's nicest touch is that it can read values from data files written by 1-2-3, Multiplan, and VisiCalc (just numbers—not formulas). This feature should make pfs:Plan even more appealing to first-time buyers.

More on SoftOffice

SoftOffice, the icon-based integrated package for the IBM PC and PCjr mentioned in this column in June, will be distributed in the last quarter of 1984 by BreakThrough Software, 505 San Marin Drive, Novato, CA 94947, (415) 898-1919. The price was not announced at press time.

A Smooth Talker

The BYTE Palo Alto office is becoming the BYTE Macintosh office, with software (pre-pre-release versions largely), hardware (such as the Corvus hard disk), and press releases rolling in every day. Amidst a growing chorus of "Yes, the Mac is fun but what can you *do* with it?" we are starting to see some real live software.

Dave Fradin, the president of First Byte, came through the office to show off the Macintosh version of Smoothtalker, a speech-synthesis program. Dave was visiting more than just the BYTE offices; he was on a full tour that included a "talk-off" the following week at Apple, where Smoothtalker and Mactalk would compete "mouth-to-mouth."

First Byte expected to sell 10,000 copies of Smoothtalker between the September 1 release date and December 1. The program was first developed for the Apple III—Dave Fradin used to work for Apple as the business unit manager for the Apple III. First Byte sprang out of PCMA (Professional Computer Marketing Associates), which distributed Apples in Southern California.

First Byte called up lots of Apple Macintosh owners and asked them if they would like a program like this. Supposedly, 70 percent said yes. When asked how much it would be worth to them, $150 was the figure that was often quoted and will be the price of Smoothtalker. In 1985, First Byte hopes that the computer that

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has speech will have an important edge over the computer that doesn't. Fradin illustrates that appeal with an analogy to Dolby sound: as Dolby is to "hiss elimination," so Smoothtalker will be to speech synthesis in personal computers.

Smoothtalker will be available only on the Macintosh at first but then will be adapted for other machines. It will be available in two forms: as a complete package for individual customers and as modules that can be linked to other software. The modules can be called directly from Pascal, BASIC, or FORTH programs.

There are already two and a half years of work in Smoothtalker, which is written mostly in Pascal and assembly language. It meets the first three criteria imposed by First Byte: adherence to the Macintosh interface, software-only implementation, and a small memory requirement (it uses only 18K bytes). First Byte also claims the Smoothtalker voice will meet their self-imposed criteria: naturalness, intelligibility, and good long-term effect (doesn't fatigue the ear).

Smoothtalker accepts ordinary English text—up to the length of a MacWrite file—and reads it through the Macintosh speaker. It is said to use 1200 rules of pronunciation, which may explain why it was able to handle numbers, symbols (such as +, $, and @), and many abbreviations. Enhancements will include foreign-language pronunciation, a user dictionary (where you can enter whatever pronunciation you want a word to have), and the ability to adjust the sex, pitch, volume, speed, bass, and treble levels of the voice. And you'll be able to change any of these factors within a speech. Smoothtalker also analyzes sentence structure to change intonation for questions and the like.

Fradin claims that the Smoothtalker in its original form—written for the Apple III—used only 20 percent of the power of the 6502 central processing unit. That is one of the claims of Smoothtalker's superiority over Mactalk. Mactalk eats up all the processor's time, says Fradin, which

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means the computer can't do anything else while it is speaking. (And please don't let me hear anyone say "Can't talk and do graphics at the same time?") The pre-release version of Mactalk I heard couldn't handle numbers or abbreviations, either.

Smoothtalker has a rasp at the end of its "s" sounds where Mactalk doesn't. The version some heard at NCC (National Computer Conference) had phonemes recorded by an engineer in a garage next to an Orange County airport. The version I heard—recorded by the same engineer but in a sound studio—was supposed to be two orders of magnitude below the version scheduled for September release. The documentation and a spoken tutorial will be on the disk.

Smoothtalker uses a proprietary wave-form compression method along with phonetic smoothing to make a sonorous voice while using only a little RAM. Fradin claims this scheme is superior to the LPC (linear predictive coding) scheme used by many other synthesizers, including Mactalk. Smoothtalker uses a digital-to-analog converter (DAC) to produce the voice. The Commodore 64 and

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the Atari computers have a DAC. The Apple II and IBM PC will require an add-on DAC board.

Smoothtalker is designed for incorporation into other programs and into computers (maybe as a ROM). The First Byte Company sees the use of Smoothtalker in various applications; for example, imagine your computers being used in the classroom, saying "Don't worry if this is the first triple-integral you've seen." In entertainment it might say "The engines can't take Warp 7 for long, sir."; in custom-product demonstrations, "Dicer-slicer-chopper-grinder, the Wonco does it all!"; as a security measure, "John, I think there's a prowler in the kitchen—let the Dobermans in, quick."; and in text-to-speech for the visually disabled, "The Source: Main Menu." First Byte even tried to appeal to my interests as a writer by suggesting that Smoothtalker could read my words back at me so I could hear their cadence. I'm not so sure I want to hear my words. But, come to think of it, maybe when I can adjust the timbre of the voice to something between James Earl Jones and Richard Burton . . . Thinking of applications for speech isn't a problem; getting good-quality speech is.

One interesting sidelight is that First Byte thinks it has the first program that can advertise itself on radio. Unfortunately, that same discussion led to expected groaners along the lines of "The product speaks for itself" and so on.

Which speech maker, Mactalk or Smoothtalker, is more glib? We haven't seen a final version of either yet and really can't make a final judgment. If the voice on the Smoothtalker version I heard is truly two orders of magnitude below the final version, Smoothtalker will probably win the contest hands down. But for now, both still sound robotic in the 1950s sense. However, I'd love to have those text-to-speech modules to plug into some of my programs, and there is no doubt at this point that Smoothtalker has a much better grasp of all the extras like abbreviations, numbers, and symbols. ■

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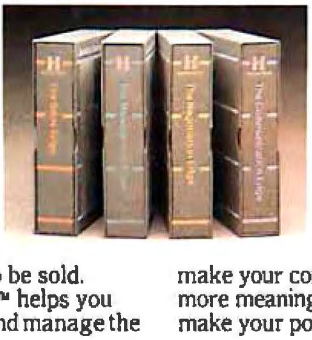

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BYTE JAPAN

Technology Shock

Comparisons
Vectorio III
NEC computers
C batches and pipes

BY WILLIAM M. RAIKE

It's been the better part of a month since I returned to Tokyo after a whirlwind U.S. tour. That two-and-a-half-week Midwest and West Coast trip was my first chance in nearly two years to glimpse firsthand the U.S. personal computer scene, and the changes were too numerous to itemize. Particularly after seeing the diversity of computers and peripheral equipment here in the Akihabara district of Tokyo, the dozen or so U.S. showrooms I walked into made me feel like a visitor from another planet. Reading about the influence of Big Blue didn't prepare me for the reality: near-total shaping of the growth of an entire market by a single product line from a single company.

I saw IBM PCs, more IBM PCs, several IBM PC-compatible machines, the occasional PCjr, various Apples, one DEC machine, and a few assorted portables. I saw lots and lots of applications software on display, the greater part of it for the PC. I saw almost no peripherals, except for the occasional printer. (Presumably it's hard for a retail store to compete with the mail-order pages of BYTE.)

COMPARISONS

Chatting with the people in the stores seemed to produce either incomprehension or surprise when they heard me comment on the lackluster performance of the IBM PC and compatibles in the Japanese market. The fact that virtually no Japanese manufacturers advertise IBM compatibility for their machines in Japan also produced surprise. This phenomenon can be explained mostly by the lack of Japanese-language software (and hardware) for the PC and partly by the intense competition within the Japanese market itself. The high level of competition has resulted in a number of technologically superior machines available at extremely low prices.

Although it may be too early to say, the language gap seems to have given Japanese manufacturers both the time and the leeway to create a substantially different and highly differentiated domestic market. Their challenge will be to exploit that market in the future. What makes their job tough is that they don't have the base of de facto standards that was available to U.S. vendors as a by-product of IBM's long domination that led in turn to the creation of so much outstanding American software.

APPLE CLONE

The most significant exception to the general lack of interest in compatibility here, apart from the Microsoft-inspired MSX standard, is the wide availability of the Apple and Asian-made Apple compatibles. A particularly interesting Apple compatible is a new machine from Honda Trading Company, a small firm in Akihabara. Honda is run jointly by Hiroo Honda and by an American, Pete Perkins, who see their future in bucking big-company domination of the Japanese personal computer market. Honda and Perkins improve their technical and engineering leverage by encouraging young engineering students to participate part-time. Additionally, they spend a significant part of their time in their showrooms, seeing who the customers really are and what they have to say.

One Honda Trading Company product, about to debut, is a 3½-inch microfloppy-disk drive that is otherwise completely plug-compatible with standard Apple drives. Another is the just-released Vectorio III portable computer, the latest in the Vectorio series. The Vectorio III is compatible with all existing Apple II+ hardware and software. It's supplied with one or two built-in 1-megabyte 3½-inch microfloppy-disk drives; standard RAM (random-access read/write memory) is 64K bytes. The processor is the 65C02, a CMOS version (and upgrade) of the 6502 workhorse, running at 1 MHz. The Vectorio III has an RS-232C interface on the board in addition to the RGB (red-green-blue), composite and RF (radio

(continued)

William M. Raike, who holds a Ph.D. in applied mathematics from Northwestern University, has taught operations research and computer science in Austin, Texas, and Monterey, California. He holds a patent on a voice scrambler and was formerly an officer of Cryptext Corporation in the United States. In 1980, he went to Japan looking for 64K-bit RAMs. He has been there ever since as a technical translator and a software developer.

frequency) video outputs, and parallel printer interface; on-board memory is expandable up to 256K bytes; either a serial or a parallel keyboard can be used; and there are five expansion slots on the main board (accessible through a "hacker's hatch" without removing the case) that accept Apple option cards.

The price for the Vectorio III with two disk drives will be around $1200; the complete board (minus the drives, case, power supply, and keyboard) is available for approximately $350.

NEC COMPUTERS

The nearest thing to single-company market dominance in Japan is the NEC line of personal computers. One survey put NEC's market share at 40 percent; whether that figure is precise or not, the company is clearly the powerhouse. However, NEC is only number two in the Japanese mainframe business, behind Fujitsu and ahead of Hitachi.

NEC's PC-8801 MkII *has a split personality.*

NEC offers dedicated (Japanese language) word processors and a separate line of small "OA" (office automation) computers in addition to its personal computers. The NEC lap-sized portable, the PC-8201, has been out for over a year and is widely available in the U.S.; the PC-8801, which I've owned for more than a year, has been replaced by the PC-8801 MkII.

The MkII is roughly equivalent to the original PC-8801, but with different packaging and a much lower price. It's based on the NEC version of the Z80A (running at 4 MHz), and the main unit includes up to two built-in 5¼-inch, 320K-byte floppy-disk drives, along with the standard 64K bytes of RAM. Also provided are another 48K bytes of graphic video RAM and 72K bytes of ROM (read-only memory). One RS-232C serial port is standard; a second port is optional. The main unit can be installed either in the conventional horizontal position or standing on edge, the smaller "footprint" being helpful on a crowded desktop or in situations that don't permit the monitor to be placed on top of the main unit.

This computer has a split personality. A DIP (dual-inline pin) switch allows you to select either of two banks of ROM: N_{88}-BASIC or the older N-BASIC from the now-obsolete PC-8001. The two are incompatible, and the NEC version of CP/M-80 boots up only from the N-BASIC ROM.

Despite its peculiarities, the PC-8801 MkII is a powerful and useful 8-bit machine and an impressive value. Dis-

(continued)

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Amazingly enough, the two-drive version (the PC-9801F2) can be bought, discounted, for a little over $1300.

counted, a two-drive version sells for about $900.

Two 16-bit NEC computers are based on the 8086 processor, not counting the older model N5200 (sold in the U.S. as the APC). One is the PC-100, introduced late last year, which runs MS-DOS and is sold bundled with Microsoft's Multiplan (the Japanese-language version) and the JS-Word Japanese word-processing program. It is supplied with 128K bytes of user RAM plus another 128K bytes of video RAM and two 360K-byte floppy-disk drives. A mouse is optional.

The most prominent feature of the PC-100 is that the video display can be installed either in the normal position or on its side, providing a total of six different screen formats (three in each position). This seems sort of gimmicky to me, but NEC apparently feels that it's worth the effort. All in all, the PC-100 seems overpriced; it lists for just under $1900, although discounts can no doubt be found.

A far more interesting (and much more popular) machine is the PC-9801F. A slight variation on this machine has been released in the U.S. as the APC III (see What's New, July BYTE, page 44), but the Japanese version incorporates 640K-byte, 5¼-inch floppy-disk drives instead of 320K-byte drives. Its 8086 processor clocks at 8 MHz (compared to 7 MHz for the PC-100), although a 5-MHz clock rate can be selected for compatibility with an earlier version of the 9801. A 128K-byte RAM is standard, expandable to 640K bytes; 192K bytes of graphics RAM and 96K bytes of ROM (including N_{86}-BASIC) are also standard. Available options include an 8087 coprocessor, a mouse, a 68000 processor board, and up to two 10-megabyte hard disks. Both the Japanese-language version of MS-DOS and CP/M-86 are available as operating systems; nothing has been announced yet about the memory-management hardware and UNIX operating system that you can get for the APC III.

Amazingly enough, the two-drive version (the PC-9801F2) can be bought, discounted, for only a little over $1300; the PC-9801E version, without any built-in drives (external drives can be connected, though), is available for only about $700.

While NEC says nothing about IBM PC compatibility for the PC-9801F here in Japan, the APC III in the U.S. is supposedly a PC-compatible machine. Further, utility programs are available for the PC-9801F that convert files from disks in the IBM-PC format to NEC format. Such conversion at least makes the huge body of CP/M-86 and MS-DOS software easily accessible to people (like me) who want good C compilers, modern word processors, and other goodies.

C ACROSS THE SEA

Living in the world of CP/M-80, I find various occasions when typing several CP/M commands on the same line (command-line batch initiation) would be convenient. An example is when I want to compile a source program, assemble the resulting object program, and obtain a printed listing of the source code without having to sit in front of the computer the whole time. The CP/M SUBMIT (and XSUBMIT) commands provide batch submission capabilities, but the com-

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mands must exist in advance in a disk file, which is awkward.

There are other times, such as when sorting the output from a text-processing program, that "pipes" come in handy. (A pipe is a way of executing a sequence of programs in such a way that the output of one program is used as the input to the next.) Various operating systems (notably UNIX) offer pipes. While true pipes have the component programs running as concurrent tasks, you can achieve a similar effect under CP/M-80 by using temporary files to hold the intermediate results.

Several commercially available software packages (such as MicroShell, Unica, and C/NIX) offer these and other useful features. More limited programs already exist in the public domain. But it's easy and instructive to implement simple versions in C.

The C program in listing 1, compiled using the Software Toolworks C/80 compiler, allows you to enter multiple CP/M commands on one line, preceded by a slash (/) and a blank and separated by semicolons (;). It then creates a CP/M SUBMIT file and executes the SUBMIT command, which processes the commands sequentially. Upon completion, the SUBMIT file is erased. If a vertical stroke (|) is used as a separator instead of a semicolon, the output of one program is used as the input to the next by redirecting the respective outputs and inputs to temporary files. (Note: individual C/80 programs automatically offer I/O [input/output] redirection. For example, the CDIR program [August BYTE, page 342] can output a file directory to a file called, say, DFILE by typing the command CDIR >DFILE. If your C compiler uses different conventions or does not implement I/O redirection, the program in listing 1 won't simulate pipes correctly. The command-line batch-initiation feature, with the successive commands separated by semicolons, will still be usable though.)

One tricky aspect is to prevent the program from simply recognizing a < or > (less than or greater than sign)

(continued)

Listing 1: *The /.c program.*

```
/*   /.c — Produces a submit file from the command line                 */
/*          and chains to SUBMIT.COM.                                   */
/*          To use, separate commands with semicolons.                  */
/*          E.g.: / c test ; as test ; pip 1st: =test.c                 */
/*          Also partially simulates pipes. For example,                */
/*            / cdir *.c | sort produces the command                    */
/*          sequence:                                                   */
/*                  cdir >1.+ + +                                       */
/*                  sort <1.+ + +                                       */
/*                  era /.sub                                           */
/*                  era *.+ + +                                         */
#include tprintf.c
#include exec.c
main( )
{       int f1, pipeflg, i; char c, s[8], *comline, *comstr, *comptr, *itoa( );
        comline = 0X82; /* CP/M stores cmd line tail at 0082H */
        i = pipeflg = 0;
        f1 = file ("/.sub", "w");
        while (c = *comline+ +)
        {       if (c = = ';') /* semicolons separate multiple cmds */
                {       putc('\n', f1);
                        while (*comline = = ' ') comline+ +;
                }
                else if (c = = '|') /* simulate pipe with temp file i.+ + +  */
                {       pipeflg = 1;
                        i+ +;
                        comptr = comstr = alloc(128);
                        fprintf(f1," >%s.+ + +\n",itoa(i,s)); /*redir. output*/
                        while (*comline = = ' ') comline+ +;
                        while ((c = *comline) != '\0' && c != ';' && c != '|')
                              *comstr+ + = *comline+ +;
                              /* next cmd to comstr */
                        *comstr+ + = '\0';
                        strcat(comptr, " <"); /* redir, input */
                        strcat(comptr, itoa(i, s));
                        strcat(comptr, ".+ + + ");
                        strcat(comptr, comline);
                          /* comptr now has the rest of the cmd line            */
                          /* with redirected input for the next cmd             */
                        comline = comptr;
                }
                else putc(c, f1);
        }
        putc('\n', f1);
        fprintf(f1, "era /.sub\n");
        if (pipeflg) fprintf(f1, "era *.+ + +\n");
        fclose(f1);
        exec("submit", "/.sub");
}
file(fname, fmode) /* general-purpose file opener */
char *fname, *fmode;
{       int i;
        i = fopen(fname, fmode);
        if (i > 0) return i;
        printf ("Can't open: %s\n",fname);
        exit( );
}
#include stdlib.c
```

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One tricky aspect is to prevent the program from recognizing a < or > as an indication to redirect its own input/output.

on the command line as an indication that its own input or output is to be redirected. (That is, I/O redirection has to be disabled for *this* program so that < or > symbols in the command line can be handled correctly.) Your C compiler might provide compile-time options to accomplish this task; the C/80 compiler doesn't, but it does supply an assembly-language file containing its normal run-time library. Deleting four lines in that file (CLIBRARY.ASM) disables I/O redirection; the lines to be deleted are lines 89 to 92: CPI '<', JZ $B1, CPI '>', and JZ $B2.

The program is reasonably straightforward. It parses the command-line tail (stored by CP/M starting at hexadecimal address 0082 in the CP/M buffer area); places successive commands on individual lines in the file /.SUB (and sets up I/O redirection to temporary files when necessary); adds a line after the last command, which causes the /.SUB file and any temporary files to be erased; and chains to the CP/M SUBMIT.COM program to start execution.

The #include files (TPRINTF.C and EXEC.C) are supplied with the C/80 compiler and contain the code for the formatted output routines and the program chaining feature, respectively. Similarly, STDLIB.C contains various standard C library functions. These files may or may not be needed with your compiler.

COMING UP

The December BYTE Japan will feature hand-held computers, particularly the Ampere Big.APL, and a comparison of several available MSX machines. ■

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Apricots and the Organiser

BY DICK POUNTAIN

One of the corollaries to Murphy's Law states that whenever you choose to go on holiday it will all start to happen at home. This proved to be true when I decided to take an unprecedented four-week vacation in June: ACT launched not one but a *whole family* of new Apricots, while Psion unveiled its first venture into hardware design—a pocket computer. Because none of them is likely to be available in the U.S.A. at the time this article appears in print, I thought you might enjoy a sneak preview.

ACT IS TOGETHER

ACT is the U.K.'s largest and most successful purveyor of business microcomputers. After an early period of selling CP/M machines and software, the company rose to prominence through marketing Chuck Peddle's 8088-based Victor 9000 under the name Sirius 1. While IBM procrastinated over European introduction of the IBM Personal Computer (PC), the Sirius 1 became *the* 16-bit business machine, particularly in the U.K. and Germany. In the intervening three years, Big Blue has not enjoyed the easy ride to dominance that was predicted for it over here, with a strange result: the Victor 9000 flopped in its home market, swamped by the IBM PC tidal wave, but prospered across the Atlantic. It was inevitable that ACT should take manufacturing into its own hands, so it designed and built the Apricot—launched just in time to take over as the Victor 9000 foundered.

The Apricot is much smaller, neater, and cheaper than the Sirius/Victor, and the software is almost entirely compatible with it, though not with the IBM PC—it uses the full 16-/16-bit 8086 rather than the 16-/8-bit 8088, and it has Sony 3¼-inch disk drives. Two versions of the Apricot were introduced to the U.S.A. earlier this year—the standard PC and the XI, which features an integral 3-inch 10-megabyte (MB) Winchester drive—and both versions were enthusiastically received by the computer press.

ACT could have been expected to take a rest at this point. Instead, they have chosen to introduce no fewer than three new Apricot models, one of which is a portable featuring one of the new 80-column by 25-line LCDs (liquid-crystal displays). All three machines are equipped with infrared cordless keyboards (à la IBM's PCjr), the world's first infrared mouse, and an icon-driven shell that sits on top of MS-DOS.

FIRST, THE F1

The Apricot F1 comes in a box that is less than half the width of the standard Apricot's processor unit. In fact, at 221 by 160 by 420 millimeters, it's not much bigger than many manufacturers' disk drives. A single Sony 3¼-inch drive with a capacity of 720K bytes is built in, along with a standard 256K RAM (random-access read/write memory) and an 8086 central processing unit (CPU) (4.77 MHz). RS-232 and Centronics printer ports are included, plus one internal expansion slot and an external bus. A 10-MB Winchester or extra Sony drives can be attached to the latter. ACT used the occasion of the launch to announce a local-area network (Point 32) and a cluster controller (Point 7), which can link all members of the Apricot family, the Sirius 1, and the IBM PC.

Three Sorcim applications, SuperWriter, SuperCalc, and SuperPlanner, come bundled with the machine, together with ACT's own drawing and diary packages and a game. The operating system is MS-DOS version 2.11 with Concurrent CP/M and the GSX Graphics extensions as optional extras. The U.K. price is £995, just under the magic £1000 barrier.

There is no integral display, but provision for color is built in, allowing it to drive either an RGB (red-green-blue) color or an Apricot monochrome monitor. (A new color monitor of Sony manufacture will be available as an option.) In addition, the F1 has a composite video output to drive standard monochrome monitors and an optional

(continued)

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UHF modulator to drive domestic TVs. Unlike the original Apricot, which inherited the very high-resolution 800-by 400-pixel Victor graphics, the F1 has 640 by 256 graphics in two modes, and 640 by 200 (for ease of software transfer from the IBM PC) in two further modes.

One dramatic improvement over the original Apricot is a smart VDU (video display unit) driver that provides what ACT has dubbed "mad" (for multidirectional) scrolling; this is said to allow you to pan the screen smoothly in any direction and define scrolling windows. I haven't seen the full thing yet but the F1 I used certainly had smooth scrolling in the vertical dimension.

The keyboard is also a new design, lacking the LCD "microscreen" of the original Apricot (which was considered virtually useless by popular consensus). Ultra-low-profile keys are used with fashionably round tops and all 92 keys are arranged in a single block, with no gaps between the QWERTY, editing, numeric, and function-key groups. The keyboard communicates with the processor unit via an infrared link, though a fiber-optic cord is available for use in crowded offices where interference might occur ("group environments," in the horrid language of the promotional leaflet). I found that the infrared link worked reliably with the keyboard sitting on the same surface as the processor box, but not so well on my knees, where the edge of the desk could shadow the sensor.

I couldn't get my hands on the infrared cordless mouse in time for press, but it appears to be highly original in design. The rotating ball protrudes from both the upper and lower surfaces of an elongated plastic box; the ball can be manipulated directly with the fingers as a trackball or, by tilting, can be brought into contact with the desktop to act as a conventional mouse. Two buttons are provided.

Photo 1: *The Apricot F1 (left) and Apricot Portable (right) from* ACT.

THE NEW SHELL GAME

It would be nice to report that the new operating system shell lived up to the innovative hardware, but it does not, at least in the early version I used. Whichever side you take in the "mouse versus no mouse" debate, you have to admit that the concept of a mouse- and icon-driven user interface, as it came from Xerox PARC (Palo Alto Research Center) through Lisa and Macintosh, is an indivisible one. The prerequisites are a completely bit-mapped display, with soft character generation and sophisticated window and menu management integral to the operating system. Such software, as Apple has shown, requires years of painstaking effort to develop. Putting a shell over standard MS-DOS, supplementing menus with little pictures, is not adequate and smacks of cashing in on fashion.

The new Apricot front-end program is called Activity (get it?) and consists of a menu along the bottom of the screen, in which words are highlighted by a reverse-video cursor and have a small icon underneath to reinforce the message. Choices can be made by using the ordinary cursor keys or the mouse. When a choice is made, the screen fills with other menus (and icons) from which selection is made by moving a separate cross-hairs cursor, using the mouse (or the numeric pad keys). The whole setup, with two totally independent cursors, was completely incomprehensible to me and inferior in ease of use to an ordinary Multiplan-style menu. I prefer to stick with the unadorned MS-DOS interface.

A reduced version of the F1 (called F1E) is to be produced for schools and universities, with 128K bytes of RAM and a single-sided 320K-byte disk drive. The attraction will be the low (£795) cost and Digital Research's Dr. Logo as bundled software.

AN APRICOT FOR THE ROAD

The most exotic of the new machines is the Apricot Portable. Sharing all of the features of the F1, this machine is packaged in a futuristic wedge-shaped case and has a full-sized (80 by 25) LCD manufactured by Hitachi. The keyboard unit is the same as the F1's though the infrared sensor sits under the beveled lower edge of the case, which makes it even more sensitive to positioning than the F1's keyboard. The Apricot Portable has its disk drive situated at the right-hand side of the case but the disk operation light,

(continued)

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along with several other indicators, is placed at the left-hand edge of the screen for visibility.

Like the F1, the Portable relies entirely on mains power, battery operation having been rejected as a design option. In this sense it's not a competitor to the new Vadem/Morrow/Osborne machine that has a much smaller footprint and a battery power option. ACT's managing director Roger Foster doesn't believe that this sector of the market demands any more than easy transportability, though I feel that some engineers, geologists, and other field workers might disagree. A very smart carrying case holds the processor/display unit and the keyboard for traveling.

The most spectacular feature of the Apricot Portable is the voice-recognition circuitry and integral microphone. This sits in a recess at the right-hand side of the screen and can be removed on a self-rewinding cable. It wasn't fitted on the early prototype I used, but according to my information the circuitry works like the Tecmar PC-Mate. The machine is trained to a person's voice by speaking the chosen keywords from three to five times. Unlike the Tecmar, however, it uses a hierarchical system of keyword storage, with 64 primary words; upon recognition of one of these words, a further 64 different words can be recognized and so on.

At £1695 the Apricot Portable is priced close to the Compaq, Kaypro, and the new Osborne Encore (Morrow Pivot).

Taken altogether, the new Apricots are smartly designed and incorporate some bold technical innovations at remarkably low prices. Their future is assured in Sirius-conscious Europe, but whether they can succeed in the IBM-dominated U.S. without IBM software compatibility remains an open question.

A PSION IN EVERY POCKET?

Psion is a successful U.K. software house that started out writing games for the Sinclair ZX81 and Spectrum and later produced the highly acclaimed applications programs for the less-than-highly-acclaimed Sinclair QL (see BYTE U.K., September, page 415). On the same day that ACT unveiled the new Apricots, Psion revealed a venture into hardware manufacture in the shape of a pocket computer called the Organiser. (See photo 2.)

Photo 2: *The Organiser pocket computer from Psion.*

The pocket computer has been alive for many years, but so far none of the offerings quite make the grade in terms of truly general usefulness. One line of thought has led to instruments like the Sharp PC1500 (and similar machines from Casio), which are the modern version of the programmable calculator. They run more or less standard BASIC with a bias toward mathematical applications, but they are limited in their data-processing capability by the use of cassette tapes for mass storage.

Another line of thought (started years ago by Toshiba) has led to a pocket database: the "electronic address book" concept. Despite some neat designs currently emanating from Casio, using expensive CMOS (complementary metal-oxide semiconductor) RAM modules, these too have been inhibited by inadequate mass-storage capacity.

The Psion Organiser spans both of these concepts, with some degree of success. It succeeds by the application of new CMOS microcomputer (as opposed to calculator) technology, together with clever firmware design.

The Organiser certainly won't have the Japanese running scared on account of its packaging. Compared to the current models from Sharp and Casio it's overly large (about the size of the older TV remote-control units) and, though it is well made, it lacks the exquisite finish that the Japanese achieve.

Inside the chunky case, however, is a proper 8-bit microcomputer, the HD6301X, which is a CMOS version of the Motorola 6800 with some extra instructions. The display is a quite ordinary single-line 16-character LCD as used in inexpensive calculators. The mass storage is something new though; Psion has adopted ultraviolet-erasable PROMS (programmable read-only memories) called Datapaks as removable storage media. These cartridges are about the size of an ordinary eraser and fit into the side of the Organiser. Two Datapak cartridges can be inserted at a time, with capacities of either 8K or

(continued)

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Battery power is supplied by a single 9-volt alkaline cell, which lasts for about six months of normal use. The HD6301X has 4K bytes of mask ROM (read-only memory) and 2K of RAM actually on the chip, and this is all the memory that the Organiser directly addresses. The Datapaks are treated as external serial devices (like disk drives) and, apart from some math routines in the ROM, all code is fetched as a serial stream into the 2K workspace. When it's switched on, the Organiser presents a real-time clock/calendar display—pressing the Mode key clears this and allows you to proceed.

DATA ENTRY

What makes the Organiser concept work is the design of the soft/firmware. This is based around a very fast search algorithm with partial word matching. With a full 16K-byte Datapak the maximum search time is 5 seconds, and retrieval is typically much faster.

All database manipulation is done using dedicated keys, so that a minimum amount of typing is required on the small alphabetically arranged (as opposed to QWERTY) keyboard.

Four keys control the storage and retrieval of data, programming, and calculation function. Records consist of free-format strings of text and numbers, up to 200 characters. You enter these in Enter mode (the Mode key steps through a circular list of the available modes) into the temporary display memory, where they can be edited at will. Hitting the Save key stores this record into a Datapak (if two Datapaks are fitted, the prompt will show SAVE1: or SAVE2: on alternate presses). To retrieve a record, merely hit the Find key (which also alternates if there is a choice of paks) and enter as much or as little of the target record as you wish to search on. Pressing the Execute key then displays all the records that have been matched, stepping through them at each press. Using an asterisk specifies that the search word must occur at the beginning of a record, so that FRE will match FRED or ALFRED, but *FRE will only match FRED. If you execute FIND with no search clue, then you can single-step through the whole database. By paying attention to the design of records (using special characters or letter codes) you can easily classify your information.

The ergonomics of the Organiser are so carefully designed that it is quite possible to operate it with one hand, using your thumb to reach the various keys. This is slightly spoiled by the small keyboard, which dictates that most keys have a shifted value—the numbers and math operators are all shifted letters and Shift toggles between sets.

The limitations of the small display are diminished by left and right scroll keys, which, rather than step by single characters, cause the display to scroll automatically until another key is hit. The Delete key was designed in a similar way. It deletes characters to the right as long as there are any, but deletes to the left if there aren't.

The Organiser has a Calc mode in which it behaves as a simple four-function calculator; BASIC-style operators are used and, on pressing Execute, the whole calculation and

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P.O. Box 1777•1187 Quarry Lane, Pleasanton, CA 94566•(415) 484-3322 Telex: 703575 result are displayed as in: 23 × 2 = 46. Arithmetic is floating point to seven significant figures, and scientific notation is supported. When the Mode key is pressed, the prompt changes but the displayed data remains the same. This allows you to do a calculation and then press Save to store either the result (adding an alphabetic label to help retrieve it) or the text of the calculation itself. This principle applies across the board; once a record has been retrieved, it behaves as if you'd just entered it, so you can calculate on it, edit it, and then resave it.

The whole design is aimed at foolproof operation; the only possible error conditions are a full or faulty Datapak, other illegal input merely being re-presented for editing. The system senses the presence or absence of Datapaks, and the Mode key is context-sensitive and displays certain modes only at the appropriate time—for example, Erase is only allowed after a Save.

POPL

The Organiser is programmable, using a specially developed language called POPL (no relation to last month's POP-11). POPL is not built into the machine but is included in each of Psion's application packs. As I write, only the Finance Pack is ready, but Science and Math/Stats Packs are in preparation. Adding an application pack (it replaced one of the Datapaks) causes a number of new modes to be added, including Prog and Copy.

POPL is a very simple language, with a syntax similar to a structured BASIC; it is procedure based and allows the passing of parameters. The input and output functions are rudimentary: IN "prompt" X causes "prompt" to be displayed and assigns the input to X, while OUT "result" X causes "result" to be displayed followed by the contents of X. All variables are local to a procedure, but there is a predeclared 20-element system array that can be used either as an indexed array or for global variables. The total workspace available for data is only 356 bytes, and this can be exceeded quite quickly if you write deeply nested procedures with lots of local variables.

You can get an idea of POPL from this factorial example:

```
FACT
IN "NUMBER" N
C=0
F=1
LOOP:C=C+1
F=F×C
IF C<N GOTO LOOP
OUT "FACTORIAL IS" F
```

This procedure is called FACT and it is saved, retrieved, and edited in the same way as any other data (except that a special mode called Cat lists only procedures and not data records; it works just like Find). Procedures can be run either in Run or Calc mode—they can call other procedures (including recursive calls to themselves)—with parameters being passed using the reserved variable names P1 to P5. No procedure may exceed 200 characters, and no one line may exceed 100 characters.

Some discipline is required to avoid squandering scarce storage and workspace. A procedure being edited is held in workspace RAM, from where you can run and test it during development, saving it only when it's fully debugged. On the other hand, to release the maximum workspace for running procedures, you must save the current procedure and then delete it from workspace (by using QUIT rather than EXIT).

A nice touch is that the source code of the built-in functions in an application pack is available to inspect and edit and can be copied to a Datapak to be incorporated into your own procedures. The Finance pack includes various compound interest, cash-flow, depreciation, and bond-yield functions, as well as some general scientific functions, such as exponentials and trigonometry.

I couldn't run the Sieve of Eratosthenes due to the small amount of workspace RAM, but an impression of the speed can be gained by timing the factorial program—the conclusion is that Seymour Cray needn't lose any sleep. Calculation of 50! took 44 seconds or almost one second per iteration, and an empty loop takes ½ second per iteration. This slow result is a consequence of the amount of overlaying from the serial EPROM, rather than a reflection of the CPU's true processing power, but it suggests that POPL will not be used much for heavily iterative programs. Recursion is worse still, as the stack quickly grows to overflow workspace. This should not be taken as condemnation though; realistically speaking, POPL is intended for writing short procedures, typically involving simple arithmetical transformations. Its ease of use, and the fact that user procedures become extensions to the catalog of available functions, makes it preferable to a cassette-stored BASIC program for most nontechnical users.

In summary then, what I find impressive about the Organiser is not its absolute performance in any sphere, but the clever design of the software for fast and foolproof use. A general-purpose BASIC machine like the Sharp PC1500 will beat it soundly at complex scientific calculations, but just try writing any sort of database program using cassette tape storage to find out what slow really means. I also liked the consistency of the Organiser environment, where records and procedures are all handled in similar ways using the same few keys; when I first received the machine, it took me only 15 minutes to discover how to do everything (apart from POPL) without any documentation or outside advice. A 16K-byte Datapak will hold over 300 average telephone-book entries, five times more than most of the competing "electronic notebooks." The price and relative difficulty of reusing Datapaks militates against using them as the exact equivalent of disk or tape; instead they are highly suitable for semipermanent information such as names and addresses or commercial data such as price lists. The machine costs £99.95 in the U.K., about the same as a BASIC pocket computer. Datapaks cost £12.95 for 8K and £19.95 for 16K. ■

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MATHEMATICAL RECREATIONS

Toggling Functions

The Slobbovian Amnesty and the Eccentric Jailer

BY MICHAEL W. ECKER

An eccentric jailer proposes the following cockeyed partial amnesty to the 100 prisoners in his 100 cells. All cells in the prison are initially closed. Then the warden walks by all 100 cells and turns his key in the door of each; however, no prisoner may leave. Then the jailer walks back and, starting with cell number 2, reverses every second cell. Hence, cells numbered 2, 4, 6, . . . , 100 are again closed. Again, no prisoner in an open cell may leave. The warden continues with every third cell, starting with 3, 6, 9, and again turns the key. This reverses every third cell, the cells formerly open are now closed and vice versa.

It starts to get a bit fuzzy as to who is in an open cell, for this process continues 100 times. On the fourth time, every fourth cell, starting with 4, 8, and so on, is reversed by a turn of the key. In general, every *k*th time, cells *k*, 2*k*, etc., are reversed. No prisoner may leave during the process. (The vicious guards see to that.)

Now, this is the offer. Any prisoner fortunate enough to be in a cell that is open at the conclusion of this 100-pass process may go free. Which prisoners will be released?

Let's first make sure we understand the problem. Take the prisoner in cell number 8. His cell will be opened at pass #1, closed at pass #2, ignored at pass #3, opened again at pass #4, ignored at passes #5, 6, and 7, and finally closed again on pass #8—not to be opened again during the rest of the warden's walks. On the other hand, the prisoner in cell number #4 is more fortunate. His cell is opened at pass #1, closed at pass #2, and opened at pass #4—never to be reversed again.

What is more special about cell number 4 than cell number 8? Let's try a BASIC program to simulate the opening and closing. Let us agree to use 0 for closed and 1 for open.

Since the cells involved are essentially being toggled, I would like to sneak in an elegant programming trick for toggling. For it, I am indebted to David B. Lewis (himself a writer of mathematical recreations and programs) for reminding me. Suppose you have a variable called *A* that is storing 0 or 1 for off and on, or for closed and open, or whatever. Ordinarily, one would use some program line in BASIC like this:

```
100 IF A=0 THEN A=1 ELSE A=0
```

or, using 0 and −1, `100 A=NOT A`

Instead, we'll use:

```
100 A=1-A
```

If $A=0$, then A is assigned the value 1, and conversely, if $A=1$ then A is now assigned the value 0. (The mathematicians reading this will note that the function $F(x)=1-x$ and the identity function $I(x)=x$ together constitute a cyclic group of order two under the operation of function composition, with F a generator.)

Type in listing 1. When you are done, you will find a fascinating result: The only cells open are those whose number is a perfect square (i.e., 1, 4, 9, 16, 25, 36, 49, 64, 81, 100).

What is so special about perfect squares? Why not the odd numbers, for example, instead of the perfect squares, as many people often incorrectly guess? Look again at what happened to the prisoners in cells 4 and 8. Note that a cell is reversed precisely at a pass number that is a *divisor* of the cell number. For 8, the divisors are 1, 2, 4, and 8. On these passes we get open, closed, open, closed. For 4, the divisors are 1, 2, 4, and we get open, closed, open. In order for a prisoner to go free, the last pass must produce an open. But for that to happen, we see that the number of divisors of the cell number must be odd. In general, each divisor d may be paired with another divisor $d'=\frac{n}{d}$. However, if the number is a perfect square, the square root is a divisor that is not paired with any other divisor.

Although you might like to say that the

(continued)

Dr. Michael W. Ecker is an associate professor in the Department of Mathematics and Computer Science at the University of Scranton.

square root should be paired off with itself, don't lose sight of the fact that the goal is to see how many divisors the number has, and we don't count any divisor twice. So perfect squares always contain an odd number of divisors. It now makes sense that the only lucky prisoners are the ones in cells whose numbers are squares.

THE ECCENTRIC JAILER'S MORE ECCENTRIC COUSIN

Mathematicians never like to leave things alone—not even nice things like the previous conclusion. In that spirit, I offer the related tale of another warden (a cousin of the first jailer) who had his own cockeyed plan. He made the same kind of offer, except that instead of turning the key once each time, he turned the key as many times as the number of the pass. On the first pass, the jailer turns the key in all cells—once. On the second pass, however, he will turn the key in cells 2, 4, 6, etc., two times. (Hence, on the second pass, nothing changes.) On pass number 3, he goes to cells 3, 6, 9, . . . and turns the key in each three times. He continues this for all 100 passes.

