PORTABLE COMPUTERS IN DEPTH

- Pied Piper
- Corona
- HP-75
- TI Compact
- Access
- How to Buy Wisely

Report from Japan

Jerry Pournelle on The Next Five Years

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The FAA and Portables

Lawrence J. Curran, Editor in Chief

The next time you use your portable computer on a commercial airliner, the flight attendant may eye you with some interest, and it won't be because you've switched to an after-shave lotion that has made you suddenly more attractive. The attendant's interest will stem from the fact that Federal Aviation Administration regulations prohibit the use of portable computers on commercial airliners, and it's the flight attendant's duty to seek compliance with that regulation. The use of portable computers is also banned on private aircraft unless the operator—the pilot—has determined that use of the machine will not interfere with the safe operation of the plane's navigation or communications equipment.

Section 91.19 of Federal Aviation Regulations outlaws the use of all but a few portable electronic devices aboard a commercial airliner or other aircraft flying under instrument flight rules because there's a risk that electromagnetic interference (EMI) from the device could hamper reception of navigation and communications signals, jeopardizing the safe operation of the plane. The only exceptions allow the use of heart pacemakers, hearing aids, tape recorders, and electric shavers in flight. If the regulation were strictly enforced, even electronic watches and hand-held calculators would be outlawed.

But the regulation isn't strictly enforced; it would be impossible to expect flight attendants or private pilots to enforce it. The FAA wants the airlines and private pilots to enforce the rule, but the airlines are especially chary of enforcing a regulation that may drive passengers away.

Bill Walters, product line manager for Radio Shack's TRS-80 Models 4 and 100 (portable), has some thoughts on the issue. He compares the FAA's position on EMI from portable electronic devices to that of the Federal Communications Commission on EMI from home computers interfering with television signal reception six years ago. Walters, a former commercial airline pilot, believes the FAA should establish an EMI standard with which all makers of portable electronic devices would have to comply, just as the FCC did in the case of home computers. We agree.

In order to gain certification to use electronic devices on aircraft under the current regulation, the device manufacturer would be required to demonstrate that use of the device does not interfere with the navigation and communications equipment on every type of aircraft that every airline uses. The cost of such testing to the device manufacturer would be prohibitive.

Walters says it's time for the FAA to establish and enforce an emission standard and bandwidth guidelines governing portable electronic devices. Certainly some reasonable test procedures can be established that would allow portable computers to be certified for safe operation aboard aircraft that wouldn't also bankrupt the FAA to administer.

Or perhaps there's a simpler alternative that would not require testing of any kind. No smoking is permitted aboard aircraft at takeoff and landing times to lessen the chance of fire in case of an accident. Warning signs and flight attendants alert passengers to this short-term smoking ban. Perhaps the use of portable computers could be banned for similar periods and in a similar manner when their use would be most likely to interfere with aircraft instrument landing systems. It's worth considering.

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The system builder's best choice for color graphics is a CSS000 color system from SCION. Its basic component is MicroAngelo, the single board graphics display computer that has revolutionized monochrome display capability with low cost 512x480 pixel graphics resolution and 40 line by 85 character text capacity.

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MicroAngelo based color graphics systems are easy to use. Just plug the boards into your Multibus or S-100 host. Or use the freestanding work station configuration with its RS-232 interface. In each case, you get high resolution color graphics for such a low price you can't afford to design your own.

Think SCION for your graphics display needs. Think MicroAngelo. Call us at (703) 476-6100.
CONVERGENT TECHNOLOGIES INTRODUCES A NOTEBOOK-SIZE COMPUTER

Convergent Technologies, Santa Clara, CA, has introduced a portable computer that measures 8 1/2 by 11 by 1 inches and weighs 3 pounds. The Convergent Workslate uses a 6303 processor—the CMOS version of the Motorola 6800—and comes equipped with 16K bytes of RAM and 64K bytes of ROM, including a ROM-based spreadsheet and datebook software. A microcassette drive, a speaker phone, a 300-bps modem, and a 15-line by 46-character liquid-crystal display are built-in features. The Workslate will be available through American Express in September for $895.

DATA GENERAL UNVEILS A MULTIUSER MICROCOMPUTER

Data General, Westboro, MA, has announced a 16-bit microcomputer that includes both an Intel 8086 and a Data General Microeclipse processor. The Desktop Generation Model 10 can use CP/M-86, MS-DOS, or Data General's RDOS or AOS operating system. It also can run different operating systems simultaneously in a multiuser configuration. A single-user system with 128K bytes of memory, a single 5 1/4-inch floppy-disk drive, and either MS-DOS or CP/M-86 costs $3265. A four-user version with 256K, a 15-megabyte hard-disk drive, three terminals, and RDOS and CP/M-86 sells for $10,960.

LEADING EDGE PRODUCTS ANNOUNCES A COLOR WORD PROCESSOR FOR THE IBM PC

Leading Edge Products, Needham Heights, MA, has announced its first internally developed product, a $300 color word processor for the IBM PC. Featuring an extensive help facility, a user-definable glossary to store any series of keystrokes, and the ability to restore deleted or overwritten text, the word processor will be the basis for an integrated package to be released later this year. The package will include spreadsheet, graphics, database-management, and spelling-checker capabilities.

DOCUTEL/OLIVETTI SHOWS AN INK-JET PRINTER, UPGRADES M20 COMPUTER

Docutel/Olivetti Corp., Dallas, TX, has introduced an ink-jet printer for $549. The PR2300 uses a single-jet replaceable printing head and either a Centronics parallel or an RS-232C serial interface. Docutel/Olivetti has also added an 8086 processor to its 8001-based M20 computer. The M20 BP with two floppy-disk drives and 128K bytes of RAM will sell for $3295. An 8086 expansion board for the standard M20 will cost $395.

BALLOCNES, STRATEGIC TECHNOLOGIES, OTRONA PREPARE 16-BIT PORTABLES

Balcones Computer Corp., Austin, TX, is at work on a portable computer based on the Xerox 820 8/16 computer. The Xport will include an 8-bit Z80 with 64K bytes of RAM and a 16-bit 8086 with a separate 128K-byte RAM (expandable to 256 or 512K). The two processors will run concurrently; the Z80 runs CP/M-80, and the 8086 runs MS-DOS 2.0. The system, which will probably only be available with one 3 1/2-inch hard-disk drive and one 5 1/4-inch floppy-disk drive, may cost as little as $3000. Strategic Technologies, Norcross, GA, is preparing a portable computer with a full-size plasma display. The PC Traveler will come in a briefcase measuring 14 by 19 by 6 inches and weigh less than 28 pounds. It will include an Amlyn 5-disk cartridge drive, a built-in full-size dot-matrix printer, dual 80186 processors, 128K bytes of RAM, an 80-character by 25-line gas-plasma display, and a bundled software package. The PC Traveler will sell for less than $5000 starting in November. Otrona Advanced Systems Corp., Boulder, CO, has introduced a dual-processor version of its portable computer. The Attaché 8:16 includes an 8-bit Z80A and a 16-bit 8086 processor, the CP/M 2.2 and MS-DOS operating systems, two floppy-disk drives, and an IBM-compatible display format for $3795. An upgrade board to convert an Attaché to an Attaché 8:16 will cost $1495.

RADIO SHACK AND SHARP INTRODUCE NEW POCKET COMPUTERS

Radio Shack's newest pocket computer, the PC-3, fits into a shirt pocket and can run programs written for the PC-1. Weighing in at 4 ounces, the PC-3 has 1.4K bytes of memory and a 24-character liquid-crystal display for $99.95. A PC-3 interface and recorder and a PC-3 printer/cassette interface each cost $119.95. Sharp Electronics Corp., Paramus, NJ, has introduced a nearly identical computer, the PC-1250, for $110. The PC-1250 measures 5-5/16 by 2 1/2 by 3/8 inches.
**MICROBYTES**

**Texas Instruments Releases Dow Jones Natural Language Interface, Dot-Matrix Printer**

Texas Instruments' new Dow Jones Natural Language interface for its Professional computer enables users to request information in "plain English," translating requests into Dow Jones' command format. The $130 package includes a $50 account fee and an hour on the Dow Jones News/Retrieval service. Texas Instruments is also expected to announce its Omni 800 Model 855 dot-matrix printer. Using a 32 by 18 printing head, the printer will include graphics capabilities and selectable fonts for under $1000.

**Micros Gain More Attention at Siggraph**

Microcomputers received increased attention from vendors showing new products at the Siggraph convention in Detroit. Micro-based products announced at the show included a graphics board for the IBM PC from Number Nine Computer Engineering Inc., Hartford, CT, for less than $1200. The board, which NNCE plans to begin shipping late in the third quarter, is based on an NEC 7270 VLSI graphics display controller. The company has been shipping a similar board for the Apple for several months. 3Design, Seattle, WA, announced an optional Wordstar interface for its graphics card for the IBM PC. The interface lets users mix Wordstar-generated text and graphics. The basic graphics card, which costs $250 and requires 128K bytes of memory in the PC, enables users to create designs, then rotate, translate, and scale them independently or in reconfigurable groups, relative to any coordinate in the system. Cubicomp Corp., Berkeley, CA, displayed its CS-5 graphics system for three-dimensional solids modeling. The under-$9000 system, which includes an interface adapter and a CS-5 graphics module, requires an IBM PC with at least 320K bytes of RAM and a high-resolution RGB monitor with long-persistence phosphors. The software runs under IBM PC-DOS. Precision Visuals, Boulder, CO, announced that it will support NAPLPS videotex standards in its DI-3000 graphics software.

**Nanobytes**

Zilog has announced the Z80000, a 32-bit microprocessor chip that is compatible with the 16-bit Z8000. Featuring a 256-byte on-chip cache, instruction pipelining, and memory management, the Z80000 can run at 10 to 25 MHz. It should be available in late 1984 for $150 in 1000-unit lots. Silicon, the basic material in microprocessors and memory chips, may be in short supply later this year if semiconductor companies fail to plan now for future needs, warns Monsanto Electronic Materials Co., Palo Alto, CA. The company bases its prediction on trends in the economy and the semiconductor industry and on the sustained increase in orders for semiconductor products. Monsanto is the leading supplier of single-crystal CZ silicon, the primary ingredient of semiconductor devices. Hewlett-Packard, Palo Alto, CA, has introduced a new 6-pen graphics plotter, the HP 7475A, for $1895. The company has dropped the list price of the HP 7470A 30 percent from $1575 to $1095. Olympia USA Inc., Somerville, NJ, has introduced the People computer, which includes both CP/M-86 and MS-DOS and two floppy-disk drives for $3595. Concurrent CP/M-86 is also available. American Bell has unveiled a videotex terminal to be sold through Bell Phone Center Stores. The terminal, which includes a 1200-bps modem and keyboard, connects to a standard television. As part of a videotex program in southern Florida, the terminals will sell for $600 there; elsewhere, they will sell for $900. Coin-operated computer terminals with attached printers are being marketed by Data and Research Technology Corp. (Pittsburgh, PA) in an effort to become "the McDonald's of information." Users with valid accounts can access local nodes of such popular networks as Compuserve, the Source, and Dow Jones for $1 for 3 minutes. The company hopes to have terminals in 50 cities by the end of the year. Tandy, parent of Radio Shack, says its preliminary sales figures for the year ending June 30 were $2,472,484,000, up 22 percent from fiscal 1982. Microsoft's MS-DOS operating system is now being supported on Digital Equipment Corp.'s Rainbow 100 and Fujitsu's Micro 16s. Corvus Systems Inc. has lowered the prices of its Concept personal workstations to $3995 for the 256K-byte version and $4695 for the 512K-byte model. The American Society of Interior Designers, New York, NY, has introduced a hardware-software package for interior designers, architects, and space planners. Based on a Victor Technologies 8/16-bit computer, the package includes drafting, accounting, word-processing and mailing-list software. Priced under $10,000, it includes training for end users and a hot-line query service. Apple Computer Inc. announced that the one millionth Apple computer was produced in June. The British-designed Dragon computer (January 1983 BYTE, p. 46) is being manufactured and sold in the U.S. by Tano Corp. (New Orleans, LA). For $399, the machine includes 64K bytes of RAM, sound, 256 by 192 color graphics, and Extended Microsoft BASIC.
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Letters

Multiplying without Zero

Multiplication by doubling and halving ("Novel Methods of Integer Multiplication and Division," June, p. 364) is discussed by Karl Menninger in his excellent book, Number Words and Number Symbols (MIT Press, 1969). Menninger credits the Egyptians with the invention of the algorithm.

Multiplication and division are difficult in any number system that does not have a zero, such as Roman numerals. The Romans bypassed the problem by doubling and halving on a counting board.

Joseph J. Brigham
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Bug-Free But Meaningless

Those seeking a textbook illustration of the dictum "garbage in, garbage out" need look no further than John Merrill's article ("Regression Fitting to Economic Indexes," May, p. 474). The author presents a lovely piece of code, perfectly logical and internally consistent, which nonetheless produces completely meaningless output because it is based on the fallacy that holds that economic data can be treated in the same way as a continuous function in mathematics—i.e., that it can be analyzed by the methods of calculus.

The reasoning that refutes this fallacy is quite straightforward and need not be rehashed here. Rothbard, among others, has argued persuasively against the notion that it is possible to treat market phenomena in terms of "infinitely small" differences (Man, Economy, and State, Van Nostrand, 1962, p. 440n). Intuitively, it should be clear that economic data, by its very nature, is discrete because it is ultimately resolvable into individual decisions to buy or not to buy, and the buying population is finite. (It does not help to argue that the population is large enough to "approximate" infinity because the market for any given good at any given time cannot be predicted in advance and may in fact consist of only a handful of people.)

Even if we concede that it is sometimes permissible, for the sake of simplicity, to work with smoothed-out supply and demand curves, it makes no sense at all to maintain that an "underlying rate of inflation" can somehow be measured by cataloging the history of prices. Such a measurement, if it could be made at all, would have to be derived from money-supply figures. The econometricians claim to be able to use the methods of statistics in order to "fit" Consumer Price Index data to a smooth logarithmic curve and then to be able to "see" the effects of the Viet Nam war in the result!

Even if the CPI were accurate and consistent (and it's neither), so many variables go into determining a market's equilibrium price that you might just as well claim you can "see" the next president's face in a lump of soggy tea leaves.

The moral for programmers is that our work can be logical, consistent, and bug-free, yet still produce meaningless results. If seemingly plausible, these results may mislead vast numbers of people, particularly when the government has involved itself in the matter. I have no fear of 10 million machine-readable files in private hands, but when the state uses its coercive authority to collect even one small database, I tremble. The issue for society is compulsion, not computerization.

G. M. Harding
FOB 7556
Carmel, CA 93921

Kudos for the Model 100

The warts to which Rich Malloy alluded ("Little Big Computer: The TRS-80 Model 100 Computer," May, p. 14) are, in fact, beauty marks! I'm a 25-year veteran of the computer field who cut his teeth on tubes and drum memory, but the bubble hasn't burst even after the first two weeks of 22-hour days of reveling in the delights of the Model 100. The designers seem to have been blessed with a Midas touch that has enabled them to turn what initially seem like drawbacks into delightful and surprising assets.

I've yet to see a criticism of the Model 100 that doesn't wither under close scrutiny. Malloy's review is the best in-depth effort I've seen so far. My only query is about the surprise of the author regarding the individual who put an $800 deposit on one the day he read
With all the clamor about personal computers, a fundamental fact is often overlooked: some simply work better than others.

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There are programs for making charts and programs for communicating with other computers.

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Letters

about it. I went out and bought 12! I now do all my correspondence with it, keep office records on it, relish the sounds of my text-to-voice synthesizer, and enjoy threatening the wags and critics with my bar-code reader wand. I estimate that I will recoup the cost of the machines within a few months.

Radio Shack has caught at least one customer hook, line, and sinker.

R. E. Cassidy
DC Consultants
38 Riddell St.
Woodstock, Ontario
Canada

Eek: Another Mouse?

I am sorry to see Apple, Visicorp, and possibly Microsoft jump onto the Xerox bandwagon and introduce a mouse into their new integrated computing software. The mouse is an inherently bad pointing device for at least three reasons: it consumes one to two square feet of flat desk space; it requires users to move their hands one to two feet from the keyboard in order to point at a screen object; and, because the mouse is not in a fixed place relative to the keyboard, users must look away from their work to find the mouse whenever it is to be used.

A much better solution to the problem of efficiently pointing at the screen is to use a trackball device located just below the space bar of the keyboard. This requires only four square inches of space, allows users to keep their fingers on the home keys of the keyboard during use, and does not require users to divert their eyes from the work. Trackballs are not more expensive than mice when both are manufactured in quantity.

Henry Hoeksma
112 Minota Hagey Res.
University of Waterloo
Canada

The Price Is Wrong

I was very excited by the article by Larry Sarisky, president of Syquest Technology, on the company’s removable media hard-disk drive (“Will Removable Hard Disks Replace the Floppy?” March, p. 110). Too bad the prices quoted in the article don’t come close to the actual figures on the price list Syquest sent me. (Unless, of course, I buy 50 or more units.

Do your readers often buy 50 or more units when purchasing hard-disk drives?)

The article said “3.9-inch drives cost less than $800, the 3.9-inch (cartridge) about $35.” Also, “The drive costs only slightly more than a floppy-disk drive. The cost of a cartridge is comparable to the cost of a box of 10 floppy disks.”

The price list that I was sent quotes the price of the removable media drive and cartridge in quantities less than 10 as $995 for a drive and $70 for a cartridge. Please be more sensitive to such exaggerated claims in the future.

K. S. Scriba
4602 Alpine
Enid, OK 73701

Larry Sarisky replies:

At the time my article was submitted, our pricing was $800 for either the SQ306R or SQ306F disk drive. The Q-Pak cartridge was $35. Recent cost increases in material and manpower resulted in a price increase on the SQ306R and Q-Pak. To quote all of our existing customers and prospects who have signed up to the slightly higher prices, “It is still the best deal around.”

I am sorry for any inconvenience this may have caused you.

Make Mine Modula-2

“Modula-2: A Worthy Successor to Pascal” by Joel McCormack and Richard Gleaves (April, p. 385) is by far the best exposition to date on Modula-2. However, the subtitle of the article might have read “And a Worthy Competitor to Ada.” Clearly, Modula-2 could give Ada a run for the money, if only the Modula Research Institute had a tenth of the funds the Department of Defense (DOD) has allocated for Ada promotion.

In Earl McCoy’s “Strongly Typed Languages,” (May, p. 418) he says that Ada “is expected to attain wide use in both civilian and military applications.” Obviously, the many firms and organizations on the military “gravy train” will indeed use Ada because it is being forced upon them. Civilian applications, however, are a different matter. Ada has not established its superiority to even extended Pascal, let alone Modula-2. It is a nightmare for compiler writers and is clearly top-heavy with complex features, whereas Modula-2 is a simpler and much more readable systems programming lan-
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And compared to conventional multi-user systems, our CompuStar systems can give you many more hours of productive labor every day—because, instead of depending on a central processor for data manipulation, each workstation in a CompuStar network has its own processor and its own 64 kbytes of ram.

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Letters

Perhaps it would be useful to follow the
text of David Packard, founder of
Hewlett-Packard. Having witnessed the
DOD as an insider (he held the title of
Deputy Secretary of Defense), he later
ran H-P on the principle that it should
stay as far away from military business
as possible. Maybe he knew something
we all should know.

Luckily, the nonmilitary option is avail­
able, and it happens to embody the best
elements for successful systems
implementations.

Lee Scott Jacobson
Bebo White
1440 Catalina St.
San Leandro, CA 94577

Wanted: a Conversion Program

I find myself viewing the advent of
16-bit personal computers with mixed
emotions.

Having purchased an 8-bit personal
computer some years ago, I have in­
vested considerable time and money in
software for the 6502 MPU. A good deal
of this investment was expensive “un­
copyable” business and business-related
programs.

My initial reaction of elation for the
IBM PC quickly disappeared when I real­
ized the limited software available at that
time and the inability to convert my ex­
isting software to the new OS/DOS used
by that machine. Despite the relatively
low cost of the IBM PC and its obvious
advantages, I was discouraged from pur­
chasing it due to the tremendous expense
in time and money to convert my existing
software to the new system.

As other newer MPUs and machines
are released to the general market with
expanded capabilities, the companies
who published their proprietary pro­
grams push their early supporters to
either repurchase the same software (if
it exists) to upgrade to a new system or
simply to make do with a smaller, less ef­
ficient system.

The personal computer industry takes
justifiable pride in the tremendous strides
it has made toward industrial standards,
while the software industry struggles
mightily to maintain parity (no pun in­
tended). The introduction of new MPUs
results in new OS/DOS systems—CP/M,
CP/M-86, Concurrent CP/M, CP/NET,
Unix, Xenix, and the UCSD p-System, to
name a few. While some of these are
cross-translatable and others can be used
on a variety of MPUs, some tremendous­
ly brilliant software is compatible with
only one or two systems. No sys­
tem = no software.

Now, I’m no expert, and it may be that
an inexpensive conversion program
exists, but I haven’t seen it advertised at
any price. On the other hand, if a trans­
lator doesn’t exist, someone stands to
make a fortune on a single program
series.

A small business or serious hobbyist
simply cannot afford to repurchase or
retype numerous programs after expend­
ing the necessary capital to purchase a
new machine. Therefore he either
decides to purchase the machine or
resorts to writing his own programs—
bugs and all. Either way, one portion of
the industry suffers.

It may be poor form to discuss price,
but for me at least, cost-effectiveness is
of paramount importance. If I want to
purchase $8000 to $10,000 worth of equip­
ment and then be forced to repurchase
a similar dollar value of software that I
already own, cost-effectiveness ceases to
exist.

John Winney
8326 228th St. SW
Edmonds, WA 98020

Corrected CASE Structure
for Fig-FORTH

Your August 1980 issue featured several
excellent articles on FORTH. Since that
time, the issue appears to have become
b门前 diversity for individuals and companies
as more and more attention is paid to
FORTH. Peopleware Systems specializes
in FORTH products, and we have re­
ceived inquiries about the Miller and
Miller article, “Breakforth into FORTH;”
(p. 50).

An example on page 180 has a subtle
bug. The example as it appeared in
essence is as follows:

```plaintext
: CASE <BUILDS SMUDGE] DOES>
SWAP 2 * + @EXECUTE ;
: OPET " AARDVARK " ; : 1PET
" BEAVER " ; : 2PET
" COUGAR " ;
CASE: ANIMAL OPET 1PET 2PET ;
```  

where 1 ANIMAL will print BEAVER,
With UltraTerm, the revolutionary new card from Videx, you’ll enjoy sweeping panoramas of spreadsheets that you’ve never seen before: 128 columns by 12 lines, 192 columns by 24 lines and even 160 columns by 34 lines. You’ll revel in the scenery of a whole year of records stretching out across your screen.
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etc.

The problem revolves around terminating the list of cases after CASE: (OPET 1PET 2PET) with { ; }.

The function of the terminator is to reset STATE to 0, which indicates execution mode. While { ; } does this, it also does some other things in fig systems... it toggles the SMUDGE bit, and hence the need for SMUDGE in the <BUILDS clause in the definition of CASE:. { ; } also executes ?CSP, and here lies the bug.

If the above example is keyed in as shown, it will work as expected. However, if the stack is altered after defining 2PET but before defining ANIMAL by putting a number on the stack, the ?CSP test will fail, giving an error message #14, "definition not finished."

If { [ } is used to terminate the list of cases, no ?CSP test will be performed, and the problem will be eliminated. If this is done, SMUDGE should be omitted from the definition of CASE:

Better yet, a synonym for { [ } can be defined to terminate the list of cases:

```
: ENDCASE [COMPIL] { ; IMMEDIATE
```

Note that { [ ] is IMMEDIATE and, therefore, requires the use of [COMPILE]; note also that ENDCASE must be IMMEDIATE.

This bug can show up if CASE: is made part of your FORTH kernel. Thus, if you boot your FORTH system after turning power on and the first definition uses CASE: to define a word, CSP will contain garbage, and the ?CSP error will result. Our P-FORTH card automatically saves compiled FORTH code in non-volatile EEROM, which makes this bug more likely to appear.

The correct example would then be:

```
: CASE: <BUILDS] DOES> SWAP 2
    * @ EXECUTE ;
    : ENDCASE [COMPIL] { ; IMMEDIATE
    : OPET ." AARDVARK" ; : 1PET
                ." BEAVER" ; "COUGAR" ;
    : CASE: ANIMAL OPET 1PET 2PET
    ENDCASE
```

Note the definition of CASE: is a fairly advanced FORTH topic, but the use of CASE: is very simple.

Fred Olson
Peopleware Systems Inc.
5190 West 76th St.
Minneapolis, MN 55435

---

**Coding between the Lines**

I was considering buying the Apple Logo for my children until I read Gary Drescher's letter (March, p. 20). I have no intention of paying for the advertising of his favorite cause or anybody else's. I wonder what he would think if, for example, his or his friend's child received a FORTRAN compiler error message such as "Evolution stinks." Would he send the ACLU to the rescue or recognize the rights of anti-evolutionists to resist? Certainly, in a democratic society there are less sneaky ways of exercising one's rights to differ from and/or resist prevailing public opinions.

George Jerinic
7 Robinwood Rd.
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Build the Micro D-Cam Solid-State Video Camera

Part 1: The IS32 Optic RAM and the Micro D-Cam Hardware

by Steve Ciarcia
A 64K-bit dynamic RAM chip is the visual sensor in this digital image camera

If you've followed the activities in the Circuit Cellar for any period of time, you have probably realized that my writing a monthly column is just an excuse to investigate and experiment with whatever I find currently fascinating. One of my lifetime fascinations has been the input of visual data to a computer. While I've presented interfaces that allow computers to determine direction and measure distances, receive a variety of sensory inputs via touch or remote signal, and even speak their minds through voice synthesis, until now I have not presented a project that enables a computer to see.

There was a time when most computers communicated via klunky teletypes at 10 characters per second. Improving output technology—high-speed video graphics displays, dot-matrix printers, and voice synthesis—has vastly improved the computer's ability to communicate results and conclusions to its user. Except in specialized applications, however, input technology has been discouragingly static. We still plod along using keyboards or mice as the primary input device even when the input data may be graphical.

So much of our existence involves visual recognition that it only stands to reason that the potential applications of computers would be enhanced if a versatile sensory-input channel were available to the machines. Then, instead of spending hours entering digital coordinates from a picture or map into a computer using a keyboard, you could easily use a "computerized camera" to make a visual snapshot of the material, instantly producing a digitized picture. Once you had such a picture in the computer, it could be interpreted, enhanced, or stored as the application might dictate.

Photo 1: In this prototype, the Optic RAM is mounted inside a light-tight box with a C-mount lens focusing light onto one of its cell arrays. The ribbon cable leads straight from the Optic RAM to the interface card in the Apple.

Computers and Vidicon Cameras

Computerized-image cameras are not new, but up to now they have always been too expensive for widespread practical use and casual experimentation. Most of the computer image-input devices currently available use a conventional black-and-white television camera as the image sensor. The camera's video output must be converted to digital logic levels for the computer: a difficult task, because the output, produced using a Vidicon-type pickup tube, is a high-frequency analog signal divided into 30 complete frames of picture information transmitted and scanned each second (or 25 frames for most TV systems outside North America).

Most high-quality TV-camera interfaces convert the analog signal for computer processing through "frame grabbing," in which one of the frames is sampled, digitized, and stored during a 1/30-second frame-scan interval. In these sophisticated visual sensing systems, a high-speed A/D (analog-to-digital) converter digitizes the analog signal in real time at sampling rates exceeding 5 megahertz (MHz) and stores the PCM (pulse-code modulated) data in a high-speed buffer made of semiconductor memory. Because they operate so fast, such units are insensitive to camera motion and fast scene changes.

In less sophisticated TV-camera interfaces, the designer has assumed that the camera and the object in its view will remain still long enough for the picture to be processed by slower, cheaper circuitry. When the TV picture is stationary, all frames in the signal are identical, so a sequential line-sampling technique is often employed. In units of this type, a low-speed A/D converter (sampling from 100,000 to 1,000,000 times per second) operates in bursts of activity shorter than a frame interval, with each successive period of activity, or sampling window, triggered at a slightly later time during the frame interval by line and pixel (picture element) position counters. In between the sampling windows, the support circuitry has time to store the digitized information and get ready for the next burst of activity. As a result, the interface assembles the single image from pieces snatched from many frames.

High-speed frame grabbers generally cost more than $10,000, while the slower units cost somewhat less, depending upon speed and resolution. You can expect a 256 by 256 pixel-resolution low-speed interface, the kind used in the computer systems often seen at conventions printing images on T-shirts, to cost between $500 and $1000; half of that price is for the camera and lens.

Solid-State Arrays to the Rescue?
The problem with the Vidicon-type camera is that it is an analog device, which must be adapted to work in digital applications. It would be far better to have a computer video camera that is inherently digital and dispense with the analog-to-digital conversion. Why not use semiconductor devices, the outputs of which are digital signals that change as a function of light level?

The barrier has been price. A variety of semiconductor optical sensors, such as photodiode and charged-coupled-device (CCD) arrays, fill the bill nicely. When I first started to think about building a solid-state image camera, I thought I could just order a 256 by 256 pixel CCD array and add a few binary-counter chips for a quick project. This idea evaporated quickly when I discovered that CCD arrays cost from $800 to $2000, depending upon the number of bad pixels you get.

My success with photodiode arrays wasn't much better. It seems that for about $100 you can buy a 128 by 1 or 256 by 1 array, but arrays more than one element wide are hard to find. To create a 256 by 128 or 128 by 128 picture, I would have needed to devise an optical, mechanical, or electronic way to move the array across the image plane, or move the
image across the array, stopping periodically for the values of the picture elements to be registered and stored. After tentatively sketching a screw drive and its associated control electronics, I gave up in disgust at the thought of how hard it would be to build.

If Memory Serves...

I had almost decided to join the bandwagon and use a Vidicon camera when I remembered experimenting with the optical sensitivity of dynamic RAM (random-access read/write memory) chips back in 1976. I had even seen a design published for a 64 by 64 pixel resolution camera when they were light-sensitive. The problem, however, is that they were designed only as memory devices and not optical arrays. To my knowledge, none of the 64K-bit dynamic RAMs on the market are configured as an orthogonal array laid out 256 elements long by 256 wide. In fact, most have 4 or 8 sections of 16K or 8K bits, and many include redundant sections that can be wired in to replace bad sections on the chip. The bit addresses don’t proceed linearly through the chip either; one bit may be in the upper-left corner and the next bit in the lower-right corner.

Just as I was about to abandon all hope, I found an unconventional dynamic-RAM manufacturer that has recognized the light-sensing potential of its 64K-byte device. Micron Technology Inc., of Boise, Idaho (certainly an unconventional place to make integrated circuits), produces a dynamic RAM chip that has its memory cells laid out in only two sections, both of which are 256 by 128 cells, as shown in figure 7 on page 31. With this configuration, the chip can easily be used as an optical sensor. One specially tested 64K-bit dynamic memory device, called the IS32 Optic RAM, comes in a package with a see-through quartz lid (see photo 4).

Per pixel, the Micron Technology IS32 Optic RAM costs 1000 times less than the earlier generation of imagesensing chips such as the CCD. The Optic RAM’s spectral sensitivity is generally the same as that of other silicon-based light-sensing media, but its bit-for-bit uniformity is not as good as CCDs. Nevertheless, the Optic RAM can bring capabilities to your computer that were previously available only to large industrial users.

Build the Micro D-Cam

This month, using the IS32, I’ll show you how to build a relatively low-cost digital image camera I call the Micro D-Cam (see photo 1). Its resolution of 256 by 128 pixels is adequate for many applications in graphics, pattern and character recognition, robotics, process control, and security. (Of course, the output of the Micro D-Cam is a digital signal; it cannot be used to directly drive a composite-video monitor.) I’ve put together versions of the Micro D-Cam for use with the Apple II computer (II-Plus and IIe, see photo 3, page 30) and the IBM Personal Computer; however, the Micro D-Cam is serially interfaced and requires only...
five wires for connection, so I’m also working on an RS-232C version that can be attached to any computer that has a serial port.

The Micro D-Cam project is rather complex, so I’ll present it in two parts. This month I’ll explain how the IS32 Optic RAM and the Micro D-Cam hardware work. Because appropriate software is vital to the success of this project, next month I’ll include a lengthy listing of a typical control program for use with the Apple II Plus version of the Micro D-Cam. We’ll also look at some of the Micro D-Cam’s capabilities.

**IS32 Optic RAM**

The IS32 from Micron Technology is an all-digital image-sensing device. Its pertinent characteristics are shown in Table 1.

The IS32 contains 65,536 (64K) light-sensitive memory cells laid out in two planar, rectangular arrays of 32,768 elements, each a matrix of 128 rows and 256 columns. The two arrays are separated by an optically nonsensitive “dead” zone about 25 elements wide. To avoid having a gap in the image or using complicated optical systems to eliminate it, only one of the arrays is usually used as an image sensor. Each of the memory elements in the matrix can be accessed randomly when the control circuitry strobos in the appropriate row and column address of the element being accessed.

### Theory of Operation

An image camera built around the IS32 focuses reflected light from the viewed object and passes it through a lens onto one of the 32,768-element arrays. When an individual element is struck by photons of light, the capacitor in the cell, which is initially precharged to a fixed voltage, begins to discharge toward zero volts. The capacitor discharges at a rate proportional to the light intensity throughout the duration of the exposure.

After the exposure interval has elapsed, the circuitry reads the element by addressing it as a memory cell. During the cell access, sense amplifiers within the IS32 read the capacitor’s voltage value and compare it to a fixed threshold voltage. If the potential is above the threshold, the picture element is deemed to be black; if the potential is too low, the picture element is declared white. The D_{w} pin of the Optic RAM is set to a logic 1 or 0 during the corresponding bit interval as a result of this decision. The raw “gray scale” of the IS32, therefore, has only two shades, white and black. (We’ll see how to compensate for this shortly.)

All dynamic-memory devices require refreshing for operation; the charge representing the data stored in each cell capacitor will leak away if left alone (exposure to light merely hastens the leakage). The charge must be sensed and brought back to the nominal voltage for the logic state it represents. This can happen when the computer reads a bit value from the cell, but more frequently it happens when circuitry external to the memory chip periodically activates the cell’s address just for the purpose. (Many memory chips, including the IS32 Optic RAM, can refresh their cells a whole row at a time.) The IS32 can be used this way as a regular memory device can, but in optical service there is a twist in the refreshing. The chip is light-sensitive only when it is not being refreshed; the key to using it in a camera is to carefully control its sensitivity by performing the refresh operation in a special way.

In the beginning of an image-sensing cycle, the Micro D-Cam’s circuitry addresses all the cells in the active array, filling them with the positive voltages that represent logic 1s. The exposure begins with the receipt of a SOAK command, which is the equivalent of opening the shutter (to allow the array to “soak” in light). Then, after the appropriate exposure interval has elapsed, the control circuitry issues the refresh command, which freezes the states of the memory cells (or pixel cells, if you will). Then the control circuitry activates the interrupt state, during which the value of one cell is fetched and transmitted. Interrupt cycles are continued until all the bits in the array have been transmitted. (The interrupt

---

**Photo 2a:** The Micro D-Cam can focus on UPC bars. Both photos shown here used the Apple II’s high-resolution graphics routines to reproduce the camera’s output.

**Photo 2b:** The Apple II’s display represents gray levels as different densities of white dots. Several different-length exposures are combined to form the gray-scale image.
mode is not maintained constantly because the IS32 cannot be refreshed during the interrupt.) The Micro D-Cam then causes all the cells to again be set to 1, and the image-sensing cycle starts over.

A white pixel (logic 0) in the output indicates that the capacitor was exposed to a light intensity sufficient to discharge it past the threshold point. A black pixel (logic 1) indicates the light intensity was not enough to discharge the capacitor past the threshold point.

How fast the camera can scan the image varies according to the light intensity. The faster the elements are scanned, or read, the greater the light intensity required. The Micro D-Cam can scan approximately 15 frames per second at maximum speed.

The Optic RAM Resembles Film

The operation of the digital image sensor can be compared to that of a black-and-white film emulsion in a conventional photographic camera. Like the film, the IS32 contains many light-sensitive elements lying in a single plane. The image is focused (optically) on the plane, the user can adjust the aperture (measured in f-stops) and the length of exposure. The aperture is an adjustment of the size of the opening through which the light is allowed to pass on its way to the light-sensitive medium (changed in both cases by mechanically opening or closing an iris). The length of exposure (corresponding to photographic shutter speed) is adjusted in the Optic RAM by the scanning function of the drive electronics. And in the Optic RAM, the film is advanced, so to speak, by refreshing the voltage on all the memory elements.

Also like film, the Optic RAM's elements respond to light in a binary fashion, indicating only black or white, the presence or absence of a certain amount of light during the exposure. However, in a photographic film, the light-sensitive elements (grains of silver-halide compounds) come in different sensitivities and respond to different intensities of light, whereas the IS32's cells all respond at about the same intensity for any given condition. To circumnavigate this limitation with the Optic RAM, varying shades of gray can be recorded by making multiple scans of the same optical image, averaging the results obtained from either changing the sensitivity of the cells, using a different threshold voltage for each scan, or varying the scan rate.

By changing the threshold voltage and keeping both the scanned image and light intensity constant, areas on the Optic RAM where intermediate brightness portions of the image fail will give differing output levels. The nominal threshold potential, 2.1 volts (V), can be adjusted though pin 1 (Analog Threshold) on the IS32 from 1.5 V to 3 V, but Micron Technology suggests that gray-scale capability can be achieved by varying the scan rate rather than by adjusting the threshold voltage. Changes will be exhibited in the response of the pixels where the image is gray (of intermediate brightness) so that the amount of light striking the cell capacitors is near the threshold voltage. Of course, a darker area of the image will generate more logic 1s as output than logic 0s, and a lighter area will generate more logic 0s. By averaging these outputs over a number of scans, the appropriate shade of gray can be produced in a composite image representation.

The Micro D-Cam may not contain a mechanical shutter, but its electronic equivalent is easily controlled by sending the appropriate commands to the control circuitry. The Optic RAM's sensitivity to light varies according to the electrical voltages present on it, allowing for precise continuous control of the Micro D-Cam's exposure values.

Ease of Use

Hooking up the Micro D-Cam to a computer is easy. The unit's control circuitry provides all the requisite timing signals and circuitry to execute commands received from the computer. The Micro D-Cam automatically sequences the Optic RAM so that each image-sensing cell is accessed and the appropriate video information transmitted to the computer for display or processing.

The Micro D-Cam uses a C-mount lens (the type commonly used in 16-millimeter movie cameras and small television cameras) with variable focus. The lens I chose was designed for viewing objects from a distance of at least 18 inches (45 cm); from this distance, the Micro D-Cam can distinguish characters of the size you are now reading. For viewing objects under greater magnification, you can insert a close-up adapter between the lens and its mount to extend the focal length of the lens. (See photo 2.)

The link between the computer and the Micro D-Cam is a TTL (transistor-transistor logic) level serial interface. The external data-rate clock signal allows the computer to be synchronized to the Micro D-Cam, so that the camera can operate at a speed of its own choosing.

Five lines run between the camera and the computer, carrying the transmit, receive, ground, and external clock signals and +5V power. A general-purpose type-6850 ACIA (asynchronous communication interface

<table>
<thead>
<tr>
<th>Table 1: Specifications of the Micron Technology IS32 Optic RAM, a 64K-bit memory chip that has the extra talent of serving as a digital image detector.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 128- by 256-element array measuring 55.04 by 1.088 millimeters</td>
</tr>
<tr>
<td>2. Element size: 8 microns by 9 microns</td>
</tr>
<tr>
<td>3. Vertical center-to-center spacing: 21.5 microns</td>
</tr>
<tr>
<td>4. Horizontal spacing: 85.0 microns</td>
</tr>
<tr>
<td>5. Spacing between left and right arrays: 150 microns</td>
</tr>
</tbody>
</table>

Editor's Note: Some often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of these past articles are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08520.

adapter) buffered chip performs serial-to-parallel and parallel-to-serial data conversion, mating the Micro D-Cam's nonspecific circuitry to the host computer, as illustrated by the Apple II Plus in this article.

**Hardware Details: Timing, Refreshing, and Interrupts**

The timing-generator circuit (see figure 1), which generates the timing signals for the operation of the Micro D-Cam, contains a CMOS (complementary metal-oxide semiconductor) oscillator circuit that generates the fundamental clock rate. This signal is divided down to produce the frequencies for various possible output data rates and controlling the IS32. The data-rate-clock signals control the sequence of operation of the interrupt generator and the transmitter circuit.

The oscillator circuit emits a fundamental 4.9152-MHz signal, which is buffered by a type-74C04 inverter section (IC20a). This clock signal is divided again by a type-D flip-flop and brought out to a set of data-rate-selection jumper connections. IC26 divides the frequency by increasing powers of 2; these various subharmonic outputs lead to other data-rate-selection jumpers. Jumper connections 5 through 8 select the data rate used in the transmitter and interrupt-generator circuit (figure 5 on page 28), while connections 1 through 4 are 16 x clock signals used in the receiver circuit. The output of IC26's pin 7 drives the Optic RAM's timing circuitry, which generates the familiar RAS (row-address strobe), CAS (column-address strobe) and R/W (read/write) signals as used by most dynamic RAM chips.

When the camera is transmitting data from the Optic RAM, it is in the interrupt mode, and the CAS and R/W signals are provided to the Optic RAM. When the camera is not transmitting, the interrupt mode is off, and CAS and R/W are disabled; the active-high interrupt signal INT is low and its complement INT is high, so the output of the AND gate driving CAS remains high and the OR gate driving R/W remains low.

During an interrupt cycle, INT goes high and INT goes low, enabling CAS and R/W. The high state of RAS' (RAS-bar-prime) passes through a delay line consisting of two inverter sections (IC20d and f) and an R/C (resistance/capacitance) network, and then, combined with INT through an AND gate (IC9c), causes CAS to go high. When this happens, the column address is latched into the Optic RAM. At this time the R/W signal is still high, so the value stored in the accessed pixel is read out. After another delay period, R/W goes low, writing a 1 bit into the accessed cell to restore its charge and make it again able to react to light. When RAS' returns low, the interrupt cycle is terminated and CAS and R/W are disabled.

**Command-Receiver Circuit**

The serial command line carries commands from the computer to the camera. This data enters the command-receiver section (figure 2) at a single bit at a time and is assembled according to the following protocol. The first bit to arrive is the start bit, followed by 8 data bits and then the stop bit. The start bit enables operation of the input shift register and starts the shift-register clock, which is initially low. When the clock goes high, the start bit, always a high level, is latched into the first of eight data positions in the shift register. When the clock goes low, the first data bit arrives at the shift register's input.

---

*Figure 2: The serial command line carries commands from the computer to the camera. The data enters the command-receiver section serially and is assembled by the shift register into a deodable word stored in the latch.*
When the rising edge of the clock pulse is detected, the shift register moves the high start bit from position 1 to position 2 and shifts the first data bit from the shift register’s input into position 1. As successive bits arrive, each one is shifted into the shift register when the rising edge of the clock pulse is detected.

When the start bit finally reaches position 8, the camera has received the entire command byte, so the first 6 data bits are transferred from the shift register into a latch (a 1-byte memory) called the command register. The clock is then disabled and the shift register cleared, leaving the 6 camera-command bits in the command register. The receiver is now ready to accept another command.

**Address Registers**

The address registers of the circuit (see figure 3) latch the row-address, column-address, and refresh pointers for the Optic RAM addressing. Address registers IC22 and IC16 hold the row and column addresses, respectively, while the third register, IC10, is the refresh register.

The first two registers are activated only when the camera is to fetch and transmit a single bit of information from the Optic RAM. (This fetch operation is the interrupt cycle, which, as we saw before, is initiated by the INT signal going high.) The cycle starts on the occurrence of the falling edge of the RAS signal and ends on the next falling edge of RAS. When the camera is not fetching in an interrupt cycle, the refresh register is active. This third address register continually increments the row-address value from 0 through to 255. Except during interrupts and exposures, this value passes through to the address lines of the IS32, performing a refresh operation. All three address registers have three-state outputs (that is, their outputs can assume a high-impedance condition, not driving the bus either high or low), and only one register is active at any one time.

The selected register drives its data onto a common bus called the present-address bus. The present address passes through the descramble-and-soak circuitry (which will be discussed shortly) to the Optic RAM, where it is used to select a row or column. The present-address bus also connects to the address circuit, where a value of 0, 1, or 2 (depending upon software-selected options) is added to the present-address value. The resulting sum is driven out of the adder onto the next-address bus, which connects to the inputs of each of the address registers. The value on the next-address bus is latched into the selected address register, and then that register is disabled.

The array-selection circuit simply selects whether one or both of the IS32’s cell arrays are to be used. If ZARRAY is high, the output of the OR gate (IC21, pin 11) is always high, and the row-register value (IC22) will never be less than 128, so only the second array (rows 128 to 255) will be addressed and transmitted. If ZARRAY is low, however, the OR gate will appear transparent and the value on the next-address-bus line D7

**An unconventional dynamic-RAM manufacturer has recognized the light-sensing potential of its 64K-bit device.**
will be driven onto IC22. This means all addresses from 0 to 255 will be selected and the values in both arrays will be transmitted.

Address Descramble and Array Soak

The internal circuitry in the Optic RAM scrambles the row and column-address values when accessing a cell. (After all, the IS32 chip was designed for use only as a memory device, not as an optical sensor.) But because element location is a critical issue in optical work, the address-descramble circuit (see figure 4, below) unscrambles the values into a new address, which the Optic RAM decodes to access the desired pixel.

Charged with the task of transforming the data from the address registers into a new address, which the Optic RAM decodes to access the desired pixel, the descrambling circuit consists of two inverters, three exclusive-OR gates, and a multiplexer (IC11). The inverters and exclusive-ORs do the actual descrambling on the row and column addresses; the multiplexer selects between the descrambled row and column addresses at the appropriate times and transmits the address to the Optic RAM.

The multiplexer uses \( \overline{\text{RAS}} \) to determine which address is selected. If \( \text{RAS} \) is low at the multiplexer's SELECT input (IC11, pin 1), the descrambled row addresses (on the B inputs) are selected. When \( \text{RAS} \) is low, the A inputs, or descrambled column-address inputs, are selected.

The purpose of the SOAK circuit is to prevent the refresh addresses from reaching the Optic RAM during the exposure cycles. (Remember, the Optic RAM is light-sensitive only when it is not being refreshed.) During periods when INT is inactive-low (with the refresh register therefore active) and SOAK is active-low, the

Figure 4: Consisting of two inverter sections, three exclusive-OR gates, and a multiplexer, the address-descrambling circuitry undoes the internal address scrambling done by the Optic RAM. The soak circuit makes the Optic RAM light-sensitive by depriving it of refresh cycles.
Figure 5: The circuitry for transmitting the pixel data to the host computer and for generating the interrupt states that allow data to be read from the pixels in the IS32.
output of NOR gate IC15d is high. This sets the multiplexer’s enable input high and drives the multiplexer’s outputs low. The high NOR-gate (IC15d) output also forces a low state at the inverter output IC18d, which forces the outputs of the four AND gates IC23a, b, c, and d low. These AND gates stand between the present-address bus and the IS32’s four low-order address inputs. Thus, the Optic RAM’s address inputs remain low, and the refresh function is performed on only address 0. When SOAK goes inactive-high, the multiplexer and AND-gate outputs are enabled and the refresh addresses reach the Optic RAM so that the entire chip is refreshed, making it insensitive to light.

Transmitter and Interrupt-Generator Circuit

This circuit, shown in figure 5, transmits the pixel data serially to the host computer, inserting start and stop bits where appropriate, and generates the INT and INT signals for fetching the pixel information from the IS32.

At the heart of this circuit is the ripple counter, IC4, enabled when the

The output of the Micro D-Cam is a digital signal; it cannot be used to directly drive a composite-video monitor.

Micro D-Cam has been commanded to transmit data. It inhibits the interrupt generator when start and stop bits are being transmitted (preventing accessing of the Optic RAM) and enables the interrupt circuit when it is transmitting data. The transmitter’s frequency is determined by the data-rate clock. During each clock cycle only one start, stop, or data bit is transmitted.

The interrupt generator is enabled by both the ripple counter (IC4) and the data-rate clock, but the interrupt cycle itself is clocked by RAS. Because the purpose of the interrupt cycle is to fetch a single pixel for transmission, only one pixel can be transmitted on each clock cycle. The rising edge of the data-rate clock enables the interrupt circuit. The next falling edge of the RAS waveform initiates the interrupt cycle, causing a pixel to be read from the Optic RAM. The INT signal feeds back into the interrupt circuit, resetting the interrupt enable.

When RAS goes low again, the interrupt cycle is terminated. The next falling edge of the data-rate clock enables the interrupt circuit again (unless a start or stop bit is to be transmitted). Thus, only one pixel is transmitted during each data-rate-

Figure 6: The adder circuit allows the Micro D-Cam to keep track of the proper values for the row, column, and refresh registers.
The control circuitry for the Micro D-Cam image camera is shown here in prototype form mounted in an input/output slot in an Apple II Plus computer.

The WIDEPIX circuit is used to help compensate for the mismatch in aspect ratios of the Optic RAM and most computer graphics screens. The Optic RAM has a ratio of 2.5:1, compared with the 4:3 aspect ratio of most cathode-ray-tube (CRT) displays, and the pixels are not square. If the image data is displayed on a screen with an aspect ratio that close to 1:1, the image will appear to have been squeezed horizontally. The WIDEPIX circuit helps compensate for this by causing each pixel to be transmitted twice, doubling the width of the image. The circuit is enabled when the Micro D-Cam is transmitting and the WIDEPIX command line is high. This causes the flip-flop IC8a’s output to toggle on every data-rate-clock cycle. This flip-flop inhibits the interrupt cycle on alternate data-rate clock cycles. During data-rate-clock cycles in which the interrupt is inhibited, the pixel from the previous interrupt cycle is transmitted again.

The LINE and LINE signals indicate that the column-address register has reached terminal count, meaning that the last column has been scanned. These signals, when active, inhibit the occurrence of further interrupts during the transmission of the current byte so that the value of the last accessed data bit is repeated to fill out the bits in the byte. This guarantees that the next byte transmitted will start off with information from the next row, i.e., that no single byte will contain picture information from two rows. When the stop bit is to be transmitted, assertion of the LINE signal at one input of exclusive-OR gate IC5b causes an interrupt request, and assertion of LINE at the input of the NAND gate IC1b ensures that the interrupt flip-flop is enabled. This “dummy” interrupt is used to increment the row-address register. The pixel that is accessed during this cycle is blanked by the transmission of the stop bit.

Adder and End-of-Frame Circuit

The adder and end-of-frame section, shown in figure 6, adds the clock cycle.

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Adder and End-of-Frame Circuit

The adder and end-of-frame section, shown in figure 6, adds the
proper increments to the row, column, and refresh registers and generates signals indicating end-of-frame (EOF) in the Optic RAM.

When any one of the address registers drives a value onto the present-address bus, the adder circuit receives this value, adds a 0, 1, or 2 to it (depending on the control inputs RAS, LINE, ALTBIT and INT), and places the sum onto the next-address bus. When the refresh register is active, the INT line causes a 1 to be added each cycle. During interrupt cycles, the row and column registers are active. The adder sequences these registers through the Optic RAM in a "column-fast" mode, i.e., the adder adds 0 to the row address and 1 to the column address until the end of the column (or end of the line) is reached. The adder then adds a 1 to both the row and column, thus incrementing the row register and resetting the column register to 0.

The ALTBIT input simply adds an extra 1 to the value on the present-address bus during interrupt cycles; thus the row and column registers are incremented by a total of 2 rather than 1.

Control and Use

The software routines that control the Micro D-Cam are menu-driven. While the camera is running, several real-time commands are available to alter the operation of the camera from frame to frame. The real-time options are displayed on the screen.

When the camera is first turned on, you start the image-gathering process by selecting one of the options from the menu offered by the software, which I'll discuss in detail next month. If everything is working properly, an image of what the Micro D-Cam is seeing is shown on the computer's video-display screen. If the display screen remains dark, the exposure interval may be insufficient; this situation may be remedied by increasing the exposure time. If the exposure time is excessive, the screen will be white. This situation may be remedied by decreasing the exposure time or changing the aperture on the lens. Eventually, a clear picture will appear on the computer's screen as you reach the proper adjustments.

Next Month:

In part 2, we'll look at the software you'll need to read the Micro D-Cam's images, including a complete listing for the Apple II Plus, and I'll explain the computer interface and how the Micro D-Cam communicates with its user.

The following items are available from:
The Micromini Inc.
561 Willow Ave.
Cedarhurst, NY 11596
(800) 645-3479 (for orders)
(516) 374-6793 (for information)

1. Complete Micro D-Cam unit including interface card, extension cable, IS32 Optic RAM, lens, remote housing, operators manual, and utility software. Specify Apple II (Plus or E) or IBM Personal Computer. Assembled and tested ........ $295
2. Same as Item 1 except in kit form. Specify Apple II or IBM Personal Computer version. Complete kit ............... $260
3. IS32 Optic RAM sold separately IS32 each ............... $42
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Computing on the Run

Portable computers are definitely the wave of the future. Incorporating new design concepts, innovative hardware, and easy-to-use software, these distinctive machines are bound to change the way we think about computers. This month's theme articles will take you on a guided tour of the industry, the main features portables offer and how to choose from among them, and the computers themselves.

Practically every major computer manufacturer has introduced, has plans for, or is in the process of introducing a portable computer. Not a month goes by that BYTE doesn't get wind of a new portable computer system. According to the Venture Development Corporation's report, "The Portable Briefcase Computer and Terminal Industry, 1982-1987: A Strategic Analysis," portable computer sales are expected to reach more than $4 billion by 1987. That figure is just for briefcase-type and transportable computers; it doesn't include hand-held computers.

This plethora of portables gives buyers more computing power and convenience for their money than ever before. But it also means that selecting a portable computer for personal or business use is more involved than ever. Each manufacturer has a different design philosophy for producing a portable. Sorting through the number of features and options available on the portables makes selecting the right one for your needs even more difficult than choosing a desktop computer.

This issue will help to eliminate some of the confusion surrounding portable computers. In addition to Mahlon Kelly's analysis of the Radio Shack Model 100, we'll take a look at the Pied Piper, a briefcase CP/M system; the powerful HP-75; and the Access Matrix portable, which some disparagingly refer to as the "Swiss army knife" of portables, while others swear by its conveniently built-in printer and acoustic modem. We also review the Kaypro II and its big brother, the Kaypro 10, with its built-in 10-megabyte hard disk; you'll see why these portables are giving the Osborne a run for its money. The Corona Portable PC, which comes under one reviewer's scrutiny, is described as an IBM-compatible portable that goes beyond being a mere clone.

In addition to system reviews, this issue offers in-depth views of the larger issues that affect the portable marketplace. A comprehensive article on CMOS technology explains how improvements in chip-fabrication technology have brought down the price of CMOS RAMs. The problems of moving delicate equipment are addressed in "The Challenge of Hard Disk Portability." To top off the issue, you can read about how the designers of the new Cavilan portable computer decided on which features to include in their computer.

To start you off, the article that follows offers a general overview of the portable field and covers some of the major features of portable computers, their pros and cons, and how to choose the portable that best suits your needs. The Portable Computer Comparison Table starting on page 36 lists the latest portables available and their specifications.

—Stanley J. Wszola
How to Choose a Portable

Photo 1: The Sharp PC-1500 is a typical pocket computer.

Factors to consider before you take the plunge

by Stanley J. Wszola

Just a year and a half ago the Osborne 1 portable microcomputer had no competitors. Today at least 50 portables fight for a share of the market, and new machines are announced almost daily.

There's definitely something going on out there, and it bodes well for the consumer. Manufacturers, trying to outdo the competition, are offering better, more powerful, and more attractive portable computers. It's the free market at its best. The only problem with this abundance of portables is that buyers often don't know where to begin. To that end, we'll start with an explanation of what a portable computer is and then explore its various components. While that won't tell you which portable to buy, it will provide some signposts to help you make an informed choice. (For a directory of portable computers, see table 1.)

The sudden appearance of portable computers results from a convergence of technologies. Many features found on portable computers have been used and refined on products such as digital watches and pocket calculators. In addition, the products of the years of research and development that went into creating today's desktop microcomputer have finally come together in the portable computer. What we have is reliable hardware and proven software in a machine that can be shuttled easily from office to home or wherever.
table computer users include business people who like the flexibility of working at home or on the road, scientists and engineers who take their portables into the field for on-site computer applications, and people who simply like to take their computing power with them.

What Is a Portable?
A portable computer is, of course, a computer first and foremost. It must have a central processing unit, memory, a method for data entry, a device for or method of displaying data output, and usually a means of storing data.

A portable computer must be easy to carry from place to place. Don't confuse "portable" with "transportable." Any computer can be transportable if you have a big enough truck. For the purposes of this article, a portable computer is one that can be carried by one person—but not necessarily easily carried. Currently, portable computers can be divided into three rough categories:

Pocket computers: These can be characterized as pocket-size, battery-powered, lightweight computers with a 1-line display, limited memory (0.5 to 10K bytes), and usually BASIC in ROM (read-only memory). Most use cassette tape for data storage. The keyboards on these computers are not suitable for touch-typing, and the 1-line display is adequate only for simple programming. Many of these computers can accept accessories (i.e., printers, serial- and parallel-port interfaces, and modems) to increase their usefulness. A good example of an adaptable pocket computer is the Sharp PC-1500 pictured at left.

Briefcase computers: As the name implies, these computers are small enough to be placed in a briefcase. They usually have a 4- to 8-line display, a full-size keyboard, provision for increasing internal memory, serial and/or parallel ports, and AC or battery power. Most briefcase computers feature BASIC in ROM, and some include applications programs for word processing, telecommunications, and appointment scheduling. Data storage can involve micro- or full-size cassette tapes, auxiliary floppy-disk drives, bubble and CMOS (complementary metal-oxide semiconductor) memory cartridges. Most have full-size keyboards that are suitable for touch-typing. Their light weight (5 to 10 pounds) and small size let you use them almost anywhere. One example of a briefcase computer is the Radio Shack Model 100.

Transportable computers: These are the heavyweights of the portable-computer field in terms of size, weight, and capabilities. I've used the term transportable because some so-called portable computers are nothing more than a boxed desktop computer with a handle on top. Most are the size of a small suitcase, weigh 15 to 40 pounds, and usually have a CRT (cathode-ray tube) display with one or more floppy-disk drives.

Any computer can be transportable if you have a big enough truck.

use CP/M-80 or CP/M-86 and MS-DOS operating systems. These computers can do anything the desktop models can do, but their portability is limited by the necessity for AC power or a heavy battery pack. The Osborne Executive is a transportable computer.

Power Sources
The growing use of low-power CMOS RAM (random-access read/write memory) chips and CMOS microprocessor chips, such as the 80C85 used in the Radio Shack Model 100, has decreased dependency on AC power sources. Battery-powered portables can be used almost anywhere. But batteries can be a curse as well as a blessing; they add overall weight to the package and always run out just when you need them most.

Most portable computers can run from 2 to 10 hours before they need a recharge. Battery life depends on the power requirements of the computer, the length of time it has been operating, and the rating of the battery. Some portables have low-voltage indicators to alert you when the batteries run low. The transportable models are more power hungry than the smaller portables. The CRT and the disk drives in the transportables require a lot of energy.

Some briefcase computers use CMOS memory chips and an auxiliary nickel-cadmium battery to preserve data in memory if the main batteries fail. For example, the nickel-cadmium batteries in the Model 100 can maintain data for 8 to 30 days, depending on how much memory the computer has. This gives you an extra margin of safety if you are unable to replace or recharge the main batteries right away.

Many transportable computers have auxiliary battery packs as options. Of course, you still face the problem of carrying the batteries as well as the computer. Finally, some manufacturers offer an optional auto adapter, which lets you plug your computer into your car's cigarette lighter. They recommend using the computer with the engine off to eliminate lost data due to voltage spikes and surges. That's just as well; you don't want to be downloading a program and downshifting at the same time.

Video Displays
The new portables use one of three types of displays: CRT, LCD (liquid-crystal display), or ELD (electroluminescent displays). CRTs have been around for a long time, but are a proven medium. LCDs, although limited in their ability to display graphics, are lightweight and don't consume too much power. The newer ELDs have the same display capabilities as CRTs with an extra advantage—their flat shape makes them ideal for use in portables. I'll explain each in detail.

The most commonly used display for portable computers is the reliable, flexible, and easy-to-use CRT. Most users are already familiar with it. Its primary disadvantages are a bulky shape and high power consumption. The CRT itself, a large, fragile glass tube, must be protected from harsh environments and airport baggage handlers.

Text continued on page 44
<table>
<thead>
<tr>
<th>Manufacturer/Location</th>
<th>Model</th>
<th>Size (Inches)</th>
<th>Weight</th>
<th>Power Supply</th>
<th>Price</th>
<th>Type of Microprocessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Matrix Corp. San Jose, CA</td>
<td>Access</td>
<td>16.5 by 10 by 10.8</td>
<td>33 lbs.</td>
<td>AC</td>
<td>$2495</td>
<td>Z80A</td>
</tr>
<tr>
<td>Adcock Johnson Fort Worth, TX</td>
<td>Model 3000 (TRS-80 Model III in a briefcase)</td>
<td>19½ by 14½ by 8½</td>
<td>28 lbs.</td>
<td>AC</td>
<td>$2895</td>
<td>Z80A</td>
</tr>
<tr>
<td>Athena Computer and Electronics Systems San Juan Capistrano, CA</td>
<td>Athena I</td>
<td>3½ by 11½ by 14½</td>
<td>15 lbs.</td>
<td>batteries or AC</td>
<td>$3950</td>
<td>NSC-800 (low-power Z80)</td>
</tr>
<tr>
<td>Casio Inc. Fairfield, NJ</td>
<td>Model FP-200</td>
<td>12½ by 2½ by 8½</td>
<td>4 lbs.</td>
<td>batteries or AC</td>
<td>$499</td>
<td>proprietary</td>
</tr>
<tr>
<td>Casio Inc. Fairfield, NJ</td>
<td>Model FX-700P</td>
<td>6½ by 2½ by ¾</td>
<td>4.2 oz.</td>
<td>batteries or AC</td>
<td>$99.95</td>
<td>proprietary</td>
</tr>
<tr>
<td>Casio Inc. Fairfield, NJ</td>
<td>Model FX-801P</td>
<td>6½ by 3½ by ¾</td>
<td>9.1 oz.</td>
<td>batteries or AC</td>
<td>$149.95</td>
<td>proprietary</td>
</tr>
<tr>
<td>Columbia Data Products Inc. Columbia, MD</td>
<td>Columbia VP</td>
<td>18 by 16 by 8</td>
<td>32 lbs.</td>
<td>AC</td>
<td>$2995</td>
<td>8088</td>
</tr>
<tr>
<td>Commodore Business Machines Wayne, PA</td>
<td>Executive 64</td>
<td>14½ by 14½ by 5</td>
<td>27.6 lbs.</td>
<td>AC</td>
<td>$995 to $1495</td>
<td>6510 (optional Z80 for CP/M)</td>
</tr>
<tr>
<td>Compaq Computer Corp. Houston, TX</td>
<td>Compaq Portable Computer</td>
<td>20 by 15½ by 8½</td>
<td>28 lbs.</td>
<td>AC</td>
<td>$2995</td>
<td>8088</td>
</tr>
<tr>
<td>Computer Devices Inc. Burlington, MA</td>
<td>DOT 3000B</td>
<td>18 by 14½ by 7½</td>
<td>31 lbs.</td>
<td>110 or 220V AC (optional battery pack)</td>
<td>$4344</td>
<td>8088</td>
</tr>
<tr>
<td>Compal Beverly Hills, CA</td>
<td>Electric Briefcase</td>
<td>9 by 20 by 15</td>
<td>26 lbs.</td>
<td>AC</td>
<td>$1995</td>
<td>Z80A</td>
</tr>
<tr>
<td>Computershop Cambridge, MA</td>
<td>STAR-Lite</td>
<td>16 by 16 by 7½</td>
<td>34 lbs.</td>
<td>AC</td>
<td>$2695</td>
<td>Z80A</td>
</tr>
<tr>
<td>Computer Systems St. Clair Shores, MI</td>
<td>PC/8088</td>
<td>19 by 16 by 7½</td>
<td>25 lbs.</td>
<td>AC (optional 12V DC battery-power supply)</td>
<td>$3388</td>
<td>8088</td>
</tr>
<tr>
<td>Corona Data Westlake Village, CA</td>
<td>Corona Portable PC Models PPC-1 and PPC-2</td>
<td>20 by 20 by 8</td>
<td>30 lbs.</td>
<td>AC</td>
<td>$2395</td>
<td>8088</td>
</tr>
<tr>
<td>Digital Microsystems Oakland, CA</td>
<td>DMS-3/F Fox</td>
<td>17½ by 14½ by 7¼</td>
<td>30 lbs.</td>
<td>110 or 220V AC</td>
<td>$3995</td>
<td>Z80A</td>
</tr>
<tr>
<td>Digital Microsystems Oakland, CA</td>
<td>DMS-15</td>
<td>17½ by 14½ by 7¼</td>
<td>36 lbs.</td>
<td>110 or 220V AC</td>
<td>$7495</td>
<td>Z80A</td>
</tr>
</tbody>
</table>

Table 1: The portable computer comparison table.
<table>
<thead>
<tr>
<th>Operating System</th>
<th>RAM Memory Min./Max.</th>
<th>Mass Storage Type, Size</th>
<th>Display Type, Size</th>
<th>Color or Software Included</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP/M-80</td>
<td>64K</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>7-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>Perfect Series and Fancy Font</td>
</tr>
<tr>
<td>TRS-DOS 1.3</td>
<td>48K min., 64K max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 64 characters by 16 lines</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>CP/M-80</td>
<td>68K</td>
<td>1 megabyte RAM disk, optional 5¼-inch floppy-disk</td>
<td>LCD, 80 characters by 4 lines</td>
<td>n.a.</td>
<td>JRT Pascal, Profit Plan, Mini-Vedit</td>
</tr>
<tr>
<td>n.a.</td>
<td>8K min., 32K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 20 characters by 6 lines</td>
<td>n.a.</td>
<td>built-in electronic spreadsheet</td>
</tr>
<tr>
<td>n.a.</td>
<td>2K min., 2K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 20 characters by 1 line</td>
<td>n.a.</td>
<td>program library for math, science, finance, other uses</td>
</tr>
<tr>
<td>Casio BASIC</td>
<td>2K min., 2K max.</td>
<td>n.a.</td>
<td>LCD, 20 characters by 1 line</td>
<td>n.a.</td>
<td>program library for math, science, finance, other uses</td>
</tr>
<tr>
<td>CP/M-86 MS-DOS</td>
<td>128K min., 256K max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 25 lines</td>
<td>graphics</td>
<td>Perfect Series, Home Accountant Plus, Fast Graphs, and others</td>
</tr>
<tr>
<td>Commodore DOS</td>
<td>64K min., 64K max.</td>
<td>1 or 2 5¼-inch floppy-disk drives</td>
<td>7-inch CRT, 40 characters by 25 lines, 16 colors and graphics</td>
<td>n.a.</td>
<td>compatible with all software for the Commodore 64</td>
</tr>
<tr>
<td>Compaq-DOS (same as MS-DOS)</td>
<td>128K min., 512K max.</td>
<td>1 or 2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 25 lines by 80 characters</td>
<td>graphics</td>
<td>IBM PC compatible</td>
</tr>
<tr>
<td>MS-DOS</td>
<td>128K min., 704K max.</td>
<td>2 3½-inch floppy-disk drives</td>
<td>5- by 9-inch CRT, 25 lines by 80 characters</td>
<td>graphics</td>
<td>IBM PC compatible, optional built-in modem and printer</td>
</tr>
<tr>
<td>CP/M-80</td>
<td>64K</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>IBM PC compatible S-100 system bus with 4 expansion slots for peripherals</td>
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<tr>
<td>CP/M-80</td>
<td>64K min., 1 MB max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>Perfect Series</td>
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<tr>
<td>MS-DOS</td>
<td>64K min., 512K max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>7- or 9-inch CRT, 80 characters by 24 lines</td>
<td>color and graphics</td>
<td>IBM PC compatible with optional color CRT</td>
</tr>
<tr>
<td>MS-DOS or CP/M-86</td>
<td>128K min., 512K max.</td>
<td>1 or 2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 25 lines</td>
<td>graphics</td>
<td>IBM PC compatible GSX graphics interpreter, Multimate word processor and an assembler</td>
</tr>
<tr>
<td>CP/M-2.2</td>
<td>64K min., 64K max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 25 lines</td>
<td>n.a.</td>
<td>can link with HiNet local-area network, HiNet electronic mail</td>
</tr>
<tr>
<td>CP/M-2.2</td>
<td>64K min., 64K max.</td>
<td>2 5¼-inch floppy-disk drives, 1 15-megabyte hard-disk drive</td>
<td>9-inch CRT, 60 characters by 25 lines</td>
<td>n.a.</td>
<td>can link with HiNet local-area network, HiNet electronic mail</td>
</tr>
<tr>
<td>Manufacturer/Location</td>
<td>Model</td>
<td>Size (Inches)</td>
<td>Weight</td>
<td>Power Supply</td>
<td>Price</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------</td>
<td>---------------</td>
<td>--------</td>
<td>--------------</td>
<td>-------</td>
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<tr>
<td>Dynalogic Info-Tech</td>
<td>Hyperion</td>
<td>16¼ by 11¾ by 8¼</td>
<td>18 lbs.</td>
<td>120 or 240V AC</td>
<td>$3395</td>
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<tr>
<td>Ottawa, Ontario</td>
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<td></td>
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<tr>
<td>Dynalogic Info-Tech</td>
<td>Hyperion Plus</td>
<td>16¼ by 11¾ by 8¼</td>
<td>21 lbs.</td>
<td>120 or 240V AC</td>
<td>$4995</td>
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<tr>
<td>Ottawa, Ontario</td>
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<tr>
<td>Epson America Inc.</td>
<td>Epson HX-20</td>
<td>11½ by 8½ by 1¼</td>
<td>3 lbs., 13 oz.</td>
<td>batteries or AC</td>
<td>$795</td>
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<tr>
<td>Torrance, CA</td>
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<td></td>
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<td></td>
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<tr>
<td>Gavilan Computer Corp.</td>
<td>Gavilan</td>
<td>11½ by 11½ by 2¼</td>
<td>9 lbs.</td>
<td>batteries or AC</td>
<td>$3995</td>
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<tr>
<td>Campbell, CA</td>
<td>Computer</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>GRID Systems</td>
<td>Compass</td>
<td>11½ by 15 by 2</td>
<td>10 lbs., 12½ oz.</td>
<td>110 or 220V AC</td>
<td>$9210</td>
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<tr>
<td>Mountain View, CA</td>
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<td></td>
<td></td>
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<tr>
<td>Hewlett-Packard</td>
<td>HP-75C</td>
<td>1¼ by 5 by 10</td>
<td>26 oz.</td>
<td>batteries or AC</td>
<td>$995</td>
</tr>
<tr>
<td>Palo Alto, CA</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Jonos Anaheim, CA</td>
<td>Escort C1100</td>
<td>17½ by 13¼ by 7¾</td>
<td>25 lbs.</td>
<td>110 or 220V AC</td>
<td>$3995</td>
</tr>
<tr>
<td>Escort C2100</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Management Techniques</td>
<td>Escort</td>
<td>7½ by 17¼ by 13¼</td>
<td>25 lbs.</td>
<td>AC</td>
<td>$3995</td>
</tr>
<tr>
<td>Inc. Boston, MA</td>
<td>Assistant</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Techniques</td>
<td>Escort</td>
<td>7½ by 17¼ by 13¼</td>
<td>25 lbs.</td>
<td>AC</td>
<td>$5595</td>
</tr>
<tr>
<td>Inc. Boston, MA</td>
<td>Administrator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro Source New</td>
<td>M6000P-Voyager</td>
<td>17 by 20 by 7</td>
<td>32 lbs.</td>
<td>120 or 220V AC</td>
<td>$3900</td>
</tr>
<tr>
<td>Lebanon, OH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modular Computer</td>
<td>Zorba 2000</td>
<td>17½ by 5 by 9</td>
<td>21 lbs.</td>
<td>AC</td>
<td>$1995</td>
</tr>
<tr>
<td>Systems Inc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zorba 2000/4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$2495</td>
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<tr>
<td>Operating System</td>
<td>RAM Memory Min./Max.</td>
<td>Mass Storage Type, Size</td>
<td>Display Type, Size</td>
<td>Color or Graphics</td>
<td>Software Included</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------</td>
<td>-------------------------</td>
<td>-------------------</td>
<td>------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>MS-DOS</td>
<td>256K min., 256K max.</td>
<td>5¼-inch floppy-disk drive</td>
<td>7-inch CRT, 80 characters by 25 lines</td>
<td>graphics</td>
<td>Microsoft BASIC</td>
</tr>
<tr>
<td>MS-DOS</td>
<td>256K min., 256K max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>7-inch CRT, 80 characters by 25 lines</td>
<td>graphics</td>
<td>Microsoft BASIC, Multiplan, Inscribe, Intouch</td>
</tr>
<tr>
<td>n.a.</td>
<td>16K min., 32K max.</td>
<td>microcassettes, 35K/side</td>
<td>LCD, 20 characters by 4 lines</td>
<td>graphics</td>
<td>Skirwriter word-processing program in ROM</td>
</tr>
<tr>
<td>MS-DOS</td>
<td>80K min., 336K max.</td>
<td>3-inch microfloppy-disk drive</td>
<td>LCD, 60 characters by 8 lines</td>
<td>n.a.</td>
<td>optional word-processing</td>
</tr>
<tr>
<td>INGRID (proprietary) or MS-DOS</td>
<td>256K min., 256K max.</td>
<td>348K nonvolatile bubble memory</td>
<td>6-inch ELD, 80 characters by 24 lines</td>
<td>graphics</td>
<td>GRID-PLAN, -PLOT, -FILE, -TERM, -WRITE</td>
</tr>
<tr>
<td>proprietary</td>
<td>16K min., 24K max.</td>
<td>magnetic card, n.a.</td>
<td>LCD, 32 characters by 1 line</td>
<td>text editor, time of day, scheduler, optional HP-IL interface loop for printer, digital cassette drive, and CRT adapter</td>
<td></td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 128K max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 25 lines</td>
<td>n.a.</td>
<td>BASIC-80, Multi-Plan, Spellchecker</td>
</tr>
<tr>
<td>CP/M</td>
<td>128K min., 128K max.</td>
<td>2 3½-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 25 lines</td>
<td>n.a.</td>
<td>(see above)</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 64K max.</td>
<td>2 3½-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>BASIC-80</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 64K max.</td>
<td>2 3½-inch 10-Mb hard-disk drives</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>(see above)</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 512K max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>BASICZ, Wordstar, Calcstar, Mailmerge, Spellstar, Superfile, Archivist, 6 expansion slots</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 320K max.</td>
<td>5¼-inch floppy-disk drive, DS/DD</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>word processor, spelling checker, spreadsheet, database manager mailing list, and CBASIC</td>
</tr>
</tbody>
</table>
| CP/M             | 64K min., 320K max. | 2 5¼-inch floppy disk drives, DS/DD | 9-inch CRT, 80 characters by 24 lines | n.a. | (see above) | optional 8088 coprocessor and internal 300- to 1200-bps modem; can read, write, and format disks for 30 different microcomputers.
<table>
<thead>
<tr>
<th>Manufacturer/Location</th>
<th>Size (Inches)</th>
<th>Weight</th>
<th>Power Supply</th>
<th>Price</th>
<th>Type of Microprocessor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modular Computer Systems Inc. Ft Lauderdale, FL Zorba 2000/8</td>
<td>17½ by 5 by 9</td>
<td>21 lbs.</td>
<td>AC</td>
<td>$2495</td>
<td>Z80A</td>
</tr>
<tr>
<td>Modular Computer Systems Inc. Ft Lauderdale, FL Zorba 2000/16</td>
<td>17½ by 5 by 9</td>
<td>21 lbs.</td>
<td>AC</td>
<td>$2995</td>
<td>Z80A, 8088</td>
</tr>
<tr>
<td>NEC Electronics Chicago, IL PC-8201</td>
<td>11½ by 8½ by 2½</td>
<td>3.8 lbs.</td>
<td>batteries or AC</td>
<td>$675</td>
<td>80C85</td>
</tr>
<tr>
<td>Non-Linear Systems Solana Beach, CA Kaypro II</td>
<td>19 by 16 by 8</td>
<td>26 lbs.</td>
<td>110 or 220V AC</td>
<td>$1595</td>
<td>Z80A</td>
</tr>
<tr>
<td>Non-Linear Systems Solana Beach, CA Kaypro 4</td>
<td>19 by 16 by 8</td>
<td>26 lbs.</td>
<td>110 or 220V AC</td>
<td>$1995</td>
<td>Z80A</td>
</tr>
<tr>
<td>Non-Linear Systems Solana Beach, CA Kaypro 10</td>
<td>19 by 16 by 8</td>
<td>27 lbs.</td>
<td>110 or 220V AC</td>
<td>$2795</td>
<td>Z80A</td>
</tr>
<tr>
<td>Olympia USA Inc. Somerville, NJ Portable Computer OL-004</td>
<td>1¼ by 9 by 3¾</td>
<td>21 oz.</td>
<td>batteries or AC</td>
<td>$380</td>
<td>proprietary</td>
</tr>
<tr>
<td>Olympia USA Inc. Somerville, NJ Portable Computer OL-0008</td>
<td>1½ by 9 by 3¾</td>
<td>21 oz.</td>
<td>batteries or AC</td>
<td>$480</td>
<td>proprietary</td>
</tr>
<tr>
<td>Osborne Computer Corp. Hayward, CA The Executive</td>
<td>20½ by 13 by 9</td>
<td>28 lbs.</td>
<td>AC</td>
<td>$2495</td>
<td>Z80A</td>
</tr>
<tr>
<td>Osborne Computer Corp. Hayward, CA Executive II</td>
<td>20½ by 13 by 9</td>
<td>28 lbs.</td>
<td>AC</td>
<td>$3195</td>
<td>8088</td>
</tr>
<tr>
<td>Osborne Computer Corp. Hayward, CA Osborne 1</td>
<td>20½ by 14½ by 8½</td>
<td>23 lbs., 8 oz.</td>
<td>AC</td>
<td>$1795</td>
<td>Z80A</td>
</tr>
<tr>
<td>Otrona Corp. Boulder, CO Attache</td>
<td>12 by 13½ by 5¼</td>
<td>18 lbs.</td>
<td>120 or 220V AC</td>
<td>$3995</td>
<td>Z80A</td>
</tr>
<tr>
<td>Panasonic Co. Secaucus, NJ Hand-Held Computer RL-H1800</td>
<td>1 by 9 by 3</td>
<td>21.9 oz.</td>
<td>batteries or AC</td>
<td>$380</td>
<td>proprietary</td>
</tr>
<tr>
<td>Panasonic Co. Secaucus, NJ JR-800</td>
<td>10½ by 5½ by 1½</td>
<td>1 lb., 1 oz.</td>
<td>batteries or AC</td>
<td>$499.95</td>
<td>80C85</td>
</tr>
<tr>
<td>Operating System</td>
<td>RAM Memory Min./Max.</td>
<td>Mass Storage Type, Size</td>
<td>Display Type, Size</td>
<td>Color or Graphics Included</td>
<td>Software Included</td>
</tr>
<tr>
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</tr>
<tr>
<td>CP/M</td>
<td>64K min., 320K max.</td>
<td>2 5⅛-inch floppy-disk drives, DS/QD</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>word processor, spelling checker, spreadsheet, database manager, mailing list and CBASIC optional 8088 co-processor and internal 300- to 1200-bps modem, can read other disk formats.</td>
</tr>
<tr>
<td>CP/M, CP/M-86, MS-DOS</td>
<td>64K min., 512K max.</td>
<td>2 5⅛-inch floppy-disk drive, DS/QD</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>(see above) optional internal 300- to 1200-bps modem; can read other disk formats.</td>
</tr>
<tr>
<td>proprietary</td>
<td>16K min., 64K max.</td>
<td>cassette n.a.</td>
<td>LCD, 40 characters by 8 lines</td>
<td>n.a.</td>
<td>built-in text processor and communication software optional 32K bubble memory cartridge</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 64K max.</td>
<td>2 5⅛-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>MBASIC, SBASIC, Profitplan, Perfect-Writer, -Speller, -Calc, -Filer</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 64K max.</td>
<td>2 5⅛-inch floppy-disk drives, DS/QD</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>MBASIC, SBASIC, Profitplan, Perfect-Writer, -Speller, -Calc, -Filer</td>
</tr>
<tr>
<td>proprietary</td>
<td>4K min., 4K max.</td>
<td>n.a.</td>
<td>LCD, 26 characters by 1 line</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>proprietary</td>
<td>8K min., 8K max.</td>
<td>n.a.</td>
<td>LCD, 26 characters by 1 line</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>CP/M, UCSD Pascal</td>
<td>128K min., 256K max.</td>
<td>2 5⅛-inch floppy-disk drives (with coprocessor)</td>
<td>7-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>Wordstar, Mailmerge, Supercalc, Personal Pearl, CBASIC, MBASIC (see above) IBM PC compatible</td>
</tr>
<tr>
<td>MS-DOS, CP/M-86, UCSD Pascal</td>
<td>256K min., 384K max.</td>
<td>2 5⅛-inch floppy-disk drives</td>
<td>7-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>CBASIC, MBASIC, Wordstar, Mailmerge, Supercalc optional double-density disk drives</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 64K max.</td>
<td>2 5⅛-inch floppy-disk drives</td>
<td>5⅜-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>graphics BASIC-80, Wordstar Plus, Charton, Valet modular construction allows 1-hour repair</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 156K max.</td>
<td>2 5⅛-inch floppy-disk drives</td>
<td>5⅜-inch CRT, 80 characters by 24 lines</td>
<td>graphics</td>
<td>BASIC-80, Wordstar Plus, Charton, Valet modular construction allows 1-hour repair</td>
</tr>
<tr>
<td>n.a.</td>
<td>8K min., 8K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 26 characters by 1 line</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>proprietary</td>
<td>16K min., 24K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 32 characters by 8 lines</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Manufacturer/Location</td>
<td>Model</td>
<td>Size (Inches)</td>
<td>Weight</td>
<td>Power Supply</td>
<td>Price</td>
</tr>
<tr>
<td>-----------------------</td>
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<td>-----------------</td>
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</tr>
<tr>
<td>Peripheral Systems</td>
<td>Eagle</td>
<td>18 by 17 1/4 by 8</td>
<td>18 lbs.</td>
<td>110 or 220V AC</td>
<td>$3495</td>
</tr>
<tr>
<td>Quasar Franklin Park, IL</td>
<td>Quasar Hand-Held Computer</td>
<td>3 1/4 by 8 1/4 by 1 1/4</td>
<td>14 oz.</td>
<td>batteries or AC</td>
<td>$329</td>
</tr>
<tr>
<td>Radio Shack Fort Worth, TX</td>
<td>PC 1</td>
<td>6 1/4 by 2 1/4 by 1 3/16</td>
<td>6 oz.</td>
<td>batteries or AC</td>
<td>$149.95</td>
</tr>
<tr>
<td>Radio Shack Fort Worth, TX</td>
<td>PC 2</td>
<td>7 1/4 by 3 1/4 by 1 1/4</td>
<td>1 lb.</td>
<td>batteries or AC</td>
<td>$199.95</td>
</tr>
<tr>
<td>Radio Shack Fort Worth, TX</td>
<td>TRS-80 Model 100</td>
<td>11 1/4 by 6 1/2 by 2</td>
<td>4 lbs.</td>
<td>batteries or AC</td>
<td>$799</td>
</tr>
<tr>
<td>Sarasota Automation</td>
<td>Husky</td>
<td>9 1/8 by 8 by 1 1/4</td>
<td>4.5 lbs.</td>
<td>batteries or AC</td>
<td>$2995</td>
</tr>
<tr>
<td>Seequa Computer</td>
<td>Chameleon</td>
<td>16 by 15 1/2 by 8</td>
<td>28 lbs.</td>
<td>110 or 220V AC</td>
<td>$1995</td>
</tr>
<tr>
<td>Sharp Electronics Corp. Paramus, NJ</td>
<td>PC-1250</td>
<td>5 3/16 by 2 3/4 by 3/16</td>
<td>4 oz.</td>
<td>batteries or AC</td>
<td>$110</td>
</tr>
<tr>
<td>Sharp Electronics Corp. Paramus, NJ</td>
<td>PC-1500</td>
<td>7 3/4 by 1 by 3 3/16</td>
<td>2 lbs.</td>
<td>batteries or AC</td>
<td>$300</td>
</tr>
<tr>
<td>Sharp Electronics Corp. Paramus, NJ</td>
<td>PC-5000</td>
<td>12 1/4 by 12 by 3 3/16</td>
<td>11 lbs.</td>
<td>batteries or AC</td>
<td>$2995</td>
</tr>
<tr>
<td>SKS Computers Inc.</td>
<td>SKS 2502 Nano</td>
<td>15 3/16 by 18 1/4 by 6 1/2</td>
<td>30 lbs.</td>
<td>AC</td>
<td>$2495</td>
</tr>
<tr>
<td>SKS Computers Inc.</td>
<td>SKS 252 Pico</td>
<td>15 3/16 by 18 1/4 by 6 1/2</td>
<td>22 lbs.</td>
<td>AC</td>
<td>$2495</td>
</tr>
<tr>
<td>SMC Corp. Atlanta, GA</td>
<td>Compucase</td>
<td>5 1/2 by 18 by 13</td>
<td>25 lbs.</td>
<td>AC</td>
<td>$7995</td>
</tr>
<tr>
<td>SORD Computer Tokyo Japan</td>
<td>M23P</td>
<td>17 1/4 by 15 3/16 by 5 3/16</td>
<td>16 lbs.</td>
<td>110 or 220V AC</td>
<td>$2595</td>
</tr>
<tr>
<td>STM Electronics Corp.</td>
<td>Pied Piper I</td>
<td>20 1/4 by 10 3/4 by 4</td>
<td>11 lbs.</td>
<td>115 or 230V AC</td>
<td>$1299</td>
</tr>
<tr>
<td>Operating System</td>
<td>RAM Memory Min./Max.</td>
<td>Mass Storage Type, Size</td>
<td>Display Type, Size</td>
<td>Color or Graphics</td>
<td>Software Included</td>
</tr>
<tr>
<td>------------------</td>
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</tr>
<tr>
<td>CP/M</td>
<td>64K min., 156K max.</td>
<td>2 3½-inch floppy-disk drives</td>
<td>7-inch CRT, 60 characters by 24 lines</td>
<td>graphics</td>
<td>electronic spreadsheet, spelling checker, word processor, inventory control</td>
</tr>
<tr>
<td>n.a.</td>
<td>2K min., 8K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 32 characters by 1 line</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>n.a.</td>
<td>1.9K min., 1.9K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 24 characters by 1 line</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>n.a.</td>
<td>2.6K min., 16K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 26 characters by 1 line</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>proprietary</td>
<td>8K min., 32K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 40 characters by 8 lines</td>
<td>n.a.</td>
<td>built-in text editor, scheduler, address handler, and communications program</td>
</tr>
<tr>
<td>CP/M</td>
<td>16K min., 144K max.</td>
<td>n.a.</td>
<td>LCD, 32 characters by 4 lines</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>MS-DOS or CP/M-86</td>
<td>128K min., 700K max.</td>
<td>2 5½-inch floppy-disk drives</td>
<td>9-inch CRT, 80 characters by 25 lines</td>
<td>graphics</td>
<td>MBASIC, Perfect-Writer, -Calc</td>
</tr>
<tr>
<td>n.a.</td>
<td>2.2K min., 2.2K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 24 characters by 1 line</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>n.a.</td>
<td>16K min., 20K max.</td>
<td>cassette, n.a.</td>
<td>LCD, 26 characters by 1 line</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>MS-DOS</td>
<td>128K min., 256K max.</td>
<td>128K bubble-memory cartridge</td>
<td>LCD, 80 characters by 8 lines</td>
<td>graphics</td>
<td>word processing, electronic spreadsheet, database manager and scheduler</td>
</tr>
<tr>
<td>CP/M</td>
<td>60K min., 60K max.</td>
<td>2 5½-inch floppy-disk drives</td>
<td>5- by 9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>Perfect Series</td>
</tr>
<tr>
<td>CP/M</td>
<td>80K min., 80K max.</td>
<td>2 3½-inch floppy-disk drives</td>
<td>5- by 9-inch CRT, 80 characters by 24 lines</td>
<td>n.a.</td>
<td>Perfect Series</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 64K max.</td>
<td>5½-inch floppy-disk drive</td>
<td>gas plasma, 50 characters by 12 lines</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>CP/M 3.0</td>
<td>128K min., 128K max.</td>
<td>2 3½-inch floppy-disk drives</td>
<td>LCD, 80 characters by 8 lines</td>
<td>color and graphics</td>
<td>SORD BASIC, PIPS</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 128K max.</td>
<td>5½-inch floppy-disk drive</td>
<td>n.a.</td>
<td>graphics</td>
<td>Perfect-Writer, -Speller, -Calc, -Filer</td>
</tr>
<tr>
<td>Manufacturer/Location</td>
<td>Model</td>
<td>Size (Inches)</td>
<td>Weight</td>
<td>Power Supply</td>
<td>Price</td>
</tr>
<tr>
<td>------------------------------</td>
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<td>--------</td>
</tr>
<tr>
<td>Sunrise Systems Inc. Carrolltown, TX</td>
<td>KP-C8</td>
<td>16 by 9 by 2</td>
<td>4½ lbs.</td>
<td>batteries or AC</td>
<td>approx. $2000</td>
</tr>
<tr>
<td>Teleram Communications White Plains, NY</td>
<td>Teleram 3000</td>
<td>13 by 9½ by 3½</td>
<td>8 lbs., 13 oz.</td>
<td>Built-in rechargeable 12-V battery (5-10 hrs.)</td>
<td>$2995</td>
</tr>
<tr>
<td>Televideo Systems Inc. Sunnyvale, CA</td>
<td>Teletoe I</td>
<td>18 by 8 by 15</td>
<td>23 lbs.</td>
<td>AC</td>
<td>$1499</td>
</tr>
<tr>
<td>Texas Instruments Inc. Lubbock, TX</td>
<td>CC-40</td>
<td>9½ by 5½ by 1</td>
<td>22 oz.</td>
<td>batteries or AC</td>
<td>$249.95</td>
</tr>
<tr>
<td>Toshiba America Inc. Tustin, CA</td>
<td>T100</td>
<td>16½ by 4 by 11</td>
<td>n.a.</td>
<td>AC</td>
<td>$1995</td>
</tr>
<tr>
<td>Universal Data Inc. Clarkston, MI</td>
<td>UDI-500</td>
<td>11 by 13 by 3¼</td>
<td>12 lbs., 13 ozs.</td>
<td>batteries or AC</td>
<td>$3995</td>
</tr>
</tbody>
</table>