Listing 2 ought to do it. Lines 35 and 45 ensure that the key is turned as many times as the number of passes made. Of course, there are shorter ways to implement the process, such as by noting that a switch is made if and only if the pass number is odd, but the idea is to let the com-

(continued)

Listing 1: *The Eccentric Jailer program.*

```
1 DIM A(100):REM ARRAY TO STORE 0 OR 1 FOR CLOSED OR OPEN FOR
  EACH CELL
10 CLS:REM CLEARS SCREEN
20 FOR PASS=1 TO 100
30 FOR CELL=PASS TO 100 STEP PASS
40 A(CELL)=1-A(CELL):REM TURN THE KEY
50 NEXT CELL
55 PRINT "PASS NUMBER" ;PASS; "COMPLETED" :REM SO YOU'LL KNOW
   THE PROGRAM IS WORKING
60 NEXT PASS
65 PRINT "OPEN CELLS ARE ..."
70 FOR CELL=1 TO 100
80 IF A(CELL)=1 THEN PRINT CELL;
90 NEXT CELL
100 PRINT: END
```

Listing 2: *The Eccentric Jailer's More Eccentric Cousin program.*

```
1 DIM A(100):REM ARRAY TO STORE 0 OR 1 FOR CLOSED OR OPEN FOR
  EACH CELL
10 CLS:REM CLEARS SCREEN
20 FOR PASS=1 TO 100
30 FOR CELL=PASS TO 100 STEP PASS
35 FOR CHANGE=1 TO PASS
40 A(CELL)=1-A(CELL):REM ELEGANT TRICK FOR SIMULATING KEY TURN
45 NEXT CHANGE
50 NEXT CELL
55 PRINT "PASS NUMBER"; PASS; "COMPLETED" :REM SO YOU'LL KNOW
   PROGRAM IS WORKING
60 NEXT PASS
65 PRINT:PRINT "THE OPEN CELLS ARE. . ."
70 FOR CELL=1 TO 100
80 IF A(CELL)=1 THEN PRINT CELL;
90 NEXT CELL
100 PRINT: END
```


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The only way to have an odd number of odd divisors is if the odd part of the original number is a perfect square.

puter do all the work. Again, stop reading and run the program.

This time it is not quite as obvious what all the open cell numbers have in common. Note that all 17 of the numbers that you should find—and no others—are expressible as a power of 2 (e. g., 1, 2, 4, . . .) times an odd perfect square. This description includes the numbers that are pure powers of 2 or pure odd squares as well, since 1 may be used as the other factor in each case. The basic idea relates to what happened in the previous problem. We can reason as follows: In the previous question, a cell wound up being open if and only if the *number* of its divisors was odd. Here, a cell will be open if and only if the *sum* of its divisors is odd. Now, if the sum of the divisors is to be odd, since the sum of the even divisors is even, the sum of the odd divisors must be odd. But if the sum of the odd divisors is odd, then there must be an odd number of odd divisors. (Otherwise, if you had an even number of odd divisors, the odd numbers could be paired off, and since odd + odd = even, we would have an even sum.)

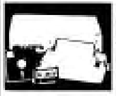
Now, by what we had before, the only way we could have an odd number of odd divisors is if the odd part (factor) of the original number is a perfect square. Thus, it follows that the number must be expressible as |2 to some power| times |an odd square|.

I have extended this even further and found that there actually exists a plan for amnesty that involves a specific number of togglings per pass in the jailer problem with the net effect that each cell is reversed exactly as many times as the cell number. This means that cell number 1 is reversed only once, number 2 is reversed a total of two times, number 3 a total of three times, etc. Moreover, the solution function involved is well known in mathematics. It is called the *Euler phi* function. This function counts the number of integers less than the number and having no factor in common with it. Since this obviously is beyond the intended scope of this column, I will merely mention that I recently published this problem in *Crux Mathematicorum*, a Canadian problem-solving journal. I will supply further information upon request.

ABOUT THE LISTINGS

The programs provided here run on a TRS-80 Model III (48K, two drives) and a Sanyo MBC-555 (256K, IBM Personal Computer data-compatible under MS-DOS with two single-sided drives that can probably read IBM BASIC programs if saved in ASCII). Users of compatible machines probably can run the programs I provide as is. Other machine users may need to make modifications.

For those of you who wish to send me suggestions, questions, improvements, etc., please feel free to use magnetic media for programs if we have compatible machines. I am interested in all comments, original problems, and whatever you feel would enhance this column. Credit for contributions will be given for any material I use. Please enclose a self-addressed, stamped envelope if you would like an acknowledgment or reply. Write to me, Dr. Michael W. Ecker, c/o BYTE, 70 Main St., Peterborough, NH 03458. ■



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8-INCH DRIVE INTERFACE

Dear Steve,

What hardware and software are available to interface an 8-inch disk drive to my Leading Edge PC?

JIM DARROUGH
San Diego, CA

I have no immediate plans for a Circuit Cellar article on an 8-inch disk controller for the IBM PC or its compatibles and have no circuit diagrams available. However, here are some companies that offer controllers, drives, and software to add 8-inch floppy disks to the IBM PC and compatibles.

Maynard Electronics
400 Semoran Blvd.
Casselberry, FL 32707
(305) 331-6402

Tecmar Inc.
6225 Cochran Rd.
Solon, OH 44139
(216) 349-0600

MicroXpress
305 South State College Blvd.,
Suite 135
Anaheim, CA 92806
(800) 632-8515
—Steve

MODEM KIT AVAILABLE?

Dear Steve,

I recently read your article in the August 1980 BYTE on constructing a modem for less than $50. What is needed to interface your modem to the Commodore 64 computer?

M. W. CAMERON
Clareinch, South Africa

The modem described in the August 1980 BYTE is no longer available from the Micromint. It has been replaced by the ECM-103 modem, which I described in March 1983. It features both originate and answer modes, has provisions for direct connection to the telephone lines, and requires no calibration or adjustment. The modem uses the Texas Instruments TMS99532 frequency-shift-keying modem chip and is available for $60 plus postage and handling (The Micromint Inc., 561 Willow Ave., Cedarhurst, NY 11516).

The modem interfaces to a standard RS-232C port and requires only pins 2, 3, and 7 of the standard DB-25 connector. Your Commodore 64 has a serial port, but the signal levels are TTL levels (+5 V) and not RS-232C levels (±12 V). Fortunately, all that is required are some level-shifter ICs to effect the necessary changes. An article for such a circuit appeared in the May 1983 BYTE, "The Enhanced VIC-20, Part 4: Connecting Serial RS-232C Peripherals to the VIC's TTL Port" by Joel Swank (page 331) describes the requirements for a VIC-20. The Commodore 64 is similar, and the article will serve as an excellent reference.—Steve

LASER CANON

Dear Steve,

Please consider designing an interface for the Canon LBP-CS laser printer.

R. T. QUENETT
Winnipeg, Manitoba, Canada

I share your enthusiasm about the new Canon LBP-CS laser-printing mechanism. It looks like it could give the higher-priced character printers some stiff competition.

However, when I write an article, I try to keep the topic as general as possible and try to use parts that are available to the individual from common sources. Canon has already stated that it will not be selling the LBP-CS directly to consumers but will be selling to original equipment manufacturers for incorporation into their equipment. These OEM prices are much lower than individual prices because the OEM buys in high quantities. This price advantage usually outweighs the savings made by designing and building your own interface electronics, and there may be no cost advantage over a commercially available unit.

If the price and availability situation changes to make the LBP-CS mechanism of interest to a wide range of readers, there could be a Circuit Cellar project on the subject.—Steve

WHERE'S THE CHIP?

Dear Steve,

The single-board computer I want to build needs an ASCII parallel keyboard. I'd like to build a serial keyboard and connect it to a UART (universal asynchronous receiver/transmitter) in the computer via a coiled cord carrying power to the keyboard and data from it. I recall you once mentioned a 5-volt encoder chip with 1200-bps serial output. Who makes this chip, and where can I get it?

MIKE OLSON
Lincoln, NE

Your power of recollection is very good. My article in the September 1980 BYTE, "Build a Low-Cost, Remote Data-Entry Terminal," revolved around a keyboard encoder that operated from a single 5-V supply and that converted keyboard depressions into an ASCII serial output at 1200 bps.

The chip that performs all this is an MM57499 and is an excellent choice for your application. For information on the availability of the MM57499, write to Product Marketing, National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051.—Steve

HOOK THE COMMODORE 64

Dear Steve,

Is there a way to hook a Commodore 64 to the Micro D-Cam? Also, is there any way to connect the 64 to the Term-Mite ST Smart Terminal without using the user port?

GREG BOLLHEIMER
Warrensburg, IL

The easiest way to connect the Micro D-Cam to the Commodore 64 is to use the serial version and connect it to the user port using its RS-232C facility. Otherwise, the Apple II+ version could be adapted by interfacing through the expansion port.

Software changes would be extensive

(continued)

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because the Commodore 64 uses not only different addresses for screen memory but also a considerably different method of producing graphics displays.

The Term-Mite terminal is basically a serial I/O device, as are most terminals, and can also be interfaced through the user port. If you are already using the RS-232C port, you might use an RS-232C switch, available from Misco Inc., 404 Timber Lane, Marlboro, NJ 17746, or build one using the circuit in my article "Build an RS-232C Code-Activated Switch" in the May 1983 BYTE. These switches make the port accessible to more than one device.

The alternative is to make your own serial port and connect it to the expansion bus. This would also require supporting software to account for the new address of this port.—Steve

BETTER THAN MICRO D-CAM?

Dear Steve,

Concerning the Micro D-Cam (September and October 1983), wouldn't it be better to use a television camera and map its output to a video-display terminal? I think that resolution would be higher. Do you know of any companies that make economical units?

Speaking of resolution, what is the resolution of the Micro D-Cam? I have in mind some image-analysis studies that involve an area of 1.5 by 2 feet with a resolution of 0.003 inch.

DAVID HOOPER
Atherton, CA

Here are some of the differences between the Micro D-Cam and commercial television digitizing systems.

The Micro D-Cam is fundamentally a digital device from the image detector to the screen, while the television digitizers convert analog signals from the camera to a digital representation of the original. This requires expensive high-speed A/D converters and associated circuitry.

The television digitizers are usually designed to operate in real time, i.e., 30 frames per second, while the Micro D-Cam produces less than 1 frame per second for a full-width picture with no gray scale (black and white only).

The Micro D-Cam produces a gray scale with reduced resolution by dithering several images taken at different exposure times.

The maximum resolution is 256 pixels per row by 128 rows for a continuous image.

A resolution of 0.003 inch over a 1.5- by 2-foot area is not easily achieved with present low-cost video equipment. You will have to divide the overall area into a number of small regions and combine the results of your analysis somehow if you want to keep costs down.

A "low-cost" digitizing system (Data Copy Model 90) is available from Data Copy Corp., 1215 Terra Bella Ave., Mountain View, CA 94043 for $9945. This was reviewed along with the Micro D-Cam in the June 26, 1984, issue of PC *magazine on page 154.*—Steve

NEEDS LISTING

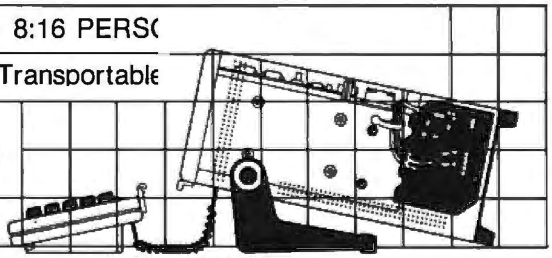
Dear Steve,

I am extremely interested in your Term-Mite ST Smart Terminal (January and February 1984). What I need is a listing of the hexadecimal code that the Term-Mite contains in its external ROM so that I can emulate other terminals and include XON-XOFF protocol. Also, any other information you have regarding the NS455A terminal-management processor (TMP) will be of great help.

Your fans here at Penn State University are always guessing what you will dream up next. Keep those articles coming, Steve. We can't learn and build enough.

DAVID G. WHITENACK
University Park, PA

The Term-Mite firmware is presently the same as the firmware supplied by National Semiconductor in the NS455A TMP but placed in an outboard EPROM. This was done so that users wanting to enhance the operation of the Term-Mite could do so by modifying the control program in the outboard EPROM. This is the approach that would have to be taken to add XON-XOFF handshaking to the Term-Mite. Modifying the firmware to include the XON-XOFF protocol should not be difficult, once a listing of the existing firmware is obtained. The firmware listings are available from The Micromint Inc., 561 Willow Ave., Cedarhurst, NY 11516, (800) 645-3479 for $20.—Steve ■



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(continued from page 128)

One way to debug the program is to delete the FORTH word —> from the ends of screens 2 through 29, then load each screen manually. In this way, you can isolate some errors to a certain screen. Once you have the program running, replace the —> at the end of screens 2 through 29 so that you can later load the go program directly from the Macintosh desktop by clicking on the Go Blocks icon.

RUNNING THE PROGRAM

Once you have correctly loaded the program, you will get the screen shown in figure 1: the go program is up and running. Before starting a game, you can use the Handicap menu to set any level (zero or two through nine stones) of handicap.

When you're ready to play, select the Start option in the Go menu. Black and White can now take turns placing stones. (The mouse cursor changes to

(continued)

THE ANCIENT GAME OF GO

There is some dispute as to just how long ago the game of go started. It is at least 2000 years old; it may well be a dozen centuries older than that. By comparison, chess (born around 650 A.D. in India) is a newcomer. Originating in China, go was carried into Japan by invading soldiers and remained long after the armies left. It is still a national pastime in Japan, with professional players competing in tournaments for prize money.

If chess depicts armies meeting on a battlefield, go represents guerrilla warfare. Players seek to capture territory as well as opponents' pieces. Fierce fights often break out at key points on the board, and the placement of a single stone may determine victory or defeat. Throughout the game, each player must be aware of both global patterns and local formations.

Go is played on a board with 19 horizontal and 19 vertical lines, forming a 19 by 19 grid of 361 intersections. Shorter games are played by using a portion of the board: 15 by 15, 13 by 13, 11 by 11, or even 9 by 9. Each player has a set of rounded, convex stones; one player has black stones, the other, white. The stones are placed on the intersections, not on the squares, of the grid.

THE RULES OF GO

Go has relatively simple rules, which may in part explain its longevity. Here's a brief summary:

- Black plays first. If White has given Black a handicap (two to nine stones placed ahead of time in a predefined pattern), then that counts as Black's move, and White places a stone.
- Opponents alternate placing stones on the board. You may choose to pass—that is, not place a stone at all. The game is over when both players pass.
- You may place a stone on any intersection, with the two exceptions noted below.
- You may capture one or more of your opponent's stones by eliminating all of their *freedoms* (see "Armies and Freedoms"). You remove them from the board and keep them.
- You may not place a stone so it has no freedoms *unless* by doing so you capture enemy stones and thereby create the freedoms you need.
- If your opponent captures a single stone of yours, you cannot on the following turn place a stone in the vacated spot and capture the stone your opponent just played. Instead, you must wait at least one move before capturing that particular stone. This situation is known as *ko*; the prohibition on immediate recapture prevents "infinite loops" with two opponents trading stones until both run out.
- When the game is over (i.e., both players pass), all "dead" stones are removed from the board and counted as captured. A dead stone is one that could be captured if the game were to continue. If there is any doubt, then you should keep playing until both of you are convinced.
- Count up the territory (empty spaces) surrounded by each color. If you have removed all of the dead stones and filled in any neutral points (empty spaces bordered on by both colors), then it is easy to see who controls which spaces, since each group of spaces will "touch" only one color.
- Each player's score is the sum of the stones captured and the territory controlled. The player with the higher score wins. [*Editor's Note: The traditional method of computing the final score involves placing captured enemy pieces to fill your opponent's territory, with the final score being the count of the territory left on each side. The preceding method produces different numbers but the same win margin for one player.*]

ARMIES AND FREEDOMS

If two stones of the same color are adjacent—that is, if they occupy two side-by-side spaces connected by a single vertical or horizontal line—they form an army. If another stone of that color is adjacent to either of those two, it is part of the same army. If a fourth stone is adjacent to any of those three, it also belongs to that army, and so on. Separate armies can be merged into one by placing a stone in a spot adjacent to all of them. A single stone by itself can be considered an army of one.

A given army (one or more connected stones) has some number of *freedoms*. A freedom is an empty (unoccupied) space adjacent to one or more of the stones in that army. To capture an army, you must take away all of its freedoms. You then remove the army from the board, keeping the stones for the end of the game.

A key concept in go is the formation of *eyes*. Stated very simply, an eye is a freedom (or group of freedoms) surrounded by an army. An army with two or more eyes cannot be captured. Why? Suppose Black has an army with two eyes, each of which has exactly one empty space in it, and suppose that this army is completely surrounded by White's stones. To capture Black's army, White must place stones in both of those eyes. But White *can't* place a stone in either eye because that stone would have no freedoms and wouldn't capture any black stones.

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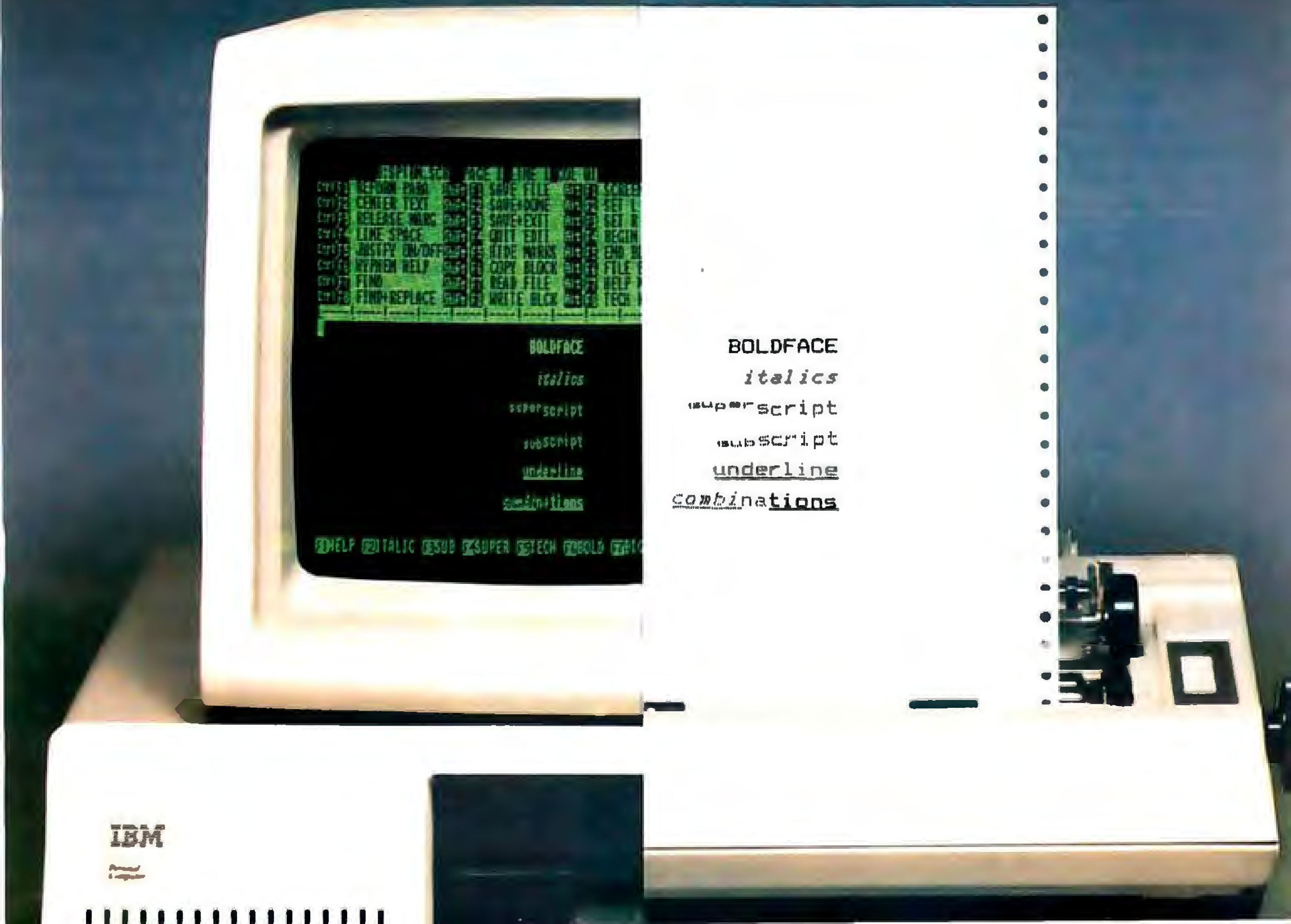
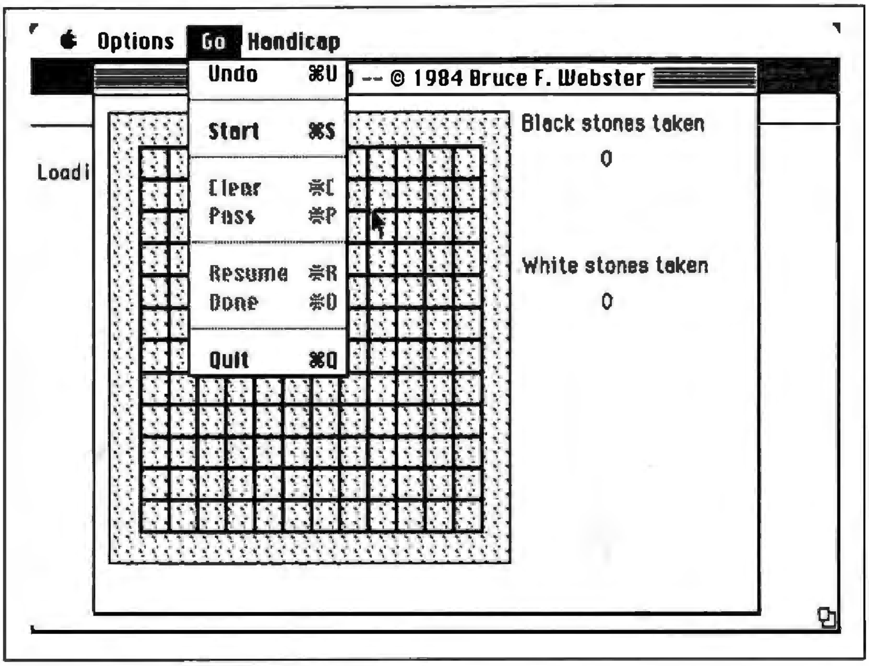


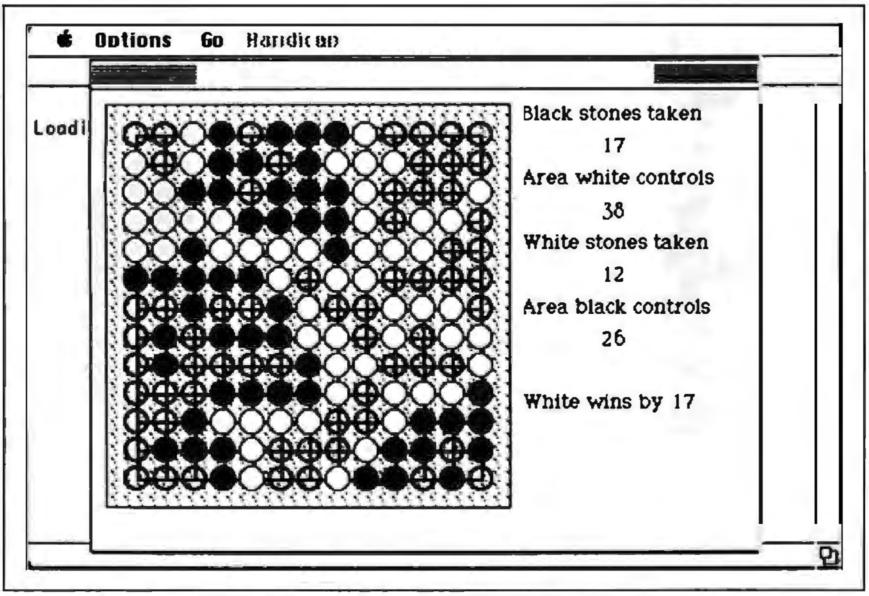
a go stone the color of the current player.) One level of "undo" is supplied (also in the Go menu), so that the last stone played can be picked up again. The game continues until both players are satisfied that no more effective moves can be made. Each player then passes, using the Pause selection from the Go menu. The mouse cursor now changes to the familiar arrow shape, and players pick up any "dead" enemy stones within their territory. When both are done, one player should choose the Done menu selection. The program then counts all the remaining territories, totals the score for each side, and declares a winner (see figure 2). You can then select Clear to start over again or Quit to end the program. Also, you can now skip the editor and load the go program directly by double-clicking the Go Blocks icon from the desktop.



```
Black stones taken
0

White stones taken
0
```

Figure 1: *The Macintosh screen immediately after listing 1 has been loaded. Notice the custom texture that fills the square used as the go board. Also note the two custom menus, Go (pulled down) and Handicap. The stage of play determines which items in the Go menu are currently active.*



```
Black stones taken
17
Area white controls
38
White stones taken
12
Area black controls
26

White wins by 17
```

Figure 2: *The end of a game. When a player chooses the Done selection from the Go menu, the program counts each side's territory (marked with hollow circles).*

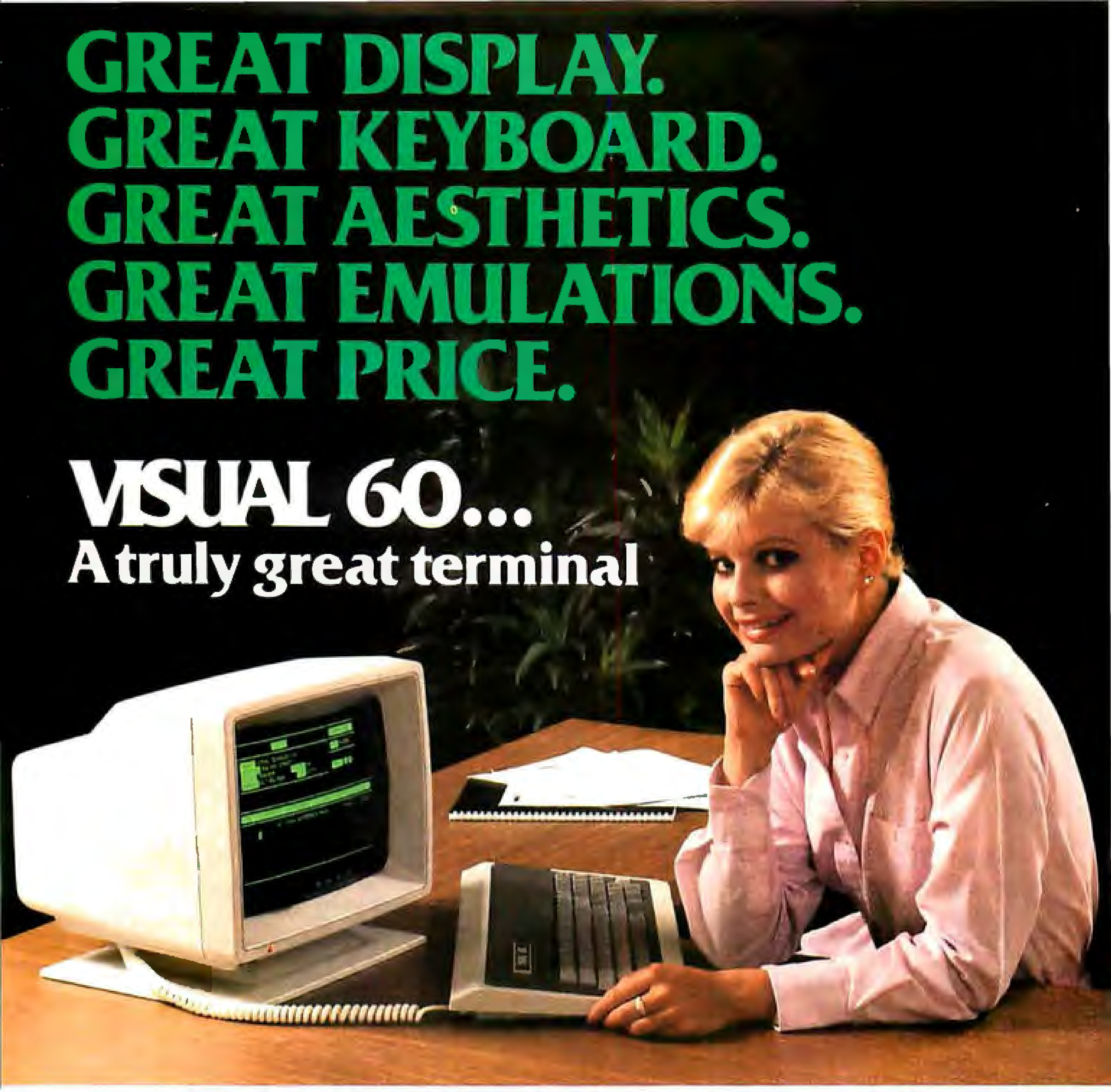
SUMMARY

Because MacFORTH was one of the first two languages available for the Macintosh, it will probably remain one of the major languages for that computer. There are already a lot of public-domain programs written in MacFORTH. You might check the Apple SIG (special-interest group) in CompuServe for FORTH programs you can download into your Mac.

It's interesting to note that this program is only 10 manuscript pages long. Brevity comes from the power inherent in both the Macintosh and MacFORTH; I don't think I could have done this program as easily or compactly using, say, Microsoft Macintosh BASIC. MacFORTH is not for everyone, but it offers a lot to the programmer willing to use it—fast, compact programs, customized language commands, and increased productivity.

The go program illustrates many features of the Macintosh and MacFORTH. Once you have it running, make a backup copy of the Go Blocks file, then start making changes and see what happens. For example, set the masks of both cursors (in screen 4) to all 0s and watch the difference as they move across the screen. You might try changing the size and location of the window or reorganizing the menus. Major changes you might try include converting the game to a full 19 by 19 board or adding a save/load game option. As you play around, you'll learn how to make the Mac do what *you* want it to.

(continued)



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(listing continued from page 128)

```
        color @ 1 = ;



                                                          ->


SCREEN # 10          "Go Blocks"          06/29/84          03:50:02 AM
 ( 2c=, 2c!, 2c*9, swap.colors                             ( 060884 bfw)
 : 2c= ( addr1 addr2 — flag | compares two bytes from addrs            )
       2dup c@ swap c@ = rot 1+ c@ rot 1+ c@ = and ;
 : 2c! ( a b addr ——| store 2 bytes                                     )
       rot over c! 1+ c! ;                    ( a -> addr, b -> addr+1 )
 : 2c@ ( addr — a b | fetch 2 bytes                                     )
         dup c@ swap 1+ c@ ;                      ( fetch addr, addr+1 )

 : swap.colors ( flag— | changes player from black to white            )
       dup 0= if             ( 0=pass — check for consecutive passes )
         pflag ! else pflag +! pflag @ 2 = if
           2 gflag !              ( game ends on two consecutive passes )
       then then bflag @ 1 = if        ( change to appropriate cursor )
         wcurse else bcurse then set.cursor
       bflag @ 3 xor bflag ! ;        ( and swap to other color player )
                                                                      ->


SCR # 11            "Go Blocks"          06/29/84          03:50:21 AM
 ( clear.stone, remove.army                                ( 060884 bfw)
 : clear.stone ( r/c —— | removes stone from board                     )
       2dup get.addr 0 swap c!          ( clear from map data structure )
       ( fill board with wood grain, redraw lines—clip if needed        )
       2dup get.bounds stretch.bounds texture pattern rectangle
       get.bounds stretch.bounds rot swap
       2dup + 2 / >r 2over r> rot over limit.bounds vector
       2swap + 2 / rot over swap 2swap swap limit.bounds vector ;
 : remove.army ( r/c —— | removes entire army                           )
     0 stptr ! 0 stones ! 2dup taken 2c!             ( initialize values )
     2dup clear.stone push begin          ( remove stone, push on stack )
       pop 1 stones +! 4 0 do 2dup i get.adj        ( get adjacent stone)
         2dup get.stone color @ = if ( if same color as dead army       )
           2dup clear.stone push else 2drop then          ( remove stone )
     loop 2drop stptr @ 0= until ;          ( continue until stack empty )
                                                                      ->


SCREEN # 12          "Go Blocks"          06/29/84          03:50:40 AM
 ( put.count, do.error                                     ( 060884 bfw)

 : put.count ( ——| put stone-captured count                            )
   320 blackif if            ( x = 320, y and value are based on color )
     40 btaken @ else 120 wtaken @ then                     ( get y, value )
     >r move.to r> . cr ;              ( move to x,y and print value )

 : do.error ( errnum —| prints out appropriate error message           )
     270 200 move.to                   ( this is all pretty self-explanatory )
     CASE 0 OF ."                   " ENDOF ( clear msg on valid move)
          1 OF ." No freedoms        "                         ENDOF
          2 OF ." Spot occupied      "                         ENDOF
          3 OF ." Ko situation       "                         ENDOF
     ENDCASE cr ;


                                                                      ->
```

(continued)

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```
SCREEN # 13          "Go Blocks"          06/29/84          03:50:55 AM
( check.for.ko, capture.armies                                ( 060884 bfw)
: check.for.ko ( ---| detects ko situations on board                       )
   0 ( set flag ) tstones @ 1 = if                   ( only if 1 stone taken )
     playy ko 2c= if                   ( stone played = stone taken last turn )
       taken 2c@ color @ put.on.map                   ( replace taken stone )
       draw.stone 3 do.error                          ( write error message )
       0 tstones ! drop -1                      ( zero tstones, set error flag )
     else taken 2c@ ko 2c! then                    ( taken -> ko for next turn )
   else 0 0 ko 2c! then ;                    ( clear ko if < > 1 stone taken )

: capture.armies                ( r c --| checks adjacent stones for capture )
   4 0 do 2dup i get.adj                         ( check adjacent locations )
     2dup get.stone color @ = if                    ( see if opposing color )
       2dup expand freedoms @ 0= if             ( count freedoms of army )
         remove.army stones @ tstones +!              ( if =0 then remove )
   else 2drop then else 2drop then loop ;                  ->     ( cleanup )


SCREEN # 14          "Go Blocks"          06/29/84          03:51:13 AM
( 14-check capture                                            ( 060884 bfw)

: check.capture                ( r/c — flag | capture enemy, check freedoms )
   bflag @ 3 xor color !                            ( look for opposing color )
   0 tstones !                                         ( clear capture total )
   capture.armies                            ( remove any freedom-less armies )
   check.for.ko                   ( lookout for ko situation—returns 0/-1 )
   tstones @ blackif if                      ( update "stones taken" count )
     btaken else wtaken then +! put.count
   dup 0= if                       ( if no ko error, then check for no freedoms )
   drop bflag @ color !                             ( switch to player's color )
   expand freedoms @ 0= dup if                     ( if stone has no freedoms )
     1 do.error drop -1                          ( then you can't play it there )
   then then ;                               ( returns -1 if illegal move, else 0 )

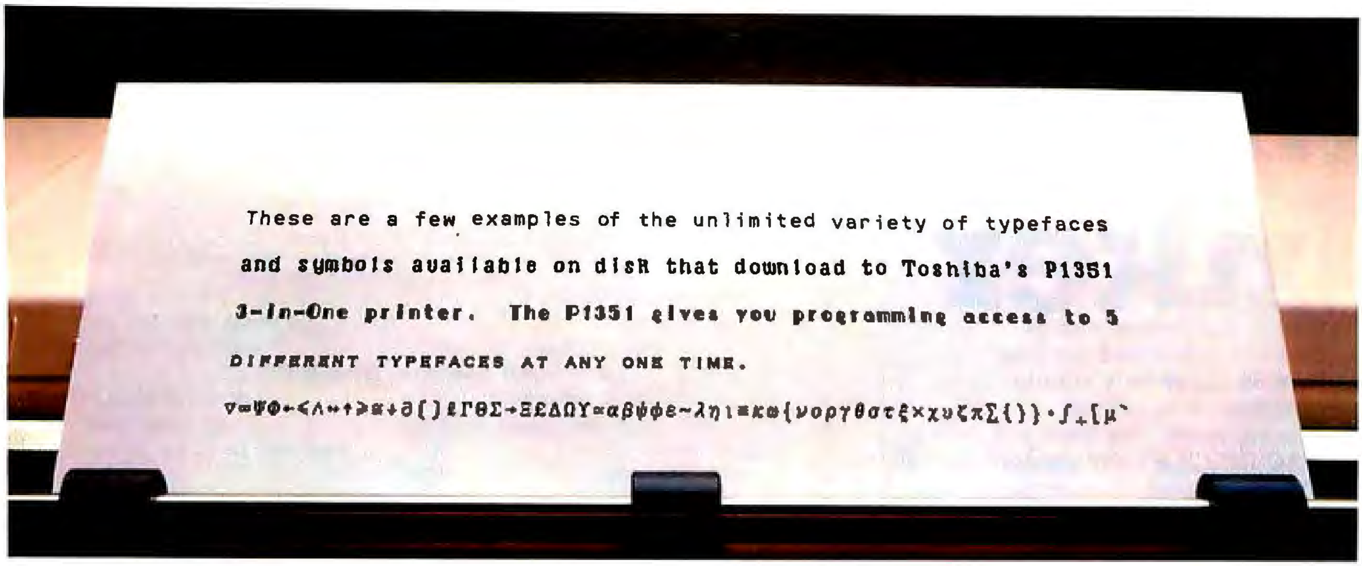

                                                                          ->


SCREEN # 15          "Go Blocks"          06/29/84          03:51:46 AM
( put.stone.down                                              ( 060884 bfw)
: put.stone.down ( ---| places stone on board                              )
   @mousexy                                          ( get mouse coordinates )
   at.point if swap at.point if                       ( check if legal position )
     empty.spot if                                          ( check if empty )
       2dup playy 2c! 2dup                             ( store for "ko" check )
       bflag @ put.on.map draw.stone                    ( place stone on board )
       2dup check.capture if                            ( check for legal move )
         clear.stone 3 sysbeep else                       ( if not: clear, beep)
         0 swap.colors 2drop 0 do.error then                 ( else o.k. move )
         else 3 sysbeep 2 do.error 2drop                   ( not an empty spot )
   then else drop then else drop then ;                              ( cleanup )
                                                                          ->




SCREEN # 16          "Go Blocks"          06/29/84          03:51:46 AM
( redraw.stones, draw.board                                   ( 060884 bfw)
: redraw.stones ( ---| draw all stones on board )
   14 1 do 14 1-do                               ( search through 13x13 board )
```

(continued)



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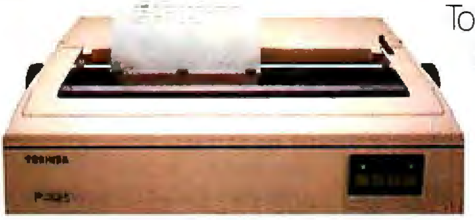

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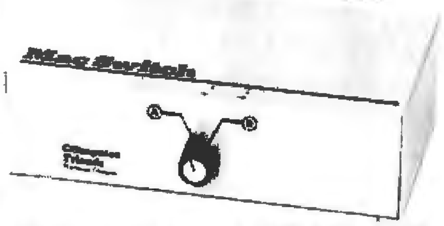

MAC GO PROGRAM

```
    i j get.addr c@ dup 0> if                        ( look for stones )
     i j rot draw.stone                        ( if found, draw on board )
    else drop then loop loop ;                     ( clean up everything )
: draw.board ( — — | draw board in window "Go board"                     )
   9 9 263 263 frame rectangle                    ( draw outline of board )
   10 10 262 262 texture pattern rectangle            ( fill "wood grain" )
   262 28 do                               ( draw lines for 13x13 go board)
      i 28 i 244 vector   28 i   244 i vector               ( vert, horiz )
   18 +loop                                     ( lines are 18 units apart )
   270  20 move.to ." Black stones taken" cr               ( set up labels )
   270 100 move.to ." White stones taken" cr
  1 color ! put.count 2 color ! put.count ;                ( redraw counts )
                                                                        —>

SCREEN # 17          "Go Blocks"          06/29/84          03:52:04 AM
 ( backup.game, restore.game                                  ( 060884 bfw)

 : backup.game ( flag —— | saves game state into bmap/cmap)
    0= if map bmap bmap map - cmove          ( flag=0 — store in bmap )
    else map cmap bmap map - cmove then ;          ( else store in cmap )

 : restore.game ( flag —— | restores game from bmap/cmap               )
    0= if bmap map bmap map - cmove          ( flag=0 — store in bmap )
    else cmap map bmap map - cmove then            ( else store in cmap )
    bflag @ 1 = if                               ( restore correct cursor)
      bcurse else wcurse then set.cursor
   draw.board redraw.stones ;                   ( redraw board, stones)
                                                                        —>




SCREEN # 18          "Go Blocks"          06/29/84          03:52:19 AM
 ( expand.empty                                               ( 060884 bfw)

 : expand.empty ( r c — | search for adjacent empty points              )
     4 0 do 2dup i get.adj                        ( get adjacent stones )
       2dup get.stone dup CASE             ( handle according to "color" )
         ( empty slot — fill up, push onto stack for later check         )
           0            OF drop 2dup fill.spot push          ENDOF
                                 ( stone — keep track to see if all one color )
          1 2  RANGE.OF freedoms @ or freedoms ! 2drop ENDOF
                                          ( edge of board — just ignore )
           3            OF drop 2drop                         ENDOF
     ENDCASE loop  ;
                                                                        —>




SCREEN # 19          "Go Blocks"          06/29/84          03:52:32 AM
 ( count.territory                                            ( 060884 bfw)
 : count.territory ( ——| tally up free areas
                                                                         )
    0 bspace ! 0 wspace ! 0 color !                     ( clear variables )
    14 1 do 14 1 do i j                         ( scan entire 13x13 board )
      get.stone 0= if                             ( look for open spaces )
      0 stones ! 0 stptr ! 0 freedoms !                  ( clear counters )
      i j 2dup fill.spot push begin              ( get x,y, trace "army" )
        pop 1 stones +! 2dup                    ( pop x,y and incr. count )
        get.bounds stretch.bounds frame oval           ( draw empty stone )
        expand.empty                                   ( look for neighbors )
       2drop stptr @ 0= until                      ( continue until filled )
```

(continued)

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MAC GO PROGRAM

```
 11    freedoms @ dup if dup 3 < if                    ( see if controlled area )
 12       color ! stones @ blackif if                  ( get controlling color )
 13         bspace else wspace then +!                 ( and increase captures )
 14    else drop then else drop then then loop loop ;               ( cleanup )
 15                                                                        -->

SCREEN # 20          "Go Blocks"          06/29/84          03:52:51 AM
  0 ( pick.stone.up                                                ( 060984 bfw)
  1 : pick.stone.up ( --| pick captured stone up from board)
  2    @mousexy                                         ( get location of cursor )
  3    at.point if swap at.point if                          ( check if on board )
  4      2dup get.stone dup 0= if                      ( see if a stone is there )
  5        3 sysbeep drop 2drop else                      ( if none, then beep )
  6                          ( else store color and increment appropriate counter )
  7        color ! 1 blackif if btaken else wtaken then +!
  8                  ( update counts, clear stone from board, cursor = arrow )
  9        put.count clear.stone init.cursor then
 10    else drop then else drop then ;                 ( otherwise, clean up stack )
 11                                                                        -->
 12
 13
 14
 15

SCREEN # 21          "Go Blocks"          06/29/84          03:53:07 AM
  0 ( turn.off, disable.all, turn.on                               ( 060884 bfw)
  1 ( these routines are used to control what is and is not active
  2  on the "go" menu )
  3
  4 : turn.off ( n —| turns off indicated item in go.menu                      )
  5   0 go.menu item.enable ;
  6
  7 : turn.on ( n —| turns on indicated item in go.menu                        )
  8   -1 go.menu item.enable ;
  9
 10 : disable.all ( --| turns off all specific items in menu                  )
 11    3 turn.off                                             ( start          )
 12    5 turn.off   6 turn.off                                ( clear, pass    )
 13    8 turn.off   9 turn.off   ;                            ( resume, done   )
 14                                                                        -->
 15

SCREEN # 22          "Go Blocks"          06/29/84          03:53:20 AM
  0 ( show.results                                                 ( 060884 bfw)
  1 : show.results ( --| show final stuff of game                              )
  2    disable.all 5 turn.on                                  ( adjust go menu )
  3    count.territory                                ( count free area on board )
  4                                         ( show how much each side controls )
  5    270  60 move.to ." Area white controls" cr                ( write values )
  6    320  80 move.to wspace @ . cr
  7    270 140 move.to ." Area black controls" cr
  8    320 160 move.to bspace @ . cr
  9                                               ( calculate and declare winner )
 10    270 200 move.to bspace @ wtaken @ + wspace @ btaken @ + - dup
 11    0> if ." Black" else ." White" then ."wins by " abs . cr
 12                                    ( wait until gflag changes [by menu] )
 13    begin do.events drop gflag @ 3 = not until ;
 14                                                                        -->
 15

SCREEN # 23          "Go Blocks"          06/29/84          03:53:36 AM
  0 ( get.pair, ?6.or.8, do.handicap                               ( 060884 bfw)
```

(continued)

HOW THE PROGRAM WORKS

BY GREGG WILLIAMS

During the editing of this article, I had trouble tracing this program's flow as it ricocheted from FORTH word to FORTH word. The notes that follow should clarify the workings of this program.

The key to this program is a variable called gflag ; its value causes the program to switch from one word to another. Here are some notes about the various values of gflag and their meanings:

gflag = 0—initial value at beginning of program, before an actual game has started
= 1—during the play of a game
= 2—possible end of game, signaled by both players executing Pass from menu
= 3—end of game confirmed by player executing Done from menu
= 4—go program being exited by player executing Quit from menu

All states except gflag = 2 are manipulated by making selections from the Go menu (see screens 26 and 27). In screen 26, menu selection names are separated by semicolons; thus, Undo is selection 1, selection 2 is unused, Start is selection 3, and so on. gflag is set to 2 by execution of the menu selection Pass (screen 27, line 6), which executes the word swap.colors (screen 10) with the argument 1 instead of the usual 0.

Another variable that helps describe the state of the program is bflag , which denotes the current player (1 = black, 2 = white). Many of the words in this program do the same work for both players—they simply look at the value of bflag to determine who is currently playing. The word swap.colors toggles the value of bflag between 1 and 2; in fact, the main loop of the program—take a move, process it, and switch to the other player—consists of swap.colors as called from the word play.go , which is itself part of a loop.

Figure 3 shows a state diagram of the program where each node is a FORTH word and the label of each connecting line describes the conditions that cause program control to transfer to another node. Notice that either a change in the value of gflag or the activation or deactivation of the board window causes these transitions. The following paragraphs provide overviews of the FORTH words in figure 3.

go.program (screen 29) executes when the window board is activated or deactivated; lines 6 to 12 execute upon activation, and line 13 executes on deactivation. Lines 6 to 12 run initialization code then fall into a loop that ends only when gflag = 4 (quit program). The initialization code sets gflag to 0, so start.new.game executes the first time through the loop.

start.new.game (screen 25) draws the board and turns on the Handicap menu and the Start selections in the Go (main) menu (the Quit selection is always active). The only way to get out of this word is to choose one of the two selections. When selected, Start causes gflag to change to 1 and program execution to pass to the word play.go .

play.go (screen 24) activates the Clear and Pass selections; it then switches to the other player (line 3) and gets the location at which the current player wants to place his piece (lines 4 and 5). Players can set gflag to 2 by choosing the Pass selection twice in succession instead of playing pieces; this causes execution to pass to the word end.game .

end.game (screen 24) activates the Resume and Done menu selections and lets players discard "dead" stones. Resume returns gflag to 1, enabling the game to continue; Done sets gflag to 3, causing execution to pass to show.results .

show.results (screen 22) activates the Clear menu selection and calculates and displays the final score of the current game. By executing Clear, the player sets gflag to 0, thus preparing for a new game.

exit.program (screen 29) removes the Go and Handicap menus, restores the normal pointing-arrow mouse cursor, and returns the MacFORTH system to the default window, sys.window .

Gregg Williams is a senior technical editor at BYTE. *He can be contacted at* POB 372, *Hancock*, NH 03449.

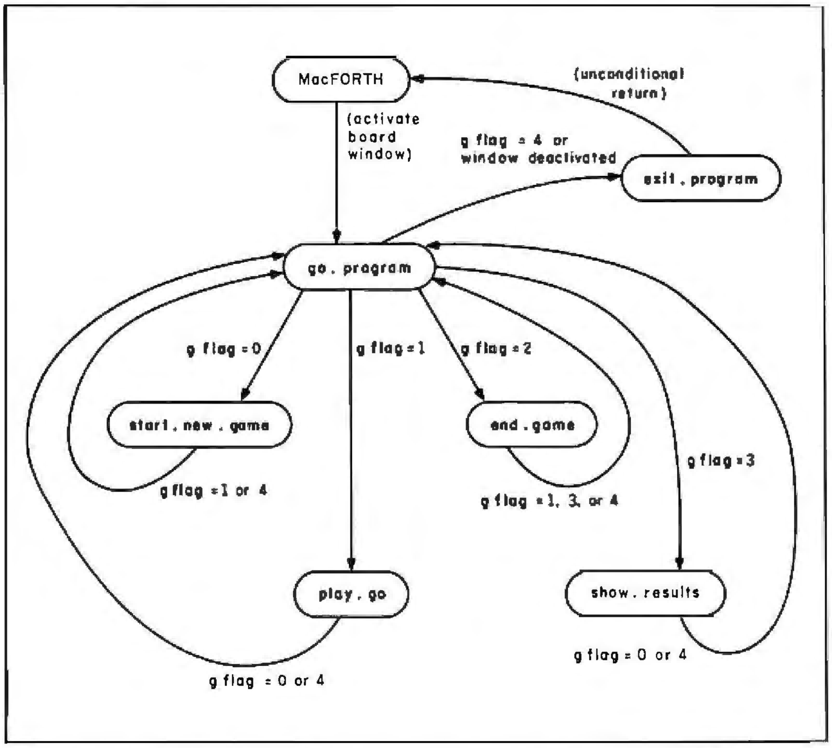

Figure 3: *A state diagram of the go program. With the exception of the MacFORTH node, each node represents a keyword within the go program of listing 1. The labels on the arrows indicate the events that cause program control to go to another word; for example, when the program is executing* go.program , *control transfers to* play.go *only when* gflag *becomes* 1 *(which happens when a player chooses the Start selection from the Go menu).*

```
 : get.pair ( addr — addr+2/r/c | gets next two values                     )
    dup c@ swap 1 + dup c@ swap 1 + rot rot ;

 : ?6.or.8 ( n — n/f | checks if n = 6 or 8 for handicap                    )
  dup 6 = over 8 = or ;

 : do.handicap ( n —| sets handicap of 2..9 stones, n=2..9                  )
    0 backup.game dup hlevel !                           ( save handicap level )
    >r stars r> 6.or.8 if 1 + then 0 do                   ( adjust for 6, 8 )
      get.pair 1 put.on.map drop drop drop             ( put stones on map )
    loop drop hlevel @ ?6.or.8 if                    ( if 6 or 8 remove center )
      drop stars 18 + get.pair clear.stone
    then drop 1 bflag ! ;                                ( set for white start )
                                                                          —>


SCREEN # 24          "Go Blocks"          06/29/84          03:54:22 AM
  ( play.go, end.game                                             ( 060884 bfw)
 : play.go ( flag | routine assigned to wptr "board"                          )
    disable.all 5 turn.on 6 turn.on                          ( adjust go menu )
    0 swap.colors                                     ( set up cursor for player )
    begin do.events mouse.down = if                   ( allow stone placement )
      0 backup.game put.stone.down
    then gflag @ 1 = not until                    ( on exit, do solid backup )
    gflag @ 1 gflag ! 1 backup.game gflag ! ;
 : end.game ( —-| finishes off game of go                                     )
    init.cursor                                     ( change to arrow cursor )
    disable.all 8 turn.on 9 turn.on                          ( adjust go menu )
    begin do.events mouse.down = if                       ( allow stone pick-up )
      0 backup.game pick.stone.up
    then gflag @ 2 = not until ;                                          —>


SCREEN # 25          "Go Blocks"          06/29/84          03:54:09 AM
  ( start.new.game                                                ( 060884 bfw)

 : start.new.game ( —-| allows players to start new game                      )
  map 256 0 fill                                                 ( clear the map )
  0 btaken ! 0 wtaken ! 0 hlevel ! 2 bflag !                  ( clear variables )
  page draw.board init.cursor 0 pflag !                   ( set up board, cursor )
  -1 hand.menu menu.enable                            ( enable handicap menu )
  0 backup.game disable.all 3 turn.on                           ( turn on items)
  begin do.events drop gflag @ 0= not until                       ( main loop)
  0 hand.menu menu.enable ;                             ( disable handicap menu )


                                                                  —>





SCREEN # 26          "Go Blocks"          06/29/84          03:54:22 AM
  ( create.menus                                                  ( 060884 bfw)
 : create.menus ( —-| creates menu for go program                             )
    go.menu delete.menu                              ( delete any existing menu )
    go.menu 1 + " Go" go.menu new.menu                ( define title for menu )
    " Undo/U; – ("                 go.menu append.items              ( add opt. )
    " Start/S; – ("                go.menu append.items
    " Clear/C;Pass/P; – ("         go.menu append.items
    " Resume/R;Done/D; – ("        go.menu append.items
    " Quit/Q"                      go.menu append.items
```

(continued)

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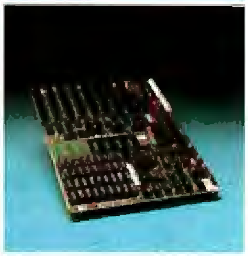

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BOOKS ON GO

Grunfeld, Frederic V., ed. *Games of the World*. New York: Ballantine Books, 1975. This volume features a concise but complete explanation of the game.

Haruyama, Isamu, and Nagahara Yoshiaki. *Basic Techniques of Go* (2nd edition). Tokyo: Ishi Press, 1973. A good second book, after your introduction.

Holmes, John C. *Go*. Mt. Vernon, VT: Paul P. Appel, 1979.

Iwamoto, Kaoru. *Go for Beginners*. New York: Pantheon, 1977. An excellent introduction by a high-ranking professional.

Kishikawa, Shigemi. *Steppingstones to Go*. Rutland, VT: Charles E. Tuttle Co., 1965. A good substitute if you can't find *Go for Beginners*.

Lasker, Edward. *Go and Go Moku*. New York: Dover Books, 1960.

Takagawa, Shukara. *Go!* Carlisle, PA: Sabaki Go Co., 1982. A reprinted combination of *How to Play Go* and *The Vital Points of Go*. The author is a former national go champion of Japan.

Mr. Quentin Dombro, of the Sabaki Go Company, says that his firm carries a complete line of go materials, including two go magazines (one from Japan) and every English-language go book available. The company will also send its catalog free upon request. The address is POB 23, Carlisle, PA 17013.

PROGRAM AVAILABLE

Readers who don't want to type in the entire go program can get a copy for $10; checks should be made payable to Bruce F. Webster.

MacFORTH Go Program
c/o Bruce Webster
7907 Ostrow St., Suite F
San Diego, CA 92111

You'll receive a 3½-inch disk with the Go Blocks file on it.

You'll still need MacFORTH 1.1, from Creative Solutions Inc. (CSI), to run the the program. CSI is located at 4801 Randolph Rd., Rockville, MD 20852.

```
  9    hand.menu delete.menu                         ( delete any existing menu )
 10    hand.menu 1+ " Handicap" hand.menu new.menu                  ( set title )
 11    " Clear;2 stones;3 stones"    hand.menu append.items
 12    " 4 stones;5 stones;6 stones" hand.menu append.items
 13    " 7 stones;8 stones;9 stones" hand.menu append.items
 14  draw.menu.bar ;
 15                                                                        -->

SCREEN # 27          "Go Blocks"          06/29/84          03:54:41 AM
  0 ( do.go.menu                                                ( 060884 bfw)
  1
  2 : do.go.menu ( --| defines actions for each menu item                    )
  3    go.menu menu.selection: 0 hilite.menu
  4    CASE 1 OF gflag @ 3 = if 1 else 0 then
  5               restore.game                ENDOF                 ( undo )
  6          3 OF 1 gflag !                   ENDOF                ( start )
  7          5 OF 0 gflag !                   ENDOF                ( clear )
  8          6 OF 1 swap.colors               ENDOF                 ( pass )
  9          8 OF 1 gflag ! 1 restore.game    ENDOF               ( resume )
 10          9 OF 3 gflag !                   ENDOF                 ( done )
 11         11 OF 4 gflag !                   ENDOF                 ( quit )
 12    ENDCASE ;
 13
 14
 15                                                                        -->

SCREEN # 28          "Go Blocks"          06/29/84          03:54:56 AM
  0 ( do.hand.menu, init.program                                ( 060884 bfw)
  1 : do.hand.menu ( --| handles handicap stuff                              )
  2    hand.menu menu.selection: 0 hilite.menu
  3    map 256 0 fill dup 1 = if                              ( clear board )
  4      0 hlevel ! 2 bflag ! else                     ( set for regular play )
  5      do.handicap then                                   ( set handicap )
  6    draw.board redraw.stones;
  7
  8 : init.program ( --| set everything up at the start                      )
  9   0 gflag ! ginit page upper.left                       ( init graphics )
 10   2 2 pensize srccopy textmode                  ( set up to draw or write )
 11   create.menus                           ( create go and handicap menus)
 12   0 hand.menu menu.enable                        ( disable handicap menu )
 13   do.go.menu do.hand.menu ;                      ( define actions for both )
 14
 15                                                                        -->

SCREEN # 29          "Go Blocks"          06/29/84          03:55:12 AM
  0 ( exit.program, go.program                                  ( 060984 bfw)
  1 : exit.program ( --| clean everything up when program is done            )
  2   go.menu delete.menu hand.menu delete.menu               ( turn off menus )
  3   sys.window window init.cursor ;               ( make sys.window active )
  4
  5 : go.program ( --| driving loop; switches between segments               )
  6   if init.program begin gflag @ CASE                  ( use gflag to select )
  7     0 OF start.new.game  ENDOF               ( handle new game selections )
  8     1 OF play.go         ENDOF                           ( play the game )
  9     2 OF end.game        ENDOF                             ( tally score )
 10     3 OF show.results    ENDOF                  ( give results of game )
 11     ENDCASE gflag @ 4 = until                      ( continue until quit )
 12     exit.program else                                  ( cleanup and exit )
 13   exit.program then ;                       ( do same on window deactivate )
 14
 15 board on.activate go.program                  ( attach program to window )
```

(continued from page 131)

This line of **reasoning** brings us to the unexpected fact that essentially random nonsense can preserve many "personal" characteristics of a source text. Travesty (listing 1), a program suitable for small systems, will scan a sample text and generate, from the sample's *n*-gram statistics, a "nonsense" imitation through which the original text, and even its authorship, is disconcertingly recognizable.

For example, we provided Travesty with 29 names of towns taken from a gazetteer of England and called for third-order (trigram) analysis. It promptly churned out a couple thousand characters. These letter groups included (1) many input words regurgitated; (2) some uninteresting letter strings that we agreed to call "garbage" (on the principle that a weed is a flower you don't want); and (3) some wondrously plausible names for English towns that don't exist but ought to. They included Bambudge, Nettlewett, Gidge, Hample, Bognorton, Chire, Clop, Tootinton, Bleweth, and Eastle. (If any of these is a real name, that's by accident; none was on our input list.) And fancy being Mayor of Clop!

The connection of the output to the source can be stated exactly: *for an order-n scan, every n-character sequence in the output occurs somewhere in the input, and at about the same frequency.* That is all, yet it is enough to account for an eerie similarity. Every string of three letters in our pseudo-place-names, "ttl" or "dge", for instance, was lifted out of a string of characters and spaces that consisted simply of the 29 input words typed one after another with one space after each.

Figure 1 shows one of the thousands of machine-generated derivations Travesty can extract from a 75-word sample of James Joyce's *Ulysses*. This passage is an order-4 scan; every *four*-character sequence in the output comes from somewhere in the input.

FREQUENCY ARRAYS

There is a lot of fun to be had here. There is also much for the student of language and literature to investigate. To what degree can personal "style" be described as a manifestation of letter frequencies? Such a question, though not new, was merely tantalizing before the modern computer; even more so before procedures were discovered—quite recently—that didn't demand impossible amounts of machine memory.

Brian P. Hayes, associate editor of

(continued)

REMARKS ON THE TRAVESTY LISTING

Pascal input/output (I/O) conventions are, to say the least, poorly standardized. We have three Pascal systems available: Turbo Pascal for CP/M and MS-DOS, Lucidata Pascal for CP/M and HDOS, and Berkeley Pascal running under UNIX—and we haven't been able to write a version of Travesty that will run on all three unmodified. Judging that Turbo is the rising young comer, we list the Turbo Pascal version, with notes on such problem areas as we know about. This version might run on UCSD Pascal too, but we've not been able to try it. Since it avoids features unique to Turbo and UCSD, it ought to be transportable to any decent Pascal system at the cost of a little attention to input and output.

Line numbers are, of course, for reference only; don't type them into your Pascal listing.

23 This value is safe and may even be increased, but remember that you'll have *two* arrays this size. How big you can make ArraySize depends on your system's memory requirements. Turbo Pascal, when compiled to disk to get the compiler itself out of the way, permitted ArraySize = 14,000 on a 64K-byte CP/M system. That's about 2300 words of input text. On an MS-DOS system with 196K bytes, maximum ArraySize increased to 21,000, or 3500 words of text, independent of whether compilation was to memory or to disk.

33 If your Pascal doesn't know about the TEXT type, change this line to f : file of char.

40 If your Pascal system has a RANDOM function, you can drop lines 40 to 44 altogether. Then change line 239 to read toss := random(total) + 1;. You should also delete lines 38, 52, and 53.

49 Many versions of Pascal don't recognize STRING types unless they have been declared:

Type STRING = PACKED ARRAY[1 . . 12] OF CHAR;

Then change line 49 to InFile : STRING.

62 Some Pascals will require you to declare a variable *i* and say, FOR i := 1 TO 12 DO READ InFile[i];.

63 Berkeley Pascal doesn't use the ASSIGN command. You'd omit this line and change line 64 to reset (f, infile);.

Also, you will probably want output to a disk file, and you'll have to set that up yourself. Add a second TEXT variable, *g*, to line 33 and a second STRING variable, OutFile, to line 49. Then insert after line 64 a request for the name of the Outfile, and ASSIGN it to *g* in whatever way your system provides. And if your system requires files to be explicitly closed, add a statement line, CLOSE (*g*), just before the final END. (Don't forget the semicolon at the end of the line above it.)

NOTES ON HELLBAT

To change Travesty into Hellbat, procedures InitSkip and Match are replaced by the versions given in listing 2, and numerous lines are deleted as shown below. Note that WriteCharacter now receives its characters from Match and has only formatting duties to perform. If your Pascal has its own RANDOM function, make the deletions listed in the section on Travesty for line 40; and the major change—applied above to the WriteCharacter procedure—should instead be made to the line in the new Match procedure that invokes Random.

Lines to delete for Hellbat include 28, 72 to 80, 269, 273 (all references to FreqArray), and 232 to 245 (process for getting a character).

Listing 1: *Travesty, a program for generating pseudo-text. The program will scan a sample text and generate a "nonsense" imitation. For an order-n scan, every n-character sequence in the output occurs somewhere in the input.*

```
PROGRAM travesty (input, output);                {Kenner / O'Rourke, 5/9/84}

(*    This is based on Brian Hayes's article in Scientific                 *)
(*    American, November 1983. It scans a text and generates               *)
(*    an n-order simulation of its letter combinations. For                *)
(*    order n, the relation of output to input is exactly:                 *)
(*             "Any pattern n characters long in the output                *)
(*                has occurred somewhere in the input,                     *)
(*                  and at about the same frequency."                      *)
(*    Input should be ready on disk. Program asks how many                 *)
(*    characters of output you want. It next asks for the                  *)
(*    "Order"—i.e. how long a string of characters will be                 *)
(*    cloned to output when found. You are asked for the                   *)
(*    name of the input file, and offered a "Verse" option.                *)
(*    If you select this, and if the input has a "¦" char-                 *)
(*    acter at the end of each line, words that end lines in               *)
(*    the original will terminate output lines. Otherwise,                 *)
(*    output lines will average 50 characters in length.                   *)

CONST
    ArraySize = 3000;     {maximum number of text chars}
    MaxPat = 9;            {maximum Pattern length}

VAR
  BigArray : PACKED ARRAY [1..ArraySize] of CHAR;
  FreqArray, StartSkip : ARRAY[' '..'¦'] of INTEGER;
  Pattern : PACKED ARRAY [1..MaxPat] of CHAR;
  SkipArray : ARRAY [1..ArraySize] of INTEGER;
  OutChars : INTEGER;      {number of characters to be output}
  PatLength : INTEGER;
  f : TEXT;
  CharCount : INTEGER;              {characters so far output}
  Verse, NearEnd : BOOLEAN;
  NewChar : CHAR;
  TotalChars : INTEGER;      {total chars input, + wraparound}
  Seed : INTEGER;

FUNCTION Random (VAR RandInt : INTEGER) : REAL;
BEGIN
  Random := RandInt / 1009;
  RandInt := (31 * RandInt + 11) MOD 1009
END;

PROCEDURE InParams;
(*  Obtains user's instructions   *)
VAR
  InFile : STRING [12];
  Response : CHAR;
BEGIN
  WRITELN ('Enter a Seed (1..1000) for the randomizer');
  READLN (Seed);
  WRITELN ('Number of characters to be output?');
  READLN (OutChars);
  REPEAT
    WRITELN ('What order? <2-', MaxPat,'>');
    READLN (PatLength)
  UNTIL (PatLength IN [2..MaxPat]);
  PatLength := PatLength - 1;
  WRITELN ('Name of input file?');
```

(continued)

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```
    READLN (InFile);
    ASSIGN (f, InFile);
    RESET (f);
    WRITELN ('Prose or Verse? <p/v>');
    READLN (Response);
    IF (Response = 'V') OR (Response = 'v') THEN
      Verse := true
    ELSE Verse := false
  END; {Procedure InParams}

  PROCEDURE ClearFreq;
  (*  FreqArray is indexed by 93 probable ASCII characters,              *)
  (*  from " " to "¦". Its elements are all set to zero.                 *)
  VAR
    ch : CHAR;
  BEGIN
    FOR ch := ' ' TO '¦' DO
      FreqArray[ch] := 0
  END; {Procedure ClearFreq}

  PROCEDURE NullArrays;
  (*    Fill BigArray and Pattern with nulls      *)
  VAR
    j : INTEGER;
  BEGIN
    FOR j := 1 TO ArraySize DO
      BigArray[j] := CHR(0);
    FOR j := 1 TO MaxPat DO
      Pattern[j] := CHR(0)
  END; {Procedure NullArrays}

  PROCEDURE FillArray;
  (*    Moves textfile from disk into BigArray, cleaning it              *)
  (*    up and reducing any run of blanks to one blank.                  *)
  (*    Then copies to end of array a string of its opening              *)
  (*    characters as long as the Pattern, in effect wrapping            *)
  (*    the end to the beginning.                                        *)
  VAR
    Blank : BOOLEAN;
    ch: CHAR;
    j : INTEGER;

    PROCEDURE Cleanup;
    (*  Clears Carriage Returns, Linefeeds, and Tabs out of              *)
    (*  input stream. All are changed to blanks.                         *)
    BEGIN
      IF (( ch = CHR(13))       {CR}
        OR (ch = CHR(10))       {LF}
        OR (ch = CHR(9)))       {TAB}
      THEN ch := ' '
    END;

  BEGIN {Procedure FillArray}
    j := 1;
    Blank := false;
    WHILE (NOT EOF(f)) AND (j <= (ArraySize - MaxPat)) DO
    BEGIN {While Not EOF}
      READ (f, ch);
      Cleanup;
      BigArray[j] := ch;                        {Place character in BigArray}
      IF ch = ' ' THEN Blank := true;
      j := j + 1;
      WHILE (Blank AND (NOT EOF(f))
```

(continued)

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```
        AND (j <= (ArraySize - MaxPat))) DO
      BEGIN {While Blank}                          {When a blank has just been}
        READ (f, ch);                                {printed, Blank is true,}
        Cleanup;                               {so succeeding blanks are skipped,}
        IF ch <> ' ' THEN                                  {thus stopping runs.}
        BEGIN {If}
          Blank := false;
          BigArray[j] := ch;                        {To BigArray if not a Blank}
          j := j + 1
        END {If}
      END {While Blank}
    END; {While Not EOF}
    TotalChars := j - 1;
    IF BigArray[TotalChars] <> ' ' THEN
    BEGIN        {If no Blank at end of text, append one}
      TotalChars := TotalChars + 1;
      BigArray[TotalChars] := ' '
    END;
    {Copy front of array to back to simulate wraparound.}
    FOR j := 1 TO PatLength DO
      BigArray[TotalChars + j] := BigArray[j];
    TotalChars := TotalChars + PatLength;
    WRITELN('Characters read, plus wraparound = ',TotalChars:4)
  END; {Procedure FillArray}

  PROCEDURE FirstPattern;
  (*    User selects "order" of operation, an integer, n, in the          *)
  (*    range 1 .. 9. The input text will henceforth be scanned           *)
  (*    in n-sized chunks. The first n-1 characters of the input          *)
  (*    file are placed in the "Pattern" Array. The Pattern is            *)
  (*    written at the head of output.                                    *)
  VAR
    j : INTEGER;
  BEGIN
    FOR j := 1 TO PatLength DO              {Put opening chars into Pattern}
      Pattern[j] := BigArray[j];
    CharCount := PatLength;
    NearEnd := false;
    IF Verse THEN (' ');                  {Align first line}
    FOR j := 1 TO PatLength DO
      WRITE (Pattern[j])
    END; {Procedure FirstPattern}

  PROCEDURE InitSkip;
  (*    The i-th entry of SkipArray contains the smallest index           *)
  (*    j > i such that BigArray[j] = BigArray[i]. Thus SkipArray         *)
  (*    links together all identical characters in BigArray.              *)
  (*    StartSkip contains the index of the first occurrence of           *)
  (*    each character. These two arrays are used to skip the             *)
  (*    matching routine through the text, stopping only at               *)
  (*    locations whose character matches the first character             *)
  (*    in Pattern.                                                       *)
  VAR
    ch : CHAR;
    j : INTEGER;
  BEGIN
    FOR ch := ' ' TO '|' DO
      StartSkip[ch] := TotalChars + 1;
    FOR j := TotalChars DOWNTO 1 DO
    BEGIN
      ch := BigArray[j];
      SkipArray[j] := StartSkip[ch];
      StartSkip[ch] := j
```

```
  END
END; {Procedure InitSkip}

PROCEDURE Match;
(*    Checks BigArray for strings that match Pattern; for each          *)
(*    match found, notes following character and increments its       *)
(*    count in FreqArray. Position for first trial comes from          *)
(*    StartSkip; thereafter positions are taken from SkipArray.        *)
(*    Thus no sequence is checked unless its first character is        *)
(*    already known to match first character of Pattern.               *)
VAR
  i : INTEGER;           {one location before start of the match in BigArray}
  j : INTEGER;      {index into Pattern}
  Found : BOOLEAN;                  {true if there is a match from i+1 to i+j-1}
  ch1 : CHAR;                 {the first character in Pattern; used for skipping}
  NxtCh : CHAR;
BEGIN {Procedure Match}
  ch1 := Pattern[1];
  i := StartSkip[ch1] - 1;                         {i is 1 to left of the Match start}
  WHILE (i <= TotalChars - PatLength - 1) DO
  BEGIN {While}
    j := 1;
    Found := true;
    WHILE (Found AND (j <= PatLength)) DO
      IF BigArray[i+j] <> Pattern[j]
        THEN Found := false                      {Go thru Pattern till Match fails}
        ELSE j := j + 1;
    IF Found THEN
    BEGIN                               {Note next char and increment FreqArray}
      NxtCh := BigArray[i + PatLength + 1];
      FreqArray[NxtCh] := FreqArray[NxtCh] + 1
    END;
    i := SkipArray[i+1] - 1                      {Skip to next matching position}
  END {While}
END; {Procedure Match}

PROCEDURE WriteCharacter;
(*    The next character is written. It is chosen at Random            *)
(*    from characters accumulated in FreqArray during last             *)
(*    scan of input. Output lines will average 50 characters           *)
(*    in length. If "Verse" option has been selected, a new            *)
(*    line will commence after any word that ends with "¦" in          *)
(*    input file. Thereafter lines will be indented until              *)
(*    the 50-character average has been made up.                       *)
VAR
    Counter, Total, Toss : INTEGER;
    ch : CHAR;
BEGIN
  Total := 0;
  FOR ch := ' ' TO '¦' DO
  Total := Total + FreqArray[ch];   {Sum counts in FreqArray}
  Toss := TRUNC (Total * Random(Seed)) + 1;
  Counter := 31;
  REPEAT
    Counter := Counter + 1;                                {We begin with ' '}
    Toss := Toss - FreqArray[CHR(Counter)]
    until Toss <= 0;                                        {Char chosen by}
  NewChar := CHR(Counter);                           {successive subtractions}
  IF NewChar <> '¦' THEN
    WRITE (NewChar);
  CharCount := CharCount + 1;
  IF CharCount MOD 50 = 0 THEN NearEnd := true;
  IF ((Verse) AND (NewChar = '¦')) THEN WRITELN;
```

(continued)

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CLEO on the IBM PC Compatibles. The CLEO software program loads from a PC-DOS diskette and contains simultaneous emulation for 3276 line protocol and up to six devices emulating 3278 crts or 3287 printers. When CLEO runs on the PC, six devices are supported (through three interface cards supplied with the CLEO software). The six supported devices include: 3278 support for the PC's console; 3287 support for the PC's printer; and, 3278 support for up to four other PC's which may be serially attached to the PC which is running CLEO.

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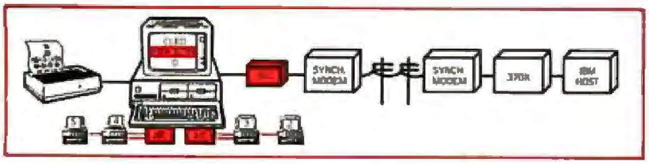

BSC and SNA versions of CLEO are available in two models. The first version is PC2 which provides 3276 emulation and support for two devices, a 3278 CRT and a 3287 printer. PC2 includes one hardware support card (PC-SIC).

The expanded or "clustered" model is called PC6. PC6 requires two additional interface cards (PC-AIC) and four 25' cables for attaching four PC's to a central PC running PC6. Physically these four PC's are attached through their asynchronous serial port (COMM1) using a 25' cable included in the PC6 package.

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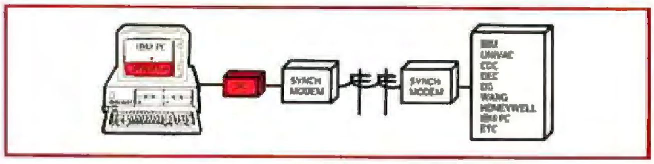
For enhanced 3278 display, the IBM color graphics card is recommended for use with CLEO.

3780Plus on the IBM PC Compatibles. 3780Plus Software is self-contained on one floppy disk and menu driven with simple commands so that you need not be an "expert" in 3780 or 2780 communications to use the package. 3780Plus for the PC includes an interface card, SIC, for interfacing to your synchronous modem.



3780Plus supports IBM's 2780 and 3780 BSC protocols for computer-to-host or computer-to-computer high speed communications. Additionally, 3780Plus has special new features for talking to other computers which are running 3780Plus. For example, files are automatically named by the receiving computer to their original name on the transmitting computer.

3780Plus allows maximum flexibility with a "System" command which allows you to execute many PC-DOS commands from within 3780Plus.

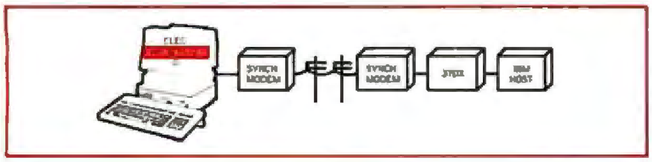
Software/ Hardware Model	Description	3270 Devices Supported	Interface Cards	Retail Price
PC2-3276/2SHM	3276 BSC for the PC	2	1	$ 795.
PC2-3276/12SHM	3276 SNA for the PC	2	1	$ 895.
PC6-3276/2SHM	3276 BSC cluster for PC	6	2	$1,349.
PC6-3276/12SHM	3276 SNA cluster for PC	6	2	$1,499.
PC-3780PlusSHM	3780/2780 emulation for PC		1	$ 795.

HP-150

CLEO on the HP-150. The CLEO software program loads from a MsDos diskette and contains simultaneous emulation for 3276/2 BSC line protocol and support for two devices, a 3278 crt and 3287 printer.

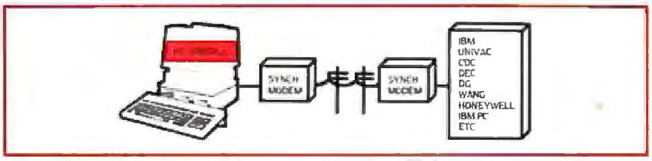
CLEO is a full 3276/2 emulator and supports all of the standard features of IBM's 3276/2; you won't need to make any modifications to your 3270 host computer. Your installation considerations for CLEO on the HP-150 will be identical to those experienced in installing an IBM 3276/2. In fact, CLEO on your 150 will readily install at any site where a 3276/2 currently operates.

Unlike a 3270 coax product, CLEO needs no additional hardware on the HP-150 and an IBM cluster controller to support a coax connection is not required. CLEO is a 3276/2 cluster controller and hooks to a synchronous modem in the same fashion as an IBM 3276/2. The HP-150's port 1 is used for the modem connection.



Keyboard decals are supplied with CLEO. These adhere to the front face of the keys on your 150 keyboard and serve as a quick reminder of the location of the 3278 keys.

3780Plus on the HP-150. 3780Plus Software is self-contained on one floppy disk and menu driven with simple commands so that you need not be an "expert" in 3780 or 2780 communications to use the package.



3780Plus supports IBM's 2780 and 3780 BSC protocols for computer-to-host or computer-to-computer high speed communications. Additionally, 3780Plus has special new features for talking to other computers which are running 3780Plus. For example, files are automatically named by the receiving computer to their original name on the transmitting computer.

3780Plus allows maximum flexibility with a "System" command which allows you to execute many MsDos commands from within 3780Plus.

The HP-150's port 1 is used to connect to the synchronous modem.

Software Model	Description	Retail Price
HP-3276/2SM	3270 BSC for HP-150	$500.
HP-3780PlusSM	3780/2780 emulation for HP-150	$500.

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- Color coding on configuration diagrams identifies components supplied in software packages.

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```
    IF ((NearEnd) AND (NewChar = ' ')) THEN
    BEGIN {If NearEnd}
      WRITELN;
      IF Verse THEN WRITE ('          ');
      NearEnd := false
    END {If NearEnd}
  END; {Procedure WriteCharacter}

  PROCEDURE NewPattern;
  (*    This removes the first character of the Pattern and         *)
  (*    appends the character just printed. FreqArray is            *)
  (*    zeroed in preparation for a new scan.                       *)
  VAR
    j : INTEGER;
  BEGIN
    FOR j := 1 to PatLength - 1 DO
      Pattern[j] := Pattern[j+1];                  {Move all chars leftward}
    Pattern[PatLength] := NewChar;                 {Append NewChar}
    ClearFreq
  END; {Procedure NewPattern}

  BEGIN {Main Program}
    ClearFreq;
    NullArrays;
    InParams;
    FillArray;
    FirstPattern;
    InitSkip;
    REPEAT
      Match;
      WriteCharacter;
      NewPattern
    UNTIL CharCount >= OutChars;
  END. {Main Program}
```

Scientific American, explained in the November 1983 issue of that publication ("Computer Recreations," pages 18–28) how the obvious approach to an order-*n* scan used *n*-dimensional arrays. Let $Array_1$ count all occurrences of all characters. Let $Array_2$ keep track of the character that follows each character. Let $Array_3$ keep track of the character that follows each pair. Now generate a random printout that reflects the probabilities recorded in the arrays. The result of this order-3 scan will be what we saw in the place-names, a scrambled impression that preserves, to a surprising degree, many idiosyncrasies of the input text.