But the advantages of the CRT outweigh the disadvantages. First, it is a luminescent display—it produces light. Therefore, it can be used under poor lighting conditions. Second, it is extremely flexible. Given a monitor with sufficient resolution, you can display any type of image upon it, including color, such as with the Commodore Executive 64. Finally, there's enough software available to take advantage of that flexibility.

The second most popular form of display is the small, lightweight LCD, which usually requires little power and is relatively immune to damage. One disadvantage is that an LCD's response time is slower than that of a CRT display in terms of speed required to write and erase a character on the display. Additionally, the LCD bit-mapped graphics are at best crude because the individual pixels (picture elements) aren't small enough to give sharp definition. And at temperatures below freezing, the LCDs may slow down even more or stop altogether.

The Sharp PC-5000 has the largest LCD currently available on a portable computer, 8 lines by 80 characters (see photo 2). Whether such a display is large enough for effective work is a matter of personal taste. Portable computers with a 1-line display are minimally usable. The HP-75 has a 1-line by 32-character display. The Epson HX-20 (see photo 3) has 4 lines by 20 characters. The Radio Shack Model 100 has an 8-line by 40-character display. You can work with all of these displays, but they are only a fraction of the size of a standard CRT display of 80 characters by 24 lines. You should carefully consider the display size in terms of your particular application and choose the portable that best fits your needs. Word processing on a 4-line display is awkward at best.

Finally, the new ELD and gas-plasma display technologies provide still another choice. ELDs use a chemical coating and a wire grid placed between two glass plates. The chemical coating emits light when an AC voltage is applied to the wires. Alphanumeric characters can be formed by applying the voltage to the correct sequence of wires. The gas-plasma display is similar to the ELD except that a gas fills the space between the two plates. The Grid Compass computer has an ELD screen.

ELDs combine the advantages of the CRT and the LCD. They can display a full 80 characters by 24 lines, offer good bit-mapped graphics resolution, and their flat shape makes them ideal for portable applications. The only disadvantage is that both their price and power consumption exceed the level of other displays. For now, field testing will have to determine whether the electroluminescent and gas-plasma displays are economical and reliable enough to replace the CRT display for portable computers.

**Data Storage**

Developments in data-storage technology have enabled portable computer users to take their data along
<table>
<thead>
<tr>
<th>Operating System</th>
<th>RAM Memory Min./Max.</th>
<th>Mass Storage Type, Size</th>
<th>Display Type, Size</th>
<th>Color or Graphics</th>
<th>Software Included</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>proprietary</td>
<td>80K min., 144K max.</td>
<td>microcassette, 512K</td>
<td>LCD, 40 characters by 6 lines or 80 characters by 3 lines</td>
<td>color and graphics</td>
<td>built-in word processing, calendar, communications, and auto-dialer</td>
<td>optional flat-pack expansion box for 8088 microprocessor and floppy-disk drives</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 64K max.</td>
<td>256K nonvolatile bubble memory</td>
<td>LCD, 80 characters by 4 lines</td>
<td>n.a.</td>
<td>Teletalk communications program</td>
<td>optional portable disk drive can read Apple, Osborne, and IBM formats; optional office station with CRT, disk drive, and 8 ports</td>
</tr>
<tr>
<td>CP/M</td>
<td>64K min., 160K max.</td>
<td>5¼-inch floppy-disk drive</td>
<td>9-inch CRT, 80 characters by 24 lines</td>
<td>graphics</td>
<td>Wordstar, Visicalc</td>
<td>includes mouse port</td>
</tr>
<tr>
<td>proprietary</td>
<td>6K min., 16K max.</td>
<td>n.a.</td>
<td>LCD, 31 characters by 1 line</td>
<td>n.a.</td>
<td>22 applications packages</td>
<td>optional plotter, printer, and stringy-floppy drive</td>
</tr>
<tr>
<td>CP/M</td>
<td>32K min., 64K max.</td>
<td>2 5¼-inch floppy-disk drives</td>
<td>LCD, 40 characters by 8 lines</td>
<td>graphics and color</td>
<td>Word Right word-processing package</td>
<td>optional CRT display</td>
</tr>
<tr>
<td>CP/M, Micro DOS</td>
<td>64K min., 256K max.</td>
<td>2 3½-inch floppy-disk drives</td>
<td>LCD, 40 characters by 8 lines</td>
<td>n.a.</td>
<td>Vedit text processor and communications package</td>
<td>built-in 300-bps modem and card slot for use with RCA CMOS microboards</td>
</tr>
</tbody>
</table>

with them. The newer half-height 5¼-inch and 3½-inch floppy-disk drives have as much storage capacity as the older 8-inch drives. Hard disks are also becoming portable. For example, the Kaypro-10 has a built-in 10-megabyte hard-disk drive. Some portables feature bubble-memory cartridges for convenient long-term data storage.

Memory is the working medium of any computer, and portables are no exception. Yet portables, because they incorporate the latest technology, offer more memory options than standard desktop computers. You can have a portable with CMOS RAM, bubble-memory cartridges, mini- or micro-floppy-disk drives, or hard disks. Each option has its own particular advantages and disadvantages.

CMOS memory is widely used in briefcase computers because of its

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Photo 2: The flip-up 80-character by 8-line LCD screen on the Sharp PC-5000 is only one-third the size of a standard CRT screen.
low power consumption. The recent improvement in chip-manufacturing technology has lowered the price and increased the performance of these memory devices. CMOS chips are still slower in operation than corresponding TTL (transistor-transistor logic) memory devices, but their speed is improving. In actual use the speed of a CMOS memory chip does not adversely affect the operation of a portable computer.

Bubble-memory cartridges have been around for a while but haven't been widely used because of their high price. But, like CMOS memory, their price is dropping and their use is increasing, especially for the briefcase computers. Bubble-memory cartridges offer several advantages over other storage media such as floppy disks. They operate like a floppy-disk drive but much faster; they have no moving parts and no disk-drive head to move from track to track. Data is stored in the cartridge as a pattern of magnetic bubbles, and when the cartridge is removed or power fails, the stored data is retained. The cartridges do not require an auxiliary battery to retain data. They require very little power to operate and are much more rugged than conventional floppy disks.

Floppy disks are still very much the medium of choice for people who work with portable computers. They are widely used, dependable, and have a broad base of available software. With the introduction of half-height and microfloppy-disk drives, floppy disks remain the primary data-storage medium. The disadvantages of floppy disks include occasional incompatible recording formats for 5¼-inch disks and the confusing differences between the various standards for the microfloppy-disk drives.

Before buying a portable or transportable computer, find out if it can read and write to disks from other computers. The Kaypro II (see photo 4), for example, can read and write to disks created with a Xerox 820-II. And the Kaypro Users Group has software available that will enable the Kaypro II to read other disk formats.

Rather than carry a lot of floppy disks, you can opt for a portable with a built-in hard-disk drive. Portables such as the Kaypro-10 (see photo 5) with its 10-megabyte hard disk and the Starlite HD20 (see photo 6) with its 20-megabyte hard disk can serve users with very large data-storage needs. Both have a staggering amount of storage for a portable computer system and can handle almost any application.

Hard-disk-drive manufacturers have studied the typical environment of a portable computer and have developed drives that have special shock mountings and head-positioning controls to withstand shock and vibration. For example, both the Kaypro-10 and the Starlite HD20 have utility programs to position the read/write head in a "safety zone" on the disk that is isolated from the data tracks; if a head crash occurs while the computer is in transit, you will probably be able to recover your data. In addition, the read/write heads have been redesigned to be lighter and less prone to shock.

Hard-disk drives are an expensive option, but their price is dropping. However, they are heavier than floppy-disk drives and consume more power because the disk is constantly spinning while it's on. Another potential problem is the possibility of data loss due to a head crash. This occurrence is more serious with a hard disk loaded with great quantities of data than for a set of floppy disks.

For most of the transportable computers that use the Z80 micropro-
With its 10-megabyte hard disk preloaded with the bundled software, the Kaypro-10 can store 50 disks' worth of information.

The Starlite HD 20 offers a staggering 20 megabytes of storage in a portable computer.

But don't let the lure of bundled software sway your decision on which portable computer to buy. You may not like a particular software package that is included with the portable computer you choose. Selecting software is sometimes a very subjective decision. The software and hardware must combine to meet your needs. If they don't do what you need, you shouldn't buy them.

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When considering the purchase of a portable computer, ask yourself one more question, "Where do I need a computer most?" Do you really need a heavy-duty CP/M system that can be transferred from the office to home? Or do you need a computer that can go on the road for data collection in the field? You may be the ultimate computer junkie who likes to work in pajamas in bed at 2 o'clock in the morning. Your ideal working environment is critical in your choice of a computer.

**Summary**

Choosing a portable computer isn't easy. The number of portables and the variety of available features make the choice a tough one. But with the right background and some in-depth research, you'll be able to find one that suits your needs.

Stanley J. Wszola is a BYTE technical editor.
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High-IQ Modems

A new generation of intelligent modems lets users concentrate on applications rather than on modem-interfacing details

by Stephen Durham

With the incorporation of sophisticated microcomputers, high-density RAMs, and advanced communications ICs, the so-called dumb modem is being replaced by a new generation of intelligent modems. These modems not only offer features that enhance data-communications applications, but also can determine the parameters of the systems in which they're installed and adjust their operation to meet system requirements. Some models, for example, can learn such system specifications as a host computer's bit speed and parity and set their own operation accordingly.

The high degree of "intelligence" contained in this new generation of modems allows telephone links between computers to be operated virtually unattended. This capability makes possible a wide range of new telecommunications applications, including electronic mail, central-data-base access, remote diagnostics, and remote-peripheral sharing.

The level of intelligence incorporated into modems determines their ability to disappear into the background of your computer system and to provide unattended communications capability.

By and large, while most of these new-generation high-IQ modems provide such features as automatic dialing, automatic answering, and automatic disconnecting, they do not take full advantage of the advanced microprocessor and memory technologies with which they are built. Largely ignored are a wide range of what can be called "system configuration" problems, which result from differing transmission proto-
Circle 21 on Inquiry card.

COLS, differing modem bit rates, lack of automatic dial-mode selection, conflicting parity states, and the lack of any means of testing the computer, the modems, or the transmission line to determine where potential failures could occur.

The traditional solution to system-configuration problems has been no solution at all. Hence, the user has been left to take care of all those nasty little details by either tweaking the hardware or reconfiguring specific application programs. In neither case is the modem operating procedure transparent to the user.

How well intelligent modems perform system-configuration functions depends not so much on how sophisticated and advanced the built-in microprocessor is or on how advanced the applications software used by the computer to operate the modem is but on the efficiency and cleverness of the modem's firmware design. In other words, the degree to which a modem performs such functions depends on how transparent its implementation can be made to the user by incorporating functions into the internal operation of the modem itself.

While the price difference between a dumb modem and an intelligent modem is still substantial, it is much less so between a moderately intelligent modem and one with a maximum of transparency. That's because the ability of an intelligent modem to perform is not a function of how much expensive and sophisticated electronics hardware it uses but of how much thought has gone into its overall design and into the internal firmware instructions that tell the microprocessor what to do. To determine a modem's IQ and therefore how easily it can be integrated into a data-communications system, you can examine its ability to handle auto-dial, auto-answer, and auto-disconnect operation as well as automatic system-configuration tasks.

Auto-Dial Operation

First, consider modem auto-dial operation, which is much more complex than simple automatic generation of dial tones or rotary-dial pulses. The modem must resolve all of the call-failure conditions that commonly exist when dialing to allow its host to make efficient use of the communications facility. Common call-failure features include line busy, no modem-answer tone, voice answer, no answer (constant ringing), no dial tone, and inability to break dial tone.

These functions are roughly equivalent to the functions of an operator making a call, including lifting the telephone handset, waiting for the correct dial tone or tones, dialing the dialed number, and possibly redialing later if the number is busy or if the call has not been answered after a reasonable length of time, and hanging up the handset at the end of the completed call.

When properly implemented, the auto-dial feature dramatically increases line utilization.

Auto-Answer Operation

When integrated into a modem, an auto-answer feature enables the modem to be placed in the answer mode automatically upon receipt of a telephone-line ringing signal. A modem with this feature makes it possible for data transmission to occur between a remote terminal and a computer or another terminal interfaced to a modem with auto-answer capability without operator intervention at the receiving end. A modem with auto-answer capability is also useful in timesharing installations where a large calling population calls a number of computer dial-in lines on a random basis.

Auto-Disconnect Operation

An auto-disconnect feature permits a modem to either disconnect if a carrier signal is not maintained after a data call has been set up or upon command from the host computer. This feature is useful in preventing the tie-up of expensive computer facilities due to such things as wrong-number calls, failure of the distant party to disconnect from a timesharing system, or line failures.
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- SL Shaw Labs

Circle 310 on inquiry card.
Automatic System Configuration

What good is a highly intelligent modem if its installation into the host terminal or computer system is unmanageable or difficult? While it's not absolutely essential in an intelligent modem, automatic system configuration does make such devices much easier to use. And incorporating this capability into the modem does not add significantly to its cost.

It is not uncommon to encounter computer- or modem-option incompatibilities during installation. Such parameters as serial speed, data bits per word, parity, and stop bits per word can initially have settings that prohibit data transmission through the modem. An installer can, of course, get out the users manuals of all the equipment involved and, through a detailed process of positioning option straps on each machine, effect a compatible installation. Many times, however, determining the specific parameters that are not aligned can be complex, especially for someone who is not an expert in communications technology.

System-configuration features enable a modem to be installed and used by a nonspecialist in communications, assuring that the modem user can concentrate on data-communication application problems instead of modem compatibility.

A Typical High-IQ Modem

Typical of the more advanced "high-IQ" modems now becoming available is Cermetek's Info-Mate 212A, shown in photo 1. This modem's architecture bears a strong superficial resemblance to others now on the market.

Where it does differ, however, is in the nature of the instructions incorporated into its firmware. As shown in table 1, this 212-type intelligent modem incorporates not only the standard automatic dial, answer, and disconnect features but a wide range of system-configuration enhancements as well. All of these features may not be necessary for any one application, but the degree to which they are implemented in a modem is a good indicator of how much thought and design went into the modem.

The Info-Mate modem automatically selects tone- or pulse-dialing, as shown in figure 1. Tone-dialing is preferred, but if it is not accepted by the local telephone equipment, the modem falls back to pulse-dialing. After dialing is completed, the modem monitors the following call-progress conditions and reports them back to the host data terminal or computer over the serial RS-232C link: dial tone, busy tone, ring-back tone, modem-answer tone, and voice. Each call-progress signal detected is indicated to the host through a serial status message.

The host can direct control over the selection of pulse- or tone-dialing through the DIAL command. Call-progress monitoring can also be deleted under host-command control, which enables the modem to auto-dial on telephone systems that use nonstandard call-progress tones. This method of dialing is generally referred to as "blind" dialing, but a more accurate term would be "deaf" dialing. In either the automatic or blind-dialing modes, the modem supports the following dialing pro-
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The Info-Mate automatically adapts to the host's speed (110, 300, or 1200 bps) and parity (odd, even, mark, and space) using a simple training sequence. To train the modem, you must send the sequence "XY. The modem uses the trained speed to originate calls at either 110, 300, or 1200 bps. On answering calls, the modem automatically adapts to the transmitting modem's speed but sends a serial change-speed status code to the host at the old speed before switching.

Command Structure Is the Key

Key to an intelligent modem's ability to protect the user from the dirty details of its operation is its command structure, or its ability to interpret commands from the host. In this context, the Info-Mate supports 16 different host commands (see Table 2), each of which is preceded by a single command character <com>. Each command line is terminated by a carriage return <CR>. Multiple commands can be placed on one line and separated by commas. Table 3 describes the commands available.

Each command consists of the command character followed by the command word, a delimiter, all arguments, and then the closing carriage return or comma. The maximum length of any command line, however, is 40 characters. Two examples of commands include the following:

```
<com> DIAL '(408) 996-1010'
<CR>
```

```
<com> DIAL '(408) 996-1010',
QUERY <CR>
```

In both cases, the notation <com> is equivalent to the single command character. The delimiter separating the command from the arguments is always a space. Only the first character of the command is significant. All remaining characters are ignored up to the first space following the command. In other words, DIAL and DANCE are treated identically by the command interpreter. Both uppercase and lowercase characters are accepted. You can transmit the command character itself by sending it twice in a row—<com><com>—if...
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Dialing Command Variations

There are five basic variations of the dialing command: dial last, dial immediate, dial-immediate alternate, dial from memory, and dial-from-memory alternate. All dialing commands can initiate either DTMF or rotary-pulse dialing.

Each dialing variation refers to a number string as a source for the number to be dialed. For immediate-type dialing commands, the number string is supplied with the command, whereas the dial-last- and dial-from-memory-type commands refer to number strings previously entered into the modem.

Along with the telephone digits, the number string can contain con-
trol characters that direct the Info-Mate to dial adaptively or interpretively using tone- or pulse-dialing. Pause or wait characters can also be inserted that enable tandem dialing through PBXs or carrier facilities such as MCI or SPRINT. Table 5 shows the characters allowed in the number string. Table 6 shows some typical number strings.

After a dialing command is given to the Info-Mate, it interprets the appropriate number string to determine how the dialing process should proceed. As the number is dialed, the dialed number string is returned to the host in the form of a status message:

```
<com> <NUMBER> <LF> <CR>
```

This message enables the host to follow the progress of the number dialed.

During the dialing process, if the modem is directed to pause and wait for the dial tone, and if the tone is not found after 5 seconds, the modem aborts the call, returning a number string that terminates with the failed-pause-for-dial-tone character. In addition to this character, a NO DIAL TONE status is returned:

```
<com> <TERMINATED NUMBER STRING> <LF> <CR>
<com> X <LF> <CR>
```

After a call has been successfully dialed, the modem monitors the telephone line for call-progress tones. If the number string is terminated with a Z, however, the modem takes no further action. Instead, the modem is left OFF HOOK, with its modulator silenced. Employing this OFF-HOOK mode is typically how you would use the modem to initiate a voice call.

**Phone Number Storage**

The modem can store as many as fifty-two 32-character strings, either phone numbers or log-on messages, or a combination of both. Each entry is stored by sending the following command from the host to the modem:

```
<com> X <sp> <LF> <CR>
```

### Table 4: Info-Mate 212A status messages.

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;com&gt;A&lt;LF&gt;&lt;CR&gt;</td>
<td>Data call answered</td>
</tr>
<tr>
<td>&lt;com&gt;B&lt;LF&gt;&lt;CR&gt;</td>
<td>Busy number reached</td>
</tr>
<tr>
<td>&lt;com&gt;D&lt;LF&gt;&lt;CR&gt;</td>
<td>Modern disconnect</td>
</tr>
<tr>
<td>&lt;com&gt;N&lt;LF&gt;&lt;CR&gt;</td>
<td>No answer or command failure</td>
</tr>
<tr>
<td>&lt;com&gt;R&lt;LF&gt;&lt;CR&gt;</td>
<td>RING-BACK tone or ring signal</td>
</tr>
<tr>
<td>&lt;com&gt;V&lt;LF&gt;&lt;CR&gt;</td>
<td>Voice received</td>
</tr>
<tr>
<td>&lt;com&gt;W&lt;LF&gt;&lt;CR&gt;</td>
<td>Modern answer but host is at wrong speed</td>
</tr>
<tr>
<td>&lt;com&gt;Z&lt;LF&gt;&lt;CR&gt;</td>
<td>Command-complete acknowledgment</td>
</tr>
<tr>
<td>&lt;com&gt;&lt;DIALED NUMBER&gt;&lt;LF&gt;&lt;CR&gt;</td>
<td>Command-entry error</td>
</tr>
<tr>
<td>&lt;com&gt;&lt;H,H2&gt;&lt;LF&gt;&lt;CR&gt;</td>
<td>Number dialed</td>
</tr>
</tbody>
</table>

H,H2 represent hexadecimal status of the program register.

### Table 5: Permissible dialing-string characters.

<table>
<thead>
<tr>
<th>Character</th>
<th>Number-String Positions</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0..9</td>
<td>1</td>
<td>Dialed digits</td>
</tr>
<tr>
<td>* and #</td>
<td>1</td>
<td>Dialed digits, tone only</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>Adaptive dialing; pauses for dial tone, then automatically selects tone- or pulse-dialing for the remaining number-string digits. At the beginning of each number string, adaptive dialing is assumed unless otherwise specified.</td>
</tr>
<tr>
<td>T</td>
<td>2</td>
<td>Pauses for dial tone, then dials the remaining digits in the number string using DTMF tones</td>
</tr>
<tr>
<td>P</td>
<td>2</td>
<td>Pauses for dial tone, then dials the remaining digits in the number string using pulse-dialing</td>
</tr>
<tr>
<td>TB</td>
<td>4</td>
<td>Inserts a blind wait of 2 seconds into the dialing sequence without monitoring dial tone, then continues to dial the remaining digits in the number string using DTMF tones</td>
</tr>
<tr>
<td>PB</td>
<td>4</td>
<td>Inserts a blind wait of 2 seconds into the dialing sequence, then continues to dial the remaining digits in the number string using rotary-type pulses</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>Inserts a 2-second pause in the dialing sequence</td>
</tr>
<tr>
<td>O</td>
<td>2</td>
<td>If the number string is terminated with an &quot;O,&quot; only the modem-answer tone is monitored for call-progress after dialing</td>
</tr>
<tr>
<td>Z</td>
<td>2</td>
<td>If placed as the last character in the number string, the modem terminates the dialing command without going into the originate-data call mode. The modem stays OFF HOOK with its modulator silenced</td>
</tr>
<tr>
<td>@</td>
<td>2</td>
<td>Placeholding characters</td>
</tr>
<tr>
<td>&lt;sp&gt;</td>
<td>2</td>
<td>Spaces are illegal</td>
</tr>
</tbody>
</table>

**Table 5: Permissible dialing-string characters.**
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Table 6: Typical dialing commands.

<table>
<thead>
<tr>
<th>Number Strings</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>767-1111</td>
<td>Diaz 767-1111 and adaptively selects tone- or pulse-dialing, if unspecified adaptive dialing is assumed</td>
</tr>
<tr>
<td>T767-1111</td>
<td>Diaz 767-1111 using tones after dialed tone</td>
</tr>
<tr>
<td>P767-1111</td>
<td>Diaz 767-1111 using pulses after dial tone</td>
</tr>
<tr>
<td>BT767-1111</td>
<td>Diaz 767-1111 using tones after dialing 2 seconds. After dialing, call-progress-tone detection is limited to modem answer tone</td>
</tr>
<tr>
<td>TB767-1111</td>
<td>Diaz 767-1111 using tones after dialing 2 seconds. After dialing, call-progress-tone detection is limited to modem answer tone</td>
</tr>
<tr>
<td>PB767-1111</td>
<td>Diaz 767-1111 using pulses after dialing 2 seconds. After dialing, call-progress-tone detection is limited to modem answer tone</td>
</tr>
<tr>
<td>PB767-1111Z</td>
<td>Same as previous number string except after dialing 767-1111 the modem does not go into the originate-data mode. It stays off hook with its modulator squelched, waiting for the next command. This is very useful for placing voice calls</td>
</tr>
</tbody>
</table>

<com> STORE <LETTER> ' MESSAGE ' <CR>

In this command sequence, LETTER specifies one of fifty-two 32-character memory locations. Although it can be a word of any length, it must begin with an alphabetical letter (A to Z or a to z). The message to be stored—MESSAGE—can be a telephone number or a log-on message, but it must be bounded by single quotes or apostrophes. Any character except <com>, QUOTE, and Control-H can be embedded between the quotes, even <CR> and <LF> characters. QUOTEs are reserved as delimiters, while Control-H or the backspace key is used to backspace over entry errors. If a <com> is entered in the message, the entire command is aborted and a new one is begun.

The & sign is a special storage character that, when entered as the first character in the message, inhibits display of that memory location when using the LIST command. Only an & is listed as a placeholder, which is meant to ensure log-on or password-message security.

To list the numbers or log-on messages stored in the modem, a host need only send the following command to the modem: <com> LIST <CR>. In response, the list appears on the video screen, with the last number stored listed first, followed by as many as 52 stored numbers or log-on-message locations.

For example, to send a message stored in location A to a remote modem for database-password access, the following command would be sent to the modem:

<com> M A <CR>

As many as 16 letters can be specified within the message (M) command. After the message referred to by the first letter, the modem sends the sec-
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Automatic Screen Design (ASD): This feature permits you to specify the design of a form (which may be multi-page) that you wish to use for data entry and data viewing. You simply layout a screen mask and within seconds, without any programming, a data entry program can be generated.

Automatic Menu Generation: This feature permits you to design your own menus in which each option in the menu may invoke an executable program or a batch file. You simply layout the menu pages, and within seconds, without any programming, your menu program can be generated. This allows you to construct user-friendly menu-driven packages.

Relational Data Base Management: Having established data base(s) through use of the ASD feature, you may use the Relational Data Base Management feature to manipulate and retrieve these data. This feature supplies 12 commands and four utility programs to support activities like Select, Sort, Index, Join, Reformat, and so on.

Report Generation: Reports generated from your data base(s) that become routine and have enduring value may be specified by you in detailed format to the Report Generation feature. It is designed to retrieve information from the database with simple statements and perform arithmetic operations.

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and referenced message, and so on. Each message can be any length but must begin with an alphabetical letter. Only the first letter is interpreted to determine which one of the fifty-two 32-character memory locations is selected. Messages sent are not displayed in order to protect the log-on password security.

Questioning the Modem
At any point during the operation of the modem, it is useful to determine its current status. With the Info-Mate, status can be determined by entering the following command:

<com> QUERY <CR>

If modem status is normal, the message <com> OCHSARDUXZ/X1X2<LF><CR> is sent to the host system. Each character has a specific meaning, as shown in Table 7. If a period (.) replaces any of the status characters, it implies the negative or opposite condition.

Testing the System
No matter how sophisticated or intelligent the modem, if, for some reason, you cannot communicate your data, all the features in the world are no help at all. When a failure occurs, it is normally a rather long and drawn-out process to determine where in the system the error has occurred: in your modem, in the telephone line, or in the other modem. This diagnostic process is simplified considerably in the Info-Mate, which can perform any of eight different tests (see box, "Info-Mate Test Modes") upon transmission of the command <com> TEST n<CR>, where the argument n indicates the appropriate test mode.

To Listen Or Not to Listen
The Info-Mate's onboard command interpreter supports two operational modes: LISTEN and UNLISTEN. In the LISTEN mode, host commands are decoded and executed. But in the UNLISTEN mode, host commands are transmitted just like data and are not interpreted. This mode allows the modem to ensure total data transparency. A unique algorithm allows the host terminal or computer to dynamically direct the modem to move in or out of the LISTEN mode.

Either of these modes is initiated using the UNLISTEN command: <com>UNLISTEN n<CR>, where n is either 0 or 1.

When n=1, the modem does not listen for commands in the data mode. When n=0, the modem does not listen for commands in the data mode until the host transmits a break (a start bit, all-0 data bits, and a 0 stop bit). Thereafter, the modem listens for the host until it is commanded to again UNLISTEN. The host's break signal is absorbed by the command interpreter and does not pass through to the phone line. This command assures that inadvertently embedded commands in blocks of data sent through the modem do not affect the data transmission. Both binary and ASCII files can therefore be passed through the modem with complete data transparency ensured.

Quiet, Please
Finally, there is the ZZZZ command—<com> ZZZZ n<CR>—which, appropriately enough, makes the modem quiet. When the command is given, the modem silences its transmitter and stays OFF HOOK. This command typically serves as a transition from data mode to voice-communication mode. To return to the data mode, the ORIGINATE or ANSWER command may be issued.

Stephen Durham is director of applications and advanced product planning at Cermetek Microelectronics (1308 Borregas Ave., Sunnyvale, CA 94089-3565).
Widely acclaimed as an editor, VEDIT has evolved to be much more. Only VEDIT offers the combination of a versatile full screen editor integrated with a powerful command language. For the first time you'll be able to perform complex, yet useful, text manipulations that are virtually impossible with other editors or word processors. Plus, its customizability and hardware support ensure that VEDIT will be perfectly matched to your individual needs and to any microcomputer you are ever likely to own.

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Developing a Truly Portable Visicalc

Now you can use an electronic worksheet on your HP-75 portable computer

by William T. Johnson

One of the most flexible and useful tools busy professionals can have in a portable computer is an electronic spreadsheet. In addition to providing standard analysis capability, a spreadsheet helps keep track of travel expenses, sales transactions, and data collection in the field, and answer urgent "what if" questions for the user on the run.

With the goal of providing such capability, Hewlett-Packard's Portable Computer Division decided to adapt Visicorp's popular electronic spreadsheet, Visicalc, to the HP-75 portable computer. The primary objective was to provide a truly portable version of this powerful software while retaining its close compatibility with other Visicalc products. Users already familiar with Visicalc will quickly recognize its characteristic features in the adapted version.

Another design criterion was to take full advantage of some of the HP-75's sophisticated capabilities—in particular, the computer's multiple-file structure in RAM (random-access read/write memory), which permits a variety of file types: BASIC programs, text and appointment files, and, with the introduction of Visicalc, worksheet files. This structure permitted development of some unique Visicalc features, including multiple worksheets in RAM, data references from one worksheet to another, and formulas in cells that call BASIC programs. In addition, BASIC programs can operate on worksheets.

To meet these criteria, an HP software team generated all-original code. The result was a 32K-byte plug-in ROM (read-only memory) module that connects to one of the HP-75's three expansion slots. To speed development, the team programmed the functional shell (VCBASIC) in 11K bytes of BASIC. VCBASIC is supported by 21K bytes of assembly language that assist in speed-critical areas and allow interaction with the HP-75 operating system. Assembly support for VCBASIC is called via keywords, which also enable other BASIC programs to create and manipulate worksheets. Table 1 lists those keywords and their functions.

The Portable Environment

The HP-75 provides the power and sophistication of a high-level-language computer in a portable system. Measuring 10 by 5 by 1 1/4 inches, it weighs 26 ounces and is fully battery operated. The unit features a single-line, 32-character LCD (liquid-crystal display) and has a built-in Hewlett-Packard Interface Loop (HPIL), so it can be used with a full-sized video display and other peripheral devices (see photo 1). A built-in magnetic card reader can be used for storing RAM files, or a digital cassette connected through the HPIL can be used for mass storage.

Standard memory consists of 16K bytes of CMOS (complementary metal-oxide semiconductor) RAM, expandable to 24K bytes. The 48K-byte BASIC operating system includes time- and appointment-mode capabilities. The keyboard is fully redefinable and overlays are available for special user needs. The HP-75 can also run BASIC and assembly language from up to three plug-in ROM modules with as much as 32K bytes apiece.

To adapt Visicalc to this portable environment, the design team had to decide how to implement the single-line display as a window into the worksheet while preserving the program's character. It chose to have the display show one cell of a worksheet at a time. Each cell can be accessed using either standard cell coordinates or user-defined labels for column and row.

---

Table 1: VCBASIC Keywords

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD</td>
<td>Add contents of two cells</td>
</tr>
<tr>
<td>SUB</td>
<td>Subtract contents of two cells</td>
</tr>
<tr>
<td>MULT</td>
<td>Multiply contents of two cells</td>
</tr>
<tr>
<td>DIV</td>
<td>Divide contents of two cells</td>
</tr>
<tr>
<td>REM</td>
<td>Remainder of division</td>
</tr>
<tr>
<td>MOD</td>
<td>Modulo of division</td>
</tr>
<tr>
<td>EXP</td>
<td>Exponential function</td>
</tr>
<tr>
<td>LOG</td>
<td>Logarithm function</td>
</tr>
<tr>
<td>SIN</td>
<td>Sine function</td>
</tr>
<tr>
<td>COS</td>
<td>Cosine function</td>
</tr>
<tr>
<td>TAN</td>
<td>Tangent function</td>
</tr>
<tr>
<td>ASIN</td>
<td>Arcsine function</td>
</tr>
<tr>
<td>ACOS</td>
<td>Arccosine function</td>
</tr>
<tr>
<td>ATAN</td>
<td>Arctangent function</td>
</tr>
<tr>
<td>SQRT</td>
<td>Square root function</td>
</tr>
<tr>
<td>ABS</td>
<td>Absolute value function</td>
</tr>
<tr>
<td>ROUND</td>
<td>Round to nearest integer</td>
</tr>
<tr>
<td>TRUNC</td>
<td>Truncate fractional part</td>
</tr>
<tr>
<td>SGN</td>
<td>Sign function</td>
</tr>
<tr>
<td>SIGN</td>
<td>Select sign of expression</td>
</tr>
<tr>
<td>IF</td>
<td>Conditional test</td>
</tr>
<tr>
<td>THEN</td>
<td>Execute if condition is true</td>
</tr>
<tr>
<td>ELSE</td>
<td>Execute if condition is false</td>
</tr>
<tr>
<td>ENDIF</td>
<td>End conditional test</td>
</tr>
<tr>
<td>PRINT</td>
<td>Display or save cell value</td>
</tr>
<tr>
<td>CLEAR</td>
<td>Clear cell value</td>
</tr>
<tr>
<td>MEMORY</td>
<td>Access RAM memory</td>
</tr>
<tr>
<td>REMEMBER</td>
<td>Access external memory</td>
</tr>
<tr>
<td>END</td>
<td>End program or subroutine</td>
</tr>
</tbody>
</table>
row headers. Pressing the Time key toggles between a cell’s default headers (columns A, B, C, etc., and rows 1, 2, 3, etc.) and such user-defined headers as January, February, March (columns) and Rent, Auto, Taxes (rows). Similarly, touching the Appt key toggles between the result-display mode for a cell and the formula-display mode.

For example, suppose the column C header is defined as March and the row 4 header is Expenses, which covers the sums of items in rows 1 to 3. If March expenses were $1000, this figure can be accessed by using either the default coordinates:

\[ C4: \text{1000} \]

or the user-defined coordinates:

\[ \text{March} \cdot \text{Expenses: 1000} \]

You can also choose to view the formula that was used to calculate the $1000 figure, either in terms of default headers:

\[ C4: \text{SUM(C1 \ldots C3)} \]

or as more meaningful, user-defined headers:

\[ \text{March} \cdot \text{Expenses: SUM([March \cdot Rent] \ldots [March \cdot Taxes])} \]

A problem that arises with this arrangement is how to examine a cell’s entire contents when they exceed the 32-character capability of the LCD. If you are viewing (not editing) the worksheet, arrow keys move the window framed by the display from cell to cell, across the columns or up and down the rows. Then, within a cell, the Run key scrolls the contents forward and Shift-Run scrolls them backward. To help you read very long contents, Tab and Shift-Tab keys cause the contents to skip forward or backward across the display one window length at a time. However, during the editing of cell contents, movement within the cell is controlled by the arrow keys.

To gain the full benefit of using the portable spreadsheet, you must also be able to use peripherals freely, as with a conventional desktop system. To permit such use, the HP-75 Visicalc must use the HPIL capability to full advantage. Provisions have thus been made to vary column width for video and printer outputs and to set line length and width parameters for HPIL video interfaces. A special printing option allows column-order listings of all the formulas used in a worksheet, along with their cell coordinates. Finally, Visicalc was also
made compatible with the HP-75 mainframe COPY command to permit storing worksheets on a magnetic card or digital cassette tape.

Product Design

Rather than running as a program, Visicalc was added to the HP-75 as another operating mode, along with Time, AppI, and Edit. One advantage of this approach is that the Attrn key does not halt Visicalc but instead always returns you to the top operational level. The top level is used for viewing the spreadsheet and entering the other two operational levels, cell-entry and command. Several operations can be carried out at the top level, including window movements. In addition, a Go To operation moves the window directly to the cell specified, and an alternate window can be defined to allow single-key toggling between two closely related cells.

The cell-entry level is entered automatically by merely selecting a cell and beginning to enter data. Full cell editing is allowed during cell entry; user-defined headers in formulas can also be entered there. Several functions are available at the cell-entry level to help create formulas, including AVERAGE, which computes the average of numbers in a list; MAXL, which computes the maximum value of numbers in a list; and SUM, which computes the sum of numbers in a list. Moreover, you can create additional extension functions using BASIC programs that can be used in formulas in the same manner as standard cell-entry functions.

You enter the command level by pressing the slash (/) key, which brings a command menu onto the display. Commands are then chosen by pressing the corresponding letter keys, which include D (deletes the column or row in which the cell display resides), M (moves the column or row within the worksheet), R (replicates cell entries across a column or row), I (inserts a blank column or row), and H (enters user-defined headers). Using BASIC programs, you can also define extended commands, which then have their own letters added to the command menu. (This capability will be discussed later in more detail.)

To program these capabilities expeditiously, Visicalc was broken down into functional modules. One module, for example, handles top-level functions and another defines special-key functions. Each command-level function has its own module. Additional support modules perform functions that are generally transparent to you, including video support, user interface and memory management, and parsing, interpreting, and decompiling formulas.

Many of these functions can be invoked using the keywords developed in assembly language to support VCBASIC. The capability to implement user-defined column and row headers was integrated into all modules.

Product Development

As much of the software as possible was developed in BASIC because that language is easier than others to write, debug, and modify. Its disadvantages are that it is not compact, presenting ROM space constraints,
nor does it effectively perform speed-critical calculations. Many functional modules that would eventually be converted to assembly language, at least in part, were initially sketched out in BASIC. An example of how this approach was followed can be seen in the development of the parser module.

The parser's role is to check for proper syntax of formulas entered into worksheet cells. One problem is that a variety of nonstandard syntactical combinations are possible. A formula can, for example, include user-defined headers, such as

```
January * Remain:
[Net Pay] - [January * Expenses]
```
or include cell references to other worksheets:

```
April * Sales:
1.02*[April * Sales]:FY1982
```

where FY1982 is the name of another worksheet in RAM. It can also include calls to BASIC programs, such as

```
Group A * std dev:
STD ([Group A]... 
[Group A] 47)
```

where STD is a program that calculates the standard deviation of a list of parameters. Making a first pass in BASIC permitted rapid development of the parsing algorithms needed to take into account all these combinations. Assembly-language subroutine calls to the HP-75 mainframe parser were then used to gain speed in critical areas.

Once assembly language had been used to develop display and keyboard-control keywords, BASIC proved adequate for producing the LCD user interface for each functional module. Care was taken in designing key functions to optimize user friendliness. For example, to alleviate potential confusion over the dual role of arrow keys, a flashing cursor appears when the arrows are used for cell editing, and no cursor appears when, in the top level, arrows are used to move the display window about the worksheet. Similarly, the split-window feature of other VisiCalc versions was adapted by creating an alternate window that can be accessed via a keystroke. Assembly language was also needed to program other support modules such as memory management.

The memory-management module stores worksheet data in a compact format as it is entered into cells. Each data item is matched to its cell location by a pointer table. A goal of the design was to return every usable byte to the user. VisiCalc overhead in RAM, plus HP-75 operating system overhead, is approximately 4600 bytes, which means that you have either 12K bytes (with standard HP-75 memory) or 20K bytes (with the HP 82700A memory module added) available to store worksheets and other files. Even the coordinate location 0,0 of the pointer table was utilized, providing an intercept for BASIC programs at start-up, cell entry, and end of VisiCalc. This efficient memory management thus permits the HP-75's 20K-byte RAM to hold 31K bytes of HP-86/87 worksheet in-

---

**Keyword**  | **Description**  
---|---
MARK | marks a cell reference as being relative  
MAX | returns the maximum column from a worksheet  
MAXCOL | returns the maximum column  
MAXL | returns the maximum of a list  
MAXROW | returns the maximum row from a worksheet  
MEAN | returns the mean of a list  
MESSAGES | returns a message  
MIN | returns the minimum of a list  
MINL | moves a column in a worksheet  
MOVCOL | moves a row in a worksheet  
MOVCOL | moves a column in a worksheet  
MOVROW | moves a row in a worksheet  
NA | returns the value NA  
NEXTREFS | returns the next cell reference in a formula  
PARSE | converts a formula into its internal form  
PRIT$ | returns the name of the PRINTER IS device  
PRWIDTH? | returns PWIDTH  
PUTFORMAT | puts a format into a cell  
PUTFORMULA | puts a formula into a cell  
PUTLABEL | puts a label into a cell  
PUTLABEL | puts a repeating label into a cell  
PUTSETUP | puts a printer setup string into a worksheet  
PUTSTATUS | puts status information into a worksheet  
PUTVALUE | puts a value into a cell  
PUTWIDTH | puts a local column width into a worksheet  
RCLASS | recalls variables  
RECALC | recalculates a cell or a worksheet  
REPLICATE | performs replication  
ROW | returns the row number of a coordinate  
SETWIN | sets the LCD window  
SOURCE | establishes the source range for REPLICATE  
SPEW | displays the internal form of a formula  
STOVAR | stores variables  
SUM | returns the sum of a list  
TARGET | establishes the target range for REPLICATE  
UNMARK | unmarks marked cell references  
UPCOL | returns the column boundary to be displayed or printed  
UPROW | returns the row boundary to be displayed or printed  
VALCHK | similar to the HP-75 VAL function  
VC | runs VisiCalc  
VLENGTH | sets the length of the video  
WIDTH | sets the width of the video  
WAITKEYS | similar to the HP-75 KEYS function  
WINSIZ | returns the size of the LCD window  
WORKSHEET | specifies the active worksheet  

---

*September 1983 © BYTE Publications Inc. 69*
FORMATION or 27K bytes of HP-85 worksheet information when the system is used in conjunction with HP-85, 86, and 87 personal computers.

Although the maximum allowable number of rows or columns is 255, available RAM determines the practical limits on the size of worksheets. How much of this space is actually available depends on how many cells are filled as well as the information in them. An empty worksheet of any size requires only 22 bytes of memory. As cells are filled in, the memory-management module dynamically reconfigures the worksheet to accommodate the data into a rectangle just large enough to include the highest-numbered column and row that contain filled cells.

The interaction between VCBASIC and assembly language in a functional module can be illustrated using the Insert command to insert a new column. VCBASIC first sets up the following prompt in the LCD:

Insert: Col Row

After the C key is pressed, a VCBASIC routine checks to see that this input is valid and branches to the appropriate line in the functional software shell. Assembly language, meanwhile, provides VCBASIC with necessary information on the spreadsheet—using the keyword MAXCOL, which returns the last active column on the right—and performs the required memory management for a column insert, using the keyword INSCOL. The line of VCBASIC that initiates the inserting of a column is thus IF MAXCOL <255 THEN INSCOL C, which translates into: "If the maximum column number in the worksheet is less than 255, then insert another column at the current column position designated by the VCBASIC variable C."

Using Keywords

A total of 82 keywords have been developed in assembly language to support VCBASIC. Some, such as those just described, are involved in memory management. Others are
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Listing 1: A BASIC program for recording travel expenses.

```
100 ! travel expense data collector - wtj - 05/11/83
110 CLRSCR & WORKSHEET "trvelsps" @ N=STR$(MAXCOL-2)
120 INPUT "Enter day numbers: ", N
130 N=INT(N) & IF N<1 OR N>9 OR N>MAXCOL-1 THEN BEEP & GOTO 105
140 FOR C=1 TO MAXCOL-2
150 IF C=H THEN 300
160 NEXT C
170 DISP "Please wait..."
180 INPUL C & PUTFORMAT C,1,4 & PUTFORMAT C,2,4
200 PUTLABEL C,0,"Day ":STR$(N) & PUTLABEL C,B,4 & PUTLABEL C,20,-
204 C=CHR$(64+C)
210 PUTFORMULA C,9,"="CH$C$(9:11..9:19)"
220 PUTFORMULA C,21,"="CH$C$(11:9:19)"
230 PUTFORMULA C,23,"="CH$C$(9:11..19)
240 PUTLABEL C,0,"C",CR
250 NEXT R
260 IF C=H THEN 2
270 V$=GETLABELS(C,R)
290 NEXT R
300 IF R=1 TO 2
310 V$=GETLABELS(C,R)
330 NEXT R
340 B=5 & E+9 & GOSUB 1000
350 R=1 & E=10 & GOSUB 1000
360 GOTO "End of program"
370 END
```

Listing 2: An empty travel-expense worksheet.

```
Travel Expense Report
03/05/30 23:45:10
```

```
<table>
<thead>
<tr>
<th>TRAVELSPS</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>date</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>city</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>air</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>auto</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mileage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>parking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>addtrans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>room</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>breakfast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lunch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dinner</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bus confi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>porter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>laundry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>phone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>addlodge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lodging</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expenses</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

Listing 3: A filled-in worksheet of travel expenses.

```
Travel Expense Report
03/05/30 23:47:10
```

```
<table>
<thead>
<tr>
<th>TRAVELSPS</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>date</td>
<td>23.22</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>city</td>
<td>121.17</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>air</td>
<td>21.07</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>auto</td>
<td>41.32</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>mileage</td>
<td>15.34</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>parking</td>
<td>6.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>addtrans</td>
<td>13.39</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Transit</td>
<td>45.65</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>room</td>
<td>67.92</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>breakfast</td>
<td>12.02</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>lunch</td>
<td>5.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>dinner</td>
<td>5.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>bus confi</td>
<td>15.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>porter</td>
<td>12.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>laundry</td>
<td>18.70</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>phone</td>
<td>4.62</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>addlodge</td>
<td>31.94</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Lodging</td>
<td>54.69</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Expenses</td>
<td>1170.98</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>
```

The use of keywords can best be introduced by an example. The BASIC program in listing 1 uses the spreadsheet language to prompt you for travel-expense items and enters the collected data into the appropriate worksheet cells. Listing 2 shows the initial appearance of the travel-expense worksheet.

The BASIC program uses keywords to create and open the worksheet "trvelsps" (line 100) and to prompt you for day entry number. If a new day number is specified, the program expands the worksheet by inserting a new column and puts the appropriate formulas into the new column (lines 200 to 230). Next, the program steps through the worksheet, accessing column and row headers and current cell entries, then prompts for more information using the worksheet headers and the cell data as default values. Finally, the program puts the collected inputs into the worksheet (lines 305 to 1060). An example of a completed travel-expense worksheet appears in listing 3.

Calling BASIC Programs

BASIC programs can be called from cell formulas because HP-75 Visicalc uses its own interpreter in assembly language instead of the HP-75 mainframe interpreter. In addition, this module also interprets VCBASIC (Visicalc thus interprets itself) and a Visi-command BASIC program that extends the Visicalc command set. Using this interpreter gives Visicalc two important types of control. First, it allows Visicalc to intercept any errors from called BASIC programs, so that you are returned to the worksheet and not locked out. Second, it prevents the Attn key from halting VCBASIC and therefore exiting Visicalc.

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Listing 4: This investment-analysis worksheet includes worksheet formulas.

Investment analysis on the sale of property.
85/05/31 14:51:11

<table>
<thead>
<tr>
<th>INVEST</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CRT</td>
<td>4050.00</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>CRT</td>
<td>-180.00</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>CRT</td>
<td>-192.00</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>CRT</td>
<td>-310.00</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>CRT</td>
<td>-192.00</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>CRT</td>
<td>-320.00</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>CRT</td>
<td>-192.00</td>
<td>9</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>total</td>
</tr>
</tbody>
</table>

9 net | 11943.00 | cash returned |
10 selling | 25000.00 |
12 balance | -10767.00 |
13 closing | -2290.00 |
14 | | net | 11943.00 |
15 net | 2.40 % per year |
18 NPV | -1174.33 |
| | | 7.00 % discount |

Worksheet formulas:
85/05/31 14:52:25

INVEST

amount total: A18B1+628B2+434B3+A2B4+A5B5+A3B6+A7B7
amount closing: -14A11+210
amount nets: A11+41A2+13
amount INR: TVM1(2,3,A1...R7,A15,B1...R7,12)+12
amount NPV: TVM1(2,3,A1...R7,A15,B1...R7,12,B18/12)(1+18/12)(1+12/100)"SUM(B1...B7)"

Other BASIC programs can also be called from the command level of HP-75 Visicalc, although the process is somewhat more complicated. First, a change must be made in the command-level prompt. This prompt is built from message 21 (command) and message 22 (DFGHIMPRVVW-) in the Visicalc ROM. The keyword MESSAGES$ is used by VCBASIC to access these messages. Alternative messages can be accessed through MESSAGES$ if they reside in the text file named VISIMSGS. By entering a replacement for message 22 into VISIMSGS:

22 DFGHIMPRVVW-E

the command-level prompt will appear as

Command: DFGHIMPRVVW-E

The final letter E provides the hook needed to call a BASIC program that defines a new command-level function. Such "Visi-command" programs are numbered sequentially in the order of the letter or letters that follow the hyphen in the command-set message. Pressing the letter E in response to the new command-set
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The Printer Optimizer can change the order in which jobs are printed, with multi-copy and selective reprinting, cutting down computer use as well as the number of forms changes.

and my (PRINTER becomes...

and my PRINTER because it turns on bold & italics
message above would call a user-written BASIC program called VISICM1. If another letter were added, it would call VISICM2, and so forth.

Visi-command programs define a set of commands that act as extensions of those defined in VCBASIC. They provide the means by which you can customize Visicalc in an unprecedented manner. Using this capability, for example, you can command the sorting and alphabetizing of data by column or row. Worksheets can be translated into other data formats. Considerable amounts of text can be entered and then formatted. Other possible command extensions include plotter and printer graphics output, creation of schedule charts, and utilities for collection and management of data.

The Resulting Product

The final HP-75 Visicalc package contains the 32K-byte plug-in module that supports the features described here, an owner's manual and a programmer's reference manual, and a keyboard overlay indicating redefined keys used with Visicalc. In addition, magnetic cards provide you with a sample worksheet, a sample BASIC program (that solves for internal rate of return), and some BASIC Visi-command programs for use with the command-extension feature. Command extensions provided include sorting, alphabetizing, and clearing data from worksheets.

The HP-75 Visicalc offers at least five unique features: (1) the first spreadsheet capability on a fully portable personal computer that can also operate as a desktop system, (2) the ability to define extended functions as BASIC programs, (3) the ability to extend the feature set for special applications, (4) the ability to overlay multiple worksheets in RAM, and (5) the ability to automate the creation and manipulation of worksheets from BASIC programs using a spreadsheet language.

The designers anticipate that by combining sophistication and portability, this new version of Visicalc will find a wide market. First-time users of an electronic spreadsheet will be able to use most of the important product features within a few hours, and sophisticated users can take advantage of its hooks to develop enhancements for an almost unlimited variety of special applications. In addition to providing the features described here, the portable Visicalc can support multilingual prompting for international markets.

In short, the HP-75 Visicalc provides the active professional with worksheet capability that can be used almost anywhere. Its unique features promise to set a new standard for power and convenience in software designed for the truly portable computer market.

William T. Johnson, a research and development engineer at Hewlett-Packard's Portable Computer Division (1000 NE Circle Blvd., Corvallis, OR 97330), headed the team that designed the HP-75 Visicalc.
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Circle 361 on inquiry card.
The Gavilan—
A Full-Function Portable Computer

CMOS logic, LCDs, and increased integrated-circuit density helped designers fit the computer and its printer into a briefcase

by F. John Zepecki

Gavilan Computer Corporation designed its mobile computer to meet the needs of the traveling professional. The company's main goal was to create a completely self-contained, full-function computer system small enough to slip into a briefcase and light enough to be easily carried.

The self-powered Gavilan (see photo 1a) has a full-size keyboard and numerical keypad, an easy-to-use display, and an internal memory large enough to support popular applications. In addition, it has removable mass storage, a modem, and serial port, and can perform everyday computer functions such as word processing and number crunching with well-integrated software. The system comes with an add-on printer that uses 8½-inch-wide paper and everything is built into a case that measures approximately 11 by 17 by 3 inches (see photo 1b).

Design Criteria

At Gavilan, we decided that several criteria had to be met if the mobile computer was to be useful to the traveling professional. The computer had to be able to run for a long time on an internal battery pack (ideally, for at least 8 hours without recharging), yet it could not weigh more than 15 pounds. It had to have a standard QWERTY keyboard with a numeric 10-key pad (we felt that miniature keyboards did not lend themselves to touch typing) and a bit-mapped display that could reproduce at least 8 lines of text as well as graphic symbols and icons. The computer also had to have 64K bytes of memory expandable to 1 megabyte, a built-in or add-on cassette for disk storage, an integrated modem, a serial port, and a printer. Furthermore, it had to support a standard operating system.

Incorporating all these features into a small package was not as much of a problem as anticipated because of the industry's progress in increasing integrated-circuit density, the availability of CMOS logic, and the perfection of relatively large-area flat liquid-crystal displays (LCDs).

A Portable 64- by 400-Pixel Display

To ensure the usefulness of the new computer's display, we agreed that it would have to present considerable amounts of data without scrolling. Furthermore, a graphics capability was essential to support anticipated applications.

A 24-line, 80-character LCD would have been ideal, but no such displays were available. Eventually a 64- by 400-pixel bit-mapped LCD was decided upon.

Resident firmware was then developed to produce lines of 80 characters. And, because the display is bit-mapped, icons and other graphic elements can be displayed.

Use of the large LCD complicated the design of the display controller. Because crystal fluid's persistence is shorter than the time it takes to scan through the display's 64 pixel rows, the LCD is divided into the horizon-
tal halves of 32 rows each, and the drivers are multiplexed so that both halves are scanned simultaneously. As a result, the display controller supplies two data streams, one for each half of the display. This way, the display's 64 rows are painted in the time it takes to paint 32 rows.

Although getting an 8-line, 80-character display in the limited space available was an achievement, an 8-line page restricted our ability to process lengthy files. To simplify this, a special Zoom function was added in firmware. The Zoom function presents an outline image of a document with the positions of the eight active lines shown in a rectangular overlay. Using this function, the overlay can be placed anywhere on the page outline, and the enclosed eight lines are displayed by a single-stroke command. Conventional scrolling is also available through a set of pressure-sensitive scroll keys located on a panel above the keyboard. Because an 8-line display might not be ideal for all applications (even with Zoom), additional provisions make it possible to feed a 24 by 80 composite video signal to an external monitor.

The LCD, its logic, and associated row and column drivers are housed in a separate assembly attached by hinges to the computer case over the keyboard. A pair of spring-loaded posts at opposite ends of the keyboard raise and lower the display for easy viewing. The display lowers for stowing as the keyboard cover.

The mechanical interface is made by hinges fastened to the top of the posts and bottom, or screen side, of the display lid (see photo 2). The electrical interface is provided by a ribbon cable in one of the posts. To operate the computer, the user pushes a button on the right side of the case, releasing the posts, which lift the bottom of the display lid above the top of the computer case. The lid then swings manually into an upright position. Mechanical detents providing 15-degree indexing beginning at 90 degrees let the user lock the display into a comfortable viewing angle. When the user is done computing, he or she folds the display lid over the keyboard and pushes the case until it locks in place.

The Gavilan has a typewriter-like keyboard with full-travel keys on the industry-standard ¾-inch spacing. The keyboard meets the DIN standards for home-row height and angle. A numeric 10-key pad was integrated into the keyboard design to suit the needs of the mobile executive.

Photo 1a and 1b: The Gavilan mobile computer offers a full-size, full-travel keyboard with a numeric 10-key pad and a fold-up 8-line, 80-character liquid-crystal display. The snap-on printer adds less than 5 inches to the computer's length, yet provides 50 cps throughput onto standard plain paper. The computer and printer fit easily into a standard-size briefcase and weigh less than 15 pounds.

Photo 2: Keys to the user-friendliness of the Gavilan's packaging are the two spring-loaded posts and the hinge assemblies that attach the display housing to the computer. The posts permit the housing to form a cover that seals the keyboard when not in use yet rises to lift the display into its operating position.
An Electronic Mouse

To make the new computer more user-friendly than a conventional desktop machine, we used a mouse rather than an individual cursor and function keys. With a mouse, symbols and icons could simplify user access of the applications software.

Because the size of the system didn't lend itself to the use of a hand-held mouse, a pressure-sensitive touch-panel electronic mouse was developed.

The Gavilan's electronic mouse is actually two parallel resistive membranes separated by spacers. The sheets in the membrane assembly are scanned so that the location of any contact closure is quickly determined and encoded. To operate the mouse, the user presses a finger against the touch panel and moves it in the direction he wants the cursor to move. The direction and speed of finger travel are determined through membrane scanning and encoding.

Finger speed is converted into pixel cursor movement, providing precise control of the cursor position. The location of the finger's contact with the touch panel is unimportant.

The touch panel supports software presenting various directories. The user selects a listing, positions the cursor next to it, and taps the panel to execute the selected action. The listing is then highlighted in reverse video. The cursor does not have to be in a specific location; it need only be positioned in the cell containing the desired listing.

The entire panel above the keyboard is a membrane assembly. On either side of the centrally located touch area are pressure-sensitive function keys that call up menus, scroll the display, and permit other communications with the processor. The panel is covered with a layer of mylar that should wear indefinitely.

Expandable Memory

The basic Gavilan has 64K bytes of user RAM (random-access read/write memory); 32K bytes are housed on the main printed-circuit board, and the remaining 32K bytes are supplied in a special capsule designed to fit into the limited space available. This memory provides better protection for the circuitry than plug-in cards or chips.

Inside each capsule is a pair of printed-circuit boards (see photo 3). The edge of one board protrudes from an opening in the capsule's bottom and serves as a male connector. There are four mating connectors used for capsule inserts on the main printed-circuit board in the left-rear corner of the computer, next to the 3½-inch floppy-disk drive.

Levers are built into the top of each capsule to facilitate removal of the capsules from their mating sockets. (Lack of space prohibits manual removal of the capsules from the sockets.)

A lithium-thionyl-chloride battery in each capsule provides memory backup. With ordinary use, the battery will last more than a year. The condition of each lithium battery is monitored through an A/D converter by a resident 80C51 CMOS single-chip microcomputer. When the battery needs to be replaced, the 80C51 signals the computer, which notifies the user through a message on the display. The contents of the capsule can be loaded onto disk before the battery is removed. Replacement of the battery involves little more than swinging out the bracket in the capsule's side and swapping batteries.

Although each expansion capsule contains 32K bytes, the memory is mapped as 64K bytes, with the remaining 32K bytes in ROM (read-only memory) on the main board. This ROM holds the Gavilan operating system. Although mapping the operating system into four expansion modules may seem redundant and wasteful, it provides much faster response to commands because the processor doesn't have to go somewhere else to pick up operating instructions. Even more significant, mapping the operating system into the memory space of all the capsules permits them to be used as applications modules containing both programming and operating-system instructions. Plugging in a capsule with an applications program in ROM converts the computer into a dedicated business machine preprogrammed to provide user support with no other instructions. If more than one applications capsule is installed, the program names appear in the main desktop, or directory. In this case, the touch panel is used to select and execute the desired application.
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**Figure 1:** Packing a 16-bit microcomputer complete with a 360K-byte floppy disk and full-size keyboard into an 11.4- by 11.4- by 2.7-inch case required some creative packaging. In the layout of the Gavilan, the 3½-inch floppy disk is mounted crosswise at the right rear with access through the right side of the case. In front of the disk-drive access port on the right side of the case jacks are located for connection to the built-in modem and for an external 24-line by 80-character monitor. The enclosure at the rear of the case fills most of the bottom of the case. Resident memory is contained on two boards mounted above the main board between the disk drive and the keyboard. Above the memory boards is the display controller board.

**Internal Layout**

Most of the Mobile Computer’s electronics are on the main printed-circuit board on the bottom of the computer’s 11.4- by 11.4-inch interior (see figure 1). These electronics include the DC/DC converter, the connectors for interfacing the printer and/or the second disk drive, an RS-232C port, a keyboard, an integrated-mouse/function-key touch panel, and a 300-bit-per-second (bps) modem with auto-answer and auto-dial. The modem accepts domestic frequencies in accordance with Bell 103 and European frequencies in accordance with CCITT V.21.

Two memory boards housing 48K bytes of resident ROM containing the display messages and the operating systems and the 32K bytes of user RAM are mounted above the main board and are interfaced by connectors. These memory boards are located between the battery pack housing and the capsules’ housing.

A third board stacked above the two memory boards contains the display controller, which can support not only the computer’s own display, but a wide variety of other LCDs. Included in the controller is a proprietary gate array that accesses a local memory to map the display screen, which can be either the computer’s 8 by 80 LCD or a 24 by 80 external CRT monitor. Selection of the display format is made under software control via the touch panel.

The computer uses a 3½-inch floppy-disk drive, which offers the ideal combination of large storage capacity and small size. The drive is mounted crosswise at the right rear of the case with disk access on the right side.
Because no industry-standard microfloppy format existed, we initially chose a 3-inch drive for the computer. It was originally the only microfloppy compatible with 5¼-inch drives in terms of rotational speed, disk format, and controller interface. Since then, however, other compatible 3½-inch disk drives have become available and may become the industry standard. With that in mind, mechanical provisions were made so that many different sub-4-inch microfloppy drives can be mounted to the case. The disk controller was also designed to be compatible with any of these drives. Disk access is through a detachable bezel that is easy to replace, simplifying drive changes during assembly.

Making It All Work

The Mobile Computer uses 10 ½-D nickel-cadmium cells that power a DC/DC converter, which in turn produces the voltages required to power specific components or subassemblies (see photo 4). The 12-volt battery's capacity is great enough to continuously power all the electronics and the disk drive in typical intermittent service for at least 8 hours on one charge. The battery can be recharged to 80 percent of capacity in less than ½ hours.

Originally, the DC/DC converter was unable to supply enough power to operate the battery pack for 8 hours. The problem was caused primarily by the NMOS 8088 processor's large power draw. Because there was no way to reduce the 8088's power consumption during operation, a scheme was devised to shut down the 8088 when it was idle. Upon completion of its task, the 8088 writes its internal states into memory and then powers down. When action is again required, the 8088's off-state is interrupted and it powers up.

The 8088 determines which circuits need power and which do not. It turns off power to circuits that have nothing to do (most notably the microfloppy's spindle motor during periods when the disk is not being accessed).

The 8088's power-down feature and its ability to control energy use in other circuits enable the DC/DC converter to supply the required 8 hours of power.

To maximize conversion efficiency while minimizing the size of the DC/DC converter, a flyback circuit converter was used. This converter supplies various voltages to power the logic bus, the EIA interface, and the disk drive. The main nickel-cadmium battery is monitored by the 80C51 microcomputer through an A/D converter (as are the expansion capsules' lithium batteries), which signals the user through the 8088 and the display when it's time to recharge the batteries.

Size and weight limitations prohibited putting a charger in the computer itself, but a separate battery charger comes with the Mobile Computer. The charger can operate the computer while recharging the batteries. The 80C51 monitors the bat-
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A Snap-on Printer

The separate printer is housed in a box with the same cross section as the computer. It can be snapped onto the computer's back panel, providing both a mechanical and electrical interface (see photo 5). The electrical interface consists of an edgecard plug on the computer's rear panel mated with a jack on the front of the printer's case. The mechanical interface uses a latching arrangement that provides easy connection and disconnection and a high level of holding tension. The final design uses two spring-loaded clamps (one on each end of the printer's front panel) that bite thin stainless-steel brackets on the computer's rear panel. The combination of the spring loading and the slant of the brackets provides a mechanical attachment between the two units that, in effect, makes them a single package. The mechanical interface is so strong that lifting the computer from its front edge will also raise the printer as if it were built into the same case.

The printer's dimensions are 4.9 by 3 by 11.4 inches, allowing it to be carried in the same standard-size briefcase as the rest of the system. It is a plain-paper thermal graphics type with a special ribbon that transfers dye to plain paper when it is heated. The ribbon rides in a special cassette between the paper and the 16-wire ceramic printhead (see photo 6). The same mechanism that advances the printhead also advances the ribbon; when the ribbon is being used, the printer prints in one direction. When used with thermal paper, however, the ribbon cassette can be snapped out of the printer, which then operates bidirectionally. Unidirectional and bidirectional printing and printhead temperature are controlled by a resident microprocessor, which also manages character formation, the input buffers, and handshaking with the computer.

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bidirectional-printing capability. The printer weighs about 5 pounds including the internal battery pack, which consists of 11 sub-C size nickel-cadmium cells. The integrated computer-printer package weighs 14 pounds.

The printer’s battery delivers about 60,000 characters between charges. The computer charger will also recharge the printer’s battery pack. Control lines handled through the computer-to-printer interface permit the 80C51 to monitor the printer battery’s charge and discharge just as it does the computer’s.

**A Snap-on Second Disk Drive**

A second disk drive with a self-contained battery pack is housed in a case about the size of the printer. A dual-drive system consisting of the computer and the second drive (in place of the printer) will also fit easily into a briefcase. The second drive can include an additional 128K bytes of main memory. The computer’s 80C51 monitors the voltage and temperature of the add-on drive’s battery as it does the battery in the printer. The add-on drive’s rear panel is equipped with the same electrical and mechanical interface as the computer, so the printer can be snapped on to form a mechanically stable, fully integrated computer system with nearly a megabyte of removable mass storage and an 8½-inch-wide plain-paper printer.

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F. John Zepecki is vice-president of hardware engineering at Gavilan Computer Corporation, 240 Hacienda Ave., Campbell, CA 95008.
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How CMOS devices are manufactured and a look at three of them

by Martin B. Pawloski, Tony Moroyan, and Joe Altnether

Photo 1: The die for the 80C51, with the functions of the various sections identified.
CMOS (complementary metal-oxide semiconductor) has often been called the ideal technology. It has low power dissipation, high immunity to power-supply noise, symmetric switching characteristics, and a large supply-voltage tolerance. But CMOS has rarely been used for advanced VLSI (very-large-scale-integration) microcomputer designs. Because of the complexity of the CMOS process, the ICs (integrated circuits) produced have traditionally had a relatively poor price/performance ratio.

As a result, CMOS was used only in applications that required low power and were neither performance conscious (such as in calculators and watches) nor cost conscious (many military applications, for example). Suddenly, however, all major semiconductor companies have announced either advanced CMOS products or the intention of designing their next generation of high-performance microprocessors using CMOS technology.

What has happened to make CMOS both affordable and high performance? For one thing, the dominant VLSI technology, NMOS (n-channel metal-oxide semiconductor), is rapidly approaching the process complexity of standard CMOS. It is not unusual nowadays for NMOS technology to have up to four transistor types with different operating characteristics. Much of the complexity of this process is added simply to help VLSI designers keep the operating power of their circuits under control.

Second, CMOS circuit designers are being more selective in the use of static CMOS logic. Critically placed dynamic logic, creative circuit design, and use of modes that offer varying degrees of power consumption are all tricks designers are using to maintain the advantages of CMOS.

Finally, aggressive reduction in CMOS transistor size is being used to bring CMOS performance in line with that of NMOS. As a matter of fact, many manufacturers are developing CMOS as a derivative of their advanced NMOS processes. This not only improves CMOS performance levels but also boosts reliability and reduces development costs.

The Evolution of LSI

Early LSI circuits were built with p-channel MOS transistors, which permitted high-circuit densities yet were relatively slow and difficult to interface to normal integrated circuits, such as TTL (transistor-transistor logic). As an example, the 1103-type 1k by 1-bit dynamic RAM (random-access read/write memory), circa 1971, required its inputs (address, controls, and data) to swing between 1 and 15 volts (V) although its output was measured in millivolts—hardly TTL compatible! About 1974, NMOS came to the rescue. It provided faster speed, and most of its inputs and outputs were TTL compatible.

Low power requirements are a major advantage of designing a system that uses CMOS.

NMOS was more difficult to manufacture than PMOS because contaminants would vary the thresholds of the n-channel transistors, causing deviations in speed and performance. But this problem was quickly overcome through ultraclean processing rooms, and NMOS became the workhorse technology because it cost less to manufacture, was easy to use, and had good speed-power characteristics. And NMOS technology had potential for greater improvement of its speed-power characteristics through scaling (or shrinking) of the silicon devices. The result of this scaling was HCMOS (high-speed NMOS), which accomplished three objectives: increased speed, reduced power, and increased density.

Over the past 10 years, the reduction in transistor size has, at the device level, increased memory density by a factor of 64, increased speed by a factor of 3, and reduced power consumption by a factor of 100. However, the scaling cannot continue ad infinitum because of resolution limitations of the photolithographic equipment used to make the circuits as well as breakdown mechanisms within the devices. More important, even before these limitations are reached, heat dissipation will prohibit major enhancements with NMOS. Heat generation increases exponentially with transistor count, and, at densities approaching 150,000 transistors per integrated circuit, special cooling measures are required. This heat can accelerate failure mechanisms within the silicon, reducing device and system reliability. To hurdle this barrier, low-power devices must be used.

The Importance of Power Consumption

The development of NMOS was spurred on by the semiconductor industry's drive to produce high-volume, large-capacity memory devices, for which high density, rather than low power consumption, was the primary concern. As VLSI began to emerge, however, power dissipation became a limiting factor in continued increases in NMOS packing densities. Thus, the semiconductor industry turned to CMOS as a potential alternative.

CMOS achieves its low power dissipation through the use of both p- and n-channel transistors (hence the name "complementary"). Essentially, no DC power is dissipated in either logical state, and AC power occurs only during the relatively short switching period. Because most circuitry in a complex design is active only 10 to 20 percent of the time, CMOS achieves a dramatic reduction in power dissipation compared with NMOS, which continually dissipates DC power whenever an operating voltage is applied.

Low power requirements are a major advantage of designing a system that uses CMOS. Reducing power requirements has a domino effect that often substantially reduces the cost of the end product.
Figure 1: A comparison of NMOS and CMOS technologies. Figure 1a shows the schematic diagrams of an inverter as implemented in both NMOS and CMOS. A hypothetical input waveform and the resulting transistor currents are shown in 1b and 1c.

- Low power allows smaller, lower-cost power supplies to be used.
- Power distribution in the system is simplified.
- Cooling fans can be eliminated.
- Printed-circuit boards can be packed more densely and can thus become smaller.

With smaller power supplies, denser circuit boards, and no fans, smaller cabinets can be used, resulting in savings in chassis and enclosure costs. Also, power fail-safe and hand-held use become possible if battery operation is feasible.

**Basic CMOS Operation**

To truly understand the promises (and problems) facing both the CMOS VLSI digital designer and the CMOS systems designer, one must first understand some CMOS fundamentals.

Figure 1 compares the circuit diagrams and current characteristics of both an NMOS and a CMOS inverter. The NMOS inverter uses an n-channel depletion-mode transistor as the pull-up device (which drives the output line high) and an n-channel enhancement-mode transistor as the pull-down device (which drives the output line low). The pull-up transistor is used as a load; its operation approximates that of a constant current source. The pull-down transistor is used as the switching device; when active, it discharges the load, and when inactive it lets the pull-up charge the load. MOS loads are primarily capacitive and include the parasitic capacitances of the inverter itself, interconnect capacitances, and the thin-oxide capacitances of all the gates the inverter is driving.

Let's note several characteristics of an NMOS inverter. When the pull-down device is turned on, it not only has to sink the current from the capacitive load, but it also has to sink the current supplied by the pull-up load device. Even in the quiescent state this current component from the pull-up device still exists. Because logic gates spend most of their time in the quiescent state, this quiescent current accounts for up to 90 percent of the total power dissipated in NMOS VLSI designs; the remaining 10 percent is switching or dynamic power.

A second related characteristic is that the inverter's output voltage in the low state, $V_{OL}$, is dependent on the ratio of the impedances of the pull-down and pull-up devices. This ratio affects the noise margin and switching speed and is generally around 4:1. Such a ratio results in a $V_{OL}$ on the order of 0.2 V to 0.3 V. It also causes asymmetric switching characteristics: the fall time of the inverter is significantly faster than its rise time.

The CMOS inverter uses a p-channel enhancement-mode transistor as the pull-up device and an n-channel enhancement-mode transistor as the pull-down device. In a CMOS inverter, both the pull-up and pull-down transistors are used as switching devices. When the input changes from low to high, the p-channel device shuts off and the n-channel transistor discharges the load. When the input changes from high to low, the n-channel device shuts off and
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the p-channel transistor charges the load. While almost all current from the CMOS inverter is used to charge or discharge the load, a small current component does not flow through the load. This is a result of the fact that both the p-channel and n-channel transistors are on for a short period of time during the input voltage transition. This current component is typically less than 10 percent of the total inverter current, though it depends greatly on the rise and fall times of the input signal.

With no quiescent power component, a CMOS inverter’s dynamic power dissipation represents only a small fraction of an equivalent NMOS inverter’s power dissipation. Also, the CMOS inverter is a “ratioless” design, having only one transistor active after an input transition. This lets \( V_{ol} \) go all the way to ground potential, resulting in better noise tolerance than NMOS inverters. It is also a simple matter to design CMOS circuits with outputs that have equal rise and fall times. While this is important in some circuits, it is generally not taken advantage of in VLSI designs because it requires greater chip area.

For NMOS and CMOS technologies with similar transistor dimensions and gate oxides, gate delays are essentially identical. The speed-power products for such a set of NMOS and CMOS technologies are shown in figure 2. This graphically illustrates the tremendous power advantage CMOS offers when used in high-performance VLSI designs.

While CMOS enjoys significant electrical advantages over NMOS, it does have a cost disadvantage. One small factor is the larger number of process steps needed to fabricate a CMOS device. More significant is the larger die required because CMOS has lower gate density.

**CMOS Technologies**

Figure 3 shows the four major CMOS technologies in use today: p-well bulk, n-well bulk, twin-tub bulk, and silicon-on-sapphire (SOS). P-well CMOS uses a p-type diffusion into an n-type bulk silicon substrate to form an n-channel transistor. The p-channel transistor is built directly in the bulk. This is the original CMOS technology, which has many years of good performance and reliability behind it.

The n-well CMOS process starts with a p-type substrate. N-type material is diffused into it to form the n-well in which p-channel devices are built. N-channel devices are built directly in the bulk substrate. An n-well CMOS process is usually derived from an advanced NMOS process. It also permits a highly optimized n-channel transistor, which yields a slight performance advantage over a p-well CMOS process.
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Bulk CMOS technologies have parasitic bipolar transistors that, if improperly biased, can cause a phenomenon called latch up. This potentially destructive action results from triggering an SCR (silicon-controlled rectifier) formed by the transistors and can cause extremely large currents to flow. Figure 4 shows the construction of the parasitic SCR in an n-well bulk CMOS device.
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Two well-defined conditions must exist before latch up can occur. First, for the SCR to be triggered, IR_{well} or IR_{nwell} must be greater than or equal to 0.7 V. This forward-biases the base-emitter junctions of the parasitic bipolar transistors. Second, to sustain the latch up condition, the product of the βs (gains) of the two bipolar transistors must equal at least 1.

In order to minimize the chance of one of the SCR's transistors being forward-biased, every attempt is made to reduce the resistance values as much as is feasible. This has the effect of requiring significantly larger injected currents before the SCR can be triggered. To reduce the resistance values, guard rings are used in the circuitry. (Guard rings are low-resistivity connections to the supply voltages placed around the CMOS p-channel and n-channel transistors.) While guard rings reduce the SCR bias resistor values, they also increase the space between n-channel transistors and p-channel transistors (thus reducing the gate density). To somewhat minimize this effect, particularly sensitive areas (like VLSI component's I/O pins) are heavily guard ringed, while the more protected internal circuitry is less so.

A less controllable method of preventing latch up is to try and decrease the βs of the parasitic transistors. While the vertical pnp transistor's β is set by the process design, the lateral npn transistor is more directly controllable. Its β can be drastically reduced by increasing the nwell-to-n+ diffusion spacing (or pwell-to-p+ diffusion spacing in pwell technology). This method reduces the β by increasing the width of the transistor's base. While this is an effective way of decreasing the gain of the parasitic structure, it also reduces the gate density.

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give absolute protection against latch up is not only tremendously expensive in silicon area, but it is also virtually impossible. CMOS designers sacrifice area to ensure there is enough margin in their design to protect it from latch up in normal operating-system environments.

Logic-Gate Structures

Gate densities are also reduced in CMOS because standard CMOS logic gates are built from more transistors than their NMOS equivalents. Standard CMOS logic-gate design has a 1:1 ratio of n-channel transistors to p-channel transistors. For example, the two input gates shown in figure 5 take four transistors in CMOS and only three in NMOS. The relative density decreases as the number of inputs increases. For example, three-input gates require six transistors in CMOS and only four in NMOS; four-input gates require eight transistors in CMOS and only five in NMOS, etc. As a matter of fact, it is rare to have a standard CMOS gate with more than three inputs because the self-loading and the transistor stack make the structure inefficient in both speed and area. On the other hand, it is not unusual in NMOS to have gates with as many as eight inputs.

Static Design Techniques

A final reason for the lower CMOS gate densities is the use of static logic (modern VLSI NMOS microcomputer designs rely heavily on dynamic circuitry). Dynamic circuitry essentially uses a small capacitor as a latch to store logic values. This technique saves both area (by reducing the number of transistors in a gate) and power (by reducing the number of gates in structures like latches, flip-flops, shift registers, etc.). Employing dynamic design can reduce an NMOS latch's area by 30 percent and its power consumption by 50 percent. However, the problem with dynamic circuitry is that the capacitor used to store the logic value is leaky and will, over time, discharge and lose its data. This is the same problem faced by dynamic memory designers. The solution is to periodically refresh the capacitor, which forces a minimum operating frequency to be adhered to.

CMOS can also use dynamic circuitry, especially to increase the ratio of n-channel transistors to p-channel transistors. Because static CMOS designs have a 1:1 ratio of n-channel to p-channel transistors, being able to increase this ratio will have the effect of giving CMOS a higher gate density (but the minimum operating-frequency characteristic of dynamic circuitry often conflicts with the CMOS potential of absolutely minimizing power). Therefore, while true static CMOS design does give the lowest possible power consumption (by allowing the device to operate at frequencies all the way to DC), dynamic CMOS designs, being more dense and resulting in smaller die sizes, tend to be more cost-effective. Thus, two trends are developing in the use of CMOS for VLSI microcomputer design.

Designers of the next generation of 16- and 32-bit microprocessors are choosing CMOS. Here, the goal is not to operate at the lowest possible power level but rather to keep the operating power under a maximum level for cooler junction temperatures, higher performance levels, and the ability to use standard low-cost packages. In these designs, extensive use is made of dynamic logic. The ratio of n-channel transistors to p-channel transistors is often as high as 3:1.

Designers of 4- and 8-bit single-chip microcomputers are choosing CMOS to accommodate a host of new portable, hand-held, and ultralow-power applications. Here, the goal is to minimize the operating power levels consistent with the performance required by the application. In the simpler microcomputers, true CMOS static logic is used—their simpler structure still allows a relatively small die size, while the low-performance applications they
are appropriate for low operating frequencies. On the other hand, the more complex, higher-performance, single-chip VLSI components still make maximum use of static logic but are forced into dynamic logic for large arrays to keep the die cost down.

**Future CMOS**

CMOS will be the technology of choice for VLSI microcomputer designs. For one thing, with the advent of hundreds of thousands of transistors on a die, CMOS is the only technology that offers a cost-effective solution to the power-density problem.

A second and more subtle future issue is reduced supply voltage. As MOS transistors continue to be scaled to smaller dimensions to eke out further performance and density advances, the standard 5-V supply voltage must be reduced, if only for internal circuitry, to limit substrate current and hot-electron effects. CMOS is better suited for lower supply-voltage operation because its switch point is a fixed percentage of the supply voltage. Also, due to its “ratio-less” structures, CMOS enjoys better noise tolerance than NMOS, another important factor at lower supply voltages.

Finally, CMOS has made and will continue to make major strides in its relative cost disadvantage to NMOS. Where CMOS formerly sold at as much as a fourfold premium, today it is selling at somewhat less than twice the price of comparable NMOS devices. With its continued use of standard, low-cost packaging technology as well as the more creative use of dynamic circuitry and hybrid static/dynamic designs, CMOS will rapidly approach the cost of NMOS. As a matter of fact, several major semiconductor manufacturers have stated that CMOS/NMOS price parity will occur this decade, and some manufacturers say it will happen as early as 1985. When CMOS and NMOS cost the same, why would anyone buy NMOS?

---

**A CMOS Single-Chip Computer:**

Intel’s 80C51

by Martin B. Pawloski

Intel's 80C51 is an interesting example of how the static logic versus dynamic logic trade-off was made in an actual product design. The 8051 is an 8-bit, single-chip microcomputer with 4K bytes of ROM, 128 bytes of RAM, two 16-bit counter/timers, multilevel interrupt control, 32 I/O pins, full-duplex UART (universal asynchronous receiver/transmitter), and on-chip oscillator and clock circuits. A die with the sections identified by functions is shown in photo 1 on page 94.

The CMOS version of the 8051, called the 80C51, is targeted at a number of applications that require both high performance and low power consumption. In areas like telephony, automotive control, industrial control, and portable instrumentation, the 80C51 operates at or near its maximum speed, even if only for short intervals. (For example, most real-time applications need an external-interrupt response time of less than 100 microseconds (µs); more demanding applications require better than 10-µs response. While the response must be quick, and the interrupt routine executed quickly, the processor spends a significant portion of its time idle.)

Once the performance requirements of the application are known, it is possible to specify a minimum operating frequency. For the 80C51, a hybrid static/dynamic design was proposed that allows a minimum die size and includes various modes of operation to minimize power consumption.

First, the only areas of the design that were made dynamic were the (very large) ROM and Control arrays. These arrays contain almost 50,000 transistors and constitute a major portion of the die. By making them...
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### Table 1: A comparison of the CMOS and NMOS versions of the 8051.

<table>
<thead>
<tr>
<th>Product</th>
<th>Technology</th>
<th>( V_{cc} ) Supply Voltage Range</th>
<th>Operating-Frequency Range</th>
<th>Normal Operating Mode power (( I_{cc} ) Max)</th>
<th>Idle Mode power (( I_{cc} ) Max)</th>
<th>Power Down Mode power (( I_{cc} ) Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80C51</td>
<td>CMOS</td>
<td>4-6 V</td>
<td>12 MHz Max</td>
<td>24 mA</td>
<td>3 mA</td>
<td>50 ( \mu )A</td>
</tr>
<tr>
<td>8051</td>
<td>HMOS</td>
<td>4.5-5.5 V</td>
<td>1.2 MHz Min</td>
<td>150 mA</td>
<td>20 mA</td>
<td>20 mA</td>
</tr>
</tbody>
</table>

#### Z80 in CMOS Clothing: National Semiconductor's NSC800

by Tony Moroyan

A CMOS processor particularly suited to portable-computer applications, National Semiconductor's NSC800 incorporates features typical of state-of-the-art NMOS devices with low-powered, high-density, surface-mounted packages (with both leaded and leadless chip carriers).

Internally the NSC800 has the same instruction set and complement of registers as Zilog's popular NMOS processor, the Z80. Externally, the NSC800 features a multiplexed data and address bus like that of Intel's 8085 processor. It dissipates only 5 percent of the power that NMOS devices in its performance class do, and yet it is capable of operating at speeds up to 4 MHz.

The chip is fabricated using National's PC-MOS process, a silicon-gate technology that achieves high pn-junction leakage. Static logic was designed in the peripheral sections in order to support this mode because no clocks are available to refresh dynamic logic. In both the Idle and Power Down modes, special provisions are made for the dynamic circuits in the ROM and Control areas to enter a pseudostatic condition that prevents any extraneous power consumption due to voltage drift on capacitive storage nodes.

Table 1 compares the NMOS 8051 to the CMOS 80C51. The 80C51, designed in Intel's HMOS-derived n-well process called CHMOS, is less than 10 percent larger than the NMOS design and consumes only 15 percent of the normal operating power. More significant power savings are possible by operating the 80C51 at lower frequencies or by using the Idle mode.

Martin B. Pawloski (5000 West Williams Field Rd., Chandler, AZ 85224) is involved in the product planning, definition, and implementation of both NMOS and CMOS single-chip microcomputers at Intel Corp.
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density by employing one level of metal for interconnection and two levels of polysilicon. (Future products will incorporate two levels of metal for further density improvements.)

A major feature suiting the NSC800 to modern computer applications is its compatibility with the wealth of available Z80-based software. Indeed, Z80-based development software, operating systems (such as CP/M), high-level languages, and applications programs will run without modification, and with no speed penalty, on an NSC800 system. This compatibility is a tremendous advantage for the small-systems builder.

With the Z80 architecture, the programmer has 158 instructions with 10 addressing modes, 22 programmable registers, 256 directly addressable I/O locations, and a 64K-byte memory-address space. In addition, the multiplexed bus frees some of the IC's 40 pins for use in implementation of extra functions not found on the Z80. These include:

- three additional interrupt lines for faster interrupt-response times
- two special status lines for decoding processor states
- an onboard clock generator
- a power-save feature for further reducing power consumption

The Multiplexed Bus

The NSC800's multiplexed bus uses 16 lines to transfer 16 address bits and 8 data bits. The upper 8 bits of the address bus are present on lines A8 through A15; lines A0 through A7 carry the 8 data bits and the lower 8 address bits, at different times. Systems can use the multiplexed bus, or the buses can be separated into a 16-bit address bus and an 8-bit data bus. All NSC800 family components (including the NSC810 RAM-I/O-Timer, the NSC830 ROM-I/O chip, and the NSC858 UART) have a multiplexed-bus structure and thus can interface directly with the NSC800. The ALE (address latch enable) control strobe of the processor controls bus demultiplexing.

The multiplexed bus requires one-third fewer bus lines to interconnect devices, resulting in reduced circuit-board complexity. (8085-type peripherals and many memory devices support this type of multiplexed bus.)

Interrupts

Three of the IC's freed pins have been used to provide more interrupts than the Z80 offers. The standard NMI (nonmaskable interrupt) and INT (multimode interrupt) are compatible with the Z80 and 8080.

The NMI is used as the highest-priority interrupt line and is useful during, for example, power failure conditions, for which the processor must be alerted for graceful power-down operations. NMI is an edgesensitive input line and causes a direct restart to memory location 0066 hexadecimal.

The INT input has three modes: 0, 1, and 2. Mode 0 corresponds to the 8080 method of interrupt handling. An interrupting peripheral places a restart instruction on the data bus, and the processor then executes the instruction, usually a call to a subroutine. Mode 1 provides transfer to an automatic restart location (0038 hexadecimal). Thus, in small systems the peripheral need not strobe the restart instruction onto the data bus. With mode 2 interrupts, the processor reads a vector from the interrupting device; that vector is used with the contents of the I register to create a pointer to the address of a table entry that contains the interrupt-handler-routine address. This interrupt is maskable on or off and is controlled by system-interrupt-enable flip-flops inside the NSC800. These can be set by software, as they are in the Z80.

The remaining three interrupt lines, RSA, RSTB, and RSTC, provide three different but fixed restart addresses. These lines are similar to the 8085 interrupts and are also maskable under program control.

Power Modes

In many applications, power consumption is so critical that it is help-
ful to put the NSC800 into a standby mode whenever possible. A single power-save input pin suspends processor operation and reduces power consumption by 50 percent. The NSC800 can be held in the power-save mode indefinitely: internal register contents are saved during this time, and the processor can resume operation without interruption. This feature does not stop clock operation, however, so some power is still consumed. With additional circuitry, even the clock can be suspended for maximum power reduction. The new 6-MHz NSC800 (available in the first half of 1984) will have this feature built in for ultralow power dissipation.

The power-save line can also be controlled by a switch to create a single-step function. When the switch moves to the normally open (NO) position, the processor executes one instruction, suspends operation, and waits for the switch to return to its normally closed (NC) position.

Another NSC800 extra pin freed up by the multiplexed-bus structure permits an on-chip clock generator, which reduces system component count and cost. In place of an external clock-generator chip, the NSC800 requires only a crystal or RC-oscillator circuit to produce the system clock.

A final difference from the Z80 is that the NSC800 has an extra bit in the refresh register used to automatically refresh 64K-bit dynamic RAM chips without any extra logic.

Tony Moray is marketing manager for the NSC800 family in the Microprocessor Group at National Semiconductor Corp. (2900 Semiconductor Dr., Mail Stop D3667, Santa Clara, CA 95051).

A Look at CMOS Dynamic Memory

by Joe Altnether

The fast-growing portable-computer market is placing severe demands on semiconductor memory. For optimum system performance, these components must limit their power dissipation to suit battery operation and backup, and they must achieve the high data bandwidths and increased speeds needed for fast processing and high-resolution graphics. As the market reaches a projected $4.8 billion level by 1987 (a tenfold increase over 1982 levels), these requirements will combine to fuel the use of high-performance CMOS dynamic RAMs.

One architecture that can increase the speed of a CMOS dynamic RAM incorporates static-column address decoders: static circuits perform the selection of the column address of the RAM. Previously, this architecture has not been used with dynamic RAMs because of the increased power consumption of the static circuits over that of the dynamic circuits, and the advantage of low power consumption would have been lost. But with CMOS, the increased power consumption is negligible.

Memory-device Architecture

RAMs are organized internally as rows and columns of storage cells. Data access occurs at the intersection of a row address and a column address. In dynamic RAMs, the row and column addresses are multiplexed to reduce package size and pin count: the row addresses are clocked into the device with the RAS (row address strobe) signal, causing one row of data (1 bit from each of the 256 columns in a 64K-bit dynamic RAM) to be fed into the 256 internal sense amplifiers. (Because of the low internal signal levels, each column must have an associated sense amplifier to sense and restore memory-cell data.) Next, column addresses are presented to the device and clocked into it with the CAS (column address strobe) signal. These column addresses are then decoded to select one of the 256 bits. Faster access and cycle times are obtained within a row (or "page") after the first access to it because the 256 bits within the row continue to reside in the sense amplifiers and need not be refetched. Reapplying only column addresses, then, in what is known as Page Mode operation, provides fast serial accesses and can increase cycle times by a factor of 2.

The CMOS dynamic RAM can incorporate static-column circuits to provide performance equivalent to that of high-speed static RAMs. With CMOS, the static-decoding circuits reduce the internal number of clocks by a factor of 3, eliminating the need to allow for setup and hold times of signals with respect to clocks and the need to compensate for timing skew.

due to process variances. With static-column circuits, precharge times are drastically reduced (in Page Mode operation of the Static-Column-mode device, precharge time is reduced from 30 nanoseconds [ns] to 5 ns). This precharge time reduction and the faster access times typically increase the memory's bandwidth to 20 MHz. (Performance of memory discussed here is based on the experimental 64K-bit CMOS dynamic RAM that Intel presented at the ISSCC conference in February 1983.)

With static-column architecture, two different types of Page Mode operation are possible: Static Column mode and Ripplemode. Static Column mode uses the RAS line and row addresses in the conventional manner, but once the row has been selected, data can be accessed merely by changing column addresses. As with a static RAM, column addresses must remain stable and valid for the entire address access cycle. Access time is measured from column addresses rather than the occurrence of CAS. (Typically, access from column addresses is 30 ns; from CAS, it is 10 ns.)

In operation, CAS is used to place the output in a high-impedance state or to activate an output buffer. CAS can be held active during the entire page cycle. In fact, it is possible to keep CAS permanently active (i.e., grounded). During a write cycle,
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however, addresses as well as data are latched by CAS or WE, whichever occurs last. Operation is identical to that of an NMOS dynamic RAM in this case. This action ensures that the data is written into the proper memory location.

Although Static Column mode provides fast, easy accesses, speed at the system level is limited by how fast addresses for the next cycle become valid; the time to generate and stabilize the addresses must be added to the cycle time. Increased system speed can be obtained by using Ripplemode. With this mode, static-column circuits are again used to obtain access from valid column addresses, but the addresses are latched on the falling edge of CAS, removing the requirement for addresses to remain valid throughout the entire cycle. As a result, during the current cycle addresses for the next cycle can be set up or pipelined.

Column addresses enter the RAM through the internal address latch. This latch, controlled by CAS, provides flow-through operation. When CAS is inactive, the latch is open, and addresses pass through continuously to the static-column decoders. Any change in address is transmitted immediately to the decoder. Consequently, access to the RAM is again measured from valid column addresses. The latch captures the current address on the fall of CAS, permitting the system address to change while the access occurs. CAS also serves as an output enable on the data output. Static Column mode and Ripplemode both permit continuous data streams up to 20 MHz.

CMOS technology and static-column architecture provide more than low power consumption and high bandwidth. In addition, static-column decoding simplifies system design by eliminating critical timing relationships while providing higher system speed. Access from column addresses gives usable speed for single random accesses within the RAM. Also, the CMOS technology enhances reliability by incorporating a mechanism to significantly reduce soft errors. Finally, increased stored charge creates larger internal signal
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levels, which can more easily be differentiated from noise. As a result, the CMOS dynamic RAM has wider operating margins and system reliability is improved.

**Power Consumption**

At the system level, dynamic memory has three components of power: active, standby, and refresh. The system's power consumption is defined as

\[ P = V(ML + KI + NI_{R}) \]

where \( P \) = system power, \( V \) = voltage (5.5 V worst case), \( I_{A} \) = active current, \( I_{S} \) = standby current, \( I_{R} \) = refresh current, \( M \) = number of active devices, \( K \) = number of devices in standby, and \( N \) = total number of devices.

CMOS reduces the first term, the active current, relative to NMOS by a factor of 2. In addition, the lower active current reduces supply voltage transients, thus simplifying printed-circuit-board design and reducing decoupling-capacitor requirements.

The second term, standby current, is also reduced by a factor of 2 at TTL input levels. Driving the RAS signal to a CMOS level \((V_{DD} - 0.5 \text{ V})\) places the device in a low-power-standby mode and typically draws 10 microamperes \((\mu A)\)—a factor of 50 reduction over NMOS!

Refresh current, the third term in the equation, is cycle-time dependent. Current increases with the frequency of refresh. In dynamic RAMs, data is stored on a capacitor that must be replenished or recharged every 2 or 4 milliseconds \((\text{ms})\). This refresh time is a function of the stored charge and the leakage current. With the CMOS dynamic RAM, the cell storage capacitance is 0.125 picofarad \((\text{pF})\) compared to 0.040 \(\text{pF}\) to 0.085 \(\text{pF}\) in an NMOS dynamic RAM. This low capacitance, coupled with lower leakage currents, permits the CMOS refresh period to be extended to 64 ms in standby.

At the standard 128 refresh cycles/2 ms \((\text{equivalent to a} 15.625-\mu s \text{ refresh period})\), the NMOS device draws about 4.8 milliamperes \((\text{mA})\) and asymptotically approaches the standby current of 4 mA as the refresh period approaches infinity. Even eliminating refresh entirely only reduces the current to 4 mA, which is only a 16 percent improvement. As a result, extending NMOS refresh does not significantly reduce the system's power consumption.

Contrast this characteristic to the improvement CMOS offers. At 15.625 \(\mu s\), the CMOS dynamic RAM draws approximately 10 percent of the NMOS current, or \(0.42 \text{ mA}\) at TTL levels. Extending the refresh period reduces the current asymptotically to the standby current of 0.05 mA. At a 64-ms refresh period, the current is reduced to 0.15 mA, a 300 percent reduction. When battery powered, the CMOS system has a 10 times longer life than does the NMOS system, and an extended refresh mode offers another fivefold improvement. A 256K-byte CMOS memory can retain data for nearly one week on only AA nickel-cadmium \((\text{nicad})\) cells—more than sufficient for most portable systems.
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High-Speed Applications

Ripplemode and Static Column mode are ideal for applications involving high-speed buffers, telecommunications, and graphics. Bit-mapped graphics systems would seem to be a natural fit with Page Mode operation. However, this was not always the case. Prior to the Intel 2164A 64K by 1-bit NMOS dynamic RAM, it was difficult to retrieve all 256 bits within a single row of memory because of the RAS-low time limitation of 10 µs. Even with a Page Mode cycle time of 125 ns, to retrieve all 256 bits would require 32 µs—three times longer than allowed. The 2164A extended the RAS-low time to 75 µs, permitting the extraction of all 256 bits during a single Page Mode cycle.

At the end of the cycle, the device cannot be reaccessed again until after a certain off-time allows internal nodes to be precharged to be ready for the next cycle. As a result, the 2164A can stream data at greater than a 7-MHz rate continuously. This function matches the timing and operation of low-performance, bit-mapped graphics memories. One 2164A, for example, can map all the data for the 256 by 256 matrix of a graphics display. During the horizontal scan time, the RAM performs a Page Mode cycle and one full line is displayed. During retrace time, the memory must be refreshed and can be updated with new data if required. This type of update is relatively slow; consequently, it limits the speed of animation on the screen because the processor has access to the memory only 25 percent of the time.

To increase resolution, more lines, each with more pixels, must be used. By performing two sequential Page Mode cycles from two different RAMs, pixel densities to 512 bits per line can be achieved. As pixel density increases, the memory cycle time must decrease to print more pixels on a line in the same amount of time. This cycle-time limitation plus the fact that memory can be updated only during blanking has precluded dynamic RAMs from use in higher-resolution graphics displays. These systems are usually built with high-speed, expensive static RAMs.

With Ripplemode, memory update during screen display time, also known as cycle stealing, is possible. As an example, a 512 by 384 display requires 512 bits/line and 1 bit every 67 ns. Data is read from four memory devices in a series of eight Ripplemode reads each. Data is temporarily stored in a video-output register file and then shifted to the video screen at a rate slower than the Ripplemode reads. Following this, enough time is available to perform an update cycle before the next eight Ripplemode reads are performed to continue screen refresh. Eight was the number chosen to minimize the time the processor must wait to update the memory. In addition to this cycle stealing, which updates during display time, memory updates are also performed during blanking. Along with this system, a similar sys-
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System was built using 2164As with Extended Page Mode operation. Each system used an iAPX 86 processor and similar software. A comparison of both systems showed the CHMOS (complementary high-speed metal-oxide semiconductor) system to have a 42 percent higher drawing speed. Animation on the CHMOS system was vastly improved.

Usable Speed
Memory design using dynamic RAMs has always been a challenge. Although multiplexing addresses does reduce the package pin count and increase system density, it limits the access and cycle times in the system. To access a dynamic RAM, low-order row addresses are presented and latched into the dynamic RAM with RAS. Row addresses must be held for a period \( t_{RAS} \) after the fall of RAS to guarantee proper operation. Next, the addresses must be changed to high-order column addresses and latched into the dynamic RAM with CAS, creating a timing window \( t_{RCD} \), which is the RAS-to-CAS delay.

Within this window, the designer must guarantee row address hold time, change the addresses, and account for any timing skew on the CAS signal. If column addresses are valid at the maximum specified \( t_{RCD} \), access time \( t_{AC} \) is measured from the high-to-low transition of RAS.

The cycle time is the sum of the access time and the cycle precharge time \( t_{RP} \). The access time is a function of \( t_{RCD} \), which has contradictory requirements. It must be as long as possible to simplify system design and at the same time as short as possible to enhance system speed. Cycle time is affected directly by the length of \( t_{RP} \).

Static-column operation eliminates the \( t_{RCD} \) problem. After row addresses have been latched into the RAM, the second portion of the access begins from valid column addresses. In other words, column access does not wait for CAS to become valid, but operates in a fashion similar to that of a static RAM. This is due to the flow-through operation of the CAS latch. CAS serves only to latch the addresses and to provide an output enable. Access from valid column addresses simplifies design by removing the CAS signal from the critical timing path.

Systems using dynamic RAMs are typically CAS access-limited because controllers generate timing signals in discrete clock increments. A CMOS dynamic RAM system might operate at 8 MHz without Wait states. Using any other 64K-bit dynamic RAM would require the injection of one or two Wait states, resulting in a corresponding performance penalty. Consequently, the advantage of higher processor speed is negated without the high-speed dynamic RAM. For systems incorporating either discrete or LSI controllers, the CMOS dynamic RAM simplifies the system design and offers higher system performance.

High Reliability
Soft errors are random, nonrecurring failures caused by ionizing radiation present within the environment. All matter contains small amounts of radioactive material. Alpha particles emitted by an IC's packaging material can penetrate the enclosed circuit. As they do so, they generate hole-electron pairs. Any high-impedance node in the vicinity sensitive to 1 million electrons may be affected, because the difference between a 1 and a 0 (known as the critical charge) is about 1 million electrons. Consequently, data in one cell could change from a 1 to a 0 or vice versa. Correct data can be rewritten into the affected cell and the memory will again function correctly, thus the term "soft error."

When first discovered during tests of 16K-bit dynamic RAMs, soft errors occurred at a rate five times greater than catastrophic or hard-error failures. While device designers worked to eliminate the alpha-particle sensitivity, systems designers added error-correcting circuits (ECC), which increased system reliability, but the systems were larger and more expensive due to the additional components required. Also, the system had to test and correct the data, slowing the system's performance. All this
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was due to soft errors. Obviously, what is really required is the elimination of soft errors.

CMOS technology offers such a solution. The CMOS dynamic RAM cell is built on an n-well in a p-substrate, creating a p-n junction or diode at the boundary. When alpha particles create hole-electron pairs in a CMOS device, something else occurs. First, the n-well is very shallow, and the majority of hole-electron pairs are created in the p-substrate. Holes cannot cross the reverse-biased p-n junction, which acts as a barrier to soft-error effects. Any electrons that do cross the junction are gathered at the +5 V node away from the storage cell. The probability that sufficient hole-electron pairs are created within the n-well that cell upset could occur is so low that the soft-error rate of CMOS dynamic RAMs is typically orders of magnitude below that of their NMOS counterparts.

High storage capacitance also plays a role in the reduction of soft errors. The number of stored charged electrons representing a 1 or a 0 is directly proportional to the storage capacitance. Higher capacitance equates to more stored charge, which in turn increases the critical charge. The critical charge is the number of particles that differentiate a 1 from a 0. Increasing the critical charge beyond 1 million electrons significantly reduces the susceptibility to soft errors. This, in addition to the n-well mechanism, reduces the soft-error rate to much less than 0.001 percent per 1000 hours.

Studies were performed to compare reliability of systems with and without error correction for both NMOS and CMOS dynamic RAMs. The results show one surprise: at 256K bytes and below, the CMOS system without ECC is more reliable than the NMOS system with ECC, because of the cycle-time dependence of soft errors. In small systems, the memory is accessed more frequently, and the probability of a soft error is increased. With a soft-error rate at the very minimum 100 times less than NMOS, the CMOS dynamic RAM does not experience this effect.

Systems below 256K-byte capacities benefit by the elimination of ECC circuits from a cost, performance, and simplicity-of-design standpoint. First, ECC increases the access time of the system by 50 ns to check and correct data. Assuming a 120-ns RAM access, ECC increases the access by 42 percent. Moreover, the penalty on cycle time is even greater, especially when you are writing a single byte into a 2-byte word. In this instance, data must be accessed and corrected, the new byte merged into the word, and check bits generated. Finally, the system must write the new data into memory. Added to this are system-timing skews. As a result, a 200-ns cycle time stretches to a 335-ns system cycle time or an increase of 68 percent. Therefore, using a CMOS dynamic RAM not only improves system reliability but enhances system speed and simplicity of design.
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The Challenge of Hard-Disk Portability

How DMA Systems designed a removable hard-disk unit for the transportable generation

by David A. Sutton

In the Old West, Winchesters were designed to be portable. They could survive weeks in dusty scabbards and still function efficiently when the need arose. These days, portable Winchester disks operate under different constraints to perform different tasks.

This is an account of the portability issues encountered by one hard-disk-drive manufacturer, DMA Systems, and of the design decisions its engineers reached.

Why does a transportable computer need a hard-disk drive? Because many of us need to transfer the power of our desktop computers to other locations, and we don't want to sacrifice software or hardware capability in terms of speed and storage capacity. Ideally, the capabilities of a hard-disk unit should be available whether the system is transportable (requires AC power) or portable (requires battery power).

A designer of a portable hard-disk system confronts a difficult task if reliability, speed, and capacity are to be preserved. The most difficult challenge designers face is developing truly portable hard-disk drives for away-from-the-office data storage, program loading, and backup storage.

Quasi-Winchester

The challenge of combining both removability and portability in a single Winchester-type device means that designers must grapple with the fact that a removable-only cartridge drive (or the removable portion of a fixed/removable drive) is not a Winchester in the classic sense. In 1973, IBM developed Winchester technology and dropped the flying height of the head from 80 microinches to as low as 15 microinches above the disk. This low flying height dictated the characteristics we now consider typical of a Winchester—heads and disk in a sealed environment, heads that land on the disk prior to flying, lubricated media, and stringent air-filtration systems. These controls enable the head to fly lower and the drive to achieve Winchester flying heights.

IBM's original 30-30 project (30 megabytes fixed, 30 megabytes removable) presumed that the only way to guarantee a contamination-proof disk surface for the low-flying Winchester heads was to package heads and disks together in a sealed environment. The cost of a removable Winchester "pack," therefore, would have to include the cost of a complete set of heads and a head-carriage mechanism. It was an impractical approach then and is even more impractical for microcomputers.

In any situation in which a disk drive may be moved, it's equally impractical to have the heads settle onto the disk area during power-down. Allowing the head to touch the media risks damage to both the data on the disk and the head itself.

Hazards of Portability

A portable hard-disk cartridge drive faces a triple set of hazards: to the cartridge, to the drive, and to the combined cartridge and drive
(operating or not operating). Cartridge and drive are both part of an electromechanical assembly that must deliver years of reliable service without requiring maintenance. It would certainly be asking too much of any user to seat the cartridge with anywhere near the level of care used in a factory clean room to align a sealed Winchester disk-and-head assembly. Instead, a drive designer must assume that both cartridge and drive, of either fixed or removable type, will be subject to every conceivable kind of abuse:

- shock and vibration that can cause head or disk-surface damage or cause data to be lost because the balance between aerodynamic lift and head-loading force has been disturbed or because the heads have been thrown off track by spurious sideways movements
- contamination (dust, cigarette smoke, moisture, or chemical fumes) that enters the cartridge or collects on the heads and actuator arm when the cartridge has been removed from the drive
- strong electrical or magnetic fields that can make data and software unreadable
- unsophisticated or unauthorized users who are convinced that their principal mission in life is to enforce Murphy’s law personally

Shrinking Size and Costs
As if these challenges were not enough, cartridge-drive designers must face the fact that the requirement for portability or transportability will only encourage the demand for smaller drives (or greater capacity within the same drive envelope). A designer’s task is to maintain reliability and performance. As disk size drops, data density steadily increases, making it all the more difficult to maintain repeatability (the capability to read recorded data when a cartridge is inserted in a drive) and interchangeability (the capability to record data on one drive and read it when the cartridge is inserted into another similar device).

In a cost-conscious market, little allowance is given to the difficulties a drive designer must overcome in this ongoing quest for miniaturization. Instead, the belief prevails that “If it’s smaller, it should be cheaper.” Maintaining reliability and enhancing performance means that a designer must rethink every aspect of the drive assembly and electronics:

- the read/write heads
- the disk media and motor
- the head-positioning servo system
- the data separator
- the drive separator
- the cartridge design

In designing its Micro-Magnum fixed/removable and removable-only drives, DMA Systems attempted to address all of these needs. Charting unknown waters, DMA engineers expected the worst (and have rarely been disappointed).

As disk size drops, data density steadily increases, which makes it difficult to maintain repeatability and interchangeability.

Contamination Control
One concern of designers has been the control and removal of contaminants that could cause severe head and media damage or destroy the integrity of recorded data. DMA’s solution to this problem is the high-capacity, closed-loop, recirculating air system for a “double half-height” fixed/removable drive.

A preliminary purge cycle removes all the contaminants that may have entered the drive when a cartridge is inserted. The impeller-drive system then continues to move all air in the drive through a recirculating filter at least once per second. The filter unit was designed to last for five years with no filter changes.

Both the drive and the cartridge have self-sealing doors to keep contaminants from entering their respective compartments and to ensure a clean head-disk interface. Whenever the spindle motor is turned off, the head assembly is completely withdrawn into the drive and the door seals the head-port opening. The cartridge also has a door to protect the head opening and a clamp that secures the hub against the cartridge to prevent foreign substances from entering the cartridge.

Most of the contaminants that enter the system were already inside the cartridge when it was inserted into the drive. The purge cycle removes most of these and also raises the pressure in the cartridge so that any air leaks vent outward and no further contaminants may enter the cartridge. Any loss due to leakage is made up by air pulled into the system through a breather filter.

Head Design
A consistent head-to-media relationship is an absolute must for data integrity and device reliability. The head and disk must maintain their critical distance, yet head and disk surface must not physically touch. This premise is overlooked in the design of most 5/4-inch Winchester disk drives—a fact that becomes critical when transporting the drive introduces the opportunity for violent head-to-disk contact.

When the disk is in a cartridge that is being pushed in and out of several drives, or even in and out of the same drive on a daily basis, elimination of head-to-disk contact is essential. Therefore DMA developed the Cushion-Aire head assembly (photo 1) to allow a Winchester air bearing to be loaded dynamically onto a spinning cartridge disk. Because the head never starts or stops touching the disk, there is no head ringing on the disk, no head-landing on top of contaminants after purge cycles, no damage to heads during transit, and no accidental jostling of the system during use.

Though nickel-zinc-ferrite and manganese-zinc monolithic ferrite heads are commonplace on larger Winchester drives, both present drawbacks when incorporated into a 5/4-inch design. At the data densities required, the signal output of nickel-zinc-ferrite heads is unacceptable,
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Circle 390 on inquiry card.
and manganese-zinc heads are only marginally acceptable. Furthermore, monolithic heads have inherently less signal output due to their relatively long flux path. To remedy the signal strength problem—and to provide less parasitic inductance—DMA chose to develop a composite head employing a discrete manganese-zinc core, glass-bonded into a ceramic Winchester-type air-bearing enclosure.

Embedded-Servo Head Positioning

To overcome errors that might occur in head tracking due to thermal expansion, cartridge interchange, friction in the cartridge, offset due to drive tilt, and disk runout, the DMA engineering staff employed another proven large-disk technique: embedded-servo head positioning.

The embedded-servo technique eliminates any requirement for head alignment and is, in fact, a key to the successful use of hard-disk cartridges. Servo codes embedded (i.e., recorded) on the disk guide the drive heads to the proper position by sending signals to the mechanism controlling the read/write head as the head passes over the disk. This technique enables the drive to actually adjust the head position in the event of errors due to heat expansion or other factors.

Embedded-servo positioning requires two steps. First, coarse positioning allows the proper track to be located. Embedded-servo data is pre-recorded on the disk during the manufacturing process and is typically contained in the first 26 bytes of each sector on the disk. The servo code contains data for each track number on the disk. As the head crosses a track, it reads the servo data and a software routine calculates a demand velocity based on the difference between current track location and target track. Head speed is controlled, in effect, by a linear-motor servo that receives continuous analog input from the drive's control electronics.

In the second step, the fine-positioning servomechanism locates the read/write head within a half-track distance of the desired location. Pre-recorded signal segments A and B define the fine-positioning servo bursts. The edges of segments A and B are recorded along the center of the tracks so that a head centered exactly on a track will read equal amplitudes from both segments (see figure 1). If the head is off center, one amplitude will read higher, the other lower. The difference is detected and used as an error signal to drive a linear-motor positioner to seek and maintain the proper track center-line position.

Drive Electronics

Shrinking the control electronics to the limited volume of a 5¹⁄₂-inch drive was no small task. This mission was complicated by the circuitry for the embedded servo and voice-coil head positioner.

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**SWTPC, HELIX, DYNABYTE, TERAK** | Taxan I | 330 |
**WICAT** | WICAT | 300 |

**MODEMS**

<table>
<thead>
<tr>
<th>D.C. Hayes</th>
<th>Smartmodem</th>
</tr>
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<tbody>
<tr>
<td>300 baud</td>
<td>230</td>
</tr>
<tr>
<td>1200/2400 baud</td>
<td>520</td>
</tr>
<tr>
<td>2400 baud modem &amp; communication</td>
<td>520</td>
</tr>
<tr>
<td>56K</td>
<td>470</td>
</tr>
<tr>
<td>Auto Link 1200</td>
<td>450</td>
</tr>
<tr>
<td>212P</td>
<td>400</td>
</tr>
<tr>
<td>212A</td>
<td>400</td>
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<tr>
<td>Novation</td>
<td>Smartsat 300</td>
</tr>
<tr>
<td>Smartcat 300</td>
<td>200</td>
</tr>
<tr>
<td>Smartcat 300/1200</td>
<td>455</td>
</tr>
<tr>
<td>J-Cat</td>
<td>130</td>
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<tr>
<td>Van-Tel</td>
<td>300 baud modem W/S/W</td>
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**SOFTWARE**

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<tr>
<th>dBase II</th>
<th>Ashton-Tate</th>
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<tr>
<td>Redding</td>
<td>488</td>
</tr>
<tr>
<td>Grifal business graphics</td>
<td>400</td>
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**Accounting software**

<table>
<thead>
<tr>
<th>Accounting Plus</th>
<th>299</th>
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<tbody>
<tr>
<td>Legal Timekeeping &amp; Accounting</td>
<td>659</td>
</tr>
<tr>
<td>Peach pak (GL, AR, AP)</td>
<td>390</td>
</tr>
<tr>
<td>CPAid</td>
<td>420</td>
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</table>

**CPAid**

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<thead>
<tr>
<th>Master Tax</th>
<th>CALL</th>
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<tr>
<td>Microsoft</td>
<td>220</td>
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**Word processing**

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<tr>
<th>IUS, Easy Writer II</th>
<th>280</th>
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</thead>
<tbody>
<tr>
<td>Multimate</td>
<td><em>Word Processing</em></td>
</tr>
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</table>

**IBM Compatible CP/M686 package** | CALL |

**PRINTERs**

<table>
<thead>
<tr>
<th>BANANA</th>
<th>50 cps</th>
<th>. .</th>
<th>215</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IDS</strong></td>
<td>110 cps, 84 x 84 graphic, pin &amp; friction feed, ser./par.</td>
<td>459</td>
<td></td>
</tr>
<tr>
<td><strong>Microprism</strong></td>
<td>200 cps, 132 col.</td>
<td>1,100</td>
<td></td>
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<tr>
<td><strong>Calor</strong></td>
<td>with graphics</td>
<td>1,180</td>
<td></td>
</tr>
<tr>
<td><strong>Gemini</strong></td>
<td>with graphic, friction</td>
<td>1,590</td>
<td></td>
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<tr>
<td><strong>Epson</strong></td>
<td>100</td>
<td>339</td>
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<tr>
<td><strong>FX-80</strong></td>
<td>180</td>
<td>560</td>
<td></td>
</tr>
<tr>
<td><strong>FX-100</strong></td>
<td>560</td>
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<tr>
<td><strong>Okidata</strong></td>
<td>ML</td>
<td>625</td>
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<td></td>
<td>83A</td>
<td>625</td>
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<td></td>
<td>84</td>
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<td></td>
<td>500</td>
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<td><strong>MT 300L</strong></td>
<td>160</td>
<td>620</td>
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<tr>
<td><strong>MT 300D</strong></td>
<td>200</td>
<td>1,393</td>
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<tr>
<td><strong>Citon</strong></td>
<td>Prowriter I par</td>
<td>410</td>
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<tr>
<td></td>
<td>800 two colors</td>
<td>1,050</td>
<td></td>
</tr>
<tr>
<td><strong>Toshiba</strong></td>
<td>P390</td>
<td>1,525</td>
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<tr>
<td><strong>Dynax 15</strong></td>
<td>13 cps (Brother)</td>
<td>520</td>
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<tr>
<td><strong>Brother</strong></td>
<td>Silver Reed</td>
<td>675</td>
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<tr>
<td><strong>Transfer</strong></td>
<td>130</td>
<td>727</td>
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**TERMINALS**

<table>
<thead>
<tr>
<th>Zenith</th>
<th>Z-29 Smart terminal</th>
<th>CALL</th>
</tr>
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<tbody>
<tr>
<td><strong>Hazeltime</strong></td>
<td>Esprit II</td>
<td>588</td>
</tr>
<tr>
<td>Esprit II</td>
<td>588</td>
<td></td>
</tr>
<tr>
<td><strong>Esprit</strong></td>
<td>Esprit III color terminal</td>
<td>875</td>
</tr>
<tr>
<td><strong>Televideo</strong></td>
<td>925</td>
<td>740</td>
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<tr>
<td><strong>Visual</strong></td>
<td>60</td>
<td>1,099</td>
</tr>
<tr>
<td></td>
<td>55 green</td>
<td>725</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>948</td>
</tr>
<tr>
<td></td>
<td>550 graphic</td>
<td>2,150</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>795</td>
</tr>
<tr>
<td><strong>Wyse</strong></td>
<td>ADDS color terminal</td>
<td>CALL</td>
</tr>
<tr>
<td><strong>Viewpoint</strong></td>
<td>CALL</td>
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**IBM COMPATIBLE**

<table>
<thead>
<tr>
<th>Zenith</th>
<th>Z-110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual drives, 128K RAM, 8/16 bit, color board, 225 x 640 graphics</td>
<td>CALL</td>
</tr>
<tr>
<td><strong>ZW-110-32</strong></td>
<td>with 11MB hard disk</td>
</tr>
<tr>
<td><strong>ZVM-135</strong></td>
<td>RGB color monitor</td>
</tr>
<tr>
<td><strong>Corona</strong></td>
<td>128K RAM, 320K floppy, 640 x 325 graphic, green monitor ser. &amp; par. port, DOS, GW BASIC, MultiMate word processing, PC Tutor</td>
</tr>
<tr>
<td><strong>Eagle</strong></td>
<td>128K RAM, two floppy disks, monitor, two ser. &amp; one par. ports. EagleWrite, EagleCalc</td>
</tr>
<tr>
<td><strong>Corona</strong></td>
<td>PCC-1 128K RAM, one 320K floppy, monitor, and serial port</td>
</tr>
</tbody>
</table>

**PLOTTER/DIGITIZER**

<table>
<thead>
<tr>
<th>Houston Instrument DMP-29</th>
<th>. .</th>
<th>1,795</th>
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<tbody>
<tr>
<td>DMP-40</td>
<td>795</td>
<td></td>
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<tr>
<td>DMP-41 &amp; DMP-42</td>
<td>CALL</td>
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<tr>
<td><strong>Amdek</strong></td>
<td>XY plotter (attached)</td>
<td>688</td>
</tr>
<tr>
<td></td>
<td>8 pens</td>
<td>1,085</td>
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<tr>
<td><strong>Sweet-P</strong></td>
<td><em>Plotter</em></td>
<td>610</td>
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<tr>
<td><strong>GTAC</strong></td>
<td><em>graphic analysis package</em></td>
<td>1,200</td>
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**POWERED DIGITIZER**

<table>
<thead>
<tr>
<th>IBM Compatible</th>
<th>with digitizer for IBM</th>
<th>2,500</th>
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<tr>
<td><strong>ZToy</strong></td>
<td>Tandon Drive 100-2</td>
<td>260</td>
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</table>

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**Monitors Monthly Special $380**

<table>
<thead>
<tr>
<th>Zenith</th>
<th>ZVM-123 12” green</th>
<th>115</th>
</tr>
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<tr>
<td>ZVM-122 12” Amber</td>
<td>129</td>
<td></td>
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<tr>
<td>ZVM-131 medium resolution</td>
<td>305</td>
<td></td>
</tr>
<tr>
<td><strong>ZVM-135 840 x 440</strong></td>
<td>550</td>
<td></td>
</tr>
<tr>
<td><strong>Amdek</strong></td>
<td>color 13”</td>
<td>340</td>
</tr>
<tr>
<td></td>
<td>color II RGB</td>
<td>699</td>
</tr>
<tr>
<td></td>
<td>color IV 720 x 400</td>
<td>1,070</td>
</tr>
<tr>
<td><strong>NEC</strong></td>
<td>12” green</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>17” green</td>
<td>170</td>
</tr>
<tr>
<td><strong>Zen</strong></td>
<td>1203 R9G</td>
<td>725</td>
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<tr>
<td><strong>Color monitor</strong></td>
<td>330</td>
<td></td>
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</table>

**TERMINALS**

<table>
<thead>
<tr>
<th><strong>COMPUTER CHANNEL COMPUTER CENTER</strong></th>
<th>Dealers Welcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDS Microprinter printer</td>
<td>450</td>
</tr>
<tr>
<td>Sanyo Color Monitor</td>
<td>600</td>
</tr>
<tr>
<td>Hazeltine Espirit III</td>
<td>665</td>
</tr>
</tbody>
</table>

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SMALL COMPlf DISC 95

In almos t every respect, currently 
available hard-disk Winchester drives 
can meet the requirements imposed

and simplify the hardware. One microprocessor is dedicated to I/O (input/output) status purposes including front-end function, safety checks, and fault algorithms. This microprocessor also preformats all SEEK commands into the form required by the second microprocessor, which controls all the internal command lines of the embedded-servo system.

The second microprocessor also receives embedded-servo information from a servo decoding unit—a custom, large-scale integrated circuit (LSI)—which gives the microprocessor the information required to perform the basic disk-drive servo functions: track following and seeking, rezeroing, and loading and retracting of the heads.

Partitioning these operations between two microprocessors helps achieve faster overall system response. For example, the second microprocessor may perform a SEEK while the first continues to handle all interface and safety functions; two microprocessors can handle emergency situations faster than a single processor.

Two custom LSI gate-array chips were also developed to achieve the needed packing density and to manage the servo data while protecting it from any accidental overwriting.

The first gate-array chip is committed to servo control of the spindle and is a 200-gate array that includes spindle-motor commutation circuits, a spindle-speed control servo, a speed-safety function, and a 10-MHz crystal oscillator. The second, an 800-gate array IC, decodes the digital information within the embedded-servo fields. Erase-gap detection, sector decoding, the location of index marks, track timing checks, and sample pulses for fine positioning of the heads are all controlled by this chip.

If the drive were ever to overwrite the embedded-servo fields, data could be irretrievably lost. To prevent this, a series of hardware and software safety checks works to protect both the embedded-servo fields and the data on the disks. The decoding gate-array chip checks hardware before clearing the way for a WRITE operation. The heads can respond within microseconds to any unsafe condition spotted by the gate-array chip. Software checks are also written into the drive firmware to enable the WRITE functions. The software will not proceed with a WRITE operation until two successive embedded-servo sectors have decoded the same track identification and no fault conditions have been found in the drive.

Packaging and Power Drain

In almost every respect, currently available hard-disk Winchester drives can meet the requirements imposed
Don't take no for an answer!

<table>
<thead>
<tr>
<th>Feature</th>
<th>DMA Systems 5½&quot; Drives</th>
<th>3½&quot; Drives</th>
<th>Other 5½&quot; Drives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Now in production</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Data interchange</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Contamination control</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Retractable heads</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Standard cartridge</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>40 ms access time</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>5 Mb capacity (formatted)</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Capacity growth capability</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Removable-only drive</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Fixed/Removable drive</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

A comparison of Winchester cartridge disk drives shows there's really no comparison.

Only DMA Systems allows you to interchange data between drives.

Only DMA Systems has a unique retractable head that ensures data integrity by never touching the disk.

Only DMA Systems has a self-sealing clean air system that prevents contaminants from reaching the data—even after thousands of insertions.

And only DMA Systems gives you a choice of fixed/removable or removable-only drives. Both models match mini-floppy front panel dimensions and adapt to existing 5½" Winchester drive controllers.

What's more, DMA Systems is the only manufacturer delivering microcomputer Winchester cartridge disk drives.

But DMA Systems drives don't just outperform other cartridge systems. They outperform all other types of microcomputer backup.

Consider the alternatives...

Floppies have low capacity, poor reliability and slow access time.

Streamers are unreliable and can't provide random access.

There's only one drive manufacturer who can answer "yes" to all of your needs: DMA Systems.

For more information write DMA Systems, 601 Pine Avenue, Goleta, CA 93117. Or call (805) 683-3811, Telex 658341.
by portability or transportability. They are reliable devices with built-in safety features and a high tolerance for abuse. But two issues still need to be addressed: packaging and power.

It is too early to say how the drives will ultimately be integrated into portable or transportable systems. Now, they are packaged as separate accessories that connect with a short cable to the back of the computer. This means that, for the first time, designers of small hard-disk drives will be concerned with appearance and with an exterior that can withstand scratches, heavy weights, and an occasional drop off a desk. Manufacturers will also be pressured to further decrease size and weight, anticipating the day when hard disks are the standard storage medium for portable and transportable computers and have moved inside the “box” to take the place of fading floppy disks.

Most hard-disk drives were designed for integration into a desktop or console cabinet, with no real limitation on the power required for driving the high-speed spindle. Drives now draw more than an ampere of current and dissipate up to 30 watts of power. This would quickly drain any battery pack that a user would be willing to carry. Therefore, despite any designer’s best efforts to reduce power requirements, true portability is still unobtainable.

Computers with hard-disk storage are still restricted to locations with external power sources, including the 12-volt cigarette-lighter jack available on most automobiles.

Despite this reservation, however, there is no question that the hard-disk cartridge will soon be a feasible storage medium for every class of small computer. In terms of convenience, capacity, and removability, it may soon be the only viable alternative.

David A. Sutton is the engineering vice-president of DMA Systems (601 Pine Ave., Goleta, CA 93117). Prior to working at DMA, he worked at General Electric and helped found Information Magnetics Corporation.
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Once you grow beyond your own personal computing needs for business, it no longer makes sense to buy a single user computer.

The cost alone—aside from the inefficiency of not being able to share data and to compute interdependently in an office environment—makes this option obsolete.

The Zeus 4 allows up to eight users to work from one system at the same time. Each can have his own terminal, CPU, and active memory. Each shares ample file storage including floppy backup. Each has a second port for his own printer or telephone modem.

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With the Zeus 4 multi-processor there is no loss in power or speed of operation when several users compute at the same time. Single processors bog down with simultaneous use. Plus, the Zeus 4 gives you total flexibility in computing with true sharing of data (not just passing from one to the next) in a complete multi-user environment. The operating features available to Zeus 4 users. Write us for a free software directory.

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The power of this machine resides in the strong integration among the built-in software packages

by Mahlon G. Kelly

I first laid my hands on a TRS-80 Model I back in 1978, and I was amazed at what it could do. It seemed obvious to me (and to many others) that the microcomputers that were then appearing—TRS-80, PET, Apple, and their ilk—would revolutionize how many of us do our work. Five years later, it's hard for me to remember what it was like not to have a microcomputer in my office. I have used more than 20 brands of microcomputers. All had their advantages and disadvantages and most did what was expected of them, but none excited me like that first generation—until now. The excitement is back: the TRS-80 Model 100 is the precursor of another revolution.

The Model 100 is very different from its predecessors: the portable and pocket computers. The portables, all more than 20 pounds in weight and with delicate disk drives, aren't suited to go wherever you want. The pocket machines can be easily carried around but are inadequate for large jobs because of their limited keyboards, displays, memory, and speed. I have often dreamed of a computer—one that had a typewriter keyboard and a useful screen display—that I could hold in my lap, carry from office to office.
and use for jobs I would otherwise do on my desktop machine.

The Model 100 is just what I wanted, a fine stand-alone machine that is also ideally suited for hooking up to other computers, either directly or over the phone. With its excellent text editor, you can use it as an electronic scratch pad and then exchange its contents with machines that have more storage, or you can use it to transfer data between incompatible machines, you can use it as a remote terminal, you can use it to gather field data, or you can simply use it as an excellent stand-alone machine.

Physical Description

The Model 100 is a little under 2 inches thick and about the size of a typical sheet of typing paper (see photo 1). The top surface has a full-size keyboard and an LCD (liquid-crystal display) showing 8 lines of 40 characters each that can be adjusted for clarity at various viewing angles. Around the edges are several sockets and switches, which should give you an idea of the power of this computer. There’s an on/off switch, two switches for the modem (one for choosing originate or answer mode and another for choosing between a direct connection and an acoustic coupler), and a push button for reset. It also has sockets for a power transformer, a bar-code reader, a tape recorder, a DB-25 connector for RS-232C communication, a modem connection to a phone line, and one for a cable to a Centronics-compatible printer. The transformer and cables aren’t included, but they’re inexpensive. On the bottom are sockets for additional ROM (read-only memory) and a bus connector, both of which hint at things to come.

Power can come either from an AC outlet or from four AA alkaline batteries. Either source continually charges nickel-cadmium (nicad) cells that maintain the memory. The four AA cells will last about 20 hours; a light on the top warns when they’re low. If they run down, the nicads will maintain the information already in the computer for many days. A switch on the back disconnects the nicads when the machine is going to be stored, but that will delete all the information in the memory.

The Model 100 is available with 8K bytes of RAM (random-access read/write memory) for $799 or with 16K bytes for $999; more can be added for a total of 32K bytes. Files and programs remain in memory until they are deliberately killed. This sharing of memory makes the 8K-byte version of the machine virtually unusable for anything serious.

Keyboard

The keyboard is as good as any I have used on a microcomputer or terminal. It’s of standard size and the feel is excellent. There’s nice audible feedback on each key, and the auto-repeat feature has a natural feel to it. A touch-typist will be right at home. Besides the normal typewriter keys (including a Caps-Lock), it has six special keys. Control and Escape keys are available mainly for use with the telecommunications program. The Model 100 itself also responds to control characters—for example, Con-
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trol-H sends a backspace and Control-I does a tab. There's also a Tab key, although you cannot define the settings.

The Num key latches in the down position and redefines a cluster of keys on the right half of the keyboard as a keypad for data entry. In some ways this is nicer than a separate keypad, because your fingers are always near the Enter, Backspace, and other keys. Code and Grph sit to the right and left of the space bar. They let you type in special graphics and alphabetic (foreign-language) symbols that are represented by ASCII (American National Standard Code for Information Interchange) numbers higher than 127. The keyboard has different characters for both shifted and lowercase Code and Grph modes. Unfortunately, because these are not standard characters, they won't be recognized by most printers.

Above the main keyboard are 16 special-function keys, eight of which are definable. The right-hand four are arrow keys for moving the cursor. I find them awkward to use; a cluster would be much better. To their left are four permanently defined keys: a Pause/Break key that makes a program pause or stop, a key for sending material to the printer, a Label key that causes the definition of the software-controlled keys to be displayed on the bottom of the screen, and a Paste key that's used with the text editor. The eight left-hand keys are definable, serving different purposes with different software.

The only problem I have found with the keyboard is that, when it's sitting on top of a desk, your thumb is likely to hit the lower edge of the case before it actuates the space bar. It's better if you put something under the back of the case to tilt the keyboard, but it would have been nice if the lower edge of the case had been slightly cut away. Others have complained about the popping noise the keys make when they're pressed. Some people, however, don't mind the sound the keys make: when I loaned the machine to a student to use during an exam, none of his neighbors complained.

Software

The way that the programs in ROM are integrated with each other and the machine makes the Model 100 revolutionary. Contained in 32K bytes of ROM are the BASIC interpreter, a versatile text editor, a telecommunication package with advanced features that supports both RS-232C hook-up and 300-bps (bits per second) modem communication, a schedule book, and an address book. The address book also contains the phone numbers for the auto-dial modem.

When you first turn on the machine, you see a menu with the files and programs, the time, day, date, and the available memory. Five programs (BASIC, TEXT, TELCOM, ADDRSS, and SCHEDL) are in ROM. Two RAM files, ADDR5.DO and NOTE.DO, are needed if the address and schedule books are to be used. Files are designated by three suffixes: .DO(ocument), .BA(sic), and .CO(mmand). A broad reverse-video cursor covers the file names and is moved by the arrow keys. Pressing Enter either executes the program pointed to by the cursor or, for a .DO file, enters the text editor and loads that file into it.

Microsoft is selling the operating system and BASIC to others, and this system may become a de facto standard. The NEC notebook computer that has recently been introduced is very similar, partly because it uses much of the same software.

The text editor is the most commonly used program. It's used to create and edit documents (including the files for the address and schedule books), and it also serves as the BASIC editor. It's simple but very versatile; it is not a word processor, however. When a document is printed, it is presented exactly as it occurs in the memory; no provision is made for page control, variable margins, and the other things that a word processor should do. But a simple BASIC program can be used to format a file (see listing 1).

The text editor is simplicity itself in concept. Only eight things can be done: text can be inserted, marked, deleted, copied, or searched for; the cursor can be moved; and files can be saved to read from tape. No type-over mode is available. To replace text, it must first be deleted, by either backspacing over it or by marking it and then cutting it out. Being permanently in an insertion mode may be confusing if you're used to more typical text editors, but the strangeness soon goes away. When pressed by themselves, the arrow keys either move the cursor up or down or one character to the right or left. They can also be used to scroll through the text. Pressing Shift and an arrow key either moves to the top or bottom of the screen or one word to the right or left. Pressing the Control key and either horizontal arrow moves the cursor to the beginning or end of a line; with the vertical arrows, Control moves to the top or bottom of the document. When supplemented by the Find function, the arrow keys make it easy to position the cursor anywhere in the text.

Cut-and-paste operations are just as easy. Pressing the key marked Sel (for select—function key F7) and then moving the cursor makes everything that the cursor passes over appear in reverse video. Text can be "unmarked" by pressing the Break key, moving the cursor back over the text, or pressing the Sel key again. Pressing Cut (key F5) removes the marked text, saving it in the paste buffer. If you press Copy (key F5), the text goes to the buffer but isn't removed from the document. At any time, pressing the Paste key puts the contents of the paste buffer into the document in front of the cursor.

I do have some criticisms of the editor. It's easy to find a string, but
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Listing 1: A Model 100 BASIC program to format text output. This program was placed in the public domain by Ed Juge of Tandy.

1 'NEWPRN.100 Ed Juge 04/19/83
2 'GRAPH$ causes forced end of page
3 'Defaults for margins (L,R), print
4 'title on page 1 (H/D) and line
5 'spacing (LS) exist in line 20,
6 
7
10 CLS CLEAR2000:LS=0:FILES
20 L=0:R=50:HD$="Y":LS=1
30 C1=STRING$(60,32):LN=0:PG=1
40 GOSUB100:INPUT$.00 file to print "H$'
50 GOSUB100:INPUT$Margins (L,R)" :L,R,FL=0:HEN=1
60 L1=STRING$(-1,32):GOSUB100:INPUT$Line Spacing (1/2) "H$'
70 GOSUB100:INPUT$Title on pg.1 (Y/N) "H$'
80 OPENH$FORINPUT$:AS1
90 GOTO110
110 PRINT205,C1:PRINT205,"":RETURN
118 CLS:IF $=" "THEN PH$=LS:DATE$:GOTO140
120 PH=$=STRING$(R-6,32):DATE$'
130 IF PH$="THEN"$=PH$1,LEN(H$))=H$'
140 IF PH$="Y"ORPH$="N"THENGOSUB 3601P=LS'
150 P=LS'
170 IFN$=SOUTHG0T330
180 FOR J=LEN(PH$)TO R
190 P=PR$+INPUT$(1,1)
200 IF EOF$(1)THEN CLOSE:EN=1:GOTO280
210 IF RIGHT$(PH$,1)=CHR$(10)THEN PH$=1:GOTO270
220 RIGHT$(PH$,1)=CHR$(128)THENP=LEFT$(PH$,J-1):GOTO330
230 NEXTJ
240 IF MID$(PH$,J,1)=" THEN260
250 J=J-1:GOTO240
260 KL=IF PH$=PH$1,R):PR$=MID$(PH$,J,1):GOTO280
270 PR$=LEFT$(PH$,LEN(PR$)-2)
280 IF MID$(PH$,J,3)=" THEN300
290 IF MID$(PH$,J,1)=" THEN PR$=MID$(PR$,2,LEN(PR$)):GOTO290
300 LPRINTPR$:LN=1:JEN=THEN300
310 IFLS=2THENPRINTLN=1
320 PR$=LEH$=MID$(PH$,J,1):GOTO170
330 FOR J=1HTG0S1PRINT:NEXTJ:PG=PG+1
340 IF PH$=THENMENU
350 IF PH$="THEN360 ELSEPRINT2160","":PRINT <ENTER> = next page, <D> = nonstop":X$
368 CLS LPRINTPH$1:LPRINT$,":Page ":PG
370 LPRINT1:PRINT=81:GOTO180

there is no provision to find a string and replace it with another. Second, it's awkward to add text from other files ("boiler plate" paragraphs and so on). The easiest way is to leave the document, enter the other file, and mark and copy the text to the paste buffer. You can then reenter the original document and paste in the text (that's not as hard as it sounds). You can also add text from tape, but that's really awkward and slow. It would be nice to have a command to insert or append text from other files.

Another problem is that when you add text to the middle of a fairly long file (2000 to 3000 characters) it's easy to type faster than the characters appear on the screen. Because there's a type-ahead buffer, your input won't be lost. Nevertheless, the delay is disconcerting, and long segments of inserted text must be proofread after the screen catches up. However, if you're typing at the end of the file, you can't type faster than the screen will display. In order to insert text into the middle of a very large file, I
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find it easier to insert text at the end of the file, mark it to be cut, and then paste it in where it belongs.

A further problem, and one that doesn't apply to just the text editor, is that there's no way of knowing how much memory is occupied by each file. Listing 2 is a BASIC program that will tell you how long a text file is, although it won't work with BASIC programs.

Finally, when you edit a file you're working directly with the text stored in memory. With disk-based editors, if you make a mistake you can reload the original file. If you do so while editing a file in the Model 100, the mistake is permanent. It's a good idea to save the file to tape or to another file before you edit it. (This rather important point is not mentioned in the documentation.)

The small LCD screen isn't as nice for editing as a 24-line by 80-character video display, but when you get used to it it's not inconvenient. I rewrote this article on the Model 100 and then sent it to my LNW-80 computer for final editing and printing (using the Newscript word-processing program). By embedding the proper Newscript formatting commands in the text itself, the file was ready for printing as it left the Model 100.

## Address and Schedule Books

These two programs, ADDRESS and SCHEDL, are virtually identical in what they do, and presumably they share the same ROM. They both simply find a block of text that contains a certain string of characters. The block, which can be someone's address and phone number or a description of an appointment, is a long string that ends with a carriage return. The address function accesses a file named ADDRS.DO (which also contains the numbers accessed by the automatic dialing procedure in the communications software) while the schedule program looks at one called NOTE.DO. But the similarity and simplicity of these two programs don't negate their usefulness. You can, for example, create a list of items that have been flagged with special characters; when you search for the special characters, all flagged items will be displayed. The items could be appointments with your boss or the addresses and phone numbers of your field representatives. The files are created with the text editor and can be sorted and rearranged with fairly simple BASIC programs. It's also possible to send the found items to a printer.

### Telecommunications

If the address and schedule programs are simple, the communications software (TELCOM) is the opposite. It's not hard to use, but it does so many things that it's hard to describe. When you move the menu cursor to TELCOM and press Enter, you go to mode 1 of the telecommunications package. Four possibilities are then offered by function keys F1 through F4: Find a name and phone number in the address file, Call the number to log on to a host, Stat, which lets you define the RS-232C parameters, and Term, which goes into mode 2, the terminal mode.

Let's look first at how you might sign on to a bulletin board system at 300 bps, with the number already in the directory. To use the modem you need a special cable. One end plugs into the Model 100, another into a wall jack, and the third is a socket for your phone. Although the manual is a bit confusing about this, telling you to plug the cable into your phone, the connections are obvious. The modem cable package is a great bargain. At less than $20, it includes an hour each on the Dow Jones and Computerserve information utilities.

The RS-232C parameters must first
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be defined (if that hasn't been done). If you hit the Stat key and enter M81E,10, you tell the UART (universal asynchronous receiver/transmitter) that the modem will be used (M), a word will be 8 bits (8), parity will be ignored (I), there's 1 stop bit (1), XON and XOFF protocols are enabled (E), and the phone will be dialed at 10 pulses per second (,10).

Table 1 shows other possibilities. Suppose the name of the bulletin board is "mousenet". Press the Find key, type "mousenet", and the name and phone number will be displayed from the address file. If it's wrong, you can hit M (for more) to see if there's another mousenet; if you change your mind, you can press Q to quit. If you press Call, the number will be dialed; when the modem tone is received, you'll be switched into mode 2, the terminal mode, connected to the host. Only pulse dialing is supported. Most tone-dialing systems will also support pulse dialing, but if you're using a ROLM or PBX system that requires tones, then the number must be dialed manually.

While in terminal mode, you receive whatever comes from the host and you are presented with four possibilities on the function keys. Pressing the Prev key will display the previous eight lines of input, in case what you want has scrolled off the screen. Pressing Full will change between full and half duplex. Pressing Echo will send everything to the printer as well as the screen. The last two keys, Down and Up, let you send and receive files. Press Down and you'll be asked for a file name. After you enter it the word "Down" will appear in reverse video, and everything you receive will be stored in the file. When you press Down again, the file will be closed and its contents saved. That's much simpler than downloading a file with a disk-based system.

Uploading a file to a host is just as easy. Press the Up key and you're again asked for a file name. When you enter it, you're asked for a width; when you answer that, everything in the file is sent to the host, with car-
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Key | Meaning
--- | ---
? | Waits for a specified character to be received by the Model 100
/ | Pauses for 2 seconds
- | Immediately precedes a "\" or "\" when those characters are to be transmitted to the remote computer
- | Sends the following character as a control character (e.g., \"K\" sends a Control-K)

Table 2: Codes for use when automatically logging onto remote computers.

Data-transfer rate to 1200 bps (see Table 2). Then when you press the Term key, you can upload and download data just as for telephone communications, but much more quickly.

Of course you need the proper software for the larger machine, but a wide variety of programs are available for most microcomputers. You can use the Model 100 as a terminal, either by direct connection or via a 300 bps modem connection, for any computer that supports an RS-232C port. I have used the Model 100 with mainframes, minicomputers, and several microcomputers (CP/M systems as well as my own LNW-80) at rates up to 19,200 bps. You can also transfer data using BASIC programs.

Using the Model 100 as a terminal has one problem. Data can come in faster than it can be scrolled by the screen. That's usually not a problem at 300 bps or when you're typing, but at faster rates the input can actually overflow the input buffer. When that happens characters are lost. The best way to avoid this is to be sure the host doesn't send linefeed after a carriage return, thus preventing the scrolling of the screen. The information will be hard to read because it all appears on one line, but it will all go into the file that's being saved.

Because of this problem, the Model 100 cannot completely replace a high-speed data terminal.

Some Applications

For me, the TELCOM communications software is the most useful part of the Model 100, and I suspect it will be for many others. In fact, although I can use four TRS-80s, several CP/M machines, and an LNW-80, since I bought the Model 100 I have used it more than any of the other machines. Maybe my experiences will show you how useful this machine can be.

One of the best uses for the Model 100 is in transporting data. I have always suffered when transferring data from a CP/M machine in my office to my LNW-80 at home. Now I can just dump a data file from the office machine to the Model 100, take the Model 100 home, and upload the data to the LNW. At 4800 bps, it takes about 2 minutes at each end, includ-
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The TELCOM communications software is the most useful part of the Model 100.

For me, the TELCOM communications software is the most useful part of the Model 100.

used to fill out in the field. I no longer have to key the data in by hand at the office, and the Model 100 takes care of a lot of the tedious calculator work that I used to do in the field.

By itself, the powerful combination of the text editor and the communications package makes the Model 100 worth its price. But the software I have described so far is only the tip of the iceberg. The Model 100 has what may be the most powerful BASIC interpreter yet written for a microcomputer.

BASIC Interpreter

The Model 100's BASIC, like the BASIC for all other TRS-80s and like the rest of the operating system on this machine, was written by Microsoft. It is as complete and extensive a version of Microsoft BASIC as is available for any machine, and it has a number of enhancements specifically for the Model 100. Its execution...
speed (as judged by a number of benchmark programs) seems to be as fast as or faster than that of the Model III. And this BASIC does all its calculations, including transcendental functions such as sin and log, in double precision (14 digits). You may be confused if you're used to other TRS-80 BASIC or Microsoft interpreters; several statements have different syntax, especially those for opening files, and you must set the number of I/O (input/output) files and the top of memory using MAXFILES and HIMEM statements—the Model 100 does not ask any questions about files and memory when you enter the interpreter.

I cannot review all aspects of the BASIC dialect here. Table 3 summarizes all the statements. A rough count gives 5 operators and 39 statements that are not included in the very powerful Model III extended disk BASIC.

The added arithmetic operators are \" \" and MOD, both of which pertain to integer division. The MOD operator gives the remainder (5 MOD 3 = 2) while \" \" gives the truncated quotient (9 \ 2 = 4). Surprisingly, \" \" is not on the keyboard—you have to use the Grph key and a minus sign. The added logical operators are XOR, EQV, and IMP. XOR does an exclusive or—when one bit is 0 and the other is 1, the result is 1. With EQV, when either both bits are 0 or both are 1, the result is 1. With IMP, the result is 1 unless the first bit is 1 and the second is 0. These new operators can often replace several awkward comparison statements.

Three new numeric functions are CRLSIN, which returns the line where the cursor is located; POS, which returns the column position of the cursor; and MAXRAM, which returns the amount of RAM installed in the computer.

One of the most significant additions to Model 100 BASIC is the use of extended-interrupt commands. Older versions of BASIC had only one—ON ERROR GOTO would make a branch when an error occurred. This BASIC adds four new ones: ON COM GOSUB branches.
when something comes in over the RS-232C interface, ON MDM GOSUB does it when the modem receives something, ON KEY GOSUB branches when a function key is pressed, and ON TIMES GOTO makes a branch at a specified time. The potential usefulness of these commands should be obvious; listing 3 gives an example. The various interrupts can be enabled and disabled by commands such as MDM followed by ON, OFF, or STOP.

All the graphics and sound commands are new. Sounds of varying tone and duration as well as beeps can be produced, individual pixels or points on the LCD can be turned on and off, and lines and boxes can be drawn between any two sets of \(x,y\) coordinates; the box can be either an outline or filled. The LCD screen has a resolution of 260 by 64 pixels.

Perhaps the most radical new feature is the use of the OPEN statement. We usually think of OPEN and CLOSE statements being associated with disk files. What's OPEN doing in a machine that doesn't use disks? Any RAM file and any peripheral device can be declared as a file for output and input. You can write to a file in memory just as you would write to a disk file. RS-232C and modem I/O are handled by declaring the device to be a file. Even the screen can be treated as a file for output, as can the printer. For example:

```
OPEN "LPT:" FOR OUTPUT AS 1
```

Table 3: A summary of TRS-80 Model 100 BASIC statements.
Other Commands

CLEAR—Clears all variable values, closes all open files, and optionally reserves string and high memory space
CLS—Clears the screen
CLOAD—Loads a BASIC program from tape
CLOAD?—Verifies a cassette load of a BASIC program
CLOADM—Loads a machine-language file from tape
CLOSE—Closes open files by number, or all files
COM ON/OFF/STOP—Enables or disables communications interrupt
CONT—Continues program execution after a STOP command or press of Break key
CSAVE—Saves a BASIC program on tape; program may be saved in compressed or ASCII formats
CSAVEM—Saves a machine-language program on tape, using start, end, and entry addresses
DATA—Defines a data set within a BASIC program
DATES—Prints or sets current date in MM/DD/YY form
DAYS—Prints or sets current day of the week
DIM—Defines array size
EDIT—Edits a BASIC program
END—Ends BASIC program execution
ERROR—Simulates an error in a program
FILES—Prints the names of data and program files stored in RAM
FREE—Returns the amount of memory available to BASIC
HIMEM—Returns highest memory address available to BASIC
INKEY$—Returns any keyboard key currently pressed
INP—Returns a value from a CPU port
INPUT—Inputs data from keyboard
INPUT #—Inputs data from a file
INPUTS—Inputs a number of characters from keyboard or from a file
IPL—Defines a BASIC program to run whenever the Model 100 is powered up
KEY—Defines function keys
KEY LIST—Lists function key definitions
KEY ON/OFF/STOP—Enables or disables function key interrupts
KILL—Erases a RAM file
LCOPY—Copies the screen text to the printer
LET—Optional assignment statement
LINE INPUT—Inputs a string from the keyboard
LINE INPUT #—Inputs a string from a file
LIST—Lists the current program to the screen
LIST—Lists the current program to the printer
LOAD—Loads a BASIC program from RAM, cassette, communications port, or modem for execution
LOADM—Loads a machine-language file from RAM or cassette
LPRINT—Prints data to the printer
LPRINT USING—Prints formatted data to printer
MAXFILES—Specifies the maximum number of files your program can have open at one time
MDF ON/OFF/STOP—Enables or disables modem interrupt
MENU—Returns to the Model 100 menu
MERGE—Combines two BASIC programs; one of the programs will be in current memory, the other will come from RAM, CAS, COM, or MDF
MOTOR ON/OFF—Turns the cassette motor on or off
NAME...AS—Renames a RAM file
NEW—Erases the current program
OPEN—Opens a RAM, CAS, COM, LCD, LPT, or MDF file for I/O
OUT—Outputs a byte to a port
POKE—Loads a value into memory
POWER—Controls the automatic power-off feature
POWER CONT—Prevents automatic power-down
POWER OFF—Turns power off; if optional RESUME is added, execution continues where it stopped before power was turned off
PRINT—Prints data to the screen (abbreviated as "?"), PRINT @—Prints at specified position on screen
PRINT #—Prints data to a file
PRINT USING—Prints formatted data to screen or file
PRINT # USING—Prints formatted data to a file
READ—Reads a data set within a BASIC program
REM—Indicates an unexecutable comment
RESTORE—Allows DATA items to be reused, the optional line number specifies which line DATA pointer is to be set to
RUN—Runs a BASIC program. May include loading the program from RAM, cassette, communications port, or modem. The .R option tells BASIC to leave open files open.
RUNM—Loads and executes a machine-language program from RAM or CAS
SAVE—Saves the current program to RAM, cassette, communications port, LCD, printer, or modem. Optional "A." may be used to store an ASCII file to RAM or cassette. Other devices automatically save in ASCII.
SAVEM—Saves a machine-language file to CAS or RAM
STOP—Stops program execution
TAB—Skips to specified column with PRINT or LPRINT
TIMES—Displays or sets the current time
TIMES ON/OFF/STOP—Enables or disables the time interrupt

They specify how soon the power should be turned off (if at all) if the computer isn't used or if it shouldn't be turned off; one turns it off from within a BASIC program and gives you the option of resuming the program when the machine is turned back on. MAXFILES, normally placed at the beginning of a program, specifies how many files will be used. TIMES DATES, and DAYS contain the time, date, and day of the week respectively.

An especially useful BASIC command (normally used as a direct command) is IPL. It lets you specify that a particular BASIC program should be run when the Model 100 is turned on. It allows a form of customization. As such, it can be used to turn the Model 100 into a turnkey computer that automatically runs a given program.

Although BASIC programs can be directly typed in, they are edited using the text editor. If you type EDIT 100, you enter the text editor with line 100 as the text. Any range of line numbers can be specified, although because it takes some time to convert the tokenized program to ASCII, programs should be edited in small pieces. If you try to return to BASIC and there is an error in the format of the edited program, you'll be given the error message "Text Ill Formed"
and you will have to correct the problem before you can reenter BASIC. A danger exists here: it's possible to make the edited program so screwed up that you can't find the error and you can't even get out by hitting the Reset button. (On the Model 100, reset is really a forced break, not a hardware reset.)

If you're used to Microsoft's usual interpreted BASIC editor, this one takes some getting used to. It's easy to use and very powerful, but it lacks some things a programmer would want. For example, there's no way to renumber a whole program. And if you renumber a statement with the editor, it will be moved in the listing, but other statements that refer to it won't. For example, there's no way to renumber a statement with the editor. It's easy to create hard-to-find errors. It also has no cross-reference utility that will show you where variable and line references occur. In other words, the editor remains a text editor and not a program editor. A nice feature is that you don't have to explicitly save programs: they remain in memory even when you return to the main menu unless you type "NEW. Also, if power is turned off while a program is running, the Model 100 will resume running it when the power comes back on.

Technical Details
The manual says absolutely nothing about the system operation of the Model 100—not even a memory map. By the time you read this, however, you'll be able to order a service manual from any Radio Shack service manual. The following has been gleaned from a preliminary draft of the Model 100's service manual, which I recommend to anyone who wants to know about the machine's inner workings.

The Model 100 has five main integrated circuits. The microprocessor is an Intel 80C85, which is a CMOS (complementary metal-oxide semiconductor) chip that uses the same instruction set as an 8080. A parallel I/O chip, an Intel 81C55, connects the microprocessor to the outside world; it handles the printer, keyboard, clock, buzzer, UART, and modem. The tape deck connects directly to the clock, buzzer, UART, and modem. The modem chip is a Motorola MC14412, also easily programmed. The clock chip is an Intel UO, and it can also be accessed with machine language.

The Model 100 uses many more I/O ports than do the other TRS-80 computers. The display, keyboard, clock, UART, modem, and buzzer are all controlled by I/O calls. The service manual gives the proper port addresses.

The system has a 40-line bus, with three of the lines not used. The bus includes all the 8085's address, data, and control lines plus optional control lines for an I/O unit and separate RAM.

The 80C85 can directly address 64K bytes of memory; 32K bytes are in low memory as ROM, the ROM that contains the operating system. The ROM in the extra socket can be bank-selected (i.e., it replaces the 32K-byte hard-wired ROM) using an OUT call. RAM can be installed in four DIP (dual-inline pin) sockets; each socket holds a custom-made DIP package that contains four 2K-byte chips wired together (see the lower left corner of photo 2 on page 158). Thus, you'll never be able to install standard RAM chips in the Model 100—they aren't what the computer expects to see in the sockets.

Documentation
By now it should be obvious that I think the Model 100 is one of the best microcomputers ever made. The documentation is its only major flaw. It's clear that a lot of work went into producing the manual, which is intended for the first-time user, and clear explanations are given for each software module. Unfortunately, the most elementary points are explained

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over and over again, while some important points are either left out or hidden in the repeated explanations. The manual’s index is inadequate—I wasn’t familiar with the MOD operator in BASIC and it’s not in the index. It took me 10 minutes to find it in the text. Many other things are left out. Another problem is that the manual doesn’t encourage the user to understand why he or she is doing something. Anyone can learn to make good use of the Model 100 in an hour or two by using the manual, but it is poor at helping you to use the full capabilities of the machine. Even the page numbering is messed up: pages 134 and 135 are reversed.

Finally, the manual does a poor job of showing what the Model 100 can really do. Although an experienced computer user would know that you can easily manipulate text files with BASIC programs, the manual doesn’t mention it. The method for inserting boiler plate that I described earlier isn’t even mentioned, although it’s an almost essential feature of the editor. No mention is made of using the machine to transport data between two other machines, and RS-232C hook-up information is relegated to the appendix, where one is led to believe that the Model 100 can be connected only to a Radio Shack Model II, III, or 16.

Some of the following points are either omitted from the manual or are so obscurely buried that they’ll be missed by most users. This is probably not a complete list:

- Escape sequences work with strings in BASIC programs. Escape and “p” forces output to be in reverse video while Escape and “q” puts it back. Other escape sequences apparently do other things, but I’ve not been able to find out what.
- The buzzing noise during a tape save or input can be turned off (or on) by typing SOUND OFF or SOUND ON while in BASIC.
- It’s possible to force a cold restart of the Model 100 by simultaneously pressing the Ctrl, Pause, and Reset switches. This wipes out every file saved in memory and is equivalent to moving the memory switch on the back of the machine.
- When setting up telecommunications parameters with the Stat key, the dialing pulse rate must be set to either 10 or 20 pulses per second—no other values work.

Other Complaints

The Model 100 is a well-thought-out machine, but it’s not perfect (although most of its problems are trivial).

Some enhancements are provided in other BASICs that are not included here. Perhaps the most glaring deficiency is the lack of any attempt to provide for structured programming. The simple addition of a WHILE... WEND statement and the ability to call named subroutines would have been appreciated by many programmers. Some have asked for BCD (binary-coded decimal) arithmetic, which allows many more decimal places but not such large numbers. Personally, I prefer the present system.

Another deficiency is the lack of any indication of file size or status. It would also be nice to have files dated when created and marked when updated.

Although much mention is made of the use of machine-language programs and there’s even a nice CALL command in BASIC, there’s no way to write a machine-language program other than by poking it into memory—a process that is tedious for short programs and impossible for long ones. Although an assembler is in the works, independent software vendors will be handicapped in their ability to create Model 100 software until it becomes available.

Finally, a few things are just missing. Although almost every use of the function keys is shown on the bottom “label” line of the LCD, function key F5 in the terminal mode, which sends all terminal interaction to a printer, is not labeled. A worse problem is the inability of the terminal program to send a true “break” signal. Luckily, most newer host computers use a Control-C instead.

But the few deficiencies are negligible compared to the machine’s tremendous ability. I was unable to find any real bugs, and I understand that the software has been more thoroughly tested than anything else Radio Shack has released.

The Future

The Model 100 just begs for additions and enhancements, both by Radio Shack and by independent suppliers. The existence of a ROM socket, the bus connector, and a socket for a bar-code reader all speak of things to come. A Tandy executive was reluctant to tell me exactly what to expect, but it’s not hard to make some guesses.

Because of the machine’s limited memory, the most obvious addition would be a mass-storage device. A good candidate would be one or two microfloppy-disk drives. Even better would be some sort of bubble-memory device. It should be possible to

Photo 2: Inside the Model 100. The main circuit board is on the left, while the keyboard and liquid-crystal-display boards are on the right. Notice the four slots for additional RAM in the lower left corner of the main circuit board.
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package 1 or 2 megabytes of bubble memory in about half the volume occupied by the machine itself. But the turmoil in standardizing microflop-pies and the cost of bubble memory will probably prevent those options. I'll bet something's coming along, however, and I expect that independent suppliers will get into the act as well.

Another obvious addition would be some sort of compact printer. Although the Model 100 now provides for printer output, it's a bit hard to carry any satisfactory printer around in your briefcase. Present technology should allow design of a unit no larger than the computer itself—and Tandy is one of the larger printer manufacturers around.

An accessory that I would really like to see is a multichannel, 12-bit analog-to-digital converter. The Model 100 is ideally suited for data acquisition in industrial and field applications. This market is smaller than for a printer or disk drive, but the Model 100 could be used as a remote data logger that would be better than anything else produced, even units in the above-$20,000 price range.

The Model 100 presents tremendous possibilities for use by the disabled. If Baudot codes could be sent with the terminal program, it could serve as an inexpensive terminal for the various phone communication services available for the deaf. And its size makes it ideal for use with a head-stick by a quadriplegic. I was disappointed to see that some key combinations require two hands; the keyboard could have been designed for use by an amputee. Perhaps the most far-out fantasy would be a microcomputer for use by the blind. The keys could have braille caps, and it should be possible to design a flat plate like the LCD with tactile "bumps" that present a braille version of the visual display.

As for software, a book/software product called the Model 100 BASIC Language Lab should be available from Radio Shack by the time you read this, and I understand that personal-productivity and personal-finance programs are in the works, with business-application software following. And, of course, it doesn't take much insight to guess that there'll be some games available.

Whatever Tandy chooses to sell as accessories for the Model 100, it is certain that programmers and hardware suppliers will recognize the tremendous market presented by this machine. I expect to see a proliferation of hardware and software add-ons that make those available for most other microcomputers seem sparse. As all those Apple ads tell you (and the TRS-80 ads should as well), it's available hardware and software that really makes a microcomputer useful.

Conclusions

I first saw a Model 100 sitting next to a radio-controlled toy car at a Radio Shack store; I quickly passed it off as a toy as well. It was only after reading about it and playing with one for about an hour that I realized how powerful a machine this is. Sadly, it is probably true that a lot of people
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who could make excellent use of the Model 100's abilities still think of it as a toy. It's too bad that Radio Shack is associated with toys and CB radio—its computers, especially the Model 100, are as good as or better than anything available at much higher prices.

I am told that it took a little more than a year from the time the Model 100 was conceived until the first units were on the market. I'm amazed by that. The Model 100 shows tremendous planning and foresight. It can do things that desktop microcomputers of several times its price cannot. The software is extremely well designed and innovative. It has the best features of a disk-based system while using only RAM storage, and the software is so well integrated that it is practically effortless to use the machine for a variety of applications. The Model 100 has a few faults, such as the documentation, but they are minor when one looks at the system as a whole.

Perhaps the most telling test of the Model 100 is that since I bought one I have cut my use of larger machines by about half. I actually prefer to use the Model 100 instead of either an LNW-80 or a TRS-80 Model III for text editing. Even more telling is that at least one executive at Tandy said he uses the Model 100 more than his TRS-80 Model 12 and Model 16 combined.

The Model 100 microcomputer is the first of a generation of really portable machines. Undoubtedly, a host of imitators will appear, and some of them may be on the market by the time you read this (the NEC notebook computer, using a very similar Microsoft operating system, was announced while I was writing this article). But the combination of hardware and software in the Model 100 will be hard to beat. I doubt that, even several years from now, I will regret having bought one of the earliest Model 100s on the market.

Mahlon G. Kelly (268 Turkey Ridge Rd., Charlottesville, VA 22901) is Associate Professor of Environmental Sciences at the University of Virginia, where he studies the environments of lakes and rivers. His other interests include freelance writing and the application of computers to environmental research.
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The New Microfloppy Standards

Only media specifications are settled at this point, but de facto standards for disk drives are already emerging

by Thomas Jarrett

Photo 1: The Shugart SA300 3½-inch microfloppy-disk drive (on the right) next to a 5¼-inch disk drive.
One of your next computers will probably have a microfloppy-disk drive that uses a 3½-inch hard-shell cartridge with an automatic shutter. It will also be compatible with the standard interface for 5¼-inch disk drives. More than 30 companies are now supporting this emerging standard in the sub-5¼-inch disk, or "microfloppy," market as a result of an agreement on disk media between the Microfloppy Industry Committee (MIC) and Sony Corporation earlier this year. While the disk drive and media specifications have been presented to the American National Standards Institute (ANSI) X3B8 committee on microfloppies, they will probably become a de facto standard in the marketplace before they gain official acceptance.

Already, many portable computer manufacturers have adopted the 3½-inch disk drive as a standard. The sales of 5¼-inch disk drives are still increasing, particularly now that half-height drives are appearing in products, but experts predict that 3½-inch disk drives will soon outsell any other size.

Microfloppy Applications

Microfloppy-disk drives are small, light, inexpensive, and powerful, representing the newest wave of miniaturization in computer mass-storage peripherals. Their range of applications includes memory typewriters, new office equipment, scientific and engineering instruments, the next generation of smaller portable computers, and other uses still on the drawing boards.

Because of strong market demand for smaller, more powerful components and systems, the greatest potential for microfloppies is in portable computers. They offer better performance and the same capacity as 5¼-inch floppy disks in a smaller and less expensive package. While today's "portable computers" are more easily transportable than desktop models, drives and media will contribute to the development of truly portable computers. Microfloppies are also suitable for any application in which 5¼-inch disks are used.

Reductions in the size and/or cost of silicon chips, displays, and disk drives lead to many new applications for small computer systems. The new semiconductor chips, cheaper memory, flat-panel displays, and sub-5¼-inch floppy-disk drives can help make for a system small enough to be carried in a briefcase. As a result, microfloppies may usher in a new era of freedom from the workplace.

The Advantages of Microfloppies

One of the most crucial factors that determines the cost and size of microcomputers is peripheral storage. In some cases, disk drives account for 60 percent of the cost of a microcomputer system. Today's most popular and powerful microcomputers have two floppy-disk drives, which increase a system's volume and weight considerably. Microfloppy-disk drives, which are one-quarter the size and one-half the weight of conventional 5¼-inch disk drives, consume 50 percent less power.

The microfloppy drives now on the market store from 358K bytes to 1 megabyte per disk; 500K bytes is typical. This is raw, unformatted storage capacity that is typically reduced to a 230K- or 360K-byte format compatible with the IBM Personal Computer disk format. This capacity is less than some of the new high-capacity 5¼-inch disks now appearing on the market, but it is equivalent to most standard 5¼-inch disks.

As microfloppy drives are integrated into consumer products, systems designers and OEMs (original equipment manufacturers) will take advantage of the 3½-inch disk's size, price, and performance to create new uses beyond those of 5¼-inch drives.

Another advantage microfloppies offer is carrying convenience. Early market research revealed that people want disks that can be carried in a pocket or purse. But because microfloppy disks are easy to transport—and therefore easy for inexperienced users to damage—the disk and drive manufacturing companies are supporting a hard-shell cartridge. Further, most disks have an automatic shutter that closes over the media surface when the disk is removed from the drive. Thus the "floppy" in microfloppy is no longer accurate. Such protective measures help ensure that beginners who don't know the meaning of computer messages such as "BDOS Error—bad sector" will not have to learn about them the hard way.

Industry Standards

Standards are essential to the efficiency and growth of every segment of the computer and electronics industry, and microfloppy drives and media are no exception. Standardization lowers costs to manufacturers, OEMs, and consumers alike by allowing the mass production of interchangeable parts. Standards also eliminate the need for expensive redesigns.

Disk and drive manufacturers can compete within the framework of an established standard. That way, OEMs and systems houses won't fail to support a customer if their main source does not have parts available. They can fall back on second sources of standard parts.

When microfloppies were first announced, the market was flooded with incompatible products. Hitachi, Matsushita, and Maxell introduced a 3-inch disk drive and media; Tabor and Dyan presented a 3¼-inch drive with soft-jacketed disks that Seagate Technology later supported; Sony introduced a 3¼-inch drive that both transferred information and rotated twice as fast as the standard 5¼-inch drive; Canon had a 3.8-inch drive; and more recently, IBM introduced a 4-inch drive. Disk-media manufacturers were endorsing several disk sizes, but most of the support was behind the 3½-inch format.

The Microfloppy Industry Committee

The Microfloppy Industry Committee (formerly called the Microfloppy Standards Committee) was formed in May of 1982 to establish a microfloppy media standard. The committee announced its activities at the National Computer Conference in June 1982 and opened its member-
ship to any interested party. Shugart Corporation was among the original four members of the committee, which by April of 1983 included 22 leading disk-drive, media, and personal computer manufacturers.

In September 1982 the MIC proposed the adoption of a 3½-inch hard-cartridge disk standard to the ANSI X3B8 committee on microfloppies. By then Sony had begun to ship its own version of a 3½-inch drive and hard cartridge. The Sony medium and the MIC’s proposed standard for 3½-inch media, while similar, differed on four main points: the number of tracks (concentric circles) on the disk, coercivity, thickness of the iron-oxide coating, and the type of shutter used to protect the head access window, where the disk drive reads and writes information on the disk.

The Sony drive had 70 tracks of information, while the MIC proposed 80 tracks as standard. Both used metal hubs in their disks to improve centering tolerance. The coercivity of the Sony medium was 580 oersteds (a unit of magnetic resistance), while the MIC had suggested 650 oersteds. Sony’s oxide layer was 100 microinches thick, and the MIC’s proposal specified 40 to 50 microinches. The thinner oxide layer and higher coercivity allow higher recording densities to be used without sacrificing reliability.

Sony’s first shutter on the disk was a simple metal slide that the user had to manually open before inserting the disk into the drive and manually close after the cartridge was removed. That procedure required touching the area around the head access window and possibly ruining the disk. Also, the shutter could slide open accidentally, exposing the head access window to contaminants.

The MIC design, in contrast, includes a spring-loaded autoshutter that automatically opens upon insertion of a cartridge into the drive and automatically closes when the cartridge is ejected. An actuator inside the drive controls the opening of the shutter and loads the read/write head(s) onto the media. This system reduces the possibility of putting the disk into the drive incorrectly and the chances of media damage due to the disk shutter being open when out of the drive. The MIC hard cartridge also has a sliding mechanical write-protect tab instead of a detachable plastic write-protect tab, which can get lost. See figure 1 for an illustration of the MIC 3½-inch hard-cartridge standard.

The most significant development in the microfloppy media standards issue was the compromise agreement Sony and the MIC reached in January 1983. The two groups agreed on 80 tracks per side of a disk, a coercivity of 625 oersteds, and an oxide thickness of approximately 60 microinches. Thus, important progress was made toward solving the thorny issue of microfloppy media standardization. Sony will be manufacturing a second-generation product compatible with the MIC cartridge and will continue to support its original drive and media. Sony will also use an autoshutter on its new media.

The agreement between the first company to ship production quantities of microfloppies and a committee of leading U.S., European, and Japanese manufacturers adds weight and momentum to the effort to establish a single microfloppy configuration as the standard. Table 1 lists the members of the Microfloppy Industry Committee and the supporters of the various disk sizes.

The Microfloppy Competitors

From the beginning, size has been the most basic bone of contention among the microfloppy-drive manufacturers. Four disk sizes ranging from 3 to 4 inches have been proposed, and each one has its supporters.

The 3-inch disk drive: The Hitachi/Matsushita/Maxell 3-inch drive has a 5¼-inch interface and an automatic shutter on its rigid-case disk. Hitachi has not announced any volume agreements with American computer makers yet, although many Japanese manufacturers are lined up behind this proposed standard. Gavilan Computer Corporation introduced its new portable computer with Hitachi’s 3-inch drive but has since decided to use the 3½-inch microfloppy. Maxell is owned by Hitachi and is therefore associated with this group. Matsushita is supporting the 3¼-inch drive as well as the 3-inch drive.
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Phone orders: 1-800-835-3823
In Colorado call: 1-303-440-3600

Table 1: The various companies supporting the different microflopopy-disk sizes. Note that some manufacturers are offering more than one type of microflopopy.

<table>
<thead>
<tr>
<th>3-inch</th>
<th>3¼-inch</th>
<th>3½-inch with Shugart interface</th>
<th>3½-inch with Sony Interface</th>
<th>4-inch</th>
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<tr>
<td>Canon</td>
<td>Brown Disc</td>
<td>Alps</td>
<td>Computer</td>
<td>IBM</td>
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<td>Fuji</td>
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<td>Tabor</td>
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<td>Toshiba</td>
<td>Toshiba</td>
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</table>

Table 1: The various companies supporting the different microflopopy-disk sizes. Note that some manufacturers are offering more than one type of microflopopy.

The 3-inch drive has two potential problems. First, because the disk is so small, both sides of it must be used to achieve a capacity of 500K bytes. Because the drive has only one read/write head, this is currently accomplished by reading one side (250K bytes) and then flipping the disk over. The company recently announced a double-sided drive that will access both sides of a disk (500K bytes) at the same time. Second, in order for 3-inch drives to achieve a 1-megabyte capacity, a track density of 200 tracks per inch would have to be used. This would significantly reduce the reliability of an open-loop drive. See Table 2 for more technical comparisons between the different microflopopy drives.

3¼-inch disk drive: The Tabor/Dysan/Seagate 3¼-inch disk also has slightly less recording area than the 3½-inch disk. This is the only group that does not offer a hard-shell cartridge because its 3¼-inch disk is covered by a more traditional soft envelope. These companies feel that the price of their disks will be more competitive because of the less expensive soft jacket (which uses existing 5¼-inch disk technology and has fewer parts). Dysan owns portions of Tabor and Seagate and has financial ties to Brown Disc, so it is not unusual to see these companies together. They have not announced any volume deals on their drives.

The 3½-inch disk drive: The 3½-inch disk format has twice the available recording area of the 3-inch disk. Higher-capacity drives are already
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<table>
<thead>
<tr>
<th>WordStar $269</th>
<th>dBASE II $459</th>
<th>SuperCalc 2 $139</th>
<th>Multiplan $199</th>
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<tr>
<td>WordMaster / MultiMerge $369</td>
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<td>A.C.E. $179</td>
<td>ALL-PRO $299</td>
<td>SpellIt $120</td>
<td>Perfect Writer/Spreads $499</td>
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<td>PROLOG $199</td>
<td>HIPPO $499</td>
<td>ReportIt $279</td>
<td>Perfect Call $169</td>
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<td>HUNGRY $299</td>
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<tr>
<td>ALPHA SOFTWARE $199</td>
<td>SMART $599</td>
<td>All Four Perfect Products $799</td>
<td>PICSICLES AND	POISSON $279</td>
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<tr>
<td>Apple II/III $179</td>
<td>MICROSOFT $399</td>
<td>Lotus 1-2-3 $149</td>
<td>FES/Visicalc $169</td>
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<tr>
<td>Microsoft Package $159</td>
<td>WordStar $139</td>
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<td>Perfect Writer/Draw $169</td>
<td>VISICALC $199</td>
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</table>

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CA residents add sales tax.

Circle 4 on inquiry card.
<table>
<thead>
<tr>
<th>Company</th>
<th>Media Size (inches)</th>
<th>Unformatted Capacity (bytes)</th>
<th>Single or Double-sided</th>
<th>Dimensions (inches)</th>
<th>Media Covering</th>
<th>Transfer Rate (kilobits/sec.)</th>
<th>Tracks per Surface</th>
<th>Track-to-Track Access Time (milliseconds) per Inch</th>
<th>Bits per Inch</th>
<th>Tracks per Inch</th>
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<td>80</td>
<td>3</td>
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<td>Tabor</td>
<td>3½</td>
<td>500K</td>
<td>Single</td>
<td>1.82 by 4.0 by 5.5</td>
<td>Soft</td>
<td>250</td>
<td>80</td>
<td>10</td>
<td>9250</td>
<td>140</td>
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<td>Shugart</td>
<td>3½</td>
<td>1000K</td>
<td>Double</td>
<td>1.82 by 4.0 by 6.0</td>
<td>Hard</td>
<td>250</td>
<td>80</td>
<td>6</td>
<td>8204</td>
<td>135</td>
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<td>Tandon</td>
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<td>1000K</td>
<td>Single</td>
<td>2.0 by 4.0 by 5.1</td>
<td>Hard</td>
<td>500</td>
<td>80</td>
<td>12</td>
<td>8717</td>
<td>135</td>
</tr>
<tr>
<td>Sony</td>
<td>3½</td>
<td>1000K</td>
<td>Double</td>
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<td>Hard</td>
<td>333.3</td>
<td>46</td>
<td>40</td>
<td>6865</td>
<td>-</td>
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<tr>
<td>IBM</td>
<td>4</td>
<td>358K</td>
<td>Single</td>
<td>2.62 by 4.5 by 6.8</td>
<td>Hard</td>
<td>333.3</td>
<td>46</td>
<td>40</td>
<td>6865</td>
<td>-</td>
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</tbody>
</table>

Table 2: Specifications for some of the different microfloppy-disk drives.

being announced as improved media and head-positioning technologies become available. Most 3½-inch disk drives use only one side of the disk to store 500K bytes. Adding a second head, a simple redesign of the present drive, will create a 1-megabyte double-sided drive. Sony and Tandon have already announced this upgrade as well as versions of their drives with both the 5¼-inch interface and the Sony interface. Tandon has announced a $310 million agreement with a major microcomputer manufacturer (rumored to be IBM) for its disk drives (probably the 3½-inch disk drive with the 5¼-inch interface).

Sony started delivering the first microfloppies in 1980 in one of its word processors. The company has since offered the microfloppy in its SMC-70 microcomputer. Hewlett-Packard placed a $30-million order for Sony microfloppy drives and recently announced that it had sold 25,000 drives in its various products, among them the Series 200 Model 16 microcomputer, which accounts for half of the estimated 50,000 microfloppy drives that have been sold so far. Computer Devices uses Sony drives in its Dot microcomputer; RCA uses them in development systems; Sord, Jonos, and Universal Data Systems all use Sony Drives in their portable computers.

Sony will continue to manufacture and support its older drives, but now that the company is offering the new 3½-inch drives with the MIC media and Shugart interfaces, it is debatable how many manufacturers will stay with the older Sony disk format or the Sony interface.

IBM’s 4-inch disk drive: While the 4-inch IBM disk has more recording area than the 3½-inch disk, it is too...
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The most popular interface for microfloppy-disk drives is the standard 5¼-inch Shugart interface used on most 5¼-inch floppy-disk drives. This standard defines the data and control lines and specifies a disk rotation of 300 revolutions per minute (rpm) and an information transfer rate of 250K bits per second. Disk drives that use the 5¼-inch interface can be easily interchanged. Systems integrators can then use the new microfloppies directly in place of the older 5¼-inch drives. Computer manufacturers in turn can take advantage of tried-and-true technology (their existing computers and the proven reliability of 5¼-inch interfaces) while getting to the market first with smaller, faster computer systems.

The new microfloppy-disk drives access information on the disk quickly. Transferring that information out of the drive and into the computer, however, can be a slow process. Systems designers may feel limited by the Shugart interface transfer speed of 250K bits per second when they want to use the new, faster microprocessors and memory that microfloppy-disk performance can’t keep up with. That’s one of the major reasons why Sony is offering its 600-rpm 3½-inch disk drive with a Sony interface that can transfer information at 500K bits per second, effectively twice the speed of the Shugart interface and the same as double-density 8-inch disk drives.

Case Study of a Microfloppy

Shugart Corporation’s entry in the microfloppy field is the SA300, a single-sided drive that stores 500K bytes on a 3½-inch disk (see photo 1). The SA300 measures 1.6 inches high, 4 inches wide, and 6 inches deep and weighs only 1.3 pounds. The drive is extremely quiet and has only nine moving parts because of its efficient, brushless direct-drive DC motor, which eliminates the need for belts and pulleys. It records with the MFM (modified-frequency modulation) method at a density of 8204 bits per inch and 135 tracks per inch, with 80 tracks per side. Track-to-track access time is 6 milliseconds. The SA300 uses +12 volts when the disk is being accessed, dissipating less than 8 watts. In a standby mode it uses +5 volts and dissipates less than 4 watts, producing about one-third less heat than standard 5¼-inch disks. In portable computer systems this translates to less draw on a battery pack and thus longer operation without recharging batteries. The lower heat dissipation also means that parts last longer.

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**The Shugart Interface also bodes well for Shugart-contender disk drives.**

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The VISUAL 500 provides selectable emulations of the DEC VT52, Data General D200, Lear Siegler ADM3A, and Hazeltine 1500 terminals. The VISUAL 550 is DEC VT100 protocol-compatible as well as a character or block mode terminal which complies to the ANSI X3.64 standard. Call or write for a free comprehensive reference booklet on graphics terminals including a glossary of graphics buzzwords.

VISUAL 500/550

<table>
<thead>
<tr>
<th>VISUAL 500</th>
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*Retrothoughts price includes DEC VT100® terminal based on published information as of 4/1/83

Circle 474 on Inquiry card.
System Review

The HP-75 Portable Computer

This briefcase computer from Hewlett-Packard has powerful real-time scheduling capabilities

by Rowland Archer Jr.

The HP-75 marks Hewlett-Packard's entry into the mid-priced portable computer fray. Truly a portable computer, the HP-75 includes a full-featured BASIC interpreter, a text editor, a real-time clock/calendar, and an appointment scheduler (see photo above).

Low-power CMOS (complementary metal-oxide semiconductor) memory (16K bytes, upgradable to 24K) retains files, programs, and the appointment calendar when the machine is switched off (only the display actually powers down). A rechargeable battery pack keeps the HP-75 running for about 20 hours of active use before it needs to be recharged.

Magnetic cards are used to save and restore programs and data files. Each card holds about 1300 bytes. Optional peripherals, such as a video-display driver, a digital cassette recorder, and a thermal printer, can be connected through the HP-IL (Hewlett-Packard Interface Loop) port on the back of the HP-75.

Display

The HP-75 has a 1-line, 32-character liquid-crystal display (LCD). System software provides automatic horizontal scrolling through a 32-character window, up to a maximum line length of 96 characters. All visible ASCII (American National Standard Code for Information Interchange) characters (uppercase and lowercase letters, numbers, and punctuation) can be displayed by the HP-75, with or without underlining. It also contains a
set of special characters: graphics symbols, a partial Greek alphabet, and several characters needed to support foreign languages, such as the umlaut over the o.

Using a computer with a 1-line display takes some getting used to, though the software makes it more tolerable. Commands such as LIST (list a text file or a BASIC program) cause the text to pause automatically after displaying each successive line. The duration of this pause can be set by a command.

Keyboard
The keyboard contains 65 keys in a standard QWERTY layout. All of the 256 possible 8-bit character codes can be generated from the keyboard. Each key repeats automatically when held down. Three special keys marked TIME, APPT, and EDIT can be pressed at any time to switch into the clock/calendar display, the appointment-scheduling program, or the text editor, respectively. The FET key can be used to fetch the message associated with the most recent error. DEL deletes single characters; CLR clears entire lines. Four arrow keys are used to move the cursor within the current line or to the next or previous line.

The keys give tactile feedback and an audible click when they are pressed, but they have a very short travel. I did not find the keyboard suitable for fast touch-typing; the calculator-like buttons are too small and require too much pressure. However, I would guess that they will remain highly reliable, based on their similarity to HP calculator keys.

A very flexible keyboard reprogramming feature lets you assign a string of characters to any one of 194 valid key codes and key combinations. For example, you could assign a set of BASIC keywords to all the ASCII control characters, so that pressing CTX (control) plus a key would enter an entire keyword. The current set of keyboard definitions is drawn from a file called keys. You can maintain keyboard redefinition files on magnetic cards or in-memory files.

Magnetic Cards
As many multiple program and data files as memory permits can be stored in the HP-75. If you need to store additional files, you can use the built-in magnetic card reader. Magnetic cards are also used to transfer software between machines. Several sample programs come with the HP-75 on prerecorded cards.

The magnetic cards store 650 bytes on each of two tracks for a total of 1300 bytes. You can read or write cards by pulling them manually through a slot in the lower right-hand corner of the machine, as prompted by the system software. It took a while to find the right speed to pull the cards through the reader. Warning messages tell you if you pulled too slowly or too quickly, but only within a limited range of the correct speed. Outside this range, you get a warning of bad read/write. My machine may have had some problems with the card reader, as it would sometimes give an error as soon as I pushed the RTN (return) button; according to the manual, there

is supposed to be about a 5-second delay before it presents an error message.

The HP-75 automatically computes the number of cards needed to save a file and prompts you to insert them one by one. When you read a file back from cards, you do not need to read the tracks back in the order you wrote them, as long as you read all the tracks at least once.

Hardware Expansion
The HP-75C comes with 16K bytes of RAM (random-access read/write memory) in addition to 48K bytes of ROM (read-only memory). I tested an HP-75D, which includes an additional 8K bytes of RAM, for a total of 24K. Most of this is available for user programs and data; my machine showed 22,463 bytes free after a system reset. If you buy an HP-75C, you can purchase the 8K bytes.
of RAM later and simply plug the module in behind the battery compartment.

Three slots on the front of the HP-75 accommodate ROM modules, which can add new functions to the system. There were no details supplied with the review machine on these functions, but reference is made in the owner’s manual to expanding BASIC with new features.

The rear of the HP-75 contains an HP-IL port (see “The Hewlett-Packard Interface Loop,” by Robert Katz, April 1982 BYTE, pages 76-92). This is a two-wire expansion bus used by HP for connecting peripherals such as a digital cassette recorder, a thermal printer, and a video interface. The same peripherals used by the HP-41C hand-held computer can be used by the HP-75.

File System
An in-memory file system is the basis for storage of text files (or documents) and BASIG programs. Files can be created and modified, renamed, deleted, and copied to magnetic card or any other device on the HP-IL. File names can have as many as eight characters. Files can be protected in two ways: First, a BASIC program can be made private, in which case it can be run and deleted, but not listed or edited. Second, a password can be supplied for any file when you copy it to a card; that card cannot be read unless you supply the correct password.

The system knows about five types of files: BASIC programs, text files, appointment files, LEX files, and interchange files. Appointment files are managed by the appointment-scheduler program. LEX files are language-extension files. They add new commands to BASIC or the operating system. Interchange files are standard-format (not specified) files used to exchange information with other computers. A command is provided to transform files between BASIC, text, and interchange formats.

Text Editor
The HP-75’s text-editing capabilities are used by all the other software (BASIC, appointment scheduler, clock/calendar program, and filer). This line editor is both powerful and easy to use.

You can move a blinking block cursor across the line with the left and right arrow keys. Characters can be changed by typing over them. One key deletes the character under the cursor, and another key toggles the editor in and out of insert mode, which lets you insert characters between existing characters.

The two modes of text editing are for BASIC programs and documents. BASIC program statements are checked for valid syntax as they are entered. Both file types require line numbers before every line of text. These line numbers are used to specify a line or range of lines to be listed, printed, moved, deleted, and renumbered.

Appointment Scheduler
The appointment-scheduling program makes extensive use of the clock/calendar system. The HP-75 software is set up so you can switch between editing a BASIC program or text file, running the appointment scheduler, and checking or setting the time, all without losing any work in progress in another mode. By pressing the APPT key, you switch to the appointment-scheduling program. If an appointment is due, it will appear in the display with the time and date underlined for emphasis. If no appointment is due, you are given a template to use to create a new appointment:

Day Mo/Dy/Yr Hr:Mn AM #1N !Note

You fill in the day, date, and time fields to indicate when your appointment comes due. There is a lot of flexibil-
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ity and ease of use here; you can fill in the day and time only, and the program will automatically supply the date of the next occurrence of that day. Similarly, the day will be supplied if you fill in the date and time.

The #1 field specifies the alarm type. Nine different types of alarms are provided, from quick beeps to urgent-sounding sirens. The alpha character is the appointment type: N stands for normal; R specifies a repeating appointment, in which case a new appointment will be automatically rescheduled at a given interval in the future as soon as this one comes due. A is like R, but you must acknowledge the due appointment before a new one will be scheduled. !Note can be anything you want. Typically it will describe the appointment or reminder, such as "phone home." You can also schedule a BASIC command (including RUN program) to be executed when the given time arrives.

When an appointment comes due, the HP-75 will take one or more actions depending on what it is doing at the time. If you are using the machine for something else, the alarm will sound and the letters APPT will show at the bottom of the display. When you are finished using the machine, the action associated with that appointment will be done (either the Note displayed or the BASIC command executed). If the display is turned off when the appointment comes due, the alarm sounds and the action is immediately performed.

I don't think average executives will forgo their secretarial support and carry an HP-75 around all day to keep their schedules. On the other hand, I think that this facility could form the basis for a powerful real-time control system. The relative immunity to power failures and the ability to schedule the execution of BASIC programs provides a great deal of flexibility for a home control system.

Immediate Mode and BASIC

When the HP-75 is in EDIT mode, you can enter arithmetic expressions to be evaluated. This is referred to as calculator mode and is like the immediate execution mode supported by most BASIC interpreters. The RES (result) function is always equal to the result of the last expression evaluated, handy for long calculations. You can assign values to variables in this mode, and the variables so defined will be kept separate from program variables. I found this concept a bit strange and prefer having one pool of variables shared between programs and calculator mode.

All arithmetic is carried out in decimal format, meaning no precision is lost in conversion between an internal binary format and an external decimal display format. You can enter numbers as long as 13 digits; all values are rounded to 12 places before storage. The range of legal value is -9.9999999999E499 to +9.9999999999E499. The smallest positive number is +1E-499; the smallest negative number is -1E-499.

Variable names can be one letter or a letter followed by a single digit. Four types of simple variables are allowed: REAL, SHORT, INTEGER, and STRING. REAL
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Listing 1: This sample program in HP-75 BASIC illustrates the user-definable function (DEF FN).

```
10 DEF FN$
20 H$ = "TIME$
30 H$ = VAL(H$(1,2))
40 IF H$ > 11 THEN FN$ = 'PM' ELSE FN$ = 'AM'
50 END DEF
```

numbers have the full precision given above. SHORT numbers take up less space, having five digits plus a two-digit exponent, giving a range of $-9.9999E99$ to $+9.9999E99$. An INTEGER can have five digits, ranging from $-99999$ to $+99999$. A STRING can be of any length up to the amount of memory in the machine. One- and two-dimensional arrays of each numeric type are allowed, but there are no string arrays.

A very complete set of numeric- and string-manipulation functions is included with the HP-75. Logical operators include AND, OR, EXOR (Exclusive OR), and NOT; HP's scientific bent shows up in its selection of trigonometric functions, which goes beyond the usual sine, cosine, and tangent functions to include arc sine, arc cosine, arc tangent, cosecant, secant, and cotangent. Arguments can be in degrees or radians, and functions to convert between degrees and radians are provided.

A built-in constant approximates pi to 12 places. String functions can find the length of a string, search one string for another, convert lowercase to uppercase, and convert numbers to strings and vice versa.

There isn't enough space here to describe the BASIC in detail. I can say in general that it has many features, and I found nothing that did not work as advertised. Most HP-75 features can be controlled from within a BASIC program, giving the system a lot of flexibility and power.

For example, the user-defined-function capability (including multiline functions) lets you define a function that returns the string AM if the time is before 12:00 noon, or PM if it is 12:00 noon or later (see listing 1).