A higher order would be even more interesting, especially if the input sample were long. But until quite recently order-4 was an exceptional achievement and no one had ever seen an order-5. Getting even as far as order-3 (trigrams) gobbles up memory if you use arrays of arrays. For example, even if you restrict the character set to a mere 28—the uppercase letters, a space, and an apostrophe—you have to store 21,952 characters to create three arrays. Most of the character combinations would actually be blanks, because most trigram possibilities don't occur: think of "cnx". A fourth array would entail over half a million places of storage. A fifth is nearly unthinkable (and almost empty).

Sparse arrays are generally a sign that a new approach is needed. It was Hayes himself who took the next step, which was to discard multiplied arrays altogether. He perceived that you could get the same result by scanning the text for patterns and simply recording the character that follows each pattern. Consider this brief text: ALL IN ALL THE CHANCES MAY WELL BE ENHANCED.

To run a trigram scan, take any two letters and see what comes next. "AL" is followed only by "L"; "LL" is followed only by a space, which we'll

(continued)

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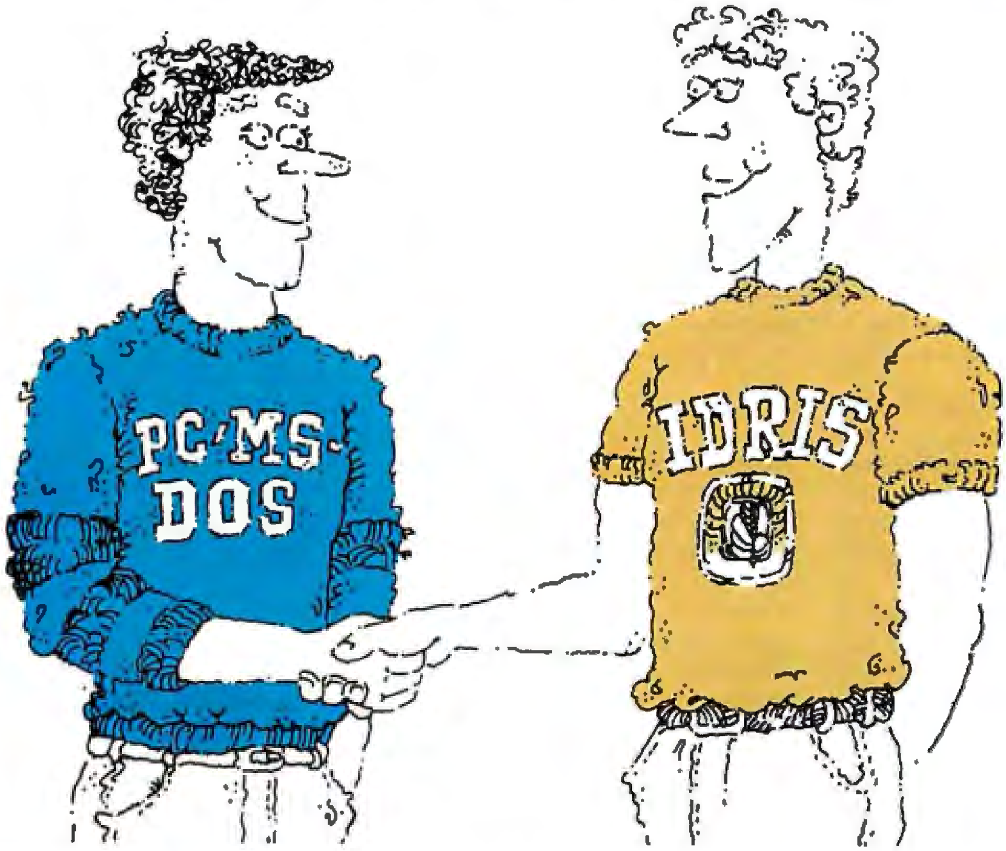

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> Gleaming harnesses, petticoats on slim ass rain. Had to adore. Gleaming silks, spicy fruits, pettled. Perfume all. Had to go back. Had to back. Had to back. His braces all him ass to adore. Gleaming harness rain yielded. A warm silver, rays of the mutely craved dorn on lim ass rays of the woman plumpnesses. Uselesh obscurely, he mutely craved down on him assailed. A warm hungered down on him assailed to adore. Gleaming silks, silver, rich from Jaffa. A warm hungered down on slim braces all. Hig

Figure 1: *An order-4 scan taken from a 75-word sample of James Joyce's* Ulysses.

represent as "__"; so the pair "AL" can only lead to the string "ALL__". But the next pair, "L__", may be followed by "I", "T", or "B". We list these characters as we come to them, then choose one from the list at random. Let's say we choose "B" so that we have "ALL__B". The next pattern is "__B", and the only thing that can follow is "E". Continue in this way, and by the time you've convinced yourself that one possible result is ALL BE ENHANCES MAY WELL THE ENHANCED, you'll have understood the method. You'll also see how it produced a word—ENHANCES—that was not in the input.

One further principle isn't illustrated by an example this short. A long text may yield a fairly long list of characters from which to make the random choice, and many of these will have turned up over and over. In such a case, frequent appearance on the list should improve a character's chance of being chosen. What we want our output to reflect is *n*-gram *frequency*, not just *n*-gram presence. Hayes's method provides for this too.

His method has several advantages. It is applicable to programs that fit a small computer. It makes feasible order-4, order-5, order-6 scans—in fact scans of any order. Nor need it conserve memory by restricting the character set; it can accommodate uppercase and lowercase letters, numerals, and all punctuation. But it does have one disadvantage. Since with his method you have to scan the entire input text to generate each character, the process can be very slow. We'll describe a partial remedy for that.

IMPLEMENTATION

In our first attempts to implement the Hayes algorithm, we left the source text on disk to be read through over and over. Though it's tempting to let source length be limited only by disk

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capacity, the amount of disk reading can be altogether unreasonable: one full read per output character. Not only is the process slow but, if you try to run the program to get a meaningful amount of output from a long text, it might consume an appreciable fraction of a disk drive's service life. We settled for a limited input sample, to be read from the disk just once and stored in an array.

In the program in listing 1, this is BigArray, indexed by a range of integers from 1 to ArraySize. As the source text is read in, linefeeds, carriage returns, and tabs are stripped out, and runs of blanks are condensed to a single blank. The cleaned-up result is stored, character by character, in BigArray. Next, for an order-n scan, the first $n-1$ characters of the source are put into a small array called Pattern. They are also printed, to get the output started. All this may take a second or a few.

The rest is simple in principle. A Match procedure runs through BigArray, checking for matches with the contents of Pattern. Each time a match is found, the *next* character is stored in a way we'll explain in a moment. At the end of the scan, one of the stored characters is randomly chosen for printing, the more frequent ones being the more likely choices. We now make a new Pattern, by dropping the old Pattern's first character and appending the character just printed. And we keep this up until we have generated as many characters of output as we want.

To store the characters from which to choose at random, we used a method suggested by Hayes. FreqArray is an array of integers, indexed by 93 ASCII (American Standard Code for Information Interchange) characters, from " " (space, ASCII 32) to "|" (ASCII 124). (We might have stopped with "z" [ASCII 122], but we had a special use for "|", as will appear.) Before each scan, all of FreqArray's elements are zeroed. After each match, the element indexed by the found character is incremented. Thus, after four "e"s have been found, FreqArray['e'] contains four. At the end of the scan, the contents of all FreqArray elements are totaled, and a random number in the range "1 . . . Total" is generated. The contents of the individual FreqArray elements (most of them zero) are then subtracted, one by one, from this number; the subtraction that drops the remainder to zero or less chooses the character that will be printed. That way, characters that index some fairly large FreqArray number stand a better chance of being chosen.

You decide how much output you want by setting the variable MaxChars when the starting menu prompts you. You also set the Order, which deter-

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The language makes three-fourths of your writing decisions.

mines the pattern length. As the Order increases, so does the likelihood of *every* pattern being unique, in which case the output would be simply the unaltered input. We set the constant MaxPat to 9, but that's an option.

The output is formatted by counting the characters printed (TotalChars) and watching for a chance to break the line whenever this total passes a multiple of 50. The next space after that will trigger a new line. To make verse look more like verse, we type a bar ("¦") at the end of each line of input text. No bar is ever printed, but if the user has selected the Verse option from the starting menu, a new line will commence whenever a bar is encountered. On top of that, any line breaks created by the "TotalChars MOD 50" test will be followed by a 5-character indent. Figure 2 shows what the result can look like. The input text was the whole of T. S. Eliot's *The Hollow Men.*

The smooth running of this system depends on the fact that a match will be found, and a new character returned, somewhere on every scan. There is one potential bug—when the new character isn't valid because the matching process stepped right off the end of BigArray. Suppose the last four characters of the input text are "it.__". Now suppose an order-4 scan has come clear to the end, seeking the pattern "t.__"; though it finds a match, the character after the match is undefined. If that character happens to get selected for printing, something unauthorized will turn up in the output. Worse, something undetermined will go into the next pattern. Whether the Match procedure can find the new pattern in the input text is now doubtful. If it can't, the program will lock into an endless loop.

Our solution was to wrap the end of BigArray back to the beginning, by appending a space (if there wasn't one) plus as many of the opening characters as there are in the search pattern. Thus the input text is, in effect, a closed loop and has no end that the matching routine can step off.

```
We are not appear
  Sight kingdom
  These do not appear:

    This very long
  Between the wind behaving alone

    And the Kingdom
  Remember us, if at all, not
    appear
  Sightless, unless
  In a fading as lost kingdom

    Remember us, if at all, not me also wear
  And
    voices are thine images
  Are raised, here, is that
    five o'clock in dreams
  In the Kingdom.
  This is
    the world ends
  There, the stuffed meaning places

    Are quiet and more solent souls, but on a bang
    but a whimper.
  Let me also wear
  Prickly pear:
```

Figure 2: A *pseudo-text version, in verse form, of* T. S. Eliot's The Hollow Men.

A FASTER VERSION

As first set up, with a simple matching algorithm, all this worked perfectly but slowly, new characters trickling onto the screen like drops of molasses. Then a way to get a dramatic speedup presented itself. Consider that the Match procedure is spending most of its time checking out cases that don't match at even the first character. They are the majority of the cases, and they are a total waste of time. Suppose we are looking for the string "rep"; is it possible to skip through BigArray, investigating *only* sequences that begin with "r"?

Yes, it is, at the cost of a second array the size of BigArray. Called SkipArray, it works as if it were many linked lists braided together. In our example, we have only to follow SkipArray's linked skein of "r"s. With its guidance, the Match procedure can skip swiftly through BigArray from one "r" to the next, ignoring all other checkpoints. If all letters were equally frequent, that would hasten the matching process by a factor of 26. In the program run that generated figure 2, the number of searches was cut by a factor of 15. If Match were the only determinant, we'd speed up execution by that much. However, other overhead stays constant and hogs time. In practice, the overall speedup approaches a limit of about 7—for big jobs, the difference between five minutes and half an hour.

SkipArray is accompanied by a much smaller array called StartSkip, which is indexed by characters and simply records the *first* location of each character in BigArray. The two of them are set up, once and for all and very quickly, by the procedure InitSkip. Once they are in place, we start each search from the information in StartSkip, and then use SkipArray as follows.

Consider our example, a pattern

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that begins with "r". Let's suppose we have learned from StartSkip that the first "r" is at BigArray[3]. Then the "r" entries in SkipArray might begin like this:

```
...3 4 5 6 7 8 9 10 11 12 13...
   7         13              22
```

At 3, we learn that the next "r" is at 7; at 7, that the next "r" is at 13; at 13, that the next "r" is at 22; and so on. Of course, the other positions in SkipArray would be filled with information about the other characters. That information is ignored this time through but stays available for other scans.

Inspection of the listing will show how the Match procedure consults StartSkip to see where, in BigArray, the first character of the Pattern to be matched first appears. Thereafter, guided by SkipArray, it can safely leave most locations of BigArray unvisited. In a count that includes the spaces, "r" occurs in English about once every 18 characters. So if BigArray were 2000 characters long, only about 110 of its locations would be checked. "P", with a frequency of about 2 percent, would trigger a mere 40 visits. The improvement in speed over our preceding versions is dramatic. Scanning a small input file on a fast system, we've seen new characters patter onto the screen faster than we could read them. The analogy is no longer with molasses but with raindrops.

TIMING ANALYSIS

Some statistics yielded by the "time" function on the UNIX system suggest two timing considerations. First, the time consumed seems independent of pattern length. (Most matches fail well before the pattern length is reached.) Second, time is largely determined by the *product* of two factors: the number of characters in the input file and the number of output characters requested. For large inputs and outputs, doubling either doubles the time, and doubling both quadruples the time. But on a small scale, the program works more slowly than that.

(continued)

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In the short run Hellbat can be disablingly input-sensitive.

More exactly, the time in seconds follows quite closely an equation of the form

$$T = K\ (i/10 + o + io)$$

where i is thousands of characters supplied as input, o is thousands wanted in the output, and K is a system constant, obtained by trial. Thus, 1000 characters both in and out (i and o both = 1) took 21 seconds on one system, a VAX 750 running Berkeley Pascal. The same job took 130 seconds with a different compiler on a 2-MHz Heath H-89. System constants were thus 10 and 62, respectively.

For large inputs and outputs, the last term—the product of i and o—predominates. On a smaller scale, the increasing weight of the first two terms will slow things down.

It is possible to obtain a measure of the speed contributed by the SkipArray process. With SkipArray deactivated so that the Match procedure must check every character, the final term gets multiplied by about 7. This factor represents an empirical weighted average of the frequency of the characters that get checked, and it means that for big jobs, where the final term predominates, SkipArray speeds up the matching of English text by 7 times. For smaller samples, the improvement factor may be closer to 4.

SHANNON'S ALGORITHM

At this point, we wondered if there wasn't still more speed to be gained. In 1948, working without a computer, Claude Shannon had not bothered to build up frequency tables at all. He opened a book at random, selected a letter, and recorded it. He then opened the book again, read till he found that letter, and recorded its successor. On another random page, he found the first successor to *that* letter . . . and so on.

This process amounts to hopping into BigArray at random and letting the first occurrence of Pattern you encounter be the one to define the following character. Why build a table, only to select one element from it at random? Why not acknowledge that the text itself *is* a frequency table and make random entries into it? So we implemented a new method and got a further speedup factor of better than 3 (listing 2). After molasses and raindrops, this was a torrent! The new version flew like a bat out of hell and got nicknamed Hellbat.

Theoretically, in the long run, Travesty and Hellbat give equivalent generation results, with Hellbat a lot faster. But in the long run, as John Maynard Keynes said, we are all dead. The world's results are obtained in the short run, and in the short run Hellbat can be disablingly input-sensitive.

Its problem is this. Let's imagine an input that contains, midway, the sequence ". . . silk stockings and silk hats . . .", and no other occurrences of "silk". Suppose the pattern we are matching is "silk__". The chances are good that a random pounce will land either before that sequence or after it. If *before*, then "silk" will be followed by "stockings". If *after*, then wraparound will carry us around to *before*, and "silk" will again be followed by "stockings". Only if the jump chances to land in the short interval between the two occurrences of "silk" can the following word ever be "hats". So the output can settle into a tedious loop, "silk stockings and silk stockings and silk stockings and . . .". Nothing but a rather unlikely jump can enable Hellbat to break out of that loop.

But note how this case would be handled by the frequency-table method of Travesty. "Silk__s" and

(continued)

Listing 2: *These routines turn Travesty into Hellbat, a faster, but finicky, version.*

```
PROCEDURE InitSkip;
VAR
  HeadSkip, TailSkip : ARRAY [' '..'¦'] of INTEGER;
  ch : CHAR;
  i : INTEGER;
BEGIN
    {Initialize HeadSkip and TailSkip to indicate that}
    {no occurrence of any character has yet been Found.}
  FOR ch := ' ' TO '¦' DO
  BEGIN
    HeadSkip[ch] := TotalChars + 1;
    TailSkip[ch] := 0
  END;
    {Link SkipArray by reverse pass through BigArray.}
  FOR i := (TotalChars - PatLength) DOWNTO 1 DO
  BEGIN
    ch := BigArray[i];
    IF TailSkip[ch] = 0
    THEN {1st occurrence}
      BEGIN
        TailSkip[ch] := i;
        HeadSkip[ch] := i
      END
    ELSE
      BEGIN
        SkipArray[i] := HeadSkip[ch];
        HeadSkip[ch] := i
      END
  END;
      {Close links from tail back to head.}
    FOR ch := ' ' TO '¦' DO
    IF TailSkip[ch] < > 0 THEN
      SkipArray [TailSkip[ch]] := HeadSkip[ch]
END;

PROCEDURE Match;
VAR
  i : INTEGER;              {one location BEFORE start of Match in BigArray}
  j : INTEGER;              {index into pattern}
  Found : BOOLEAN;               {true if there is a match from i+1 to i+j-1}
  ch1 : CHAR;                    {first character in Pattern; used for skipping}
BEGIN
  ch1 := Pattern[1];
                                      {Hop into BigArray at a random location}
  i := TRUNC((TotalChars - PatLength) * Random(Seed));
                                  {Search for an instance of ch1 at location i+1}
  WHILE BigArray[i+1] < > ch1 DO
    i := (i+1) MOD (TotalChars - PatLength);
  Found := false;
  WHILE (NOT Found) DO
BEGIN
  j := 1;
  Found := true;
  WHILE (Found AND (j < = PatLength)) DO
    IF BigArray[i+j] < > Pattern[j]
      THEN Found := false
    ELSE j := j + 1;
    IF Found THEN
      NewChar := BigArray[i + PatLength + 1]
    ELSE i := SkipArray[i+1] - 1
  END
END;
```

silk__h" would be considered equally likely; the letters "s" and "h" would ring up the same increments in FreqArray; and the upshot, all else being equal, would be truly 50–50. Travesty, in short, makes probability independent of the spacing of items. Though slower than Hellbat, it is less particular about peculiar input structures.

Hellbat, on the other hand, is temptingly fast; the *io* term disappears altogether from its timing equation, which takes the form

$$T = K\ (i/5 + o)$$

For order-5, and input and output of 1,000 characters each, the two machines that took 21 and 130 seconds to run Travesty ran Hellbat in 4 and 50 seconds, respectively.

Because a long pattern is apt to entail more tries before a match is found, Hellbat's time, unlike Travesty's, is order-dependent. The dependency could be incorporated into *K*, which could then stand for both the computer system and the order.

So, if the input text is fairly free of repeated words clumped together, or if it is long and varied enough for such words to be scattered elsewhere also, then Hellbat (jump in with closed eyes) is the algorithm of choice. Otherwise, opt for the inefficiencies of Travesty and its frequency table. We print herewith (listing 1) the Pascal code for Travesty (modified Hayes) and append instructions for converting it into random-jump Hellbat (Shannon) (listing 2). The nature of your input must decide which version is for you. ■

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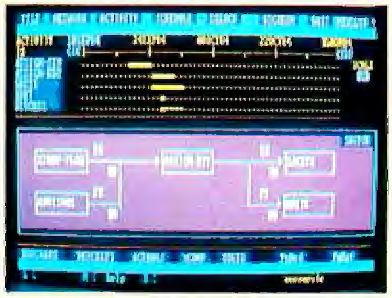

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(continued from page 133)

of Open Architecture, a new release of the operating system that is now being readied.

STORED COMMAND SEQUENCES

Proc, the stored-procedure processor, is roughly equivalent to a cross between the UNIX concept of a script and a highly sophisticated job-control language. It lets you store command sequences and call them by name. It also provides tools for a number of tasks associated with these functions.

For example, Proc has a series of commands that makes it easy to set up a command menu screen. With Proc you can set screen characteristics, position the cursor, display screen prompts, and check keyboard input.

Proc can also string together other Pick utilities. In general, if a command or process is available on Pick at the TCL (terminal-control language) level, it can be incorporated in a stored procedure, or Proc (similar to a batch file). BASIC programs, Access sentences, and other contructs can be used. Procs can even call other Procs. In addition, Procs can test for conditions and branch on the results. Proc includes facilities for labeling statements and can use those numbers as references for commands like GO.

Proc also has commands that test for errors or a specific error and perform a specified command if the error occurs.

Structurally, a Proc is an item in the user's master dictionary, or a Proc library, and is called by its ITEM-ID. This lets you call Procs by name, as if the Proc were a TCL command.

TERMINAL-CONTROL LANGUAGE

TCL is rather like the command processor in a microcomputer operating system. When you log onto the system, you are normally in TCL. However, for the benefit of users who need a specific application or applications or who shouldn't be allowed access to TCL for security reasons, this is easily changed by automatically transferring into a Proc.

There is a great deal to TCL, much more than it's microcomputer equivalents. Among other things, TCL commands let you create files and new accounts, set the time and date, clear files, compare files, perform a system backup, reorganize files, send messages to other users, copy files to magnetic tape, and other system-maintenance functions. For the user, TCL tends to blend in with Proc and Access.

OTHER FEATURES

In addition to the parts already named, Pick has several other useful segments. One of them is Runoff, a fairly elaborate print formatter. Runoff is a text formatter rather than an editor or word processor, but it provides many of the features normally associated with word processors.

Spooler is a print spooler that includes a variety of commands to help manage the printer function on a multiuser system. Spooler supports multiple print queues so it can handle multiple printers, and it can mix dot-matrix, letter-quality, and other kinds of printers. It includes restart capabilities that let it search a document for a character string and restart printing on that string. Spooler can also send reports to tape or other back-up media for archival storage.

Pick has several security and data-protection features, including built-in permission levels. It also has a form of file and record locking. Instead of locking the file or the record, Pick locks the group in virtual memory.

The Pick editor is a full-function line editor for entry and editing of Pick

(continued)

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files of all sorts, including programs and Procs. Like the rest of Pick, it is rich in commands to make life easier for programmers. For instance, the REPLACE command has an option for global replace, replace between specified lines, and replace in specified columns. You can concatenate editor commands, store them, and call them using a single command. You can replace the first occurrence of string A with string B and then replace every occurrence of A with B in columns 5 through 9 of the next 10 lines with one stacked command.

PORTING PICK

Below the visible level of the Pick operating system are the software structures that make it operate. This is a level of the system that few programmers ever see. As has been mentioned, it is elaborate and rather complex.

The Pick operating system is divided into two parts (see figure 1). About 95 percent of it is in the hardware-independent portion called the virtual, or (more narrowly) ABS. About 5 percent of the system is the monitor, which is roughly equivalent to the BIOS (basic input/output system) in CP/M. Like the CP/M BIOS, the monitor is the part of the system that interacts directly with the hardware. In addition, the monitor contains the virtual memory manager (VMM), the time-sharing executive, and the hardware interrupts for I/O to terminals and other slow devices. Virtual interacts with the hardware entirely through the monitor.

Pick, as it exists on a host computer, is entirely in machine language. To port it over, a two-pass table-driven assembler is constructed on the host machine running Pick and sent to the new machine.

The assembler used to move Pick to a new machine works like most assemblers, but above the native (executable) object code and the assembly language (called native, or host, assembly language) is the Pick operating software in Pick pseudo-assembly language, sometimes called the "missionary" source code (see figure 2).

The Pick pseudo-assembly language is the mother tongue of the Pick operating system. Virtual is written in it. The monitor part of Pick, however, is written in the host assembly language of the target machine.

The Pick assembly language is the language of the Pick paper computer. To translate Pick into something that will run on a real machine, the Pick assembly source code is put through a two-pass table-driven assembler. On the first pass, it is translated into host assembly language, and on the second pass, into executable host object code.

(continued)

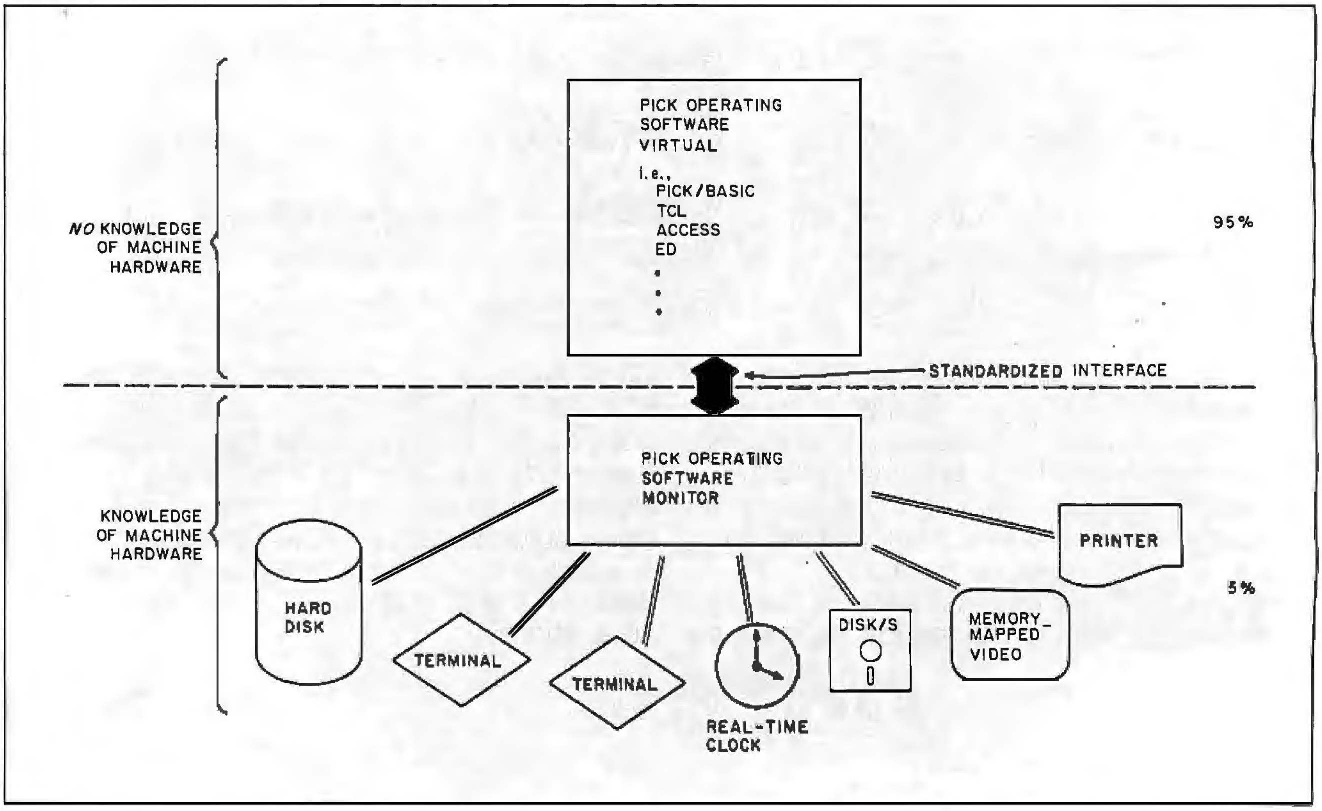
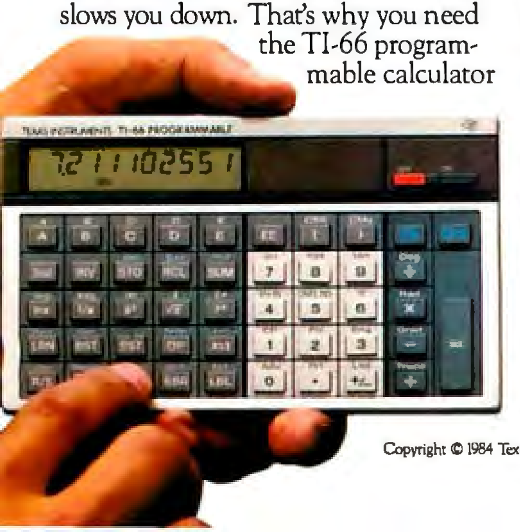


Figure 1: *The parts of the Pick operating system and some supporting hardware. The interface between "virtual," which contains most of the Pick operating system, and the monitor, which connects to the hardware, is standardized. Only about 5 percent of the code in Pick is in the monitor.*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In a microcomputer assembler, the machine-code sequence to be generated by each instruction is fixed and embedded in the assembler itself. Because of the structure of the assembler, changing the translations would require a major rewrite.

In the Pick assembler, these translations are kept in a separate table. This makes the operating system more portable and it allows tweaking those instructions to speed up operation without rewriting the assembler. There are two such tables for every Pick machine, one for going from Pick assembly language into host assembly language and one for going from host assembly language into host object code. Each of the 600 or so instructions in Pick assembly language is represented by an entry in the tables.

To make all this work as efficiently as possible, close attention is paid to optimizing Pick when it is transported to a new computer. The translation tables are reviewed carefully to make the best use of the architecture of the new microprocessor. There is also an automated optimizer built into the assembly process. It is used after the first assembly pass.

The Pick virtual machine has 16 pseudoregisters. One of the main jobs of the optimizer is to map those pseudoregisters onto the actual hardware registers. Obviously, the more swapping of values in and out of registers it takes to perform mapping for the different instructions, the less efficient the implementation will be. The optimizing process seeks the best possible match between the pseudohardware and actual hardware to minimize these kinds of inefficiencies.

After the optimizer has done its job, the same instruction in Pick assembly language may produce very different host source code depending on the instructions that went before it and the state of the machine. This avoids many of the inefficiencies built into simple assemblers and compilers and speeds up system operation.

Finally, the optimized version in host assembly language is put through the second pass of the assembler and emerges as host object code.

PICK ASSEMBLY LANGUAGE

It is possible to write in Pick assembly language, but most applications programmers don't.

As you might expect from an assembly language with more than 600 instructions, Pick assembly language was designed for use by assemblers, not humans. Furthermore, it is not

(continued)

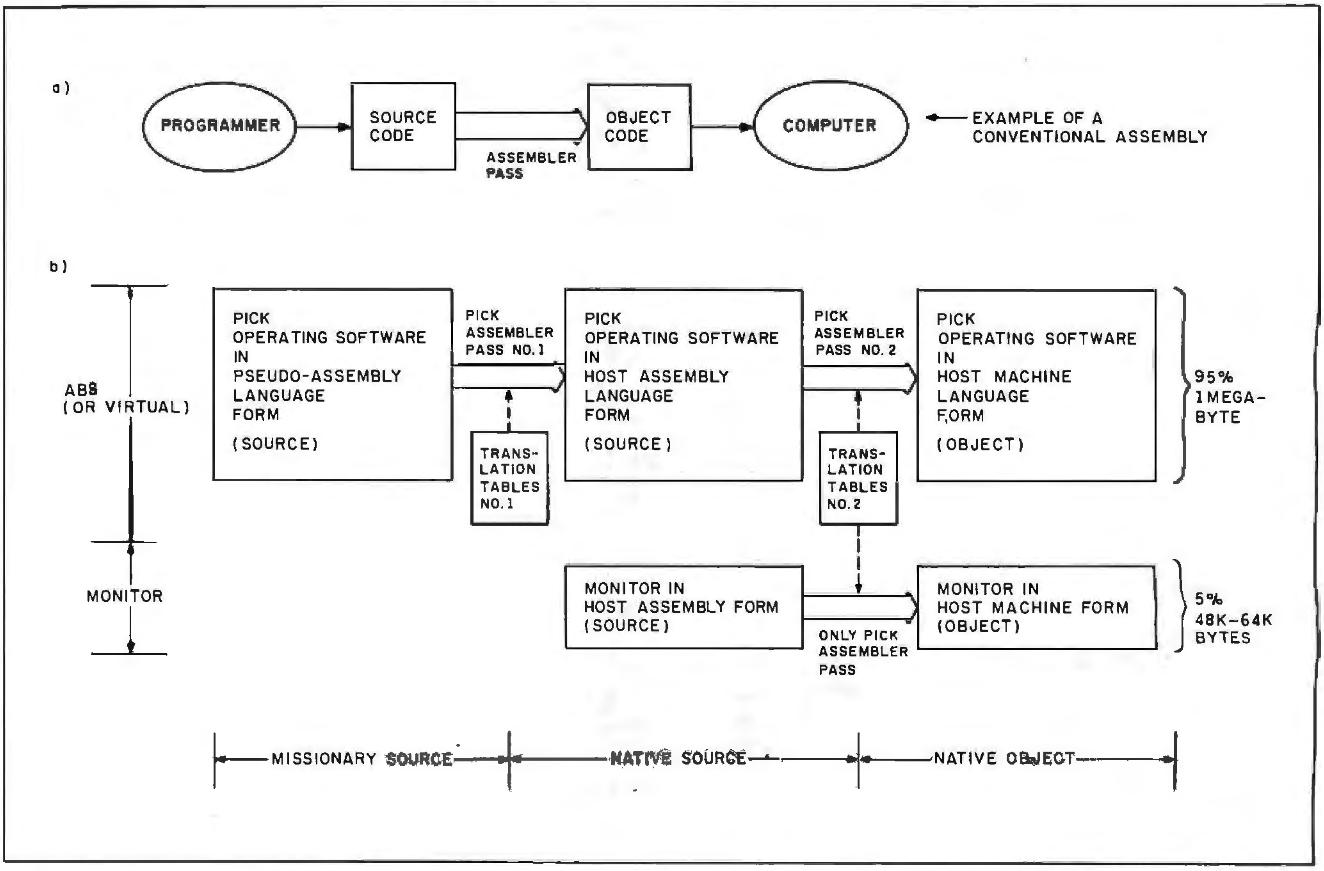

Figure 2: *Stages in transporting the Pick operating system. The process of porting Pick to a new machine uses a two-pass table-driven compiler that ultimately produces a machine-language version of the system. The code sizes are for the* IBM PC *implementation of Pick.*

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Few programmers know their way around in Pick assembly language.

machine-oriented. That is, it is quite different from the assembly language for any physical machine, and those differences extend right down to the concepts.

Because the virtual machine does not have physical registers, it uses a data structure called the primary control block (PCB) as a scratch pad to keep track of things like the contents of each pseudoregister. To list the registers, flags, and all the other things you must keep track of, a description of a PCB takes up an entire 8½- by 11-inch sheet of paper. Beyond that you must keep track of a secondary control block (SCB), a tertiary control block (TCB) or debugger control block, and other things.

The main difficulty with writing in Pick assembler, though, is that Pick is tightly integrated and not written in a highly structured form. Unless you are very careful and quite knowledgeable, an assembly-language program in Pick is likely to produce all sorts of unwanted side effects. Few programmers know their way around in Pick assembly language.

The biggest reason that so few people program in Pick assembly language is that they don't feel the need. Working in an information-management environment there is little you cannot do through Pick BASIC, Proc, Access, TCL, or the other easy-to-use Pick features.

PICK VIRTUAL MEMORY

In keeping with its philosophy of leaving the user free to concentrate on the data and not the details of the hardware, Pick uses virtual memory. Like almost everything else on the microcomputer implementation of Pick, this is done entirely in software.

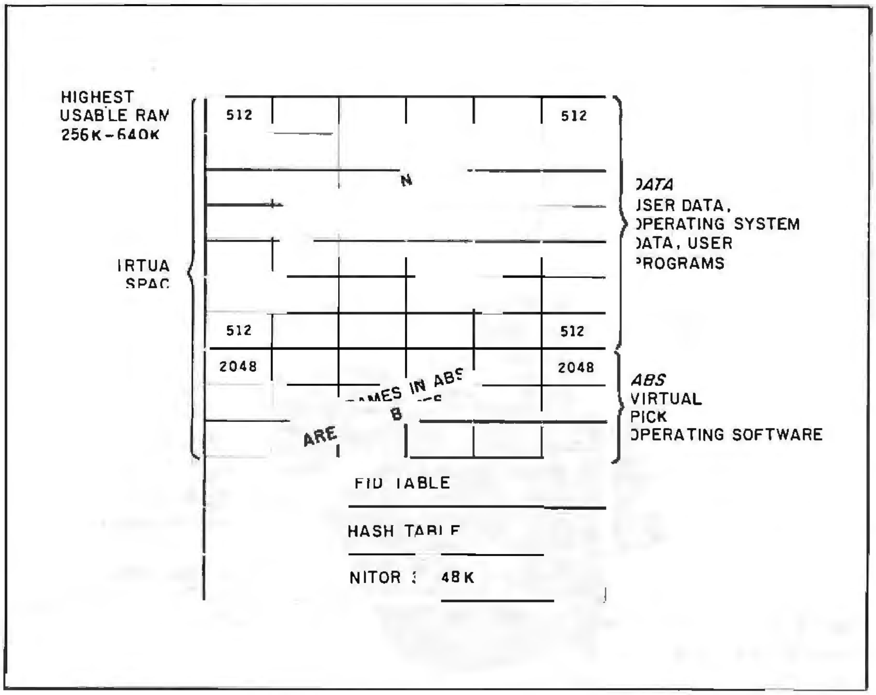

Figure 3: *The memory allocation on the Pick operating system for the* IBM PC. *The monitor is in the lowest part of* RAM, *with the hash table and* FID *tables above it. Above them is the virtual space, which is divided into pages. On the* IBM PC, *Pick uses pages of two different sizes. The lower section of virtual is reserved for* ABS, *the operating system proper. Frames in* ABS *are* 2048 *bytes each. Everything above* ABS *is divided into pages of* 512 *bytes each and used for data, programs, etc.*

On Pick the virtual memory is so well integrated into the system that programmers (other than assembly-language programmers) never have to deal with it. Figure 3 shows the memory structure of Pick.

Pick divides the RAM (random-access read/write memory) available on the computer into three main areas. The lower 32K to 48K bytes of memory is occupied by the monitor, which is always resident. Above that are two sets of tables used by the memory-management system. One of them is the hash table and above that is the frame identification (FID) table. Above that are the frames (pages) of virtual memory space. (In Pick, the subdivisions of memory are called "frames" when they are on the disk and "pages" when they are in RAM. To keep things simple, we will call them frames all the time.)

On the IBM PC implementation, the virtual space is divided into two parts. One part, ABS, is for operating-system code and the other part is for data. The frames in ABS are 2048 bytes each, while the ones in the data space are 512 bytes. It is more efficient to bring in the Pick system in larger pieces because the program can transfer more code on a single read operation.

Above ABS is the data area. This area contains user data, operating-system data, and user programs.

When the system is running, there are a few frames of the virtual operating system in memory, even if no one is on it. Basically, it is executing a tight loop waiting for someone to give it instructions. As soon as someone logs on, the monitor detects it and calls for frames that are not resident in memory required to service the user. These can be frames of data or frames of the operating system. The frames are swapped in by the virtual memory manager (VMM) in the monitor.

As a program or part of the operating system executes, it eventually reaches a boundary of a frame. The VMM portion of the monitor detects this and looks to see if the next needed frame is already in memory. First it checks the hash table to find out roughly where the appropriate frame identification entry would be in the FID table, and then it searches that section of the FID table. This cuts the time needed to search the FID table by a factor of 256. The FID table has 8-byte entries, each describing frames in RAM. After a short search, the monitor knows whether the page is in RAM. If it isn't, the memory-management portion of the monitor can locate it on the disk and load it into RAM.

Given the size of Pick frames and the way the system works, there are a lot of searches through the hash and FID tables. This is another area where Pick is carefully optimized for speed.

If the frame that is needed is in memory, the VMM directs the program to it and execution continues. If it isn't, the virtual memory manager puts a disk-access request for the needed frame in the disk queue, the user loses the time slice, and the system goes on to service the next user.

As the system loads up and more users log on, the VMM has to decide which frames to swap out to get the room it needs to bring in new frames. Pick uses a variation of the clock algorithm to determine which frames to replace. Every time the monitor determines it needs to swap out a frame to make space for a needed one, it begins searching sequentially through the FID table, checking flags for candidates. When it reaches the end of the FID table, it goes back and starts searching through again. The process is something like the sweep of the hand on a clock, hence the name for the algorithm.

The system maintains flags for each frame in RAM. These flags tell whether the frame has been referenced since it was last checked and whether it has been changed (dirty) or not changed (clean) since it was read into RAM.