```
TIME$ is a built-in function that returns a string containing the current time (based on the 24-hour clock), such as 10:07:42. Line 30 converts the first two characters (10 in this case) to a number representing the hour of the day. Line 40 sets the value of the function to PM or AM based on a comparison to 11 a.m. If your BASIC program contains a call to FN$, AM or PM will be supplied according to the time of day.
```

More BASIC Features

A BASIC program can contain as many as 1001 timers. Each timer can be individually set to delay an event for anything from fractions of a second to centuries. The ON TIMER # <n>, <delay> <statement> statement will set the <delay> for timer number <n>, and execute...
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Circle 356 on inquiry card.
<statement> every <delay> seconds. It is possible to write a program that runs, establishes some timers, and turns the machine off, but keeps the timers active. When a timer runs out, the specified action will occur.

A single program can access up to 9999 files; in practice, the actual limit will be determined by available memory. Data is stored in a file by a succession of BASIC DATA statements. Each data statement has a line number, and you can specify a line number in a READ statement to start reading data from any line in the file. Entire arrays can be written and read using a single statement. For example, to write the two-dimensional array A(i,j) to file number 1, just type “PRINT #1; A(i,j)”.

Programs can call other programs, which in turn can call others up to the limit of available memory. Variable values are passed between programs by writing them to a file.

Hewlett-Packard has provided good debugging capabilities. The TRACE statement can display the line number of the executing statement and (optionally) the value of any simple numeric variables changed in that statement. Programs can be stepped through one line at a time; each line is displayed before it is executed. You can use ON ERROR GOTO and ON ERROR GOSUB statements in your program to take action when an error occurs. The ERRN and ERRL functions return the error number and line number in which the error occurred.

Documentation

The HP-75 comes with a hefty manual (larger and heavier than the HP-75 itself) packed with 360 pages of information about the machine. The manual is well written and organized. The first three chapters provide an overview of the system, with hands-on examples that familiarize you with the editor, clock/calendar, appointment scheduler, and file system. This is an introduction for the beginner, yet it has you doing useful things fairly quickly.

The second part of the manual contains seven chapters that cover every part of the HP-75 in detail, except BASIC, which is covered later. Keyboard redefinition, connection of HP-IL peripherals, immediate mode numeric calculations, use of the card reader, and all the details of the clock/calendar and appointment scheduler are discussed.

The third part of the manual contains seven chapters describing HP-75 BASIC. Numerous examples are provided to facilitate learning. Some examples are on prerecorded magnetic cards; others give you practice typing in a program.

Eight appendixes cover accessories, warranties, a summary of keyboard and display usage, the HP-75 character set, memory requirements of various system functions, machine defaults, a table of legal abbreviations for keywords, error conditions, listings of prerecorded programs, a glossary, and a syntax summary. The manual ends with a detailed subject index and instruction-set index.

According to the preface, there is a smaller, more portable reference manual that summarizes the HP-75’s commands; this would certainly be a useful adjunct to the machine.

Conclusion

This is a well-integrated and powerful machine. I did get an opportunity to use it with the optional digital-cassette and thermal-printer devices, and they work smoothly and effectively. The HP-IL loop works well and enables the computer to communicate with other HP peripherals. However, it does tie you to HP’s devices, rather than letting you use devices that interface to standard serial or parallel ports such as modems.

Overall, I am very impressed with the quality of construction and programmability of this machine. If you are interested in a single-vendor solution to your needs for a very portable computer with powerful real-time scheduling capabilities, you should look closely at the HP-75.
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MODEMS

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<td>80 Column Card:</td>
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<td>Vexor w/softswitch</td>
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We built our reputation on low prices for the informed computer user.
The Access Portable Computer

This portable offers all the hardware a computer user could want in a small package

by Terry Kepner

Would you buy a computer primarily because it comes with almost all the hardware you'll ever need? The Access Matrix Corporation is betting you would. The Access portable computer includes all the components most users find necessary: a full-sized detachable keyboard, a 7-inch (diagonal) amber display, two double-density disk drives; an 80-column dot-matrix printer; acoustic and direct connect modems; two RS-232C ports; one IEEE-488 port; one 8-bit parallel port; a composite video output jack, and an 8-inch disk driver interface. All this hardware comes in a package that weighs just 33 pounds (see photo 1).

Also included with each Access computer is a complete set of software: Perfect Writer, Perfect Speller, Perfect Calc, Perfect Filer, PFONT, CP/M 2.2, Microsoft's NBASIC, and Digital Research's CBASIC.

Setting up the Access is easy: open the shipping box, lift out the computer, and plug in the power cord. If you're familiar with CP/M, you can start using the computer and its software right away. The users manual includes a short tutorial on CP/M but if you're unfamiliar with the program you'll need another source of information to learn CP/M's intricacies.

The Hardware

The Access features a 4-MHz Z80A microprocessor and 64K bytes of dynamic RAM (random-access read/write...
A separate Z80A controls the video display, the real-time clock, and the keyboard interface. The printer uses two other microprocessors (an 8741 and an 8749), and an 8749 controls keyboard scanning. An additional 4K-byte RAM is used for the system monitor, two 4K-byte system EPROMs (erasable programmable read-only memory) hold the bootstrap firm, and one 256-character EPROM is used as the display generator.

The 7-inch amber screen has 24 lines of 80 characters featuring the full 96 ASCII (American National Standard Code for Information Interchange) character set, both uppercase and lowercase. The characters on the review unit were made up of 5- by 7-dot patterns within an 8 by 11 matrix (the specifications sheet incorrectly stated that the characters are 7 by 9 in a 9 by 11 block). The characters are difficult to read on a 7-inch screen, but, according to Access Matrix, the production units will have 6- by 8-dot characters (a 25 percent size increase), making the characters much easier to identify. A twenty-fifth line on the screen is reserved by the system as a status information line.

The separate processor for the video display makes it possible to assign attributes to the screen. These include inverse video; blinking characters; underlined and double-underlined characters; and half-intensity and full-intensity display characters. It is also possible to define the cursor as either a line or a block, blinking or not blinking. Even special features, such as protected and unprotected fields; insert/delete characters or lines, and erase and other useful functions, can be assigned to the screen.

The Access's video display was designed to emulate the Soroc 120 video terminal and will respond to the control codes used by the Soroc.

Keyboard

The keyboard is full-size and low-profile. In addition to regular typewriter keys, a block of 15 keys does double duty as either a numeric keypad (with plus, minus, and equals signs) or as a set of 15 special-function keys. The keyboard also has cursor-control keys, Caps Lock, Tab, Backspace, Escape, Control, Control Lock, Clear Screen, Print Screen on Printer, Delete, and Video/Printer On/Off-line keys.

When moving the computer, you can fold the keyboard up over the screen. When the computer is in use, the keyboard can be attached or detached from the main unit. When detached, the cord between the keyboard and the terminal stretches 4 feet. The cord's reach allows the user ample room to situate himself comfortably when an auxiliary monitor is attached to the computer.

A tilt stand is built into the two front feet of the computer to lift the video display to a comfortable reading height and angle.

Printer Unit

The printer mechanism is an Epson MX-80, one of the most popular dot-matrix printers (see photo 2). Friction feed moves the paper, and the unit prints bidirectionally at 80 characters per second. Four column widths are available: 80 (normal mode), 40 (expanded mode), 132 (compressed mode), and 66 (compressed-expanded mode). The printer mechanism can print standard ASCII characters (both uppercase and lowercase alpha) as well as 73 graphic characters and special characters in a 9 by 9 dot matrix. For charts and diagrams, it can print dot-addressable graphics.

The platen control knob, located below the printer dust cover, is a geared wheel that you turn. Controlling the printer off line (linefeeding, formfeeding, and setting top of form) is done through software commands from the keyboard. A $40 tractor feed is available as an optional extra.

Mass Storage

The disk drives, mounted to the immediate right of the video-display terminal (see photo 3), are 5½-inch,
At a Glance

Name
Access Portable Computer

Use
General-purpose computing, word processing, programming, spreadsheet, and file management

Manufacturer
Access Matrix Corporation
2159 Bering Dr
San Jose, CA 95131
(408) 263-3660

Size
16½ by 10 by 10½ inches

Weight
33 pounds

Standard Features
Hardware: 7-inch (diagonal) amber display (80 characters, 25 lines), dual 184K-byte disk drives, dot-matrix printer, acoustic and direct-connect modems, 64K-byte RAM, two RS-232C ports, one parallel port, one IEEE-488 port, composite video output, 8-inch disk-drive interface, and detachable keyboard.
Software: Perfect Writer, Perfect Speller, Perfect Calc, Perfect File, MBASIC, CBASIC, PFONT, TELCOMU (communications program), Systems Utilities, CPIM 2.2

Documentation
Manuals for the Perfect programs, Access Manual in three-ring binder

Price
$2,495

Options
Uninterruptible power supply, $239; tractor feed for printer, $40; double-sided disk drives, $100 each; carrying case (not yet available); softcover ($30), hardcover ($130), shipping case ($250)

half-height units. Each single-sided double-density drive has a formatted capacity of 184K bytes, organized as forty 18-sector tracks with 256 bytes per sector. To the right of the drives is a recess in which you can store about 10 floppy disks. At the front of the recess is a lip that prevents the disks from falling out. Additional double-sided double-density drives with more than 700K bytes of storage on line can be added if more storage space is needed.

Communications
The acoustic modem is mounted behind the printer and is designed to accept a standard Bell telephone handset (see photo 4). On the back of the Access computer, behind and below the acoustic modem, are the two modular jacks for direct connection to the phone line. By placing the Access in line between the telephone and the wall jack, you can use your phone normally or use the computer to auto-dial and connect to another computer. Of course, the auto-dial and auto-answer features will not work if you’re using the acoustic coupler. The modem can be operated from 0 to 300 bits per second (bps), full or half duplex.

The Access computer has two RS-232C ports that support any data rate from 61 to 9600 bps. The two ports, labeled port A and port B, are terminated with DB-25 connectors. Port A is electronically connected to the direct-connect phone jack, so that any information arriving over the phone appears at port A. Incoming phone information can be monitored on a terminal and/or an RS-232C printer attached to port A. Port B is a general-purpose serial port.

The 8-bit parallel port can be configured as a Centronics-compatible printer port for external printers or as a bidirectional port for connecting to outside peripherals.

Power Option
An optional combination battery pack and uninterruptible power supply (UPS) affords both convenience and true portability. Not only does the UPS provide 1 hour of emergency battery-power backup, it also incorporates a line filter to eliminate power surges and voltage spikes. The UPS can be recharged from standard 115, 220, and 12-volt supplies (your car’s electrical system can power the Access).

Hardware Hassles
I have a few complaints about the review unit. First, the latch that holds the keyboard closed is an invitation to broken fingernails. To open the keyboard, the user must press down on its edge and bend the plastic case while simultaneously pulling the keyboard forward and outward to release the metal retaining pin. In terms of engineering, this latch is not only inelegant, it is inept! I was not the only one who found this inexcusable—Access Matrix has informed me the latch mount has been redesigned to eliminate this problem.

My second gripe concerns the carrying handle, which is not mounted over the computer’s center of gravity. When you move the computer, it tilts forward instead
NOW 1 MEGABYTE MAX FOR ALPHA MICRO

CHATSWORTH—June 30, 1983—Mike Pelkey, Macrotech International President, announced today that a special version of MAX is now running in Alpha Micro Systems.

This special version is available only through Soft Machines of Champaign, IL. (217) 351-7199. Howard Ogle of Soft Machines stated, "The new AM-MAX runs full speed with all three Alpha S100 machines." Ogle also said, "The AM-MAX is not only the most economical memory for Alpha, but the most versatile as well. The system is even faster with Soft Machines' 'GO FAST' disk cache utilities!"

Bob Rubendunst of Soft Machines reports, "Every MAX is shipped with software that greatly simplifies implementation on bank switched systems. Also included are detailed installation instructions and diagnostic programs."

Dealer inquiries and orders should be directed to Bob at Soft Machines.

MAX SERIES GAINS WIDE ACCEPTANCE

CHATSWORTH—June 30, 1983—S100 systems manufacturers, integrators and users have been ordering and implementing MAX for a wide variety of environments and applications. These environments would include both 8- and 16-bit processors. Typical examples would include graphics and virtual disk implementations.

These environments include 16 bit systems such as those manufactured by Empirical Research Group, Dual Systems, Compupro, Cromemco, Lomas and Seattle. MAX has been used in non IEEE/696 systems such as Alpha Micro.

These MAX users have taken advantage of the density, high speed and low cost per bit to bring large system memories to S100 buyers.

Ralph Ring of Compatible Systems Engineering of Annandale, VA, (703) 941-0917 has used 4 MAX boards in a dual system UNIX* environment. Mr. Ring stated, "My application required a 4 megabyte system memory. Quarter meg boards were impractical, the MAX is ideal for this system."

Systems builders are using the M* option to utilize large memories in 8-bit environments. Using the MAX board in this environment means using a single board for all memory needs. This includes functioning as system memory, virtual disk or cache memory. Some of these 8-bit environments include Compupro, CCS, Tarbell, 1MS & Ithaca Intersystems.

M* translates the 16 logic bits from an 8-bit processor into 24 physical address bits. This opens up the system to a 16 meg address space. Using software provided in the manual, virtual disk can be implemented using CP/M 2.2* or MP/M 3.0* operating system.

If you think about it—quality, price, performance, and the reputation of Macrotech International—it's no wonder so many demanding systems builders have used MAX series dynamic memory. The S100 world's only full function one megabyte IEEE/696 memory.

Virtual Disk Gives MAX Split Personality

BURBANK—June 30, 1983—"Many current operating systems permit MAX to double as both virtual disk and system memory," stated Dan West of Westcom Systems. As an example, an MP/M 2.1* system using MAX-M could be configured as a 512K system memory and a 512K Vdisk. A typical CP/M 3.0* configuration could be 256K of system memory and up to 768K Vdisk. CP/M 2.2* of course, only permits a 64K system memory, leaving the balance for a virtual disk. With MAX, or the 128ST, both functions can run simultaneously in a single memory board.


Circle 270 on inquiry card.
of hanging level. When set down, the keyboard edge strikes the surface before the rubber feet. Not only is this disconcerting, the unit could receive quite a jolt if the carrier misjudges the surface clearance.

Third, the folks at Access must design a more secure cover for the printer mechanism. The present plastic cover pops off whenever brushed against. And, finally, the entire unit should have some sort of carrying case because the backplate is a perforated metal panel and the external connectors (RS-232C, parallel port, etc.) are exposed (see photo 5).

Software

In addition to CP/M 2.2, Access Matrix includes the following software with the computer: Perfect Writer, a word processor; Perfect Speller, a spelling checker; Perfect Filer, a file manager; and Perfect Calc, an electronic spreadsheet. Two high-level languages are also included: Microsoft's MBASIC and CBASIC from Digital Research. The manuals for these programs are softcover, perfect-bound books, with complete descriptions, examples, and indexes. They also contain summary cards of the commands.

Along with these "canned" programs, Access Matrix includes some "custom" software—programs expressly tailored to the Access portable. The two most important are a telecommunications program and a print control program.

The telecommunications program (TELComU) gives you control over the RS-232C ports and the modems. It lets you select the operating modes, ports, and UART settings. The main failing of TELComU is that it isn't complete. Several features listed in the menu aren't explained in the manual, and several features mentioned in the manual cannot be implemented. In fairness, the manual is stamped preliminary and the final version may correct these failings.

PFONT, the print control program, is a subset of the text formatter, Fancy Font, and could be used instead of the formatter built into Perfect Writer. PFONT lets you control the usual functions: margins, headers and footers, vertical and horizontal page centering, line centering, page length, tabs, and page numbering. PFONT is important because it offers a number of print fonts: Roman (8, 10, 12, 18, and 40 point), bold Roman (10, 12, and 18 point), italics Roman (10, 12, and 18 point), script (12, 18, and 20 point), sans serif (8, 10, 12, and 18 point), italic sans serif (12 point), and Old English (18, 20, and 40 point). These are in addition to the 10 fonts available on the standard Epson printer. PFONTs can be combined on a single line (as can Epson fonts). However, you cannot mix PFONTs and Epson fonts on one line.

CP/M Utilities

Other programs supplied with the Access include a configuration program to change the defaults of the video monitor, printer, RS-232C ports and parallel port; a program to set the correct time and date on the system clock; a program to format and copy disks; and a program to display a disk file on the monitor.

Summary

The Access is a complete, portable, hardware/software system designed for the average user. Its main drawback is that its TELComU program and accompanying documentation are not complete.

In spite of this and its hardware problems, which are being corrected, the Access is a system I can recommend to anyone needing full computer support in a (trans)portable package.

Terry Kepner is a full-time programmer and writer who has had articles published in BYTE and other periodicals. He can be reached at POB 481, Peterborough, NH 03458.
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Powerful, automatic formatting plus simple on-screen manual editing.
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You probably don't want to know how a word processor works.

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All Perfect Software™ programs can be configured to take best advantage of the sophisticated features offered with today's computers and smart printers.

You can use all of your function keys—including the more than 50 function keys on the IBM-PC. Perfect Writer™ fully utilizes printers with proportional spacing, too. Print with a choice of up to six typefaces.

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<th>Document Formatting</th>
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<td><strong>Print time formatting</strong></td>
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<td><strong>AUTOMATIC:</strong></td>
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<tr>
<td>Just write. Perfect Writer™ does the rest for you. Document design formats such as footnotes, indexing, tables of contents, and report formats—they're all automatic.</td>
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<td><strong>Screen formatting</strong></td>
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<tr>
<td><strong>MANUAL:</strong></td>
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<tr>
<td>What you see is what you get. Manually control the screen and print exactly what's there.</td>
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*Only Perfect Writer™ does both!*
Finally. A word processing program for any computer in your office.

**Perfect Writer**™ is the most compatible word processing program.

Everything you compose with Perfect Writer™—every chart, every table, every document—everything can be used by virtually any other word processing program or dedicated word processing system.

That’s because Perfect Writer™ uses true ASCII data files to store your documents. ASCII is the computer industry standard. It’s read and recognized by computer systems worldwide, regardless of disk format or size, whether it’s used locally or sent over telephone lines.

**Spreadsheets can be included.**

Want to illustrate your Perfect Writer™ document with a financial table or graph that’s stored in a Perfect Calc™ spreadsheet? You can—easily. In fact, you can even edit the numbers for your Perfect Writer™ document without disturbing the original Perfect Calc™ spreadsheet. That’s Perfect Software’s™ fully integrated programs at work.

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You can view and edit two documents on the screen at the same time with Perfect Writer’s™ unique split screen feature. One simple command moves you easily between documents. And you can even review a spreadsheet while editing up to six other documents! It makes the preparation of complex documents easier than ever before.

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Perfect Speller’s™ in-text spelling checker finds spelling errors and typos at a rate of 4,000 words per minute. (That’s 20 pages every three minutes!) Then, at a single command from you, Perfect Speller™ lists the misspelled words or marks errors in the text of your document.

**Self-teaching software makes it easy.**

Perfect Writer’s™ document design tutorials are matched to the easy-to-read user guide. Eight lessons are included. Learn how to handle form letters, how to write business correspondence, and how to create your own special spelling dictionary. On-line reference and English prompts provide assistance anytime you’ve got a command question. All tutorials are software-based, interactive programs to make learning easy and fun.

**Available for all IBM PC-DOS® and MS-DOS® CP/M* computers.**

When you upgrade to new hardware, Perfect Writer™ keeps right on working. All text files are transferable. No other software works with a wider range of personal computers. In fact, Perfect Software™ will soon be available for all of the most popular 8-, 16-, and 32-bit computers.

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**Perfect Calc** makes it easy.


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With Perfect Calc's multiple window display, you can see two different spreadsheets at the same time. Change your figures and see how the resulting variations affect each spreadsheet. Up to seven spreadsheets on-line at once.

**Multiple Spreadsheets**

Associated Spreadsheets

AUTOMATIC:

No double work — use any information you choose simply by referring to other spreadsheets. Move information, formulas or whole spreadsheets freely between multiple spreadsheets. Permits fill-in-the-blanks automatic forecasting and planning. 16 built-in application programs are included.

Spreadsheet Consolidation

MANUAL:

Simple cut-and-paste spreadsheet entries. Line, column, or whole spreadsheet additions from any one of seven on-line spreadsheets are also easy with Perfect Calc.

Only Perfect Calc does both.

How Perfect Calc's multiple file association really pays off.

A good example is the built-in Income Statement Program. The income spreadsheet automatically reads from three other spreadsheets: Cost of Goods Statement, General and Administrative Expenses Statement, and Sales Expenses. All four are on-line simultaneously. All you do is fill in the blanks.

Then use all that information to perform an instant analysis and illustrate the results of potential budget cuts or increases. You change just one spreadsheet using the fill-in-the-blanks style. Perfect Calc automatically takes care of the rest.

**Setting up the Perfect spreadsheet!**

Entering titles, labels, and additional information on your spreadsheet is easy with Perfect Calc. It recognizes words automatically and handles them correctly without any special commands. If you want to use numbers — like dates — for item labels, that's easy, too.

Individually variable column widths add flexibility in setting up your Perfect Calc spreadsheet. And once you've developed one spreadsheet, you can use it as a template for other applications. Simply refer to it.

**Self-teaching software.**

Easy, software-based lessons are included to make learning spreadsheet techniques simple. The lessons are matched to guides in the user manuals so
Sixteen applications built in. And that's only the beginning.

**Perfect Calc**

**Sixteen applications built in.**

...you can follow along in the text. Because you learn on the computer at your own pace, there's no pressure to perform. Try new applications when you are ready.

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Perfect Calc™ is the only spreadsheet you can buy with 16 applications built in. Standard paper and pencil financial tools are ready to use. All you do is fill in the blanks.

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**Handy cursor commands.**

You can move the cursor easily to the top of a column, beginning or end of a line, to the page before or after— with a single command.

And you can go back and forth between two spreadsheets on split-screen display with just as much ease. That makes multiple spreadsheet handling easier than ever before.

**The most compatible spreadsheets.**

Perfect Calc™ data is stored in true ASCII files—the files read and recognized by every computer system. So, it's simple to use a Perfect Calc™ spreadsheet in a Perfect Writer™ report or letter. Or, build graphic displays using the information in one of your spreadsheets.

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Using simple plain English prompts and on-line references, you can do sophisticated forecasting and planning in minutes.


Start planning for success today with Perfect Calc™

Perfect Software, Inc.
The powerful records management solution for the personal computer user.

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Most information management systems are either too small or too difficult to use. Now there's Perfect Filer™. It's an executive management information system that's easy to use. You can keep track of mailing lists, clients, sales, merchandise, names and addresses, and much more.

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Two ready-to-use data entry forms are provided so that you can begin using Perfect Filer™ immediately. One is for individuals, the other for companies and organizations. You only type important information once. Perfect Filer™ does the rest for you. No special training is required, and your entire staff can use it.

Information Management

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<td>Use Perfect Filer's® built-in data entry forms to create your own records file. All of the parameters have been pre-defined. Just enter information on the convenient entry form.</td>
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<tr>
<td>MANUAL:</td>
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<tr>
<td>Create custom data bases with ease. You can build an entirely new structure or use data entry groups from existing formats to construct a customized data base with exactly the information you want to manage.</td>
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Only Perfect Filer™ offers you both.

Form letters. Specialized record-keeping forms and sorted lists. You can choose from the two data entry forms provided or from seven data entry groups.

Creating custom data bases has never been this automatic.

Single-keystroke data entry menus do the work for you. You enter your data just once on a blank Perfect Filer™ data entry form — whether it be client addresses, direct mail sorting codes, payment records, inventory, or standing orders.

Perfect Filer™ makes successful information management simple.
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Perfect Software™ All of the most-asked-for business and personal computer applications in one complete package. Word processing, financial planning, mail management, records keeping. Solutions to all those everyday problems in one simple, integrated software package.

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Perfect Writer™ Perfect Calc™ And Perfect Filer™ Each a powerful program with dozens of extra value-packed features included. Together, they're the top performing software solution available on the market:

Common control commands. Learn one Perfect Software™ program and you've learned them all.


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Self-teaching software. Learn at your own pace without pressure to perform.

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Epson's HX-20 and Texas Instruments' CC-40

Portable notebook computers hold more promise than performance
by David Ramsey

The microcomputer revolution caught everyone by surprise. When the first Altairs became available, no one had any inkling that personal computing would be more than an expensive hobby for eccentrics. Things didn't work out that way, of course. And now we're on the verge of a submovement: the portable computer revolution.

In this article we'll take a look at two of the many portables available today: the Epson HX-20 and the Texas Instruments Compact Computer 40.

The Epson HX-20

The Epson HX-20 is the Japanese computer that was going to set America on its ear. It didn't, although its brisk early sales were encouraging. After an initial spurt of interest, people began to note that no accessories or software were available for the machine. In an unusual case of Japanese marketing failure, Epson had the lap computer market to itself for almost a year and did nothing with it.

Fortunately, it looks as if a truckload of new software and peripherals for the HX-20 is just around the corner. Epson has recently upgraded the standard $795 machine, which now includes the formerly optional (at $160) microcassette drive and a simple word processor called Skiwriter. Disk drives for the machine are due out before the end of the year, and a telecommunications ROM (read-only memory) should be available by September.

The basic machine contains two 6301 processors, CMOS (complementary metal-oxide semiconductor) implementations of the 6800 architecture that run at 614 kHz. One processor handles computing chores while the other handles I/O (input/output). Included in the standard machine are 16K bytes of RAM that can be expanded to 32K with the addition of the $150 expansion unit. The standard 40K-byte ROM includes BASIC, the routines to drive the printer and microcassette drive, and the small word processor. BASIC and the word processor share the same addresses—the application not in use at the time is bank-switched out. (See the "At a Glance" box.)

Epson's goal with the HX-20 was to provide a complete portable computer system that includes a printer and mass storage. The HX-20 has a 60-key, full typewriter keyboard, a 4-line by 20-character LCD (liquid-crystal display), and a 20-column impact dot-matrix printer (which is, incidentally, the smallest impact dot-matrix printer in the world). It is also equipped with RS-232C (albeit through a DIN connector) and serial ports and a computer-controlled microcassette mechanism for program and data storage.

The display has an important capability not found in competing machines: the ability to act as a window on a "virtual screen" of arbitrary size. Theoretically, a screen of up to 255 rows of 255 columns can be supplied; realistically, however, the 64K bytes of memory that would require don't exist in the machine. Still, allocating an 80 by 24 screen is as simple as typing WIDTH 80,24 in BASIC. You can use the cursor keys to move around the virtual screen with scrolling in all directions, and various control keys provide larger (more than a single character) jumps in any direction. The display is also dot-addressable as a 120 by 32 array, and commands to plot points and draw lines are included in the BASIC.

Along with the standard typewriter keyboard, the HX-20 has three dedicated keys (Break, Pause, and...
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PLATO

COMPUTER-BASED EDUCATION

CONTROL DATA PUBLISHING
At a Glance
Name
Epson HX-20 Notebook Computer
Manufacturer
Epson America Inc.
3415 Kashiwa St.
Torrance, CA 90505
(213) 539-9140
Price
$795
Dimensions
11.3 by 8.5 by 1.7 inches
Display
20-character by 4-line liquid-crystal display
Keyboard
Typewriter style
Software
BASIC, Skiwriter (a word processor)
Memory
16K bytes of RAM
Included Interfaces and Peripherals
Microprinter, microcassette, RS-232C interface, bar-code interface, external cassette interface, system bus connector
Documentation

Menu) and five user-definable keys that shift to provide 10 functions. System assignments to the function keys allow manual control of the microcassette drive and printer. Interfaces for an external cassette recorder and bar-code reader are also provided, although the former will probably not be used much now that the microcassette drive is standard.

Built-in Software
The HX-20 comes with BASIC in ROM and a small word-processing editor called Skiwriter. Also in ROM are a small machine-language monitor and routines to drive the microcassette, printer, external cassette (including motor control), and serial and RS-232C interfaces. The BASIC, which is supplied by Microsoft, is a fairly standard implementation that supports both single- and double-precision real numbers as well as integers. Epson adaptations include specifying the position of the cursor anywhere on the virtual screen, commands to control the microcassette, and commands to set and read the time-of-day clock/calend a r incorporated into the machine. A TONE statement allows precise control of the duration and pitch of notes through the HX-20's piezoelectric speaker.

A notable extension to the BASIC is its ability to load, save, and merge programs to and from the microcassette, external cassette, RS-232C port, or serial port. If you have a larger computer with a serial port, you can edit BASIC
code for the HX-20 on it, connect the two machines, and easily download the text of the program.

The BASIC editor is impressive. Just move the cursor anywhere on the virtual screen, type your changes (using INSERT and DELETE if necessary), and press RETURN to resubmit the line. Why don't we have editors like this on our Apple and Radio Shack machines?

When the HX-20 is turned on, the screen displays a menu of up to 10 options. The standard machine displays three choices: Monitor, BASIC, and Skriwriter. At this point you also have the option of pressing Control-@ to initialize the machine (i.e., clear memory and reset the clock). BASIC programs may be given titles, which will appear as part of the menu until the title is removed or the program is erased. Pressing a menu number immediately executes the desired application.

The HX-20 has an in-memory program and data file system. Five program partitions—P1 through P5—exist, and you can switch between them by entering LOGIN (partition). The memory allocation among the partitions is completely dynamic: any program can expand to fill available memory. In addition, a user-controllable area known as the RAM File, an area of memory whose size is chosen by the user, serves as a random-access data file. The command DEF(ILL (record size), (offset) defines the behavior of the special GET and PUT statements. The first parameter defines the size of the record, while the second defines how many bytes into the RAM file record 0 begins. Several files of differing record lengths can be kept in memory at one time.

Built-in Peripherals

The HX-20 is alone in the lap computer market in providing both a printer and mass storage as parts of a standard unit. The little printer is nothing short of amazing: it prints 20 columns on plain paper and consists of four print wires spaced equidistantly across the 20-character width of the platen. As the printer prints, the head wobbles back and forth until one horizontal line of dots is printed. The paper then advances one dot, and the process is repeated. The procedure sounds slow, but the printer finishes a little more than one line per second. The printer is controlled by BASIC LPRINT and LIST commands. For those cases in which you need more than a microprinter, any printer with a standard serial port can be connected to the HX-20 and used for listings and printouts.

The HX-20 supports the microcassette drive with a minimal set of commands. LOAD and SAVE take care of program storage; WIND winds the tape until the (software) tape counter reaches a specified value, and serial data files can be written by opening the cassette as a file and using the INPUT# and PRINT# statements. A random-access file could theoretically be implemented by determining the amount of tape each record took and using the WIND statement to position the tape before reading and writing, but the procedure would probably be too slow to be useful.

I admit to ambivalence about the microcassette drive. On one hand, it's very handy to have integrated mass storage. On the other hand, it's a pretty minimal implementation. My principal objection to the microcassette implementation, however, is that it's basically just the standard audio recorder moved onto the machine. Convenient, yes . . . but how about keeping directories on the tape? How about a real operating system so I can catalog the tape?

In Epson's defense, the company does provide a set of BASIC programs for manipulating a simple directory on the tape. The program builds a directory by scanning an entire tape at the normal read speed (which takes 15 or 30 minutes, depending on the tape length) and then placing a directory at the start of the tape. The same program then lets you select a directory entry for loading...
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and winds directly to it. But the slow scanning process must be repeated every time you want to update the directory, and there's no protection against a program growing to overwrite it. But the slow scanning process must be repeated every time you want to update the directory, and there's no protection against a program growing to overwrite it. Hewlett-Packard does far better with the HP-75, and it doesn't even have the advantage of working with a capstan drive.

The RS-232C port implements lines 1 through 8 of the RS-232C standard on a DIN connector. Epson supplies two cables with DB-25 connectors; one has pins 2 and 3 reversed for use with a modem. Although Epson offers a fine CX-20 acoustic modem, no terminal program is commercially available for the HX-20 at present. This terminal program that drives a Hayes Smartmodem through the serial port. The serial port supports a variety of data formats—the user can set the bit-per-second (bps) rate (110 to 4800), the number of bits, parity, and type of handshake, although the very standard XON/XOFF software handshake protocol is curiously absent and must be handled in software. Programs using the port with systems that expect this protocol must query the buffer status to determine the number of characters and transmit XON and XOFF where appropriate.

The serial port obeys the signal level standards for RS-232C but implements only pins 1 through 5. The bps rate goes to 38,400. In Japan, this connection is used for the TF-120, a dual 5¼-inch floppy-disk drive. Epson is working on a drive for the American market that is due to appear before the end of the year. It is rumored to contain its own Z80 processor and a fair amount of CMOS memory. The TF-120 requires AC power, but Epson has said that new peripherals for the HX-20 will be battery powered, which almost certainly means sub-5-inch drives. Rumor also has it that a larger LCD will be a plug-in option.

**Skirwriter**

Skirwriter, a small word-processing program on a Z84 ROM, was written by Kenneth Skier, who also wrote all of the HX-20 manuals and was one of the programmers for Wang's word processor. Now standard on the machine, Skirwriter is also available as a separate product for those who bought earlier versions of the HX-20.

Skirwriter is well designed and easy to use. A simple program, it offers only three output formatting commands: line spacing and left and right margins (defaults are 1, 10, and 70, respectively). The user enters text in free format, and words wrap at the boundary of the 20-column screen. Horizontal scrolling is not used, presumably because it would make reading a document on the screen more difficult.

Skirwriter lets the user mark, copy, and delete blocks of text, find (although not replace) strings, and reset the format (line spacing and margins) at any point in the
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document. This last feature is useful for setting off sections of documents. You can also insert formfeeds into the document at any time. Skiwriter has two 16-byte buffers whose contents are sent to the printer before printing (for the preprint buffer) and after printing (the postprint buffer). That way, the user can put control and escape sequences in these buffers (which are normally filled with nulls) to get the printer to a particular state. I think Skiwriter would be much more useful if it let you insert control and escape sequence commands directly in the text.

When you make an error, Skiwriter beeps. You can continue, but pressing the Help key displays a help screen detailing the error. This is a nice touch, especially for people who have little previous computer experience.

You can save and restore documents to either the microcassette or an external cassette, and documents can be printed on the internal microprinter or through the RS-232C port. Documents can be read in from either cassette and appended to the document in memory, a useful feature.

You can't use Skiwriter to edit BASIC text, but the standard HX-20 BASIC editor is so good that you don't really mind.

[Editor's note: Skiwriter may be available for other microcomputers in January 1984. . . . R. M.]

The Monitor
The machine-code monitor comes as a pleasant surprise, especially for those who enjoy digging into the (undocumented) workings of a machine. The monitor uses the physical screen only—you're limited to the 20 by 4 display—and normally displays the contents of the A and B accumulators in the index register, stack pointer, condition code register, and program counter. The following single-keystroke commands are available:

B Return to BASIC
K Set the "keystack sequence," a group of keystrokes that is automatically executed whenever the HX-20 is turned on
D Dump memory (in hexadecimal)
G Execute a routine in memory with optional breakpoints
S Set new memory values—used for entering data in hexadecimal
X Display and (optionally) change register contents
R Read a file from external cassette, microcassette, serial port, or ROM
V Verify file saved on device
W Write file to device
A Return starting and ending addresses of file as well as the entry point

Documentation
Four manuals are supplied with the HX-20: a two-volume BASIC Tutorial and Reference Manual, a Guide to Operations, and Skiwriter and microcassette manuals. All
are complete and well written. *The Guide to Operations* is a profusely illustrated work that gently guides the neophyte. Topics such as the virtual screen and the concepts of "programs" and "data" are handled very well. Overall, I'd have to rate the documentation high.

Summary

The HX-20 has a lot of potential. The introduction of the Radio Shack Model 100 has given the HX-20 very stiff competition, and compared to Radio Shack's 40 by 8 display, the HX-20 looks primitive. But Epson's new wave of peripherals and software, if introduced in a timely manner, will probably save the machine. Currently, its big selling points are the integrated microcassette and printer, features no other portable offers yet.

The Texas Instruments Compact Computer 40

I tried to be unbiased and objective about this machine, I really did. I kept reminding myself what a notebook-sized BASIC computer would have meant to me just a few years ago. And the price of the TI CC 40 is only $250.

But there's no clock. No file system. Only one BASIC program at a time can reside in memory, and the user can work with only about 5200 bytes of that. And the keyboard is vile.

There's also no cassette interface. If you want to store programs or data, you have to buy the TI wafertape drive. The CC 40 offers neither built-in storage nor a standard audiocassette interface. It could be argued, however, that you can buy a CC 40, the optional wafertape for mass storage, and another 16K bytes of memory, and still have an inexpensive computer. Unfortunately, none of these accessories was available at the time this review was written.

The CC 40 has a 31-character display, a sort-of-type-writer keyboard, and a separate numeric/cursor keypad. The keyboard spacing is so small that it's essentially impossible to touch-type on it. The Shift and Control keys lock for one keystroke—to type an uppercase character, you press and release the Shift key, then press the character key. There's only one Shift key; the space normally occupied by the right-hand Shift key is taken up by the Return key.

The CC 40 does make a dandy scientific calculator, and perhaps that's the market it should be aimed at. Good scientific programmable calculators cost about as much and are not nearly as powerful as the CC 40. Up to 10 user-definable key sequences can be entered, and the Playback feature recalls the line last entered on the display for editing and resubmission. All BASIC keywords can be entered with a two-keystroke sequence (FUNC followed by another key), which is handy considering how difficult it is to type on this machine. There is a slot for ROM or RAM cartridges in the upper-left corner of the machine. None were available at the time of this writing.

Built-in Software

The TI BASIC included is a good extended BASIC with several interesting features, among them a subprogram capability (with local variables); an ACCEPT statement that combines the functions of the normal INPUT statement with automatic positioning of input and length and type checking; a PRINT USING and IMAGE capability that allows some elaborate output formatting; and some real oddities such as SETLANG, which sets the output language for system messages. The standard computer includes English and German, so you can set your error messages to be displayed in German if you wish. Some ROM cartridges presumably offer the option of other languages.
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### At a Glance

**Name**
Texas Instruments Compact Computer 40

**Manufacturer**
Texas Instruments Inc.
POB 53
Lubbock, TX 79408
(800) 858-4565

**Price**
$249.95

**Dimensions**
9.2 by 5.7 by 1 inch

**Display**
31-character by 1-line liquid-crystal display

**Keyboard**
Miniature typewriter style

**Language**
BASIC

**Memory**
6.2K bytes of RAM

**Peripherals**
Printer/plotter, RS-232C interface, wafertape digital tape drive, Hex-bus interface, socket for ROM cartridges

**Documentation**
One 280-page manual

### Peripherals
The CC 40 includes an integral Hex-bus interface, which TI describes as "a medium speed (6000 bytes/second) 4-bit interface." The Hex-bus is used to connect peripherals such as the wafertape drive (which old-timers may remember as the Exatron stringy floppy) and printer.

### Documentation
The CC 40 is accompanied by a single manual describing the computer and explaining BASIC. About two-thirds of the bulk of the manual is BASIC reference. Several appendices describe the ASCII code, error messages, the internal structure of the machine (including memory maps), and warranty and service information.

### Summary
The redeeming feature of this machine is its low price. Virtually all of its competition vastly outstrips it in power and features. If you don't need portability, TI's own 99/4A home computer will give you much more memory, color graphics, sound, and lots of expansion capability for a mere $99. The CC40's true utility cannot be judged until at least some of the peripherals and software become available.

---

*David Ramsey is a programmer in the Concept group at Corvus Systems Inc. (2029 O'Toole Ave., San Jose, CA 95131).*
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The Pied Piper Portable Computer

Briefcase styling and low cost in a Z80 machine

by Seth P. Bates

Resembling a small, thin attaché case, the Pied Piper packs 64K bytes of RAM (random-access read/write memory), a single disk drive, and the Perfect Software package into a 12-pound portable computer system for $1299. Because it lacks an internal display device, this lightweight system will cause less muscle strain. To see your work, you must use an external monitor or television set. So although this computer won’t do you much good while you’re on the road, it delivers a low-cost Z80A system that is easy to move from one location to another.

General Observations

The Semi-Tech Micro (STM) Electronics Corporation designers intended the Pied Piper to be truly portable and immediately usable. The exclusion of the monitor was a decision the machine’s designers expected to appeal to those who don’t like the thought of carrying the added weight of a video display and its power supply. Even the smaller monitors in the Orona and the Osborne systems add considerably to the bulk and weight of a computer system. Possibly because of a recent drop in prices of LCDs (liquid-crystal displays), the company plans to offer a 2-line by 80-column display in the near future. Until then, however, an RF modulator provides an inexpensive way to use your television with the computer. You can also plug an 80-column monitor in directly.

To further reduce the weight of the system, its designers eliminated a second drive. Instead, a Mitsubishi drive with 784K bytes of formatted capacity is included. With this high density, a single 5¼-inch floppy disk holds Perfect Writer, Perfect Speller, and the Perfect Formatter/Printer software as well as the CP/M command library, with over 400K bytes remaining for user program storage. The single drive increases the time required to transfer files between disks. For example, making a backup copy of the system disk took 8 minutes. One method of avoiding this lengthy procedure is to use the TRANSFER utility when you back up a recently updated text or data file. With this shortcut, a single-disk system works well at home and on the road, but for extended use in the office, a second floppy-disk drive or a hard disk soon becomes a necessity. An additional 784K-byte drive conveniently plugs into a connector on the back panel to provide extra disk capacity.

The company wisely planned for user expansion by including interfaces for both this drive and a hard-disk drive on the motherboard. Two expansion slots will also eventually house serial interfaces and modems. STM offers a serial board and plans to introduce several others, including an integral auto-dial/auto-answer 300-bps modem and dual serial ports on a single board.

The Pied Piper is easier to use than any other computer I know of. Its simple operation, bundled software, and clear documentation make it an ideal first system for business users. The 78-page users manual isn’t indexed but includes a thorough table of contents and is logically organized, which makes locating informa-

Photo 1: A prototype Pied Piper portable computer with optional second disk drive, monitor, and printer.
tion a simple task. By writing clearly and from a novice’s point of view, the authors present a document particularly suited to the needs of a first-time computer user. The manual contains instructions for starting the Pied Piper and connecting it to a television set or a monitor as well as descriptions of all the major CP/M commands. Guidelines for basic disk usage and file management are also included.

For novices, the Perfect Software Primer provides a well-written guide to Perfect Writer, Speller, Filer, and Calc. The primer and its accompanying files not only help you learn about the software but also tell you which of the many lesson files you can safely delete from your working disk. This manual, however, suffers from one fault not shared with the rest of the documentation—it’s hard to read. Apparently, the company produced it with a dot-matrix printer on 8½-by-11-inch paper then reduced it to 7 by 9 inches to conform to the dimensions of the other documentation. It’s nice to have everything the same size, but I’d rather be able to read the manual.

Problem Solving

The Pied Piper is manufactured for STM in Hong Kong and tested at several points during manufacture and shipping. One test includes dropping the system from nine feet while it’s in the carton and dropping it from three feet without the carton. I didn’t notice any problems that might have resulted from the testing. But after three hours with a prerelease version of the Pied Piper, I noted several potential problems with the documentation and the system’s case. However, in the release version of the machine, every item on my list had been fixed, including a revision of the documentation. The only other problem was some interference with a wireless telephone. After locating the problem in the radio unit, I concluded that the shielding for the Pied Piper may not be adequate for use near those phones.

Although the company believes its testing will eliminate any problem units, it does offer an extended warranty through Xerox Service Centers at $199 per year for those who like a little extra insurance. The service centers promise a 16-hour or two-business-day turnaround on all repair work.

The Perfect Software Package

The four bundled software programs leave me with favorable impressions. Especially impressive were the ease of use, carry-over command structures, and the thorough implementation of the program’s features. Only Perfect Filer seemed scant in its features, but it doesn’t claim to be a true database system. With its selection of this package of software, STM appears to have correctly addressed the needs of the Pied Piper’s intended user. This factor should figure strongly in the machine’s success.

Perfect Writer. After two hours I felt comfortable with this package. During that time Jerry Pournelle’s comments about word processors that are continuously “nattering” at you seemed appropriate. Perfect Writer uses two lines at the bottom of the screen (called the Mode Line and the Echo Line) to inform you of the status of the system. At least half of this information isn’t necessary, the rest of it is essential, and none of it can be altered to fit your particular needs. Most troublesome, however, is that each time you press a key, the cursor appears momentarily at the end of the Mode Line. This is very irritating, and the reason for it escapes me. I have learned largely to ignore it, but some users may not adjust to it well at all.

Other aspects of Perfect Writer are more noteworthy. The designers did an excellent job of thinking out the command structure ahead of time. An example is the set of commands for cursor movement. In general, where a Control code is used for local and small-scale movement, equivalent Escape codes are used for larger-scale movements. For example, where Control-P and
Control-N get the previous and next lines, respectively, Escape-P and Escape-N access the beginning of the previous and next paragraphs. An implementation such as this makes it easy to remember most commands.

Perfect Writer, like all of the Perfect packages, is menu driven. If you want to get back to the previous level of menu at any time, the Escape key does the job. Control-Y will "Yank back" the last text alteration. Control-G will "Go back" to before the last unexecuted command (a command in progress); take care not to confuse it with the letter G (Go), which starts an operation selected from a system menu.

Perfect Speller. Proofing with Perfect Speller is fantastic. Words you use frequently can be added to the dictionary, and special dictionaries can be constructed for different projects. Once the program locates misspelled words, it asks you to provide a one-key code indicating whether to mark it for correction, add it to the dictionary, or ignore it. When this is done, you exit directly to Perfect Writer and move through your text to each marked word, correcting your spelling as you go. As yet, Perfect Speller hasn't failed to find a misspelled word.

Perfect Filer. It takes longer to learn Perfect Filer, and some of its advanced features, like reformatting an existing database, require a two-disk system. Still, the program comes with several built-in systems that business users will find immediately useful. As an added bonus the tutorials on modifying existing field and record formats make it simple to develop new databases from the existing ones.

Perfect Calc. While I didn't spend as much time with this program, Perfect Calc appears to include all the major features offered by other spreadsheet packages. The control and command structure remains consistent with the other Perfect programs, reducing learning time. Tutorials in the software manuals assist novices in grasping the basics needed to start using the system. In addition, as with Perfect Writer and Filer, the program disk includes sample files to modify, so you can learn to use the system with a minimum of lost time and effort. Several useful sample spreadsheets are the Family Budget program, the Financial Net Worth program, the Check Register program, and the Individual Tax Return Analysis program.

Conclusion

The Pied Piper offers real business features at toy prices. Although a few of its features might have been designed differently, as with any machine, STM offers a good system for the money. Models II and III are already in the works, and one of them is a 16-bit machine. These additions to the line, along with the promise of the 2-line LCD option, make the Pied Piper's future look bright.

Seth P. Bates is assistant professor in the Division of Technology at San Jose State University (San Jose, CA 95192) and president of Teknos, a small firm that does systems integration.

The Pied Piper uses its own disk format. Software in this format is available from selected distributors. Currently available are M.BASIC, Pascal, FORTRAN, dBASE II, PPL, Bottom-line Strategist, Wordstar, Condor, T-Maker III, Supercalc, and the American Training Institute training packages.
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The Kaypro II

Dependable hardware and extensive software make this affordable portable a winning package

by Roger Fager and John Bohr

One industry pundit insists that for a microcomputer system to be successful, it need only be adequate—which is to say complete, reliable, standard, and inexpensive. The Kaypro II from Non-Linear Systems epitomizes these homely virtues.

A complete system encased in aluminum, the Kaypro II contains a single-board computer, two 5½-inch floppy disks, and a 9-inch (diagonal) green-phosphor video screen that displays 24 lines of 80 characters. A 6-foot coiled cord hooks a high-quality, 76-key detach-
able keyboard to the Kaypro's chassis. It uses a Z80 microprocessor running at 2.5 MHz and has 64K bytes of RAM (random-access read/write memory) plus an RS-232C serial port and a Centronics-compatible parallel printer interface.

The Kaypro II comes bundled with extensive software, including CP/M 2.2 and the Perfect Software series: Perfect Writer (a word processor), Perfect Filer (a database program), Perfect Calc (an electronic spreadsheet), and Perfect Speller (a spelling checker). In addition, the manufacturer supplies Profit Plan (a simplified spreadsheet) and two forms of BASIC: S-BASIC, which is structured, compiled BASIC, and MBASIC, the de facto standard, interpreted BASIC. To round out the software package, Kaypro II includes The Word Plus (a powerful spelling checker) and several game programs.

Hardware

On examining the machine we immediately noticed that the Kaypro II's hardware is solid and obviously designed for transport. When you want to move the Kaypro II, the keyboard snaps onto the case to form an 18- by 15%- by 8-inch suitcase that weighs 26 lbs. Heavy-gauge aluminum surrounds and shields the keyboard and the main chassis.

Inside the case, Non-Linear Systems' test-equipment expertise is readily apparent. The major subsections are firmly mounted to the case, far apart from each other. Not only does isolating components provide space for air circulation and heat removal, it also makes all the major components readily accessible for examination and repair.

The layout of the main circuit board (see photo 2), suggests that the system was designed as four subsections. The main computer subsection consists of the Z80 microprocessor, the ROM (read-only memory) chips, and 64K bytes of dynamic memory. The floppy-disk-control subsection consists of a 1791 disk controller and TTL (transistor-transistor logic) support chips. The I/O (input-output) subsection includes two Z80 PIOs (parallel input/output devices), a Z80 SIO/0 (serial input/output device), TTL buffers, and connectors. The final subsection is the digital part of the video generation system: 2K bytes of static RAM for screen memory and a character-generator ROM. The chips are socketed and easy to get at.

Surprisingly, the system clock rate is only 2.5 MHz (a rate of 4 or 6 MHz is possible with a Z80A or Z80B and corresponding support chips). At least one other potential hasn't been tapped: each of the PIO chips can support an additional 8-bit parallel port. This means that with existing hardware the Kaypro II could easily drive an IEEE-488 port to supplement the parallel and serial ports already available. The IEEE port could be im-

Photo 2: The main printed-circuit board of the Kaypro II.
At a Glance

Name: Kaypro II

Manufacturer
Kaypro Division
Non-Linear Systems Inc.
533 Stevens Ave.
Solana Beach, CA 92075
(619) 755-1134

Dimensions
Folds to an 18- by 8- by 15¾-inch suitcase-like metal box with a handle; weighs 26 pounds

Components
A Zilog Z80 microprocessor running at 2.5 MHz; 64K bytes of dynamic RAM and 2K bytes of screen memory; an 80-column by 24-line green-phosphor display with brightness control; a selective-style keyboard with numeric keypad; two single-sided, double-density 5¼-inch drives, each with a capacity of 193K bytes (formatted); RS-232C serial and Centronics-compatible parallel ports

Software
CP/M 2.2; the Perfect Software family: Perfect Writer (word processor), Perfect Files (database), Perfect Calc (spreadsheet), Perfect Speller (spelling checker), tutorial disks; The Word Plus (spelling checker); Profitplan (spreadsheet); MBASIC (interpreted BASIC with games); S-BASIC (structured, compiled BASIC); system utilities.

Documentation
System manual; standard CP/M manual; Perfect Software manuals; The Word Plus and Profitplan manuals; S-BASIC and MBASIC manuals (language descriptions)

Price
$1595

Options
Vinyl and nylon cases

implemented by software routines to do the timing for the various control lines. This would enable the Kaypro II to interface directly with intelligent test equipment.

Despite those two missed opportunities, the computer is dependable and well laid out and runs coolly even over long periods of use.

Human Interface

The detached keyboard has contoured keys and a standard IBM Selectric layout supplemented by these special keys: ESC, CTRL, Line Feed, Tab, Caps Lock, Backspace, DEL, and four cursor keys. The numeric keypad has its own period, comma, and Return keys. An LSI (large-scale integration) chip within the keyboard generates serial signals, which are communicated through a 6-foot coiled cord with modular telephone-handset-style RJ12 connectors on both ends.

The 9-inch green-phosphor display gives a sharp, stable image in an 80-character by 24-line format. In addition to the ordinary ASCII (American National Standard Code for Information Interchange) characters—upper- and lowercase, numerals, and punctuation—the Kaypro II displays the Greek alphabet. The only graphics available are simple character graphics.

Storage

The Kaypro II comes with two double-density single-sided disk drives, each of which provides 193K bytes of storage (see the text box on "The Kaypro 4 and the Kaypro 10" for other configurations). The floppy-disk drives can read and write disks in Xerox 820 format; therefore most CP/M software is available to the Kaypro owner. Software is now available from Kaypro to read other 5¼-inch disk formats (including those of the Osborne 1 and Radio Shack Model I).

Hardware Hardships

A machine of this weight needs a comfortable handle; however, the Kaypro's handle will cut two parallel grooves into your hand if you carry the system for more than a short time. A well-designed, padded handle would be a considerable improvement.

Perfect Writer's multibuffer memory architecture allows you to edit as many as seven documents at one time, transferring sentences or paragraphs between them.

The Kaypro II's lack of environmental seals is also a problem. There are no covers for the interface jacks, and the air circulation holes at the top can serve all too well as inlet ports for rain when the system is moved. The unsealed junction of the keyboard and case also invites contaminants into the keyboard circuitry and floppy disks. (The manufacturer offers a protective vinyl cover as an extra-cost option.)

Unfortunately, the Kaypro II provides no means to carry its software treasure. For convenience, some other portable computers have integral disk holders.

Software

Non-Linear Systems, aware that the typical user is not a computer professional or hobbyist, has wisely selected a package of user-friendly software. Purchased separately, Perfect Writer, Perfect Filer, Perfect Calc, Perfect Speller, Profitplan, MBASIC, S-BASIC, Word Plus, and CP/M 2.2 would cost much more than the Kaypro II package.

Perfect Writer

Perfect Writer uses a distinctive command structure for inserting, editing, deleting, and replacing text. The program is similar to the text editor MINCE, which in turn is based upon a mainframe editor called EMACS. As with these forebears, not all of your document needs to be in memory; the virtual memory technique uses a disk swap file to extend the size of a document up to or beyond 64K bytes' worth of characters. Another im-
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Standard Features—CLEO 3780
- Point-to-point and multipoint communications
- Available for CP/M®, MP/M®, MsDOS®, TurboDOS®, Unix®, and Xenix®.
- Supports transparent mode
- Coded in C language
The Kaypro 4 and the Kaypro 10
by Arthur A. Little

The editing routines are presented in tutorial form with illustrations of the commands (such as CTRL and ESC key sequences), and there are abundant examples of edited documents.

Although the documentation is helpful, the program itself is annoyingly unforgiving of mistakes. Perfect Writer may terminate suddenly if you type in a wrong control code, wiping out your newly created document. The “delete sentence” command will hang up the system if there are no more periods in the file, which could occur when you edit toward the end of your document. Perfect Software is aware of the problem, and later revisions should eliminate this problem—an example of practice making perfect, no doubt.

Perfect Filer
Perfect Filer enables you to create a database record as long as 1024 characters, enter data under cursor-key
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control, use up to five sort keys, and print out any subset of your stored records in form letters, mailing lists, or specialized forms. You can also change the format of a database without losing your data. Because Perfect Filer is fully menu-driven, you don't have to be a programmer to handle these rather sophisticated tasks.

As examples of how to construct your own file managers, two predefined database templates accompany Perfect Filer: an individual member mailing list (name/address/phone/busphone/organization) and an organizational mailing list (org/address/phone/contact/comment).

Another uncomplicated menu-driven subprogram enables you to define a subset for search (for example: all New York names entered after November 1982). The results of the search can be output to the display, printer, or disk file for use in Perfect Writer.

The Perfect Software programs share commands, facilitating crossover learning from one application to the next.

**Perfect Calc**

The electronic spreadsheet, Perfect Calc, displays an entry window of 8 columns by 24 rows on a 52-column by 255-row worksheet. Perfect Calc features cursor-key directed movement, instant recalculation of formulas, and a Help menu.

The master disk supplies 29 formatted spreadsheet templates with applications varying from checkbook balancing to income-tax calculation. The users guide suggests that they "may require modification to meet your particular needs." This is an understatement because many of the templates contain bugs. For example, the accounts-receivable worksheet formulas call for variables from accounts-payable entry sheets, and the Payroll analysis set depends on a spreadsheet, "payfacts.pc," which Perfect Software has not included.

Still, Perfect Calc itself is comfortably bug free. It has the same split-screen, virtual-memory, multibuffer editing features as Perfect Writer. The control commands are identical, except that there are extensions for the editing of columns. You can pass entries or blocks of entries between any number of spreadsheets, and a powerful "associate files" option links the formula calculation and calling into memory of separate sheets. Although the Kaypro II does not do graphics, Perfect Calc allows you to format a bar graph as varying strings of asterisks. The user manual is written in jargon-free English and is well illustrated.

The biggest disappointment is the lack of communication between the Calc and Filer programs. If you need totals in Perfect Filer, which does not perform arithmetic, you have to transfer the numbers individually to a Calc file using split-screen editing, then key the totals back by hand.

The Perfect programs in the Kaypro II package were

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designed as an integrated package and share command structures, format, and an overall functionality. This means that there is considerable crossover learning from one program to the next—a boon to users. Perfect Software is not perfect, but considering the price, portability, and commitment to improvement, it is very good indeed.

Profitplan
Kaypro also includes Profitplan from Chang Laboratories. This spreadsheet program is appropriate for simple applications: data and formula entry are fairly straightforward, but once you make a "what if" projection, you can't restore your original spreadsheet.

The Word Plus
Although Perfect Speller is still included in the Kaypro II software package, it has been largely superseded by The Word Plus from Oasis Systems. The Word Plus lists words it doesn't recognize and asks whether they need correction. It can display the words in context and will generate a list of likely corrections at your request. Next, it automatically makes the corrections in your text and writes an updated file to disk. The program will even "learn" new words and add them to its dictionary for future use.

Furthermore, The Word Plus displays total word count, frequency of occurrence, homonyms (such as colonel and kernel), anagrams (debug and budge), and lists of rhymes. It also assists in solving crossword puzzles and playing Scrabble. These word-puzzle routines are so intriguing and so much fun that The Word Plus may interfere with your time management; sooner or later you will lose an entire morning playing with them.

The 45,000 words of the main dictionary were selected on the basis of frequency of occurrence and frequency of misspelling and were checked for accuracy by proofreaders and by existing lexical programs. In addition, you can create specialized dictionaries (e.g., legal, medical or scientific terminology) and specify them at run time.

Because the S-BASIC manual lacks illustrations of actual code, it takes some trial and error to type certain S-BASIC statements in a way that pleases the compiler.

Down to BASICS
MBASIC from Microsoft is so widespread within the microcomputer world that we need only say that this interpreted BASIC works as expected and makes a huge software base available to the Kaypro owner.

The S-BASIC compiler is an interesting mixture of BASIC syntax and Pascal control structures. BASIC programmers may find little need to change their programming methods except that variables must be declared. (However, if they want to write more readable, debug-
For Line Surge Suppression

SYSTEM SAVER provides essential protection to hardware and data from dangerous power surges and spikes. Dangerous voltage spikes are clipped off at a safe 130 Volts RMS/175 Volts dc level. High frequency noise is smoothed out before reaching the Apple II.

For Cooling

Today's advanced peripheral cards generate more heat. In addition, the cards block any natural air flow through the Apple II creating high temperature conditions that substantially reduce the life of the cards and computer itself. SYSTEM SAVER's fan exhausts 15 cubic feet of air per minute.

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$89.95 at dealers everywhere or order direct by phone or mail. For phone or mail orders include $2.50 for handling. New York State residents add sales tax. VISA and MASTERCARD accepted. Dealer inquiries invited.

S-BASIC offers good internal documentation with its variety of commenting structures. Variables can be declared and documented on the same line, and COMMENT...END allows a whole block of comment lines to be entered. S-BASIC supports interactive programming with an assortment of INPUT statements, and a single instruction outputs an entire block of display lines. Its "advanced structured techniques" show a strong similarity to Pascal: WHILE...DO; REPEAT...UNTIL...; CASE...OR...END; as well as procedures and functions which allow parameter passing and recursion.

Boolean variables are fully implemented although there is not a separate boolean type. A statement such as FLAG = (X < Y) will work whether FLAG is declared as integer, real number, or string. In the latter case, a string that begins with "Y", "y", "T", or "t" is evaluated as true. You might use the variable in a routine similar to the following:

INPUT "DO YOU WANT DOUBLE WIDTH PRINTING"; FLAG
IF FLAG THEN DOUBLE.WIDTH

S-BASIC aims to be a tool for the experienced programmer of structured languages, improving on Pascal by adding string variables and random-access file I/O and dispensing with its tedious punctuation (a = b replaces a : = b). It does not have Pascal's power in describing data types, however. There are no pointer variables, sets, records, or scalar subrange variables.

Parameters in a procedure are used somewhat differently. First, all parameters are of the pass-by-value type. In other words, none of the arguments of a function or procedure can be altered by it. While this may not meet the approval of Pascal purists, I feel that the resulting independence of modules is an aid to program structure. S-BASIC handles the problem of a multivalue function by using global variables. Remember that microcomputer programming is not a likely environment for a major team software project. The clarity of a program that will take up only 60K bytes of memory is not going to suffer from a few extra global variables. Furthermore, arrays are not allowed as parameters. Also, a parameter declaration is not permitted to have the same name as a global variable or as a variable local to another procedure.

Software Problems

The current S-BASIC manual, although an improvement over the original, does not have sufficient illustrations of actual code, so it takes a certain amount of trial and error to type some of the statements in a way that pleases the compiler. The following statement, which is meant to call up the execution of a separately compiled program, is an example:

chain "b:program.com"
INTRODUCING THE SAFT STANDBY POWER SYSTEM. IT KEEPS YOU FROM LOSING YOUR MEMORY WHEN THE LIGHTS GO OUT.

If the power fails while you're reading this ad, everything your computer knows could be lost.

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And during normal operation it acts as a line filter, protecting against damaging voltage spikes.

Ask your dealer about the Saft Standby Power System. It's the first standby system designed specifically for small business computers. And offered at a small business price.
This statement produces run-time errors until you discover that the file name must be typed in uppercase letters. The manual does not make this clear.

Another problem is a statement with more than 65 characters. The compiler uses a linefeed as the delimiter of a program statement, and neither the manual nor the Kaypro II users guide hints that specifying Perfect Writer’s “normal” mode is the way to turn off word wrap.

Compiler error messages are noticeably weak. For example, “$$$$$$$Cannot process this / Statement error” is the only message covering a large class of syntactical errors in REPEAT, WHILE, ELSE, and CASE statements. Incredibly, S-BASIC has no test for an end-of-file condition. Thus, a program will crash unless you take the trouble to define a counter field that you increment when you write a new record. ‘Modulo’ and ‘odd’ functions have been omitted for the sake of economy, leaving the programmer to grapple with integer-division expressions.

Aside from these rough edges, writing structured code was easy and natural. With improvements, S-BASIC could be highly suitable for introducing microcomputer users to the advantages of structured programming.

The Company

When you are buying a computer, your scrutiny should not end with the hardware, software, and documentation. The company matters, too. Non-Linear Systems has been around for a long time. In the 1950s the company president, Andrew Kay, invented the digital voltmeter, and Non-Linear has been a major supplier of portable test equipment for the last 30 years. His son, David Kay, is product manager for the Kaypro Line. They seem genuinely committed to customer service and are well organized for it. As part of this customer support, Non-Linear Systems publishers Pro-Files, a Kaypro users magazine. Pro-Files is available free for one year to Kaypro owners.

Conclusion

If Kaypro II is the answer, then the question might be, “What is the best value in a practical portable computer?” Though it has some limitations, the Kaypro II is both good and affordable. For $1595 you get an extensive software package with high-quality documentation, standard hardware that works all the time, a fine keyboard, an 80-character display, standard interfaces, and good floppy-disk drives. That’s what we call “best value.”

Editor’s Note: Shortly after this review was written, Non-Linear Systems announced that it has changed its corporate name to Kaypro Corporation. Non-Linear Systems will become a division of the parent company.

Roger Fager is associate professor in the Physiology Department at the University of Virginia School of Medicine in Charlottesville. John Bohr has a degree in mathematics and is a part-time computer science student.
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Product Description

The Corona Portable PC

A new portable IBM PC-compatible computer with an eye-catching display

by Rich Malloy

If you’ve attended any of the recent computer trade shows, you’ve probably seen a reasonably priced portable computer that rapidly flashes a series of eye-catching pictures across a very high contrast green display screen. This machine, the Corona Portable PC (photo 1), along with its sister desktop version, the Corona PC, offers stiff competition to the numerous machines compatible with the IBM Personal Computer.

Corona Data Systems, the manufacturer of the new systems, is one of the several start-up companies spawned by the IBM PC. It was founded two years ago by Dr. Robert Harp, who a few years earlier had been the founding wizard of Vector Graphic. Before announcing its new line of IBM-compatible systems, the new company was known primarily for its hard-disk drives.

The two Corona machines are very similar. The portable has an 8088 microprocessor, 128K bytes of memory, one or two half-height double-density double-sided floppy-disk drives (storing 320K bytes each), a 9-inch high-contrast green monochrome display screen with graphics capabilities, a serial port, a parallel printer port, four IBM-compatible expansion slots, and a fairly sizable bundle of software: Microsoft’s MS-DOS operating system and GW-BASIC language, Softword Systems’ Multimate (a word-processing program), and PC Tutor, a program to teach you how the system works. The price for all this is $2945 for the two-disk-drive model (the one-disk-drive model is $400 less). The computer weighs 28 pounds and measures 9.6 inches high by 18.8 inches wide by 19.8 inches long.

The desktop machine (photo 2) has everything the portable has except that it has a 12-inch screen instead of a 9-inch screen. It will use standard-height disk drives until more half-height drives become available. The two-drive desktop model sells for $2995. The one-drive unit is $400 less.

Because the machines are so similar, it is hard to talk about one without discussing the other. But in keeping with the theme of this issue of BYTE, I’ll restrict my observations to the portable version. Bear in mind, though, that most comments apply equally to both models.

Compatibility

The first thing to think about when considering an IBM-compatible computer is, “How compatible is it?” Despite many manufacturers’ claims, it is very difficult, and illegal, to produce an exact copy of the IBM Personal Computer. For the machine to be legal, at least some of its parts have to be different (for instance, the copyright notice). It is essential to find out that the software (or expansion hardware) you need will run on the machine you are interested in.

The Corona portable comes with the MS-DOS operating system (essentially the same as IBM’s PC-DOS), and Digital Research’s CP/M-86 is offered as an option. Any program that is written for MS-DOS or CP/M-86 should run on the Corona. Any program, however, that accesses IBM’s proprietary ROM (read-only memory) routines to drive the display and keyboard may not run on the Corona or most of the other IBM Personal Computer clones. The best way to test this, of course, is to try to run your favorite IBM Personal Computer program on the Corona.
For this Product Description I did not have time to do an exhaustive test of the software written for the IBM Personal Computer, but I was able to test one of my favorites, Peachtree Software's Peachtext, configured for the IBM PC, at the spring Comdex show in Atlanta.

After watching an MS-DOS program called PC Tutor running on the Corona, I discreetly asked if I could try to run a Peachtext disk that was in my pocket. The people at the Corona booth hemmed and hawed a bit, but they finally led me to a desktop version of the machine off in the corner where no one would see it should it fail. Their hesitancy was unnecessary. The disk booted up without a problem, and a few keystrokes later Peachtext was processing a text file.

This was, of course, far from an acid test of compatibility, which will have to wait for a future issue of BYTE. But it is a test I highly recommend: take a program you like and see if it actually works before you buy.

Video Display
As mentioned earlier, the most eye-catching feature of the Corona is its green monochrome video display. It has an extremely high contrast, which seems to reduce eyestrain. Photographs may not capture its clarity, so I recommend you visit your local computer store to have a look.

The screen, which also has graphics capabilities, can display 25 lines of 80 characters. According to Corona Data Systems, each character is formed on a 16- by 13-pixel (picture element) grid. That's 16 pixels wide, not high! The horizontal size of the pixels is presumably half that of the vertical size. If you consider that there are 80 characters per line and 16 horizontal pixels per character, the effective horizontal resolution is an incredible 1280 pixels!

Like the IBM Personal Computer, the Corona Portable PC supports two levels of intensity for each character. It also supports reverse-video characters, underlining, and blinking.

Graphics
The aforementioned high-contrast screen is coupled with high-resolution graphics capabilities (640 by 325 pixels). Unfortunately, this is not the same format as the IBM color/graphics display-adapter board (640 by 200 pixels). But the IBM color/graphics board can be plugged into one of the expansion slots, thus giving the Corona more compatibility with programs such as Lotus Development's 1-2-3.

The Corona graphics format is supported by an extra set of BASIC commands in its GW-BASIC interpreter. It should also be supported by the GSX graphics interpreter that can be attached to CP/M-86. GSX (Digital Research's Graphics System Extension) promises to give its users a layer of compatibility in graphics, the same way CP/M gave us a layer of compatibility for general 8-bit software (see reference 2). When CP/M-86/GSX software becomes available, the Corona should be able to run it.

Two other nice features of the Corona are that graphic images can be placed anywhere on the screen, regardless of text-character placement. And graphics information can be placed anywhere in memory. This allows for the quickly changing pictures I mentioned at the beginning of this article.

Keyboard
The Corona Portable PC, like many of the new personal computers, uses an IBM-like keyboard from Key Tronic (see reference 1). This keyboard has a layout similar to that of the IBM Personal Computer, but has an indicator light for the Caps Lock and Num (numeric) Lock keys. It also has a much lighter "feel" for each keystroke and it does not make a loud click as the IBM unit does.

Key Tronic makes two versions of its keyboard. On one, the layout of the keys is exactly the same as that of the IBM. On the other, the keys are arranged in a more traditional layout; that is, the left Shift key is to the immediate left of Z, and the Return (or Enter) key is just to the right of the quotation marks key. These positions are more in line with other keyboards used in the United States.

Corona Data Systems originally offered the exact IBM key layout, but recently it decided to offer the more traditional keyboard because many users had requested it. This is a prime example of the adaptability of smaller companies. I wish IBM could display similar flexibility in its choice of components.

Durability
A prime factor in the selection of a portable computer
is its ability to survive travel. The unit used at the Com-­
dex show offered evidence of the Corona's ruggedness. 
The Corona prototype I saw had been subjected to some rough handling on an airplane flight, enough to 
break off the front panel. Another prototype was not 
available, so the broken one had to be used. During the 
show, the front panel had to be propped up against the 
machine. But despite what must have been a fairly severe blow, the prototype still worked. Let's hope the 
mass-produced versions fare as well.

Multimate

Multimate, the word-processing program that comes with the machine, is somewhat similar to the software 
Wang Laboratories uses on its dedicated word processors. Developed by Softword Systems of East Hartford, Connecticut, Multimate is fairly powerful and has the ability to merge letter files with address files.

Options

One of the options for the Corona Portable PC is Cor-

At a Glance

Name
The Corona Portable PC

Manufacturer
Corona Data Systems
31324 Via Colinas, Suite 110
Westlake Village, CA 91361
(800) 621-6746

Size
19.8 inches long by 18.8 inches wide by 9.6 inches high

Weight
28 pounds

Hardware
8088, 16-bit processor; 128K bytes to 512K bytes of memory; 9-inch green phosphor display, 80 by 25 characters, reverse video, underline, blinking, high-intensity, 640 by 325 pixels; Key Tronic keyboard with modified IBM-PC key layout; mass storage: 1 or 2 half-height floppy-disk drives. 320K bytes each; interfaces: RS-232C serial port, Centronics parallel printer port; expansion: four IBM-PC compatible expansion slots

Software
MS-DOS operating system, GW BASIC interpreter, Multimate word processor, PC Tutor

Options
Extra memory, 128K-byte modules, $295 each; second floppy-disk drive, $450; hard-disk drive, 10 megabytes, $2695

Documentation

Price
PPC-1 (one floppy disk), $2545
PPC-2 (two floppy disks), $2945
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A Report on the Consumer Electronics Show

A bird's-eye view of the latest offerings

by Phil Lemmons

A single event dominated the Consumer Electronics Show held in Chicago: the introduction of the Adam, Coleco's personal computer (see the photo above). Just as the Osborne computer once revolutionized the personal-computing marketplace by bundling applications software, languages, and all the basic hardware except a printer for $1795, Coleco now offers a computer system with more standard features than seem possible for $599.

The Adam personal computer contains a Zilog Z80 microprocessor with 80K bytes of RAM and a word processor in ROM. A full-sized keyboard has a diamond-shaped cursor pad, function keys, and built-in numeric pads on the two standard game controller units. According to Coleco, a 512K-byte digital data pack system will rival the transfer rate of a floppy disk. The speed of the bidirectional daisy-wheel printer included with the Adam is less than 15 characters per second (cps), but that doesn't detract from the sharp quality of the characters. The standard Adam lacks a monitor but can use a television screen as a 40-column display and offers an optional 80-column card for those who buy a monitor. The Adam is CP/M-compatible, and Coleco promises to make the most popular CP/M programs available on digital data packs. The company also claims its BASIC is source-code compatible with Applesoft. And if the computer features aren't impressive enough, don't forget the Adam's ability to run games written for Coleco's line of game machines.

The Adam wasn't the only important machine introduced at CES. Atari presented four new machines based on a 6502C microprocessor running at 1.79 MHz. The least expensive of these was the $199 600XL featuring 16K bytes of RAM expandable to 64K bytes and 24K bytes of ROM. In addition, a CP/M module is available as an accessory. Atari also introduced the 1027 letter-quality daisy-wheel printer for the low price of $349.95. The 1027 prints at 20 cps, faster than Coleco's printer by 5 cps. The 1027, the Atariwriter word-processing cartridge, and the 600XL computer are bundled as a word-processing system for $599.95. But keep in mind that the keyboards of all the new Atari machines have only 62 keys, no cursor-control keys, and only four function keys. That's understandable, for the price, but for word processing the Atari can't compare with the Coleco Adam keyboard or the Video Technology Laser 3000, which I'll describe shortly. Atari's 800XL has 64K bytes of RAM and
produces output to drive a monitor, whereas the 600XL has output for a television only. Both the 1400XL and 1450XLD contain a built-in 300-bit-per-second modem and a speech synthesizer but the 1450XLD adds a built-in disk drive to the package.

**More Machines**
Spectravideo improved its 318—a Z80 running at 3.6 MHz—and introduced the more powerful 328 (see photo 2). Although the 328 lacks the earlier model's built-in joystick, it provides cursor-control keys, a numeric pad, and five programmable function keys. The 328 has 48K bytes of ROM expandable to 96K bytes and 80K bytes of RAM expandable to 256K. The standard ROM contains BASIC, a word processor, a terminal program, and online documentation.

Tomy introduced its 16-bit, $129.95 Tutor, a microcomputer that is based on the TMS 9905 microprocessor (see photo 3). Tomy's promotional effort stressed that the Tutor can instruct children without parental supervision. The machine features a rubber keyboard, and a disk drive is available.

The fastest 6502 machine on view was the Video Technology Laser 3000 (see photo 4), which runs at 2 MHz. The machine's keyboard features cursor-control keys, a numeric pad, and eight programmable function keys. A plug-in Z80A cartridge enables the machine to run CP/M software, and its 64K bytes of RAM are expandable to 192K bytes. The Laser 3000 has an Apple-compatible mode, and Video Technology says that two custom large-scale integration chips replace more than 100 discrete integrated circuits that would otherwise be necessary. The chips also perform video processing, memory management, and system control. The Laser 3000 displays 80 columns of text and has 560 by 192 pixels (picture elements) in the color-graphics mode. Standard items include four-channel sound generation, a Centronics parallel-printer port, and a cassette interface. Although the machine can support as many as four disk drives with 164K bytes, neither
The Unisonic Wafer-Driven Home Computer System is based on the wafer drive from Entrepo. The wafer drive evolved from continuous-loop recording tape, formerly called a stringy floppy.

General Consumer Electronics introduced a keyboard and light pen for use with the Vectrex Graphic Computer System, its 6809-based game system. GCE also demonstrated programs that used the light pen to compose and edit music and to generate animated graphics. The software helped produce animation by interpolating lines between those drawn with the light pen. The light pen sells for about $40, and the basic system's price has dropped to $100 without a keyboard.

Texas Instruments displayed a cosmetically improved version of the TI 99/4A but declined to announce the forthcoming 99/8. The 99/2, which was announced at the winter CES in January, has been discontinued.

Commodore demonstrated Magic Desk, a desktop manager for the Commodore 64 home computer, dropped prices, and once again introduced its Executive 64 portable computer, which looks just as good now as it did at the winter CES and at the National Computer Conference. The Executive 64 is a portable Commodore 64 with a 6-inch color monitor and one or two disk drives in a compact 27-pound package. It does not come equipped with a printer. The price for a one-drive system with 64K bytes of RAM is $995. An optional Z80 cartridge permits running CP/M programs.

Standard Miracles

As of summer CES 1983, the only low aspect about the low end of the personal computer market is the price of the systems. The one possible exception concerns the speed of mass storage. Depending on how fast the wafer drives and digital data packs prove to be in normal use, people may demand the speed of random-access storage devices as standard equipment in their home computers. The company to be the first to introduce a $600 system that includes both a floppy-disk drive and a letter-quality printer may be the next market leader.

Phil Lemmons, West Coast Bureau Chief of BYTE, can be contacted at BYTE/McGraw-Hill, 4th Floor, 425 Battery St., San Francisco, CA 94111, (415) 398-7990.
The Next Five Years in Microcomputers

Our user unlocks his crystal ball and becomes a seer

by Jerry Pournelle

I've told this story before, but it's worth repeating. In 1954 I was invited to the University of Illinois to see the ILLAC, which at that time was the world's most powerful computer. Housed in a gymnasium, it was supported by the world's largest air-conditioning system.

ILLAC was a vacuum-tube machine. Two undergraduates had the singular job of rushing about inside ILLAC with shopping carts full of tubes; when one burned out, they'd replace it. It did all its calculations three times and took a majority vote on the answer, because a tube might burn out while it was making a calculation.

For all that, time was scheduled on ILLAC months in advance; it really was the world's most powerful machine.

The TI-59 programmable scientific calculator is considerably more powerful than ILLAC was.

That development took 30 years, but technology always accelerates. Barring nuclear war, there should be nearly as much change in computers in the next 10 years as there was in the preceding 30.

When you try to predict trends, you're usually too far out over the short run and too conservative over the long haul. Still, we can see where the computer revolution is taking us: by the year 2000, anyone in the West who seriously wants to will be able to get the answer to any question, the answer to which is known or calculable.

That's a pretty strange world, but it's nearly inevitable. Microcomputers will contribute to that world: they'll be the link between the big machines and the ordinary citizen. Having stepped that far out, let's get closer to home and look ahead five years.

When the micro world first started, it was all one community: hobbyists. The last time NCC was held in Anaheim, everything—all the microcomputers, software, hardware, support people, the whole works—was hidden away in one back room at the Disneyland Hotel.

Like pariahs. As if AFIPS (American Federation of Information Processing Societies, which sponsors NCC) was ashamed of us.

This year's NCC is dominated by microcomputers. The old high priests of the computer industry may still dislike us, but they can't ignore us.

In those days, hobbyists dominated the micro world. If you weren't a hobbyist, if you were just a user like me, you were not only rare, you had no choice but to team up with one of the wizards. You didn't just walk into a store and buy a computer system. Good equipment was put together, often from kits.

That's all changed now. One of the people who changed it was Adam Osborne, who packaged a working system with enough software to make it useful and sold the whole works—machine, software, and all—for about half what anybody else charged for a comparable package.

That's one of the currents in the micro stream. Another is represented by Bill Godbout and his Compupro team. They sell advanced equipment. Compupro machines are widely used for software development, but you still have to know something about microcomputers, or have consultants who do, in order to take full advantage of the Compupro line.

Another trend is represented by Apple's Lisa: not really all that advanced, maybe even overpriced when you consider what's inside the machine, but sold to a market that's interested in the convenience. Lisa doesn't really compete with Osborne or Compupro; as far as I can see, Lisa is cutting into a market that's used to paying a lot more than $10,000 for machinery. This is the computer as executive perk.

Clearly then, trends will affect the Godbouts and the Osbomes quite differently, and those two won't be the whole story either. Microprocessors are going to appear in all sorts of ways that won't be recognizable as computers. Home appliances, cars, television sets, home security systems, games, and a lot more—all those industries will be affected.

In other words, there's no such

This article is based on a presentation given at the 1983 National Computer Conference. Dr. Adam Osborne was the other speaker at the presentation.
thing as "the" future of the microcomputer industry; it's a bit like asking someone in 1950 to talk about the future of the transistor. We can look only at broad trends.

Adam Osborne is interested in the mass market and predicts that most micros will, in the next few years, be sold to people who don't want computers at all. They only want machines that do things.

He may be right, although—given the trends toward making "computer literacy" the new buzzwords and requiring an understanding of computers for graduation from college and perhaps even high school—one could argue that Osborne has misread the trend. In any event, I'll stay mostly with things that look and act like computers.

Hardware

We can sum up the hardware trend in one sentence: more capability for less money. That trend will accelerate.

Memory: the price of memory has fallen every year. When I first bought Ezekial, my late friend who happened to be a Z80, 16K bytes of high-quality (Industrial Micro) static memory cost more than $500. That's $31.25/K. Today, top-quality static memory (Compupro) costs $995 for 128K bytes, or $7.77/K. Dynamic memory has become more reliable, and it's a lot cheaper. This month's BYTE advertises deals such as 256K bytes for $795, or $3.10/K.

I can do even better than that. I have a Macrotec dynamic board: a full megabyte for $1983 list. That works out to $1.94/K. These are advertised retail prices for single quantities.

The next generation in memory requires some new technology; it won't be enough to simply glue a batch of the 64K-byte chips together. However, there's absolutely no reason to suppose the new technology won't be forthcoming, either from here or from Japan. Thus we can in confidence say that five years from now memory will cost no more than 15 percent of what it does now. The smallest machines will have a full megabyte; most will have a lot more.

Ten-megabyte microcomputers will be common.

ROMs: ROMs will be cheaper, too, so that it will be easy to have ROM software as part of a computer package. Instead of programs on disks, machines will have their operating system, text editor, and other commonly used stuff built in, the way BASIC was built in on the old TRS-80 Model I.

Use of ROMs as a means for distributing software may cut down a lot on piracy.

EROMs (erasable read-only memory) will let you do things like reconfigure the keyboard and otherwise customize the system. You do that once and forget it.

Mass storage: I've titled this section mass storage rather than disk drives. I think floppy disks will be with us in five years, but they may largely be relegated to their original purpose of transferring information from one machine to another, rather than as a mass-storage device.

Incidentally, my engineering advisors predict that in five years both the 8- and 5¼-inch floppy disks will be a dying breed; they'll be replaced by some kind of hard disk, possibly the cartridge Winchester, and one of the vest-pocket disk systems. The vest-packet (3½- to 3½-inch) disks would already have made great inroads into the 5¼-inch market if the industry could agree on some kind of standard.

Note the trend in disks. Ezekial's disk system—two drives, controller, interface, and cables—cost $2000 for 241 x 2 = 482K bytes of storage, or $4.15/K. This month's BYTE advertises Compupro double-sided quad-density disks with controller at $1595; for that you get 2.2 megabytes, 2200K, or $0.73/K.

The trend in hard disks is just as dramatic. Five years ago, you couldn't afford hard disks. Now, George Morrow will sell you 16 megabytes formatted, with controller, for $1595; that's $0.099, less than a dime per K!

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Precisely what we'll be using five years from now. We can, however, be sure that it won't cost more than a nickel a K, and will probably be a lot less; and it will be fast.

Five years from now it won't be worthwhile building a micro with less than 10 megabytes of mass storage.

CPU: an interesting race is going on: which chip will dominate the next few years? The leading contenders are the 8086 and its successors versus the 68000. The Z8000 seems to have dropped out of contention. The 16032 is a dark horse, with very interesting chip architecture.

Most analysts believe that the 8086 will be followed by the upward-compatible 2-86, possibly followed by more upward-compatible successors, and the 68000 are the chips to watch. Which one you ought to go with is a financially important decision, but it's not crucial to our analysis.

We're pushing out to the limits of VLSI (very-large-scale integration) technology, but there are bound to be breakthroughs. If we assume CPU complexities will go up by only a factor of two while the price is cut in half, we get a fourfold increase in bang for the buck.

Linking: the main problem with Ethernet is that it's expensive. That won't last. I don't mean that the hardware for Ethernet itself will necessarily fall in price, although that's very likely; I do mean that hardware for linking computers together into networks will be made steadily more available.

Some engineers think the RS-232C system, carried to its full potential, will be more than sufficient. Others reject that. Few, however, believe we won't have reliable, fast, and low-cost intersystem communications hardware well before 1988.

For example, I fully expect one day to talk to my editor in New York while we both have text on our screens. I'll use a light pen, or something similar, to mark my text, and my editor will see the same thing happen on her screen, but we won't have to give up our voice communications to do that. The limiting factor here isn't computer technology, it's the phone company.

Other stuff: Pournelle's Law: Iron is expensive, but silicon is cheap.

Modem hardware, memory-management units, system support, math chips, voice-recognition units, and all that paraphernalia will get cheaper and more plentiful.

The trend in printer equipment isn't quite as dramatic. In 1978 I paid about $3000 for a good letter-quality printer. I'd have to pay about $2000 today, and I'd be surprised if I didn't have to pay at least $1000, possibly $1500, in 1988.

Impact printers require a good bit of machined metal, and that gets more, not less, expensive. The cost of chips has dropped enough that printers can be smarter and still be less expensive, but there's a minimum that mechanical equipment isn't likely to fall below.

However: machines that are a combination of laser printer and copy machine are available this year for about $15,000 in quantity one and about $7000 in quantity 1000. The usual trend is for this year's quantity 1000 price to be next year's quantity one price. Within five years, laser printers that will also be your office copy machine will be available for no more than letter-quality printers cost today. This will give us amazing capabilities for producing camera-ready copy, complete with variable typefaces and excellent graphics.

Bottom line on hardware: hardware costs less for more capability. Total systems costs are coming down.

In 1977 Ezekial, my first Z80 machine, cost about $12,000, including software, systems integration, letter-quality printer, modem, cables, and a maintenance contract. He was a very advanced machine for his time.

In 1983 Zeke II cost about $8500. In speed and other capabilities, Zeke II is at least twice as powerful as Zeke I was. He's three times as fast, has a 1200-bps modem, twice as much memory, and almost 10 times as much disk storage. He has more and better software. Yet his costs only 75 percent as much.

If all I wanted was enough equipment for word processing, I could save even more by getting an
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Osborne, the communications pack, and a tolerable printer. I'd was, same capability. I'd was, same capability.

That trend will obviously continue. In five years you should be able to get a full business-quality system for what home computers cost now; while microcomputers that will do nearly all that the $100,000 minicomputers can do will be available for less than $10,000. Notice that I'm using real dollars, with no adjustments for inflation.

Software

The general statement is simple: software is going to be cheaper, more universal, and easier to use.

For instance, right here at this show Epson America is showing some pretty radical software: it's Chris Rutkowski's Valdoc's system, which in effect uses the text editor as an operating system.

The Valdoc concept is certainly headed in the right direction. You turn on the machine and it comes up in the text editor. If you want to call a friend, you push a couple of keys and you're in communications, either by voice (by picking up your phone) or computer-to-computer. If you want to see today's schedule, you push another button. You can get a printout of your next week's appointments. Another button uses your computer as a desk calculator.

In theory, you don't have to refer to the documentation; you find out how to use Valdocs with online help.

That's where software is going. It isn't there yet, because (in my judgment) the Z80 isn't fast or powerful enough to support all that work with tolerable speeds. No matter. The hardware exists. I think it would be easy to get Valdocs working like a stripped ape on a machine like the Eagle 1600, for example, with its hard disk and fast screen.

Other trend-setting programs are on display out there. Lotus 1-2-3 is moving in the right direction. So is Visi On. Richard Frank's people at Sorcin haven't yet integrated Superwriter and Supercal, but that's only a matter of time.

Voice-controlled systems are available, and of course there's Apple's Lisa.

They're all headed in the same direction: making very complex programs easy to use. They integrate the computer directly into people's lives and make it accessible to people who aren't interested in learning CP/M and BASIC; this trend will accelerate.

Prices will inevitably fall: as the market base expands, it will be possible to make large profits from moderately priced software. Books, after all, sell for less than $25, but there's no shortage of people willing to write them, and some of us make a fair living writing books. Software development will be the same.

As software prices fall, support levels will fall: documents will be better, there will be more and better online help features, and the need for expensive people to answer tele-
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"News/Retrieval puts an incredible amount of information at our fingertips," says Harold's wife, Elinor. "It's really broadening all our minds and is especially good for the kids. When you have something that's both fun and educational, you have something very special."

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The fun part is accessing the information. There's a natural love affair between kids and computers. Seventh-grader Ronald and his 15-year-old sister, Ingrid, are proof of this. "It really makes learning fun," Ronald explains. "I've already used the electronic encyclopedia more in just a few weeks than I have our printed encyclopedia in my whole life."

Both Ronald and Ingrid have found the easy-to-use encyclopedia and the various news-oriented data bases invaluable for a variety of school projects, from special reports to biographical data.

But the sports database for Ronald and the movie reviews for Ingrid are the real passion. "Sometimes I'll go into the encyclopedia," confesses Ronald, "just for an excuse to go into sports later. They've got everything."

For Elinor, the News/Retrieval shop-at-home service "makes it easy to comparative shop. But I'm most excited about the way the kids are learning to become computer literate, which will be so important later on in their lives."

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As for Harold, his initial enthusiasm for News/Retrieval hasn't changed a bit. "As far as my investments are concerned, it's already paid for itself for life. I have more control over my investment decisions than ever before."

But there is one problem. As Ronald puts it, "Sometimes I think we need more than one computer."

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phones will disappear. Companies that can't do it right the first time won't survive.

Programming languages are getting more accessible, and a lot of people will learn to program. A few years ago, hardware was available, and some people took advantage of it to start new companies. The result was Altos, and Apple, and some other outfits you've heard of.

A number of well-known software houses started the same way.

That will happen again and again over the next five years as development-qualification systems become available at popular prices. Languages are falling in price: I've recently been told of a $100 BASIC compiler for less than $100. JRT Pascal isn't likely to be the only high-level language for less than $50.

As micros become more powerful, imagination and program design gets more important than the ability to write efficient code. If you can make your program easy to use, who cares how elegant it is? Not very long ago, what was important was the ability to do fantastic tricks in assembly language. When memory gets cheap, however, it's not worth paying computer wizards to write memory-efficient code.

Even now, what's really important is the ability to describe needed programs—to write what my mad friend MacLean called a metalinguage description of a program. Coding Visicalc so that it would run on an Apple was really brilliant work; writing the same program in Pascal to run on the Sage 68000 is a student exercise.

Some other discontinuities are just around the corner. For example, within the next five years, probably a lot sooner than that, someone is going to build software that amounts to a LISP machine for micro prices. A lot of software is being written in LISP: text editors, spelling programs, that sort of thing, and also a lot of teaching programs. A lot of artificial intelligence people will suddenly be able to write programs with a potential market of tens of thousands of copies.

The educational potential of computers hasn't even been touched. In my judgment, it's better that kids program computers than that the computer programs the kids; I've never been wildly fond of so-called programmed learning. On the other hand, the use of computer games to teach valuable lessons has hardly been exploited at all. There's potential for a billion-dollar industry in educational software, but first it has to be created.

Will Micros Really Rival Minis?

Answer: yes.

There are some definite hardware limits to microcomputers. You can do only so much with a single chip before you run into fundamental problems. Those limits won't matter, though, because of parallel processing. Concurrent CP/M-86 is just now catching on; when people realize just what you can do with concurrent processing, it will really take off.

Example: the Valdoc program I mentioned earlier tries to do everything by overlays. When you call the scheduler, or address book, it saves off your text automatically. It effectively logs you out of the editor, and you're limited by the speed of your disk drives.

With concurrent processing you won't have to do that, and programs to accomplish all that Valdocs does, and more, won't be hard to write, especially with a language like Modula-2 to write them in.

A few years ago, those of us who like peering into the future said that the trend was toward "one user, one CPU." We believed that multiuser systems were swimming against the current.

Now I think it's clear: we're headed not just for "one user, one CPU," but several CPUs for each user. We haven't even begun to wring out the potential of parallel processing.

The kind of multiuser system I see coming gives each user several CPU chips connected through a bus and capable of doing concurrent processing; quite a lot of memory; a terminal; and some kind of disk drive, quite possibly a small Winchester. His operating system will allow concurrent processing, so that he can ap-
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pear to be several "virtual terminals"; one of those terminals has his text editor, another his scheduler and card-file box, another is connected to an electronic-mail network.

Locally he'll be connected to other users through a network that lets him share use of a laser printer and a really big hard disk with tape backup.

The only difference between what I've described and a VAX is that the micro system will be a lot easier to use, and it will be cheap.

The trend, then, is clear: micros will get more like minis at the same time their prices are falling, while higher-level languages will be more widely available and cheaper.

That's significant, because the trend will be toward portability and modularity. It won't be necessary to start over when writing a new program. Programmers can bring over a number of modules intact and just write new stuff. They'll also be able to understand their programs.

Meanwhile, we'll see a trend toward making graphics available to a wider and wider group of programmers. You won't have to be a wizard in order to write decent graphics. Languages like Modula-2 really lend themselves to this, and I expect in the next couple of years to see Modula graphics modules offered for sale to programmers. Graphics statements in many BASIC languages are available right now. The Otron has them, and the Zenith Z-100 even has color statements in its BASIC.

All this will make graphics available to the business and educational programmer as well as to the gamer.

Games

Speaking of games: Larry Niven and I are at this moment writing a game around our book Inferno. I notice that Infocom, the company that markets Zork and various other script-driven interactive games, has sufficient cash flow to take out really big ads now.

We can expect to see a lot more of this, and gaming rights will become as important to authors as their foreign rights. If you couple video disks to interactive games, you get a possibility of a whole new entertainment form, a story in which the reader can participate. I notice that's already happening in certain comic books, where you're instructed to turn to different pages depending on your decision at various points in the story.

Videodiscs, languages like PILOT, and new cheap, fast processors can create a new entertainment field. I'm not sure when it will happen, but it can't be too long before you can buy a videodisc and game cartridge that lets you be the central character in a Star Wars adventure, and when it comes time to fly your ship, or shoot the bad guys, you actually control the ship and the gun turrets: combining interactive fiction with an arcade-type game.

Miscellaneous

So far I haven't even said anything about new languages or trends toward programs like PEARL and The Last One, so-called program-writing programs. Both trends will continue, of course. Computer-assisted programming is one of the goals of the artificial intelligence community. This too will contribute to the software explosion, driving it to the
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logical limit: if you can describe what a program does, you can write the program.

I do not think we will reach that limit in five years; but we will have moved a surprisingly long way toward it.

**Talking Computers**

I've seen some spectacular things done in this field, but I don't really have a good feel for how quickly it will develop. Certainly the hardware will be available. It already is. The difficulty is in devising crashproof software. That's going to depend a lot on the AI community, and predicting the state of AI is a risky business. They're always going to have a breakthrough Real Soon Now.

Then they get one, and things change rapidly.

**Specifics**

I'll make a few guesses based on the above analysis.

I'll make a guess that there's a 50 percent probability that by 1988 Dr. Osborne's company will be selling machines that talk and listen. The odds are 4 to 1 that CompuPro will have such machines.

Interactive fiction and script-driven games will be a significant part of the entertainment industry. Old-line firms like Doubleday and Ballantine and Random House will publish and distribute these games, and they'll be sold in B. Dalton bookstores.

Word-processing systems will out-sell typewriters.

The telephone company will offer an information utility service.

Information utilities will be a lot easier to access and will make available a lot more data. We won't quite be to the point where anyone who wants can get the answer to any question, but we'll be approaching it.

Someone will begin to worry about the kinds of information available and will want to restrict such things as the formula for mustard gas and how to make botulin toxin. A lot of lawyers will get rich arguing about this.

The ability to ask questions and know where to find information will be at least as important as memorizing facts, and some educational theorists will notice that. Lord knows what kind of crazy fad that will start. There's no predicting what a PhD in education can dream up.

Within five years we'll see computers included as part of television sets. When you buy a TV, you'll get the computer.

There will be a noticeable trend toward "The Electronic Cottage": more people working at home with communications by computer. They'll go to the office perhaps one day a week.

Finally: about five years ago, John McCarthy of Stanford bought a Heathkit color television. The intention was to have a robot build the television set.

As of this year, the robot hasn't even been able to open the box. Within five years, John's robot will certainly have opened the box and removed the components. I doubt that it will have built the set—but I won't give long odds.

Jerry Pournelle is a former aerospace engineer and current science-fiction writer who loves to play with computers.
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Here they are—the winners of the Second BYTE Games Contest. The good news is that all the games are outstanding. The bad news is that almost all of them were written in assembly-language code, which means their listings are too long to include in BYTE. Fortunately, however, most of the authors are making the games available on disk (see the text box for details). We've compiled a brief dossier on each winner.

**Game:** SIZZLE (second prize)

**Author:** Shawn Day; Kelowna, British Columbia, Canada

**Judges' comments:** Shawn Day is a teenager who, with about a year's experience on the Apple, wrote this classic arcade game in about a week during Christmas vacation. Sizzle uses the familiar game motif of descending attackers, but Day adds an element of whimsy: your player has to eat the aliens on a moving barbecue grill. If the aliens land, you can't get near them until they explode (of their own accord). You lose a player if a grounded alien touches you or if your barbecue runs out of propane—in that case, the occasional appearance of a floating propane tank (which you have to shoot) becomes quite important.

Sizzle's graphics are excellent, but the game is somewhat flawed by the passive nature of the grounded aliens—unable to harm you if you stay away from them, they can only limit your movement temporarily. Still, Sizzle is the best classic arcade game we received.
The Second BYTE Games Contest Winners

Game: DUAL DUEL (first prize)
Author: Aaron Pratt, Ypsilanti, MI

Judges' comments: When they heard he'd won our contest, Aaron Pratt's friends said, "Of course you won," and if you could see this game, you'd be just as sure. In Dual Duel, two human players slug it out in a tank-vs-tank battle via two Apple computers connected through a game paddle. Each player can turn left or right, move forward or back, and fire a missile. The small square in the upper half of the screen is a sort of "radar" that shows you the position of the enemy tank relative to you. As you can see from the first two photos, a player's view changes as his tank moves (the animation is as smooth as you would find on any commercial game). The third photo shows what happens when your tank gets shot.

A tribute to both the ingenuity of microcomputer programmers and the versatility of the machines themselves, Dual Duel compares favorably to arcade games that have far more computational resources than the Apple II. Author Pratt wrote the game in RGL (Real-time Graphics Language), a compiled C-like language optimized for three-dimensional graphics.
Game: **JUGGLE** (third prize)
Author: William P. Porter, Coral Springs, FL

**Judges' comments:** Juggle is actually a simulation of juggling as many objects as you dare. Each ball can be thrown high or low on the screen and has a realistic trajectory. The integration of music with realistic, real-time movement of multiple objects is a real programming feat for which author William Porter deserves credit.

In Juggle, you are working against a clock, and you get points for keeping objects in the air and for putting additional objects in motion. Low tosses get you more points than high tosses. Juggle is a game in the sense that you can compete against another player or against yourself for the highest score, but it is primarily a simulation that has much of the feel of juggling actual objects. We had a lot of fun with it.

**Judges' comments:** Tony Ray distinguished himself last year with an abstract target game called Charge. This year, he's given us a maze-and-dot game, but with a twist—maze walls are replaced by radioactive pits into which you fall if you don't move your player (called a Grimpet) just right. You can also lose your player if a Winlybird picks it up. As in most games, however, you...
Game: **IT'S THE PITS** (fourth prize)
Author: C. Anthony Ray, Urbana, IL

are not totally defenseless—if you pick up the hat in the maze and get through the maze successfully, you’ll get a candle in the next one. The candle, which goes on top of the hat, spells instant death to any Wirlybird that tries to pick up your player.

It’s the Pits is maddeningly frustrating (although in video games, that’s not necessarily bad) and demands unwavering attention. One of the judges found that it became tedious because of its lack of variety. Nevertheless, the game is a professional one, and its animation is superior to this year’s other game winners.

**Judges’ comments:** This game marks the second occasion that William Hubbard has won a contest; the first time, he won first place in a Halloween costume contest—dressed as a computer. Rescue is the only game winner written in BASIC, but we chose it because its original idea put it ahead of some less original (but technically more professional) games. The object of the game is to find and rescue stranded survivors of an ocean liner crash. You start by helicopter from your island Coast Guard base (top photo) and search until you find an inhabited island (bottom photo), which contains trees, pit traps, cannibals, lions, and (invisible) quicksand and headhunters.

We liked the basic idea of Rescue and its combination of strategy (luring lions into pits, for example) and luck as the key to success. The game is slow only when drawing a new island; fortunately, that doesn’t happen too often. We also liked Rescue because it was written in BASIC, which makes it easy to modify.

Game: **RESCUE** (fifth prize)
Author: William Hubbard, Tucson, AZ

**Games for Sale**
Four of the winning games are for sale. All inquiries for further information must be accompanied by a stamped, self-addressed envelope.

- **Dual Duel** (for Apple II, Atari 800/1200XL, Commodore 64; both game and the development language used, RCL, are available): Microcraft Systems Inc., FOB 1109, Ann Arbor, MI 48105.
- **Jiggly** (for Radio Shack TRS-80 Models I and III only; “Big Board” CP/M system): William P. Porter, 1364 NW 82nd Ave., Coral Springs, Fl. 33065.
- **It's the Pits** (for Apple II): C. Anthony Ray, 39 Carriage Pl., Urbana, IL 61801.
- **Rescue** (for Apple II): William Hubbard, Re: Apple game, 3415 Calle del Prado, Tucson, AZ 85716
Photo 1: The Akihabara quarter in Tokyo.
Update on Personal Computing in Japan

Battery-powered systems, optional communications, and attractive packaging highlighted the Japan Microcomputer Show '83

by Phil Lemmons

The Japan Microcomputer Show '83, held May 25-28 at Ryutsu Center in Tokyo, showed more low-end home computers, notebook-sized and hand-held computers than the more expensive desktop machines. All but a few of the machines at the show were on display and on sale in Akihabara—Tokyo's electronics quarter—before the show opened. Nevertheless, the thousands of Japanese who packed Ryutsu Center each day were just as intensely interested as those who attended the larger Japan Data Show last October.

New Personal Computers

The most striking new machine, the Canon X-07 Handy Personal Computer, combines battery power, attractive packaging, and intermachine communication through inexpensive optical couplers (see photo 2). For a base price of $445 (104,800 yen at 235 yen per dollar, but prices in the United States are generally higher than the exchange-rate equivalent), Canon provides a Z80-compatible NSC800 CMOS (complementary metal-oxide semiconductor) microprocessor, 20K bytes of ROM (read-only memory) containing an interpretive BASIC, and a 4-line by 20-character display. A compact dot-matrix printer costs about $192. The X-07's RAM (random-access read/write memory) is expandable to 24K bytes and ROM to 42K bytes. Further memory expansion comes in the form of "memory cards," which resemble credit cards and fit into a slot in the bottom of the computer. These cards contain ROM, battery-backed CMOS RAM, or a combination of the two. A 4K-byte RAM card costs about $42, while a card containing 8K bytes of software in ROM and 4K bytes of RAM costs about $64. The keyboard is not quite large enough for adult touch-typists. Indeed, the X-07 measures only about 8 by 5 by 1 inch and weighs just over 1 pound.

The X-07's optical coupler plugs into the machine at left rear and costs $42.

Machines using the optical (infrared) couplers can communicate directly through the air, using BASIC statements to send data between machines. A printer attached to one machine prints data transmitted from another. One exhibit at the show depicted students in a classroom transmitting answers during an exam to a teacher's X-07. Indeed, the classroom seems to be one of the major targets of this machine. Shared software cards would reduce the cost per user to reasonable levels, perhaps making a room full of X-07s the least expensive intercomputer communications system available.

Usually, software availability is a problem for new computers, but a software house called dB-SOFT was promoting a series of five cassettes of business programs for the X-07 and another five of games. The business cassettes covered credit calculations, other financial calculations, sales management, inventory management, and marketing management. The business cassettes cost about $16 each, while the game cassettes cost about $12.

Two other attention grabbers are the Casio-FP 200 (see photo 3) and the National (Panasonic) JR-800. With a few changes, the FP-200 could challenge the NEC PC-8201 among Japan's full-keyboard, battery-powered portables. The FP-200 keyboard is large enough for touch-typing but seems to have a rollover problem. The 8-line by 20-character dis-
display is only half as large as the PC-8201's but much larger than the Epson HC-20's display.

When introduced, the FP-200 had only two pieces of software, a BASIC in ROM and another programming language called CETL (Casio Easy Table Language). CETL seems more like Visicalc than a traditional programming language.

Although an FP-200 with 8K bytes of RAM and 32K bytes of ROM costs only about $300 (as against the PC-8201's $590), without additional software, specifically a text editor, the FP-200 cannot offer serious competition for the PC-8201 or the Radio Shack Model 100 as an electronic notebook. The omission of a text editor and the presence of a keyboard rollover problem are hard for some visitors to Japan to understand because they frustrate a major application of the machine (namely, text editing), but an American computer scientist living in Tokyo was not surprised. He pointed out that most Japanese have never used a typewriter. Most business correspondence in Japan is still handwritten. The Japanese are moving directly from handwriting to computing, and their language's large character set has prevented the emergence of a standard keyboard. A typewriter keyboard, for the present, may not sell any more machines in Japan than the smaller keyboards on hand-held machines.

Another interesting battery-powered machine present both at the show and in Akihabara is the National JR-800 (see photo 4), called the Panasonic JR-800U in English promotional literature. At a list price of 128,000 yen (roughly $550), the JR-800 is an impressive concentration of computing power. The processor is a 63A01V, an 8-bit CMOS microprocessor compatible with the Motorola 6801. The system has a full QWERTY keyboard, a numeric pad, and 10 programmable function keys. Each programmable key can hold two values; the second set is accessed with the shift key. Unfortunately, you must also use the shift key to move the cursor left or down because the keyboard has only two cursor control keys. The keyboard is a little too small for touch-typing and has only a tiny space bar, which is placed awkwardly at the lower right where a second shift key might be expected.

The JR-800's liquid-crystal display (LCD) can show 8 lines by 32 columns. While a little smaller than the PC-8201's display, the JR-800's is almost as easy to read and ranks among the largest hand-held-computer displays. The JR-800's other features include a built-in calendar/clock, 16K bytes of user RAM expandable to 24K, 20K bytes of ROM containing BASIC, 1552 bytes of video RAM, and a five-octave music function with a dynamic speaker. The JR-800 will run for 25 hours on batteries, weighs only 1% pounds, and measures 10¾ by 5% by 1% inches. Options include a graphics printer, an I/O (input/output) interface unit, and expansion cartridges. The only software on view at the show or in Akihabara was the built-in BASIC language. The BASIC does calculations up to 20 digits with an exponent of ±153. The optional printer costs about $150 and weighs a little over 1 pound.
A Portable Network?

A unique portable was introduced by a smaller Japanese firm named Logitec, which is related to Kanto Denshi, a trading company. Called the AT-1000 (see photo 5), the machine uses the 6301, a CMOS 6801 microprocessor, and has 32K bytes of ROM and 32K bytes of CMOS RAM expandable to 576K bytes. The AT in AT-1000 stands for “active terminal,” but the system really differs from both computers and terminals as we know them. Although it contains its own microprocessor, the AT-1000 cannot do any processing until you insert an AT-100, a hand-held terminal with 32K to 64K bytes of CMOS RAM. The AT-1000 can hold six of these. The AT-100 includes a 2-line by 16-character LCD and from 32 to 64K bytes of CMOS RAM. AT-100s can be inserted into one of the two slots in the front of the AT-1000 or one of the four slots in back. Once the AT-100s are inserted, the host machine can function as a multitasking, multiprocessing portable under the control of the AT-100 processor located in its first slot of the AT-1000. AT-100s can serve as microprocessors or simply pass data to the AT-1000 for transmission through its RS-232C serial port. An AT-1000 packed with AT-100s is like a local area network in a lunch pail. Logitec promotional literature uses the metaphor of the kangaroo and its young to explain the physical relationships among the parts of the system. Because there is no such thing as an applied kangaroo, however, the metaphor does not enlighten us about the intended applications of the AT-1000. Kanto Denshi spokesmen mentioned insurance as a possibility.

While the current AT-100 is based on the 6301 microprocessor (CMOS 6801), future models may be based on CMOS versions of the Z80 or the 6502. That opens the possibility of turning the AT-1000 into a CP/M or Apple-compatible machine.

Unlike most of today’s battery-powered portables, the AT-1000 uses a cathode-ray-tube display rather than an LCD. As a result, the AT-1000 runs for just three hours on a single charge. The display measures only 1½ inches (diagonally) but tilts up and is legible through its viewing glass. Amazingly enough, the tiny screen will display 20 lines of 64 columns or 10 lines of 32 columns. The system has video output to drive a larger monitor when AC power is available.

The ROM contains an interpretive BASIC that resembles Microsoft BASIC.

Some of the AT-1000’s features seem well designed for American use. The detached keyboard has a coiled connector that permits a wide range of motion, a full QWERTY set of keys, plus six programmable keys, four cursor keys, and Menu, Insert, Delete, and Break keys. The Logitec machine has interesting possibilities but needs a microprocessor capable of running existing American software if the machine is to sell in the United States.

Home and School Computers

Several new computers targeted for home or school use drew crowds at the show. Seiko showed its Seikomap (see photo 5), which would look equally at home in the classroom or the living room. The basis of the system is the MAP-1010, a Z80A computer with 24K bytes of ROM containing BASIC and 32K bytes of RAM. TV interface and color graphics are standard, as is a built-in cassette drive for mass storage. The keyboard has four programmable function keys, four cursor keys, and a numeric pad. The system unit has a switch to select between two monitors and a knob to set the volume of the speaker. Disk drives, a printer, a graphics tablet, and a joy-

Photo 6: The Seikomap.

Photo 7: Toshiba’s Pasopia 5 and Pasopia 7.
stick are available. The Seiko-map-1030 I/O unit provides interfaces for all these devices.

Six CAI (computer-aided instruction) cassette packages for elementary school children were prominently displayed in the Seiko booth. The price of the system unit and keyboard, about $417, seems appropriate for both home and school. The industrial design, much like that of stereo components, would look good alongside the family television.

NEC displayed its new PC-8000 Mark II, its recently introduced portable PC-8200, and the rest of its line—from the PC-2000 hand-held computer to the PC-9800 and N5200 16-bit machines. In the United States, the N5200 is called the Advanced Personal Computer. There has been speculation that NEC would either sell both the APC and the 9800 in the United States or replace the APC with the 9800. Shunzo Hamada, assistant general manager of NEC's EDP Small Systems Division, dismissed those rumors in an interview at NEC headquarters in Morinaga Plaza, Tokyo. “We will not sell the PC-9800 in the West,” he said. “The next 16-bit computer that we introduce in the United States will be an entirely new machine that responds to the challenge of the IBM PC recently introduced here in Japan.” That version of the IBM PC, the 5550, has very high resolution graphics and greater mass storage than its American cousin.

Toshiba showed its new Pasopia 5 and Pasopia 7 (see photo 7), both Z80A-based machines that support color graphics. The main difference between the two systems is that the Pasopia 7 also generates music over a range of six octaves. The Pasopia 7 has 64K bytes of user RAM, 56K bytes of video RAM, 16K bytes of operating system in ROM, and another 52K bytes of ROM containing T-BASIC 7. The system can display 25 lines by 80 columns or 20 lines by 40 columns. The highest graphics resolution is 640 by 200 pixels. With two disk drives and a monochrome monitor, the Pasopia 7 costs about $1350 in Japan. A 14-inch color monitor adds about $300 to the cost.

Fujitsu’s major entrant in the low end of the market is the FM-7 (see photo 8). According to some sources in Japan, this machine is already the second-best-selling system in the domestic market. Fujitsu is fond of the 6809, the 8-bit processor with internal operations done in 16 bits. Like most Fujitsu microcomputers, this one contains a 6809, but it also has a Z80A processor. A 44K-byte ROM contains BASIC. The FM-7 has lots of RAM—117K bytes plus 64K for BASIC and 64K for video. The base price is about $540. A 640- by 200-pixel color monitor costs $430. A floppy-disk drive adds another $420. For about $1800, you come away with a powerful two-drive system, color graphics, and ample memory.

Fujitsu also displayed the impressive FM-11 (see photo 9), with a 2-MHz 68B09E, an 8-MHz 8088, and a 4-MHz Z80A as microprocessors. The FM-11 also has 128K bytes of RAM expandable to 1 megabyte, 76K bytes of RAM set aside for BASIC, and 192K bytes of video RAM. When the 8088 is playing central processing unit, the 6809 manages the graphics. That and the abundance of memory
make the color graphics run like lightning, even at a resolution of 640 by 400 pixels. Fujitsu sells MS-DOS and CP/M-86 for the 8088, CP/M for the Z80, and three operating systems for the 6809: OS-9 (a multitasking system with window management) and the more familiar FLEX and UCSD Pascal. Prices are attractive, but Fujitsu probably will not sell the FM-11 in the United States.

The Japan Microcomputer Club

With its Information Center on the top floor of the 10-story Omron personal computer store in Tokyo’s Ginza, the Japan Microcomputer Club has 28 branches in Japan and a membership of 8000. The Information Center has meeting rooms, seminar classrooms, and a library of software, books, manuals, and magazines. The club has 11 different microcomputers. Its avowed goals are promoting popularization of microcomputers and technical advancement among members. The method of achieving technical advancement is somewhat more formal than American practice. The Japan Microcomputer Club gives a qualification test, issues licenses, and assigns members to one of four grades. Grade 1 is top level and requires more than five years of experience. Grade 4 is the lowest, and it requires “efficient manipulation of a personal computer.” Grade 3 requires “highly experienced operating and programming,” and grade 2 requires “wider and higher experience in hardware and software.”

The club’s sixth annual “Micro-Contest” had the theme “Intelligent Micro-Robot and Microcomputer Art” and awarded 13 prizes. The technical prizes were for a color- and sound-sensing robot made by Naotaka Yokoyama and a shape-selecting robot made by Tadashi Hino. Yokoyama’s robot, NAOTA 3, can recognize, interpret, and act upon traffic signals—red, yellow, and green.

Market Trends

In general, the emphasis continues to be on more functional battery-powered machines, greater integration with video and home-entertainment equipment, attractive consumer packaging of systems and accessories, and a surprising degree of interest in optical communications.

The allocation of the crowded shelvespace in Akihabara’s personal computer stores suggests that NEC is still leading the sales race. The most popular 16-bit personal computer, the PC-9801, seems to be the focal point.
of domestic 16-bit software development. Photo 1 on page 250 shows a stack of boxed PC-9801s waiting for customers on a street in Akihabara. NEC's PC-8201 dominates the portable market, attracting much more attention than the pioneering Epson HC-20. Tomihiro Matsumura, associate senior vice-president of NEC, said the company will develop smaller and more powerful battery-powered portables and may market those models, rather than the 8200, in the United States. Asked whether these would have microfloppy-disk drives, Matsumura said that NEC's advanced CMOS technology would render that unnecessary. But he added, "Compactness is very important in home computers." The PC-8000 Mark II and PC-8801 8-bit systems are seen everywhere.

Sharp's position appears to have improved over the past six months. Its battery-powered portable, the PC-5000, with 8-line by 80-character LCD and bubble-memory cartridges appeared at the Microcomputer Show '83 (see photo 10) and enhanced Sharp's position in the office market. The Sharp XL, introduced last October and seen in photo 11 in an Akihabara store display, enjoys great popularity among 8-bit customers. Expect to see further integration of video and home computing equipment with slick consumer packaging. Making a color television that turns into an RGB (red-green-blue) monitor at the flick of a switch gives Sharp a clever way to let its home computer marketing benefit from existing channels for consumer electronics. The idea also saves consumers the expense of buying a redundant color CRT. Sony's SMC-70, also an impres-

sive machine, could challenge the Sharp XL by reducing its price and widening its marketing to include the home as well as the office.

The Sanyo MBC-55, an 8088-based machine with attractive consumer-electronics styling (see photo 12) does not appear to have been widely distributed since its introduction in October. The Toshiba Pasopia 16, the Hitachi Basic Master 16000, and the National Mybrain 3000—three attractive 16-bit systems introduced in October—appear in many stores in Akihabara but not in numbers to rival the NEC PC-9801. The Mitsubishi Multi-16 seems to be somewhat popular.

Published survey results confirm the apparent trends in Akihabara. The Nikkei Keizai Shimbun Market Share Survey for 1982 shows NEC's share of the personal computer market growing to 45%. Sharp ranks second with 17%, and Fujitsu finishes third with 12%, almost double its 1981 percentage. (These figures are in terms of production from April 1981 through March 1982).

Nikkei Personal Computing (April/May 1983) reports that as of December 1982, NEC had 34.3% of the market for business microcomputers, followed by Fujitsu's 11.8%, Sord's 9.6%, and Sharp's 7.8%. (These percentages reflect installed systems rather than annual production). The NEC PC-8001 and PC-8801 were by far the most popular machines in December 1982.

The magazine also explains that the most commonly reported operational and organizational problems with microcomputers in Japan were the time-consuming nature of input (reported by 42.2% of those surveyed), difficulty in programming (also 42.2%), and insufficient corporate understanding of microcomputers (37%). While the problem of input may be worse in Japan because of the size and complexity of the character set, the latter two problems are probably just as common in the United States.
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The Unix Tutorial
Part 2: Unix as an Applications-Programs Base

A look at the availability of applications programs for the Unix operating system and customizing Unix for individual users

by David Fiedler

Last month, we examined the birth and growth of the Unix operating system from Bell Laboratories and looked at some Unix commands and how they fit together in simple and consistent ways. This article presents commercially available applications programs for Unix systems and illustrates some ways to make Unix more useful to you from both a user-interface and an applications perspective.

Almost as soon as Unix started becoming popular, people lined up on either side—for it or against it. Many self-proclaimed authorities felt that Unix would never make it in the commercial marketplace because it was unfriendly, too slow, lacked commercial features, and had no applications software.

In many respects, they were right, although perhaps they had their own reasons for implying these conditions would always hold. The people who have been around Unix for years know that besides being an ideal program development environment for computer professionals, it is also a powerful and flexible operating system for using applications programs.

Unix offers multiuser and multitasking capabilities, a hierarchical file system, I/O (input/output) redirection, and hundreds of utilities, such as electronic mail and typesetting. The appearance of Unix to the user and the structure of its commands can be customized to suit the sophistication of each user. The availability of Unix on microcomputers like the Apple Lisa, IBM Personal Computer, and TRS-80 Model 16 is directly related to its portability. This is due in large part to the C programming language used to write the Unix operating system. Most applications programs and utilities for Unix also tend to be written in C.

The Change in Languages

Some of us remember when advocating structured programming, writing readable documentation, and using a computer terminal instead of a card punch were considered revolutionary or at least seditious acts. Then a few years ago, almost every software engineer was frantically studying Pascal, which was then clearly the wave of the future, or so it seemed. Pascal would be the universal structured language, suitable for any project; school children would learn it instead of BASIC; Pascal programs would be the same everywhere; be able to write Pascal and you would always have a programming job. If I didn’t know that the same had been claimed for PL/I, I might have been fooled. Today, of course, we know “better”: we have Ada. But I digress.

Pascal does have its virtues, but not enough of them. The C programming language, however, has just the right extra features needed to make it a viable candidate for widespread acceptance: the ability to manipulate pointers to information, the de facto standard system interface provided with Unix, and fast-running and compact code. The biggest plus for C is the instant portability of programs not only between separate Unix systems running on different processors, but also between other operating systems and Unix. Admittedly, the expectation of a huge market for Unix applications is the biggest push behind C. In contrast, the chief operating system associated with Pascal has been the UCSD p-Sys-
I don’t claim that C will be the universal language. C is too cryptic for many people, too close to assembly language for others. It’s not as terse as APL, but it’s not the gothic novel that COBOL is, either. C is just a very good language for what it was designed for, namely, systems programming—writing operating systems, device drivers, compilers, high-speed utility programs, and the like. For writing quick and easy general-purpose programs, BASIC is the popular choice. Engineers and scientists will continue to crunch numbers with FORTRAN, and Big Business will probably use COBOL until the end of the century. For those are the stated purposes of these languages; like an athlete, each excels in its own special area.

Assembly language will continue to be necessary for those things that cannot be done in C, which raises the question, why doesn’t someone just make a computer that uses C as its assembly language?

In 1981, BBN Computer Company did just that. The BBN C Machine was billed as “the first computer optimized to execute the C language.” It uses 17 addressing modes while implementing often-used C constructs in microcode. An implementation of a similar machine as a single silicon integrated circuit is not far off; possibly the Bellmac-32 processor from Western Electric will be the closest to this.

In fact, now that AT&T has announced that the central kernel of Unix will not be changed, Unix on a chip is not far off, either.

With the Unix kernel on a chip, a reasonable implementation of Unix could be built with about two dozen main integrated circuits, such as eighteen 256K-byte RAM chips giving a full half-megabyte of parity-protected memory, a microprocessor, a memory-management device (if not included on the microprocessor), the kernel chip, a Winchester disk controller, and serial port controller. Bearing in mind the dropping prices of Winchester disks, this could mean an end-user price of $2500 to $5000 for Unix-based computers—just about the range I’ve predicted for AT&T’s systems.

Where Are the Programs?

Some industry watchers are still leery of Unix, waiting for the promised applications programs, friendlier and more capable than those available on current 8-bit computer systems.

Patience, say I. We have to remember the classic sequence of events that goes along with any major new phenomenon in the computer field.

First, the hard-core computer people discover the product. From 1975 to 1979, Unix and C were known to comparatively few students, computer scientists, and advanced users.

Next, a few entrepreneurs notice the product’s potential. Between 1979 and 1982, firms such as Whitesmiths Ltd., Interactive Systems, and Onyx Systems began selling Unix-related hardware and software. The computer press started to print articles discussing Unix and why pro-
grammers liked to use it. Then, marketing panic develops around the product as it gains mass appeal. The market begins to be saturated with similar products whose differences can hardly be distinguished by the untrained observer. Beginning in 1982, dozens of companies, ranging in size from one-man firms to the IBM Corporation, have offered Unix, Unix-based computers, Unix look-alike software, and a smattering of applications.

Finally, the shakeout occurs. By this time, the largest companies have split up the lion’s share of the hardware market by dint of service, advertising, and cut-throat competition. The best software has emerged from rough beginnings or has been written recently in response to the cries of the end users. For Unix, this period is only now beginning and will most likely continue for a number of years.

As I’ve said, this series of actions is not new. It happened in the S-100 industry a few years ago, it is happening in the portable computer market now, and it happened in the mainframe and minicomputer business a decade or so ago. Notice how stable the applications software market is in the minicomputer and mainframe industry and how few different operating systems are widely used on the 8080/Z80 class of processors. These markets have now settled down, and the needs and wants of hobbyists have been superseded by those of the folks in three-piece suits. This is generally better for the average businessperson wanting to use computers.

Unix, however, is still basically in the stage of market panic. Until software firms with a great deal of capital invest their people’s time in creating the kind of software the market desires, the only software available will be that which programmers want to write. Because many C programmers—typically systems programmers by nature—often feel that applications code is beneath their dignity, they will not write it willingly; they have no personal interest in it. And frankly, C is a lousy language for writing accounts-receivable programs. Therein lies the reason for the general lack of applications software in C, and therefore for Unix. But good old portability, along with AT&T, saves the day again.

I mention AT&T because it has planted a small army of programmers (2500 or so) in and around Lisle, Illinois, for the express purpose of creating supportable, marketable programs for use on Unix machines. Expect a small mountain of code from that source! Generally, however, many of the classic applications programs now available on Unix systems are written in classic applications languages: COBOL and BASIC. Companies such as Ryan-McFarland, Silicon Valley Software, and Science Management Corporation have simply ported compilers
<table>
<thead>
<tr>
<th>Company</th>
<th>Price</th>
<th>Language</th>
<th>Operating System: Processor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Business Systems Inc.</td>
<td>$1000 to</td>
<td>RM/COBOL</td>
<td>Xenix, Unix; Z80, 28600,</td>
<td>Business Accounting Control System: accounts payable, accounts receivable,</td>
</tr>
<tr>
<td>3 Littleton Rd.</td>
<td>$1500</td>
<td></td>
<td>68000, T1990</td>
<td>reports, order and inventory management, financial modeling program, report</td>
</tr>
<tr>
<td>Weston, MA 01886</td>
<td>each</td>
<td></td>
<td></td>
<td>writer</td>
</tr>
<tr>
<td>(617) 592-2800</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIS Software Ltd.</td>
<td>$20,000</td>
<td>RM/COBOL</td>
<td>C</td>
<td>BONDAID: written for international bond market, gives information on history,</td>
</tr>
<tr>
<td>York House</td>
<td></td>
<td></td>
<td>Unix System III; Onyx,</td>
<td>parity, floats, yields position and pricing in international bond market</td>
</tr>
<tr>
<td>199 Westminster Bridge Rd.</td>
<td></td>
<td></td>
<td>68000, Plessey, Perkin-Elmer</td>
<td></td>
</tr>
<tr>
<td>London, SE1 7JT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>England (01) 928-3551</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer Masters</td>
<td>$8000</td>
<td>RM/COBOL</td>
<td>Unix, Oasis, CP/M, MP/M</td>
<td>Marker: Portfolio for small/large companies</td>
</tr>
<tr>
<td>25 West 39 St.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York, NY 10016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(212) 221-3016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyma Corp.</td>
<td>$1055 to</td>
<td>C-BASIC</td>
<td>Cromix, Unix</td>
<td>general ledger, accounts payable, accounts receivable, payroll, inventory,</td>
</tr>
<tr>
<td>2160 East Brown Rd.</td>
<td>$2795</td>
<td></td>
<td></td>
<td>Time Billing for Professionals, other vertical market packages</td>
</tr>
<tr>
<td>Mesa, AZ 85203</td>
<td>each</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(602) 835-6880</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IRIS Systems Inc.</td>
<td>$500 to</td>
<td>COBOL</td>
<td>Uniplus+, Unix V7; 68000,</td>
<td>ACUITY: general ledger, payroll, accounts payable, accounts receivable,</td>
</tr>
<tr>
<td>225 West 30th St.</td>
<td>$650</td>
<td></td>
<td>PDP-11, VAX</td>
<td>order entry, inventory management, customer order processing, fixed assets</td>
</tr>
<tr>
<td>National City, CA 90205</td>
<td>each</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(619) 474-2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lime Tree Computer Systems</td>
<td>$700</td>
<td>RSTS,</td>
<td>RSX-11, RF11, Unix, PDP-11</td>
<td>Labor and job tracking for manufacturing support</td>
</tr>
<tr>
<td>1 Penn Plaza</td>
<td></td>
<td>RSX-11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New York, NY 10001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(212) 594-6172</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MBSI</td>
<td>$1000</td>
<td>RM/COBOL</td>
<td>CP/M, MS/DOS, Unix; 68000,</td>
<td>accounts payable, accounts receivable, general ledger, payroll, sales</td>
</tr>
<tr>
<td>Dover Rd.</td>
<td>each</td>
<td></td>
<td>8080, Z80, 8088</td>
<td>analysis, order entry/inventory</td>
</tr>
<tr>
<td>Willow Hill Building</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chichester, NH 03263</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(603) 798-5700</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Systems Inc.</td>
<td>$595</td>
<td>COBOL,</td>
<td>BASIC, Xenix for Lisa or</td>
<td>Vertical Market Packages for Ad Agencies: estimating, cost tracking, billing,</td>
</tr>
<tr>
<td>430 Oak Grove</td>
<td>each</td>
<td></td>
<td>Altos, CP/M, MP/M, MS-DOS,</td>
<td>bookkeeping. Electronic Calendar emulates DayTimer scheduling reminder</td>
</tr>
<tr>
<td>Minneapolis, MN 55403</td>
<td></td>
<td></td>
<td>RMCOS, Oasis, 68000, 6080,</td>
<td></td>
</tr>
<tr>
<td>(612) 870-3515</td>
<td></td>
<td></td>
<td>6086, 68000</td>
<td></td>
</tr>
<tr>
<td>Quadratrons Systems</td>
<td>$395 to</td>
<td>C</td>
<td>Unix; 68000</td>
<td>Vertical Market Packages for Ad Agencies: estimating, cost tracking, billing,</td>
</tr>
<tr>
<td>14542 Venture Blvd.</td>
<td>$495</td>
<td></td>
<td></td>
<td>bookkeeping. Electronic Calendar emulates DayTimer scheduling reminder</td>
</tr>
<tr>
<td>Suite 205</td>
<td>each</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sherman Oaks, CA 91430</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(213) 789-8588</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientia Computer Applications</td>
<td>not</td>
<td>C</td>
<td>Unix</td>
<td>shareholder register, accounting, DBMS with report generator, mailing list/</td>
</tr>
<tr>
<td>5001 Beach Rd.</td>
<td>available</td>
<td></td>
<td></td>
<td>membership program</td>
</tr>
<tr>
<td>-06-26 Gold Mine Complex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singapore 0719</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unisoft Inc.</td>
<td>$400 to</td>
<td>Unix,</td>
<td>Xenix, PDP-11, VAX; 28600,</td>
<td>Viewcomp: spreadsheet designed specifically for Unix, has macros, bar</td>
</tr>
<tr>
<td>303 West 42nd St.</td>
<td>$800</td>
<td>Venix,</td>
<td>68000, 8086</td>
<td>graphs, choice of absolute, relative, or computed coordinates</td>
</tr>
<tr>
<td>New York, NY 10036</td>
<td></td>
<td>Xenix,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(212) 327-6800</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban Software Corp.</td>
<td>$385</td>
<td>C</td>
<td>Unix, Xenix; PDP-11, 68000,</td>
<td>Leveredge: mailing list/information manager, can print letters or labels,</td>
</tr>
<tr>
<td>330 West 42 St.</td>
<td></td>
<td></td>
<td>Z8000, 8086, VAX</td>
<td>on-screen search capability</td>
</tr>
<tr>
<td>New York, NY 10036</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(212) 736-4030</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: A sample of business applications programs available for the Unix operating system.

for their languages (RM/COBOL, SVS Basic-Plus, and SMC BASIC) to Unix-based computers. Then, programs that have been available on various minicomputers for several years are moved to the new machine and recompiled—and almost magically, you can buy applications on Unix.

Tables 1, 2, and 3 show some of these programs and their sources. Keep in mind that, in the rush to be the...
Introducing the People personal microcomputer from Olympia. Engineered to be powerful. Engineered to be people-friendly. Engineered for office performance.

In fact, chances are you can't buy a personal microcomputer that gives you more for your money. Because the People has all the features that ensure the system will be just as viable tomorrow as it is today. And it's compatible with major software packages, such as WordStar™, SuperCalc™, and dBase II™.

For more reasons why you should buy the People for your people, send for our free brochure: Olympia USA Inc., Dept. BY9, Box 22, Somerville, NJ 08876.

Or call the Olympia Sales Office in:
New Jersey—(201) 722-7000;
NYC—(212) 697-9051;
Chicago—(312) 640-0300;
Sealy, TX—(713) 885-7473;
El Monte, CA—(213) 350-4173;
Burlingame, CA—(415) 692-2880.
<table>
<thead>
<tr>
<th>Company</th>
<th>Price</th>
<th>Operating System; Processor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touchstone Software Corp</td>
<td>$495</td>
<td>Unix: 8086, VAX, PDP-11, 28000, 68000</td>
<td>MIMIX: lets you run CP/M operating system with special help for new users.</td>
</tr>
<tr>
<td>Virtual Microsystems Inc.</td>
<td>$3500</td>
<td>Unix, RT-11, IAS, RSX-11, RSTS, VMS, AOS, RS/1</td>
<td>The Bridge: lets you run CP/M binary code.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Table 2: Operating-system emulators for Unix.</td>
</tr>
<tr>
<td>Computer Methods Ltd.</td>
<td>$2000 to $750</td>
<td>Unix, V7, System III or V, Berkeley 4.2, Xenix, Uniplus+, VAX, PDP-11, 68000, 28000, 8086</td>
<td>XED: has spelling checker, math, spreadsheet and mailing list capabilities, works over 1200 bps modem. XPR: formatter processes output of XED for precision line printers.</td>
</tr>
<tr>
<td>Handle Corp.</td>
<td>$200 to $500</td>
<td>Unix, Xenix, Hewlett-Packard, 68000 (68066 underway)</td>
<td>Handle Writer: with modules for word processing, mail merge, spelling checker, graphics capability, document writer. Table of contents and indexing, calculations, document management, security function key driver.</td>
</tr>
<tr>
<td>HCR</td>
<td>$750</td>
<td>Unix V7 or System III; PDP-11</td>
<td>HCR/EDIT: upwards compatible with ed (the standard Unix editor), uses standard control keys, termcap library.</td>
</tr>
<tr>
<td>Information Nexus Ltd.</td>
<td>$450 to $750</td>
<td>Unix; PDP-11, 68000</td>
<td>NEX: horizontal scroll, dynamic window size, changing, error recovery.</td>
</tr>
<tr>
<td>Info Sciences Dept.</td>
<td>$200</td>
<td>Unix V6, V7, and 32V; PDP-11, VAX</td>
<td>&quot;te&quot;: enhancement of red (new Unix editor), can edit multiple files at once, recovery from system crashes, on-screen justify, fill. Can manipulate files while in editor.</td>
</tr>
<tr>
<td>The Santa Cruz Operation</td>
<td>$750</td>
<td>Unix, Xenix, Z8000, Altos, PDP-11, Lisa</td>
<td>Uniplex: menu driven, cut and paste, file locking, user-configurable.</td>
</tr>
<tr>
<td>Softest Inc.</td>
<td>$500 to $750</td>
<td>Uniplus+, Xenix, MS-DOS, 68000, 8086/8088</td>
<td>LEX: menu-driven, proportional spacing, mass mailing document merge, calculator, spelling dictionary.</td>
</tr>
</tbody>
</table>

Table 3: Word processors and full-screen text editors.
MULTIUSER SYSTEMS MADE POWERFUL...

MultiMicro Computer raises expectations for multiuser systems. In fact, our new system is so good we call it the MicroMainframe.
And we can prove it.
Each user gets their own processor. Each processor has 64 K of RAM. The MicroMainframe has over 1 megabyte of system memory and up to 450 megabytes of hard disk memory.
That's right, 450 megabytes.
There's more. An 8" double sided, double density floppy drive, RS-232, RS-422 or Centronics parallel interfaces, 20 slot chassis, real time clock, true record locking and quiet operation are standard. Streaming tape backup and 6 MHz operation are available.
It's also simple. Up to 16 users can be accommodated easily. The power supply and cooling system have been designed for straightforward, plug-in expansion.
...AND FAST...
Best of all, TurboDOS takes full advantage of the MicroMainframe's direct memory access, memory management, and slave level memory architecture. That makes our system fast. Very fast. It can also run any CP/M™ program.
The best MicroMainframe around?
The only MicroMainframe around.
...AND INEXPENSIVE.
Our Base, 4 user system with 320 K of system memory, 16 megabytes of hard disk storage and a 1.2 megabyte floppy disk drive retails for only $8950.00.
That's a fully expandable, 20 slot system. Additional users can be added for under $750.00.
CALL.
Call today. We'd like to help you solve your multiuser problems.

MultiMicro Computer
9631 Netherway, Huntington Beach, CA. 92646, 714/963-8954

CP/M™ Digital Research. • TurboDOS™ Software 2000 Inc. • Centronics™ Centronics, Inc.

Circle 312 on inquiry card.
If you're serious about word processing on your Apple*Ille, you may be bewildered by the sheer number of programs available. And a tad perplexed by their claims and promises. After all, a glamorous package that says "easy to use," may not even be easy to open.

The dilemma is real. And Quark is happy to provide the solution.

A proven program for serious word processing.

Quark's new Word Juggler Ille turns your computer into a dedicated word processor. You get the extraordinary ease of use, sophisticated capabilities and straightforward documentation that make our original Word Juggler a best seller on the Apple Ill.

For example, there's virtually nothing to memorize. Because principal editing functions are identified on a unique keyboard template — and nineteen, easy-to-install, replacement keycaps.

Changing keys is quick and simple, too. Just slide our special keycap remover over the key — twist — and pull. Your new keycaps can be in place in less than two minutes.

A flexible tool to increase your productivity.

But don't be deceived by Word Juggler Ille's disarming simplicity. The program packs the powerful features you need to quickly perform the most complex editing tasks.

Characters, words, even entire paragraphs can be deleted with a single keystroke. There are search and replace keys. Block move and copy keys. And you always have instant control over page length, margins and any other formatting parameters.

Document display and print out are easy, also. One keystroke displays your document on the screen. Another prints it. And whether
you need to print only specific pages, multiple copies, or even documents too large to fit in memory, Word Juggler Ile can easily accommodate you.

**A clever way to foil Mr. Murphy.**

Even the best of us occasionally forgets when “i” does *not* come before “e” — and even the most agile fingers can press the wrong key. So you should also give serious consideration to Quark’s new Lexicheck™ Ile — a spelling checker with a highly compressed, 50,000 word dictionary.

Accessed from within the word processor, this program lets you virtually eliminate typographical errors and common misspellings. Lexicheck Ile will scan your document at up to 8,000 wpm — then highlight, in context, the first occurrence of any word it does not recognize.

If the word is correct, as in the case of industry jargon or abbreviations, you can simply add it to your personal dictionary. If the word is actually misspelled, you can swiftly correct it.

**A lot more.**

These are only some of the ways Word Juggler Ile and Lexicheck Ile can help solve your word processing dilemma. Your Quark dealer has even more details, as well as complete information on our line of office automation tools for the Apple III.

Ask for a demonstration today.

*Apple is a registered trademark of Apple Computer, Inc.*

Quark, Word Juggler and Lexicheck are trademarks of Quark, Incorporated, Denver, Colorado.

---

**Word Juggler Ile**

$239. sug. U.S. retail price

**Lexicheck Ile**

$129. sug. U.S. retail price

Circle 376 on Inquiry card.
While new printers with impressive specifications are introduced on an almost daily basis, only time will tell the true quality of the product. Over the past 2 years our customers have continued to buy the DS180 printer, not only because of its impressive performance and competitive price, but also because of our outstanding track record for product reliability and customer support.

We have continually improved on the performance of the DS180 by incorporating such enhancements as dot addressable graphics, 6 user-selectable print sizes and a 2000 character buffer. These features coupled with 180 cps printing, parallel and serial interfaces, adjustable tractor feed and over 40 other programmable features, make the DS180 one of the most versatile matrix printers available today.

Before you select your next printer, why not take a look at a time-proven performer—the Datasouth DS180.

The DS180 printer is available nationwide through our network of sales/service distributors.
<table>
<thead>
<tr>
<th>Company</th>
<th>Price</th>
<th>Operating System; Processor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Software Design Inc.</td>
<td>$850 to $2500</td>
<td>Xenix, TRS-80 Model 16</td>
<td>Data Ace: relational database, English query commands, demonstration disk $20</td>
</tr>
<tr>
<td>International Software Enterprises</td>
<td>$2200 to $20,000</td>
<td>Unix, Xenix, PDP-11, 8086, 82800</td>
<td>MDBS: English-language queries, report writer can physically cluster related records, encryption capabilities, password access code facilities, data validation, written in C</td>
</tr>
<tr>
<td>Logical Software Inc.</td>
<td>$5000</td>
<td>Unix, Xenix, UNOS</td>
<td>Logix: interactive programming, database management, report and form generation, educational license available, database for engineering</td>
</tr>
<tr>
<td>Rod Maris</td>
<td>$250</td>
<td>Unix, Unixplus, 68000</td>
<td>/db: uses Unix utilities; accounting and manufacturing packages available, written with the database</td>
</tr>
<tr>
<td>Pacific Software Mfg. Co.</td>
<td>$1395 to $12,000</td>
<td>Unix System III, CP/M, CDOS, Isis, North Star DOS</td>
<td>Sequitur: relational DBMS, integrated word processing, can recover earlier versions of changed records, report generator, built-in screen editor, written in C</td>
</tr>
<tr>
<td>PHACT Associates Ltd.</td>
<td>$250 to $950</td>
<td>Unix and look-aliikes, Idris, MS-DOS; 68000, Z8000, 8086, VAX, PDP-11, Perkin-Elmer</td>
<td>PHACT-dbrms: relational database manager, data dictionary, ISAM and relative record access, written in C</td>
</tr>
<tr>
<td>Relational Database Systems Inc.</td>
<td>$4000</td>
<td>Unix and look-aliikes</td>
<td>Informix: relational database, audit trail and recovery, report writer, other packages to go with it</td>
</tr>
<tr>
<td>RHODNIUS Inc.</td>
<td>$5000</td>
<td>Unix V6, V7, and 32V, PWB, Zeus, Xenix, VAX, Onyx, ZLOG System 8000, Perkin-Elmer</td>
<td>Mistress: educational license, relational database, with report generator, user-friendly query language, Unix shell interface, two C language interfaces, report writer, interactive interface, small-to-medium database</td>
</tr>
<tr>
<td>Science Management Corp.</td>
<td>$595</td>
<td>Unix, Onyx, IBD Series/1, T19900, Mercator 8086, Basic 4, Rexon Pertec</td>
<td>Idol: interactive, menu driven, can have passwords, audits, documentation control, statistics report</td>
</tr>
<tr>
<td>Unily Corporation</td>
<td>$3000</td>
<td>Unix: VAX, PDP-11, 88000, 8086</td>
<td>Unily: menu-driven, interactive, applications and development tools include menu handler, automatic data entry, query by forms, report generator, and SOL—a structured query language based on IBM's Sequel 2 relational language</td>
</tr>
<tr>
<td>A.I. Wasserman</td>
<td>$200</td>
<td>Unix, VAX, PDP-11</td>
<td>Troll: relational DBMS with screen editor</td>
</tr>
</tbody>
</table>

Table 4: Database management systems for the Unix operating system.

The tables should not be viewed as all-encompassing but rather as a guide to general availability.

Database Management Systems

Except for ported applications, the first business programs to appear on a new system such as Unix are

first with Unix-based applications, some of the software brought from larger and faster computers may not have been redone so as to make the best use of Unix features, or it may tend to use system resources more heavily on a smaller system. As always, it pays to investigate software carefully before betting your business on it.
The programmer can create, fairly quickly, a set of applications programs, whereas otherwise they would be out of place here, your first step should be to decide what type of application you require. This type of application may be found in accounting packages and partly because they are more interesting to write than they are useful. A simpler data management system, often implemented as a mailing list package, may be all you require. This type of application may be found in table 1, while table 4 summarizes information about some of the true DBMS systems available for Unix-based computers.

Using Applications on the Unix System

If you're the type of person who learns by using a new computer by plugging it in and trying it out, probably don't have to enroll in any sort of formal training course to use Unix. Many other people will be exposed to Unix in the next few years who have never used a computer before. This fact is responsible for the sudden appearance of quite a few organizations that will teach you or your staff how to use Unix more effectively. Most of these firms do their instruction in seminars and will do in-house courses; a few, such as International Technical Seminars, the Institute for Advanced Professional Studies, and Structured Methods Inc., specialize in actual hands-on work with a Unix-based computer. User Training Corporation's courses are self-taught using audiodigital technology, which combines an instructor's voice with an actual session shown on your display screen, while the Computer Technology Group features video-tape-based training.

My experience in training people with a wide range of expertise how to administer Unix systems, however, leads me to point out the following: It is not always a good idea to teach everyone how to use the system all at once.

Many businesses that will be buying Unix computers, especially small businesses, will have little or no experience with multiuser systems. With single-user microcomputers such as Apple or CP/M systems, it is fairly easy to control system use. Just limit computer access to those who must perform the work. When you begin putting terminals around the office connected to a central Unix facility, more people will get a chance to use the new machine, passwords will be passed around, and some people will experiment more than others. At this point, those who have some knowledge of the system are the most dangerous in terms of system integrity and security (i.e. not having your sensitive files looked at, changed subtly, or even removed). Deliberate malicious acts are not the worry here—it's mistakes made while experimenting that can be dangerous (naturally, this doesn't apply to software development environments where the highest priority is that your programmers learn the system). We have found that in many organizations this is also the critical time when backup procedures are still not totally worked out.

Is this a plea for a return to the days of keeping or-

generally database management systems (DBMSs). This is partly because they are more interesting to write than accounting packages and partly because they are used as building blocks for general applications. A DBMS is a system of programs that can be thought of as a high-speed interface between data stored on a computer system and applications code. With a DBMS, a skilled programmer can create, fairly quickly, a set of applications programs in a fraction of the time it would take to write them otherwise. The programmer is freed from the necessity of maintaining the data files and just has to worry about the relationships among the data items themselves. The true DBMS is not a predefined program for managing data, therefore, but a base for creating applications.

While a complete guide to selecting a DBMS would be out of place here, your first step should be to decide how much programming you wish to do and how flexible your needs are. A simpler data management system, often implemented as a mailing list package, may be all you require. This type of application may be found in table 1, while table 4 summarizes information about some of the true DBMS systems available for Unix-based computers.

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EM 983
Table 6: Menu systems or Unix Shell replacements that present a simple view of Unix for the novice user.

<table>
<thead>
<tr>
<th>Company</th>
<th>Price</th>
<th>Operating System; Processor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logical Software Inc.</td>
<td>$10,000</td>
<td>Unix; Onyx, VAX</td>
<td>Softshell: menu/full-screen or Shell-like operation. Source code only. For OEMs primarily</td>
</tr>
<tr>
<td>Quadratron Systems Inc.</td>
<td>$295 to $495</td>
<td>Unix; 68000</td>
<td>Configurable Menu System: screen development package; can act like Fortune menu system with window extensions</td>
</tr>
<tr>
<td>Schmidt Associates</td>
<td>$400</td>
<td>Unix; 68000</td>
<td>/menus: configurable menu system, to make Unix easier for novices; good for administration and maintenance</td>
</tr>
<tr>
<td>Softest Inc.</td>
<td>$250</td>
<td>Unix; PDP-11, 68000</td>
<td>Menu Creation/Interpretation System (MCIS): error recovery, user profiles, inter-menu linking; easy to reconfigure</td>
</tr>
</tbody>
</table>

As people learn more about the system, their access to other commands can be expanded as necessary. Properly handled, this expanding access technique is useful in exposing people gradually to the power of Unix, without overwhelming them with the sheer number of commands and options or opening the system to many novice users all at once. Some Unix-based systems are using this technique already; for example, the Fortune 32:16 computer implements the entire user interface as one large menu system that allows even a novice to follow logical steps in performing tasks previously reserved for “experts,” such as adding new users, backing up the system, and installing new software. Meanwhile, expert users can bypass the menu entirely.

This type of menu facility can be created on any Unix machine by a competent programmer, but it may be easier to start from an established base. Table 6 lists a number of commercially available menu systems for a range of computers. While these are most useful to an OEM (original equipment manufacturer) or system house wishing to create a better working environment for clients, they might well come in handy for end-user organizations as well.

Aside from adding menus, you can customize your Unix environment in many different ways. For instance, one of the biggest complaints some people make about Unix is the way the commands are named. The terseness that characterizes Unix is certainly most apparent in command names like cp, mv, cat, and lpr. If you don't like them, it's perfectly possible to change them.

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```
$ su
Password: (you forgot that you renamed the mv command)
# cd /bin
# mv cp copy
# mv mv rename
# mv mv cat type
mv: not found
# rename cat type
# rename lpr print
```