Every time a frame is used, it is marked as referenced. What the VMM is looking for as it sweeps through the FID table is frames that are both clean and not referenced. Each time it checks a frame, it resets the reference bit to show the frame as not referenced. If the frame has not been referenced by the time the clock hand comes around again, it is considered a candidate for replacement. If the frame is dirty, the VMM puts it in the write queue to be written back to the disk. Once it has been written, it becomes clean—and available for replacement.

There are complexities in this area that go beyond the obvious. For example, what happens if a frame has been added to the write queue and then it is called again? The Pick version of the algorithm was designed to handle these situations with the greatest possible efficiency.

CONCLUSIONS

The Pick operating system is far easier to work with than UNIX. It offers a practical alternative to UNIX as a well-established multiuser operating system for the business community and applications programmers. Setting up the various dictionaries and data files requires a somewhat sophisticated user, but actual use of the system is straightforward. ■

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ACKNOWLEDGMENT

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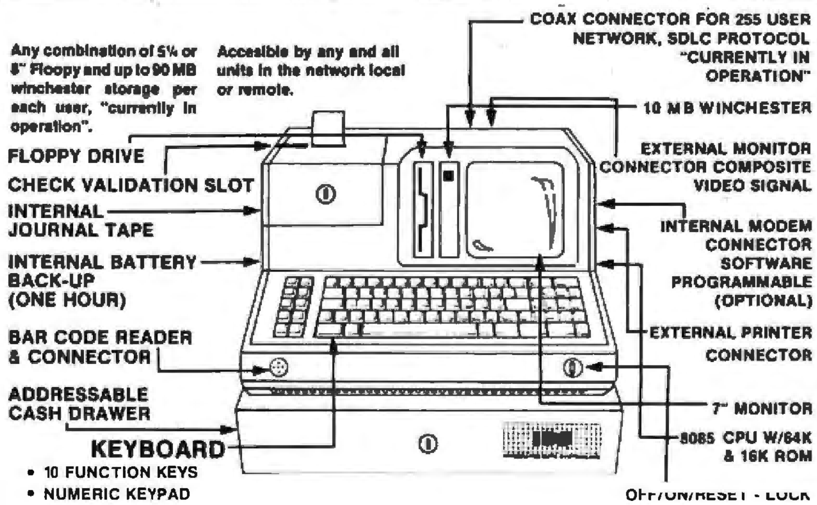

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(continued from page 136)

It was obvious that the system was using Apple Tool Kit to produce the Cyrillic characters for the user interface. Listing the program confirmed this.

It was also apparent from the listing that a variant of Applesoft was in ROM (read-only memory). I say variant because, while all the normal Applesoft commands were present, they were occasionally used a little differently. A few of the keywords were parsed differently as well. An example is the TEXT command. On the AGAT, TEXT could be used with a number to specify cursor position. Calls could be made to the usual places to perform the usual things. I did not test them all, but all those I did test worked normally.

One feature that I liked was the ability to directly address text pages and graphics pages—there were three text pages available in the demonstration program. I understand that it is possible to address a total of seven text pages, but I didn't try it. Since the basic machine is only equipped with 64K bytes of RAM (random-access read/write memory) and there is no apparent way to expand the memory, I wonder how useful that ability would be.

There are three graphics modes—low, medium, and high resolution—producing graphics much as you would expect. The medium-resolution mode has almost the same resolution as high-resolution, with all the colors of low-resolution and very little bleeding. Another nice feature was the ability to specify color in text mode. Also, text could be printed to the screen in medium-resolution mode.

The screen appears to be bit-mapped and the software switches are identical to the Apple's, with the addition of switches for the extra screens. By using the color and plot statements in low-resolution mode, I could print letters to the screen with the Apple parameters. This leads me to believe that the screen is mapped identically to the Apple's.

The only "application" I saw was a surgical calculation program. The ELORG officials told me that it was "forbidden" to list the program, but I worked around their protection scheme quickly, much to their dismay. The program was written in mishmash BASIC, in English. The programming was clumsy, using a lot of IF. . .THEN loops. I shortened the program by 5K bytes, just by tightening the code for them.

BENCHMARKS

I had not come prepared for elaborate testing, but I did have a back issue of BYTE in my apartment, which contained an article on benchmarks. I ran the Sieve of Eratosthenes and Fibonacci routines on the AGAT and found it to be about 30 percent slower than the Apple. A SAVE to disk was 15 percent slower for a BASIC program and 22 percent slower for a text file or binary program. LOADS were somewhat faster, but still slower than Apple.

(continued)

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> *My overall impressions of the system were favorable, considering the source, although I wouldn't buy one. It's too difficult for a non-Russian to use the keyboard, and the system is too slow to compete with what's already available.*

Ordinary number crunching was also slower, but harder to measure. I ran a calculation program involving heavy use of SQR and SIN functions on the AGAT. I copied this program onto a disk that I had with me and ran it on the Apple when I returned home. Apple is faster by 6 percent. I have to attribute this to a deliberate system slowdown, probably because of poor chip performance or because of the long conductor runs and point-to-point wiring of the system. This could produce problems at higher chip speeds. However, as I am not an electronics engineer, I am probably missing something.

A Closer Look at the DOS

During my most recent visit to the Soviet Union, in April of 1984, I saw the AGAT again and was given a copy of a disk containing the DOS to try on the Apple at home. The boot portion of the code is not identical to DOS 3.3, and it is not possible to boot a disk initialized with this system on an Apple. This is probably an effort to avoid being sued by Apple.

The reverse is not true. Examination of the initialized disk with a "nibble editor" such as Locksmith 5.0 shows that the VTOC (volume table of contents), the RWTS routine within DOS (the routine that reads and writes disk sectors), and the file manager are identical to DOS 3.3. Once booted, disks from either system can be read from or written to the other system. There are some gaps in the Soviet DOS not present in Apple DOS; it's the bootstrapping portion that seems to be missing. Since Apple includes the bootstrapping portion only to make the DOS compatible with old Apples having less than 48K bytes of memory, it is not needed in this machine. But the commands are all there—a CHR$(4), for example, will route a command string to DOS on the Russian system—so the differences are not material.

An AGAT for the Teacher?

My overall impressions of the system were favorable, considering the source, although I would not buy one. It is just too difficult for the non-Russian to use the keyboard, and the system is too slow to compete with what is already available. It's akin to the old Apple I. Because of the Western boycott on computer exports to Eastern bloc nations, there is an unfilled demand for such devices in

(continued)

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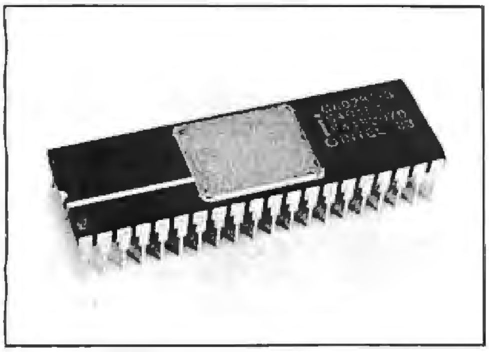

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Eastern countries, so the AGAT may find a home outside of the Soviet Union. It should do very well in Russia as a computing device in an institute or other facility, though not in the home.

If ELORG plans to distribute the AGAT widely in the West, they will have to cut the price dramatically from $17,000 (the price that I was quoted), which includes software, of course. When I told ELORG officials what kind of a computer I could buy for that price in the United States, they were shocked. I'm not certain they believed me. Clearly, they had not researched the competition.

As a government agency, ELORG could afford to offer the AGAT at a very low price in order to develop a market for it. I believe, though, that it wouldn't stand a chance in today's international market, even if they gave it away. It has neither the polish nor the sophistication to compete. The Soviets seem to lack a certain business acumen—especially in this area.

If ELORG has manufactured this computer for home consumption in the Soviet Union, then the AGAT would seem to herald an unprecedented move by the government toward the public at large. However, considering their fantastic paranoia about information and their tendency to bury it under layer after layer of red tape, it does not seem likely that it was intended for home use. The Soviet leaders themselves are highly suspicious of new technology and could view general use of a cybernetic device as hazardous.

Even if a microcomputer were available to Russians for use in the home, it would have to be very cheap to compete with more mundane, but more desirable, consumer goods such as refrigerators and washing machines. Besides, what would Soviet citizens do with a home computer? They certainly don't need to worry about investments or figure out income tax.

It is quite possible that the AGAT has been developed with education in mind; it may be intended for centers of higher learning. I just can't see them placing any in secondary schools, at least not in the near future. Russian education stresses the three R's, with rote and recitation given high marks. In my view, the rigidity of the lower school education system weighs heavily against the possibility of computers in the classroom.

Don't expect to see the AGAT in your local computer store any time soon. The high value of the American dollar in the foreign exchange and the nearly 60 percent duty that would be tacked on this machine by the U.S. puts this device into the category of the exotic. ■

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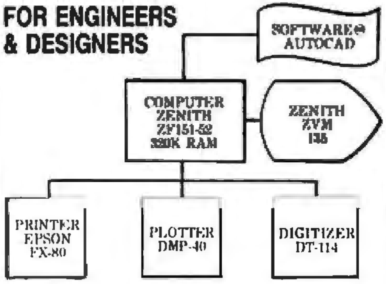

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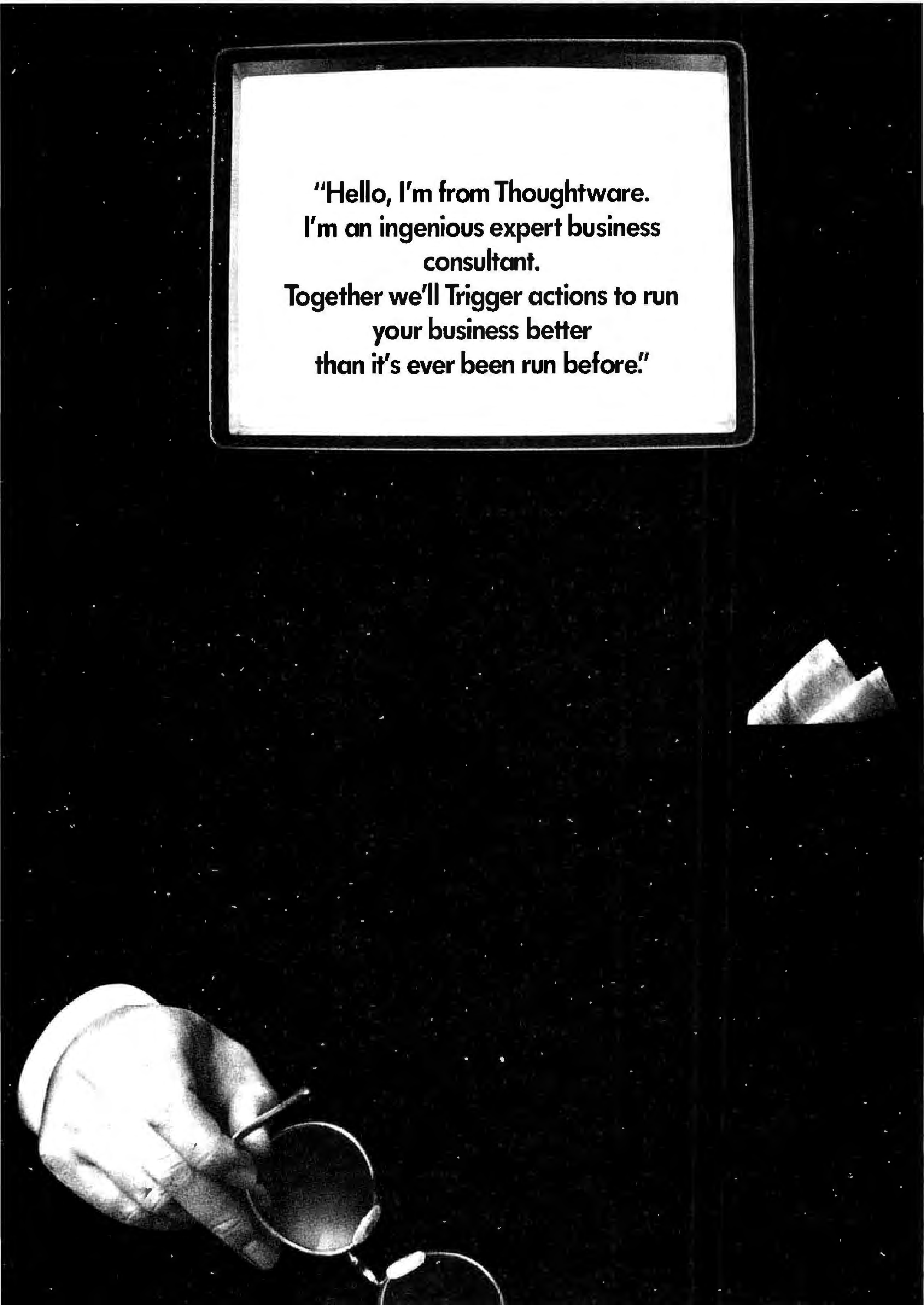

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BOOKS RECEIVED

THIS IS A LIST of books recently received at BYTE Publications. The list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

Adam's Companion, Ramsey J. Benson and Jack B. Rochester. New York: Avon Books, 1984; 416 pages, 15.3 by 22.8 cm, softcover, ISBN 0-380-87650-7, $9.95.

An Analysis of CAD/CAM Applications, Richard Stover. Englewood Cliffs, NJ: Prentice-Hall, 1984; 306 pages, 18.3 by 24.3 cm, hardcover, ISBN 0-13-032871-5, $32.

The Art of Micro Design, A. A. Berk. Kent, England: Newnes Technical Books, 1984; 310 pages, 13.8 by 21.5 cm, softcover, ISBN 0-408-01403-2, £13.95.

Ascent to Orbit, Arthur C. Clarke. New York: John Wiley & Sons, 1984; 238 pages, 22 by 29 cm, hardcover, ISBN 0-471-87910-X, $19.95.

Assembly Language Primer for the IBM PC & XT, Robert Lafore. New York: Plume/Waite, 1984; 510 pages, 18.5 by 23.3 cm, softcover, ISBN 0-452-25497-3, $21.75.

BASIC Primer for the IBM PC & XT, Bernd Enders and Bob Petersen. New York: Plume/Waite, 1984; 448 pages, 18.5 by 23.3 cm, softcover, ISBN 0-452-25495-7, $16.95.

The BBC Microcomputer for Beginners, Seamus Dunn and Valerie Morgan. Englewood Cliffs, NJ: Prentice-Hall, 1983; 320 pages, 14.5 by 22.8 cm, softcover, ISBN 0-13-069328-6, $13.95.

Pluebook of Assembly Routines for the IBM PC & XT, Christopher L. Morgan. New York: Plume/Waite, 1984; 258 pages, 18 by 23 cm, softcover, ISBN 0-452-25497-3, $19.95.

Book Bytes—The User's Guide to 1200 Microcomputer Books, Cris Popenoe. New York: Pantheon Books, 1984; 240 pages, 21.3 by 27.5 cm, softcover, 0-394-72273-6, $9.95.

The Bytes Brothers, Lois and Floyd McCoy. New York: Bantam Books, 1984; 128 pages, 10.5 by 17.5 cm, softcover, ISBN 0-553-24419-1, $2.25.

The C Programming Tutor, Leon A. Wortman and Thomas O. Sidebottom. Bowie, MD: Robert J. Brady Co., 1984; 288 pages, 17.8 by 23.5 cm, softcover, ISBN 0-89303-364-2, $17.95.

Commodore 64, Larry Joel Goldstein and Fred Mosher. Bowie, MD: Robert J. Brady Co., 1984; 320 pages, 17.8 by 23.5 cm, softcover, ISBN 0-89303-381-2, $15.95.

Commodore 64 Subroutine Cookbook, David D. Busch. Bowie, MD: Robert J. Brady Co., 1984; 208 pages, 17.8 by 23.5 cm, softcover, ISBN 0-89303-383-9, $12.95.

Comparing & Assessing Programming Languages, Alan Feuer and Narain Gehani, eds. Englewood Cliffs, NJ: Prentice-Hall, 1984; 288 pages, 18.3 by 24 cm, hardcover, ISBN 0-13-154857-3, $24.95.

Computer Aided Design, J. Encarnação and E. G. Schlechtendahl. New York: Springer-Verlag, 1983; 360 pages, 17 by 24.8 cm, hardcover, ISBN 0-387-11526-9, $29.50.

Computers for Realtors, Laurence Gonzales. New York: Ballantine Books, 1984; 144 pages, 13.5 by 21 cm, softcover, ISBN 0-345-31477-8, $6.95.

Computers for Writers, Laurence Gonzales. New York: Ballantine Books, 1984; 144 pages, 13.5 by 21 cm, softcover, ISBN 0-345-31476-X, $6.95.

Computers, Information and Manufacturing Systems, David Rhodes. New York: Praeger, 1984; 158 pages, 15.5 by 24 cm, hardcover, ISBN 0-03-071672-1, $29.95.

Construction of Data Processing Software, John Elder. Englewood Cliffs, NJ: Prentice-Hall, 1984; 448 pages, 15.3 by 22.8 cm, softcover, ISBN 0-13-168675-5, $22.95.

CP/M Software Review, Michael L. Gonzales. Reston, VA: Reston Publishing, 1984; 208 pages, 17.5 by 23.3 cm, softcover, ISBN 0-8359-1101-2, $19.95.

dBASE II for the Programmer, Nelson T. Dinerstein. Glenview, IL: Scott, Foresman and Company, 1984; 176 pages, 18.8 by 23.5 cm, softcover, ISBN 0-673-15956-6, $19.94.

dBASE II Programming, Albert L. Peabody and Richard H. C. Seabrook. Englewood Cliffs, NJ: Prentice-Hall, 1984; 176 pages, 17.5 by 23.3 cm, softcover, ISBN 0-13-196148-9, $14.95.

Distributed Data Processing—Technology and Critical Issues, M. P. Mariani, ed. Amsterdam: North-Holland, 1984; 240 pages, 15.5 by 22.8 cm, hardcover, ISBN 0-444-86796-1, $40.

DOS Primer for the IBM PC & XT, Mitchell Waite, John Angermeyer, and Mark Noble. New York: Plume/Waite, 1984; 208 pages, 18.5 by 23.3 cm, softcover, ISBN 0-452-25494-9, $14.95.

The Easy Guide to Your Atari 600XL/800XL, Thomas Blackadar. Berkeley, CA: Sybex, 1984; 222 pages, 15 by 22.8 cm, softcover, ISBN 0-89588-125-X, $9.95.

8086/88 Assembly Language Programming, Leo J. Scanlon. Bowie, MD: Robert J. Brady Co., 1984; 224 pages, 17.8 by 23.5 cm, softcover, ISBN 0-89303-424-X, $16.95.

Enjoying BASIC: A Comprehensive Guide to Programming, Richard D. Greenwood and Ignatius F. Brodzinski. New York: Harper & Row, 1984; 290 pages, 21 by 27.8 cm, softcover, ISBN 0-06-042504-0, $19.50.

The Epson QX-10 User's Guide, James M. Hansen. Glenview, IL: Scott, Foresman and Company, 1984; 176 pages, 19.3 by 23.5 cm, softcover, ISBN 0-673-15973-6, $17.95.

Experiments in Logic and Computer Design, Albert Y. Teng and William A. Malmgren. Englewood Cliffs, NJ: Prentice-Hall, 1984; 192 pages, 21.3 by 28 cm, softcover, ISBN 0-13-295833-3, $15.95.

Exploring Applesoft, Roger McShane. Englewood Cliffs, NJ: Prentice-Hall, 1983; 176 pages, 15 by 22.8 cm, softcover, ISBN 0-13-295916-X, $19.95.

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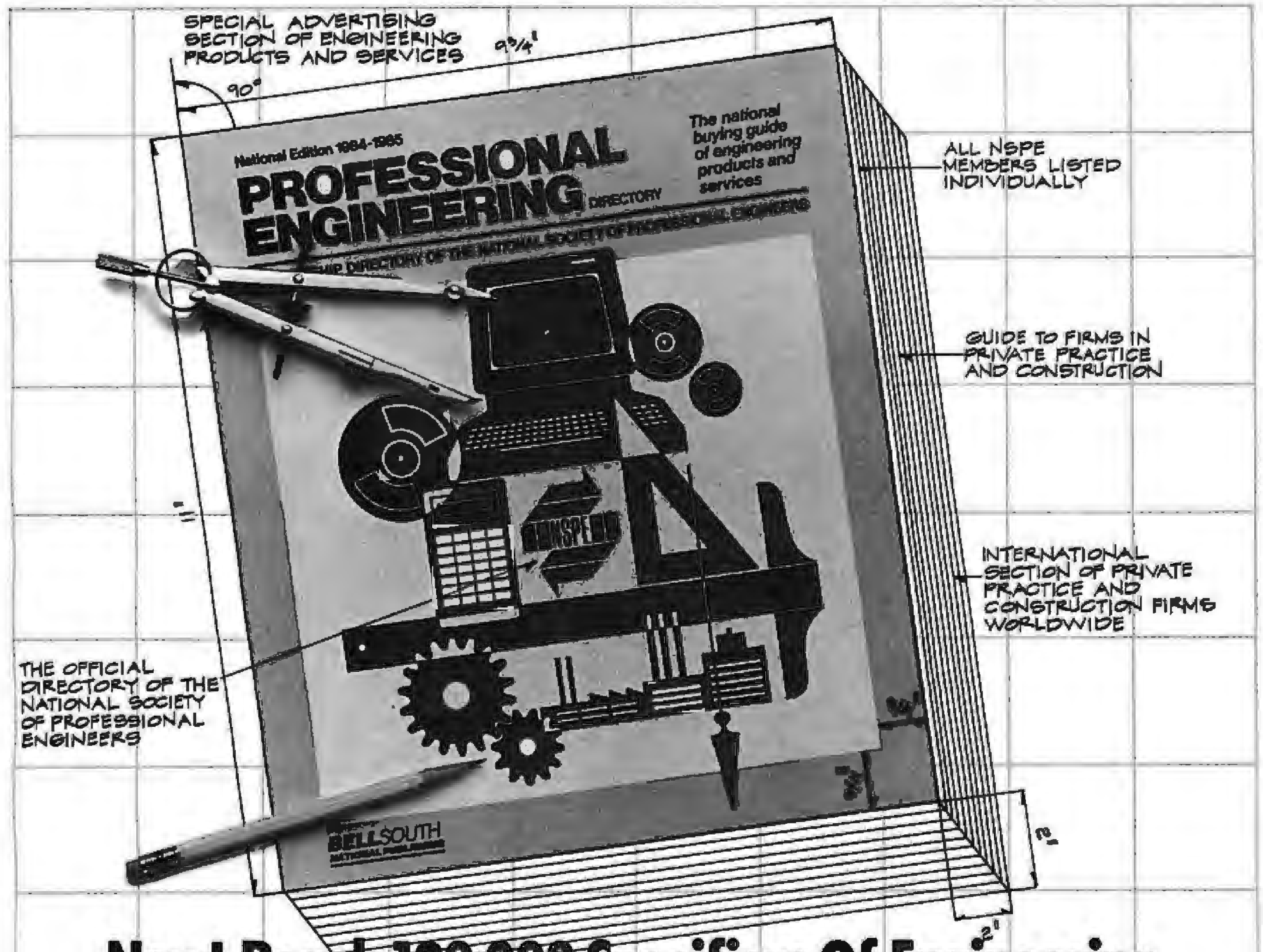

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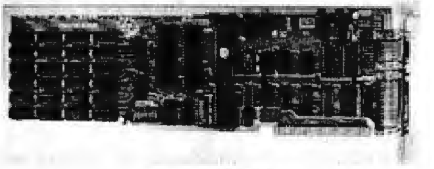

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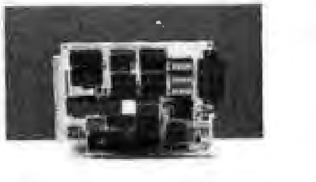

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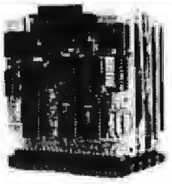

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BCC14 Assembled & Tested w/4K RAM	S120.

Cross Assemblers

From Micro Resources

IBM PC, APPLE, 6502 Systems 5¼", CP/M 2.2 8"	S75.

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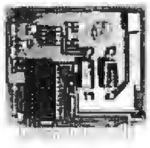

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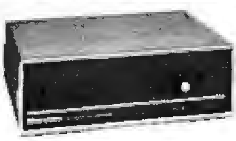
ST22 SWEET TALKER II Apple II compatible speech synthesizer with text-to-speech algorithm on disk	S104.

Microvox Text-to-Speech Synthesizer



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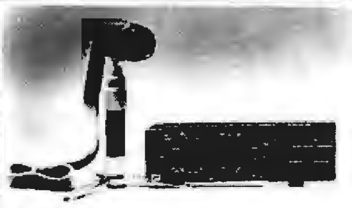

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TI01 Sonar Ranging Experimenters Kit	S60.

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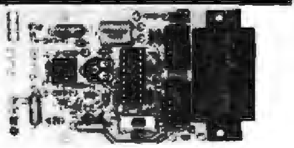

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WORDSTAR AS A PROGRAMMING TOOL

BY VINCENT ALFIERI

Put the power and flexibility of WordStar to work when you program

MICROPRO'S WORDSTAR has its faults, but for power and versatility in a word processor you would be hard-pressed to find its equal. WordStar is set up to handle any number of word-processing tasks, including the text processing that programmers engage in to put their hard-earned code into a form for compiling.

Don't be too upset that WordStar calls programs "nondocuments." This is merely its way of distinguishing those files that aren't set up with standard formatting—in this case, programs—from those that require formatting for a printout, such as letters or articles. Nondocument files (created and edited with the N command from the opening/no-file menu) are actually standard ASCII (American Standard Code for Information Interchange) files, while WordStar's normal document mode (created and edited with the D command) contains WordStar's special use of the high-order bit.

Because inputting programs is a function more akin to word processing than to the actual business of writing code, programmers are well advised to take advantage of some of the tricks of the trade used by professional word-processing operators to save time, work, and frustration.

This article serves a double purpose: it suggests how to use several word-processing tricks in program development, and it covers ways to get around some of WordStar's quirks (for example, what to do about space limitations and the iniquitous .BAK |BACKUP| files). Even if you *don't* use WordStar to write programs, you might find the programming tools presented here applicable on your own word-processing or text-editing setup.

KEY POSITIONS IN A FILE

Four commands that no professional word processor should be without allow the operator to move quickly to key places in the file. These commands move the cursor to (1) the beginning of the file, (2) the end of the file, (3) the left side of the line, and (4) the right side of the line.

Being able to skip over large chunks of the file, especially to arrive at the beginning of the file (to start checking it through, for example) and the end of the file (to begin entering more text), is crucial for saving time and work. You do not want to crawl slowly through an entire file of code with the one-step cursor commands.

Similarly, going from one side of the line to the next quickly by skipping over the rest of the line is another way to save time and work. You'd be surprised how often these commands are used (some programming-language editors, such as Microsoft BASIC, also provide these commands).

WordStar has these four quick commands, all invoked with the Control-Q prefix. They are Control-QR (cursor to beginning of file), Control-QC (cursor to end of file), Control-QS (cursor to left side of line), and Control-QD (cursor to right side of line). (On the IBM PC, Control-QR can be effected

(continued)

Vincent Alfieri, Ph.D. (4118 Los Feliz Blvd., Los Angeles, CA 90027), has recently completed a book, Mastering WordStar, *on practical applications for WordStar. He is a software analyst at the University of Southern California.*

> *You can save a great deal of frustration with the abandon edit command.*

with the F10 key and Control-QC with the F9 key for most versions of WordStar.)

Actually, both Control-QC and Control-QD do something that is of great significance. They take you to the *last entered character*, either in the entire file or on the particular line. Thus, you can get quickly to where you left off by hitting the appropriate command. For example, if you catch a typo on the left side of the line, hit Control-QS and then use the arrow key to reach the mistake, correct it, and then hit Control-QD to resume typing at the last entered character on the line.

MOVING AND DELETING

Don't forget the other cursor-movement commands when you wish to locate specific words: Control-F will take you to the first letter of the next word on the line, while Control-A takes you to the first letter of the previous word ("|F|ore" and "|A|ft," as it were). These two commands are most effectively used with Control-T, which deletes a word (including the spaces after it up to the beginning of the next word), or with two other useful deleting options that are available: Control-QY and Control-Q-.

These latter commands allow you to delete from the *cursor position* either to the right side (Control-QY) or the left side (Control-Q-) of the line. (On the IBM PC, the command Control-Q- is Control-Q Backspace.) The advantage of these two commands is that they don't eliminate the entire line; nor do they remove the ending carriage return. They are much safer than Control-Y, which deletes the line *and* everything on it (including the carriage return).

A SECOND CHANCE

If you find, however, that you have accidentally deleted a crucial line and you've forgotten its exact contents, instead of pulling out your hair and figuring the code out from the beginning, you can save a great deal of frustration with WordStar's abandon edit command. Provided you have already saved a version of your file to disk, this lets you abandon the current editing session and reinstate the file as it was *before* you opened it. The abandon edit command is Control-KQ. It is a good way to give yourself another chance.

THE TOP-DOWN APPROACH

You can apply your knowledge of programming structure and the top-down method and use WordStar to help you. For example, most programming languages—such as C and Pascal—let you create *procedures* and functions as separate modules and then call them up whenever they're needed in the program.

Word processors have long known the benefit of working with modular units, especially when the memory and storage limitations of the computer allow files of only a certain maximum size. For procedures and functions, you can use WordStar to write these parts of the program, each in its own separate file. Then, whenever you need to insert a procedure or function into another program, use WordStar's versatile read file command Control-KR, which lets you copy another file from the disk into the current file. Thus, you can set up an entire library of procedures and functions and call them up quickly whenever needed.

Here's another little trick that many

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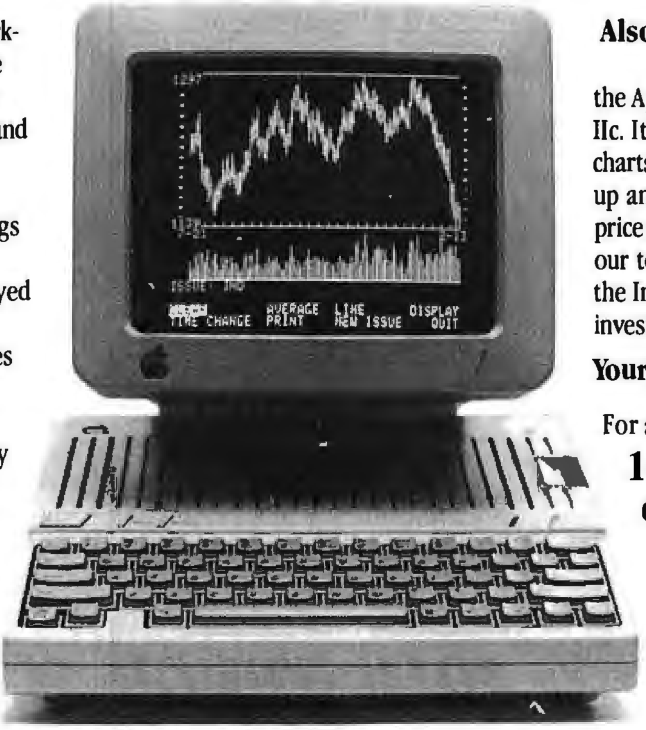

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people don't know. You can even have your procedure and function files on other disks. When you need one, merely hit Control-KR, then wait for the program drive (A) to stop rotating. Remove the program disk from the A drive, insert the library disk, type the desired filename with the "A:" prefix, and hit the carriage return. Then, when the file is copied into your current work file on the B drive and before you do anything else, replace the WordStar program disk in the A drive. This trick provides a great deal of copying flexibility between files. It lets you bypass exiting WordStar and entering the operating system or having to keep all available library files on the same disk. And anyone with single-density systems knows how hard that can be.

GOING THE OPPOSITE WAY

Just as you can use Control-KR to call up separate modular files that contain procedures and functions, you can also move parts of files in the opposite direction with WordStar. For instance, after developing a procedure or function in a program, you decide to add it to the library. Merely block it out (with Control-KB to begin the block and Control-KK to end the block [F7 and F8, respectively, on the IBM PC]) and write it to another file with Control-KW. Make sure that the file with the written-to text block has a new filename (otherwise, WordStar will ask if you wish to overwrite the existing file).

And don't forget that you can then delete the same block from the current file after writing it to its own separate file (with Control-KY), move it around in the current file (with Control-KV), or even copy it again in the current file (with Control-KC). These block maneuvers can save a great deal of programming time, especially after you've gotten your program structure totally organized.

KEEP FILES SMALL

A major problem with using WordStar is its strange habit of keeping a backup file every time you edit an

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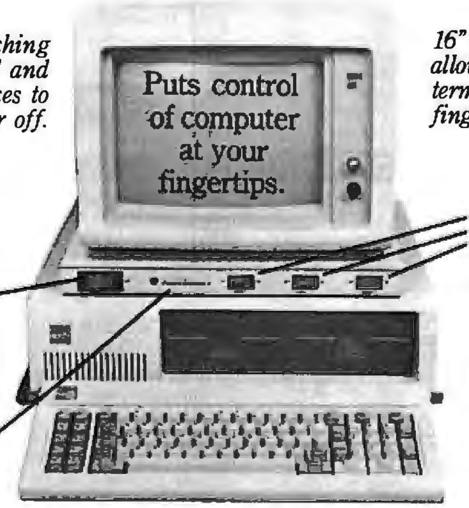
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Strange as it seems, you can get more pages on a disk with many small files than with one large file.

existing file. This means, in effect, that you must maintain a great deal of disk space for the necessary backup files. Once again, anyone who has a single-density system knows what can happen if you are not careful about disk space: WordStar will refuse to save a file that is too large, and you're stuck.

When doing word processing and when inputting large programs with WordStar, I have found it a good idea to divide them into smaller files, no matter how large the eventual size of the document or program is. One obvious advantage of this method is that you don't run the risk of losing as much work in a 5-page file as you would in a 20-page file, should Mr. Murphy be lurking around (which is usually the case).

The other important advantage to this method is that small files in turn create small backup files, and—strange as it may seem—you can actually get *more* pages on a disk with many small files than with one large file. Think about it: a small file needs only, at any one moment, a small amount of disk space for its backup. Try it; it works.

Here's another useful tip: distinguish related files with the file extension. By this, I mean labeling files like "P.1," "P.2," "P.3," instead of "P1," "P2," "P3." The reason for this is that WordStar will create a backup file only once, no matter how many "P" files there are, because the ".BAK" is a file extension.

Thus, when you edit "P.1," WordStar will create a backup file called "P.BAK." When you then edit "P.2," WordStar will create another backup file called "P.BAK" to *replace* the first backup file, and so on. You therefore need to have *at the most* only one small backup file on a disk for all these different modular files. Of course, this means that you should be even more careful than usual to keep *separate* backup copies of your files.

HOW TO CONCATENATE

Sometimes it is necessary to use the operating system when working with WordStar, especially when you have large programs and limited disk space.

I recently agreed to type the entire FIG-FORTH code on my trusty, but limited, Osborne 1. As it turned out, the entire listing took up slightly more than 60K bytes on the disk. It would have been impossible to have it in one

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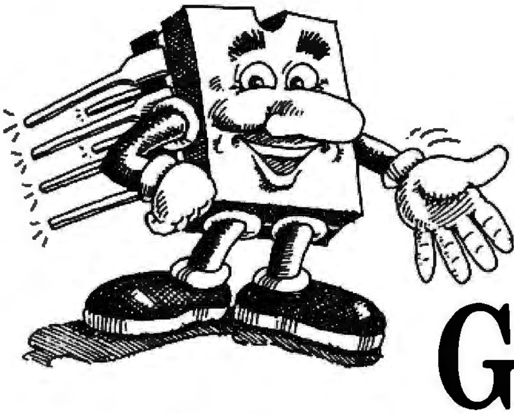

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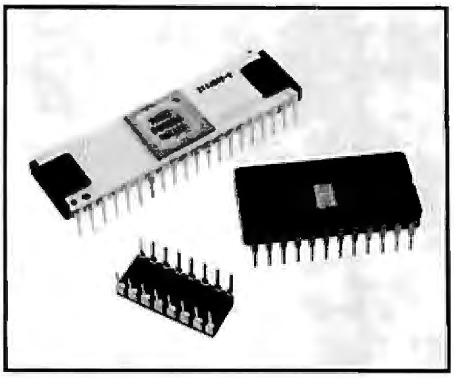

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B/11

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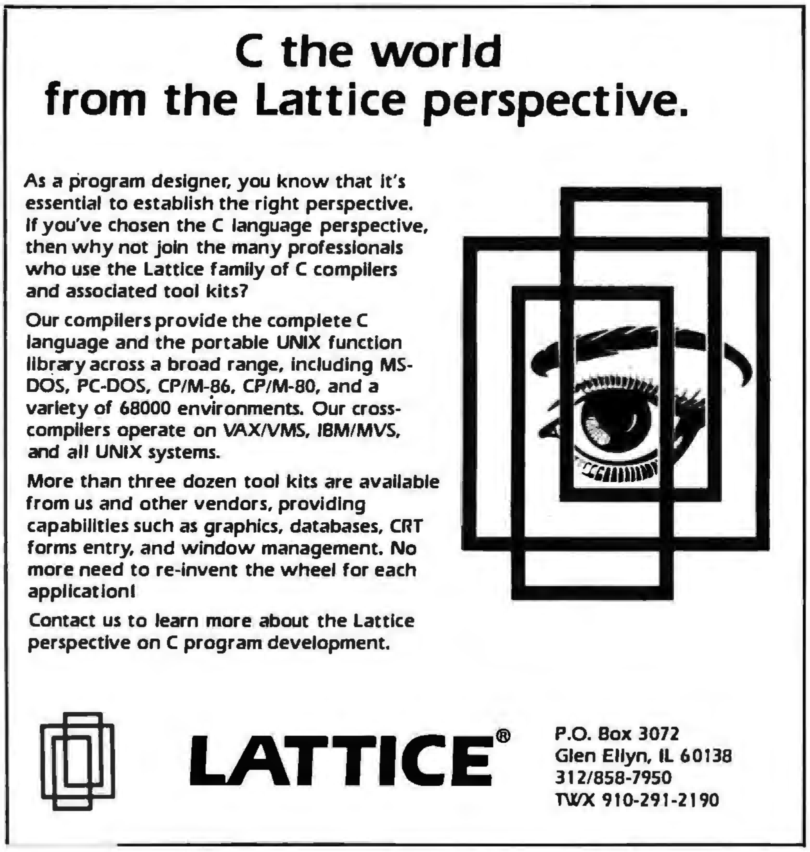

file, because if I had to edit the file (as is always the case), I couldn't have saved my corrections because there would not have been enough space on the disk for the backup file.

Instead, I broke up the entire job into four separate files that all fit on the same disk because each was a workable size. I named the four modules "F.1," "F.2," "F.3," and "F.4," with only one small backup file on the disk at any time.

Then, after I had corrected each module file, using CP/M's powerful PIP feature, I copied the four files into a single file named "FORTH" on the other drive. I did this by concatenating the four files during the copying operation. The command looked like this (after invoking PIP):

```
* b:forth=a:f.1|v|,f.2,f.3,f.4<CR>
```

where the four files were on the A drive and the new, composite file was to be created on the B drive. Note the placement of PIP's verify parameter (|v|) after the *first* filename. With an IBM PC running Microsoft's MS-DOS, the command line would be

```
copy a:f.1+f.2+f.3+f.4
b:forth/v<CR>
```

A trick is involved with concatenation, however. Make sure that the last line in each separate file is a blank line. In other words, whatever the last program line in the file, make sure that you have hit the Carriage Return key and brought the cursor down to the next blank line. This prevents the first line of one file from joining with the last line of the previous file during the concatenation process.

After concatenating the four files with PIP, I was ready to assemble it in the normal fashion. And I could go back to make corrections in the module files, reconcatenate them into one file, and reassemble them.

WATCHING YOUR PROGRAM PASS BY

Most word-processing programs, including WordStar, let you scroll through a file slowly to check it for obvious errors. In WordStar, you can

(continued)

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-den. 31^{5}

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d-den. 22^{9}

d-side
d-den. 30^{50}

s-side
quad 34^{5}

d-side
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s-den. 28^{5}

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• 8" •

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d-den. 31^{95}

-side
-den. 34^{95}

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WordStar's power and flexibility make it a true programming tool.

scroll by line up with Control-W and down with Control-Z. A more useful way to scroll, however, is by screens: up screen with Control-R and down screen with Control-C. (On the IBM PC, these two commands are also effected with the Pg Up and Pg Dn keys, respectively.)