This will work, but imagine the confusion that would result when someone else attempted to use the normal terse command names. A more reasonable solution is to create new links to the command names, which essentially allows the same file (a command is, after all, just an executable file) to be called by more than one name.
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- 20 bus Slots
- dBASE II
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The difference between an extra link and a copy of a file is that creating a link creates a new directory entry that points to an existing file and doesn't take up extra space in the file system. This is especially handy when creating links to large files like multimegabyte databases.

However, this prevents ordinary users from creating their own programs with these names. So the easiest way is to change the order in which the Shell searches directories for your commands. This affects no one else, requires no special permissions, and can be changed at any time, but you must set up a new directory:

```sh
# mkdir /alias  (create special directory for links to system files)
# chown +rwx /alias  (allow others to create their own alias files)
# chmod 777 /alias/*  (chmod 777 for those with older systems)
#$ echo $PATH+:/alias:/bin:/usr/bin  (become a regular user again)
$ PATH=/alias:/bin:/usr/bin  (set up your terminal characteristics and default execution path)
```

Why must you be a super-user to do this? The /bin directory is generally on a different logical file system than the users' personal directories. Due to the way the link command works, you can't link across different file systems, so it is impossible for a regular user to create a set of links under that user's home directory to system files.

What about the $PATH we used? Like the other variables beginning with a dollar sign ($), this is interpreted by the Shell. The $PATH may be shown (with the echo command) or changed at any time, much like an ordinary variable in C or BASIC. And .profile is simply a file that the Shell executes if the file is found in your home directory when you log in; it's expected to hold a number of Shell commands and is typically used to set up your terminal characteristics and default execution path. It can be changed easily and so is ideal for starting novice users off with certain programs. Another popular Shell variable to modify is the prompt, which you can change to whatever you want in the following manner:

```sh
$ PS1="Yes, master."
Yes, master.
```

The .profile is called .login on systems using code developed at the University of California at Berkeley (UCB) or derivations from that code. UCB systems will also have a Shell command called alias that performs the same function as this $PATH modification. Otherwise, if you wish to accomplish aliasing (rename commands) on an individual basis without being the super-user, it is necessary instead to make each new command simply a one-line shell program:

```sh
$ cd  (go to your home directory)
$ chdir bin  (create a personal command directory)
$ cd bin  (go to it!)
$ echo 'mv $' > rename  (put the system commands in your selected file names)
$ echo 'rm $' > type  (refer to last month's article)
$ echo 'grep $' > search
$ echo 'pr -w132 $ |pr &' >lp  (make these files executable, or chmod 755)
$ cd  (go back "up" one level to home directory)
$ ed .profile  (modify your .profile to include the new directory)
```

Because this is something any user can do, variations of this technique are usually discovered eventually by anyone who wishes a customized environment. Naturally, these short shell programs can be made longer; perhaps setting up particular files or directories to be used,
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5¼" Same as above, but bulk pack w/o envelope M11AB 1.29  
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5¼" SSSO 16 Hard Sector w/Hub Ring         M51A 1.40  
5¼" SSDO Soft Sector w/Hub Ring            M13A 1.79  
5¼" SSSO 10 Hard Sector w/Hub Ring         M43A 1.79  
5¼" SSSO 16 Hard Sector w/Hub Ring         M53A 1.79  
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BYTE September 1983  275
Ishell: A Unix Information-Retrieval System

Ishell is a simple data-retrieval system comprising a data file of logical records and the associated Unix Shell command files that process the data file and produce a formatted report. Implemented with selected system utilities found on Unix, Ishell may be used to keep track of almost any kind of data, from a project development team's ideas-and-documents file to a writer's drafts of different articles and their reference documents.

Each record in the data file consists of a series of physical records. The first physical record contains up to four fields: the logical record identification number, a capital N (standing for name or title), the record title, and an optional locator field. Subsequent physical records contain three fields: the logical record ID, a capital K (for keyword), and a freeform content line. For example:

000199:N:Spectragraphics:work file cabinet
000199:K: System 1250—a 16-color raster or graphics display
000199:K: system that emulates the IBM 3250 graphics display
000199:K: system. Local or remote configuration, supports
000199:K: up to 4 workstations per controller or up to 64
000199:K: workstations per channel controller.

The logical record ID—000199, in the example—is a sequentially assigned number that links together the physical records into one logical record. It has meaning only to the Shell programs and never appears in the output. The record title and locators fields—Spectragraphics and work file cabinet in the example—are context dependent and may be used to describe the data entry and a particular physical (i.e., noncomputer) location where the source data may be found. The locator field, in particular, permits anyone who may access the data file to find further information on the data.

Using Ishell

The data file is called Ishell.data, and it may be edited with any standard text editor available. You must assign a new logical record number for each product or project to be entered into the system. Following the format of the previous example, a short article may be entered, and keywords may be input on lines of their own. This will facilitate later retrieval by use of the dictionary file Ishell.dict, which may be created by running the program create.dict.

You search the data file by following three steps. First, find the appropriate terms to search for by looking in the dictionary file. Next, edit the file awk.search to contain the string to look for by using a proper Boolean equation. Then run the Ishell program, which will automatically display the information thus found. The output file Ishell.out contains this information and may be printed or edited further.

Program Logic Flow

The commands used in the Ishell information and retrieval system are shown in listing 1. The Ishell file contains all the commands necessary to perform the search. The awk.long program creates one long physical record for each set of logical records with the same record ID in the data file. The output is directed both to the Ishell.long file and to the search program awk.search. This program creates a sorted list of record ID numbers matching the search criteria called Ishell.list, which is then joined to the Ishell.long file and piped to sort to create the Ishell.sort file. Finally, the awk.short and awk.out programs are used to format the selected output file Ishell.out and direct it to the terminal.

Improvements

Ishell is not a fast or particularly user-friendly system, but it does illustrate the concept of developing a useful tool with Unix utilities. Much faster searches, if quality of output is not important, may of course be done by searching the data file for a particular keyword using grep, finding the matching record ID numbers, and using grep again for those ID numbers, thereby finding all associated entries.

A Shell or C program could easily be constructed to accept and prompt for user input, automatically assigning record ID numbers and adding the N and K fields. Menus and prompts for keywords to search on could be added. But as it stands, Ishell will run on virtually any Unix or Unix-like system as is; just type in the programs given in listing 1 and your data.

Some Real Examples

The classic example of a "home-built" application on Unix is that of the personal phone directory. I'll show you how this can be done and suggest some methods of improving it as we go along. Then we'll explore some more elaborate applications that can be constructed using standard Unix utilities.

A phone directory can be as complex or as simple as you wish. I've seen some people go to the trouble of writing a program that would format names, addresses, and phone numbers and provide menus for selection by category. Most people will just want something simple to understand and use. The simplest directory is merely a file of names and phone numbers:

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone 1</th>
<th>Phone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joe Blow</td>
<td>(201) 686-1913</td>
<td></td>
</tr>
<tr>
<td>Elia Fitz</td>
<td>(415) 339-9001</td>
<td></td>
</tr>
<tr>
<td>Ada Lovelace</td>
<td>(800) 543-7885</td>
<td></td>
</tr>
<tr>
<td>Rosanne Rosannadonna</td>
<td>(212) 986-1717</td>
<td></td>
</tr>
<tr>
<td>Anna Stasia</td>
<td>(201) 310-4887</td>
<td></td>
</tr>
<tr>
<td>Tricia McMillan</td>
<td>(440) 276-709</td>
<td></td>
</tr>
</tbody>
</table>

After creating your file, which I'll assume is named phonelist or something similar, the simplest way to retrieve data from it is to use the string-and-pattern finding pro-
gram, grep:

```
$ grep Joe phonelist
  Joe Blow   (201) 666-1913

You can find all the New Jersey listings just as easily:

$ grep 201 phonelist
  Joe Blow   (201) 666-1913
  Anna Stasia (201) 310-4697

The first improvement to be made is to make a command that knows the name of the phone number file:
```

```
$ grep $1 phone
$ chmod +x phone
$ phone Anna
Anna Stasia   (201) 310-4697
```

This is easier to type, and you don't have to remember the name of the phone file. But suppose you're in a different directory when you want to look up someone's number? We have to build the fully qualified name of the file into the phone command, so that it should now read:

```
grep $1 $HOME/phonelist
```

Using the Shell variable $HOME (which is equivalent to spelling out the entire name of your actual home directory) not only saves typing but lets the system do the thinking, keeping the program as general as possible. You can substitute your home directory for the $HOME used here, but that's not recommended because system administrators have been known to move things around over the weekend. Besides, this keeps even your Shell programs portable: you can use them as is on another system or allow your friends to copy them without having to do a lot of editing. Speaking of your friends, maybe you don't want anyone else to see your personal phone list:

```
$ chmod go= phonelist
```

Now nobody but you (and the super-user) can read your phonelist. But the super-user can't read what he doesn't know about! Renaming your file to .phonelist will work on most systems so that listing your files won't reveal it exists (don't forget to change your phone program too) because files and directories whose names begin with a period are not shown by ls unless a special option is used.

It must be noted at this point that the grep program is sensitive to upper- and lowercase; in particular, you can't type phone anna and expect to get Ms. Stasia. Care must therefore be taken when entering the command line. If you don't want to continually press the shift key, you can convert the entire phonelist file to lowercase:

```
$ tr "[A-Z]" "[a-z]" < .phonelist > temp
```

(translate all letters found, in order)

```
$ mv temp phonelist
$ phone Joe
Joe Blow   (201) 666-1913
$ phone Anna
rosanne rosannadanna   (212) 986-1717
anna stasia   (201) 310-4697
```

Joe Blow (201) 666-1913
Anna Stasia (201) 310-4697

Joe Blow (201) 666-1913
Joe Blow (201) 666-1913

The second example above shows that this conversion also means less precision in interpreting your requests. But sometimes “too much” output can be helpful. If you add the name of each person’s company or job title to their entry in your “phone book,” you can search by this information as well as name. Or adding the address (make sure you keep one entry to a line) allows you to search by city or state. This extra information comes in handy when you forget the exact name of the person you were looking for but know some other information about her or him:

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone</th>
<th>Company/Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>joe blow</td>
<td>(201) 686-1913</td>
<td>kokomo travel agency</td>
</tr>
<tr>
<td>ella fitz</td>
<td>(415) 339-8001</td>
<td>audiotape testing</td>
</tr>
<tr>
<td>ada lovelace</td>
<td>(800) 543-7895</td>
<td>structured programming group</td>
</tr>
<tr>
<td>rosanne rosannadanna</td>
<td>(212) 988-1717</td>
<td>snl newbreak</td>
</tr>
<tr>
<td>anna stasia</td>
<td>(201) 310-6878</td>
<td>salty cardine company</td>
</tr>
<tr>
<td>tricia momillan</td>
<td>440(0) 276-709</td>
<td>mouse computer inc</td>
</tr>
</tbody>
</table>

If you wish to develop this idea further, look at the options available to you using some more Unix utilities, such as awk, sort, cut, and paste. These, along with the programming constructs available as part of the Shell, can provide you with all sorts of fancy formatting fun. Data entry may be controlled by another Shell program or a C program especially written for this purpose. Such usefulness has not gone totally unnoticed by the commercial community. For instance, a mailing list/form letter package called Leverage (see table 1) implements data entry and screen formatting with C programs and uses grep for searches, nroff for creating form letters, and awk programs for printing formatted lists and labels. Other firms have similar products, some of which use fewer system utilities and more proprietary programs; these tend to be more expensive but have better performance. If you don’t mind a bit of typing, a simple yet complete data retrieval system can be built using standard Unix utilities (see the text box “Ishell: A Unix Information Retrieval System”).

A Few More Programs
A word or two should be written about awk. This is a C-like string-handling language that is used for manipulation of data files; in particular, it is good for writing quick programs that scan for strings, rearrange data fields, and take action based on the contents of a file. Again, see the Ishell text box for some examples of awk programs.

Mentioned earlier, the programs developed at Berkeley (usually referred to as UCB) have been a major addition to the world of Unix software. One of the most useful UCB programs is the screen editor vi, which has spread throughout the Unix community so quickly that AT&T is now distributing it with Unix System V. The UCB C-Shell was created as an alternative to the standard Unix Bourne Shell developed by Steve Bourne at Bell Labs. The C-Shell has several unique features, such as the ability to repeat or edit previous commands, the aliasing mechanism described before, and expansion of various special characters to save typing. Other UCB programs include more, which lets you read a file a screenful at a time; finger, which displays detailed information about each user on the system; and apropos, which helps you search the online programming manuals for information by keyword. Most UCB programs have been created specifically for the purpose of making people’s work with Unix easier.

We’ve examined some more Unix commands and facilities and some of the diverse applications available on Unix-based machines, seen how to customize the environment, and tasted the flavor of home-built applications. Next month’s article will examine some of the currently available computers running Unix, the different software implementations of Unix, and what can be expected in the next few years.

Thanks to Rosemary Simpson, director of educational systems at Access Technology Inc. for the ISHELL material, to Rob Cohen at Polymorphic Systems Inc. for the use of its Pixel computer, and to my wife Susan for digging through back issues of Unique and compiling the tables.

David Fiedler (Infinite Systems, POB 33, East Hanover, NJ 07936) is the editor of the monthly newsletter Unique: Your Independent UNIX and C Advisor and the magazine UNIX Review. He is also an analyst for The Perchwell Corporation, a consulting firm assisting management of companies using Unix.
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### COMPANY CONSOLIDATED MONTHLY PAYROLL

<table>
<thead>
<tr>
<th>Emp#</th>
<th>Employee name</th>
<th>Status</th>
<th>Gross Salary</th>
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<th>Net Pay</th>
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<th>SDI</th>
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</thead>
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<td></td>
<td></td>
<td></td>
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</tbody>
</table>

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Just Rewards for Programmers

In the microcomputer industry, it’s not always obvious how to divide up the profits

by Barbara Robertson

To paraphrase Gilbert and Sullivan, the programmer’s lot is not a simple one. Some have superstar status, and others crank out code for a weekly paycheck. Some work for equity, others earn royalties based on retail prices that range from a few dollars to hundreds of dollars. Dividing up the profits is done in many ways. But the issues that burn in programmers’ and publishers’ minds are the same: who gets the money, and who handles pricing, distribution, and marketing?

The corollary, “Who ought to get the money?” depends on the originality of the idea, who developed it and whether it changed, the difficulty of the coding and who did it, and the breadth of distribution and marketing and who manages and funds it. Arrangements vary enormously within the industry. Let’s look at a few examples drawn from actual events.

Eagles Neuvelstorm shut down the computer and began locking up. Once again, he was the last one to leave the office. The company had sure changed since he and a few others put old Dynamodata on the market a couple of years before. Some things were good—for one, the company’s newly hired product manager seemed to like the idea the design team had conceived. A fully integrated multiwindow, artificially-intelligent, mouse/touchpad/voice-driven, omnitasking, full-color graphic videotext communications program was finished. That should satisfy the marketing guys, thought Eagles. And it looked as if the team could actually produce the product, what with all the money available for people and machines from Dynamodata’s profits. Of course, the programming team wouldn’t be seeing any royalties on this one, but the programmers’ salaries and benefits were good, and the product’s success might mean the company would go public.

Eagles wondered if the new programmers had been offered stock options when they were hired. Had he heard they had to work a year first, but there didn’t seem to be any hard-and-fast rules yet.

In this case, the idea is a marketing department decision that has been refined by a design team and product manager and will be programmed, documented, marketed, and distributed by other members of the company. The product clearly belongs to the company. The programmer can negotiate for rewards within the range of traditional corporate benefits: salary and stock options. Here the programmers are not stars but part of a team. In this environment, programmers and designers are in the same position as most inventors working for large corporations. The corporation owns the copyrights.

Joe Machinecode’s case is easy. The program is his idea, and as long as he does all the work and invests only his own money, he determines the price and reaps 100 percent of the profits. While this may seem an ideal arrangement, it’s becoming more difficult for such “garage” software producers to compete, and Joe may find that he doesn’t have the same talent for business, marketing, and customer service that he does for programming. Let’s look at two ways Joe might get help and what will happen to his 100 percent in each case.

First, let’s assume that Joe decides the documentation needs to be improved, so he hires Chris, a writer. Chris makes suggestions about the user interface that Joe incorporates into the program and also introduces Joe to a product manager at the General Enormous Software house. General Enormous Software decides to buy exclusive rights to the products. Joe pays Chris a flat fee, takes the rest of the money, and moves to a tropical island.

Meanwhile, General Enormous Software does market research studies, modifies the program to meet those studies and fit in its product line, mounts a massive advertising campaign, puts the product and

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Computational
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Jeffrey D. Ullman

This excellent, comprehensive new book on algorithms and the VLSI revolution introduces the NMOS circuit design and describes a number of design systems, including CHISEL (a preprocessor of C), LAVA (a sticks language); Igen (a logic language, and SLIM (a controller design language). Algorithms for compiling such languages into layouts are discussed, as well as algorithms for implementing design tools like circuit extractors, design rule checkers, simulators, and automatic routers. The book covers many other areas of VLSI. Order your copy today. September, 1983. $32.95. 0-914894-95-1.

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### Printers

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microline 92</td>
<td>$524.88</td>
<td>UPS DELIVERED</td>
</tr>
</tbody>
</table>

An exceptional printer (even Creative Computing thought so). The Microline 92 has 80 columns, a 150 x 144 dpi matrix, and a 40 x 60 dpi matrix. The printer also supports epson-compatible fonts, a 120 x 120 dpi matrix, and a 240 x 240 dpi matrix. It also supports multiple paper sizes, including A4, B5, and A5. The printer is equipped with a built-in校对 software and can be used with a variety of software packages.

### Starwritter

The Starwritter has 40 columns of true Diablo emulation, on 136 columns per page. It also supports a 120 x 120 dpi matrix. The printer is also compatible with a variety of software packages.

### Starwriter

The Starwriter has 40 columns of true Diablo emulation, on 136 columns per page. It also supports a 120 x 120 dpi matrix. The printer is also compatible with a variety of software packages.

### ComRiter

ComRiter supports a 120 x 120 dpi matrix and a 240 x 240 dpi matrix. It also supports a variety of software packages.

### Epson

Epson supports a 120 x 120 dpi matrix and a 240 x 240 dpi matrix. It also supports a variety of software packages.

### Gostwriter

Gostwriter supports a 120 x 120 dpi matrix and a 240 x 240 dpi matrix. It also supports a variety of software packages.

### Starwriter

Starwriter supports a 120 x 120 dpi matrix and a 240 x 240 dpi matrix. It also supports a variety of software packages.

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half or more of the royalty money. Some people argue, however, that unless the programming is especially creative, Rob occupies essentially the same role as a ghostwriter and deserves pay but no royalties. And what about the programmer brought in by the publisher—should she get credit in the promotion? Who pays for her time?

Rob and Mary have further complicated the question of how to apportion profits (and perhaps increased their potential profits at the same time) by taking the product to a software publisher interested in promoting the product beyond the traditional marketing channels. Rob and Mary’s names are used in the promotions, and if the product is a success they’ll soon see Speldata T-shirts and little stuffed Dumptrucks in the stores. How much of the profits do they deserve for each T-shirt and little stuffed Dumptruck that’s sold? And if Rob and Mary’s names become household words as a result of the promotion, how will superstardom affect the royalties they can demand on their next product?

**CASE**

**#4**

Walt Wizard, masterful money handler, and Tom Brightman, well-known program designer, met at one of those cocktail parties that make big computer shows almost worth attending. It didn’t take them long to realize that they had the same idea in mind for a new product and that they were a potentially great team. The Wizard knew what had to be on the screen and in the reports, and Tom could write the system design specs. The Wizard would attract the financiers, and together they could build a company that would skyrocket if they could move fast enough. They knew the product’s success depended largely on getting it into the market very quickly, and the one person who could do the job was Sam Supercoder, a programming genius at implementing complex ideas in assembly language. Sam looked at Tom’s design specs, suggested some improvements to which Tom and the Wizard agreed, and finished coding in three days, which gave them the edge they needed. The Wizard took the finished product to a group of venture capitalists who gave the threesome start-up money in return for 49 percent of the company.

In this case, all three will share in the profits and help determine pricing by virtue of their equity ownership in the company they’re building. But how should the 51 percent share be split among them? The original idea came from Tom and the Wizard. Tom wrote the design specs, but all of them contributed to the design. How much is the Supercoder’s contribution worth? After all, he got the product to market within the time frame.

**CASE**

**#5**

Susan Smart had been working as a computer programmer and systems analyst for a management consulting firm during the day and spending all her spare time designing a microcomputer software system. When she had a reasonably good plan down on paper, she approached Clyde Dealmaker with her idea. Clyde convinced a management team to invest its time and enough money for Susan’s salary and start-up costs on his
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assurance that the venture capitalists would soon be eating out of their hands. The management team liked Susan's concept but soon came up with an entirely new user interface for the program that they felt had a better chance of success. Susan improved the design and began writing code.

As it turned out, Clyde was wrong about the venture capitalists. The management team, desperate to recoup its investment of time and money, sold the program idea to a hardware vendor, who would use an in-house software team to develop it.

In this case, the idea for the program was Susan's, but the program changed considerably after she brought it to Clyde. No coding was done beyond what was needed for a demo, and because Susan was paid a salary, she assumed little risk. Clyde invested time, but no money. The management team, which contributed to the design, invested its own money and time without compensation. Was the vendor's decision to buy the program based on the management team's interface design or Susan's original concept? Who should profit from the sale?

Alternate Arrangements
There are probably as many stories as there are programs. Programmers are faced with several complex alternatives from which to choose, and they don't have much help in choosing. Going to work for a major software house for a salary and stock options is one. This option means a lower risk for the programmer and potentially lower gain. Working for a start-up company for a salary and equity usually translates to higher risk and potentially greater gain. Employment agents may be able to offer some help in negotiations.

If, however, a programmer decides to develop a product, the issues get muddy. How much is the idea worth? How much are the coding, documentation, marketing, and distribution worth? George Tate of Ashton-Tate, a software publisher that also develops in-house software, notes that advertising and marketing are now by far the biggest costs in bringing a product to market, exceeding the costs of research and development. This factor is bound to have some effect on the price.

Traditional software publishers such as Ashton-Tate, Digital Marketing, Software Publishing, and Information Unlimited Software offer independent software vendors a variety of choices, among them buy-out agreements, licensing agreements, stock offerings, and royalty arrangements. The amount of money publishers are willing to pay depends on the amount of work done by the author, anticipated market share, and pricing. However, there is no clear-cut formula. Some software publishers may be willing to help develop a program if the idea has market potential, but most prefer to take on a product that's near completion. All will assume documentation, marketing, distribution, and pricing responsibilities.

New software producers like Electronic Arts and International Microcomputer Software Inc. offer programmers another choice. Some will promote the authors and give them status and possibly even some control. Electronic Arts calls itself an "association of electronic artists" and puts the software authors' names on the cover of the software package. IMSI, for example, lets authors hire and fire their product managers.

Software producers tend to pay higher royalties than software publishers, but the amount of royalties and advances varies widely. It might seem that with a software producer the programmer can become a superstar. But what happens when a producer comes up with the idea or if he asks a famous mystery writer, sports car driver, or tax analyst to design a product? Will the programmer share equally in the royalties and fame?

Changing Rules
Clearly, it's not always obvious how to divide up the dollars. In the complex, undefined microcomputer software industry, the rules change as fast as the technology. Both the amount of the royalty and the basis on which royalties are paid vary from one publisher to another. Royalties can be based on wholesale revenues, gross profits, or retail prices, and it takes an expert to assess the best arrangement. Unfortunately, however, a programmer whose expertise lies in software development cannot become an overnight expert in contract law, marketing research, and distribution.

Peter Sinclair of Software Publishing, a company that develops in-house software and markets software from independent vendors, says that the independent software producers he sees are often naive not because they haven't done enough background work but because no clear, in-house work for information exists. The book hasn't been written yet. And while many standards of excellence exist as guides for programmers—proposed graphics standards, communications standards, and even operating system standards—there are no established algorithms for the business and marketing sides that will guarantee programmers a fair share of the profits. Many programmers learn the hard way that it's not unusual for someone else to make a fortune from their genius.

The book publishing, recording, and movie industries have agents and standard contracts. Now agents are emerging for software authors, but standards for determining the value of ideas and programming remain undefined. Programmers as a group need to exchange information, perhaps through electronic bulletin boards and networks as a means of establishing those standards. It might be worth some programmer's time to set up a database and begin collecting information.

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It is difficult to say whether C has become so popular because it is the major language Unix is written in or because it is in its own right a clean, small, highly expressive language. C allows programmers to write programs that package assignment expressions inside a logical test, as in this example:

```
#define EOF -1
main () {
    int byte;
    while ( (byte = getchar()) != EOF)
        putchar (byte);
}
```

In this case the while statement makes the program one executable statement in length. It copies characters until EOF (end of file) is reached. Such economy does have its disadvantages in that obscure C code is fairly easy to write. A programming language purist can rightly accuse C of inviting side effects in coding. But to the C language veteran, the side effects are desirable and should be treated with proper respect.

The proper C program is organized into functions, one of which must be named main. When a C program executes, control is given to main first. As we saw in Part 1, it is common practice in C to organize particular aspects of processing into functions called by main.

In this second and final part, we shift our emphasis from language fundamentals to the important concept of tool building in C. As we write programs we will be alert to code that could be packaged into a general-purpose function and employed in solving more than one problem.

Arrays of Characters
Because C contains no built-in function to read an entire line of input, it could be called a rather primitive language. Yet part of C's elegance and appeal is due to its encouragement of tool building. You can build a routine to read a line of input and package it as a function named getline that you can then use whenever the need arises. The next two examples develop a slightly modified version of the getline function found on page 26 of Kernighan and Ritchie's book *The C Programming Language* (Prentice-Hall, 1978). The first example focuses on character arrays, and the important work is done in main.

```
#define EOF -1
#define NL ' \n'
#define EOS '\0'
define LIMIT 1024

main ()
{   int byte, index;
    char line[LIMIT];
    for (index = 0; index < LIMIT - 1; index++) {
        if ((byte = getchar()) == EOF) break;
        else if (byte == NL) break;
        else line[index] = byte;
    }
    if (byte == EOF) break;
    else if (byte == NL) line[index++] = byte;
    line[index] = EOS;
    printf("%s", line);
}
```

This example begins by defining several preprocessor variables; the backslash-zero combination inside single
quotes in line A is C notation for a byte of all zeros, by convention the end-of-string maker in C. In C, any single byte of data inside single quotes tells the compiler to use the value of the byte as an integer. Character strings are enclosed in double quotes, as they are in the printf statements used in earlier examples.

In line F the end-of-string marker is assigned following the last character in the array just before it is printed. The %s format code indicates that the line is a character string. To verify that the zero byte is needed, run this example without lines A and F. Be sure to enter more than one line in assessing the effect of not having the end-of-string marker.

Line B shows how arrays are declared in C. The brackets distinguish arrays from functions. As mentioned in Part 1, a preprocessor variable is used to specify the array bounds; thus you can easily change the value throughout the program simply by changing the preprocessor command.

Line C shows a for loop that, undisturbed, will run forever. You can exit the loop using the break command if the end-of-file character is reached. Note that break on end-of-file occurs twice here, once to exit the for loop in line D, and once to exit the for loop in line C.

The for loop beginning with line D gets one character at a time and puts it into the array. The value of index starts at zero because arrays in C start at zero. The limit of the array must be adjusted down by one to compensate. The expression LIMIT-1 is calculated only once, at compile time.

There are three conditions for exiting this inner loop: if the array is full, as tested for in line D; upon reaching end-of-file, as in line E; and upon reading a newline character. If these conditions do not exist, the byte is added to the array.

The next example illustrates the use of arrays as function arguments. The code in the inner loop of the previous example is the heart of the next version of getline. Preprocessor variables are defined in getline because they are used there, although they could have been defined with the others at the beginning of the code for main.

/* -- getline2.c To package getline as a function */
#define ALLDONE 0
#define LIMIT 1024

main()
{
    char string[LIMIT];

    while (getline(string, LIMIT) != ALLDONE)
        printf("\%s", string);
}

getline(line, toobig) /* -- To read a line into an array */
#define NL ' \


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Circle 413 on inquiry card.
```c
#define EOS '\0'
#define EOF -1

char line[];
int toobig;

{ int byte, i;

    for (toobig-- , i=0; i<toobig && (byte = getchar()) != EOF &&
                   (byte != NL); ++i) {
        line[i] = byte;
    }

    if (byte == NL) line[++i] = byte;
    line[i] = EOS;
    return(i);
}
```

The parameters of getline are defined in line G and the subsequent line. Note that these declarations are made before the brace that contains the body of the function. The declaration for line as a character array lacks a number in the brackets because the true array will be handed to getline, and its length will have been determined in main.

Parameters in C are passed not as addresses of locations in the calling routine, as in many languages, but as their values. Consequently, values given to getline may be changed by code in getline without affecting their counterparts in main. If we pass simple arguments, such as the constant 1024 or a variable such as byte, a copy of the value is given to the function. If we pass an array, however, the address of the array is passed to the function rather than the contents of the array.

One consequence of this approach is that we can write getline as we did, but if we wrote a similar function—say, getbyte(byte)—we would hand the function the current value of byte as a parameter and, upon return, the value would be unchanged. To programmers this means that functions return only one value, and that is through the return statement. All values passed as parameters become copied into areas local to the function. If you pass an array as a parameter, you will actually be passing a pointer to the array (that is, its address). We'll return to this in the section introducing pointers in C.

Now let's look at what the user would see as the program code is being compiled.

```
$ cc -v -o getline getline2.c
```

getline 2.c;

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The first line asks that cc (the C Compiler) be run, with the option -v indicating that each stage of the compilation process is to be reported as it is entered. The -o option tells cc that the executable version of the program is to be stored in a file named getline. When the processing is complete, the shell returns with its prompt: $.

To execute the program you need only type its name and press the Return key. Then give it some data:

```
$ getline
This is some normal data.
This is some normal data.
$ 
```

Here a line of data was typed, followed by a Return and then the end-of-file signal Control-D. Two lines appear because the first line is the Unix shell's transcript of what you typed and the second line is getline's output.

In the example that follows, a line is typed, but instead of pressing Return, Control-D is typed at the end of the line:

```
$ getline
Here I type Control-D
$ 
```

Everything seems run together, but that is because we typed Control-D instead of Return. The shell's transcript of what you typed runs on the first >, getline's output continues on the same line until the second >, and the shell's prompt appears at the end of the line. On a video terminal, the cursor would be waiting at the end of the line for you to type another command line.

The Switch and System Statements

The last control structure we'll discuss is switch, which allows a multi-way decision via an elegant construct. We introduce switch with the system statement, which enables you to issue commands to the host operating system from your C program. Our example issues Unix commands, but that's because the system on which the program runs is Unix. Properly implemented, the system function simply hands the host operating system a pointer to a character string containing a command, then returns control to the user's program. The example that follows is a simple but suggestive help program for C programmers.

```
/* switch.c Demonstrate switch command and system call */
#define NL ' 
#define EOF -1
main() 
```

```
#include "stdio.h" 

int main() 
{ 

    printf("Hello world!");
    return 0;
} 

```
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int byte = 0;

int byte = getresp();
if ((byte = getresp( )) == EOF) system("exit");
printf(" 
"n); 
switch (byte) { 
case 'c ': system ("man cc"); break;
case ' b ': system ("man cb''); break;
case 'n ': system ("man lint"); break;
case ' m ':system ("man make"); break;
default: system ("echo Uh —
please rerun the program");
break
}

getresp () /*— Get nonwhite character from input —*/
int byte;
for (;;) {
if ((byte = getchar( )) == EOF) break;
else if ((byte != BLANK) &&
(byte != TAB) &&
(byte != NL)) break;
}
return (byte);

The function greet is just what its name implies and need not be discussed in further detail here. The packaging of getresp into a function may seem unnecessary, but it was done primarily to make a point about the human engineering of software. Some users of interactive programs type a space or even press Return before entering a response, just as someone about to give a talk in front of a group may blow into the microphone before speaking. Good human engineering of software allows for such responses. While we're on the subject of human engineering of software, note, too, the space after the question mark inviting a request. The space not only makes the message more readable but makes it more inviting to answer than if the space were not there.

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if it is an end-of-file character, the function system executes the Unix command, given as a character string, "exit". The exit system call to Unix is the usual way of terminating a process. The other system calls are to print pages from the Unix Programmer's Manual or to use echo to print a message to the user. Though printf could have been used instead of a system call to echo, the point was to illustrate system. Of particular note is that the shell scans the command it is given for metacharacters, except character-delete and line-kill, just as if the command had been keyed at your terminal.

The switch statement evaluates the expression in parentheses—which must evaluate to an int—and transfers control to the case matching the value, resuming execution with the statement following the case keyword. For example, if byte contains a c, it will match the first case, and the system call will be to print the manual pages for cc, the C compiler. The break statement afterwards keeps execution from continuing with the next system call to print the pages for cb, the C beautifier program.

You might think of switch as switching you to a matching case, where execution resumes. The case values mark places in the code, like labels, to which control is transferred. By pairing a switch with each case, you isolate each case's treatment. The default keyword in a switch catches all other instances beyond the ones matched earlier. If default is not in the switch, unmatched cases cause no action, as if the switch were not there. As Kernighan and Ritchie note in their discussion of switch, it is best always to put a break after the last case, so that if a new case is added later execution will not accidentally "fall through" to the newly added case.

Pointers

To some people, an aura of mystery surrounds pointers, as though there were some trick to them. Pointers are variables that have addresses as their values, just as an integer variable has integers as its legal values or a character variable has characters as its legal values. The following example is a version of hello.c that has been rewritten to introduce pointers.

/*-- point1.c To introduce pointer variables --*/

main()
{
    char *message; /* A */
    message = "Hello, world! \n"; /* B */
    printf(message); /* C */
}

The declaration in line A places an asterisk before message, indicating that message is a pointer to a character variable. In line B, what looks to be the assignment of a character string to message is the assignment of the address of the literal "Hello, world! \n" to message. There are no operations on entire arrays or strings in C. In line C the only argument is message, indicating the address of the message to be printed.

Line C gives us some insight into how printf works as a function. The control string we give to printf is stored away by the C compiler, and its address is given as the first argument to printf. As a result, printf sees just what any function in C sees—a list of values; here, the list contains a pointer to character string. We can take this point one step further:

/*-- point2.c More on pointer variables --*/

#define NL '\n'

main()
{
    char *message;
    message = "Hello, world!%c"; /* D */
    printf(message, NL); /* E */
}

In this example, we use the control string pointed to by message to print the newline character. The \%c is replaced by \"\n\", just as if the character string had appeared in the call to printf. So you've already seen pointers in C several times so far without knowing it!

Pointers are common in C programs that manipulate strings or arrays. Here is an adaptation of the function that copies a string, from Kernighan and Ritchie's book.

/*-- strcopy.c Pointers used to copy a string --*/

#define BIG 1024

main()
{
    char *original, copy[BIG]; /* A */
    original = "This will repeat once. \n";
    strcopy(copy, original);
    printf(original);
    printf(copy);
}

strcopy(tostr, fromstr) /* use: fromstr is copied to tostr */
{
    char *tostr, *fromstr;
    while (*tostr++ = *fromstr++)
    {
    }
}

Line A draws attention to the close relationship between arrays and pointers. Here original is a pointer to a character string and copy is a declared array. Yet in the call to strcopy the names appear side by side, and in the definition of strcopy both are declared as pointers to characters. Array references in C translate to pointers to the array plus the appropriate offset.
The work in `strcpy` is done in the condition for the while—yet another instance of the terse code often found in C programs. We will read it from the inside outward. The character pointed to by `lromstr` (think of the asterisk as representing the phrase "pointed to by") is copied to a location pointed to by `tosttr`. After this copy is done, the two pointers, `tosttr` and `fromstr`, are incremented. The value assigned also becomes the value of the expression in parentheses. When the end-of-string marker is copied to `tosttr`, its value, 0, becomes the value of the expression for the `while`. In C this means "false," and the while loop ends. The semicolon marking the body of the `while` is lined up under the `w` to tell a human reader that the body of the `while` is empty.

You might want to alter this program to see what happens when both `copy` and `original` are declared as pointers. The run-time errors are amusing enough to encourage several tries. If `copy` is declared as a pointer rather than as an array, the value it contains is undefined; where it will store the characters assigned in the function is anyone's guess. You might run this version through lint, which checks the style of programs, to see what it thinks of the code.

Next, let's look at how a function can return a pointer to a character string. The function in the next example is a model for functions that, given an integer, might return the corresponding month or part-name or job title—the uses are many, and the present example is perhaps one of the simplest. As indicated in line A, the function's type must be declared in `main` if it returns non-integer values.

```c
/* weekday.c introduce static variables and ?: construct --*/
main()
{
    char *weekday();
    /* A */
    printf("I was born on a %s\n", weekday(4));
    char *weekday(number) /* return pointer to name of weekday */
    int number;
    
    static char day[] = {
        "Oopsday",
        "Monday",
        "Tuesday",
        "Wednesday",
        "Thursday",
        "Friday",
        "Saturday",
        "Sunday",
    };
    return( (number < 1 || number > 7) ? day[0] : day[number]);
}
```

---

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The function weekday returns a pointer to character data, and it must be declared as such. Until now, our functions that returned anything returned integers, the default in C. The strategy behind weekday is that the integer will be the index into an array of pointers pointing to character strings containing the names of weekdays. That is, the value of day[4] is the address of the character string Thursday.

The declaration of day as an array of pointers to character data has several aspects worth noting. First is the word static, which refers to the storage class for the array of pointers. Normally in C, local variables in functions are allocated each time the function is called and deallocated when the function is exited. These are automatic variables. If you want the variables in a function to remain allocated after the function is exited, you must specify that the variables be static.

We certainly want the names of the weekdays and their pointers to stay around. If they disappeared after the return from the first call, subsequent calls would not have them or would have to reinitialize the array. C circumvents this by prohibiting aggregate initialization of automatic variables. If you omit the static declaration, the C compiler will complain, and compilation will not be successful.

The number of elements in the array is not specified within the brackets. Because the array is initialized in its declaration, the compiler will count the number of elements and allocate that much space. Again, you should note that pointers to the names are the values being stored in the array day rather than the names themselves.

The return statement contains a rarity in programming languages, a ternary (three-item) operation. Parts one and two are separated by a question mark, and parts two and three by a colon. The expression in parentheses is evaluated, and if its value is true, part two is executed. If the expression is not true, part three is executed. This is similar to an if-else construct, but it is working at the level of an expression rather than as a full-fledged control structure. The condition tests whether number is outside the range of a valid weekday number (between 1 and 7), and, if so, returns a pointer to the string Oops-day. Otherwise it returns a pointer to the name of the weekday. The ?: construct is both powerful and compact. You might rewrite weekday without it to see how much less readable the code becomes.

Structures

Structures did not enter the language until 1973, but they cap the major developments of C. A structure is like a record in Pascal or levels in COBOL Data Division entries. These next examples show a transcript of part of a Unix session using Mark Horton's scdp t utility to record what appeared on the video display. Here a program using structures is listed using the cat command (think of cat as being short for "copy all text"), then compiled, and finally run to produce the output of three names and telephone numbers.

```
/* struct.c Show an array of structures */
maint
{
    static struct list {
        char *name;
        char *number;
    } phones[3] = {
        "Jim Joyce", "415-621-6415",
        "Time", "415-767-2676",
        "Story", "415-626-6516"
    }
    int i;
    for (i=0; i<3; i++)
        printf("%12s %12s \n", 
            phones[i].name, phones[i].number);
}
```

The program listing starts with the by-now-familiar comment line having as its first word the name of the file—the absolute minimum that good documentation practice requires. Line A begins the structure's definition. The keyword struct announces that a structure is being defined. It is a static variable, and the structure will be initialized at compile time. We recently saw a variable declared static; now we can state a generality about initializing arrays and structures: automatic structures and arrays cannot be initialized. If you try to compile this example without the keyword static, the C compiler will complain:

"struct.c", line 9: no automatic aggregate initialization

The name list at first looks like a variable but is really a structure tag. Using a structure tag, you can declare other variables as being a structure having the form described in the structure tagged list, without having to enumerate the members. The structure has two members, both pointers to characters: name and number. Line B names the structure as phones, and we note that phones is an array. What we have created is an array of structures. Others might simply call phones a table.

The assignment operator here, as in the previous example, indicates that the variable phones is to be initialized. The three lines following are pairs of strings; the first to name and the second to number. The elements are separated by commas, with each "line" of the structure on its own line; this format helps readability.

In the printl statement we see how to access the members of the structure. The name of the structure is given first, then a pair to separate the two tokens, and then the member name. This example is admittedly contrived to show a simple example of a structure and how
to access members. We could have written the printf as
printf("%d12s, %d12s\n", phones[i]);

with the same result.

Quite apart from the topic of structures is the control string for the printf. The %d12s specifies that the output string is to be 12 characters long. Surprisingly, the strings are justified at the right margin in the field, as we see in the resulting output:

$ cc -o struct struct.c
$ struct

Jim Joyce 415-621-6415
Time 415-767-2676
Story 415-626-6516

This format conversion is simply part of printf. To have the string output justified at the left margin, we would write %-12s. Page 147 of Kernighan and Ritchie’s book details the options.

Going Further in C

By now you have seen quite a bit of the programming language C, but not all of it by any means. As you may have noticed, the examples have gradually increased in complexity and sophistication. By now you should have enough experience with the language to write useful programs and to learn more of the language from Kernighan and Ritchie. Among the topics you will want to read more about are preprocessor facilities, structures, and the Unix system interface. You might consider adopting the approach that has guided the examples you have seen here; that is, write programs for yourself that focus on the language feature you are learning. Then, once your example is working, modify it to introduce deliberate errors so you will recognize them later.

Another valuable tool for learning C is Alan Feuer’s The C Puzzle Book: Puzzles for the C Programming Language (Prentice-Hall, 1982). When you get a copy, be sure to add the missing right brace at the end of the program on page 53. Then key in each example and run it, taking care to include spaces, tabs, and blank lines where Feuer puts them.

The puzzles in Feuer’s book are working programs that illustrate the major aspects of the language: operators, basic types, included files, control flow, programming style, storage classes, pointers and arrays, structures, and the preprocessor. The second half of the book offers a step-by-step discussion of just what the programs do, with helpful diagrams for the puzzles about pointers. Do let me know about other simple examples of C constructs that should be shared, and there may be a follow-up article in the future.

James Joyce is president of International Technical Seminars Inc. (520 Weller St., San Francisco, CA 94117) and founder of the Unix Bookstore.
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I surrender. Next week I'm going out to buy an IBM Personal Computer, rotten keyboard and all. (Of course I'll use Jim Baen's Magic Keyboard on it; I haven't gone completely mad.)

Obviously there's a reason: software compatibility. Over in one corner there's four cubic feet of unevaluated software, much of which won't run on anything but an IBM PC.

Although a lot of machines claim to be 100 percent IBM PC compatible, I've yet to have one arrive at Chaos Manor. Now true: some of the machines we have, such as the Eagle 1600 with hard disk and the Eagle PC, have some awfully strong points compared to the genuine IBM. In fact, compared a feature at a time, I think I'd prefer the Eagle, which is faster and has a much nicer keyboard. A lot of our PC-type software runs quite well with the Eagle.

There's the Compupro 10-MHz 8086; Tony Pietsch has just dreamed up a new method whereby we can boot PC-DOS (the disk operating system for the IBM PC) off 5 1/4-inch disks even though the primary disk system for the Compupro machines is 8-inch. A fair amount of PC software will run with that machine, as well as, naturally, our Compupro 8085/8088 dual processor.

We also have the Zenith Z-100, which has a number of features in common with the PC. Some PC-type software runs fine with the Z-100.

Alas, a lot of stuff doesn't run with Eagle, Z-100, Compupro, or anything else we have around here. Some of that software looks pretty nifty. Then too, my contract for the Inferno game based on Inferno (Larry Niven and Jerry Pournelle, Pocket Books) calls for it to run on an IBM PC. Finally, I keep getting letters from readers concerning the genuine IBM PC: "Try it, you'll like it."