An even easier way to scroll through a file is with WordStar's *repeating* command Control-QQ. By appending Control-QQ to another one-letter command, you get continuous movement. Thus, Control-QQR scrolls the file continuously up by a screen and Control-QQC scrolls it continuously down. Similarly, Control-QQW scrolls continuously up by line, while Control-QQZ scrolls continuously down by line. To stop the repetition, hit the space bar once. (On the IBM PC, you cannot use the Control-QQ feature with the Pg Up or Pg Dn keys, however; you would have to use the WordStar originals.)

This repeating function gives you the option to view the file easily without having to hit the scrolling commands over and over again. You can even vary the speed of the repetition by hitting a number key (1 is fastest, 9 is slowest). You just sit back and watch your work scroll by, stopping only where necessary (by hitting the space bar) and avoiding unnecessary keystroking.

A NONDOCUMENT PRINTOUT

You can print your nondocuments if you wish, but the formatting is no great shakes. There is, however, nothing to stop you from copying your program file to another file, which you would edit with the standard document command (D) and then format as you wish, utilizing WordStar's many dot commands for headers, footers, fancy pagination, special print features, etc. One especially useful, and little-known, feature is the page offset command (.po plus an integer number), which decides where the first column of the file will print on the page. With page offset, you can center the output on the page without having to change the left margin setting in the file.

Just remember that your compiler will not be able to compile a program with WordStar's special formatting commands, so distinguish between the real program and the printout program.

WordStar's power and flexibility make it an ideal choice both for your regular word-processing needs and for helping you write programs. It is a true programming tool. ■

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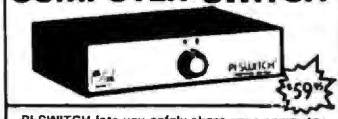

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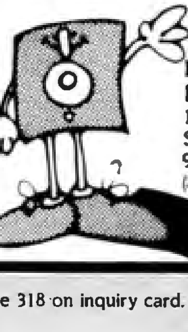

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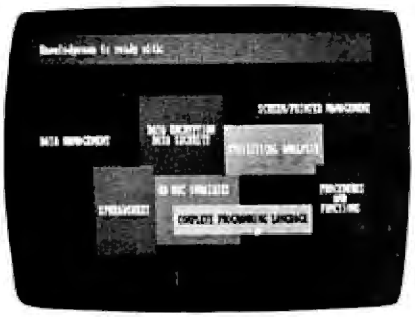

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Ordinary software packages can be frustratingly easy to outgrow. Not KnowledgeMan. Each KnowledgeMan component has more power than you'll probably ever need—far more than conventional integrated programs. With KnowledgeMan, you don't sacrifice capability, capacity or convenience. So with KnowledgeMan, you spend your time solving problems—not trying to overcome software limitations.

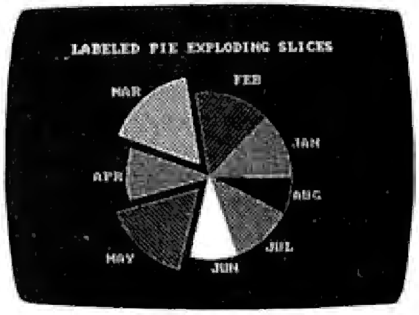
A partner that protects your interests.

KnowledgeMan offers sophisticated security features. Unauthorized access to data is next to impossible, thanks to password checking, thousands of access code combinations and data encryption.

So your secrets are safe with KnowledgeMan.

A partner you can build on.

To add yet another dimension to KnowledgeMan's capabilities, you can get fully-integrated options like K-Graph, an extensive business graphics facility that lets you plot information in a variety of colorful graphs, charts and diagrams. For text processing, the K-Text option lets you incorporate data into written documents quickly and easily. Or, create highly-polished, full-color customized forms with K-Paint, our forms painting option. To short-cut the keyboard, put the K-Mouse option to work.



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To see KnowledgeMan in action, visit your dealer. Or contact Micro Data Base Systems, Inc., P.O. Box 248, Lafayette, IN 47902, (317) 463-2581, Telex: 209147 ISE UR.

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Current version is 1.07 as of 9/10/84. KnowledgeMan, K-Graph, K-Paint, K-Text, and K-Mouse are trademarks of Micro Data Base Systems, Inc. MDBS is a registered trademark of Micro Data Base Systems, Inc.

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Circle 270 on inquiry card.

NEW SYSTEMS

Portable Micro Designed for Communications

The Orcima Solution is a portable microcomputer designed for communications with mainframes using high-level, high-speed communications protocols. This 23-pound computer comes with a 2400-bps auto-answer/auto-dial synchronous modem and with software that supports both bisynchronous IBM 3280 batch protocol and IBM 3270 interactive terminal protocol. The modem connects directly to the telephone lines; a telephone is not required for operation.

The batch-transmission software permits text- or binary-file transfers. File transfers can take place on an unattended, delayed basis for automatic overnight transmissions.

The 3270 terminal emulator provides full keyboard and screen support for all functions. A twenty-fifth status line keeps you abreast of status and errors.

Basic system hardware comprises a 4-MHz Z80A microprocessor, 64K bytes of RAM, and an RS-232C serial port. The 9-inch amber display features an 80-character line, 7- by 9-dot characters in an 8- by 12-dot cell, and lowercase descenders. Video attributes, which are user-selectable, include underline, reverse, intensified, blinking, and block graphics. The DOS is Infosoft's I/OS, a CP/M 2.2-compatible operating system.

Mass storage is provided by a 3½-inch Epson microfloppy-disk drive, which can handle 322K bytes of formatted data. A Winchester hard-disk drive is optional.

Miscellaneous features include 12 programmable function keys, a separate numeric keypad, three expansion slots, and a built-in carrying handle. The list price is $2995. For more information, contact Orcima Corp., 8406 Center Dr., Minneapolis, MN 55432, (612) 784-7926.

Circle **611** on inquiry card.

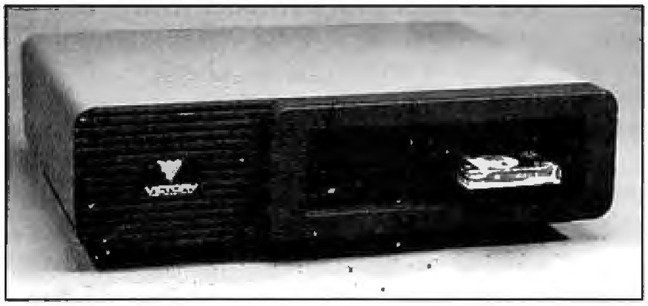
UNIX-Based Computer Supports Four Users

The MicroFactor is a 32-bit UNIX-based system for four users. It has a VME bus architecture, a Motorola MC68000 microprocessor, a 43-megabyte Winchester hard-disk drive, 512K bytes of RAM, four serial RS-232C ports, and a Centronics-compatible 16-line parallel port. Two backup storage systems are offered: a 5¼-inch floppy-disk drive or a 32-megabyte streaming-tape unit.

MicroFactor supports such languages as C, FORTRAN, and Pascal, and it can run the VRTX real-time kernel. Available applications software includes accounting, database management, and vertical-market packages.

Two versions are offered. The first, MicroFactor/FD, comes with Winchester and floppy-disk drives. It lists for $9990. The MicroFactor/ST is supplied with the Winchester drive and the streaming-tape unit. It sells for $11,990. Contact Victory Computer Systems, 1610 Berryessa Rd., San Jose, CA 95133.

Circle **612** on inquiry card.



Select Desired Central Processor

The Microkey 4500 is offered with a choice of central processors: 6502, 6809, or Western Design Center's 16-bit W65SC816. It's available in two basic units, the 65xx family and the 6809E FLEX package, both of which can be upgraded to the other.

The Microkey 4500 has a pair of independent composite-video monitor outputs, each software scrolled. Video controllers achieve a resolution of 640 by 200 pixels in either 16-color analog or 8-color TTL. A very-high-resolution mode offers 1280- by 200-pixel monochrome displays.

Standard are 128K bytes of dynamic RAM, 32K bytes of EPROM, a serial interface, a 16-color board, a pair of 8-bit bidirectional ports, a cassette interface, and connectors for microfloppies and most standard 5¼-inch disk drives.

The 65xx family package is based on the 6502 microprocessor and comes with an implementation of FORTH-79 and FIG-FORTH. The 6809E FLEX package features the 6809 microprocessor as well as the FLEX operating system so that you can run such languages as FORTRAN, BASIC, and polyFORTH.

The base unit in the 65xx family is £925, which includes a central processor, color board, RAM, and FORTH-79. The 6809E package, which comes with FLEX, 6809 and 6502 microprocessors, FORTH-79, RAM, 16-color analog video board, IBM-style keyboard, and a disk drive, is £1550. Contact Microkey Ltd., 98a St. James St., Brighton, East Sussex BN2 1TP, England; tel: Brighton (0273) 672911.

Circle **613** on inquiry card.

ADD-INS

Professional Computer Expansion

Western Automation Laboratories' Seeker series expands the capabilities of the Texas Instruments Professional and Portable computers. The primary product in the series is the Seeker S1 multifunction board.

The S1 provides up to 512K bytes of RAM, an asynchronous/synchronous RS-232C communications port, and an SCSI/SASI interface for up to eight internal or external Winchester disk drives. A battery-backed real-time clock is optional.

Currently, Western Automation offers a 10-megabyte Winchester, with a 20-megabyte Winchester and a 60-megabyte streaming-tape backup scheduled for delivery by the end of this year.

A shielded data cable attaches the external drives to the S1. The enclosures complement the Professional Computer's. The internal Winchesters occupy the space set aside for a second Professional Computer floppy-disk drive. Both drive packages come with a format program, bootstrap EPROM, disk-format and verify routines, and required cabling and hardware.

The Seeker S1 board is $425 without memory. With its full 512K-byte memory complement, it's $1095. A 10-megabyte Winchester raises the price to $1895. Contact Western Automation Laboratories Inc., 5595 Arapahoe, Boulder, CO 80303, (800) 227-4635; in Colorado, (303) 449-6400.

Circle 614 on inquiry card.

Data Acquisition Without Programming

Analog Connection data-acquisition and control cards do not require any special programming because ranges, engineering units, data-log intervals, alarm limits, and control levels are selected through menus. The cards accept signals from thermocouples, RTDs, pressure sensors, and voltage and current sources without additional modules.

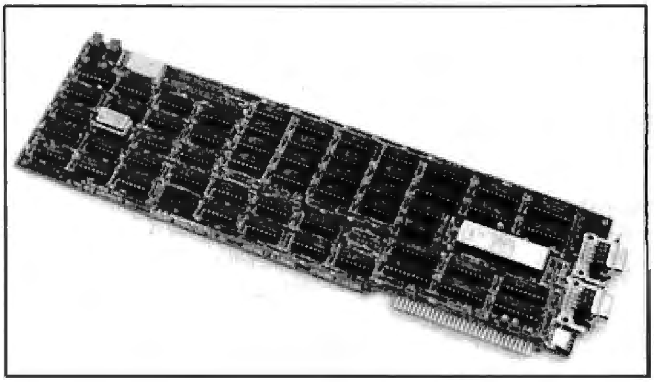
Analog input resolution is 14 bits. The digital I/O lines drive relays or detect events. Expansion is accomplished by adding more circuit cards to your computer. On the IBM PC, data manipulation and graphic analysis can be performed on logged data using Lotus 1-2-3.

Minimum Apple system requirements are 48K bytes of RAM, one disk drive, Applesoft BASIC, and DOS 3.3. Memory requirements for the IBM PC or PC XT are 64K bytes, a disk drive, and PC-DOS 2.0. Analog Connection also works with the Franklin Ace 1000.

An eight-channel card for the IBM PC costs $889. For the Apple II+ or IIe, it's $695. Contact Strawberry Tree Computers, 949 Cascade Dr., Sunnyvale, CA 94087, (408) 736-3083.

Circle 615 on inquiry card.

Ultra Hi-Res Adapters



The Ultra-Res Graphics adapters, models 4-79 and 4-111, provide the IBM PC with a programmable display resolution to 1024 by 1024 and 2048 by 2048 (interlaced) pixels, from a memory of 1 million or 4 million pixels, respectively. These controllers, which use a single expansion slot, feature the NEC 7220 chip and are programmed by means of I/O commands or DMA.

Vector, circles, and arcs are drawn at rates of up to 1 million pixels per second. Zoom from 2 to 16 times is provided. Pan is smooth vertically but coarse horizontally.

The 4-79 and 4-111 controllers have a standard 9-pin D-type connector for TTL direct drive. An analog video signal can also be generated. Software drivers in FORTRAN are supplied.

Optional software drivers include a subset of Plot-10. The Ultra-Res 4-79 is $995. The 4-111 is $2000. Contact C. S. D. Inc., POB 253, Sudbury, MA 01776, (617) 443-2750.

Circle 616 on inquiry card.

Expand PC AT's Storage

Internal hard-disk drive and ¼-inch streaming-tape upgrade kits for the new IBM PC AT are available from Emerald Systems. The hard-disk drive capacities are 40, 70, 140, and 280 megabytes, and the streaming-tape cartridge provides 60 megabytes of backup.

The tape-drive subsystem is said to be 30 percent faster than the IBM 20-megabyte hard-disk drive. It allows you to back up multiple files, and it provides an incremental database file growth beyond 32 megabytes. It supports DOS 2.0, 2.1, 3.0, QNX, PC/IX (IBM's version of UNIX), Concurrent DOS, UCSD p-System, PC XT/370, 3270 PC, and PC-compatible networks. It also provides user-configurable disk-caching of up to 4 megabytes.

Emerald System's BRU (backup and restore utility), which lets you transfer files to the tape medium, comes with the tape drive. It provides menu- and command-driven file management.

The tape-backup system kit is $1950, including hardware, BRU and installation software, and manual. Hard-disk pricing begins at $4350; the full 280-megabyte drive is $15,850. For further information, contact Emerald Systems Corp., 4901 Morena Blvd., San Diego, CA 92117, (619) 270-1994.

Circle 617 on inquiry card.

(continued)

PERIPHERALS

Two-Line Telephone/Modem

Code-A-Phone's Tel-A-Modem is an intelligent modem coupled with a two-line desk telephone. The modem is compatible with AT&T 212A-type modems, such as Hayes's products, and with Smartcom and other communications software. It'll work with any RS-232C terminal and is designed to be a direct replacement for any modem.

Tel-A-Modem combines a full function-key telephone with the modem to provide simultaneous voice/data communications. Its telephone lets you select either pulse- or Touch-Tone dialing, and it provides an audio/visual phone-status reports, hold functions for both lines, last-number automatic redial, nine-number memory automatic dialer, and individual volume controls for ring signals and line monitors.

A direct-connect modem, Tel-A-Modem lets you initiate a carrier on either line with a push button. The default switches for setting the modem's operation parameters are readily accessible. Miscellaneous modem features include 300- and 1200-bps data-transmission rates, full-duplex operation, automatic answer, automatic selection of data rate and answer/originate tone, and programmable signal interchange.

The Tel-A-Modem is $695.95. Contact Code-A-Phone Corp., 16261 South East 130th Ave., Clackamas, OR 97015, (503) 655-8940.

Circle 618 on inquiry card.

Rainbow Touch Screens

Touch-screen kits for the DEC Rainbow and Professional 350 are available for OEMs and systems integrators. The kit includes a touch screen, controller board, and firmware.

The controller is fully programmable, allowing data rates, data formatting, calibration, and other modes of operation to be set from the host computer. The controller averages the entire area touched to a single discrete point, making it possible to manipulate a single letter. It's available with an EEPROM for storing the calibration values and other parameters.

An optional firmware package, Command*Point, provides all the codes necessary to create and manage touch zones, which helps reduce software-development time. The program is able to off-load work usually performed by the computer, and it allows the application software to dynamically reconfigure the screen into touch-sensitive zones of differing sizes and shapes. It also monitors lift-offs and touchdowns and manages such zone attributes as timeouts and audio feedback.

Installation can be done by the manufacturer or the user. Including installation, the single-unit pricing for the DEC kit is $1595. The kit will also work with VT220, VT240, and VT100 terminals. Contact MicroTouch Systems Inc., 400 West Cummings Park, Woburn, MA 01801, (617) 935-0080.

Circle 619 on inquiry card.

CITTT Modem

The Fujitsu 1915L, a CCITT V.27 bisynchronous terminal-compatible modem, is designed for four-wire, unconditioned leased lines. It operates at 2400- or 4800-bps and is equipped with an equalizer that continually adapts to transmission-line characteristics.

The 1915L's 32-character LCD panel lets you monitor operation, check signal quality, and do local and remote loopback. The LCD and the local and remote strap setting controls are on the front panel.

The 1915L is $1695. Contact Fujitsu America Inc., 3055 Orchard Dr., San Jose, CA 95134.

Circle 620 on inquiry card.

MacPhone Dials 200 Numbers

The MacPhone Tele-Management System is a software and telephone handset package for the Macintosh. It features speed dialing, automatic logging capabilities, note and memo pads, a billing feature, a built-in three-month calendar, and an area-code directory.

Up to 200 numbers can be stored and dialed with the MacPhone. Its calendar includes an appointment book and a note pad for annotating calls. Your notes are automatically filed in a telephone log, which lists the person called, the time the call began and ended, the date, the cost, and any consultation charges. The phone log can be displayed on screen and printed out.

MacPhone supports speaker phones, headsets, and modems. Miscellaneous features include a tone signaling the passing of a minute or hour, Touch-Tone compatibility, the ability to work with long-distance services, and a MacWrite-compatible memo pad for recording larger notes.

MacPhone works with a standard telephone jack. The suggested price is $199.95, which includes software, manual, and connecting cords and plugs. Contact Intermatrix, 5547 Satsuma Ave., North Hollywood, CA 91601, (818) 509-0474.

Circle 621 on inquiry card.

PERIPHERALS

Communications Line Protection

DataGuard from Control Industries gives you a protected, dedicated communications line. Once you've installed DataGuard, your logged-on modem will always have priority while on line. Consequently, data loss or tripped communications resulting from someone picking up on the same line are eliminated.

DataGuard comes in two models: in-phone and snap-in cord. The in-phone model is not visible after installation, and the snap-in cord model features a 12-foot cord that replaces your present telephone cord. Normal telephone functions are not interfered with, and no external power is required.

The suggested retail price is $39.95. Contact Control Industries, POB 6292, Bend, OR 97708, (503) 389-1969.

Circle **622** on inquiry card.

488 Port for Mac

The MAC 488 connects directly to the Macintosh's rear-panel serial port and provides IEEE-488 bus control. Simple high-level commands transmitted to the MAC 488 are converted into 488 bus protocols and handshaking. Responses from an IEEE-488 device are sent to the Macintosh through the serial port.

The MAC 488 has an 800-character I/O buffer. It's supplied with BASIC routines for creating IEEE-488 bus-control programs. Indicators for talk, listen, SRQ, and error are front-panel-mounted.

The suggested list price for MAC 488 is $595, which includes a manual and connecting cables. Contact IOtech Inc., POB 21204, Cleveland, OH 44121, (216) 321-0609.

Circle **623** on inquiry card.

SOFTWARE • CP/M/MS-DOS

Software Protection Software

Ultralock, a file-encryption software system, intercepts data written on or read from a disk and scrambles or unscrambles it according to your key. A key can be a word or phrase, including punctuation, from 8 to 60 characters. You can use one key for all files, or separate keys for each file.

It lets you copy scrambled disks, but they cannot be read without Ultralock and the key words. In the Concurrent CP/M version, different users can protect their files simultaneously.

Ultralock's operation is transparent. When it's booted, Ultralock asks you what files you want protected and what the keys are for each file. It uses 16-byte keys (the American Data Encryption Standard uses 7-byte keys), which provides a total of 2^{128} possible keys.

Ultralock will work on any 8-bit computer running CP/M-80 and 16-bit machines with either Concurrent CP/M or Concurrent DOS. It costs £190 (approximately $240). Contact Business Simulations Ltd., Scriventon House, Speldhurst, Kent TN3 0TU, England; tel: Langton (0892 86) 3105.

Circle **624** on inquiry card.

TEA for WP

Colossum Software's TEA is a tree-editor word-processing package. It lets you break up files into mini-files, called leaves, that you can connect using a tree structure that reflects the structure of your document. TEA can serve as a scratch pad for ideas that can later be strung together logically and for designing or writing programs.

A TEA tree can contain 500 nodes; each leave counts as 1 node. Up to 99 nodes can be attached to a single parent, and a tree can have as many as 35 levels. A TEA file can contain 2 million characters.

Each leaf or branch can contain a header and a two-line summary describing its contents. You can scroll through documents one leaf at a time or jump from leaf to leaf. Blocks of text can be swapped, and leaves or subtrees can be exchanged.

Printing a document is said to a be merely a matter of letting TEA use the tree to work out the order of leaves. All tree facilities can be disabled, which automatically creates a single-leaf file. External word-processing files can be read into this program, and TEA files can be converted for use by other word processors.

A string-combination search that locates combinations of separate words occurring in any order within a leaf, sub-tree, or header is provided. Other features include the use of function keys, the ability to split screens, date stamping, and background printing.

Currently, TEA does not support spelling checking, proportional spacing, index generation, or mail-merge. It runs on 64K-byte Z80 systems running under CP/M. An MS-DOS version is planned. It costs £245. (In the U.S., it will range in price from $149 to $199.) Contact Colossum Software Ltd., 310 Finchley Rd., London NW3, England; tel: 01-435-9321.

Circle **625** on inquiry card.

(continued)

SOFTWARE • APPLE

68000 Cross-Assembler

Owners of 64K-byte Apple II, II+, and IIe computers can develop MC68000 assembly programs with the SX-68 cross-assembler from Allen Systems.

Made up of an editor and an assembler, the SX-68 package provides 15 commands, including ASM and Find, and 7 pseudo opcodes. DOS 3.3 can be accessed from SX-68. The instruction set considered legal by the assembler is that specified by Motorola for the MC68000.

The editor lets you create 68000 assembly programs and regular text files. Programs can be saved on disk or employed as input to the assembler.

The assembler generates both program listings and object codes. An assembly consists of two passes. The first pass defines all symbols; the second is responsible for generating the object code and program listing. Errors are reported on each pass.

The maximum text size is 24K bytes, and the object code can be as large as 4K bytes. The maximum number of symbols is 450, and the maximum number of statements is 9999.

SX-68 is $100, including documentation. A disk drive is required. Contact Allen Systems, 2151 Fairfax Rd., Columbus, OH 43221, (614) 488-7122.

Circle **626** on inquiry card.

Voice for Mac

SmoothTalker is a text-to-speech synthesizer for the Macintosh. This software package accepts plain English text from either the keyboard or from a text file and synthesizes it into an adult female or male voice. The voice is broadcast through the Mac's internal speaker or through an external amplifier.

With SmoothTalker, you can control the speed, pitch, volume, bass, and treble levels of speech, each with nine levels of control. You can switch between voices and define a custom dictionary. SmoothTalker is said to understand phrasing, intonation, such salutations as Dr. and Ms., and mathematical symbols. SmoothTalker can read MacWrite text files and selected portions of text.

An on-disk tutorial is supplied. The retail price is $149.95. Versions for other computers will be announced. To hear a demonstration, call (714) 536-0086, ext. 999. Contact First Byte Inc., 2845 Temple Ave., Long Beach, CA 90806, (800) 523-8070; in California, (800) 624-2692 or (213) 595-7006.

Circle **627** on inquiry card.

Data Bridge Between MAC and PC

MacLink is a data bridge between comparable applications on the Macintosh and the IBM PC. Through the use of matched software on the two computers, data can be moved at your request and automatically translated for the application being used.

MacLink will move such spreadsheets as Lotus 1-2-3 and VisiCalc from the IBM PC to the Macintosh and translate them for use with Multiplan. Word-processor and general text files are recognized and converted for the Mac, and BASIC programs are recognized and relocated for use in Microsoft BASIC.

The entire process is user-controlled from the Mac. The program is available for $95, which includes a pair of disks and instructions. Complete with an 8-foot cable, it's $125. Contact DataViz Inc., POB 1319, Norwalk, CT 06856, (203) 866-4944.

Circle **628** on inquiry card.

Data-Analysis Programs

Scopex-I and Frequency Spectrum are available from MAP International. Both programs run on 48K-byte Apple II+/IIe systems equipped with a fast analog input interface, such as the AI-13 from Interactive Structures. A disk drive is also mandatory.

Scopex-I turns the Apple into a digital-to-memory oscilloscope; up to 2560 points can be processed. Its functions include a program sampling time from 28 to 2570 microseconds, *x-/y*-axis factors, zero-line offset, delay, auto/manual ranging, and minimum/maximum, rms, and average calculations. With a single keystroke, you can display the signal received and produce hard copy.

Frequency Spectrum, which comes with all the features of Scopex-I, calculates a frequency spectrum using a file of overlapping-bandpass filters. Analysis parameters can be stored in AN.files for routine analyses.

Scopex-I costs $135, which includes documentation and a backup. Frequency Spectrum is $222. Contact MAP International, Herculesweg 116, NL-2624-VT, Delft, The Netherlands; tel: 015-561750.

Circle **629** on inquiry card.

SOFTWARE • IBM PC

Computer Activity Log

Oak Tree Technologies' PCLOG keeps track of your daily computing activities, which can be useful for establishing your federal income-tax deduction or tax credit. With this program, you can track the time spent on one or more projects or tasks.

PCLOG automatically creates a log file entry, or you can define its parameters. The default values for a project name and remark are user-definable. It gathers time and date information from the system clock. All parameters can be overridden. PCLOG can be called from an AUTOEXEC.BAT file, a .BAT file, or from DOS.

You can use this program with the IBM PC, the PCjr, the AT&T PC6300, and a variety of IBM PC compatibles. System requirements are 64K bytes of RAM and a single floppy-disk drive.

The list price is $19.95, which includes a manual and a print utility. For further information, contact Oak Tree Technologies, 2619 Quail Valley Rd., Solvang, CA 93463, (805) 688-1495.

Circle 630 on inquiry card.

Interactive Software for Scientists

ASYST is a three-package set that gives scientists data-acquisition, analysis, and graphics functions. It operates under standard PC-/MS-DOS and uses the IBM PC's 8087 microprocessor to achieve 80-bit internal precision. With ASYST, your applications can be as large as the full 640K bytes available with the IBM.

All ASYST commands are written in so-called conceptual terms, rather than programming syntax. On-line help and a glossary of keywords are provided.

Multiple operations can be condensed into single names, and you can program your function and control keys to execute ASYST words or commands in a single keystroke.

The first module, called Systems/Graphics/Statistics, establishes the system environment, stores data, and provides graphics and basic mathematics/statistics functions. Data Analysis, the second package, lets you reduce, manipulate, and analyze data. It also provides advanced mathematical capabilities. The Acquisition module allows you to interface with various scientific instruments.

Each module comes on a double-sided, double-density floppy disk. Module 1, which can be used as a stand-alone program, is required to load the other two. The complete package is less than $1800. Modules can be purchased separately. Contact Macmillan Software Co., 866 Third Ave., New York, NY 10022, (212) 702-3438.

Circle 631 on inquiry card.

Multifont Printing from WordStar

Tech/Print is a multifont printing program for WordStar users. It replaces WordStar's Print command and is compatible with all WordStar control characters and dot commands.

Tech/Print comes with a number of ready-to-run fonts, including IBM graphics, mathematics/scientific, and italic fonts. A font-design tool, Tech/Font, is also provided. Four fonts can be printed simultaneously.

An IBM PC or a PC-compatible computer with 96K bytes of RAM and a single floppy-disk drive are required. It supports the IBM Graphics Printer or Epson's RX-, MX-, or FX-80 printers. It costs $69.95. For more information, contact Goldstein Software, 2 Redgate Court, Silver Spring, MD 20904, (301) 384-5565.

Circle 632 on inquiry card.

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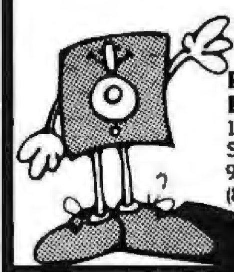

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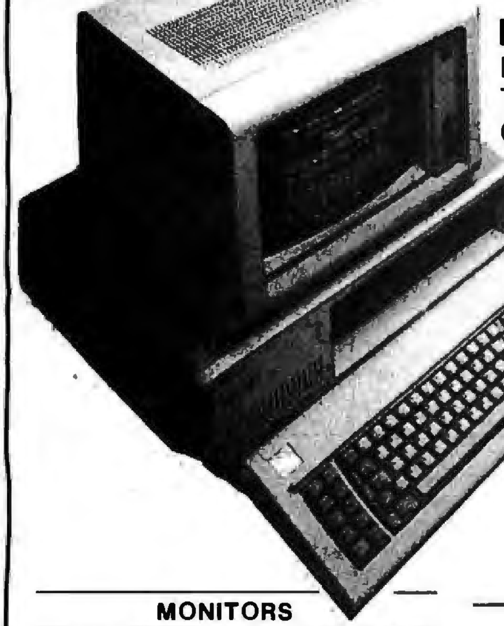

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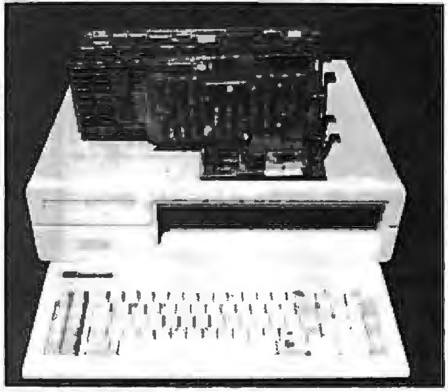

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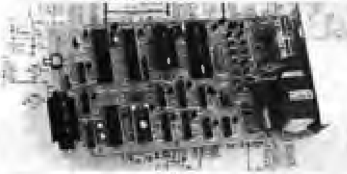

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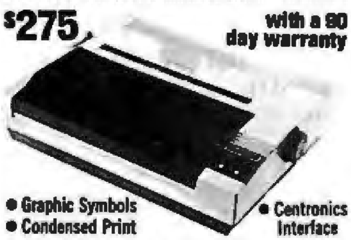

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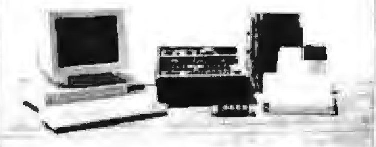

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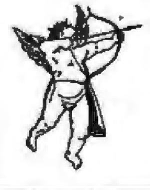

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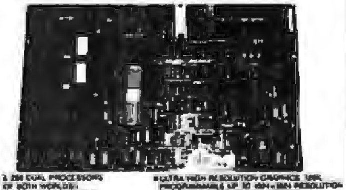

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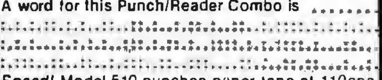

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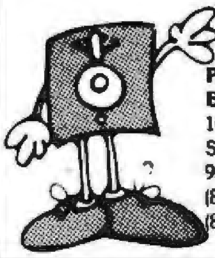

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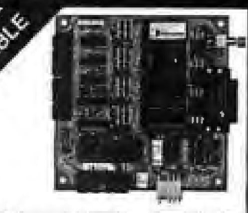

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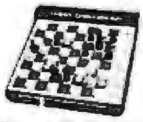

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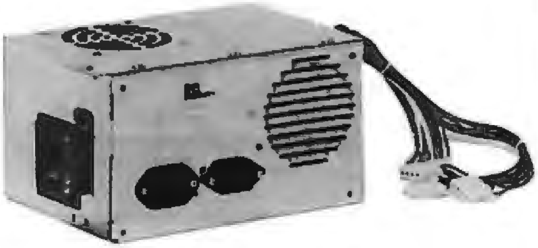

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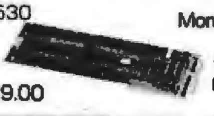

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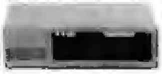

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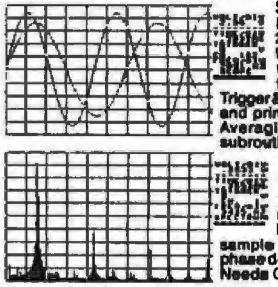

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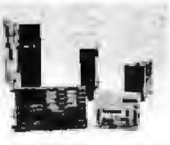

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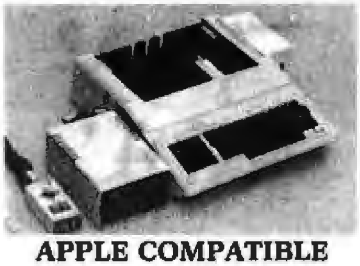

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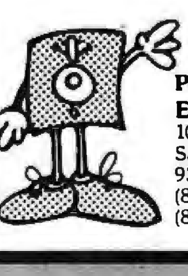

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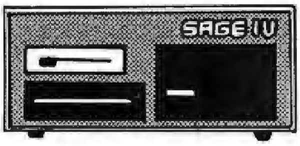

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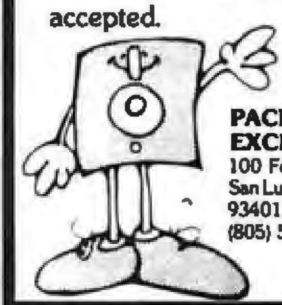

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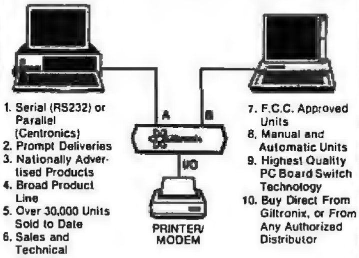

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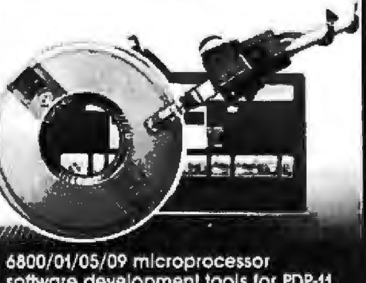

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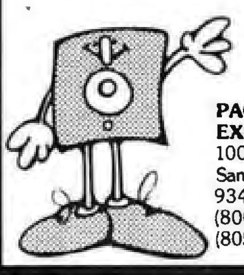

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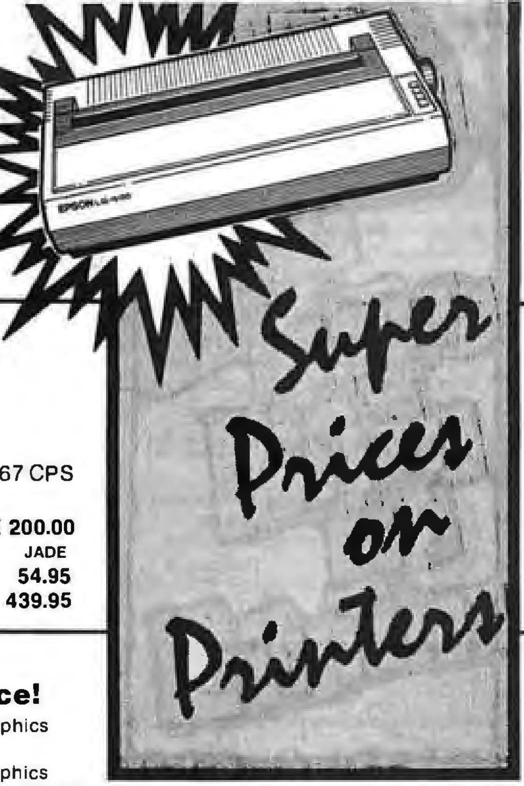

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Comrex CR-II *5K parallel*	599	399.95
Comrex CR-II *5K serial*	644	499.95
Tractor for CR-II	120	99.95
Keyboard for CR-II	199	179.95
Sheet feeder for CR-II	259	199.95
Silver Reed 500 *14 CPS*	599	499.95
Tractor for 500	149	124.95
Silver Reed 550 *18 CPS*	699	599.95
Tractor for 500	159	129.95
Silver Reed 770	1295	999.95
Tractor for 770	159	139.95
Juki 6100 *18 CPS*	599	449.95
Tractor for 6100	149	124.95
NEC 3550 *33 CPS*	2250	1699.95
Tractor for 3550	265	229.95

TOSHIBA P1351
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High quality 24 pin head, 192 CPS draft mode, 96 CPS letter quality

	LIST	JADE
P1351	1895	1299.95
TRACTOR	195	174.95
SHEET FEEDER	1095	899.95

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	LIST	JADE
IBM PC style cable	54	28.95
STANDARD parallel cable	40	28.95
APPLE Card & Cable	109	49.95
TRS-80 MDL-3 cable	109	49.95
COLUMBIA MPC cable	50	39.95
RS-232 serial cable	30	24.95
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APPLE IIC cable	39	27.95

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Expandable to 64K (parallel model expands to 512K)

Parallel in/Parallel out	LIST	JADE
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128K	445	269.95

Serial in/Parallel out		
8K	199	169.95
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Parallel in/Serial out		
8K	199	169.95
32K	260	199.95

Serial in/Serial out		
8K	199	169.95
32K	260	199.95

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Stand alone Microbuffers	LIST	JADE
Parallel, 32K	299	229.95
Parallel, 64K	349	269.95
Serial, 32K	299	229.95
Serial, 64K	349	269.95
64K add-on board	179	149.00

Microbuffers for Apple II		
Parallel, 16K	259	189.95
Parallel, 32K	299	229.95
Serial, 16K	259	189.95
Serial, 32K	299	229.95

Microbuffers for Epson Printers		
Parallel, 16K	159	129.95
Serial, 8K	159	129.95

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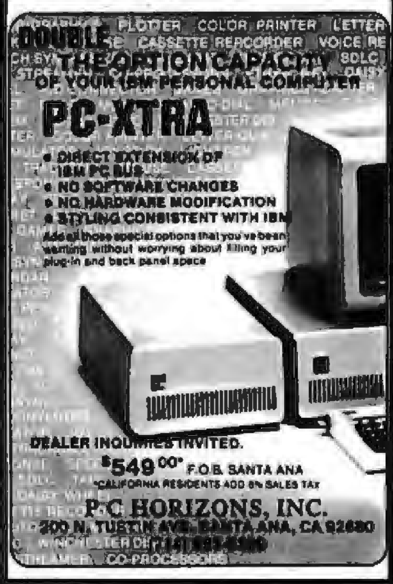

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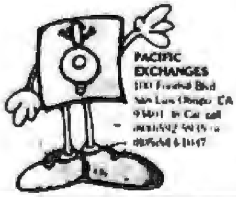

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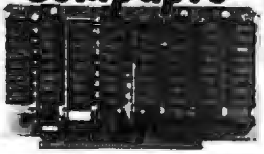
TeleVideo

$795

The Televideo TPC/1 portable micro is a full featured computer with the advantage of portability. The 9inch amber phosphor offers easy readability and a non-glare surface for easy on the eyes screen display. TPC 1 has an IBM style, low profile keyboard, detachable for comfortable data input which folds up to make a compact carrying case. The alpha numeric displayed character set includes 96 ASCII characters, 32 control codes, along with 10 programmable function keys. The TPC/1 portable uses the Z80 microprocessor and provides 64K of user RAM along with 32K of screen memory which is used for both text and graphics. The standard software package includes Telewrite exclusive word processor, Telecalc spreadsheet, Telechart business graphics and CPM operating system which makes the portable compatible with the largest library of microcomputer software available. TVI-TPC/1

Compupro $629



RAM 21

16 BIT MICROPROCESSORS

Octagon dual CPU 8088/Z80, & controller.	OCT-88Z80	795.00
Compupro 8088/8087 microcomp. 16 bit.	GBT-8687	495.00
Compupro dual processor 8085/8088, 8/16.	GBT-8588	359.00

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Advanced Digital, Floppy & 64K	AMD-Z80	750.00
Teletek System master, 765 floppy, 64K.	TEL-SM1	895.00

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Compupro Z80, 24 bit extended add.	GBT-Z80	250.00
California Computer Z80 microprocessor	CCS-2810	275.00
Tarbell Z80 with two RS232 ports	TAR-Z80	339.00

MEMORY BOARDS

Calif. Digital 256K dynamic expand to 1 Meg.	CAL-D256	495.00
Compupro Ram 16, 64K 16 bit data transfer	GBT-R16	429.00
Compupro Ram 17, 64K 8 bit 24 bitaddress	GBT-R17	359.00
Compupro Ram 21, 128K byte 8/16 transfer	GBT-R21	629.00
Compupro Ram 22, 256K static 16 bit transfer	GBT-R22	1179.00
Compupro Ram 23, information pending	GBT-R23	call

FLOPPY DISK CONTROLLERS

Compupro Disk 1A, double density.	GBT-DSK1A	495.00
California Computer 2422A with CPM	CCS-2422	339.00
Tarbell Electronics double density	TAR-DDC	419.00
Tarbell Electronics single density	TAR-SDC	279.00

CPM OPERATING SYSTEM

Digital Research CP/M 3.0, 8" sgl. den.	DRC-CpM30	249.00
Compupro CPM 2.2 for Disk 1.	GBT-CpM22	159.00
Compupro CPM86 for 8088 and 8086	GBT-CpM86	265.00
Tarbell Electronics CPM 2.2	TAR-CpM22	159.00

HARD DISK CONTROLLERS

Octagon hard disk controller with E/C.	OCT-HD1	475.00
Godbout Disk 2, 8" & 14" hard disk	GBT-DSK2	569.00
Godbout Disk 3, for 5¼" Winchesters	GBT-DSK3	629.00
Western Digital new WD-1001 (not S-100)	WDI-1001	319.00

EPROM BOARDS

Inner Access EPROM Bd. programs 27128	IAC-P100	465.00
Digital Research PROM board, 32K	DGR-P32	119.00

INTERFACE BOARDS

Compupro interfacer II, with 5 serial ports	GBT-135A	495.00
Compupro interfacer II, with 8 serial ports	GBT-138A	585.00
Compupro interfacer IV, 3 serial, 2 parallel	GBT-187A	329.00
California Computer 2710, 4 serial ports	CCS-2710	279.00
California Computer 2719, 2 serial, 2 par'l.	CCS-2719	295.00
California Computer 2720, 4 port par'l.	CCS-2720	219.00

SPECIAL FUNCTION BOARDS

QT Computer clock calendar, battery	QTC-CC100	139.00
Compupro System support board, 4K EPROM	GBT-SYS1	259.00
Dual Systems, 4 channel 12 bit D/Aconv.	DSC-AOM12	619.00
Dual System 12 bit resolution, 32ch. A/D	DSC-AIM12	629.00
Mullins Opto-isolator, controls 8ch.	MUL-ICB10	179.00
Mullins extender board with logic & probe	MUL-TB4	79.00
I/O Technology wire wrap prototype	IOT-W100	48.00
Artec Electronics wire wrap prototype	ART-WW100	25.00

MAINFRAMES & MOTHER BOARDS

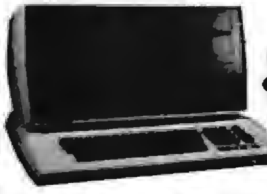
Eclipse Data, stainless, 22 slot torid supply	EDP-100	495.00
Compupro Enclosure 2, 20 slots	GBT-MF2D	675.00
California Digital 18 slot mother board	CAL-MB18	35.00

ENCLOSURES

California Digital manufactures an asortment of stock and custom disk drive enclosures. If the volume is justified we will custom design an enclosure for your application. The following disk drive enclosures are available from stock- All include power supplies the 8" enclosures are supplied with exhaust fans.

• Horizontal mount dual 8" full height drives.	$279.00
• Vertical mount dual full height 8" drives.	299.00
• Horizontal mount one full height or two half height 8".	239.00
• Horizontal one full height or two half height 5¼".	89.00

EAGLE

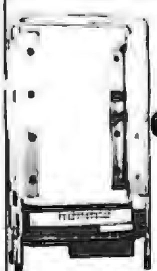


$895

The Eagle IIE/2 Computer features a 12" non-glaregreen phosphor CRT, typewriter style keyboard with separate numeric cluster. This unit provides two 5 1/4" drives for a combined storage capacity of 780 K/Byte. The computer contains a 4Mhz Z-80A, DMA disk interface, two RS-232C serial ports, Centronics printer interface, along with an auxillary parallel port.

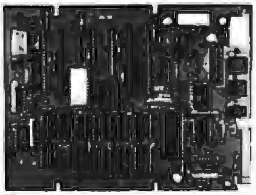
Software included consists of ULTRACALC electronic spread sheet, SPELLBINDER word processor, CBASIC2, CP/M 2.2, and an exclusive Eagle menu driven utility package.

These units are all "factory new" and are being offered far below their suggested price of $2495. This is your opportunity to purchase a complete CP/M system for only $895.



DEC Q-BUSS $49

This is the same backplane used with Digital Equipment PDP-11/23 computer. Four slot dual height suitable for use on all kinds of Q-buss systems. DEC-H9281



Ampro $339

Little Board

The Ampro Little Board is a single board Z-80A microcomputer with on board 5¼" disk controller, 64K/btyes of memory two serial ports along with a Centronics parallel printer port. This computer is supplied with enhanced CP/M 2.2 with well documented user manual. APO-LB1A

Commodore HesModem $39

The HesModem 1 is designed to be used with the VIC-20 or the Commodore 64 microcomputers. The Hes Modem 1 comes complete with terminal communication software. Plugs directly into the communications port of your Commodore Computer. HES-M1

CONRAC $59

9" MONITOR

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AST $219

SIX PAK PLUS

MULTIFUNCTION CARDS

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AST SixPackPlus	64K	with software	265.00
AST SixPackPlus	384K	fully populated board	499.00
AST MegaPlus II	64K	to 512K with MegaPak	269.00
AST MegaPak	256K	piggyback / MegaPlus	279.00
Persyst Board	64K	with software	319.00
Quadboard	64K	with six functions	249.00
STB RIO Plus	64K	with PC accelerator	279.00
STB Super I/O		serial/par'l/game port	184.99

VIDEO DISPLAY CARDS

AST Monograph Plus	monochrome/graphic	449.79
Hercules Graphic	two year warranty	339.89
PC Peacock Color	mono. RGB, graphics	229.00
Plantronics ColorPlus	printer port / software	379.98
Quad Color I	expandable, high res.	209.75
STB Graphics Plus	with software	379.67

HARD DISK DRIVES

Franklin 10MB ext.	controller, power	1195.45
Franklin 10MB int.	3X speed of XT	995.95
Maynard 10MB int.	full XT emulation	998.97

INTEGRATED CIRCUITS

4164 Memory Chips	150 or 200 ns	5.95
64K Set (9 chips)	with instructions	48.95
8087 CoProcessor	arithmetic chip	199.54

CONNECTORS

S-100 Gold

DB25P

GOLD S-100 EDGE CARD CONNECTORS	catalog	each	10-99	100+
Imsai s/t 250	CNE-IMS	2.95	2.50	2.19
Sullins Hi/Rel	CNE-H100	4.19	3.65	3.47
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Actur 100 s/t	CNE-100A	4.95	4.50	4.19
.156" CENTER EDGE CARD CONNECTORS				
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43/72 Moto s/t	CNE-72S	6.60	6.15	5.75
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Other connectors available upon request

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DB25P male	CND-r25P	5.65	5.25	4.15
DB25S female	CND-r25S	5.95	5.50	4.90
57-30360 male	CNC-r36P	7.95	6.75	5.90
57-30360f male	CNC-r36S	7.95	6.75	5.90
20 pin edge	CNI-DE20	4.35	3.30	2.90
20 pin socket	CNI-DS20	2.75	1.95	1.80
26 pin edge	CNI-DE26	4.95	3.50	2.70
26 pin socket	CNI-DS26	3.50	2.40	2.15
34 pin edge	CNI-DE34	4.95	4.50	3.90
34 pin socket	CNI-DS34	4.50	3.95	3.15
50 pin edge	CNI-DE50	5.95	5.00	4.80
50 pin socket	CNI-DS50	4.95	4.60	3.80

"D" TYPE	catalog	each	10-99	100+
DE9P male	CND-9P	1.60	1.40	1.30
DE9S female	CND-9S	2.25	2.00	1.30
DE hood	CND-9H	1.50	1.35	1.20
DA15P male	CND-15P	2.35	2.10	1.90
DA15S female	CND-15S	3.25	3.10	2.90
DA15 hood	CND-15H	1.60	1.35	1.30
DB25P male	CND-25P	1.95	1.75	1.35
DB25S female	CND-25S	2.95	2.55	1.65
DB25 hood	CND-25H	1.35	1.15	.77
DC37P male	CND-37P	4.30	3.95	3.65
DC37S female	CND-37S	6.95	5.75	5.50
DC37 hood	CND-37H	2.25	1.95	1.65
DD50P male	CND-50P	6.50	6.10	4.75
DD50 hood	CND-50H	2.60	2.40	2.10
Hardware 2/set	CND-2HS	.99	.69	.42
AMPHENOL / CENTRONICS TYPE				
57-30360 36/P	CNC-36P	7.95	6.35	3.97
IEEE-488, C cbr	CND-24P	7.95	6.35	5.35
DISK DRIVE POWER CONNECTORS				
8" 6 pin D C	CNP-6DC	1.95	1.29	.89
8" 3 AC Sgl/S	CNP-3SS	1.69	1.09	.89
8" 3 AC Dbl/S	CNP-3DS	1.69	1.09	.89
5¼" 4 pin D C	CNP-4DC	1.79	1.19	.89
3 pin DIN recpt	CNP-D3P	2.50	1.99	1.59

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Shugart

$159

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These units are current production, rack mountable LSI technology. The drives are identical to drives currently sold by distributors at $600.

California Digital has aquired these NEW units as a result of a change of marketing strategy of the A.M. Jaquard Corporation. This is the best value that has ever been offered on any Shugart eight inch disk drive. SHU-801R

$389

TANDON 603SE

These Tandon 14.2 Megabyte hard disk drives are the excess inventory of a major computer company. Each unit has passed 24 hours of incoming burn-in.

Five Inch Winchester Hard Disk Drives

	One	Two
FUJITSU M2235AS 27 Meg.	999	959
RODINE RO-208 53 Meg.	1589	1493
MAXTOR XT1065 65 Meg.	1995	1965
SHUGART 712 13 Meg. ½ Ht	795	765
TANDON 503 19 Meg.	795	775
TANDON 603 14.2 Meg.	389	379

Three Inch Disk Drives

SHUGART SA300	229	219

Upon request, all drives are supplied with power connectors and manual

MEMORY

4164 DYNAMIC MEMORY 150ns

$5.95

DYNAMIC MEMORY

		1-31	32 +	100 +
4116 150ns.16K	ICM-4116150	1.75	1.65	1.45
4116 200ns.16K	ICM-4116200	1.75	1.65	1.45
4164 150ns.64K 128 refresh	ICM-4164150	5.95	5.25	4.95
41256 150ns. 256K	ICM-41256150	39.95	34.85	27.70
DP8409 dynamic controller	ICT-8409	39.00	35.00	29.00

STATIC MEMORY

21L02 200ns. 1K static	ICM-21L02200	1.49	1.29	1.15
21L02 450ns. 1K static	ICM-21L02450	1.29	1.15	.99
2112 450ns. 2K static	ICM-2112450	2.99	2.85	2.75
2114 300ns. 1K x 4	ICM-2114300	1.95	1.85	1.75
4044TMS 450ns. 4K x 1	ICM-4044450	3.49	3.25	2.99
5257 300ns. 4K x 1	ICM-5257300	2.50	2.25	1.99
6116 P4 200ns. 2K x 8	ICM-6116200	4.85	4.65	4.50
6116 P3 150ns. 2K x 8	ICM-6116150	5.25	4.05	4.85

EPROMS

2708 450ns. 1K x 8	ICE-2708	[illegible]	[illegible]	[illegible]
2716 450ns. 2K x 8	ICE-2716	[illegible]	[illegible]	[illegible]
2716TMS 450ns. Tri-voltage	ICE-2716TMS	[illegible]	[illegible]	[illegible]
2732 450ns. 4K x 8	ICE-2732	[illegible]	[illegible]	[illegible]
2764 250ns. 8K x 8	ICE-2764	[illegible]	[illegible]	[illegible]
27128 300ns. 16K x 8	ICE-27128	[illegible]	[illegible]	[illegible]

$139

Your Choice

TEAC 55B 55F 48TPI-96TPI

Five Inch Single Sided Drives

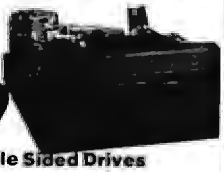
	One	Two	Ten
TEAC FD-54A half height	99	95	89
SHUGART SA400L full height	189	179	175
TANDON TM100-1 full height	169	165	179

Five Inch Double Sided Drives

TEAC FD55B half height	139	135	129
TEAC FD55F 96 TPI, half ht.	139	135	129
CONTROL DATA 9409 PC	219	199	195
CONTROL DATA 9428 ½ ht.	219	199	195
SHUGART SA455 Half Height	189	179	175
PANASONIC JA551/2N (455)	139	135	129
SHUGART SA465 ½ Ht. 96TPI	269	259	249
TANDON 100-2 full height	179	175	169
TANDON 101-4 96TPI full ht.	329	319	305
MITSUBISHI 4851 half height	169	159	155
MITSUBISHI 4853 96/TPI ½ ht.	179	169	165
MITSUBISHI 4854 8" elec.	395	385	375
QUME 142 half height	219	205	199

REMEX

DOUBLE SIDED $219



Eight Inch Single Sided Drives

SHUGART 801R			
SIEMENS FDD 100-8	129	125	119
TANDON 848E-1 Half Height	369	359	349

Eight Inch Double Sided Drives

SHUGART SA851R	495	485	475
QUME 842 "QUME TRACK 8"	459	459	449
TANDON 848E-2 Half Height	459	447	435
REMEX RFD-4000	219	219	209
MITSUBISHI M2894-63	447	439	433
MITSUBISHI M2896-63 ½ Ht.	459	449	409

FREE

Plastic library case supplied with all diskettes purchased from California Digital.

DISKETTES AS LOW AS $16.50

FIVE INCH SINGLE SIDED DOUBLE DENSITY

	Soft Sector Ten Sector Sixteen	Each box	10 Boxes	100 Boxes
CAL DIGITAL	CAL-501 CAL-510 CAL-516	18.95	17.50	16.50
SCOTCH	MMM-744/0 MMM-744/10 MMM-744/16	24.95	22.75	21.75
VERBATIM	VRB-525/01 VRB-525/10 VRB-525/16	24.95	22.75	21.75
MEMOREX	MRX-3481 MRX-3483 MRX-3485	24.95	21.75	17.75
MAXELL	MXL-MD1 MXL-MH1/10 MXL-MH1/16	24.95	22.[illegible]	[illegible]1.25
DYSAN	DYS-104/1D DYS-107/1D DYS-105/1D	35.00	33.00	30.50

FIVE INCH DOUBLE SIDED DOUBLE DENSITY

CAL DIGITAL	CAL-551 CAL-561 N/A	24.95	22.75	20.50
SCOTCH	MMM-745/0 MMM-745/10 MMM-745/16	37.95	35.95	31.25
VERBATIM	VRB-550/01 VRB-550/10 VRB-550/16	37.95	35.95	32.75
MEMOREX	MRX-3491 MRX-3493 MRX-3495	32.95	31.25	26.25
MAXELL	MXL-MD2 MXL-MD2/10 MXL-MD2/16	37.95	35.95	33.75
MAXELL / 96	MXL-MD2/96 N/A N/A	45.00	43.00	41.25
DYSAN	DYS-104/2D DYS-107/2D DYS-105/2D	42.50	40.50	35.50
DYSAN / 96	DYS-204/2D N/A N/A	49.95	47.95	45.75

EIGHT INCH SINGLE SIDED SINGLE DENSITY

SCOTCH	MMM-740/0	28.50	27.50	23.80
MEMOREX	MRX-3062	27.75	26.60	22.25
VERBATIM	VRB-34/9000	31.50	29.50	25.60
DYSAN	DYS-3740/1	35.75	32.75	29.75

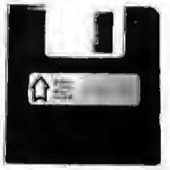
EIGHT INCH SINGLE SIDED DOUBLE DENSITY

SCOTCH	MMM-741/0	33.95	31.75	29.15
MEMOREX	MRX-3090	31.95	27.75	26.15
VERBATIM	VRB-34/8000	35.25	33.25	28.75
DYSAN	DYS-3740/1D	40.75	38.75	32.25
MAXELL	MXL-F01	45.50	39.75	35.15

EIGHT INCH DOUBLE SIDED DOUBLE DENSITY

SCOTCH	MMM-743/0	45.95	43.25	37.50
MEMOREX	MRX-3102	37.95	36.75	31.50
VERBATIM	VRB-34/4001	41.75	37.50	32.25
DYSAN	DYS-3740/2D	54.65	49.75	40.50
MAXELL	MXL-F02	52.50	48.75	40.45

$49 Apple Macintosh Diskettes



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NEC RGB COLOR MONITOR $259

The NEC JC-1401D is a 13" medium/high resolution RGB monitor suitable for use with the Sanyo MBC-550/555 or the IBM/PC. The monitor features a resolution of 400 dots by 240 lines. Colors available are Red, Green, Blue, Yellow, Cyan, Magenta, Black and White. These monitors are currently being used in applications far more critical than microcomputers.

The NEC monitor carries the Litton-Monroe label and was originally scheduled for use in their "Office of the Future" equipment. A change in Monroe's marketing strategy has made these units excess inventory which were sold to California Digital. We are offering these prime "new" RGB monitors at a fraction of their original cost. Sanyo compatible NEC-1401/S; IBM/P/C Computer compatible NEC-1401/PC

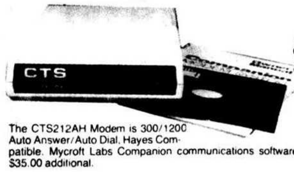
MONITORS

BMC 12A green phosphor 15 MHz. composit video.	BMC-12A	78.95
BMC 12" high resolution, 20MHz.	BMC-12EN	119.00
Amdek 300G 12" green phosphor	AMK-300G	128.95
Amdek 300A 12" amber phos., hi-resolution	AMK-300A	138.95
Amdek 310A designed for IBM/PC, amber	AMK-310A	158.95
Zenith ZVM122 Amber Phosphor 12" 40/80 column switch.	ZTH-122	94.95
Zenith ZVM123 green phosphor 12" 40/80 column switch.	ZTH-Z123	94.95
NEC JB1201 green phosphor 18 MHz. composit video.	NEC-JB1201	159.00
NEC JB1260 commercial grade composit.	NEC-JB1260	119.00
Motorola 23" open frame blk/white composit video.	MOT-BW23	159.00
Conrac 9" open frame requires horz sync. & 12v. supply.	CON-BW9	59.00

COLOR

NEC JC1401D Medium/High 13" RGB	NEC-1401/X	259.00
BMC AU9191U Color composit video with sound	BMC-9191	238.95
BMC 9191M RGB designed for use with the IBM computer.	BMC-9191M	379.00
NEC JC1203DM, RGB color monitor	NEC-1203	699.00
NEC JC1201 color composit.	NEC-JC1201	339.00
Zenith ZVM135 RGB & composite suitable for IBM PC	ZTH-Z135	475.00
Amdek Color I, 13" composit video	AMK-100	299.00
Amdek Color II+, 13" RGB hi/resolution	AMK-200	419.95
Amdek Color III+, 13" RGB, medium resolutiion	AMK-300	359.95
Princeton HX-12 RGB IBM/PC compatible	PRN-HX12	478.95

MODEMS



$319

The CTS212AH Modem is 300/1200 Auto Answer/Auto Dial, Hayes Compatible. Mycroft Labs Companion communications software $35.00 additional.

CTS 212AH 1200 baud, auto dial	CTS-212AH	319.00
Signalman Mark 12, 1200 baud, Hayes compatible.	SGL-MK12	259.00
Signalman Mark 1, direct connect with terminal cable.	SGL-MK1	75.00
Hayes Smart Modem 1200 baud, auto answer, auto dial	HYS-212AD	479.00
Hayes 1200B for use with the IBM/PC, 1200 baud.	HYS-1200B	429.00
Hayes Smartmodem, 300 baud only, auto answer, auto dial	HYS-103AD	229.00
Hayes Micromodem II, 103 Apple direct connect	HYS-MM2	279.00
Hayes Chronograph, time & date	HYS-CHR232	199.00
U.S. Robotics 212A 300/1200 baud, auto dial/answer.	USR-212A	439.00
U.S. Robotics Password 300/1200 baud	USR-PW212	389.00
Penril 300/1200 industrial quality	PEN-12AD	595.00
Universal Data 103LP, line power, answer & originate	UDS-103LP	169.00
Universal Data 202, 1200 baud, half duplex only	UDS-202LP	219.00
Universal Data 212LP, full 1200 baud duplex, line power	UDS-212LP	359.00
Novation 'J' Cat, direct connect, auto answer	NOV-JCAT	115.00
Novation SmartCat 103/212, 1200 baud auto dial	NOV-SC212	529.00

ASCII KEYBOARD $49

California Digital has purchased over 3000 of these Microswitch keyboards from the General Dynamics Corporation. 93 ASCII encoded Hall effect switches includes 8 function keys and 14 key numeric cluster make this keyboard an excellect value at only $49. MIC-93GD 5 lbs.
We also have available a matching General Dynamics steel trim panel. $10.

Non-encoded Hytek 58 key metal contact keyboard. HIK-58 $24.95. Matching 15 key numeric cluster $9.95. HIK-15 Both for only $29.95. HIK-5815.

Return of a Smash Hit Sellout

DRAGON $139

Compatible with the Radio Shack Color Computer. The world famous Dragon computer is now available in the United States. Manufactured by the Tano Corp. under license of the British Broadcasting Company. The Dragon comes complete with 64K Byte of memory, serial modem port along with a Centronics printer interface. This unique microcomputer features Motorola's advanced 6809E microprocessor and comes standard with Microsoft Color Basic, data base manager, and a complete word processing package. The computer outputs color composite video along with R.F. video that allows the unit to be used in conjunction with any color television. This is the Ideal low cost computer to be used with any dial up information system such as the Source, Western Union's EasyLink or any other time share service.

California Digital has agreed to act as exclusive agent for North America in an effort to assist The Tano Corporation in reducing their overstock. For a limited time California Digital can offer the Dragon computer for only $139.

PRINTERS

MATRIX PRINTERS

Star Gemini-10X 120 char/sec.	STR-G10X	279.00
Star Gemini-15X, 100 char./sec. 15" paper.	STR-G15X	389.00
Star Gemini Delta 10, 160 Char/sec	STR-D10	399.00
Star Coex 80FT friction & tractor	VST-C80FT	195.00
Toshiba P1351, 192 char/sec. letter quality	TOS-1351	1495.00
Okidata 82A serial & parallel 9½" paper	OKI-82A	347.00
Okidata 92A parallel interface, 160 char/sec.	OKI-92A	427.00
Okidata 83A & parallel 15" paper	OKI-83A	567.00
Okidata 84A & parallel 15" paper	OKI-84A	997.00
Okidata 2350 (new) 350 char/sec	OKI-2350	1995.00
Epson RX-8010" 120 Char/sec.	EPS-RX80	317.00
Epson FX80, 10" 160 char./sec. with graphtrax	EPS-FX80	529.00
Epson FX 100 15" 160 char./sec with graphtrax	EPS-FX100	719.00
Anadex 9501B high speed with graphics	ADX-9501B	1029.00
Anadex 9620B 200 char/sec. par'l & serial.	ADX-9620B	1129.00
Prowriter 8510 parallel 9½" paper	PRO-8510P	359.00
Prowriter II, parallel 15" paper, graphics	PRO-2P	689.00
Dataproducts B-600-3, band printer 600 LPM.	DPS-B600	6985.00
Printronix P300 high speed printer 300 lines per minute.	PTX-P300	3995.00
Printronix P600 ultra high speed 600 lines per minute.	PTX-P600	5795.00

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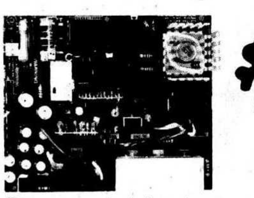
NEC7710 55 char/second, serial interface	NEC-7710	1795.00
NEC7730 55 char/sec, par'l interface.	NEC-7730	1795.00
NEC3550 popular printer designed for the IBM/PC	NEC-3550	1599.00
NEC2050 designed for IBM/PC 20 char/sec. par'l.	NEC-2050	995.00
Silver Reed EXP500, 14 char/sec. par'l interface	SRD-EXP500	459.00
Silver Reed EXP550 17 Char/sec par'l interface.	SRD-EXP550	659.00
Diablo 630 40 char/sec. serial	DBL-630	1765.00
Diablo 620, proportional spacing, horz.& vert. tab. 20 cps.	DBL-620	879.00
Juki 6100, 18 char./sec. SPECIAL.	JUK-S6100	319.00
Brother HR1A serial interface	BTH-HR1S	695.00
Starwriter F10 serial, 40 char/sec.	PRO-F10S	1125.00
Starwriter F10 parallel, 40 char/sec.	PRO-F10P	1125.00
Comrex CR2, 5k buffer, proportional spacing, par'l.	CRX-CR2P	495.00

TERMINALS

Freedom 100, split screen, detatchable keyboard	LIB-F100	495.00
Qume 102 green phosphor terminal	QUM-102	539.00
Ampex Dialogue 125 green screen,	APX-D125G	675.00
Ampex Dialouge 175 amber screen, two page, func. keys	APX-D175A	719.00
Wyse 50, 14" green phosphor	WYS-50	595.00
Wyse 300, Eight color display, split screen.	WYS-300	1159.00
Zenith 29 terminal, VT52 compatible. detatch.ble keyboard.	ZTH-Z29	765.00
Televideo 910 Plus, block mode	TVI-910P	575.00
Televideo 925, detatchable keyboard, 22 function keys	TVI-925	759.00
Televideo 950, graphic char.,split screen, 22 func.	TVI-950	950.00
Televideo 970, 14" green, 132 column, European	TVI-970	1095.00

Switching Supply $49



Power your single board system with one supply! This Kepro switcher power supply outputs +5 volts at 5 amps, +12 volts at 1.8 amps, 2.8 amps surge, −12 volts at 0.5 amps, and a second +12 volts at 2.0 amp output. It is jumper selectable for both 120 volt and 220 volt operation. Units measures approximately 6" by 8". This board is capable of supplying power for two 5¼" Winchesters, a single board computer along with a hard disk controller. Also suitable for use with all IBM look-a-likes. Priced at only $49.95 this power supply offers excellent value along with high reliability. KPT-512

SANYO IBM Compatible $759

The Sanyo MBC-550 Microcomputer includes 128K byte of memory, a 5¼" disk drive along with a parallel printer port. The computer outputs both RGB color and monochrome composite video. Extensive software such as Sanyo Basic, Wordstar, Calcstar and Easy Writer I is included with the MBC-550.

Sanyo 550	**reduced SALE price**	**759.00**
Sanyo 550 Plus	**two single sided drives**	**829.00**
Sanyo 550-2	**one double sided drive**	**949.00**
Sanyo 550-2 Plus	**two double sided drives**	**1095.00**
Sanyo 555	**two sgl. drives, bonus soft.**	**1095.00**
Sanyo 555-2	**two dbl. drives, bonus soft.**	**1249.00**
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Serial Card	**modem interface**	**85.00**

Advanced Logic Systems CP/M 3.0 CARD $179

Includes Digital Research C/PM Plus

We have just purchased from Digital Research over eight hundred of the Advanced Logic Systems CP/M 3.0 cards. This unique product offers performance upto 300% faster than existing Apple CP/M cards.

Featuring a 6 MHz. Z80B micro-processor, 64K/Byte of on board memory, with CP/M 3.0 along with GSX 80 graphics and CBasic. The ALS card supports larger programs with enhanced CP/M editing features.

Manufacturers suggested price on the CP/M board is $399. while supplies last California Digital is offering this card at only $179. ALS-Z80

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IBM

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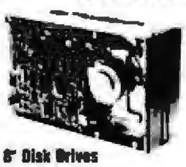

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64K RAMS

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BUSINESS

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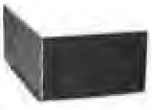

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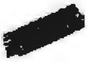

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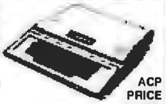

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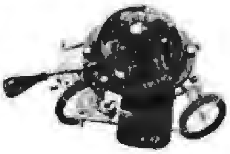
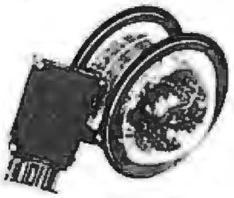


PEPPY's 2-way sensor is susceptible to noise and solid objects in its path. When the front sensor contacts a wall or other obstacle or hears a loud noise, such as a hand-clap, it automatically turns to the left. Uses 2 AA and 1 9V battery (not included).

MV-916 $24.95

CIRCULAR



Two large wheels roll this new robot left or right, forward or round & round; controlled by hand-held remote control box. Uses 3 AA and 2 9V batteries (not included).

MV-935 $69.95

PIPER-MOUSE

Controlled by a Supersonic sound sensor and a 1-channel electronic circuit. Use the whistle in this kit and Piper-Mouse will follow your commands, immediately turning left, stopping, turning right, advancing and stop. Uses 2 AA and 1 9V battery (not included).

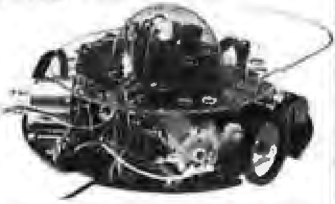
MV-915 $44.95

AVOIDER

Emits an infra-red beam to detect obstacles in front. Knows how to avoid hitting walls! Uses 2 AA and 1 9V battery (not included).

MV-912 $44.95

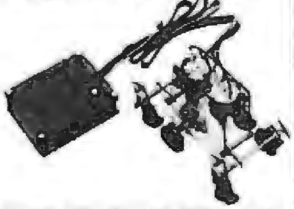
LINE TRACER II



Uses an infra-red light sensor to automatically follow a black line (min. 10mm wide) drawn on white paperboard. (Minimum turn radius 15cm.) Uses 2 AA and 1 9V battery (not included).

MV-913 $39.95

MR. BOOTSMAN



Two speeds with six legs! Walks or runs forwards, backwards, left, right, even full circle turns. Wired control.
Uses 2 AA batteries (not included).

MV-931 $32.95

TURN BACKER

When its about to hit a wall, just yell "Look Out!" and the robot automatically turns left. Requires 4 "AA" batteries (not included).

MV-911 $39.95

MEMOCON CRAWLER

Runs through the program you input on the included keyboard: forward, turn right or left, pause, sound buzzer or turn light beam on. Uses 2 AA and 1 9V battery (not included).

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The **MOVIT** line is a series of computerized (and logic controlled) battery robot kits that can teach the basic principles of robotic sensing and locomotion. Each of the kits features pre-assembled pc boards, hardware and mechanical drive systems that can be handled by anyone. Only basic hand tools are required for assembly. You can experience and learn any one or all of the following features: remote control, sound sensor, infrared sensor, wired control or programmable memory.

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Medusa's electronic brain registers your command and starts to hobble on its 4 legs, stopping after a preset time. Sensor includes condenser microphone Uses 2 N size 1.5 V (E90, MN9100) batteries (not incl.)

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LP = Low Power Qstat = Quasi-Static

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74LS28	.34	74LS161	.84	74LS366	.48
74LS30	.24	74LS162	.88	74LS367	.44
74LS32	.28	74LS163	.84	74LS368	.44
74LS33	.54	74LS164	.88	74LS373	1.35
74LS37	.34	74LS165	.94	74LS374	1.35
74LS38	.34	74LS166	1.90	74LS377	1.35
74LS40	.24	74LS168	1.70	74LS378	1.13
74LS42	.48	74LS169	1.70	74LS379	1.30
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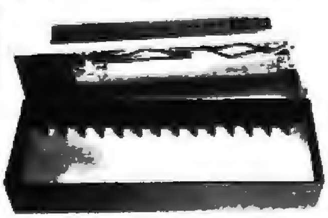
QUV-T8/1 EPROM Eraser



QUV-T8/1 Economy Model:

Lowcost EPROM eraser in plastic enclosure. The UV element is in the lid and you place the EPROMS in the bottom half. No timer or switch option.

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2.4576 MHz	2.69	14.3182 MHz	2.69
3.2768 MHz	2.89	15.0000 MHz	2.69
3.5795 MHz	2.89	16.0000 MHz	2.69
4.0000 MHz	2.89	17.4300 MHz	2.69
4.1943 MHz	2.89	18.0000 MHz	2.69
4.9160 MHz	2.69	18.4320 MHz	2.69
5.0000 MHz	2.69	19.6608 MHz	2.89
5.0688 MHz	2.69	20.0000 MHz	2.69
5.1850 MHz	2.69	22.1184 MHz	2.89
5.2429 MHz	2.89	32.0000 MHz	2.69
5.7143 MHz	2.89	36.0000 MHz	2.69
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7805K	1.34	7912K	1.44
7812K	1.34	7915K	1.44
7815K	1.34	7924K	1.44
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20 pin ST.	.28	20 pin WW.	1.04
22 pin ST.	.29	22 pin WW.	1.34
24 pin ST.	.29	24 pin WW.	1.44
28 pin ST.	.39	28 pin WW.	1.64
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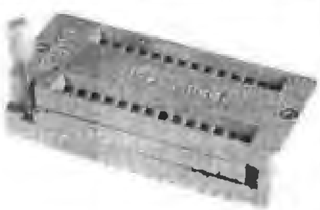

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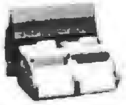

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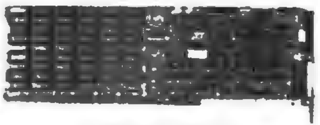

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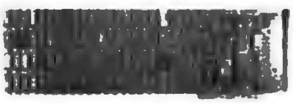

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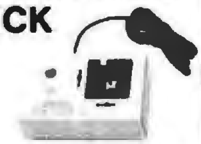

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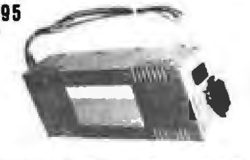

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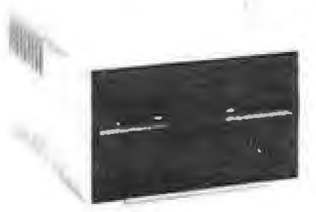

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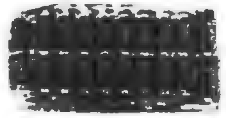

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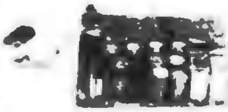

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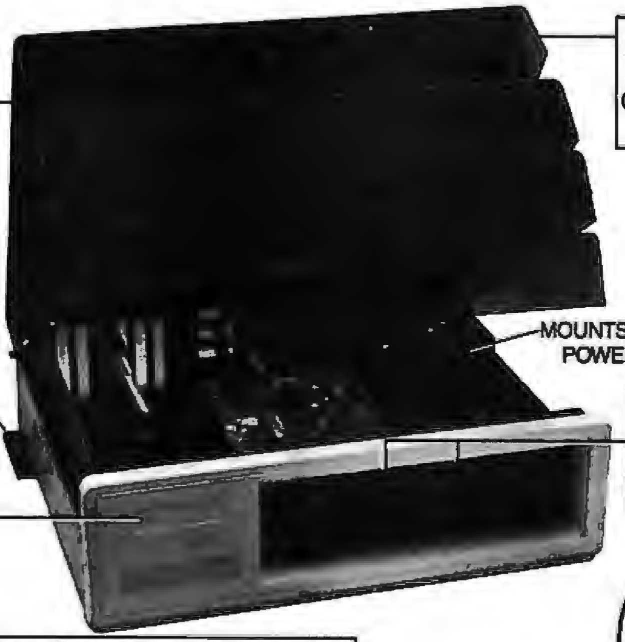

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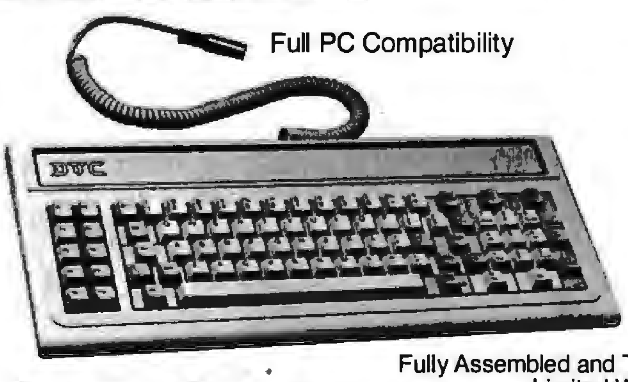

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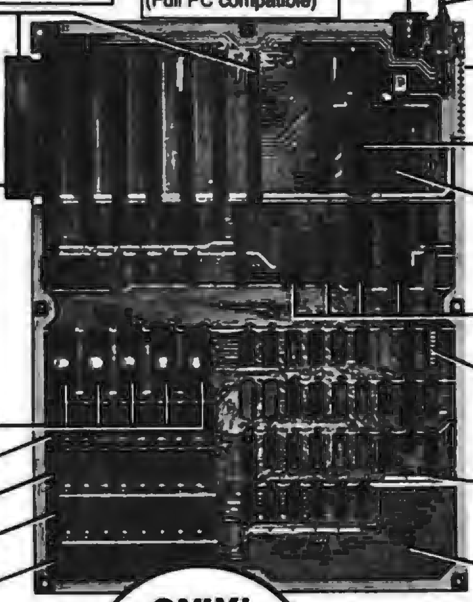

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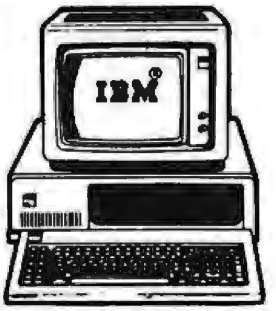

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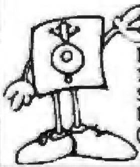

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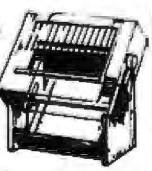

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5101	256x4	(450ns)(cmos)	3.95
2102-1	1024x4	(450ns)	.89
2102L-4	1024x1	(450ns)(LP)	.99
2102L-2	1024x1	(250ns)(LP)	1.45
2125	1024x1	(45ns)	2.95
2111	256x4	(450ns)	2.49
2111L	256x4	(450ns)(LP)	2.95
2112	256x4	(450ns)	2.99
2114L-15	1024x4	(150ns)(LP)	8/19.95
2114	1024x4	(450ns)	8/9.95
2114-25	1024x4	(250ns)	8/10.95
2114L-4	1024x4	(450ns)(LP)	8/12.95
2114L-3	1024x4	(300ns)(LP)	8/13.45
2114L-2	1024x4	(200ns)(LP)	8/13.95
TC5514	1024x4	(650ns)(cmos)	4.95
2141	4096x1	(200ns)	2.95
2147	4096x1	(55ns)	4.95
2148	1024x4	(70ns)	4.95
TMS4044-4	4096x1	(450ns)	3.49
TMS4044-3	4096x1	(300ns)	3.99
TMS4044-2	4096x1	(200ns)	4.49
TMS40L44-2	4096x1	(200ns)(LP)	4.95
UPD410	4096x1	(100ns)	3.95
MK4118	1024x8	(250ns)	9.95
TMM2016-200	2048x8	(200ns)	4.15
TMM2016-150	2048x8	(150ns)	4.95
TMM2016-100	2048x8	(100ns)	6.15
HM6116-4	2048x8	(200ns)(cmos)	4.75
HM6116-3	2048x8	(150ns)(cmos)	4.95
HM6116-2	2048x8	(120ns)(cmos)	8.95
HM6116LP-4	2048x8	(200ns)(cmos)(LP)	5.95
HM6116LP-3	2048x8	(150ns)(cmos)(LP)	6.95
HM6116LP-2	2048x8	(120ns)(cmos)(LP)	10.95
TC5516	2048x8	(250ns)(cmos)	9.95
TMS4016	2048x8	(200ns)	6.95
Z-6132	4096x8	(300ns)(Qstat)	34.95
HM6264P-15	8192x8	(150ns)(cmos)	34.95
HM6264LP-12	8192x8	(120ns)(cmos)	49.95
HM6264LP-15	8192x8	(150ns)(cmos)	39.95