So I'm going to try it. While I'm at it, I'll try to buy the absolute minimum from IBM itself and get my disks and memory and such like from less expensive sources; that should give me something to write about and justify the expense.

The Eagle 1600

We've had the Eagle 1600 for about a month and it runs fine. Eagle justifiably brags about how easy it is to get this machine out of the box and up and running. It took us about 5 minutes.

The 1600 has a 20-megabyte hard disk that contains all the operating system and applications programs: the machine boots off that disk. When it comes up, you have a choice of Eaglerwriter, which is Lexisoft's Spellbinder text editor; Eaglecalc, which is a general-purpose spreadsheet; backing up the hard disk; exiting to the PC-DOS operating system; or shutting down the system.

Incidentally, that last choice retracts the hard-disk head and protects the system. The Eagle documents insist that you use that method whenever you turn off the system, and they warn you that if you shut down without going through the regular shutdown command sequence, you can damage things. The documents don't say what will happen if you have a power failure and can't use Eagle's orderly procedure. In my case what happened was nothing; the system worked fine after two blackouts.

Spellbinder is a more than adequate text editor with all the usual text-editing commands. I have friends who work for the U.S. Congress; they've been using Lexisoft's Spellbinder editor for a couple of years and are well pleased with it. A lot of special-function keys are on the Eagle's keyboard, and this version of
Spellbinder has been tailored to use them, making Eagle with Eaglewriter at least as easy to use as most dedicated word processors. I still prefer Zeke II and WRITE, but I'm pretty set in my ways. I can recommend the Eagle 1600—with reservations.

On the positive side, the Eagle's keyboard is much nicer than the IBM PC keyboard. It has a better feel, and the key layout is standard Selectric. It's also capable of doing everything the PC keyboard can do. Alas, Logitech's IBM PC Mouse won't work with the Eagle; I understand that both Eagle and Logitech are working on that problem.

Also very much to the Eagle's credit, it's fast, much faster than the IBM PC, and that makes up for a lot. Sorts and spreadsheet recalculations take about half as much time. If you're looking for a PC-like machine that runs much (but alas not, by a long shot, all) of the IBM PC software, check out the Eagles. They're well made, quiet, and likable machines, and they sure are fast.

There are a couple of drawbacks.

First, the Eagle 1600 is big, I mean really massive; the machine itself, without keyboard, measures 19 by 19 by 6 inches. The detached keyboard is also large, 19 by 9 inches, so that the Eagle plus keyboard barely sits on a desk 28 inches deep, and even then things are jammed together. You'll want to think about where to put the Eagle before you buy one; ideally, you'd want one of those workstation tables that has a separate (and lower) shelf for the keyboard. Given that, the Eagle's size won't matter.

Second, the screen's scrolling is not very pretty. When you scroll text, it sort of ripples up and down on the screen. Once it has scrolled, it's rock steady, and the character set is attractive enough. It all depends on what you're used to; some won't find this a problem at all. I do, but recall that my primary machine uses memory-mapped video for superfast scrolling and text movement.

Now to my reservations.

First: there's a fatal error in the Eaglewriter I have. The hard disk is disk A:, and a single floppy disk is designated C:. Disk B: does not exist. However, you can, from within Eaglewriter, try to access all kinds of nonexistent disks. With most, such as E: or M:, nothing happens. However, if you try to access B: for reading or writing, the machine hangs, and you must reset to get back in control. Any text you had in the text editor is lost. Text editors that lose text are not acceptable.

Second, PC-DOS 1.0 and 1.1 have no provision for user numbers or any other kind of structured directory; neither does the Eagle 1600. This means that the hard disk soon fills with programs, directories take a long time to list out, and finding anything becomes impossible.

Third, a lot of programs will run with the Eagle. You can boot Lotus 1-2-3, for example; you hold down the F key while the 1600 is booting up, and it will boot from a floppy disk rather than from the hard disk.

Once you have Lotus 1-2-3 running, the program complains that the Numlock key is depressed and urges you to fix that condition. There is no Numlock key. However, Control-Shift-N will have the same effect.
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as the Numlock key on the IBM PC.

Alas, those latter two features (how to boot from a floppy and how to numlock) are not documented; indeed, while the documents for Eaglewriter and Eagelecalc are really very nice, the system documentation for the machine itself is plain lousy.

Finally, I can't get Concurrent CP/M-86 to run on the Eagle 1600. That can be serious; see below.

I've told the Eagle people all this, and they claim that by the time you read this all will be fixed, with the possible exception of running Concurrent CP/M-86, and they'll work on that.

Certainly the fatal text-losing error will be fixed now that they're aware of it.

PC-DOS 2.0 has a structured directory system, and one assumes that by the time you read this the Eagle 1600 will have DOS 2.0 or later, making it a lot easier to find files.

Finally, it can't be that hard to write adequate documents for the machine, and they swear they're working on them.

Before you buy an Eagle 1600, check the above points. Otherwise, I can recommend this machine.

**Recommended Editors**

Ian Morton of St. Paul writes, "As respects CP/M, consider ED. No, don't consider it—wipe it out. Bury it in the Love Canal.

"Surely ED is the most preposterous piece of software ever written."

He's very nearly right. ED is the text editor you get free with CP/M. It's overpriced. No one could do any serious writing, whether creative text writing or programming, with ED.

Mr. Morton asks what editors I recommend.

I have a lot of text editors and have used most of them. The following are my personal preferences.

For text creation, we continue to use WRITE, which is for 8080, 8085, and Z80 machines only. Its strong points are that it is transparent to the point of invisibility and it's very flexible. I can write a lot of words in a big hurry with WRITE.

For programming, I continue to use Wordmaster, but that's in large part due to sloth; it's not really the best programming editor available.

Two very good programming editors are Superwriter, by Sorcin, and Vedit, by Compuview. Vedit is by all odds the most flexible programming editor I've ever seen. It is also one of the most complex. The version I've got isn't easy to install, and the instructions for learning to use it aren't at all clear. Ted Green of Compuview swears he's fixing all those problems as a result of my grousches.

A lot of good programmers swear by Vedit; one of its best features is multiple buffers; that is, you can store chunks of programs in various places and pull them out into your main file when needed.

Vedit also has excellent macro capabilities; that is, you can go through a long program and make complicated changes with conditions: such things as "If a GOTO statement is...

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Chart-Master™ turns volumes of complex data into easy-to-understand graphics.

"A picture is worth a thousand words." With this simple concept as a building block, Chart-Master is changing the way busy executives, analysts and secretaries look at, interpret and present information. In a fraction of the time required to wade through volumes of printouts, you can produce easy-to-understand bar charts, pie charts and scatter diagrams quickly and dramatically. Chart-Master makes it easy to customize reports and presentations with six different fonts, label placement, proportional pie charts and more.

Menu-driven Chart-Master allows you to enter data and select a chart format at the press of a button. You then preview your selection on your personal computer screen as it would appear in final form. Or, you can review the various Chart-Master graphic options to make sure you have selected the most effective format. When satisfied, you can transfer your selection to paper or acetate transparencies for a colorful, presentation-quality chart in seconds.

Chart-Master presents a clear picture of the "bottom line," which conveyors of information understand and decision makers appreciate. That's why major corporations like GE, Eastman Kodak, Exxon, Union Carbide, GM, AT&T, DuPont, 3M, Citibank, Motorola, Procter & Gamble, and GTE rely on Chart-Master to translate "volumes of complex data into meaningful information."

Chart-Master supports the IBM Instruments XY750, Panasonic VP Series, Houston Instruments DMP29, Yokogawa PL1000 and Strobe plotters, in addition to the Hewlett-Packard family of plotters, for use with IBM PC and other compatible computers.

The retail price of Chart-Master is $375. For a complete information kit and name of your nearest dealer, contact Decision Resources, Inc., 25 Sylvan Road S., Westport, CT 06880. (203) 222-1974.
followed by 456 then change it to GOSUB, and at the end of the line add the following REMARK.

Superwriter, though not as flexible, is much better documented and a lot easier to get running. It too has many positive features and a number of passionate supporters.

I intend a full review of both Vedit and Superwriter as soon as I have stable installations: both are somewhat dependent on what terminal you use, and around here that has changed several times in the past few weeks. By the time you read this, we will almost undoubtedly have converted to either Superwriter or Vedit as our programming editor.

Either Vedit or Superwriter would be adequate for text creation, although I'd hate to have to write this article with either.

Wordstar remains adequate. Used with a machine that's been tailored to it—as an example, the special-function keys for the Otronix have been geared to Wordstar—the editor goes well beyond adequate. Used with a silicon disk, or something like MicroCache, Wordstar really works. If I didn't prefer WRITE, I'd be tempted to Wordstar because there's so much auxiliary software, such as Footnote, and Index, and the like. As it is, I sometimes translate WRITE files into Wordstar so that we can use the auxiliary programs.

Magic Wand, which has become Peachwriter now that it's owned by Peachtree, and Palantir, which was written by the author of Magic Wand, the editor goes well beyond adequate. Used with a silicon disk, or something like MicroCache, Wordstar really works. If I didn't prefer WRITE, I'd be tempted to Wordstar because there's so much auxiliary software, such as Footnote, and Index, and the like. As it is, I sometimes translate WRITE files into Wordstar so that we can use the auxiliary programs.

Magic Wand, which has become Peachtree, now that it's owned by Peachtree, and Palantir, which was written by the author of Magic Wand, is more than adequate. Both have very good documentation, including tutorials. They have extensive "auto types" features, so that you can use them to send "personalized" computer-generated letters to a large mailing list. Each also has "features" I find annoying.

As mentioned above, Spellbinder is much more than adequate, and a lot of professionals swear by it. You want to get a version configured for the terminal you like, because a good part of Spellbinder's convenience comes from special-function keys; given that, it's quite a good editor, and very possibly what I'd adopt if I didn't have WRITE.

Mark of the Unicorn's MINCE and Final Word editors are quite nice if you're used to MIT's EMACS; if you're not, you might not like them. The commands tend to be complicated, and I don't care for the "philosophy"; that is, Control-f means "forward a space" while Escape-f means "forward a word." This is a mnemonic for some, but a pain for me. MINCE has a million commands; Control-meta-CokeBottle probably means something. Everything else does.

Lobo Users Group

Carl Rankin of Chelsea, Michigan, informs me there's a Lobo users group, Maximul, for those interested in the Lobo Max-80 computer. Barry Workman tends to rely on Ralph, his Lobo Max-80, for a great deal of production work, and he's never had a glitch. As I write this, there's not much software included with the Lobo; otherwise, it would be a strong contender for the best deal in microcomputerland. As it is, it's a lot of machine for the money.

A users group ought to make the Lobo even more valuable. An issue of Maximul's newsletter informs me that for $30 Lobo owners can upgrade their machines to run CP/M Plus. Maximul (POB 19525, Orlando, FL 32814) sells disks of utilities considered especially valuable for the Lobo.

CP/M Source Code

The darnedest thing I ever did see is a program called M/PC. Distributed by C. C. Software, M/PC will disassemble your CP/M 2.2x, add comments, and give you a commented source file. You no longer need MOVCPM to change your system, because you can reassemble the source code after making any changes (such as system size) that you like.

Naturally this is mostly useful to the hackers among my readership. For those who can use it, however, it's really neat.

The version I got was sold as an .INT file for CBASIC, along with a whole raft of data files that contain
"I hate the Qantex 7040 multimode printer."

Since the Qantex 7040 offers absolute compatibility with the Diablo 630 daisy wheel printer, it's not surprising the old gentleman is burned up. After all, now Diablo can be replaced on almost any of today's computers. What's more, all word processing systems having software that supports Diablo can be used with the 7040, protecting your investment.

What makes him boil, too, is the fact that the 7040 can do a lot Diablo can't. Not only is it a letter quality printer, but it performs like an angel for word processing, data processing and graphics.

Qantex 7040 combines both roller and tractor drive and easily handles both continuous form and single sheet documents.

When used for word processing, it gives you all the features of our 7030, such as proportional spacing, justification, auto underline, overprint and bold. You can also choose from up to 3 letter-quality fonts online without changing print wheels.

For data processing, the 7040 prints bidirectionally at 180 or 450 cps, and has 6-part forms capability. For graphics, the 7040 is full dot addressable, has a density of 144 x 144 dots per inch and offers a full selection of line drawing graphics.

With all its sophisticated capabilities, the 7040 is a workhorse. It has a 500-million-plus character print head and industrial quality construction.

Price? That's got the competition hot under the collar, too. See why. Contact Qantex for details or a demo at 60 Plant Ave., Hauppauge, NY 11788. Call toll-free 800-645-5292; in New York State 516-562-6060.

Qantex
the comments. MIPC disassembles the CCP (console command processor) and the BDOS (basic disk operating system) of your CP/M. It doesn't attempt to disassemble the CBIOS (customized basic input/output system). However, if you have your BIOS source—and you should—you now have everything you need to really customize heck out of your system.

Clark Calkins of C. C. Software says this is a goofy way to distribute a disassembly of CP/M, but he has no choice; else he'd be violating Digital Research's copyright.

You must run the program; it took about an hour with a 2.5-MHz Z80 and regular disks. With a 5-MHz 8085 and M-Drive pseudo disks (memory that your computer thinks is a disk drive; it's wonderful) the disassembly is a lot faster. I found this sufficiently interesting that I was willing to help Mr. Calkins and compiled his program with CB-80; it now runs in about 11 minutes on his system. I presume it would go in half that time on mine. I presume he now supplies the compiled .COM file as well as the .INT file.

MIPC sells for $35, and if you're at all interested in what's going on in your system, it's worth it.

Hacking Up Your Kaypro
If you like customizing your keyboard, it turns out to be simple with the Kaypro II. Daniel Wiener of Simi Valley, California, writes:

The Kaypro allows you to redefine the cursor (arrow) keys and the 14-key numeric pad by assigning any hexadecimal codes you want to them. . . .

I took advantage of this by simply setting the eighth bit: the keypad 0 was changed from 30 to B0; Enter was changed from OD to 8D; etc. Normal operation is not affected, since the eighth bit is usually ignored. But now the Enter key is potentially distinguishable from the Return key.

Next I bought a neat little program called Smartkey ($60 from Heritage Software Inc.). It intercepts keyboard calls to the CP/M BIOS, and allows you to redefine any key as a string of commands and/or characters.

He uses this to redefine various keys for use with text editors. I'm trying to see if we can do that to redefine escape sequences sent by terminals like the Telewedge; that would really be useful. So far we haven't been able to do it. Even so, Smartkey is a good value for those who like customizing their systems.

Appli-card for Apple
The PCPI 6-MHz Appli-card is a one-card solution to running CP/M on the Apple. Being very fast, you notice the speed improvement over the Microsoft Softcard. The Appli-card has a one-disk copier program, letting you copy any CP/M Apple disk. My boys installed it, and they use it a lot.

The Appli-card converts the Apple to 70-column video, with uppercasing and lowercasing. (These work only when the Apple is under CP/M.) Running it is simple: put in the CP/M master disk, and it boots as CP/M; put in any other disk, and it boots as
Amazing! This was Printed on an Epson
by The Fancy Font™ System from SoftCraft

Letter Quality
Say good-bye to correspondence quality and hello to Fancy Font's high-resolution, proportionally spaced, letter quality. Fancy Font provides fonts in sizes from 8 to 40 points; styles include Roman, Bold, Italic, Script, Old English, and more (see samples below). All this on low-cost Epson MX and FX printers.

Create Your Own Characters
You can use over 30 font sets in the Fancy Font package and furthermore, can create any new characters or logos you like, up to 1 inch by 1 inch. A database of over 1500 characters is included in the package.

Font Style and Size Samples
(actual size)
8 point Roman 10 point Roman 12 point Roman
18 point Bold 18 pt. Sans Serif
18 pt. Italic 20 pt. Script
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Easy-to-Use
Fancy Font is a software package for CP/M and IBM PC compatible systems; no special hardware or installation is required. With Fancy Font you use your favorite editor or word processing package to create a file to be printed. Include as few or as many formatting directives as you desire. Then use Fancy Font to print your file.

Numerous Applications
Fancy Font customers are constantly discovering new applications. For example:
- Business and personal letters
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- View Graphs
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SoftCraft, Inc 8726 S Sepulveda Bl Suite 1641 LA, CA 90045 (213) 821-8476

Fancy Font now available for CP/M and IBM PC systems!
an Apple. Because the Appli-card has its own onboard memory, you can have up to a 64K-byte CP/M system.

In fact, this is in essence a one-card computer that turns your regular Apple into a kind of terminal. You can think of it as a computer that happens to use parts of the Apple.

Incidentally, when running under Appli-card, Reset forces a CP/M cold boot, giving you a way out of some programs. Under regular Apple DOS, Reset may not do anything at all, and sometimes the only escape is to turn the machine off . . .

Epystack's New World
Reviewed by Richard Poumelle, age 12, a user.

"New World is about the conquest and colonization of the New World. There are three countries: Spain, France, and England. You may play a one-, two-, or three-person game."

"The main flaw is that Spain is the weakest country, but when you play a one-player game you always get Spain. The computer gets France and starts with 16 colonists, while Spain has only 2."

"The game is rather slow. Sometimes if you hit Return when you are not supposed to, it stops the game and you cannot restart it. Also, at one time, for no reason at all, it took away my chance to go on an expedition."

"The graphics are very nice, also the way the letters are written is very nice. I don't like it much when you have to play against the computer, but if you play a three-person game it is fun. It is sort of a family-type game. On a rating of 1 to 10 I would give it a 5."

Book Learning
When I first got involved with microcomputers, there weren't a lot of choices about programming languages; you used BASIC, which was cumbersome and slow, or you used assembly language, which was fast but hard to learn.

Assembly language is one (fairly large) step up from what the computer itself knows. That is: in BASIC

if you want to add two variables, you say something like

LET A = A + B

while in assembly language you must find the address of A, move the number into the accumulator, find the address of B, add what's at that address into the accumulator, then take the result and store it where you found A. Of course that's what the BASIC statement did, but higher-level languages spare you the gory details.

It's now possible for computer users to get along without ever learning assembly language, which is just as well, because assembly-language programs are by definition not portable. (In the example above we assume there is an accumulator, which isn't true of all systems; even where the instructions are similar, an assembly program written for one kind of machine is highly unlikely to run on another.)

However: if you're after fast and efficient programs that don't waste memory, there's nothing like assembly language. Fortunately, some fairly good books on the different assembly languages are available. I'm not competent to judge the merits of most of them. However, I have done some 8080 and Z80 assembly-language programming, and for those I found the best reference works to be the Osborne/McGraw-Hill books by Lance Leventhal.

Leventhal's books have an introductory section explaining what assembly languages are and why they're important. Even so, they wouldn't be my first choice as elementary texts—but I would be sure to get the proper Leventhal book at the same time I bought the elementary textbook, because his examples are clear and his books are very complete.

Leventhal has written a whole series of these works covering just about every microcomputer chip. As it happens, I've known Lance Leventhal since I served as his unofficial high school adviser in Seattle in the early 60s. I therefore have some confidence that all his books will be as good as the ones I can read.
Now your computer can say anything and say it well.
Introducing the Votrax Personal Speech System.

Quite articulate.
The unlimited vocabulary Votrax Personal Speech System is the most sophisticated, low cost voice synthesizer available today. Its highly articulate text-to-speech translator lets your computer properly pronounce conversational words at least 95% of the time.
For all those unusual words and proper names, you can define an exception word table and store your own translations. And remember, the entirely self-contained Votrax PS System gets your computer talking without using any valuable computer memory.

Built-in versatility.
Much more than just a voice output device, the Votrax PS System lets you mix either speech and sound effects or speech and music. A programmable master clock and 255 programmable frequencies give you unmatched control of speech and sound effects.
The Votrax PS System offers user expandable ROM for custom applications, user downloadable software capability and sound effects subroutines for easy user programming. Its programmable speech rate provides more natural rhythm, while 16 programmable amplitude levels give you greater control of word emphasis.
Actual size: 12.2" x 4.5" x 2.6"

Friendly to humans.
Designed to look like a printer to your computer, the Votrax PS System is extremely easy to use. It can be used in tandem with your printer without an additional interface card. Both serial and parallel ports come standard, allowing you to connect the Votrax PS System to virtually any computer. Speech, music and sound effects are only a PRINT statement away.

What to say after "Hello".
Businesses will appreciate spoken data transmission, narration of graphic displays and unmanned, oral product demonstrations. Spoken verification of data input will make computers much easier for the blind to use. School children can receive comprehensive computer instruction with voice textbooks as well as spoken drills and testing. And then, late at night, you can make those adventure games explode.

A quick list.
- Highly articulate Votrax text-to-speech translator.
- 255 programmable frequencies for speech/sound effects.
- 16 amplitude levels.
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- Real time clock and 8 user defined alarms.
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- Programmable Baud settings (75-9600).
- Interrupt driven Z-80 microprocessor.
- Parallel Serial interconnect modes.
- Proper number string translation: the number "154" is pronounced "one hundred fifty four".

To order, see your local computer retailer or call toll-free
1-800-521-1350

Michigan residents, please call (313) 588-0341. MasterCard, VISA or personal check accepted. The price is $395 plus $4 for delivery. Educational discount available. Add sales tax in Michigan and California.

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Circle 476 on inquiry card.
They all look useful. For some in the book aren't listed until page 163. The listing there is complete enough, once you find it.

There's a good section on programming practices and another on common errors. Both would be better for an analytical table of contents. The other books in the series have excellent analytical contents tables; I can't think why this one doesn't.

Don't let that stop you from getting the book, though; if you're writing in Z80 assembler, it's just about guaranteed to save time and frustration.

Floods of Programs

We get a lot of programs. For some reason, a lot of them come packaged in a rather odd way.

Typically, in these cases, the documents are printed on cheap paper offset from a Spinwriter. We read the documents two or three times, and sometimes we figure out what the program does. Sometimes, though, we're just out of luck. We're fairly sure it does something, but we can't quite puzzle out what.

The documents are generally written by a programmer. Typically they say, "Here's this program. I use it a lot, so it's easy to use. I like it, and you will too. It's set up to run on a TzQ-820 terminal running off the Z79 chip; it might not run on your system, but just use DDT to patch it in the usual way, and I'm sure you'll love it."

 Needless to say, every office has suitable receptacles for stuff like that...

More Licensing Agreements

Ralph McElroy of ZXY Controls sends his candidate for the Most Absurd Licensing Agreement of 1983. It looks to be a leading contender.

It's from Avocet Systems Inc., apparently for an 8048 cross-assembler. Under this agreement, you promise to destroy all the software within five days if Avocet cancels your license.

Avocet explicitly warrants absolutely nothing if you use its program with any non-Avocet software (such as CP/M). If the disk is no good and you respond quickly enough, Avocet might replace it, although it doesn't have to.

The agreement also incorporates a "Statute of Limitations" as follows:

7.6 Statute of Limitations. No suit shall be brought on an alleged breach of this Avocet Warranty more than Twelve (12) months following delivery of the SOFTWARE to LICENSEE.

Apparently, no one has told its lawyer that a statute is an act of a legislature, not a term in a contract. Ah, well.

It also says that if you open the package and don't sign, you'll be deemed to have signed the warranty anyway. If you do sign, you're to send the company the make, model, and serial number of your computer; naturally you've agreed to use its product on one and only one machine. The agreement doesn't say you can take the output of the cross-assembler and use it on another machine; one presumes Avocet will allow this because otherwise the product is useless.

There's enough of this sort of thing that I'm contemplating an award each year in the April issue of BYTE for Most Absurd Licensing Agreement Silliest Documentation Most Obscure Document

Readers are encouraged to send me candidates. The award is guaranteed to be valueless and in bad taste. It should be much coveted.

Happy Endings

Some time ago I got a copy of a letter to Bill Godbout from an information systems company in Quebec. It was written in much better English than my French.

The problem was that the company had bought a Compupro system and it wouldn't boot. The Canadian company had bought the system through was either unwilling or unable to help. Godbout's people tried, but over the phone they couldn't figure out what was wrong (I don't know if Chris or Peggy speaks French; if not, they must have really had a time of it)...

The company sent another letter to Godbout. "Because we found it so difficult to proceed only by phone and mail, we decided to find somebody who wanted to receive us. We contacted Micro-Computer Technology Corp. in Florida and they accepted."

The consultants soon discovered that the ROM (read-only memory) chip sent with the Disk 1 controller was for software version E, while the CP/M system received was version F.

The letter continues, "As our system was now working, we bought an M-20 hard disk from Pragmatic Design with a Disk 2 controller and an extra RAM16 board. . . . it is important to have centers that are responsible and friendly like Micro-Computer Technology.

"We are now running our system with CP/M-86 and Pascal MT+86 for nearly one month and we are very happy. The system is the fastest microcomputer we ever saw. I want to let you know how happy we are to arrive at the end of problems with our system."

When ordering equipment across international boundaries it's especially important to work with systems integration people who know what they're doing. Many of the problem stories I hear—and all of those concerning Compupro equipment—involve international transactions. If you intend to mix equipment, be especially careful you're dealing with people who know what they're doing.

Not long ago I read in Infoworld the sad story of a lawyer who decided what equipment she wanted (it wasn't what I'd have recommended) and proceeded to purchase it by ordering parts from three different places, each of which had a special price. She saved a few hundred dollars that way, but the result was horrible.

What did she expect? As someone later commented about her case, if you decided you wanted a Harvester engine, Fisher body, Bendix brake
system, Saginaw steering, and shopped by mail for all these by price alone—would you expect to have a working car when you got done?

S-100 bus systems have nearly become standardized; but it's just not true that randomly selected S-100 systems are certain to work together, unless they're really and truly IEEE-696 standard (and not just "696 compatible"). Even then you want to know what you're doing.

Know what you're doing, or deal with those who do, and you can assure yourself of a happy ending, at ultimately lower costs.

Zenith Z-100/IBM PC Compatible

This is going to get a little technical. Sorry, it's important.

Victor Wright of Louisville, Kentucky, has a Zenith Z-100 and has done considerable research on which IBM PC programs will run on it.

In CP/M and Zenith ZDOS, the BIOS is a program on the so-called system tracks of your master disk. It is read into the machine when you first turn it on (or reset). The 8088 chip allows a total of 256 different interrupts. ZDOS uses interrupt 21 to make BIOS calls: such things as "Read a character from the keyboard," or "Close file," or "Rename file," or "Print a character to the console," etc. This is all explained in some detail in the BIOS source code, which is furnished with ZDOS.

Alas, IBM built the CBIOS for the IBM PC into ROMs. That has its good points, but it also causes some problems because you can't make changes.

Here's where the incompatibilities come in: although PC-DOS uses interrupt 21 just as ZDOS does, it also uses a number of other interrupts that call the BIOS directly—and those are not implemented in the Z-100. The result is that programs for the IBM PC that use interrupts below 20 hexadecimal will blow the Z-100 sky-high.

The upshot, according to Mr. Wright, is that if you're contemplating PC software for the Z-100, test it before you buy it or else be certain that it doesn't use interrupts below 20 hexadecimal. I'm not en-
Congratulations. We published your program.

The envelope, please.
There's an acceptance letter inside. And a check that could have your name on it. (If we select your program, that is.)

But remember.
We pick our winners carefully.

Because the software we publish for the IBM Personal Computer has to be good enough to complement IBM Personal Computer hardware. (See the box at right.)

Like our hardware, this software should be simple to use. Friendly. Fast. And written to help satisfy the needs of the individual.

Our Personal Editor is a perfect example. A versatile text editor, it not only helps the user save time, but lets him easily tailor a task with definable function keys. And it sets a standard of excellence.

Of course, every person will use the IBM Personal Computer differently. That's why we plan on publishing many different programs.

Entertainment programs. And educational programs. And business programs. And personal productivity programs. And graphics. And games.

And more.

We'll also consider software written by programmers for programmers. For example, the BASIC Program Development System, Professional Editor and Diskette Librarian.

---

IBM PERSONAL COMPUTER SPECIFICATIONS

<table>
<thead>
<tr>
<th>User Memory</th>
<th>Display Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>64K-60K bytes</td>
<td>Color or monochrome</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>High resolution</td>
</tr>
<tr>
<td>InNat 8008</td>
<td>80 characters x 25 lines</td>
</tr>
<tr>
<td>Auxiliary Memory</td>
<td>Upper and lower case</td>
</tr>
<tr>
<td>2 optional internal</td>
<td>Operating Systems</td>
</tr>
<tr>
<td>diskette drives, 3.5&quot;</td>
<td>DON CAS Operating System</td>
</tr>
<tr>
<td>32K/32K/64K/64K /</td>
<td>CP/M/805</td>
</tr>
<tr>
<td>per diskette</td>
<td>Languages</td>
</tr>
<tr>
<td><strong>Keyboard</strong></td>
<td>BASIC, Pascal, FORTRAN</td>
</tr>
<tr>
<td>90 keys w/ 6, cord</td>
<td>MAC II Assembly</td>
</tr>
<tr>
<td>attachable to system unit</td>
<td>C II III</td>
</tr>
<tr>
<td>10 function keys</td>
<td>Printer</td>
</tr>
<tr>
<td><strong>Diagnostic</strong></td>
<td>All ports addressable</td>
</tr>
<tr>
<td>Power on self testing</td>
<td>graphics capabilities</td>
</tr>
<tr>
<td>Panel checking</td>
<td>Bisectorial</td>
</tr>
<tr>
<td></td>
<td>10 character symbols</td>
</tr>
<tr>
<td></td>
<td>16 character styles</td>
</tr>
<tr>
<td></td>
<td>9 x 12 character matrix</td>
</tr>
</tbody>
</table>

Permanent Memory

IBM 160K bytes

Color/Graphics

For model:

160 char.

256 characters and symbols on IBM Graphics console

4 color resolutions

256 x 256
capability

Com munications

RS-232 C Interface

NEXT interface

Baud rates in multiples of

150, 300, 1200 bits per second

---

The IBM Personal Computer

A tool for modern times

Circle 507 on Inquiry card.
tirely certain how you can make sure it doesn't use those, short of asking the program's author; few dealers would know.

We've found that some PC programs run on the Z-100 and some don't. Lotus 1-2-3 doesn't, although by the time you read this there may be a Z-100 version of it. IBM PC Pascal runs fine. CBASIC and CB-86 for the PC work.

A sufficiently clever programmer could probably rewrite the ZDOS BIOS to make the machine entirely compatible. I've heard rumors of a ROM for the Z-100 that would do the same job, but I don't yet know where to get one. Incidentally, Mr. Wright concludes, "I certainly won't trade my Z-100 for any other computer."

While we're on the subject of the Z-100, one of my major complaints about it is that the big color monitor is both too big and has no controls whatever. At NCC I saw a new color monitor working with the Z-100. It's smaller, sharper in image, and has full controls. Anyone contemplating a Z-100 ought to insist on seeing the new screen.

There's also a persistent rumor that next year Zenith will bring out a version of the Z-100 with a detachable keyboard. I sure hope so; the Z-100 keyboard is much nicer than the IBM PC keyboard, but it's attached to that really big machine; it would be a lot easier to use if the keyboard were detachable.

**One Way to Tame a Telewidget**

I've made no secret of my difficulties with the Back Tab key on my Televideo 950; because it is placed outboard of the Shift key and just below Control, it's very easy to hit by mistake.

Several readers took pity on me and sent little plastic gizmos called "keylocks." They look like little plastic horseshoes. It's not at all obvious how they go on—one must have faith that they will go on before you can put them on—but they sure do the job. It's now impossible to depress the Back Tab key on both our Telewidgets. This greatly improves my temperament.

Incidentally, we're probably going to abandon the Televideo for the Zenith Z-29 terminal. I'd probably have done that already except that NCC and other stuff interfered with getting my favorite text editor installed on it properly. We like the Z-29 a lot, and anyone contemplating purchase of a terminal really ought to look at one.

**Creeb File**

I like the new manual sizes used by IBM and Digital Research, really I
SuperSoft BASIC Compiler
for CP/M-86®, MS DOS, and PC DOS

Compatible with Microsoft BASIC
The SuperSoft BASIC compiler, available under CP/M-86 and MS DOS, is compatible with Microsoft® BASIC and follows the ANSI I standard. If you want to compile BASIC programs under CP/M-86, PC DOS, and MS DOS, SuperSoft's BASIC compiler is the answer.

Greater accuracy with BCD math routines
If you have used other languages without BCD math, you know how disconcerting decimal roundoff errors can be. For example:

<table>
<thead>
<tr>
<th>With IBM PC* BASIC</th>
<th>With SuperSoft BASIC with BCD math</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 A=.99</td>
<td>10 A=.99</td>
</tr>
<tr>
<td>20 PRINT A</td>
<td>20 PRINT A</td>
</tr>
<tr>
<td>30 END</td>
<td>30 END</td>
</tr>
<tr>
<td>Output: .9899999</td>
<td>Output: .99</td>
</tr>
</tbody>
</table>

As you can see, SuperSoft BASIC with BCD provides greater assurance in applications where accuracy is critical.

SuperSoft's BASIC is a true native code compiler, not an intermediate code interpreter. It is a superset of standard BASIC, supporting numerous extensions to the language. Important features include:

- Four variable types: Integer, String, and Single and Double Precision Floating Point (13 digit)
- Full PRINT USING for formatted output
- Long variable names
- Error trapping
- Matrices with up to 32 dimensions
- Boolean operators OR, AND, NOT, XOR, EQV, IMP
- Supports random and sequential disk files with a complete set of file manipulation statements
- IEEE floating point available soon as an option

In addition, SuperSoft BASIC has no run time license fee. SuperSoft's line of fine language compilers includes FORTRAN, BASIC, C, and Ada.

Requires: 128K memory
BASIC compiler: $300.00

SUPERSOFT LANGUAGES: THE STANDARD OF EXCELLENCE.


SuperSoft BASIC lets me run compiled BASIC programs under either CP/M-86 or MS DOS.

*SuperSoft BASIC is compatible with Microsoft BASIC interpreter and IBM PC BASIC. Due to version differences and inherent differences in compilers and interpreters some minor variations may be found. Machine dependent commands may not be supported. The vast majority of programs will run with no changes.

Requires: 128K memory
BASIC compiler: $300.00

SUPERSOFT LANGUAGES: THE STANDARD OF EXCELLENCE.

Circle 420 on inquiry card.
do—but why couldn't they have given us some blank paper properly punched? I have discovered that stationery stores have several not-quite 8½ by 11 sizes of notebook paper, and only one is the proper size for adding to the new manuals. Alas, whichever one I buy is not the right one.

Meanwhile, I have got some review software that is bundled in a notebook that is yet another size, neither full 8½ by 11 nor the smaller size favored by DR, nor even 9½ by 6 which I brought home by mistake...

Please, fellows?

Language War

The war between Digital Research and Microsoft is heating up, now that Digital Research is heavily into languages and Microsoft is marketing the MS-DOS operating system. It's hard to say who's winning, although it is clear that Digital Research made some terrible mistakes in the marketing of its CP/M-86.

The IBM PC can run the Microsoft MS-DOS (called PC-DOS) or Digital Research's CP/M-86. Neither actually comes with the machine, but nearly everyone buys PC-DOS. You could buy CP/M-86 at extra cost, but that cost was high; consequently, fewer than 5 percent of PCs were sold with CP/M-86, and Digital Research found itself squeezed out of the fastest-growing microcomputer market.

Like The Empire, DR has struck back: first, it's dropped the price of CP/M-86 for the PC to something less unreasonable. Second, it put out CB-86, its CBASIC Compiler, to run with MS-DOS. Third, it developed Concurrent CP/M-86, which is the most exciting new operating system I've yet seen. Note: I've recently learned that all DR languages will now run with PC-DOS.

Concurrent CP/M-86 is a way of making your IBM PC get instant schizophrenia: you can make it run up to four jobs at once. As an example, you can write a text file and start it printing; then, leaving that run, you can bring back the editor and edit another file. Unlike "spooler" programs, this method works without distracting you.

You can compile a long program while simultaneously editing another; look up data in one file while editing something else entirely; and in general be up to four separate users without having separate terminals or equipment. I expect Concurrent CP/M-86 to become very popular with PC users.

That was Digital Research's move. Microsoft, meanwhile, has challenged DR's popular CB-86 CBASIC Compiler: it's brought out Microsoft Business BASIC.

Business BASIC is a recognizable outgrowth of regular Microsoft BASIC, but it has a number of features obviously derived from CBASIC. It even comes with a program suggestively named CTOMB that will convert CBASIC source files into MS Business BASIC.

Business BASIC is both interpretive and compilable. Like CBASIC, it requires no line numbers; referenced lines must be identified, but that can be by a label rather than a number. However, that's for the compiled program only; if you want to run the program interpretively, you still must use numerical line numbers for every line.

A number of features formerly in
SuperSoft FORTRAN is the answer to the growing need for a high quality FORTRAN compiler running under CP/M-86 and IBM PC DOS. It has major advantages over other FORTRAN compilers for the 8086. For example, consider the benchmark program used to test the IBM FORTRAN in InfoWorld, p. 44, Oct. 25, 1982. (While the differential listed will not be the same for all benchmark programs, we feel it is a good indication of the quality of our compiler.) Results are as follows:

<table>
<thead>
<tr>
<th>IBM FORTRAN:</th>
<th>38.0 Seconds</th>
</tr>
</thead>
<tbody>
<tr>
<td>SuperSoft FORTRAN:</td>
<td>2.8 Seconds</td>
</tr>
</tbody>
</table>

In its first release SuperSoft FORTRAN offers the following outstanding features:

1. Full ANSI 66 standard FORTRAN with important extensions
2. Standard data types, double precision, varying string length, complex numbers
3. Free format input and free format string output
4. Compact object code and run time support
5. Special functions include string functions, dynamic allocation, time/date, and video access
6. Debug support: subscript checking, good runtime messages
7. Full IEEE floating point
8. Full 8087 support-available as option ($50.00).

Program developers:

SuperSoft’s family of FORTRAN compilers means you can write your programs once and they will run under CP/M-80, CP/M-86, and MS DOS. This lets you get your applications running fast no matter what the environment.

The current compiler allows 64K code space and 64K data space with expansion anticipated in future releases.

SuperSoft FORTRAN: available NOW and working great!

Requires: 128K with CP/M-86 or MS DOS, 32K with CP/M-80
Price: $425 (in each environment)
CBASIC have been added to the Compilable version of Business BASIC. The language has been made modular, so that you can compile chunks of it and link them together at a later time; this is a great boon for developing large programs. Business BASIC allows multiple-line functions. Another new feature is external subroutines called "subprocedures." Both functions and subprograms can be called by name; you don't have to "GOSUB."

Enough differences exist between MS Compilable Business BASIC and DR Compiled CBASIC to make impossible any simple comparison. MS Business BASIC allows compact random-access files that take up considerably less disk space than CBASIC's; but you pay for that by having to learn the dreaded FIELD statement, and LSET, and other horrors. CBASIC's documentation is much better than Microsoft's for Business BASIC; Digital Research has made enormous improvements in its documentation.

Neither language has a noticeable speed advantage. The Microsoft system has some advantages: you can test out various tricks in the interpretive mode, thus finding out quickly whether or not something will work. On the other hand, to do that you have to use line numbers, and some of the tests you want to perform won't work in the interpretive mode, which can be confusing. Both compilers allow separate compilation and modular program construction.

I have a mild preference for Compiled CBASIC's method of libraries from program modules, and CBASIC does have one very large advantage. The new Compilable Business BASIC lets you chain programs together and create overlay programs. If you're writing programs for sale, however, you must pay Microsoft a royalty for using its run-time library. There is a "free" library module for Compilable Business BASIC, but it does not support chaining programs and putting variables in common. Thus, if you're thinking of creating large programs for sale, you should look into Microsoft's royalty pricing before making a decision.

Both compilers are priced far too high. We can hope that continued competition will remedy this situation: in fact, next month I hope to report on a BASIC compiler that will sell for less than $100.

The Atari Connection

Vincent Cate continues to improve his Critical Connection. This gadget makes an Atari think a CP/M computer system is a set of disks. The only requirement is that your CP/M system have an RS-232C serial port operating at 19,200 bps. Given that, you needn't buy disks for an Atari; by using the Critical Connection, you can make the Atari believe you have four disks. The really nice part is that you can use 8-inch as well as 5½-inch disks.

Cate's new software package has automatic installation for a number of CP/M systems, including Kaypro, North Star, Sanyo, CCS, Heath/Zenith, and Morrow. He also explains how to use DDT to install it for other systems; you'd need to know something of what you're doing to do that. Cate's documentation is improved, but it's not what I'd call good. Still, you can puzzle it out, and if you don't want to invest a lot in an Atari system but still want to use disks with it, Cate's Critical Connection is the way to go.
Your computer can probably do more for you than you originally thought. And learning to expand its capabilities is as easy as reading a good book.

SYBEX is the pioneer of computer book publishing, offering over 60 titles developed for beginners through advanced. They are so well written and easy to understand that virtually anyone can learn to operate a computer in a matter of hours.

**Doing Business with Pascal** by Douglas Hergert and Richard Hergert ($17.95) The first of its kind, this book uses examples and explains how to design business systems in Pascal, write practical business programs and use powerful Pascal language.

**Your First BASIC Program** by Rodney Zaks ($9.95) Write your first BASIC program in one hour! At last, a "how-to-program" book for the first-time computer user, aged 8 to 88. Colorful illustrations and simple diagrams make this book both easy and entertaining.

**Mastering CP/M** by Alan R. Miller ($16.95) Now you can use CP/M to do more than just copy files. With this book you will learn how to incorporate additional peripherals with your system, use console I/O, use the file control block and much more. Also included is a library of useful macros.

**The Apple Connection** by James W. Cottron ($12.95) Now you can learn the simple techniques for pulling your computer to control external non-computer devices in your home or office. Design a computer-controlled burglar alarm system and control lights, electricity, and other non-computer devices in your home or office. And all are explained in simple, non-technical terms.

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Prior to the announcement of micro/SPF™ development software, experienced programmers felt programming a personal computer was a lot like playing with a toy. You couldn't take it seriously.

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Programming experts can take advantage of skills they've spent years perfecting.

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Programming professionals who've spent years perfecting the art of writing sophisticated code deserve to work with state-of-the-art tools, not toys. Find out how micro/SPF™ can help you do work-compatible programming on your personal computer today!
The IBM PC and the Intel 8087 Coprocessor

Part 2: Interfacing to IBM Pascal

Using the 8087, you can speed up most Pascal programs by at least a factor of three

by Tim Field

Last month we looked at the Intel 8087 Numeric Data Processor (NDP) and saw how to provide software support (M8087.MAC) for the assembly-language programmer using the IBM Macro Assembler. This month we build on the support provided by M8087 to develop a higher level of support for the Pascal programmer using the IBM Pascal Compiler.

This software support package consists of two basic components: PAS87 (listing 1) and P87_INT (listing 2). PAS87 is an assembly-language file that, through the extensive use of the macro-processing capability of the IBM Macro Assembler, builds a set of assembly-language subroutines that are Pascal-callable as standard procedures and functions and provide complete access to the full 8087 NDP instruction set.

P87_INT is a file of Pascal procedure declarations that define all routines found in PAS87 in such a manner that the Pascal compiler can readily access those routines. The P87_INT file is to be included in any Pascal program that uses a PAS87 operation.

PAS87 Overview

The best method of providing Pascal support for the 8087 would be to make that support invisible to the programmer. In this approach, if the program executed a "y := x + z" instruction, the concern whether this was executed using software routines or the 8087 would be immaterial to the user—the compiler would automatically emit the code for the 8087 use. Under this scheme, any standard Pascal program would show some level of performance improvement by a simple recompilation of the program using a revised compiler. The problem with this approach is that it requires rewriting portions of the compiler. This non-trivial task is beyond the scope of this article.

The PAS87 software support presented here does not provide this "invisible" support. Rather, it lets you execute 129 individual 8087 instructions, each of which is callable as an external Pascal procedure. Because individual 8087 instructions are fairly powerful, you can get a lot of work done with only a few 8087 calls—the biggest drawback is that the user must be conscious of the inner workings and current state of the 8087. As a bonus, direct use of the 8087 lets the Pascal programmer "cheat" the Pascal type-checking mechanism by manipulating data types that the IBM Pascal Compiler does not allow.

The Pascal Frame

When a Pascal procedure or function is compiled, the code produced
is a typical machine-language subroutine. A standard mechanism (defined in the IBM Pascal User’s Manual) specifies how parameters are passed to the procedure or function and how, in the case of a function, a result is returned to the caller. Any time the compiler finds an invocation of a procedure or function, it emits the machine-language code that causes the parameters to be set up properly, calls the subroutine for the procedure or function, and handles the result returned by a function.

The IBM Pascal Compiler provides the means by which we can write our own procedures or functions in assembly language. As long as we meet the parameter-passing requirements established by the compiler, our routine can find and use the parameters passed to it by Pascal; if necessary, it can also return results to Pascal.

A knowledge of frames is needed to modify but not to use the PAS87 file in Pascal programs. If you want to know more about frames, look at the “Internal Calling Conventions” section of the IBM Pascal User’s Manual.

PAS87–8087 Support for the Pascal Programmer

The most important initial question in deciding how to support the Pascal compiler to access the 8087 is “How do we want to trade off performance versus code size?” The constant battle in software development is deciding whether to sacrifice some performance to gain in the compactness of the resulting code or to instead sacrifice the code length for maximum speed of execution. The final verdict almost always lies at some happy medium within the boundaries of the two extremes.

For PAS87 the two extremes were these: first, we could develop a single assembly-language subroutine that would receive as parameters the 8087 operation to be performed and any parameters needed for that operation; second, we could develop a separate subroutine for each and every 8087 operation. In the former case, we would have no repetition of

Listing 1: The PAS87 assembly-language file, when compiled and linked to a Pascal program object file, lets the program use the 8087 Numeric Data Processor through procedure calls. To save space, the functions CHK87, EXAM87, GETST, and STATUS have been omitted. Their full definitions, starting with the word PUBLIC and ending with the word ENDP, should be copied into this file from listing 3 of last month’s article.

```
Listing 1 continued on page 334
```
If you bought your computer to save time, then you need SUPER, the most powerful database system you can use. Power is a combination of speed, ease of use and versatility. SUPER has them all.

FAST - To demonstrate SUPER's speed, ISA retained a professional dBASE programmer to benchmark SUPER vs. the acknowledged leader. A simple mailing list application was chosen to minimize dBASE programming cost. The results:

<table>
<thead>
<tr>
<th>Task</th>
<th>SUPER Time</th>
<th>dBASE II Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up/Program</td>
<td>5:20 min.</td>
<td>12:18 hrs.</td>
</tr>
<tr>
<td>Input 100 records</td>
<td>50:29 min.</td>
<td>1:27:50 hrs.</td>
</tr>
<tr>
<td>Sort &amp; Print Labels</td>
<td>6:41 min.</td>
<td>4:18 min.</td>
</tr>
<tr>
<td>Totals</td>
<td>1:02:30 hrs.</td>
<td>13:50:08 hrs.</td>
</tr>
</tbody>
</table>

Notice that SUPER was faster at every task where your time is involved—and saving your time is probably the whole reason you bought a computer.

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various sections of code, but the code would be complex and would require numerous tests to determine the operation being requested. In the latter case, we would be able to maximize the performance of each interface to the 8087, but the large number of definitions would add to the length of the PAS87 file.

After realizing that the main reason for using an 8087 chip is to decrease program execution time, I found that I could follow the latter objective without prohibitively adding to the size of the program that uses PAS87. The PAS87 package we are about to look at in detail increases the size of a compiled Pascal program by some 5000 bytes, which will increase the size of the “average” Pascal program by about 12 percent. At the same time, execution speed of a Pascal program making heavy use of the 8087 via PAS87 can be cut by 67 percent or more. This is, in my opinion, an acceptable trade-off.

Dividing the Tasks

At first glance, it appears that we will have to individually write every one of the 129 routines to be included in PAS87. This would be a repetitive and error-prone job, definitely not a task to look forward to. For example, 11 different 8087 operations use a short-real memory operand. Each requires identical manipulation of the operand and will differ only on the actual 8087 instruction escape (ESC) sequence.

Because PAS87 is written entirely in assembly language, the power provided by the IBM Macro Assembler as discussed last month indicates that repetitive functions can be handled easily and automatically through the use of macro definitions. This approach works beautifully and greatly simplifies the building of PAS87.

Upon examination, the 8087 operations fall into two basic categories: those that don’t require parameters and those that do. For example, the classical stack operation FADD doesn’t require parameters. It always operates on two values already in the 8087 system stack. On the other hand, the 8087 operation FADD
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SHORT R VALUE requires a parameter (R VALUE in this case) that specifies the real number to be added from memory to the top element on the 8087 stack.

Of the 129 operation types that PAS87 supports, 44 don’t require parameters. We can make these operations accessible from Pascal through a procedure call that passes no parameters. We can divide the 85 remaining PAS87 operations, all requiring parameters, into four subgroups: 24 operations requiring a real-memory operand, 24 requiring an integer-memory operand, 24 needing register numbers (specifying the "i" in ST(i)), and the remaining 13 that can be grouped as needing a special-memory operand type (operations that use operands of 2, 14, and 94 bytes, as well as packed decimal).

The real-memory, integer-memory, and special-memory operands are passed to and from the 8087 as part of the operation. Because they come in different sizes (including 16-, 32-, and 64-bit integers; 32-, 64-, and 80-bit real numbers; and from 16- to 80-bit special values), it at first appears that PAS87 will have to handle each case in a separate manner. However, if we treat all memory operands as pass-by-reference parameters (where operands, regardless of length, are specified by their 16-bit addresses), the routines in PAS87 do not have to differentiate between the various operand sizes.

The remaining type of parameter to be considered is the register-operation type. We would like to let the user specify some register operation (such as the 8087 FADD ST,ST(i) instruction) in the Pascal program and pass as a parameter the register number i to be used. The PAS87 operations supporting this type of call would need to look at the register specified and invoke the appropriate 8087 operation.

Because all 8087 register operations are one-way (that is, they leave their results on the 8087 stack and do not return a result), we need not specify the parameter passed to the PAS87 routines as pass-by-reference. Furthermore, because all register opera-
Listing 1 continued:

PAS87 FMOVINT
PAS87 FSALD SPECIAL
PAS87 FSALD SPECIAL
PAS87 FSCALE
PAS87 FCLRT
PAS87 FFT ST(i)
PAS87 FFT ST(i)
PAS87 FSTP ST(i)
PAS87 FSTP ST(i)
PAS87 FSTD TEMP
PAS87 FSTSW SPECIAL
PAS87 FSUB
PAS87 FSUB ST,ST(i)
PAS87 FSUB ST(i),ST
PAS87 FSUB SHORT
PAS87 FSUB LON
PAS87 FSUB TEMP
PAS87 FSUB ST,ST(i)
PAS87 FSUB ST(i),ST
PAS87 FSUB SHORT
PAS87 FSUB LON
PAS87 FSUB TEMP
PAS87 FSUB ST,ST(i)
PAS87 FSUB ST(i),ST
PAS87 FSUB SHORT
PAS87 FSUB LON
PAS87 FSUB TEMP
PAS87 FSUB TEM
PAS87 FSUB ST,ST(i)
PAS87 FSUB ST(i),ST
PAS87 FSUB SHORT
PAS87 FSUB LON
PAS87 FSUB TEMP

***************
| Define some special purpose routines here. All must be | |
| callable by Pascal. | |
| ****************|

PAGE

; Procedure C_IBM_0087( VAR X : REAL )
;
; This routine converts a real number from IBM format to 8087 format
;
PUBLIC C_IBM_0087

SECTORS restrict the register to a value between 0 and 7, we know in advance that the pass-by-value parameter of any register operation can be contained within a single word (the smallest parameter passed by Pascal).

To summarize, we have divided the PAS87 operations into three main types: those without parameters, those with memory operands, and those with register specifications. We can thus handle all PAS87 operations in one of three ways. This provides a uniform approach that we will take advantage of in developing the macros used to generate the PAS87 code.

**PAS87 Macro Generator**

Take a moment to look at listing 1—the assembly-language code that produces the PAS87 operations. It consists of three macros (PASSTACK, MEMOP, and PAS87) followed by 129 macro calls to PAS87 (with various parameters, of course). Following these are some assorted utility routines (to be discussed later).

Now look at listing 2, the PAS7_INT file. This is a file that any Pascal program wishing to access PAS87 operations will use $INCLUDE to incorporate it into the program (see the IBM Pascal User's Manual for instructions on $INCLUDE). This listing defines all EXTERN procedures that access PAS87 routines and thus use the 8087 from Pascal. PAS7_INT establishes the interface to each PAS87 routine for the Pascal compiler.

A side-by-side comparison of the PAS87 macro calls in listing 1 and the procedure declarations in listing 2 may help in your initial understanding of how the PAS87 macro will work. There is a one-to-one correspondence between the two listings. The macro expansion of the calls in listing 1 builds subroutines that meet the Pascal internal calling conventions. Let's now look at the PAS87 macro and see what happens at assembly time.

The PAS87 macro builds complete subroutines. Each of the 129 PAS87 macro calls in listing 1 results in a full subroutine specification. Notice that each macro call has from one to three parameters. The first parameter is...
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always the basic 8087 operation that the subroutine is to invoke. These are the same 77 basic operations defined last month in the M8087.MAC assembler software support. In fact, each PAS87 macro expansion will in turn invoke the M8087 macro specified by the first parameter. This means that the PAS87 file in listing 1 requires the M8087.MAC program from last month.

An assembly-language subroutine has three parts: the initial declaration of the routine (consisting of two parts, a PUBLIC ROUTINE__NAME command that specifies the routine to be made public to external modules and a line of the format ROUTINE__NAME PROC FAR to signify a subroutine of type FAR with the name ROUTINE__NAME), the code that makes up the subroutine, and the closing or delimiting portion of the routine (which has the syntax ROUTINE__NAME ENDP).

PAS87 Naming Conventions

If PAS87 is to produce 129 separate subroutines, we have to come up with 129 unique routine names. The syntax that I use in PAS87 is the following: all PAS87 routine names begin with an F followed by the type of operation to be performed, an underscore_, and end with the 8087 mnemonic operation name.

The possible types of operations include SHORT, LONG, WORD, TEMP, SPECIAL, ST, STI, and "no op." The first four types refer to the memory operand type used in the operation (for example, the FSHORT__FADD operation in PAS87 uses a short-real memory operand to execute the 8087 FADD operation). The SPECIAL operation type handles such special operands as the 94-byte control-word operand used in the FLDCW operation.

The ST and STI operation types refer to the register operations. Any register operation of the type f-op ST, ST(i) is considered to be of the ST type. The f-op ST, ST(i) 8087 operations fall under the STI classification. Thus, an FSTL__FSUB procedure executes an 8087 FSUB ST,ST(i) instruction. An FSTL__FSUB procedure does the FSUB ST,ST(i)ST.
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8087 FLDPI operation to load floating-point numbers. These operations are characterized by the mnemonic command. For example, FLDPI refers to the FLDPI instruction, which has operands. These instructions are followed by the 8087 mnemonic command. For example, the FLDPI procedure executes the 8087 FLDPI operation to load PI onto the 8087 stack.

Given this naming scheme for the PAS87 operations, we can use the MACRO ability to manipulate macro parameter strings to build the name of each procedure from the parameters passed in the PAS87 macro call. In each PAS87 macro call, the first parameter, P1, specifies the 8087 instruction to be executed and the second parameter (if there is one), P2, specifies the “type” of that operation.

The MEMOP Macro

Examining the PAS87 macro now, we see that the macro immediately tests the second parameter of the macro call. If there is no second parameter, then the 8087 needs no operands and we simply establish the procedure entry and exit and issue a call to the M8087 MAC routine.

If P2 equals SHORT, LONG, TEMP, WORD, or SPECIAL, then PAS87 invokes the MEMOP macro. MEMOP inserts the assembly-language code needed to properly pass the address of the operand to the procedure. Listing 3 shows an example of this, the code generated by the expansion of the macro call PAS87 FADD SHORT (here, P1 = FADD and P2 = SHORT).

The PASSTACK Submacro

The three types of 8087 register operations (f-op ST(i), f-op ST,ST(i), and f-op ST(i),ST) cause PAS87 to invoke the PASSTACK macro. For these register operations, we expect to receive a call-by-value parameter that specifies the register number (0 to 7) to be used for the operation. As a result of this parameter, the proper 8087 ESC sequence must be executed.

Listing 2 continued:

```
Listing 2 continued on page 347
```
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to accomplish the register operation. Therefore, we can have any one of eight variations to the register operation executed.

The obvious method of approaching this would be to compare the register parameter with each possible value from 0 to 7 and execute the appropriate 8087 command when a match is found (i.e., "IF REG = 0 THEN XXXX ELSE IF REG = 1 THEN YYYY . . . "). But this requires up to seven run-time comparisons for each call. Because these comparisons slow down the actual execution of register-based PAS87 procedures, I looked for another way around the problem.

Looking at the structure of the 8087 register operations, I made two observations:

1. All register-operation op codes require exactly 2 bytes.
2. The register selection for each of these op codes is encoded in the same manner for all such operations. The low 3 bits of the second byte store the register number (thus allowing for the eight registers that the 8087 contains).

Because all 8087 register operations use the same 3 bits to specify the register in the ESC command, we can do a naughtly thing and set up some self-modifying code. Self-modifying code is tricky and somewhat risky because it relies on changing the machine-language code during run time for correct operation. This is dangerous for numerous reasons, not the least of which is that this code must never be put into read-only memory because it could not modify itself and thus would not work correctly.

Let's look at PASSTACK as found in listing 1 and see how it works. The first six instructions make the actual code modification. The line immediately following the FLAG: label (containing R1 R2 R3) is the line of code to be modified. Upon macro expansion of PASSTACK, R1 through R3 will be replaced by the parameters passed, which will in turn cause some M8087 macro to be invoked, resulting in a 2-byte ESC 8087 instruction.

As an example, look at the macro expansion of the PAS87 FADD ST,ST(i) macro call. PAS87 receives P1 = FADD, P2 = ST, and P3 = ST(i). Checking P2, it matches ST and invokes PASSTACK, passing to it P1, P2, and P3. PASSTACK then has R1 = P1 = FADD, R2 = P2 = ST, and R3 = P3 = ST(i). The result of this expansion is given in listing 4. Notice that the line after FLAG: is now FADD ST,ST(i). This invokes the M8087 FADD macro and results in the 8087 ESC 00H,AX command (equivalent to FADD ST,ST(i)) being assembled. This is then assembled into the machine-language instruction D8 C0 (hexadecimal). The lowest 3 bits of the C0 byte specify the
register to be used. Thus, by changing the lower 3 bits of the second byte before executing any register operation, we will change the register used.

The code preceding the FLAG label accesses the second byte of the 8087 operation, adds in the register value passed as the parameter from Pascal (using a logical OR operation), and stores the byte back in memory before executing it. This results in the proper register value being used.

If the use of the JMP FLAG instruction in listing 4 puzzles you (the JMP simply moves to the next instruction because FLAG is immediately after the JMP), look it as the penalty for using self-modifying code. I spent several long and frustrating days trying to figure out why the PAS87 register operations were not working quite right before I determined the cause of my problem and its solution.

The problem, to make a long story short, is that the 8088 CPU is too efficient. The Intel 8088 and 8086 CPUs have internal instruction prefetch queues that are used to fetch instructions for the CPU before they are actually needed. This greatly improves the speed with which the CPU can execute instructions.

The 8088's internal queue is 4 bytes long—that is, the CPU loads the 4 bytes into the prefetch queue immediately following the one being executed. Look at the code expanded in our example and mentally remove the JMP operation momentarily. The MOV CS:[BX],AL instruction modifies the 8087 register operation (in the example of listing 4, the instruction FADD ST,ST(i)) and immediately executes that operation. However, this MOV instruction modifies the FADD instruction in program memory—an unmodified copy of this instruction is already in the prefetch queue, and it is this copy that is about to be executed. Result: things don't work as expected (a true understatement).

The solution to the problem is the JMP instruction. The CPU will always discard its internal queue and reload it starting with the destination of the jump instruction. Even though the JMP in PASSTACK does not really change the flow of the program, it fools the CPU into flushing its internal queue. The CPU then fetches the next instruction after the JMP, which happens to be the correctly modified 8087 register operation.

This problem was almost enough to convince me to change PAS87 to the more straightforward approach of comparing the parameter received from the FADD call with the values 0 to 7 and executing the appropriate 8087 instruction. But this would increase the execution time of the register-based procedures, so I stuck with the self-modifying approach. If you would rather not use self-modifying code, simply rewrite the PASSTACK macro and reassemble PAS87.

PAS87 Design Conclusions

We have now looked at the methods I used to construct the PAS87 file shown in listing 1. When assembled using the IBM Macro Assembler, this produces a library of Pascal-callable procedures that access the 8087 NDP. Listing 2 (P87_INT) lists the corresponding Pascal procedure declarations for each PAS87 routine.

PAS87 is assembled one time by the user, and the resulting object file is linked with any compiled Pascal object files that need these routines. To access any PAS87 routine, the Pascal program need simply include the statement {$INCLUDE P87_INT}.

At this point, we have finished the discussion of how PAS87 works. When listing 1 is assembled, all 129 operations for the 8087 are set up as callable procedures from Pascal. To assemble PAS87, you need to have the M8087.MAC file examined last month on the disk. Due to the heavy use of

Listing 5: An IBM Pascal program to repeatedly perform a complicated arithmetic calculation described in the listing. The text describes the results of comparing this program with a similar one that does not use the 8087 for its calculations.
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nested macros in PAS87, its assembly takes more than 25 minutes. But this is a one-time cost. After the initial assembly, you simply keep the resulting object file around to be linked with any Pascal program that needs it.

The compilation time of a Pascal program using PAS87 via the P87_INT declaration file is not visibly affected. Listing 5 contains an imaginary Pascal application program that uses the PAS87 package. This program takes two large arrays of real numbers (x and y) and calculates

$$\sum_{i} x[i]^2 + e^{y[i]^{0.5}}$$

**Pascal Type Extensions via PAS87**

I need to comment briefly on using PAS87 and the 8087 capabilities to support numeric data types not supported by IBM Pascal. PAS87 provides a way for Pascal programs to bypass the type-checking protection features of the Pascal compiler and perform numeric calculations with a higher degree of accuracy. For example, Pascal does not handle double-precision real numbers (64 bits long). If you want to use numbers of this precision, you can do so as long as you are very careful.

Perhaps you have an application that requires greater accuracy than that offered by the IBM Pascal's single-precision real numbers. You would thus like to do all your numeric calculations in double-precision arithmetic. Of course, the 8087 stack mechanism lets intermediate results be left on the stack as 80-bit temporary values. But if you have hundreds or thousands of intermediate double-precision results, you might want to keep them in a standard Pascal array or some other data structure. You can sneak around the Pascal single-precision limitation as long as all input and output operations (using READ and WRITE) occur using standard single-precision Pascal numbers.

For example, suppose you want to set up an array of 100 double-precision real numbers in your Pascal program. You cannot declare in

```pascal
Listing 5 continued:
```

```pascal
12 32
12 33
12 34
12 35
12 36
12 37
12 38
12 39
12 40
12 41
12 42
12 43
12 44
12 45
12 46
12 47
12 48
12 49
12 50
12 51
12 52
12 53
12 54
12 55
12 56
12 57
12 58
12 59
12 60
12 61
12 62
12 63
12 64
12 65
12 66
12 67
12 68
12 69
12 70
12 71
12 72
12 73
12 74
12 75
12 76
12 77
12 78
12 79
12 80
12 81
12 82
12 83
12 84
12 85
12 86
12 87
12 88
12 89
12 90
12 91
12 92
11 93
86 94
end.
```

**Errors Warnings In Pass One**

```pascal
Circle 187 on inquiry card.
```
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Pascal DBL : array[1..100] of double_reals; You can, however, declare DBL : array[1..200] of real; This tells Pascal to set aside room for 200 32-bit single-precision real numbers. You can then turn around and use this structure to store 100 64-bit numbers on a temporary basis.

You begin to trick Pascal when you call a PAS87 procedure such as FLONG_FST(DBL[0]). This operation will move a long-real value from the top of the 8087 stack into the address that points to the zeroth slot in DBL. The 8087 takes over, moves 64 bits of data from the stack to that address, and returns; note that it moves 64 bits of data, not the 32 bits that Pascal itself associates with DBL[0]. Pascal has no idea that anything out of the ordinary has happened. Of course, what did happen is that slots 0 and 1 of DBL have been filled to store the 64-bit value.

As long as you, the programmer, are aware of what has occurred, everything is okay. You simply have to remember that the first long-real will be found at DBL[0], the second at DBL[2], the third at DBL[6], and so on. This technique can be expanded and refined as long as you are very careful. Remember, you are defeating the type-checking mechanisms that make Pascal so nice to use, so beware.

PAS87 Utility Routines

We will now look at the supporting procedures and functions in listing 1 starting with procedure C_IBM_8087. They should look familiar because we used them last month. (Actually, the last four, functions CHK87, EXAM87, GETST, and STATUS, are listed only as comment lines. Their full definitions, starting with the word PUBLIC and ending with the word ENDP, should be copied into this file from listing 3 of last month's article.) PAS87 users need these routines to use the 8087 from Pascal.

Recall from last month the different storage formats used to define IBM-format real numbers versus 8087-format real numbers. In IBM Pascal, any real number that is defined as a constant or is input (using a READ) or output (using a WRITE) must be in the IBM real-number format. On the other hand, all real numbers sent to and received from the 8087 must be in 8087 format. The C_IBM_8087 and C_8087IBM procedures convert short-real numbers from IBM format to 8087 format and vice versa. These routines convert the short-real number found at the memory location specified—that is, they convert the value "in place," destroying the number in its original format.

It is up to the user to ensure that the values being used in a program are always in the appropriate format. If you move an IBM-format real number into the 8087 or print an 8087-format real number, you will be working with or printing incorrect numbers; to make things worse, you may not get any indications that you are in error. As a general approach to handling the format problem, you can try to convert all IBM-format values into 8087 format as early as possible and leave them in the 8087 format until it is absolutely necessary to convert them back to IBM format.

In several programs I have written using PAS87, I was able to make a single conversion from IBM format for all my variables at the beginning of the program and use a special CONV_WRITE procedure that would automatically convert 8087 numbers into IBM format, print them to the screen, and convert them right back to 8087 format for additional computation. The conversion routines are very efficient, but it is best to avoid too many unnecessary conversions.

(Notice that this number-format problem does not affect the use of integer values. The 8087 word-integer format is the same as the IBM integer format.)

The last four functions perform needed tests on the internal state of the 8087. These are CHK87 (which returns the results of an 8087 compare or test operation), EXAM87 (which determines the validity of the number currently on top of the 8087 stack), GETST (which returns the current stack-top pointer value), and STATUS (which returns the value of the 8087 status word). These were explained in greater detail in last month's article.

Performance of PAS87

The big question is "How much does my application benefit by using PAS87?" In other words, will extensive use of the 8087 from Pascal really be worth the trouble? If you are interested in high performance and you have a number-crunching application, the answer is yes.

As a very simple test, I implemented the program of listing 5, adding some additional commands that let me accurately measure the time needed to execute the program for various sizes of arrays. I then rewrote the program to accomplish the same thing from standard Pascal. Testing the running time (excluding the time to initialize the arrays) for arrays from 500 to 5000 real numbers in size gave an average execution time for the PAS87 implementation that was 65 times faster than the straight Pascal execution time. For example, with 5000 elements the PAS87 implementation took less than 4 seconds to run; the standard Pascal version, however, required more than 265 seconds.

Now this is an impressive improvement. But it is misleading, too, because it emphasizes the very operations that show the 8087 to its best advantage. To be fair, I also tested a long and fairly complex general linear-equation solver library in IBM Pascal, a program with an instruction mix much closer to an average Pascal program you might write.

It is beyond the scope of this article to go into much detail about this program except to say that it uses Gaussian elimination with partial pivoting to factor and solve a set of linear equations. The linear equations...
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are entered in matrix form, factored into their lower- and upper-triangular matrix (LU) components, and then solved.

The 8087-Pascal and Pascal-only implementations of the program were designed to record the times required to factor and solve matrices from 5 by 5 up to 120 by 120 (an upper limit dictated by the 64K-byte data area allotted by IBM Pascal). The 8087 version of the program was written directly from the straight Pascal version so that they are as close to identical in structure as possible.

After timing the programs and analyzing the results, I came to the following conclusions: the use of the 8087 consistently sped up the factorization of the different-sized matrices by a factor of three, and the 8087-based program solved the factored matrix twice as fast as the Pascal-only program. (It took the IBM PC 461.9 seconds to factor a 120 by 120 matrix and another 10.5 seconds to solve the LU matrix. The 8087 cut this time to 154.5 seconds to factor and 5.2 seconds to solve the same matrix.)

This program shows the 8087 contributing a less spectacular but still significant improvement to the execution speed of Pascal programs. The 8087 caused a smaller improvement in this case for two reasons: first, the general-purpose overhead in this program (similar to the overhead in most Pascal programs) does not involve the kinds of functions the 8087 contributes; second, the standard IBM Pascal is already able to do some of the arithmetic in this program (addition and subtraction, for example) quite competitively. As a general rule, computation-intensive programs can expect an improvement of 3 to 10 times through the use of the 8087.

Conclusions
The Pascal support package for the 8087 (PAS87) discussed in this article provides access for the user to the full 8087 instruction set. The negative side of PAS87 is that it does require you to fully know the inner workings of the 8087. Because you must understand and manipulate the current state of the 8087, you will be working at a programming level that is about the same level as assembly-language programming. The unarguable positive side of using PAS87, though, is that it provides a remarkable improvement in execution speed to the Pascal programmer. Thus, PAS87 brings the power of the 8087 to both the experimenter and the programmer who needs extra performance in Pascal programs.

Tim Field has a master's degree in computer science from Purdue University. He is currently involved in some freelance technical writing and software development projects for the IBM PC.
Echonet

Part 1: A Flexible Programming System

This interactive system combines natural language and machine-native code to revolutionize the way we solve problems with computers.

by C. Bradford Barber

Echonet is an interactive system that lets you manage and create programs in much the same way that we manage and expand our natural language. To do this, Echonet has a dictionary of entries (useful functions) that perform specific tasks. Instead of one programming instruction for a thousand different uses, Echonet has a thousand entries, one for each different use. Echonet entries are defined by other entries and compiled, from those entries, into complete, executable programs. (Note: Last year’s version of Echonet used 8080 instructions to define some of the entries. The next version will define all entries in terms of entries. I’ll explain the process in part 2.)

Perhaps the most important concept employed by Echonet, though, is the separation of an entry’s meaning from its definition: the meaning of an entry is what we understand it to do and what the computer does when it executes the entry; an entry’s definition is how

| Blackboard | go to blackboard entry |
| Commands   | go to commands entry   |
| Compile    | compile relocatable code for the entry |
| Do         | compile and execute the current instruction |
| Entries    | go to . . . entries entry |
| Get        | get the contents of stored text |
| Go To      | go to the entry indicated by the current instruction |
| Help       | go to . . . help entry |
| Next       | go to the next entry (usually the working entry) |
| Previous   | go to the previous entry |
| Steno      | insert the matching word |
| Stop       | stop execution |
| Test       | go to test text for the entry |
| Text       | store an entry definition into stored text |
| Work       | define the current entry as the working entry |

Table 1: The function keys available on the author’s Echonet system and used in this article.
the entry is described in terms of other entries.

To introduce the system, let us follow Carl, a hypothetical Echonet user, as he develops a program for controlling a robot vacuum cleaner. Then I'll show how Carl creates an instruction (part of an entry) by adding an entry to the Echonet dictionary. Through these examples, you will see that writing entries takes the place of writing and maintaining programs. (Next month I'll describe entry compiling and define how Echonet works.)

The examples are based on an Echonet system that runs on a Z80 microcomputer with 8-inch floppy disks. The computer's terminal is a Heath WH19 with labeled function keys (see Table 1). All keys, except for Compile, complete their operation almost immediately.

A Scenario
Carl returns to his computer lab after a week's vacation in the mountains. He turns on his computer and it starts humming. Text appears on the screen. "Oh yes," Carl remembers, "I was finishing my robot vacuum-cleaner program. Let's see how far I've gotten." Carl presses Compile, but the compiler saw an unknown instruction in his program. Carl presses entries to find the correct wording for the unknown instruction, edits his program, and again presses Compile.

Let's go over Carl's actions in detail. Here is what he saw after he turned on his computer:

Vacuum one room
repeat for 15 minutes
adjust floor brushes for Vacuum
check Vacuum nozzle
while Vacuum...isStopped do
rotate Vacuum by 90 degrees
move Vacuum forward for 3 seconds

This block of information displays an entry in an Echonet dictionary. It shows an entry name ("Vacuum one room") and an entry definition: ("repeat for 15 minutes," etc.). The entry name lets you indicate the entry with an instruction. For example, if an instruction (one line of text) was "Vacuum one room," Carl could position the cursor to that instruction and press the Go To key. The display would then show the entry Vacuum one room.

The entry definition contains six instructions, one instruction per line. The second, third, fourth, and sixth instructions form a sequence by starting at the same column. They also form a subprogram, or indented program, of the first instruction. The indented program repeats for 15 minutes. First, it directs the robot vacuum cleaner to adjust the floor brushes for carpets or hard floor. Second, it checks the vacuum to see if the nozzle is blocked. Third, it rotates the vacuum if the vacuum is stopped by an obstruction. Fourth, it moves the vacuum forward for three seconds.

When Carl pressed the Compile key, he could hear whirring and clicking from the disk drive as Echonet read entries from a floppy disk. In about 20 seconds, a message appeared on the screen: "unknown instruction: rotate Vacuum by Number degrees." Carl remembered an entry for rotating the vacuum cleaner, so he positioned the cursor to the word "Vacuum" and pressed the Entries key. Almost immediately, the entry Vacuum one room moved to the bottom of the screen and the following entry appeared at the top:

Vacuum entries
adjust floor brushes for Vacuum
check Vacuum nozzle
display room with Vacuum
display Vacuum statistics
lower floor brushes for Vacuum
move Vacuum backward for Number seconds
move Vacuum forward for Number seconds
raise floor brushes for Vacuum
rotate Vacuum clockwise by Number degrees
turn off Vacuum
turn on Vacuum
turn Vacuum left
Vacuum one room

Echonet took the word "Vacuum" and appended "entries" to get "Vacuum entries." Then it found the entry with a matching name in its dictionary. This entry lists other entries that use the Vacuum object. In Echonet, objects serve the same role that variables, arrays, data types, and data structures serve in a programming language. Object names always start with a capital letter.

Entry Names
An entry definition contains instructions that indicate entries with entry names. An entry name describes what an entry does. This is important. It means you can read
and understand an instruction without reading the corresponding entry definition. Table 2 shows a list of entry names as examples.

If you cannot figure out an entry from its name, you have several options. First of all, many words and objects have Help entries that you can find by moving the cursor to the word or object and pressing the Help key. Here is the Help entry for HanoiTower (which will be discussed further next month):

HanoiTower help
A HanoiTower is one of three towers for displaying the solution of a Hanoi tower puzzle.

The rings on a HanoiTower are called TowerRings.
The first HanoiTower is number 0.

With many keywords and objects you can press the Entries key and see a list of related entries. Carl did this when he wanted to look at the Vacuum entries. You can also read the entry's definition by pressing Go To, or write an instruction and press Do to see what it does.

Let's get back to Carl. His screen showed a list of entry names that use the Vacuum object. Carl scanned down the list to find an entry that would rotate a Vacuum. He found:

rotate Vacuum clockwise by Number degrees

He realized that in his robot program he had forgotten the word "clockwise," so he pressed the key labeled Previous and the entry Vacuum one room (the previous entry) reappeared on his display.

With Echonet, you always work with a screen editor on the current entry, so Carl could quickly change "rotate Vacuum by 90 degrees" to "rotate Vacuum clockwise by 90 degrees." Carl pressed Compile and the compiler successfully generated relocatable code.

The Scenario Continued
Carl presses Test and finds the tests he developed a month ago while working on an earlier version of the vacuum-cleaner program. Now he presses Do. A top-view diagram of a room appears on his screen with boxes showing furniture and a circle showing his robot vacuum cleaner. As the circle moves, it leaves behind a cross-hatched pattern. Carl observes that the robot keeps following the same path. He thinks, "Must be something wrong. It keeps turning at right angles. Let me check my program." Carl presses Stop and then Previous. His program reappears. "Oh yes, it shouldn't turn 90 degrees each time. Let me try a prime number." Carl picks 73 degrees; he then presses Compile, Test, and Do. The display fills up with cross-hatching.

When Carl pressed Test, the entry Vacuum one room moved to the bottom of the screen and new text appeared at the top. Carl then saw the following:

test Vacuum one room
show Vacuum on Console during

display room with Vacuum
Vacuum one room
display Vacuum statistics

The test screen is another page of text associated with an entry. In this case, it consists of instructions for testing Vacuum one room. The first three instructions model the vacuum cleaner using graphics. The last instruction, "display Vacuum statistics," displays statistics collected while running the model.

Carl positioned the cursor to the instruction "show Vacuum on Console during" and pressed Do. Echonet compiled, loaded, and executed relocatable code for this instruction. A diagram then appeared at the bottom of the screen, showing the position of the robot vacuum cleaner (marked by a circle) in relation to existing pieces of furniture (shown by boxes).

As Carl watched the display, the circle started moving, leaving a trail of cross-hatching behind it. Carl pressed Stop. The cursor returned to the test text at the top of the screen. After pressing Previous, Carl saw:

Vacuum one room (compiled)
repeat for 35 minutes
adjust floor brushes for Vacuum
check Vacuum nozzle
while Vacuum_isStopped do
rotate Vacuum clockwise by 90 degrees
move Vacuum forward for 3 seconds

Carl reduced the amount of rotation to 73 degrees and retested the entry.

Commands
Its last test completed successfully, Carl's robot vacuum cleaner appears to work. Carl presses Previous and then Commands, finds the instruction "store code for Previous_Entry into PROM," loads a PROM into the PROM slot, and presses Do. Carl moves the new PROM to his robot and starts the robot vacuuming. Finally, he has a clean room.

Carl pressed Previous to return to Vacuum one room; then he pressed Commands, and a new entry appeared at the top of the screen:

commands
edit backup text for Previous_Entry
edit archive text for Previous_Entry
list code for Previous_Entry
print text for Previous_Entry
store code for Previous_Entry into PROM
load code optimizer

The entry commands is a list of useful instructions that act on the previous entry. The third instruction lists relocatable code for the previous entry; a listing helps you fine-tune short entries. The last instruction loads a code optimizer for generating more efficient code.