LP=Low power   Qstat=Quasi-Static

DYNAMIC RAMS

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2107	4096x1	(200ns)	1.95
MM5280	4096x1	(300ns)	1.95
TMS4050	4096x1	(300ns)	1.95
UPD411	4096x1	(300ns)	1.95
TMS4060	4096x1	(300ns)	1.95
MK4108	8192x1	(200ns)	1.95
MM5298	8192x1	(250ns)	1.85
4118-300	16384x1	(300ns)	8/11.75
4116-250	16384x1	(250ns)	8/7.95
4116-200	16384x1	(200ns)	8/12.95
4116-150	16384x1	(150ns)	8/14.95
4116-120	16384x1	(120ns)	8/29.00
2118	16384x1	(150ns)(5v)	4.95
MK4332	32768x1	(200ns)	9.95
4164-200	65536x1	(200ns)(5v)	9/44.95
4164-150	65536x1	(150ns)(5v)	9/49.00
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MCM6665	65536x1	(200ns)(5v)	8.95
TMS4164	65536x1	(150ns)(5v)	8.95
4164-REFRESH	65536x1	(150ns)(5V)(REFRESH)	8.95
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41256-150	262144x1	(150ns)(5v)	44.95
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5v=Single 5 Volt Supply   REFRESH=Pin 1 Refresh

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TMS2616	2048x8	(450ns)(5V)	5.50
TMS2716	2048x8	(450ns)	7.95
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2732	4096x8	(450ns)(5V)	4.95
2732-250	4096x8	(250ns)(5V)	8.95
2732-200	4096x8	(200ns)(5V)	11.95
2732A-4	4096x8	(450ns)(5V)(21V PGM)	4.95
2732A-35	4096x8	(350ns)(5V)(21V PGM)	4.95
2732A	4096x8	(250ns)(5V)(21V PGM)	9.95
2732A-2	4096x8	(200ns)(5V)(21V PGM)	13.95
2764	8192x8	(450ns)(5V)	6.95
2764-250	8192x8	(250ns)(5V)	7.95
2764-200	8192x8	(200ns)(5V)	19.95
TMS2564	8192x8	(450ns)(5V)	14.95
MCM68764	8192x8	(450ns)(5V)(24 pin)	39.95
MCM68766	8192x8	(350ns)(5V)(24 pin)	42.95
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27128-30	16384x8	(300ns)(5V)	22.95
27128	16384x8	(250ns)(5V)	24.95

5V=Single 5 Volt Supply   21V PGM=Program at 21 Volts

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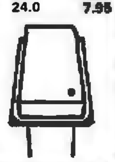

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74LS08	.28	74LS195	.69
74LS09	.29	74LS196	.79
74LS10	.25	74LS197	.79
74LS11	.35	74LS221	.89
74LS12	.35	74LS240	.95
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74LS20	.25	74LS244	1.29
74LS21	.29	74LS245	1.49
74LS22	.25	74LS247	.75
74LS26	.29	74LS248	.99
74LS27	.29	74LS249	.99
74LS28	.35	74LS251	.59
74LS30	.25	74LS253	.59
74LS32	.29	74LS257	.59
74LS33	.55	74LS258	.59
74LS37	.35	74LS259	2.75
74LS38	.35	74LS260	.59
74LS40	.25	74LS261	2.25
74LS42	.49	74LS266	.55
74LS47	.75	74LS273	1.49
74LS48	.75	74LS275	3.35
74LS49	.75	74LS279	.49
74LS51	.25	74LS280	1.98
74LS54	.29	74LS283	.69
74LS55	.29	74LS290	.89
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74LS109	.39	74LS373	1.39
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74LS114	.39	74LS377	1.39
74LS122	.45	74LS378	1.18
74LS123	.79	74LS379	1.35
74LS124	2.90	74LS385	3.90
74LS125	.49	74LS386	.45
74LS126	.49	74LS390	1.19
74LS132	.59	74LS393	1.19
74LS133	.59	74LS395	1.19
74LS136	.39	74LS396	1.89
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74LS145	1.20	74LS490	1.95
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74LS153	.55	74LS640	2.20
74LS154	1.90	74LS645	2.20
74LS155	.69	74LS668	1.69
74LS156	.69	74LS669	1.89
74LS157	.65	74LS670	1.49
74LS158	.59	74LS674	14.95
74LS160	.69	74LS682	3.20
74LS161	.65	74LS683	3.20
74LS162	.69	74LS684	3.20
74LS163	.65	74LS685	3.20
74LS164	.69	74LS688	2.40
74LS165	.95	74LS689	3.20
74LS166	1.95	81LS95	1.49
74LS168	1.75	81LS96	1.49
74LS169	1.75	25LS2518	4.13
74LS170	1.49	25LS2521	2.80
74LS173	.69	25LS2538	3.74
74LS174	.55	25LS2569	2.80
74LS175	.55	26LS31	2.19
74LS181	2.15	26LS32	2.19

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6.0 MHz

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6500

1.0 MHz

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2.0 MHz

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6809	11.95
6810	2.95
6820	4.35
6821	2.95
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	12.95
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6850	3.25
6852	5.75
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6800=1 MHz

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68B09	29.95
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68B00=2 MHz

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8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	79.95
8272	39.95
8274	39.95
8275	29.95
8279	8.95
8279-5	10.00
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74S04	.35	74S140	.55	74S257	.95
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74S08	.35	74S153	.95	74S260	.79
74S09	.40	74S157	.95	74S273	2.45
74S10	.35	74S158	.95	74S274	19.95
74S11	.35	74S161	1.95	74S275	19.95
74S15	.35	74S162	1.95	74S280	1.95
74S20	.35	74S163	1.95	74S283	3.29
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7404	.19	7490	.35	74176	.89
7405	.25	7491	.40	74177	.75
7406	.29	7492	.50	74178	1.15
7407	.29	7493	.35	74179	1.75
7408	.24	7494	.65	74180	.75
7409	.19	7495	.55	74181	2.25
7410	.19	7496	.70	74182	.75
7411	.25	7497	2.75	74184	2.00
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7413	.35	74105	1.14	74189	2.99
7414	.49	74107	.30	74190	1.15
7416	.25	74109	.45	74191	1.15
7417	.25	74110	.45	74192	.79
7420	.19	74111	.55	74193	.79
7421	.35	74116	1.55	74194	.85
7422	.35	74120	1.20	74195	.85
7423	.29	74121	.29	74196	.79
7425	.29	74122	.45	74197	.75
7426	.29	74123	.49	74198	1.35
7427	.29	74125	.45	74199	1.35
7428	.45	74126	.45	74221	1.35
7430	.19	74128	.55	74246	1.35
7432	.29	74132	.45	74247	1.25
7433	.45	74136	.50	74248	1.85
7437	.29	74141	.65	74249	1.95
7438	.29	74142	2.95	74251	.75
7439	.79	74143	4.95	74259	2.25
7440	.19	74144	2.95	74265	1.35
7442	.49	74145	.60	74273	1.95
7443	.65	74147	1.75	74276	1.25
7444	.69	74148	1.20	74278	3.11
7445	.69	74150	1.35	74279	.75
7446	.69	74151	.55	74283	2.00
7447	.69	74152	.65	74284	3.75
7448	.69	74153	.55	74285	3.75
7450	.19	74154	1.25	74290	.95
7451	.23	74155	.75	74293	.75
7453	.23	74156	.65	74298	.85
7454	.23	74157	.55	74351	2.25
7460	.23	74159	1.65	74365	.65
7470	.35	74160	.85	74366	.65
7472	.29	74161	.69	74367	.65
7473	.34	74162	.85	74368	.65
7474	.33	74163	.69	74376	2.20
7475	.45	74164	.85	74390	1.75
7476	.35	74165	.85	74393	1.35
7480	.59	74166	1.00	74425	3.15
7481	1.10	74167	2.96	74426	.85
7482	.95	74170	1.65	74490	2.55

CMOS

4000	.29	4532	1.95
4001	.25	4538	1.95
4002	.25	4539	1.95
4006	.89	4541	2.64
4007	.29	4543	1.19
4008	.95	4553	5.79
4009	.39	4555	.95
4010	.45	4556	.95
4011	.25	4558	2.45
4012	.25	4560	4.25
4013	.38	4569	3.49
4014	.79	4581	1.95
4015	.39	4582	1.95
4016	.39	4584	.75
4017	.69	4585	.75
4018	.79	45151	12.95
4019	.39	4702	12.95
4020	.75	4724	1.50
4021	.79	74C00	.35
4022	.79	74C02	.35
4023	.29	74C04	.35
4024	.65	74C08	.35
4025	.29	74C10	.35
4026	1.65	74C14	.59
4027	.45	74C20	.35
4028	.69	74C30	.35
4029	.79	74C32	.39
4030	.39	74C42	1.29
4034	1.95	74C48	1.99
4035	.85	74C73	.65
4040	.75	74C74	.65
4041	.75	74C76	.80
4042	.69	74C83	1.95
4043	.85	74C85	1.95
4044	.79	74C86	.39
4046	.85	74C89	4.50
4047	.95	74C90	1.19
4048	.69	74C93	1.75
4049	.35	74C95	.99
4050	.35	74C150	5.75
4051	.79	74C151	2.25
4052	1.99	74C154	3.25
4053	.79	74C157	1.75
4060	.89	74C160	1.19
4066	.39	74C161	1.19
4068	.39	74C162	1.19
4069	.29	74C163	1.19
4070	.35	74C164	1.39
4071	.29	74C165	2.00
4072	.29	74C173	.79
4073	.29	74C174	1.19
4075	.29	74C175	1.19
4076	.79	74C192	1.49
4077	.59	74C193	1.49
4078	.29	74C195	1.39
4081	.29	74C200	5.75
4082	.29	74C221	1.75
4085	.95	74C224	2.25
4086	.95	74C373	2.45
4093	.49	74C374	2.45
4094	2.99	74C901	.39
4098	2.49	74C902	.85
4099	1.95	74C903	.85
14409	12.95	74C905	10.95
14410	12.95	74C906	.95
14411	11.95	74C907	1.00
14412	12.95	74C908	2.00
14419	7.95	74C909	2.75
14433	14.95	74C910	9.95
4502	.95	74C911	8.95
4503	.65	74C912	8.95
4507	1.25	74C914	1.95
4508	1.95	74C915	1.19
4510	.85	74C918	2.75
4511	.85	74C920	17.95
4512	.85	74C921	15.95
4514	1.25	74C922	4.49
4515	1.79	74C923	4.95
4516	1.55	74C925	5.95
4518	.89	74C926	7.95
4519	.39	74C927	7.95
4520	.79	74C928	7.95
4521	4.99	74C929	19.95
4522	1.25	74C930	4.95
4526	1.25	80C95	.85
4527	1.95	80C96	.95
4528	1.19	80C97	.95
4529	2.95	80C98	1.20
4531	.95		

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC175	.99
74HC02	.59	74HC193	1.25
74HC04	.59	74HC194	1.04
74HC08	.59	74HC195	1.09
74HC10	.59	74HC238	1.35
74HC11	.59	74HC240	1.89
74HC14	.79	74HC241	1.89
74HC20	.59	74HC242	1.89
74HC27	.59	74HC243	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC251	.89
74HC74	.75	74HC257	.85
74HC75	.85	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC367	.99
74HC125	1.19	74HC373	2.29
74HC132	1.19	74HC374	2.29
74HC138	.99	74HC393	1.39
74HC139	.99	74HC4017	1.99
74HC151	.89	74HC4020	1.39
74HC153	.89	74HC4024	1.59
74HC154	2.49	74HC4040	1.39
74HC157	.89	74HC4049	.89
74HC161	1.15	74HC4050	.89
74HC164	1.25	74HC4060	1.29
74HC166	2.95	74HC4511	2.39
74HC174	.99	74HC4538	2.29

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT175	1.09
74HCT02	.69	74HCT193	1.39
74HCT04	.69	74HCT194	1.19
74HCT08	.69	74HCT195	1.29
74HCT10	.69	74HCT238	1.49
74HCT11	.69	74HCT240	2.19
74HCT14	.89	74HCT241	2.19
74HCT20	.69	74HCT242	2.19
74HCT27	.69	74HCT243	2.19
74HCT30	.69	74HCT244	2.19
74HCT32	.79	74HCT245	2.19
74HCT51	.69	74HCT251	1.09
74HCT74	.85	74HCT257	.99
74HCT75	.95	74HCT259	1.59
74HCT85	1.49	74HCT273	2.09
74HCT86	.79	74HCT299	5.25
74HCT93	1.29	74HCT367	1.09
74HCT125	1.29	74HCT373	2.49
74HCT132	1.29	74HCT374	2.49
74HCT138	1.15	74HCT393	1.59
74HCT139	1.15	74HCT4017	2.19
74HCT151	1.05	74HCT4020	1.59
74HCT153	1.05	74HCT4024	1.79
74HCT154	2.99	74HCT4040	1.59
74HCT157	.99	74HCT4049	.99
74HCT161	1.29	74HCT4050	.99
74HCT164	1.39	74HCT4060	1.49
74HCT166	3.05	74HCT4511	2.69
74HCT174	1.09	74HCT4538	2.59

SPECTRONICS CORPORATION

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		9	8,000	$83.00
PE-14T	x	9	8,000	$119.00
PE-24T	x	12	9,600	$175.00
PL-265T	x	30	9,600	$255.00
PR-125T	x	25	17,000	$349.00
PR-320T	x	42	17,000	$595.00

VOLTAGE REGULATORS

TO-220 CASE PACKAGE

7805T	.75	7905T	.85
7808T	.75	7908T	.85
7812T	.75	7912T	.85
7815T	.75	7915T	.85
7824T	.75	7924T	.85

TO-3 CASE PACKAGE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49

TO-92 CASE PACKAGE

78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79

OTHER VOLTAGE REGS

78M05C	5volt	½amp	TO-220	.35
LM323K	5volt	3amp	TO-3	4.95
LM338K	Adj.	5amp	TO-3	3.95
78H05K	5volt	5amp	TO-3	9.95
78H12K	5volt	5amp	TO-3	9.95
78P05K	5volt	10amp	TO-3	14.95
UA78S40	FAIRCHILD		DIP	1.95

LINEAR

LM301	.34	LM567	.89
LM301H	.79	NE570	3.95
LM307	.45	NE571	2.95
LM308	.69	NE590	2.50
LM308H	1.15	NE592	2.75
LM309H	1.95	LM709	.59
LM309K	1.25	LM710	.75
LM310	1.75	LM711	.79
LM311	.64	LM723	.49
LM311H	.89	LM723H	.55
LM312H	1.75	LM733	.98
LM317K	3.95	LM741	.35
LM317T	1.19	LM741N-1	4.35
LM318	1.49	LM741H	.40
LM318H	1.59	LM747	.69
LM319H	1.90	LM748	.59
LM319	1.25	LM1014	1.19
LM320	see7900	LM1303	1.95
LM322	1.65	LM1310	1.49
LM323K	4.95	MC1330	1.69
LM324	.59	MC1349	1.89
LM329	.65	MC1350	1.19
LM331	3.95	MC1358	1.69
LM334	1.19	MC1372	6.95
LM335	1.40	LM1414	1.59
LM336	1.75	LM1458	.59
LM337K	3.95	LM1488	.69
LM338K	3.95	LM1489	.69
LM339	.99	LM1496	.85
LM340	see7800	LM1558H	3.10
LM348	.99	LM1800	2.37
LM350K	4.95	LM1812	8.25
LM350T	4.60	LM1830	3.50
LM358	.69	LM1871	5.49
LM359	1.79	LM1872	5.49
LM376	3.75	LM1877	3.52
LM377	1.95	LM1889	1.95
LM378	2.50	LM1896	1.75
LM379	4.50	ULN2003	2.49
LM380	.89	LM2877	2.05
LM380N-8	1.10	LM2878	2.25
LM381	1.60	LM2900	.85
LM382	1.60	LM2901	1.00
LM383	1.95	MPO2907	1.95
LM384	1.95	LM2917	2.95
LM386	.89	LM3900	.59
LM387	1.40	LM3905	1.25
LM389	1.35	LM3909	.98
LM390	1.95	LM3911	2.25
LM392	.69	LM3914	3.95
LM393	1.29	LM3915	3.95
LM394H	4.60	LM3916	3.95
LM399H	5.00	MC4024	3.95
NE531	2.95	MC4044	4.50
NE555	.34	RC4136	1.25
NE556	.65	RC4151	3.95
NE558	1.50	LM4250	1.75
NE564	2.95	LM4500	3.25
LM565	.99	RC45580	.69
LM566	1.49	LM13600	1.49
		LM13700	1.45

H=TO-5 CAN, K=TO-3, T=TO-220

RCA

CA3023	2.75	CA3083	1.55
CA3039	1.29	CA3086	.80
CA3046	1.25	CA3089	2.99
CA3059	2.90	CA3096	3.49
CA3060	2.90	CA3130	1.30
CA3065	1.75	CA3140	1.15
CA3080	1.10	CA3146	1.85
CA3081	1.65	CA3160	1.19
CA3082	1.65	CA3183	.99

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75108	1.49	75453	.39
75110	1.95	75454	.39
75150	1.95	75491	.79
75154	1.95	75492	.79
75188	1.25	75493	.89
75189	1.25	75494	.89

BI FET

TL066	.99	LF347	2.19
TL071	.79	LF353	1.00
TL072	1.19	LF355	1.10
TL081	.79	LF356	1.10
TL082	1.19	LF357	1.40
TL083	1.19	LF411	1.29
TL084	2.19	LF412	1.99

TRANSISTORS

2N918	.50	2N3772	1.85
MPS918	.25	2N3903	.25
2N2102	.75	2N3904	.10
2N2218	.50	2N3906	.10
2N2218A	.50	2N4122	.25
2N2219	.50	2N4123	.25
2N2219A	.50	2N4249	.25
2N2222	.25	2N4304	.75
PN2222	.10	2N4401	.25
MPS2369	.25	2N4402	.25
2N2484	.25	2N4403	.25
2N2905	.50	2N4857	1.00
2N2907	.25	PN4916	.25
PN2907	1.25	2N5086	.25
2N3055	.79	PN5129	.25
3055T	.69	PN5139	.25
2N3393	.30	2N5209	.25
2N3414	.25	2N6028	.35
2N3563	.40	2N6043	1.75
2N3565	.40	2N6045	1.75
PN3565	.25	MPS-A05	.25
MPS3638	.25	MPS-A06	.25
MPS3640	.25	MPS-A13	.40
PN3643	.25	MPS-A55	.25
PN3644	.25	MPU-131	.99
MPS3704	.15	TIP29	.65
MPS3706	.15	TIP31	.79
		TIP32	.79

IC SOCKETS

	1-99	100
8 PIN ST	.13	.11
14 PIN ST	.15	.12
16 PIN ST	.17	.13
18 PIN ST	.20	.18
20 PIN ST	.29	.27
22 PIN ST	.30	.27
24 PIN ST	.30	.27
28 PIN ST	.40	.32
40 PIN ST	.49	.39
64 PIN ST	4.25	CALL

ST=SOLDERTAIL

8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80

WW=WIREWRAP

INTERFACE

8T26	1.59
8T28	1.98
8T95	.89
8T96	.89
8T97	.89
8T98	.89
DM8131	2.95
DP8304	2.29
DS8833	2.25
DS8835	1.99
DS8836	.99
DS8837	1.65
DS8838	1.30

INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	3.95
ICM7207A	5.59
ICM7208	15.95

DATA AQC

ADC0800	15.55
ADC0804	3.49
ADC0809	4.49
ADC0816	14.95
ADC0817	9.95
ADC0831	8.95
DAC0800	4.49
DAC0806	1.95
DAC0808	2.95
DAC1020	8.25
DAC1021	7.95
DAC1022	5.95
MC1408L6	1.95
MC1408L8	2.95

EXAR

XR2206	3.75
XR2207	3.75
XR2208	3.75
XR2211	5.25
XR2240	3.25

9000

9304	.95
9316	1.00
9328	1.49
9334	2.50
9368	3.95
9401	9.95
9601	.75
9602	1.50
9637	2.95
96S02	1.95

SOUND CHIPS

76477	3.95
76488	5.95
76489	8.95
SSI-263	39.95
AY3-8910	12.95
AY3-8912	12.95
MC3340	1.49
SP1000	39.00

OPTO-ISOLATORS

4N26	1.00	MCA-7	4.25
4N27	1.10	MCA-225	1.75
4N28	.65	IL-1	1.25
4N33	1.75	ILA-30	1.25
4N35	1.25	ILQ-74	2.75
4N37	1.25	H11C5	1.25
MCT-2	1.00	TIL-111	1.00
MCT-6	1.50	TIL-113	1.75

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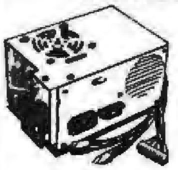

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-5V @ .5A
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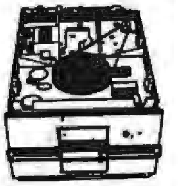

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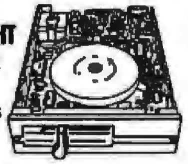

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- DS/DD
- INCLUDES INSTRUCTIONS

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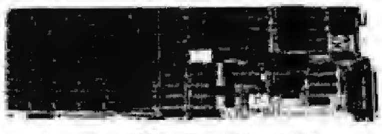
MAXIMIZER by SIGMA DESIGNS, INC.



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RS-232 Serial	2[2]	1
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Clock Calendar	YES	YES
Game Adaptor	OPTIONAL	OPTIONAL

[1] With Optional 128K MAXISTACK
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OPTIONS:

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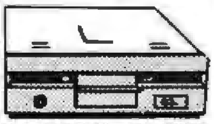

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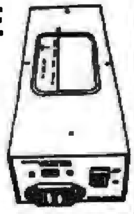

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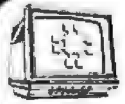

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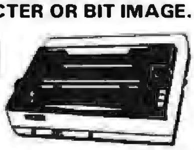
$249



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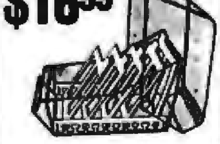

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NOTE: Please include sufficient amount for shipping on above items.

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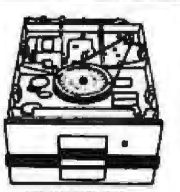
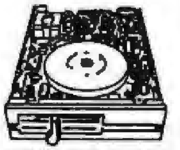

TANDON 5¼"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10	.50	4.40	.83	7.30
16	.55	4.80	1.00	8.80
20	.65	5.70	1.25	11.00
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40	1.32	11.60	1.92	16.80
50	1.38	12.10	2.50	22.00

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72 pin ST	6.95
72 pin WW	7.95
50 pin ST	4.95
44 pin ST	2.95
44 pin WW	4.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS								
		8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxx-ST	.99	.99	.99	1.69	1.89	1.89	1.99	2.49	2.99
COMPONENT CARRIERS (DIP HEADERS)	ICCxx	.65	.75	.85	1.00	1.25	1.25	1.35	1.50	2.10
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	—	1.45	1.65	—	—	—	2.50	—	4.15

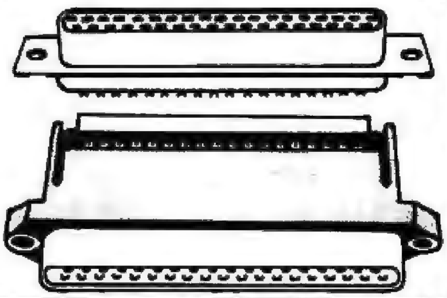
For order instructions see "IDC Connectors" below.

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS				
			9	15	25	37	50
SOLDER CUP	MALE	DPxxP	2.08	2.69	2.50	4.80	6.06
	FEMALE	DBxxS	2.66	3.63	3.25	7.11	9.24
RT. ANGLE PC SOLDER	MALE	DBxxPR	1.65	2.20	3.00	4.83	—
	FEMALE	DBxxSR	2.18	3.03	4.42	6.19	—
IDC RIBBON CABLE	MALE	IDBxxP	3.37	4.70	6.23	9.22	—
	FEMALE	IDBxxS	3.69	5.13	6.84	10.08	—
HOODS	BLACK	HOOD-B	—	—	1.25	—	—
	GREY	HOOD	1.60	1.60	1.25	2.95	3.50

MOUNTING HARDWARE - $1.00

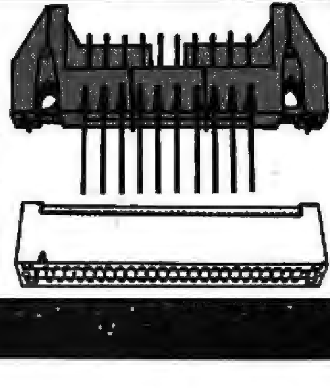
For order instructions see "IDC Connectors" below.



IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS					
		10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RT. ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RT. ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	1.15	1.86	2.43	3.15	3.73	4.65
RIBBON HEADER	IDMxx	—	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	2.25	2.36	2.65	3.25	3.80	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "xx" of the "order by" part number listed. EXAMPLE: A 10 pin right angle solder style header would be IDH 10 SR.



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WITH HUB RINGS

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	6V	10V	15V	20V	25V	35V
.22uf						.40
.27						.40
.33						.40
.47				.35		.50
.68						.45
1.0			.40	.40	.45	.45
1.5				.45		.50
1.8						.75
2.2		.35	.40	.45		.65
2.7		.40	.45			.90
3.3		.45	.50	.55	.60	.65
3.9			.45			
4.7	.45	.55		.60	.65	.65
6.8			.70		.75	
10	.55	.65	.80	.85	.90	1.00
12	.65		.65	.90		
15	.75	.85	.90			
18			1.25			
22		1.00	1.35			
27			2.25			
39		1.50				
47	1.35					
56	1.75					
100		3.25				
270	3.75					

DISC

10pf	50V	.05	470	50V	.05
22	50V	.05	560	50V	.05
25	50V	.05	680	50V	.05
27	50V	.05	820	50V	.05
33	50V	.05	.001uf	50V	.05
47	50V	.05	.0015	50V	.05
56	50V	.05	.0022	50V	.05
68	50V	.05	.005	50V	.05
82	50V	.05	.01	50V	.07
100	50V	.05	.02	50V	.07
220	50V	.05	.05	50V	.07
330	50V	.05	.1	12V	.10
			.1	50V	.12

MONOLITHIC

.1uf-mono	50V	.18	.47uf-mono	50V	.25
.047uf-mono	50V	.15	.01uf-mono	50V	.14

ELECTROLYTIC

RADIAL			AXIAL		
.47uf	50V	.14	1uf	50V	.14
1	25V	.14	4.7	16V	.14
2.2	35V	.15	10	16V	.14
4.7	50V	.15	10	50V	.16
10	50V	.15	22	16V	.14
47	35V	.18	47	50V	.20
100	16V	.18	100	15V	.20
220	35V	.20	100	35V	.25
470	25V	.30	150	25V	.25
2200	16V	.80	220	25V	.30
			330	16V	.40
			500	16V	.42
			1000	16V	.60
			1500	16V	.70
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MAN 74	.3"	CC	.99
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FND-500 (503)	.5"	CC	1.49
FND-507 (510)	.5"	CA	1.49
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NEEDED: Nonprofit organization seeks tax-deductible donations of disk-based computers and peripherals (Apple II, IBM PC, VIC-20) to teach computer technology and programming to economically disadvantaged students. American Philanthropy Association Inc., 101 Santa Barbara Plaza, Los Angeles, CA 90008, (213) 295-3707.

WANTED: Apple II or CP/M-compatible hardware for a financially distressed grade/high school seeking to expand computer training program. Will pay shipping and provide receipt for tax purposes. Yeshiva Achei Tmimim, 2408 Fifth Ave., Pittsburgh, PA 15213, (412) 681-2446.

WANTED: Small grade school seeks donation of Apple II+ or IIe to introduce small children to computers. Donation is tax deductible. Dick Stringham, St. Mary's School, 195th St., Mokena, IL 60448, (312) 479-2526.

WANTED: Tax-deductible donation of Commodore 64 computers and appropriate hardware accessories for Commodore 64 and TRS-80 for use in K–12 school system classroom activities and programming. W. David Turner, Superintendent, Mt. Morris Community Unit School, District #261, 401 South Fletcher, Mt. Morris, IL 61054, (815) 734-6032.

WANTED: Tax-deductible donation of computer, monitor, disk drives, and printer for nonprofit "rights of animals and those who protect them" group. B. J. Huffman, Robinwood, 8591 Kennard Rd., Lodi, OH 44254, (216) 948-4101.

WANTED: New England Sierra Club needs a computer for filing, accounting, mass mailing, and word processing. Two workstations, letter-quality printer, and modem needed. Tax-deductible contribution; we pay shipping. IBM compatibility preferred. Jonathan Driller, (617) 227-5339 or (617) 522-9239 evenings.

WANTED: Biologist needs donation of IBM or compatible computer for environmental water quality study. Goals are to improve supply, quality, and cost-effectiveness of present system. Resulting simulation software will become public domain. Grant Barkman, 2602 Edgar St., Regina, Saskatchewan S4N 3L7, Canada.

NEEDED: Near-bankrupt, nonprofit public-domain software group would appreciate CP/M-86 or MS-DOS business computer (Fujitsu, DEC Rainbow, TI Professional, etc.) for organization automation. Will pay shipping. Alex Gray, 922 West Duarte, Apt. 3, Arcadia, CA 91006.

WANTED: Apple computer for church to keep member mailing lists, personal information files, and bookkeeping. Donation is tax deductible and a letter of confirmation will be sent. St. James Baptist Church, c/o Stuart H. Brooks Jr., 1429 Briarcliff Ave., Charlottesville, VA 22903, (804) 979-0146.

WANTED: Missionary responsible for introduction of computer system (MC68000 multiuser micro with UNIX) in Christian publishing organization needs books (UNIX, C, DBMS, word processing, etc.) or magazines. Anything will help. Ingo Haake, Beth-Shalom, Caixa Postal 1688, 90000 Porto Alegre RS, Brazil.

NEEDED: I need help (including modems) to form the first international bulletin-board service in Europe. The Commodore 64 will be the first system. Contributors will come on line first. SFC C. P. Daniels, HQ 7th Medcom, Box #1, APO NY 09102.

NEEDED: Donated computer equipment for noncommercial, open-access RBBS/RCPM. Need 1200-bps modem, 8-inch disk drives, and computer. Prefer MITS Altair but can use any CP/M computer. Mark D. Pickerill, 80 Desmond Rd., Salinas, CA 93907.

WANTED: Computer engineer seeks donation of hardware to set up full-time, nonprofit bulletin-board service. Robert F. Foery Jr., 103 Smith-Monroe Hill, Charlottesville, VA 22904, (215) 436-0266.

NEEDED: Information on good statistical and other software packages available for the NCR Decision Mate V. Plan to purchase; need opinions on performance. J. E. Bangali, PEMSU, Ministry of Agriculture and Natural Resources, Freetown, Sierra Leone, West Africa.

WANTED: Tax-deductible donation of a computer system for nonprofit arts organization in Appalachian mountains. For use with mailing lists, accounting, word processing, graphics, and teaching youth. Will pay shipping. James Agee Film Project, 316 East Main St., Johnson City, TN 37601, (615) 926-8637.

WANTED: Small church needs computer for word processing and newsletter mailing-list maintenance. Donation is tax deductible. United Church of God, POB 45, Lake Winola, PA 18625, (717) 378-2056.

NEEDED: Nonprofit organization researching schizophrenia and drug abuse needs donation of computer, disk drives, printer, and information on computer diagnosis systems. Stephen Resch, PSR Research Group, 651 Lakecrest Dr., Menasha, WI 54952, (414) 722-9626.

NEEDED: New York scriptwriter requests advice on using WordStar to write and edit scripts. Gary Apple, 165 West 47th St., New York, NY 10036, (212) 787-8741.

WANTED: A used printer for a VIC-20. I will pay for shipping and will accept almost any reasonable offer. Brett Greenberg, POB 1553-VHFS, Warrenton, VA 22186, (703) 754-8621 weekends or evenings.

FOR SALE: Micromation chassis, IMSAI chassis, IMSAI SIO board, four PTC 3P+S I/O boards, four S-100 32K memory boards, two IMS PIO boards, two INFO 2000 adapter boards, Dynabyte Naked Terminal board. Exercisor and parts for PerSci floppy-disk drive, two digital voltmeters, and Educassette data recorder. For prices send SASE. John Freeman, 855 West 1800 North Place, Grove, UT 84062.

WANTED: Information on laser, artificial intelligence, and holography. Donald Sutherland, C-60410/N-162-L, POB 2000, Vacaville, CA 95696.

WANTED: People interested in joining a Televideo users group for the East Coast. Jon Cohen, 115 Country Club Place, Cherry Hill, NJ 08003.

FOR SALE: CDR FDC 880H 5¼- and 8-inch disk controller with dual board modification kit and Livingston Logic Labs CDR BIOS. Best offer or trade. Jim Cunningham, 1563 Van Wyck Rd., Bellingham, WA 98226, (206) 733-8820 evenings.

FOR SALE: Netronics Explorer-85 with 4K RAM, six-slot S-100 card cage, RS-232C, cassette interface, and power supply: $400. Netronics terminal: 64 by 16, RS-232C, case, cable: $150. S-100 64K dynamic RAM board: $225. All three: $650. Cassette deck with power supply and cables: $50. Sanyo 12-inch monitor: $75. Richard J. Havanec, 575 Sedgewick Ave., Stratford, CT 06497, (203) 377-4080 evenings.

FOR SALE: Two Std-Bus Z80 systems: each has Mostek MDX-CPU-11 Z80 board, MDX-SIO board, and prolog #7702 2716 EPROM card (16K). One system with monitor and keyboard. Excellent working order with documentation: $500 firm. Larry Stack, 9037 Stack Rd., Colfax, NC 27235, (919) 993-5828.

FOR SALE: ERG-68000 System II with 24-megabyte 8-inch Winchester disk, DMA controller, 10-MHz CPU, eight serial I/O lines, and 18-slot solid card cage with 30-amp power supply. Like new. Original cost $13,000; asking $8000 or best offer. Mitch Bogart, 268 Foster St., Brighton, MA 02135, (617) 890-8558 days, (617) 782-5789 evenings.

FREE: Information about public-domain software and a directory of users groups for the Commodore 64. Dallas Computer Club, C-64, 2914 Poplar Trail, Garland, TX 75042.

FOR SALE: S-100, Z80 microcomputer, 48K single Micropolis Model II drive, with Amdek 100 monitor and Centronics 779 printer: $950. Atari 800 bare boards: $50. TI 59: $50. Pat Fitzgibbons, 235 East Viking Dr., #355, St. Paul, MN 55117, (612) 481-9296, 5–6 or 10–11 p.m.

WANTED: Information on 3-bit red and white plastic computer circa 1968, that programmed with different lengths of drinking straws and ran programs as fast as you could cycle the clock lever by hand. It also played NIM and did binary arithmetic. David Dubowski, Q9 Estes Park, POB 3318, Chapel Hill, NC 27515-3318.

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FOR SALE: H-11A computer. Compatible with DEC PDP-11/03. Serial and parallel interfaces, extended arithmetic chip, 32K bytes. Manuals and relevant Heath Users Group Remarks. Will consider trade for $3000 value, but prefer cash offer. John Potter, RR 5, Eganville, Ontario K0J 1T0, Canada, (613) 625-2137.

FOR SALE: TRS-80 Model I with 48K expansion interface, monitor, external disk drive, RS-232, voice synthesizer, quick printer II, cassette recorder, all cables, and reference literature. Fully operational: $950. Joseph J. Cappello, Eagle Valley Rd., Sloatsburg, NY 10974, (914) 753-5536 after 7 p.m.

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FOR SALE: Godbout desktop S-100 enclosure with 20-slot motherboard, CPU-Z 6-MHz Z80 card, one DMA floppy-disk controller, two RAM 20 boards, Interfacer 2, memory-mapped video board, dual Shugart 801Rs with power supply, monitor, and keyboard: $3000 or best offer. Bjorn Helgaas, RR 2, Luverne, MN 56156, (507) 283-4751.

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FOR SALE: HP Series 80 package. Includes HP-87A: $990. HP9121: $990. Both for $1800. HP-86A: $850. Three Epson IEEE-488 adapters: $50 ea. Many accessory modules, ROMs, and supplies: 50–75 percent off list or best offer. Don Person, Box 3103, Albany, NY 12203, (518) 482-9023.

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THE PICK OF THE CROP

Readers selected the review of "The Macintosh" for the top spot in the August tally. Bruce F. Webster will be sent the $100 bonus because he reviewed the Mac prior to his appointment as a Contributing Editor. Jerry Pournelle's variety of reflections, obtained "Between Conventions" while Computing at Chaos Manor, wins second mention. In third place is the renowned Niklaus Wirth, who wins $50 for "History and Goals of Modula-2." Steven Hendrix's "The 65816 Microprocessor, Part 1: Software" about the successor to the 6502 takes fourth place. And in fifth place is the BYTE West Coast interview conducted by editors John Markoff and Ezra Shapiro, "Macintosh's Other Designers."

BIG BLUE BOMB RESULTS

The results for the *BYTE Guide to the IBM Personal Computers* are in as well. First place and a c-note go to Stephen S. Fried for "Evaluating 8087 Performance on the IBM PC." William J. Claff's "An Introduction to PC Assembly-Language Programming" takes second place and $50. "Modems: The Next Generation" by Mark Klein wins third place. BYTE congratulates all these writers.

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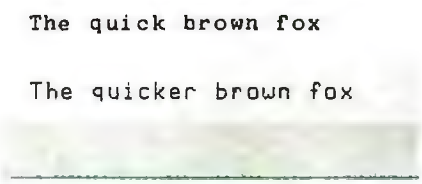

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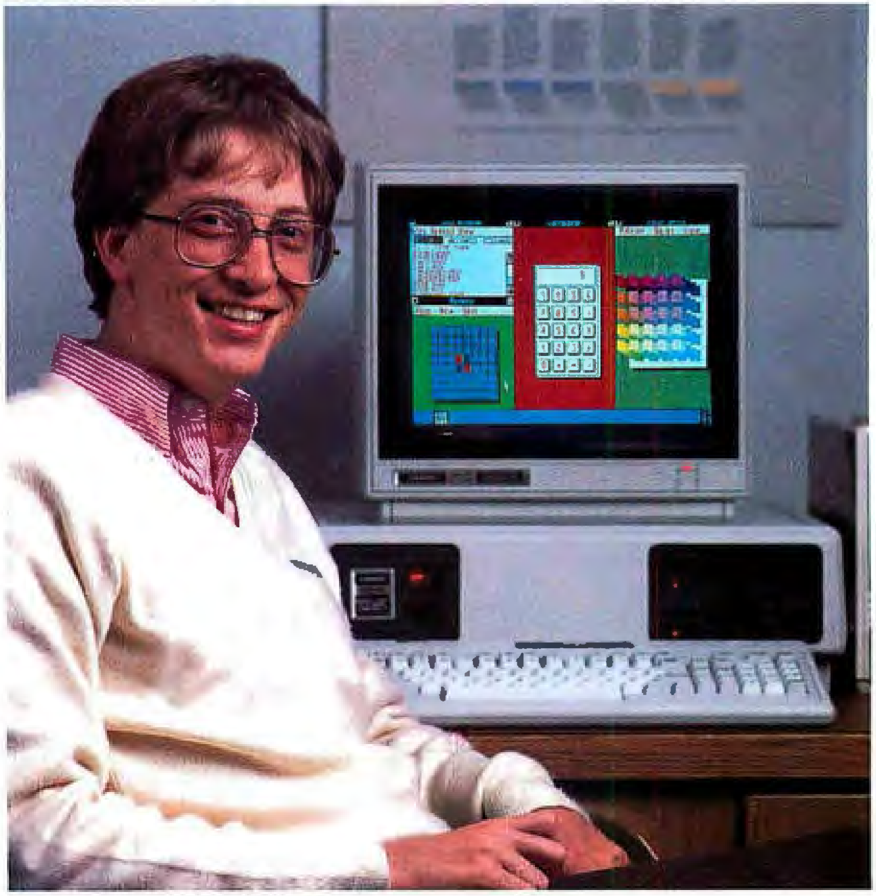

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