The entry commands is similar to a menu: You can position the cursor to any instruction and press the Do key. But unlike most menus, you can edit commands
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any way you want to. If you find that you seldom need to list relocatable code, you can move the instruction "list code for Previous_Entry" to a different entry. Similarly, if there is an instruction that you frequently execute, you can add it to commands. Smalltalk provides a similar facility (see the August 1981 BYTE for information about the Smalltalk language).

Carl wanted the fifth instruction, "store code for Previous_Entry into PROM." He positioned the cursor to that instruction and pressed Do. Echonet displayed the following message:

place PROM in PROM slot and press any key

Carl did this; he put the new PROM into his robot and started the robot vacuuming. Everything worked fine.

Creating an Entry

Working the Echonet involves writing and modifying entries. To demonstrate this, I'll describe how Carl would write an entry for "while . . . do" instructions. This entry repeats an indented program as long as a conditional clause remains true.

The "while" entry already occurs in the Echonet dictionary, but let us suppose that Carl wants to create it. To do so, Carl first presses the Blackboard key, moves the cursor to the bottom of the blackboard entry, and types "while." He then sees the following on the display:

blackboard
today is 10,18,62
Echonet message message0310
benchmark
display solution for 5 TowerRings
while

This entry acts as a scratch pad for new and current work. For example, the second instruction "Echonet message message0310" indicates an entry containing messages displayed by Echonet.

Carl next presses the New key and the Go To key. A new, empty entry appears at the top of his screen:

while

Carl presses Work to make this his working entry. Carl decides that while while use an indented program, so he types "IndentedProgram" and presses Entries. The entry while then moves to the bottom of his screen and another entry appears on top:

IndentedProgram entries

do IndentedProgram
if ConditionalClause then IndentedProgram
if ConditionalClause then IndentedProgram else IndentedProgram
for Integer from IntegerA to IntegerB do IndentedProgram
repeat IndentedProgram
repeat Integer times IndentedProgram

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For more information about VoiceDrive call or write: SuperSoft, P.O. Box 1628, Champaign, IL 61820, 217-359-2112. Telex 270365.

Circle 423 on inquiry card.
Because the "while" instruction is similar to "repeat," Carl moves the cursor to "repeat IndentedProgram" and presses Text. This key stores the entry definition of repeat IndentedProgram into an entry named stored text. Carl presses Next to return to while, deletes a line, and presses Get to recover the contents of stored text. He then sees:

```plaintext
while
  label Loop
  do IndentedProgram
  goto Loop

The while entry now has the same definition as repeat IndentedProgram. Carl returns to IndentedProgram entries by pressing Previous. He positions the cursor to "if ConditionalClause then IndentedProgram" and presses Text and then Next. He deletes the line reading "do IndentedProgram" and presses Get. Now he sees:

```plaintext
while ConditionalClause do IndentedProgram

label Loop
if not ConditionalClause goto Exit
  do IndentedProgram
label Exit
go to Loop
```

When Carl pressed Get he inserted the entry definition for if ConditionalClause then IndentedProgram between the first and last line. Carl reverses the instructions "label Exit" and "go to Loop." He positions the cursor one space after the while and types "C." Then he presses the Steno key. This key searches for a word in the entry with the same prefix (in this case, "C") and inserts the rest of that word. Carl types "do I" and again presses the Steno key. Now he sees:

```plaintext
while ConditionalClause do IndentedProgram (compiled)

label Loop
if not ConditionalClause goto Exit
  do IndentedProgram
goto Loop
label Exit
```
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### Table 3: Comparison of the Gilbreaths' prime-number benchmark as performed under EchoNet versus other languages.

<table>
<thead>
<tr>
<th>Language</th>
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<th>Size (bytes)</th>
<th>Total Run-Time Size (bytes)</th>
<th>Compile and Load Time (seconds)</th>
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<td>243</td>
<td>763</td>
<td>22.0 (3.7)</td>
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<td>216</td>
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<td>29.0 (4.1)</td>
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<td>5977*</td>
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<td>203</td>
<td>3816</td>
<td>103</td>
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<tr>
<td>(version 1.46)</td>
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<tr>
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<td>816</td>
<td>50.8</td>
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<td>Digital Research</td>
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<tr>
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<td>n/a</td>
<td>n/a*</td>
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<tr>
<td>Interactive</td>
<td>18.5</td>
<td>292</td>
<td>867*</td>
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<td>Systems ZC</td>
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<td>8282</td>
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</table>

Carl tests the new entry by pressing Test and typing a small test program:

```plaintext```
  test while ConditionalOause do IndentedProgram
  program
clear Count
while Count < 10 do
  display Count
  increment Count
```

Carl now positions the cursor to “program” and presses Do. EchoNet displays a line of numbers, one number for each repetition of the “while” instruction: 0 1 2 3 4 5 6 7 8 9. Carl replaces the 10 with 1 and presses Do, and EchoNet displays a single number: 0. Carl replaces the 1 with 0, presses Do, and EchoNet displays nothing. The “while” instruction works well. Carl is finished.

**Benchmark of EchoNet**

EchoNet outperforms programming systems currently in use: its programs execute faster, its code requires less space, and its entries compile faster. I compared EchoNet to other programming systems with the benchmark program published by Jim and Gary Gilbreath in “Eratosthenes Revisited: Once More through the Sieve” (January 1983 BYTE, page 283).
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Listing 1: The prime-number sieve entry used for benchmark comparisons. Listing 1a is the Echonet entry itself, while listing 1b shows the disassembled relocatable code produced by Echonet.

(1a)

**benchmark**

```assembly
uses {{False True}}
Console line <- "10 iterations.", ConsoleBell
repeat 10 times
  clear Count
  PrimeSieveFlags_size bytes of PrimeSieveFlags <- True
  for PrimeSieveFlags_size Index's starting at 0 do
    if PrimeSieveFlags [Index]. true then
      Prime <- Index + Index + 3
      SieveIndex <- Prime + Index
    
    while SieveIndex < PrimeSieveFlags_size do
      PrimeSieveFlags [SieveIndex] <- False
      bump SieveIndex by Prime
    
    bump Count
    ;:Console line <- Prime " is a prime."

  Console line <- Count " primes.", ConsoleBell
```

(1b)

`;:Listing for benchmark

```assembly
  "uses {{False True}}
  0000 11 lxi d,‘001 ;;Console line <- "10 iterations.", ConsoleBell
  0003 CD call id: 0696
  0006 11 lxi d,‘000D
  0009 CD call id: 0696
  000C 21 lxi h,000A ;;repeat 10 times
  000F: 0011 CD call id: 0696
  0023 12 shld ‘0000
  0015 21 lxi h,0000 ;;clear Count
  0018 22 shld ‘0000
  001B 3E mvi a,FF ;;PrimeSieveFlags_size bytes of PrimeSieveFlags <- True
  001D 01 lxi h,1FFF
  0020 11 lxi d,‘0002
  0023 12 shld d
  0024 62 mov d,h
  0025 6B mov l,e
  0026 13 inx d
  0027 0B dcr h
  0028 ED z80 ldir
  0029 B0
  002A 21 lxi h,0000 ;;for PrimeSieveFlags_size Index's starting at 0 do
  002D 22 shld ‘2001
  0030 21 lxi h,1FFF
  0033 1C mov e,h
  0034 05 ora l
  0035 1A mov c,a
  0038 05 ora l
```

Listing 1b continued on page 370
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Circle 47 on inquiry card.
Listing 1b continued:

```assembly
0039 2A lhld *2001
003C 11 li d,*'0002
003F 19 dad d
0040 7E mov a,m
0041 EB or a
0042 22 shld *2004
0045 19 dad d
0048 LL xi d,0002
0049 19 dad d
0050 7E mov a,m
0053 EB or a
0054 22 shld *2004
0057 19 dad d
005A 36 mvi m,00
005B EB or a
005C lhld *2001
005F 19 dad d
0062 3E mov a,m
0065 EB or a
0068 22 shld *2004
006B 19 dad d
006E 2A lhld *200A
0071 2A lhld *2000
0074 11 li d,1FFF
0077 EB or a
0078 lhld *200A
007B 11 li d,0003
007E EB or a
0081 lhld *2004
0084 2A lhld *200A
0087 23 inx h
008A 2B dcx h
008D C3 jmp 0033
008F 2A lhld *2000
008C 11 li d,0000
0090 19 dad d
0093 2A lhld *2001
0096 23 inx h
0099 22 shld *2001
009C 2B dcx h
009F C3 jmp 000F
00A2 2A lhld *0000
00A5 11 li d,*'0000
00A8 CD call id- 0587
00AD 11 li d,*'0003
00A0 CD call id- 0596
00A3 11 li d,*'0000
00A6 CD call id- 0596

 literals for code
0000 OD 0A 96 20 70 72 69 6D 65 73 2E 07 96 OD 0A 96 -- primes,---
0010 31 30 20 69 74 65 74 69 6F 6E 73 2E 07 96 10 iterations.--
```

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Table 3 compares Echonet with the best language for each measurement. Optimized Echonet uses a code optimizer that removes superfluous load and store instructions. Listing 1a shows the benchmark entry, while listing 1b shows the disassembled 8080/2.80 code produced by the Echonet lister.

As of October 1982, the Echonet dictionary contained 870 compiled entries, 324 text-only entries, and 347 objects. Its capacity is 2000 entries and objects. Its compiled entries include programs that can do the following:

- Display solution for Towers of Hanoi puzzle
- Generate prime numbers using Eratosthenes sieve
- Optimize register usage for compiled code
- Print the Echonet dictionary
- Sort entry names using a bank of memory
- Verify the Echonet dictionary for internal consistency

The benchmark and implemented programs confirm that Echonet is a practical system. The scenarios for Vacuum one room and while ConditionalClause do IndentedProgram show Echonet's flexibility, ease of use, and quick interaction with the user.

Natural System

Underlying Echonet is a natural system, i.e., a system that evolves. For example, the English language forms a natural system, as does the common law—neither was created as a complete unit. English uses many words evolved from a variety of sources, while the common law uses many "judicial decisions based on custom and precedent" (Webster's New Collegiate Dictionary, 8th edition. Springfield, MA: G. & C. Merriam Co., 1981).

Let's look at English as represented by Webster's New Collegiate Dictionary. The 8th edition was published in 1981. It replaced the 7th edition that appeared in 1963. The 8th edition has already sold over 12 million copies. It contains 150,000 words and 191,000 definitions. Of these, 2,200 words and definitions are new; that's over 10 percent more than the 7th edition.

In English, words are made up by users and then come into common use. If a word becomes widely used, the editors of Webster's dictionary will probably notice the word and include it in their next edition. The new words are not made up by Webster's editors; English speakers make up and use new words. Then the editors decide if the words meet their criterion of usefulness.

In Echonet, entries are like words in a dictionary. Echonet evolves as users write and modify entries; it can evolve in any direction.

Separating Definition from Meaning

Echonet does not use a created language such as BASIC or Pascal. Instead it builds entries out of entries. This is possible because Echonet separates the definitions of entries from their meanings.

English dictionaries also separate definition from meaning. Let's look at one definition of "entry" in Webster's New Collegiate Dictionary: "a headword with its definition or identification."

If definition and meaning were the same for English, then substituting definitions for words should not destroy the meaning of a sentence. This is not the case; substitution produces gibberish. To illustrate that point, here are two definitions of the word "entry." The second definition is made from the first by substituting a definition (from Webster's New Collegiate Dictionary, 8th edition) for each word of the first:

entry: a headword with its definition or identification.
entry: used as a function word before singular nouns when the referent is unspecified a word or term placed at the beginning [as of an entry in an encyclopedia] used as a function word to indicate combination, accompaniment, presence, or addition or relating to it or itself a statement of the meaning of a word or word group or a sign or symbol a function word to indicate an alternative evidence of identity.

In natural language, the meaning of a word determines its definition. Behind every definition in a dictionary there is a set of sentences collected from books, magazines, and newspapers. These sentences illustrate the actual uses of words, and hence their meanings.
In Echonet, the reverse is true: the definition of an Echonet entry determines the entry's meaning. Its meaning is relocatable code that the computer can execute along with data that the computer can access. This relocatable code was compiled from text that defines the entry.

FORTH and Macroinstructions

On first sight, Echonet looks like either FORTH or a macroprocessor. Both define names in terms of other names, but the system underlying each is different from Echonet. In particular, FORTH and macroprocessors equate meaning with definition.

The August 1980 BYTE covered the FORTH language. A FORTH program consists of words in a dictionary. Each word is defined by other words or by some combination of about one hundred primitive words. The computer executes a FORTH word by executing its component words. The meaning of a word—the code that is executed—is the group of words that define a word.

Macroprocessors are available with most assemblers and as preprocessors to many compilers. A macroinstruction's definition consists of a name and text. When an assembler or compiler sees a macroinstruction's name, it replaces the name with the macroinstruction's text. Instead of writing the same text over and over again, the programmer just writes the name of a macroinstruction. The meaning of a macroinstruction—the code that is assembled or compiled—is the text that defines the macroinstruction.

The separation of definition and meaning in Echonet may appear to be insignificant, but its consequences are far-reaching. The separation allows every entry to be defined with entries and objects. This makes Echonet a visible system; i.e., every part of Echonet is defined in the Echonet system.

By separating definition from meaning, the Echonet dictionary can contain many entries without affecting performance. This is not true of FORTH and macroprocessors; as the number of FORTH words or macrodefinitions increases, performance slows down. In Echonet, another entry only takes disk storage, so increasing the number of entries does not decrease the performance of Echonet, even if Echonet contains hundreds of thousands of entries. This allows many people to add entries to Echonet over many years.

Summary

I've demonstrated Echonet's operation with scenarios and a benchmark. The key ideas I've tried to convey are (1) that Echonet is an interactive system for managing and creating programs with a dictionary of entries and objects, (2) that every entry in Echonet is defined by entries and objects in Echonet, (3) that the name of an entry is a phrase that describes the entry, and (4) that Echonet is a natural system that separates entry definition from entry meaning.

In your mind, an entry's name should become a symbol for the entry's meaning. Programming becomes a process of design in a symbolic language instead of encoding into a programming language. By separating definition from meaning, Echonet lets you work with symbolic text while the computer works with numeric data.

Echonet is a programming system that responds to the creativity and ingenuity of its users and user groups. Like a natural language, Echonet can grow in elegance and usefulness as the needs of its users develop and change.

Brad Barber runs Echo Systems Company (POB 5192, Westport, CT 06881), a one-person research firm. He recently joined ITT Programming as part of a research group that works on coordination systems.

Echonet is a research project of Echo Systems Company. To receive the next Echonet Newsletter, please send a stamped, self-addressed envelope to Newsletter, Echo Systems Company, POB 5192, Westport, CT 06881.

Acknowledgments

Careful reviews by Terry Baker, Charles Barber, Robin Barber, Earl Gilmore, Chris LeFig, and Gregg Williams greatly enhanced this article. My thanks to them and to the editors of BYTE for their help and encouragement.
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Organize your files to eliminate confusion

by Robert B. Johnson

Recently, after spending days straightening out the disk files for my personal computing system, I realized the results of improper data file management. At first, managing files for two operating systems, two versions of Visicalc, two versions of a word-processing program, three language packages, and a few applications packages didn't seem difficult. But with the passage of a year, I no longer knew what data files went with what programs, what versions of programs were the most current, or what modifications were installed on what disks. I desperately needed a simple system of data file management that could provide program and data security, continuity of work flow, maximum standardization and software compatibility, and minimal maintenance. To meet these objectives, I designed the following system, which can also successfully handle the needs of a small business. The system described can expand and grow to meet the changing needs of the organization.

Objectives

There are two aspects to the first objective. Providing for program and data security means that a workable system must have backup copies of critical programs and data files so that a minimum amount of time is lost when the inevitable data loss occurs. Security also refers to the need to restrict the disseminaton of sensitive or confidential information to only those users who require access to this information to perform their jobs.

The second objective, continuity of work flow, is the ability of the system to allow easy assimilation of one employee's duties by another. Illness, vacations, promotions, and terminations all require that employees be trained to perform new duties. When all employees are familiar with and use a common system, this continuity of work flow is more easily realized.

The third objective, standardization and software compatibility, is required because of the enormous costs associated with software development. To achieve the greatest degree of compatibility, the data file management system must provide a means of assuring that all programs developed by one user are compatible with the rest of the system. Also, the system must provide a means to evaluate the total impact of contemplated changes before they are made.

To meet the fourth objective the ideal system will provide an efficient way to make changes. All changes, record keeping, and educational or other activities associated with a program or data file that is accessed by more than one user should be performed by a single person (or group of persons) who has been given that responsibility.

System Overview

The system is based on the concept of control services residing at discrete control levels. Each level has its own standards of control that specify such parameters as software and data change restrictions, required password protection, file backup requirements, testing required to verify changes, etc. Whenever there are two or more users of a given program, data file, or related service, a control entity is established at the next higher level of control to provide and coordinate the required services. Whenever there is a single user of a program or data file, control services for that program or data file are the responsibility of that user.

Figure 1 shows a block diagram of a generalized system with five levels of control. The highest level is the computer network, essentially a communication system linking a number of computer systems. The next level down is the computer system, which is defined as a particular hardware configuration. For data file management in an organization, all computers of the same make and model are considered part of the same computer system. The next level contains the operating system. For our purposes, an operating system is defined as any control program that has more than one application program dependent on it for proper operation of the computer system. The next lower level is for application programs. A typical small business would have application programs to perform functions such as payroll, accounts receivable, accounts payable, word processing, etc. The lowest level is the user level. When there is more than one user on any level, control resides at the next higher level. Programs and data files that have only one user have the least number of controls placed against them in terms of change restrictions. There are procedures that require backup protection for files at the user level.
You must design your own specific and detailed procedures for maintaining the security of your data files and application programs.

Figure 1: Data file management system block diagram. The system is divided into five levels, each with its own procedures for control. You must design your own specific and detailed procedures for maintaining the security of your data files and application programs.
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It is important to mention that the upper levels were not selected on the basis of stringency of control but to provide convenient control points based on areas of expertise. By convenient control points I mean that it is convenient to provide control at the point where two or more persons are using the same application program. The levels are chosen on the basis of expertise because in a small business it is possible, and more efficient, to have the control services provided by those persons who know the most about a particular area. For example, in a small business the author of an application program should assume the control responsibilities for that program because he or she is best equipped to provide these services in an efficient manner. If programs are purchased from outside sources, it is best to train one person to become familiar enough with the program and its internal usage to provide the control services.

The value of standardization can be easily seen by referring to figure 1. Much control effort can be avoided when only one computer and one operating system are used. Also note from figure 1 that details on file usage are given for the user level only. This is because the file management activities of the other levels are performed by persons who are also users. Therefore, good generalized file management procedures for the user level will automatically take care of the other levels as well.

The User Level

The system presented here relies heavily on the individual users for success. This is consistent with the small-business environment where individual employees are aware of the overall goals of the organization and are familiar with the reasons behind, and importance of, established procedures. Referring to figure 1, a typical user of a computer system would have a filing system that consists of four major parts: a file with one or more working copies of an application program, a current working file, a user file library, and controlled access to a permanent filing system that is shared among all users.
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<th>Software</th>
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<td>HOME ACCOUNTANT</td>
<td>$49</td>
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### Software
- **APPLIED SOFTWARE TECHNOLOGY**
  - VersaForm: $389 / $252
  - VersaForm (hard disk): 495 / 323
- **ASHTON TATE**
  - dBase II: 700 / 395
  - Financial Planner: 700 / 452
- **BRODERBUCH**
  - Bank Street Writer: 70 / 46
- **CONTINENTAL**
  - Home Accountant: 75 / 49
  - Property Management: 150 / 96
  - 129
- **EMERGING TECHNOLOGY**
  - Edix / Wordix: 295 / 184
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  - Real Estate Analyzer II
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  - Creative Financing
    - APPLE: 195 / 126
    - IBM: 250 / 162
- **LOTUS 1-2-3**
  - 495 / 325
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  - Volkswriter: 195 / 129
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  - Crosstalk: 195 / 117
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  - Word Star
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    - IBM: 250 / 162
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  - Info Star: 495 / 320
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    - APPLE: 275 / 178
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  - Flight Simulator: 50 / 33
- **PBL CORPORATION**
  - Personal Investor: 145 / 94
- **PEACHTREE**
  - General Ledger
    - APPLE: 400 / 237
    - IBM: 60 / 355

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</table>

### Other Prices
- **LOTUS 1-2-3**
  - Account Payable
    - APPLE: 400 / 237
    - IBM: 600 / 355
  - Account Receivable
    - APPLE: 400 / 237
    - IBM: 600 / 355
  - Peach Pack: 595 / 300
  - SOFTWARE PUBLISHING
    - Pfs/File
      - APPLE: 125 / 81
      - IBM: 140 / 91
    - SORCIM
      - SuperCalc: 195 / 130
      - Super Writer: 295 / 195
  - SYNSAPSE
    - File Manager: 150 / 97
  - VISICORP
    - Viscalc: 250 / 165
    - VisiFile
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      - IBM: 300 / 198
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### Floppy Disk Drives - 8"

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<td>REMEX</td>
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<td>RFD-960</td>
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<td>Pyxis 13</td>
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<td>Pyxis 27</td>
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### Winchester Subsystems

| Media Distributing | MO-10          | 11MB capacity | 2695.00        |
|                    | MD-20          | 22MB capacity | 3595.00        |
| (For Z-80, CP/M/IBM PC systems) |

### Terminals

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<td></td>
<td>D-150 (green phosphor)</td>
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<td></td>
<td>D-175 (green phosphor)</td>
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<td>QUME</td>
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### Terms and Conditions

- COD, CASH WITH ORDER, MASTERCARD, VISA
- FREIGHT CHARGES WILL BE ADDED TO ALL ORDERS

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The working copies of an application program are files that contain day-to-day copies of programs used in the performance of the user’s job. A typical user might have working copies of Visicalc, Pascal, and a word-processing program, for example. There is no need for the user to maintain backup copies of these files because they are available from the person designated control coordinator for each application program.

The current working file is a small file that can contain any program or data file that the user is currently using or developing. It is periodically backed up (approximately once a day) by the user to assure against data loss. About once a week, the current working files are transferred to a user file library for more permanent storage.

The user file library is a collection of files maintained by the user and intended for long-term data storage. The files in this library are arranged in a logical sequence determined by the user and designed to facilitate retrieval of programs and data. The file-naming conventions and volume names used are to be documented in a user records document. Backup copies of the contents of the user file library are maintained by the user.

The controlled access central archivial storage is a permanent storage area where critical files, backup copies, and related documentation are permanently stored. Files are stored and removed from central storage in accordance with estab-
lished procedures defined in a user procedures document.

The user procedures document is used to communicate to all users the procedures that govern usage of the computer system. The document contains standard operating procedures and methods, definitions required to promote common understanding of the procedures, listing of those persons responsible for the various control activities, and all other information required to enhance the orderly functioning of the system. The user procedure document is maintained at a central location within the organization and is used to communicate information of a general nature to all system users.

The user records document is maintained by the user and communicates, in standard format, critical information regarding the user's files. This document contains file names and descriptions, program names and usage, storage volume directories, naming conventions, storage locations, and other pertinent data related to the user's employment of the system. The user records document is maintained by the user as a general index to his or her filing system; it is also used by persons who may need to access this information in the absence of the user.

The User Procedures Document

The user procedures document communicates procedures required to meet management's goals regarding the use of the computing facilities. It is a working document that should be updated frequently and used as a helpful source of information. The contents of this document depend to a large extent on the nature of the organization, but they can be generalized.

Table 1 is an outline of the contents of a generalized user procedures document. Many of the topics outlined are self-explanatory, while others require additional explanation. Paragraph 4.0, system configuration, should be a block diagram, similar to Figure 1, that shows the details of the specific computing facility. It should clearly show the specific control levels that will be used in the organization as well as all computer systems, operating systems, application programs, and other pertinent features that require control. Include on the diagram the names of the people who will act as control coordinators for each control point. The user procedures document is the place to define responsibilities crucial to the success of the system.

Paragraph 5, control matrix, defines specific procedures that govern control at each level. For example, your procedures may require that each user's current working file be backed up once a week if it contains level 1 files and once a day if it contains level 2, or higher, files. Procedures should be included here to govern such things as: file backup frequency; file backup methods; change restrictions, including approval levels; password protection for files; and verification tests that must be performed after changes or revisions. Procedures for each of these and other relevant control areas must be specified for each controlled area and control level. A matrix of control procedures should result. If the control procedures appear in coded form on a diagram, the codes should be defined in this paragraph.

Paragraph 6 is a listing of those persons responsible for each control point with a description of the duties to be performed by them.

Paragraph 7 contains the format, update requirements, and other procedures that govern the user records document to assure that all employees are familiar with the document and can use it effectively when needed.

Paragraph 8 contains the procedures that are associated with the storage and retrieval of files from central archival storage.

The User Records Document

The user records document has a general format specified in the user procedures document; it is maintained by the computer system user. This document serves as an index to the user's files and is helpful to both the user and to other persons who may need to access the files. Table 2 is an outline of the essential contents of a user records document. Again, the specifics of the document are dependent on the particular organization.
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Paragraph 2, user responsibility, contains specific information on files the user is control coordinator for. This section should contain volume names, file names, backup volume and file names, storage locations, and the names and locations of historical documents associated with the files under his control.

Paragraph 3 contains the user's volume and file-naming conventions. This section is particularly useful in assisting those unfamiliar with the user's files in locating a particular file or determining file usage. This section should, at minimum, contain: volume-naming conventions, file-naming conventions, and file extension-naming conventions.

Paragraphs 4 through 7 contain the indexes to the user's working copy files, current working files, user library files, and permanent storage files. These indexes contain volume names, important file names, and storage location information.

Conclusion

This outline for the data file management system is adaptable to almost any small business environment. However, the only way to ensure that this system works is to carefully record the procedures that your company's computer users must follow. By clearly recording and presenting these procedures to your employees, you will eliminate many potential problems that could plague your computer. You and your employees will be happier with a computer system that clearly defines the lines of information access.

Robert Johnson holds a BS in electrical engineering from the University of Vermont and is president of a computer consulting firm. He can be reached at the Engineers Collaborative, Mears Rd., Milton, VT 05468.

Readers who wish to obtain outline copies of the user procedures document and the user records document should send a check for $15 and a self-addressed, stamped envelope to:

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| Model            | MuSYS NET/work 8816 | ALTOS 8000-10 | Televideo 806/20 | Micromation Matrix
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An Introduction to Layered Protocols

Understanding layered protocols can help you evaluate network architectures of data-communications products

by Michael Witt

Product announcements for computers and peripherals increasingly include claims of some sort of networking capability. To understand the network architectures of these products, it is essential to understand the concept of layered protocols. In this article, I'll discuss a reference architecture based on the International Standards Organization's (ISO) model for open-systems interconnection. This architecture provides a framework within which protocol layering can be explained. I will also briefly investigate protocol design issues within the different layers.

The Reference Architecture

Several years ago, the ISO, which is made up of national standards organizations from various countries, recognized the need for a basic framework in which computer networking standards could evolve. A subcommittee (SC16) was appointed to develop a model for “open systems interconnection.” The resulting model is called the “ISO OSI model.”

The ISO model is intended to be a vehicle for the development of specific standard protocols, but I use it here for its value as an architectural reference model. A reference architecture sets forth a general framework and principles by which a system is designed to operate. The model is presented here in a very simplified form, and I have taken some liberties with it to increase its value in this particular discussion. References 1 and 2 provide a precise, detailed description of the ISO model.

The physical link resides at the lowest protocol layer.

Layering, Protocols and Interfaces

Figure 1 shows a layered network in two computers (hosts) connected by a physical communications channel.

At a given layer (layer n), a program communicates with the corresponding layer in another host. This is peer communication. Because communication in a computer network is based on formalized communication protocols, peer protocol is used to describe the interaction of the corresponding layers in a communications network. Logically, these two layers communicate directly with one another (the dotted line), but in reality all communication must take place at the lowest layer because the only actual physical link is there (the solid line).

Communication between hosts takes place when layer n on the transmitting host formats a message and passes it down to its layer n−1. (Communication between two layers in one host is called an interface.) The message continues to be transmitted down until it reaches the bottom layer. It is then sent over the physical link to the receiving host. After being accepted by the lowest layer, the message works its way up to layer n in the receiving host.

An analogy can be made here to the type of communication that goes on in an office environment. For example, suppose the president of ABC Company decides that his softball team should play a series of games against the team sponsored by XYZ Corporation. He calls the captain of the softball team into his office and asks her to find out how XYZ Corporation feels about this plan. The softball team captain asks her...
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secretary to deliver the message to the captain of the softball team at XYZ Corporation to find out where XYZ Corporation would prefer to play if a series of games is scheduled.

The ABC secretary calls XYZ Corporation, relays the message and adds some information regarding the team's schedule.

When XYZ's softball team captain arrives at the office, his secretary informs him of the challenge from ABC Company, and he checks with the president of XYZ to find out if he may schedule the games. After receiving permission he asks his secretary to tell ABC Company that the challenge is accepted and that the games should take place in the park.

The two secretaries talk again, and then ABC’s softball captain reports to her president that the offer has been accepted and all arrangements have been made.

In this example, the only physical communication took place when the secretaries talked on the phone. However, there was a logical, or virtual, communication between the two company presidents (advancing and accepting the challenge) and between the two softball team captains (arranging the details of the game).

The communication between the layer n in figure 1 is the same as the communication between the company presidents in the example.

Peer protocols must follow the specifications of the network architecture precisely if information exchange is to be successful, but the interface between layers may be implemented in any way because it does not affect communication between the two hosts.
Using a layered approach to design computer networks is advantageous because the layers are relatively independent of one another and can be replaced without affecting the entire design. For example, if you have a layered network based on an underlyi

The distinction between the subnet protocols and the higher-level protocols is particularly important when public data networks are involved because it is this subnet that is supplied to the customer by the public data network.

**The layered approach is advantageous because the layers are relatively independent and can be replaced without changing the entire design.**

**The physical layer resides at the level of the transmission medium (referred to also as the link or channel) over which information is sent between two or more nodes in a network.**

The basic unit of information sent and received at this level is the "bit" (one binary digit). Bits can be encoded in a variety of ways depending on the transmission medium employed. Transmission mediums include: a particular voltage signal on a wire for a given time period (baseband signaling), a carrier signal modulated at a certain frequency (frequency-shift keying or FSK), phase changes in a modulated carrier (phase-shift keying or PSK), and coded pulsations of light transmitted over an optical fiber.

One example of an established physical-layer protocol is CCITT's X.21 standard for the connection of a customer's data-terminal equipment (DTE) to the public data network's data circuit-terminating equipment (DCE).

The physical channel is imperfect; not all information will be transmitted and received without error. Therefore, the higher layers must have error-detection and recovery measures.

The data-link layer transfers groups of bits, called frames, between adjacent nodes (machines) in a network. To complete this transfer, the data-link layer has two checks to perform.

First, because the data-link layer may receive invalid data from the imperfect physical layer, a checksum (a single calculated value based on a numerical operation involving each information unit in the frame) is usually affixed to each frame as it is sent by the data-link layer in the transmitting node. When the frame arrives at the receiving node, the appended checksum is compared with a checksum generated locally, and if the two don't match, the receiving data-link layer knows that a transmission error has occurred.

Second, because not all nodes in the network can send and receive data at the same rate, the data-link layer must take charge of flow control. Many different data-link-level protocols allow reliable transmission and balanced flow control.

Two popular flow-control link protocols are "stop-and-wait" and "sliding window" protocols. The stop-and-wait protocol uses the positive acknowledgment method to control data flow, in which an acknowledgment (Ack) signal sent back from the receiving node to the transmitting node indicates that the transmission was successfully received and that the receiver is ready for more data. Sliding-window protocols assign each frame a sequence number, and both the sender and receiver maintain a "window" of valid sequence numbers. This method is dependent on...
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on the receiver's ability to process received data while receiving still more data; thus, the transmitter may send several frames (determined by the window size and other factors) without stopping to wait for an acknowledgment. Transmission of data is held up only when the receiver is incapable of further processing. This method is suitable for full-duplex situations (in contrast to the stop-and-wait method, which is suitable for half-duplex).

In other schemes separate credit frames are sent to the transmitter when the receiver is ready to process more data.

**The network layer** (the last layer of the subnet) handles routing; it determines what path a message, or packet, will take through the network to get from the transmitting host to the receiving host.

In a network environment, two host computers generally are separated by an arbitrary number of other nodes not directly involved in that particular communication. Any given node in the network layer must have some way of determining which way to forward data so that it reaches its intended destination.

There are four states of routing protocols: centralized versus distributed and static versus adaptive.

### The network becomes congested when the hosts pump data into the network faster than it can be absorbed and delivered.

A centralized routing protocol stores information regarding network topology at one site. Information on how to route packets resides in each node. This routing protocol has the advantage of centralized control and ease of implementation, but it has two disadvantages: the central site becomes vulnerable because the network cannot function if the routing capability is lost, and the higher level of communications activity around the routing center can present a throughput problem.

In distributed routing, much depends on the sophistication of the network nodes. Simple nodes can only be supplied with a routing table or an algorithm such as flooding. If the nodes are more sophisticated, an adaptive technique can be used.

With a static routing protocol the routing tables are calculated in advance and no changes can be made in network topology without bringing the network down; in adaptive routing there is some provision for recognizing topology changes and incorporating this information into future routine decisions. Reference 8 provides more information on routing protocols.

The network layer must also deal with congestion. The network becomes congested when the hosts pump data into the network faster than it can be absorbed and delivered. Congestion is similar in some respects to the problem of flow control in the data-link layer, and some methods of dealing with it are the same (the issuing of credits, for example). For a discussion of network congestion and techniques for dealing with it, see reference 4 (pages 215-225).

Because few network architectures have implemented the higher-level protocols, explanations tend to get more abstract once you leave the subnet.

**The transport layer** ensures an error-free end-to-end connection between two or more communicating hosts. This layer, and all of the higher layers, need to exist only on network hosts (machines that take part in end-to-end communications over the network).

Although the data-link layer ensures reliable communication over the separate data links, it does not guarantee reliable exchange of data between hosts. Consider the network depicted in figure 3. Hosts A and B are engaged in an exchange of information over the shortest available path (in this case, the solid line through nodes 1 and 2). In the middle of the dialogue, node 2 becomes...
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Figure 3: A network that could employ adaptive routing to ensure continuing host-to-host communication in the event of a node failure.

The situation is as bad if an alternate path (the dotted line through nodes 5, 4, and 3) is established. How does host A know which packet to begin sending over the new path? Host A knows only that the last packet sent reached node 1 without error. There is no way for host A to determine if the packet was received by node 2 before it crashed, much less if it was successfully forwarded to host B.

The transport layer also must concern itself with end-to-end flow control. Many of the flow-control measures in this layer are similar to those in the data-link layer.

In some networks, the subnet provides a virtual-circuit service. This means that when host A wishes to communicate with host B, host A requests that a connection be set up to host B. This connection is called a virtual circuit because once set up, it can be used in much the same manner as a circuit on a circuit-switched network.

In other networks, the subnet provides only a datagram service. Each packet is considered a separate datagram, and each packet must contain the entire destination address (instead of just a virtual-circuit number). When using the datagram service the subnet does not guarantee the order in which datagrams will be delivered. The transport layer must sequence the data flow.

The session layer sets up, maintains, and closes down sessions (specific periods of communication) between specific layers on different host computers.

The most important responsibility of this level is that of remote log-on, in which a user on one host logs on to a second; that way, it appears to the second host as if the user is local.

Another session-layer activity is bracketing, which prevents execution of a critical database update until all information needed for that update is received, eliminating the chance of a partial update when transmission is interrupted. An opening bracket indicates to the session-layer protocol that a critical transaction is starting. When the closing bracket appears, it is safe to allow the transaction to be recorded. If the network should crash before the closing bracket is received, no update takes place.

Current networking architectures do not provide a good example of a distinct session layer. In most of the networks that implement the functions described here, those session-layer functions are subsumed in the transport and/or presentation layers.

The presentation layer formats the information being delivered. Some presentation activities are data com-
Encryption and Decryption Procedures

In traditional cryptography, plain text (symbolized by the letter P) is passed through an encryption process (E) to produce cipher text (C). To recover the original plain text, it is necessary to pass the cipher text through a decryption process (D). This procedure is illustrated in figure 4.

Encryption and decryption procedures are generally parameterized with a key (K). Two correspondents wishing to engage in a secret communication agree on a key. Their dialogue will be secure (even when encryption and decryption procedures are public knowledge) because no one else knows the key.

The functional notation generally used to describe the encryption process is \( C = E_k(P) \), which means that the cipher text \( C \) is produced by applying the encryption procedure \( E \), parameterized by the key \( K \), to the plain text \( P \). The decryption process is notated as \( P = D_k(C) \). For two correspondents to be able to read each other's messages, it must be true that \( P = D_k(E_k(P)) \).

An encryption method is considered symmetric if \( P = E_k(E_k(P)) \), meaning that the encryption process and the decryption process are equivalent. One example of such a process is the exclusive OR of the key value with that of the plain text.

There have been schemes proposed that differ from traditional cryptography; some prominent of these are public-key encryption. Public-key encryption constructs the encryption and decryption procedures so that it is possible to choose a pair of keys \( K_1 \) and \( K_2 \) for which \( P = D_{K_1}(E_{K_2}(P)) \) holds true, but \( P = D_{K_2}(E_{K_1}(P)) \) does not. In other words, text encrypted with \( K_1 \) must be decrypted with \( K_2 \). \( K_1 \) can then become the public key, accessible to anyone who wishes to send a private message to the owner of \( K_2 \).

Public-key encryption yields a promising method of obtaining digital signatures. Digital signatures will become important as more and more business is transacted via company networks. They can be implemented as follows: \( K_1 \) and \( K_2 \) are again used, however; this time \( K_2 \) is in a public file while \( K_1 \) is a user's private key. If the user wants to send a digital signature to his bank, for instance, he encrypts his name (or some other predetermined text) using his private key \( K_1 \). In other words, he performs \( C = E_{K_1}(\text{signature}) \). Upon receiving the message, the bank performs the decryption signature \( D_{K_2}(C) \). If the decrypted signature matches the expected one, the message must have been sent by the authorized user.

![Figure 4: An illustration of the encryption and decryption process.](image-url)
might be placed in a layer other than the presentation layer) may be necessary in a computer network. One is link encryption, in which data is encrypted by the link (or physical) layer as it flows between two network nodes. The other is end-to-end encryption, in which the encryption and decryption take place between the hosts involved and are performed at the transport layer or above.

Link encryption is valuable as a means of thwarting traffic-flow analysis, where an eavesdropper on the network attempts to gain information by reading the source and destination addresses in the packets to find out who is talking to whom, even though he may not be able to determine exactly what they are saying. If the link layer is to encrypt the packet headers to prevent traffic-flow analysis, each node in the network must know the key to decrypt the headers to determine the route of the packet.

It is unlikely that many users would trust their keys to every network node. Therefore, all networks will probably support some form of end-to-end encryption, and networks in which traffic-flow analysis is an issue will also use link encryption.

For an introduction to cryptology as it applies to information systems, see reference 9; also, see reference 10 for an up-to-date look at security measures in a layered-network environment.

The presentation layer must also be able to translate files from the format of one machine to another so that network users may take advantage of files that exist on the various hosts. Possible kinds of translations range from easy to beyond what is now state of the art.

Translation of a print format is relatively straightforward. However, translations of a syntactic nature (for example, moving floating-point numbers or more complicated data structures from one machine to another) are a little more difficult.

The most difficult translations, in which the actual semantics of the data are involved, have only been addressed in limited research settings. One example of this kind of transla-
tion would be to send an actual applications program from one computer host to another.

The presentation layer is also responsible for virtual terminal protocols. These protocols eliminate the problem that occurs when some terminals in a computer center are unable to accept a program because they use a different sequence of control characters than the others do to position the cursor.

The virtual-terminal protocols define a hypothetical terminal (the network virtual terminal). Mappings are then established between the virtual terminal's defined functions and the real terminal's functions. If the programmer follows the rules established by the virtual-terminal protocols, his program will run on all of the supported network terminals.

See reference 11 for a summary of virtual-terminal protocols currently in use.

The applications layer is responsible for network-wide program applications. No currently existing network has a truly integrated applications layer, but the most important research topics with regard to the applications layer are distributed databases, distributed computational models, and distributed operating systems. Designers of network-wide applications must determine how to distribute functions that traditionally existed within a single computer to two or more network hosts (distributed control).

There are several motivations for having distributed databases. If different subsets of the database are accessed more frequently in different geographic areas, a distributed database will help keep telecommunications costs down. Also, local control of data may sometimes be appropriate for political or business reasons.

There are two basic models for distributed databases: the replicated database, in which all information is duplicated at each site, and a partitioned database, in which the information is divided up among the various sites. Figure 5 shows how a relational database might be distributed among three different sites using these two methods. A parti-

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**Figure 5:** Two methods of distributing a database among three sites. In a replicated database, all information is duplicated at each site; in a partitioned database, the information is divided among the three sites.

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**Figure 6:** A distributed computational model (a) acting as a mainframe as it shares more than one processor per task. Compare this to a single mainframe handling multiple tasks (b).
tioned database is useful when you know that a certain part of the database (specific relations, for example) will be updated only at a certain location. A replicated database is more appropriate when each individual site will be doing a lot of queries, but updates are infrequent.

Usually, however, the choice is not this simple, and a combination of these models will be used. Many technical problems must be overcome before general-purpose distributed database systems become commercially viable. Some problems will be solved through services provided by the applications layer (see reference 4, chapter 10.1) and some through improved database architecture (see reference 12).

Research on distributed computational models is aimed at developing a way to schedule more than one processor per task in the distributed network, just as more than one task per processor can be scheduled in the central mainframe (see figure 6). This will make it possible to attain a high degree of generality in task/processor binding and will mean that network designers will have the greatest possible latitude in deciding how to distribute applications.

The next step in generalizing the networking environment will be to distribute the operating system among the computers in the network. It is difficult to determine where distributed computational facilities end and a distributed operating system begins, but the operating system would be more visible to the person who is using the network. See references 13 and 14 for descriptions of two research implementations in these two areas.

Conclusions

Today most network systems implement only a few of the seven layers of communications protocols described here. The ISO OSI model was designed to incorporate a lack of standardization at lower levels, as long as the differences remain hidden from the higher levels of protocol. Consequently, most implementation occurs at the subnet levels where this variation is allowed. And, until more work is done to establish compatible higher-level protocols, the use of networks will remain limited.

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References


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Much has been written about codes and ciphers and their many computer applications. Obviously computers can be used to decode messages and to create code books. They can also encipher and decipher messages by means of a previously agreed upon algorithm. In a sense, algorithms are what computing is all about.

A code is a system of symbols or words with meanings previously determined by those exchanging messages. For instance, a set of five-letter groups such as “ASDMN HCTWL DZCHW” might mean “sell our current gold holdings today,” with each group standing for a word or phrase in the appropriate code book. A cipher, on the other hand, consists of transforming the original text in accordance with an algorithm previously agreed upon by the message exchangers.

Perhaps one of the most secure enciphering methods of all is the one-time pad system. In this system, sender and receiver have identical note pads, each page of which lists a series of random numbers. The person sending the message sequentially transforms the characters in accordance with the random numbers on the pad’s top sheet. The person receiving the message uses the duplicate of that sheet for deciphering the message. The sheets are then destroyed. Because the same random-number sequence is never used twice, and because each character is encoded randomly (making character-frequency analysis impossible), the system is quite secure.

The enciphering/deciphering program given in listing 1 uses a similar system. The message is encoded via a set of random numbers derived by the programming language’s (here, Microsoft’s MBASIC) random-number generator. In this case, the random numbers are generated in a manner that uses the ASCII (American National Standard Code for Information Interchange) character set above decimal 32 as cipher characters.

Use of the random-number set for encoding prevents decipherment by frequency analysis. But what about the possibility of repeating the same number set used to encode a series of messages? The program presented here uses a keyword or phrase to determine a number to be used for “seeding” the random-number generator. In this
Programming Quickies

Listing 1: Enciphering/deciphering program for Microsoft BASIC. The program uses a keyword or phrase as the seed for generating a random-number series; the series is then used as the basis for encoding (or decoding) a message.

```
0   ' CIPHER PROGRAM
20   ' Copyright (c) 1981 by Theodore C. Hines
30   ' This program uses an enciphering algorithm which
40   ' fairly closely approximates the one-time pad technique.
50   ' It can be made more secure by using a personal
60   ' randomizing function.
70   ' However, even if the keyword and the randomizer
80   ' are known, the algorithm for determining the
90   ' randomizer number must be figured out. Users may
100  ' devise their own algorithm for this purpose.
110  'KEYWORD SUBROUTINE
120  150 INPUT "DO YOU WANT TO ENCODE OR DECODE? (E OR D)?", AS
130  160 IF LEFT$(AS,1)="D" THEN 410
140  165 IF LEFT$(AS,1)="E" THEN 170
150  170 INPUT "FILE TO READ FROM?", AS
160  180 OPEN "I" #1 AS #1
170  190 INPUT "FILE TO WRITE TO?", AS
180  200 OPEN "O" #2 AS #2
190  210 GOSUB 620
200  220 RANDOMIZE C
210  230 IF EOF(#) THEN 400
220  240 INPUT AS#1 AS
230  250 PRINT AS
240  260 IF AS="" THEN GOTO 310
250  270 FOR I = 1 TO LEN(AS)
260  280 C=INT(RND(1)+95)+1
290  300 D=ASC(MID$(AS, I, 1))-8
310  320 B=D+C
320  330 IF B>95 THEN B=0-95
330  340 B=B+32
340  350 Bi=Bi+CHR$(B)
350  360 NEXT I
360  370 PRINT Bi
370  380 Bi=""
390  400 GOTO 230
400  410 ' DECRYPT
410  420 INPUT "FILE TO READ FROM?", AS
420  430 OPEN "I" #1 AS #1
430  440 INPUT "FILE TO WRITE TO?", AS
440  450 IF AS="" THEN GOTO 620
450  460 FOR I = 1 TO LEN(AS)
460  470 C=INT(RND(1)+95)+1
480  490 D=ASC(MID$(AS, I, 1))-8
500  510 IF D<32 THEN D=0+95
510  520 D=D+32
520  530 Bi=Bi+CHR$(D)
530  540 NEXT I
540  550 PRINT Bi
550  560 IF S=1 THEN PRINT #2, Bi
560  570 PRINT Bi
570  580 GOTO 400
580  590 CLOSE: PRINT "CLOSED!": END
590  600 END
600  610 ' KEYWORD SUBROUTINE
610  620 620 FUNCTION SRC$(I, AS)
620  630 C=INT(RND(1)+95)+1
630  640 A=ASC(MID$(AS, I, 1))
640  650 D=A+C
650  660 SRC$=SRC$+CHR$(D)
660  670 NEXT I
670  680 PRINT SRC$(I, AS)
680  690 RETURN
```
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Programming Quickies

program, the seed is very simply derived by adding together the ASCII values of the characters in the keyword. Much more complex algorithms could be used. The keyword could be varied with each message, or a number from some predetermined sequence (such as pi) could be added to the keyword figure to form the seed. Other bewildering elements might be included, such as starting with an agreed upon nth number in the random series, omitting every nth number, or skipping n random numbers in the table. You could insert a personal randomizing algorithm rather than use the one built into BASIC. Most users could easily adapt the BASIC code given here to their particular machines and applications. Note that TRS-80 Level II BASIC's randomizer can be given a known seed by poking the seed in the bytes located at 16554 through 16556 (decimal).

Some versions of BASIC (Applesoft and TRS-80 Level II, for example) do not have a LINE INPUT function. This means that either you may not be able to key in commas or colons in the data to be coded or that you'll need to write a new input loop using the INKEY$ or GET functions for inclusion of these punctuation marks in your input string. Similarly, input from a file in these versions of BASIC may ignore information in a sequential-file record that follows a colon or comma. In this case, you'd need to convert these characters to the ASCII value of some character not in the data or use some other method. The encoding routine must not generate a comma or a colon. (If this puzzles you, drop us a query.)

In a way, the program given here is just a sample of what could be done. Those who have to send their code on paper (instead of in machine-readable form) to the receiver might want to restrict the cipher alphabet to capital letters and to print out the cipher text in five-letter (or so) groups. The computer could simply produce a pair of one-time pads, or the cipher as sent might consist only of numbers—random plus ASCII—rather than being translated into ASCII as is done here.

The enormous effort of trying to crack such a cipher would hardly be repaid by finding out from the local CBBS (computer bulletin board system) or electronic mail that George wants Matilda to meet him at Leon's Lounge at 12:30 or that Al won't go any higher than $250 for the S-100 board in question. On the other hand, the program is easy to implement, reasonably secure, fun to play with, and will cost you considerably less than commercial cipher programs.

As noted earlier, codes, ciphers, and computers seem to go together. If you like this program, you may want to get a copy of David Kahn's *The Codebreakers* (Macmillan, 1967), an enormously entertaining and informative history. It will also give you lots of ideas for programs.

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Does Your Printer Work with Wordstar?

Overcome compatibility problems between Wordstar and your printer

by Charles Stevenson

You might think it's reasonable to assume that getting a popular word-processing program, an equally popular personal computer, and a printer to work together would be a breeze—just plug everything in and go.

Nothing is ever that simple.

Even with such widely used products as IBM's Personal Computer and Micropro International's Wordstar program, compatibility can be a problem. In this article, I will point out some of the troubles you may face when trying to combine these two with a printer, and I will describe ways to get around these problems.

Printer Pointers

First, you must make sure your printer will work with Wordstar. Unfortunately, there is little standardization in the printer industry, which means that not all printers will work with all word-processing programs.

When you have determined that your printer is compatible with Wordstar, your next step is to connect the printer to the computer. This task will be easier if you break it into three parts: get your computer system to work, get it to work right, and get it to work at its best.

To get your system to work, first make sure the printer itself works. Many new printers have a self-test mode. Use this to find out if the printer has survived its trip from the factory to your computer. Be sure that the ribbon and print wheel are properly installed and that other adjustments required prior to first use have been made.

Even slight variations from printer standards can wreak havoc with software.

Next, check that the cable between the printer and computer will work. The IBM Personal Computer usually accepts printers with parallel interfaces. If the printer has a Centronics-type 36-pin male connector, it should mate with the parallel printer cable sold by IBM, but there are exceptions. There is at least one printer on the market with a Centronics connector that requires a special cable because the electrical signals are not on the same pins. A connector with the wrong gender (the Centronics connector on the end of the IBM-supplied parallel printer cable is female) will require a gender-changer cable.

Serially interfaced printers may cause different problems. The asynchronous port on the IBM Personal Computer is defined as a modem port, rather than a printer port. A modem port puts the remote computer in charge while the IBM Personal Computer acts as a terminal, but a printer port assumes that the Personal Computer is running the show. To put your Personal Computer back "in charge," a number of wires must be interchanged through a special cable, not usually supplied by either the printer manufacturer or IBM. To wire your own cable, interchange pins as shown in figure 1.

If the cable still doesn't work during the testing (described in a moment), consult the appropriate manuals to determine what signals are required at each end of the cable. You may need to experiment a bit before you get it right, but your
This means that the printer is set up to run at 1200 bps (bits per second), with 8 data bits, 1 parity bit, 1 stop bit, and the printer option. The second:

**MODE LPT1: =COM1**

switches the output from the parallel port to the serial port. See the PC-DOS manual for further details.

If the printed directory is unrecognizable or if nothing prints, then the data rate is probably incorrect. If you get gaps, misalignment of columns, or other printing that is almost right, there is probably a problem with handshaking on the serial port, causing characters to be lost because of buffer overflow. If this has happened, check your cabling. If the cabling seems all right, contact the printer manufacturer or your dealer for help.

Note: printers that are connected through the parallel port can also fail to handshake properly if they are not set to respond to the **STROBE** line correctly. (This is a control line that signals when data is valid.) The IBM Personal Computer expects the printer to accept data when **STROBE** is low. In some cases, the printer's strobe input may accept data when high. There may be a switch somewhere inside the printer to invert this signal. If you suspect this to be the problem, change the switch position and try again.

At this point, your system is working and may be working correctly. Next test: find (or create) a text file that will fill at least two pages. After running the printer on with Control-P (or Control-PrtSc), use the TYPE command from PC-DOS to print the text file. Examine the printout carefully. If you find no errors, such as missing characters or lines, you can be sure the connection is correct.

Run one more test to make sure your system is working right. Using the Install program that comes with Wordstar, select the nonspecific (fixed-escapement) serial printer option for your first attempt at Wordstar (this will appear as the 'Teletype-like printer' or 'standard printer' option; specify the backspacing capability that is appropriate for your printer.) Run Wordstar and print the test file on the Wordstar distribution disk (EXAMPLE.TXT or PRINT.TST, depending on the version of Wordstar you have). If this output looks acceptable (don't worry about vertical positioning of subscripts and superscripts or about the lines in the test output that mention character width and line height), run Install once again. This time, select the option appropriate for your printer by name. Then, reboot Wordstar and print the same test file. If your printer can handle all the Wordstar output commands, you will see a remarkable transformation in the printout. Subscripts and superscripts will be in the right places (a little below or above the printing line rather than a whole line space apart). Boldface type will look bold. The lines in the test files that show the effects of changing character width and line height will do so.

If this happens, and if nothing was misprinted or lost, your system is working at its best. If the printout doesn't look right, you may still have a handshaking problem that can only be resolved by the printer manufacturer or computer dealer.

### Teletype versus Microspaced Printing

You may wonder why Wordstar prints the file correctly when the printer operates as a Teletype-like device but loses characters when the printer is formatting output for a microspaced specialty printer like a Diablo, Qume 1, or NEC Spinwriter.

This happens because specialty printers are sent a large number of extra characters to tell it to set the width of individual characters to justify the text. The extra characters cause the buffer in the printer to fill much more quickly with formatted output (occasionally causing the loss of some characters) than it does when the printer output is in the nonspecific (Teletype) mode.

The problem of lost characters may not be discovered when there are only a few pages of text because there may not be enough text to fill the buffer. The larger the buffer, the longer it takes to find out that some
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characters are being lost. (Incorrect cabling is often the cause of this problem.) On the other hand, the faster the data transmission, the sooner the problem will show up. The quickest way to find buffering problems is to reduce the buffer size to the minimum and increase the data rate to the maximum.

Some printers do not have the features the specialty printers have to produce elegant Wordstar printing. (See the sidebar “Necessary Printer Functions for Wordstar.”) The problem stems from the two mutually exclusive printer-driver routines in Wordstar. The PDAIS routine requires that the printer understand a small but necessary set of commands, and if the printer does not understand even one of them, PDAIS cannot be used. The PTTY routine can be activated instead of PDAIS, but it has limited expandability. The Wordstar overlay structure prohibits PTTY and PDAIS from being stored in memory at the same time.

**Patching Wordstar**

Dot-matrix printing technology has produced a great variety of relatively low-cost printers suitable for IBM’s Personal Computer. Each of these printers has a number of enhanced printing modes that people would like to use, but there has been little consistency in the implementation of these features. Also, very few of these printers can do all the things required by PDAIS.

Some users have sent program patches (modifications) to Micropro that open up many of these printing modes for Wordstar use, and some patching packages are being marketed by firms other than Micropro. These patching techniques take one of the user-print functions, such as Control-PQ, and extend it to a three-letter control sequence. Doing this requires that every character be intercepted as it is being sent to the printer driver to see if it is, in this case, Control-P. If so, the patch must divert the next character to a new piece of code that checks it for extended capability. These operations make use of a memory area called
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MORPAT, and code placed in that area is not supported by Micropro. Furthermore, Micropro cannot commit itself to leaving MORPAT in the same place in future versions of Wordstar, so new versions of Wordstar may require new versions of the printer patch code. A worse problem could be created if the user buys another program that connects to Wordstar through MORPAT, resulting in a conflict that might mean that neither enhancement would work.

Wordstar was designed for specialty printers. Low-cost matrix printers can provide an inexpensive way of obtaining output from Wordstar, but will never be of the same quality as the engraved-print daisy-wheel and thimble printers. (Be aware, however, that not all daisy-wheel printers can be used as specialty printers under Wordstar. If in doubt, ask your dealer.)

Future Compatibility

Many printer manufacturers are now conferring with software manufacturers before their printers hit the market. Software designers can often detect and report hardware problems, incompatibilities, and design errors in printers in time to get them fixed before distribution. Printer manufacturers who disregard these offers of cooperative assistance run the risk of producing products that never perform satisfactorily in their intended roles.

Cooperative assistance between printer and software manufacturers should help alleviate future compatibility problems among programs, printers, and computers.

References


Charles Stevenson is chief programmer at Micropro International Corporation (33 San Pablo Ave., San Rafael, CA 94903)
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Circle 328 on Inquiry card.
In-Circuit Emulation for the Apple II Computer

You can convert your Apple into a host for testing a target system’s hardware and software

by John D. Ferguson

Without doubt, the easiest method of debugging any microprocessor-based computer system is to access that system through its processor socket. Using in-circuit-emulation (ICE) techniques, the most powerful diagnostic aids currently available, the processor of the unit under test (the target) is removed, and a second microcomputer system (the host) is linked to the target through the target’s processor socket.

Emulators are usually associated with expensive microprocessor development systems or equally expensive troubleshooting tools such as the Fluke 9010A (manufactured by the John Fluke Company of Everett, Washington). However, with one simple circuit you can turn your Apple II into a host computer for emulation purposes. This allows it to test hardware and evaluate software in a target system based on a 6502 microprocessor (or one compatible with the 6502). The Apple II in-circuit emulator is carried on one Apple card. A 40-conductor ribbon cable, terminated in a dual-inline plug, connects the ICE to the target microcomputer (see figure 1). The ICE card gives the Apple limited emulation capability, allowing it to relocate any 2K-byte block of address space in the target system into the normally free memory area at locations C800 through CFFF hexadecimal in the Apple (see figure 2). The memory region observed in the target system is software selected by writing to an address-select latch. Because this selection is under program control, you can write routines in the host system to test the target system’s entire memory map.

With one simple circuit you can turn the Apple II into a host computer for emulation purposes.

Test software can be written in either a high-level language, such as BASIC, or in machine code, and it can be directed at the main functional blocks within the target system: system buses, RAM (random-access read/write memory), ROM (read-only memory), and I/O (input/output) devices.

Routines written in BASIC tend to be inconveniently slow for even the simplest tests. The more effective approach is to write standard test modules in machine code and use a BASIC program to form an overall test strategy that sequences the tests and guides the user with recommendations if a fault is detected.

In this article I’ll describe test modules for exercising the system buses and testing RAM and ROM. I’ll conclude with a case study that illustrates how the Apple ICE can be used to test Rockwell International’s AIM-65 single-board computer.

ICE Hardware

Figure 3 on page 422 shows a circuit diagram of the ICE card. Address lines A0 to A10 together with control lines R/W, φ0, and RES pass directly from the Apple to the target system via octal driver chips IC4 and IC5. However, address lines A11 to A15 in the target system are not obtained from their Apple equivalents but are instead generated by the block-select latch IC3. For selection of the five most significant lines in the target system, a control word is first written to this latch, which is clocked by the Apple I/O SELECT line. Hence, if the ICE was in slot 5, the following short program would set A11 to A15 in the target system to zero:

LDA #$00 \ sets A11 to A15 to zero
STA C500 \ activates the I/O SELECT line in slot 5.

After the block-select latch is con-
figured, any read or write operations to memory locations between C800 and CFFF hexadecimal in the Apple activate the address decoder chip IC1 and enable the output of latch IC3, establishing corresponding addresses between 0000 and 07FF hexadecimal in the target system.

The address decoder (IC1) also enables the octal transceiver (IC2), allowing data to be either written to or received from the target system. The decoder IC1 might seem unnecessary because I/O STROBE is active low for addresses between C800 and CFFF hexadecimal. However, close examination of I/O STROBE's timing shows that its low state appears too late in the timing cycle to enable slow memory or I/O devices in the target system (see figure 4 on page 427).

Test Software

The software required for testing falls into two categories: (1) routines that exercise and test the various functional areas of the target microcomputer—its system buses, RAM, ROM, and I/O devices—and (2) the overall test program, which guides you through the test sequence, calling the functional tests and performing the tasks normally performed by a fault-finding tree (i.e., pinpointing the source of the fault and suggesting a remedy—for instance, "replace IC28"—or initiating a new test to gather more information).

The following section describes the functional tests, providing three routines written in 6502 assembly language. Each program operates on the memory window at locations C800 to CFFF hexadecimal between the Apple and the target system.

Address and Data-Bus Toggle Test

Before launching into complex tests of the system's ICs, test the integrity of the system buses. With a toggle test you can exercise the address and data-bus lines by alternately driving them high and low. Listing 1 on page 427 shows such a test program, which starts by selecting addresses in the binary pattern 10101... in the target system. A dummy read is then made to address AAAAA hexadecimal.
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Circle 268 on inquiry card.

Byte September 1983 421
Figure 3: A circuit diagram of the Apple IIE card.

<table>
<thead>
<tr>
<th>Number</th>
<th>Type</th>
<th>+5 V</th>
<th>GND</th>
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<tr>
<td>IC1</td>
<td>74LS138</td>
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<tr>
<td>IC2</td>
<td>74LS04</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>IC3</td>
<td>74LS374</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>IC4</td>
<td>74LS244</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>IC5</td>
<td>74LS244</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>IC6</td>
<td>74LS244</td>
<td>20</td>
<td>10</td>
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</tbody>
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mal, placing the high, low, high, low pattern on the target-system bus. The select latch is again accessed and addresses in the binary pattern 01010... are selected, followed by a dummy read to location 5555 hexadecimal, thus complementing the previous address-bus pattern. This procedure is repeated 256 times before a similar test pattern is started on the target system's data bus.

Exercising the system buses with this pattern allows the operator to determine, using an oscilloscope or logic probe, whether each line in the target system is drivable (i.e., no lines are stuck high or low) and whether each line is continuous from its source (the processor socket) to its destination on each chip.

A more complex test could also check for shorts between lines by injecting a characteristic frequency or pattern onto each line. You could then use a frequency meter or oscilloscope to check for corruption between lines.

Toggling the system buses 256 times does not allow enough time for checking even one circuit node. The short routine below illustrates how the bus test (BTEST) is used in the test sequencing program:

180 PRINT "BUS TESTING—PROBE TARGET SYSTEM BUS"  
190 PRINT "PRESS SPACE FOR NEXT TEST"
200 CALL BTEST
210 IF PEEK (-16384) < =127 THEN 200

Listing 1: Toggling all address and data-bus lines.

SOURCE FILE: APPTOG
0000: 1 ;
0000: 2 :ADDRESS AND DATA BUS TEST
0000: 3 ; TOGGLE ADDRESS BUS AAAA-5555
0000: 4 ; 256 TIMES
0000: 5 ; TOGGLE DATA BUS AA-55
0000: 6 ; 256 TIMES
0000: 7 ;
0000: 8 ;
C500: 9 SELECT
--- NEXT OBJECT FILE NAME IS APPTOG.OBJO

2100: 10 ORG $2100
2100: 11 LDX #00
2102: 12 ; EXERCISE ADDRESS BUS
2102: 13 ABUS LDA #$AA
2104: 14 STA SELECT
2107: 15 AD AA CA LDA #$3A
210: 16 STA SELECT
210C: 17 AD CS 56 LDA #$95
210F: 18 AD 55 CD STA SELECT
2112: 19 CA LDA #$CD 55
2115: 20 ED BNE ABUS
2118: 21 ; EXERCISE DATA BUS
2118: 22 DBUS LDA #$90
2117: 23 STA SELECT
211A: 24 AA STA SELECT
211E: 25 C8 00 C9 LDA #$C900
211F: 26 AA STA SELECT
2121: 27 DBUS LDA #$C900
2124: 28 CA DEX
2125: 29 EE BNE DBUS
2127: 30 RTS

*** SUCCESSFUL ASSEMBLY: NO ERRORS

By placing the test within a loop that also checks the keyboard, the test repeats until you press the space bar, signaling that further testing isn't needed.
RAM Checkerboard Test

The basic strategy for testing RAM requires writing a test pattern into memory, reading it back, and checking that both the write and read operations were successful. Many different test patterns can be used; each is sensitive to particular failure modes of the memory. One popular pattern that provides a reasonable amount of time a test of the read/write capability of every bit in the RAM is the checkboard test pattern (see figure 5).

Listing 2 shows this RAM test program. In it, a RAM location is selected and 55 hexadecimal (01010101 binary) is stored in the location and then read back and compared. If the comparison fails, the test terminates with the Apple displaying a RAM failure message. If the comparison passes, the location is then tested with the complementary pattern AA hexadecimal (10101010 binary). The test then moves on to the next location and continues until all locations within the window (C800 to CFFF hexadecimal) have been exercised and tested.

Before the RAM test in the main test program is called, the memory should be written to, moving the RAM to be exercised into the ICE test window. For example, the following program would test RAM from 0800 to OFFF hexadecimal in the target system:

250 PRINT "RAM TESTING 0800—OFFF"
260 POKE SELECT, 08:CALL RAMTEST

ROM Signatures

The usual method for testing ROMs involves forming a checksum based on a sum of all the data within the ROM. However, faults could be concealed by several errors that cancel each other out. A technique that is more sensitive and less likely to mask errors involves performing a cyclic redundancy check (CRC) on the ROM contents. It originated in data communications, but more recently it's been used in signature analysis, a relatively new troubleshooting tool pioneered by Hewlett-Packard. Like most jobs in computing, the cyclic redundancy check can be evaluated by either hardware or software. The hardware model proves the simplest to illustrate.

Figure 6 on page 435 shows a typical CRC evaluation circuit using a 16-bit linear shift register with feedback. Each bit of data is fed serially into the register. When the data stream ends, the final binary pattern remaining in the register forms the 4-digit cyclic redundancy check. The feedback paths effectively form a sum to the base 2 between the data fed back and the new data entering and ensure that every bit entering the register contributes toward the final CRC or signature.

An equivalent software routine is presented in listing 3. In this scheme, each byte from the ROM under test is fed serially (bit 0 to bit 7) to the subroutine FEEDBACK, which performs a sum to the base 2 of bits 15, 11, 8, and 6 within the register and the incoming bit. When 16,384 (2K x 8) bits of data have entered the feedback algorithm, the pattern remaining in locations SIGH and SIGL forms the final signature.

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BYTE September 1983 429
Listing 2: A program to checkerboard-test RAM.

SOURCE FILE: APPRAM

0000: 1 ;**************************************************************************
0000: 2 :PROGRAM TO CHECKERBOARD TEST RAM
0000: 3 ;(C800-CFFF)
0000: 4 ;**************************************************************************
0000: 5 ;

FD8E: 6 COUT EQU $FD8E ;CHARACTER TO SCREEN
FDDE: 7 CR8UT EQU $FDDE ;C-RETURN TO SCREEN
FDE3: 8 PRHEX EQU $FDE3 ;OUTPUT HEX DIGIT
000B: 9 POINT EQU 08 ;POINTER

---------- NEXT OBJECT FILE NAME IS APPRAM.OBJ0

2030: 11 ORG $2030
2030: 12 ;
2030: 13 LDA #00 ;POINT TO C800
2032: 14 STA POINT
2034: 15 TAY
2036: 16 LDA #$C8
2038: 17 STA POINT + 1
203A: 18 START LDA #$55 ;START TEST WITH 55
203C: 19 STA (POINT), Y ;STORE
203E: 20 CMP (POINT), Y ;READ BACK AND COMPARE
2040: 21 BEQ OK
2042: 22 IMP ERROR ;DISPLAY ERROR MESSAGE AND END
2044: 23 OK LDA #$AA ;NOW TRY AA
2046: 24 STA (POINT) , Y ;STORE
2048: 25 CMP (POINT) , Y ;READ BACK AND COMPARE
204A: 26 BEQ OKI
204C: 27 IMP ERROR ;DISPLAY ERROR MESSAGE AND END
204E: 28 OKI INC POINT ;NEXT LOCATION
2050: 29 INC POINT + 1
2052: 30 INC POINT + 1
2054: 31 LDA POINT + 1
2056: 32 CMP #$D0
2058: 33 BNE START ;END OF BLOCK?(CFFFl
205A: 34 RTS ;TEST COMPLETE
205C: 35 ;
205C: 36 ;ERROR DISPLAY ROUTINE
205C: 37 ;
205C: 38 ERROR LDX #00 ;POINTER FOR MESSAGE
205E: 39 NEXT1 LDA MESS,X ;MESSAGE TO SCREEN
2060: 40 ISR COUT ;MESSAGE TO SCREEN
2062: 41 INX ;NEXT CHARACTER
2064: 42 CPX #$OF ;MESSAGE COMPLETE?
2066: 43 BNE NEXT1
2068: 44 LDA 09 ;FAIL ADDRESS TO SCREEN
206A: 45 BNE
206C: 46 SBC #$C8
206E: 47 ISR PRHEX ;C-RETURN TO SCREEN
2070: 48 ISR CROUT ;AND FINISHED
2072: 49 RTS
2074: 50 ERROR MESSAGE
2076: 51 MESS ASC " \nERROR ON PAGE "

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bytes, three routines are used. The NSIG (new signature) routine resets the shift register pair SIGH, SIGL to zero and forms a signature on 2K bytes of ROM. In CSIG (continue signature), the shift register is *not* reset to zero at the start, thus allowing a continuation of a signature for ROMs greater than 2K bytes. The DISPLAY routine shows the contents of the shift register pair SIGH, SIGL in hexadecimal form.

The following listing shows how all three routines can be used to evaluate the signature of a 4K-byte ROM located at B000 to BFFF hexadecimal in the target system:

```
320 REM B0 HEX IS 176
330 POKE SELECT,176
340 CALL NSIG:REM FIRST 2K BYTES
350 REM B8 HEX IS 184
360 POKE SELECT,184
370 CALL CSIG:REM CONTINUE WITH NEXT 2 BYTES
380 CALL DISPLAY:REM DISPLAY FINAL SIGNATURE
```

Implementing a Test Program

The Apple ICE described here can be used with a wide range of 6500 microcomputers designed to run at 1 MHz if all the onboard circuitry is controlled by the processor's φ₂ clock. The AIM-65, for example, provides an ideal target system, containing as much as 4K bytes of RAM, 20K bytes of ROM, and a wide range of I/O devices—two 6522 Vias (versatile interface adapters), a 6520 PIA (peripheral interface adapter), and a 6532 RIOT (RAM input/output timer). Figure 7 provides an overview and a memory map of the AIM-65, and a test sequence is shown in listing 4 on page 443. The program begins by testing the system buses, followed by a RAM test on the 4K bytes of RAM and a ROM test that forms signatures for each of the five system ROMs. The test sequence concludes with a check on the user 6522 VIA. For this test, the ports are linked together

---

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*Text continued on page 444*
Figure 7: The layout and memory map of the AIM-65.
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Listing 3: A program to evaluate ROM signatures.

SOURCE FILE: APPSIG

0000: 1 1
0000: 2 ; PROGRAM TO EVALUATE SIGNATURE
0000: 3 ; OF 2KBYTE BLOCK (C800-CFFF)
0000: 4 ; EACH BYTE IS SERIALIZED BIT-BIT
0000: 5 ;
0000: 6 ;
0000: 7 ;
0000: 8 ;

--- NEXT OBJECT FILE NAME IS APPSIG.OBJ0

0000: 9 2000 1
0000: 10 COUNT EQU $2000 ;STORE FOR SUM
0000: 11 SIGL EQU $1900 ;CURRENT SIGNATURE LOW BYTE
0000: 12 SIGH EQU $1902 ;CURRENT SIGNATURE HIGH BYTE
0000: 13 POINT EQU $0008 ;BYTE COUNTER
0000: 14 TEMP EQU SIGL+1 ;TEMPORARY STORE
0000: 15 PRBYTE EQU $FDFA ;PRINT A HEX BYTE
0000: 16 CROUT EQU .$FD8E ;GENERATE C-RETURN

2000: 17 ;
2000: 18 START LDA #00 ;ZERO SHIFT REGISTER
2000: 19 SIA SIGL
2000: 20 STA SIGH ;WARM START
2000: 21 WSTART LDA #00
2000: 22 STA POINT
2000: 23 TAY
2000: 24 A9 00 ;ZERO SHIFT REGISTER
2000: 25 STA POINT+
2000: 26 BNE NBYTE ;FOR 8 BITS
2000: 27 INC POINT+1
2000: 28 80 03
2000: 29 JSR FEEDBACK ;APPLY FEEDBACK
2000: 2A CA 34
2000: 2B EXE FF
2000: 2C DEX
2000: 2D BNE NBYTE ;END OF BLOCK? CFFF
2000: 2E 90 03 ;NEXT BYTE
2000: 2F 6A NEX2 ROR A
2000: 30 90 03 ;TEST BIT 11
2000: 31 EE 00 19 INC COUNT
2000: 32 6E 00 19 ROR COUNT ;SUM INTO CARRY
2000: 33 2E 01 19 ROL SIGL ;CARRY INTO BYTE
2000: 34 2005:8E E4B ;FEEDBACK ALGORITHM—SUMS BITS
2000: 35 2005:8E E4B
2000: 36 BNE NBYTE ;BACK FOR NEXT BIT
2000: 37 90 03 ;TEST BIT 6
2000: 38 EE 00 19 INC COUNT
2000: 39 2E 01 19 ROL S lGL ;CARRY INTO SITO LBYTE
2000: 3A 2005:8E E4B ;TEST BIT 8
2000: 3B 2005:8E E4B
2000: 3C 90 03 ;TEST BIT 15
2000: 3D EE 00 19 INC COUNT
2000: 3E 60 NEX3 LDA SIGL ;BOTTOM HALF OF SIG
2000: 3F 51 BPL Nex1 ;TEST BIT 15
2000: 40 52 Nex1 ROR A
2000: 41 53 BCC Nex2 ;TEST BIT 8
2000: 42 54 INC COUNT
2000: 43 55 Nex2 ROR A
2000: 44 56 ROR A
2000: 45 57 ROR A
2000: 46 58 BCC Nex3 ;TEST BIT 11
2000: 47 59 INC COUNT
2000: 48 60 Nex3 LDA SIGL ;BOTTOM HALF OF SIG
2000: 49 61 ROL A
2000: 4A 62 ROL A
2000: 4B 63 BCC Nex4 ;TEST BIT 6
2000: 4C 64 INC COUNT
2000: 4D 65 Nex4 ROR COUNT
2000: 4E 66 ROL SIGL ;CARRY INTO BIT 0 BYTE

Listing 3 continued on page 443
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Listing 3 continued:

205C:2E 02 19  67 ROL SIGH ;CARRY INTO BYTE
205F:60 68 RTS
2060:AD 02 19 69 DISPLAY LDA SIGH ;MSB TO DISPLAY
2063:20 DA FD 70 JSR PRBYTE ;ONTO APPLE DISPLAY
2066:AD 01 19 71 LDA SIGL ;LSB TO DISPLAY
2069:20 DA FD 72 JSR PRBYTE ;ONTO APPLE DISPLAY
206C:20 8E FD 73 JSR CROUT ;C-RETURN
206F:60 74 RTS

*** SUCCESSFUL ASSEMBLY; NO ERRORS

Listing 4: Applesoft BASIC program sequencing tests.

listing 4

50 REM AIM85 TEST ROUTINE
60 HOME
70 REM DEFINE SYSTEM ADDRESSES
80 SELECT = - 15100
90 DISPLAY = 8288
100 NSIG = 8192
110 CSIG = 8200
120 BTEST = 8448
130 RAMTEST = 8336
140 PRINT ""
150 PRINT "LOADING MACHINE CODE TESTS"
160 PRINT "BLOAD APPTESTS"
170 PRINT ""
180 PRINT "BUS TESTING-PROBE TARGET SYSTEM BUSSES"
190 PRINT "PRESS SPACE FOR NEXT TEST"
200 CALL BTEST
210 IF PEEK (- 16384) < 127 THEN 200
220 PRINT ""
230 PRINT "RAM TESTING 0000-07FF"
240 POKE SELECT,0: CALL RAMTEST
250 PRINT "RAM TESTING 0800-0FFF"
260 POKE SELECT,0: CALL RAMTEST
270 PRINT ": PRINT " RAM TESTS COMPLETE ":
280 PRINT ""
290 PRINT "ROM SIGNATURES BLOCKS B,C,D,E,F"
300 PRINT ""
310 FOR N = 176 TO 240 STEP 16
320 POKE SELECT,N: CALL NSJG
330 POKE SELECT,(N + 8): CALL CSIG
340 CALL DISPLAY
350 NEXT N
360 PRINT ": PRINT " ROM SIGNATURES COMPLETE"
370 PRINT ""
380 PRINT " VIA TEST"
390 POKE SELECT,160: REM SELECT BLOCK AXXX
400 APRT = 51201:BPRT = 51200
405 ADIR = 51203:BDIR = 51202
410 POKE ADIR,0: POKE BDIR,255
415 REM A INPUT - B OUTPUT
420 FOR N = 0 TO 255
430 POKE BPRT,N
440 IF PEEK(APRT) < > N THEN PRINT "VIA ERROR"
450 NEXT N
460 POKE BDIR,0: POKE ADIR,255
465 REM B INPUT - A OUTPUT
470 FOR N = 0 TO 255
480 POKE APRT,N
490 IF PEEK (BPRT) < > N THEN PRINT "VIA ERROR"
500 NEXT N
510 PRINT " ": PRINT " TEST COMPLETE"
520 END

Listing 4 continued on page 444
Listing 4 continued:

RUN

LOADING MACHINE CODE TESTS

BUS TESTING-PROBE TARGET SYSTEM BUSES (PRESS SPACE FOR NEXT TEST)

RAM TESTING 0000-07FF
RAM TESTING 0800-0FFF

RAM TESTS COMPLETE

ROM SIGNATURES BLOCKS B,C,D,E,F

BB9C
A181
F727
B072
8A9E

ROM SIGNATURES COMPLETE

VIA TEST

TEST COMPLETE

with a hard-wired fixture connecting PA0 to PB0, PA1 to PB1, and so on. The routine starts by configuring port A as an input and port B as an output. A test pattern is then written out port B and read and checked at port A. The role of the ports is then reversed, and the test is repeated.

This example illustrates some techniques that can be used with the Apple ICE. A more detailed program for the AIM-65 would test the remaining I/O devices, such as the display, printer and keyboard, and more thoroughly guide the user. However, the ideas presented here illustrate the principles behind the techniques and mirror those found in commercial instruments. The Apple ICE is therefore not only a practical fault-finding tool but also an ideal, low-cost, educational aid.

John D. Ferguson is a lecturer with the Microelectronics Educational Development Centre at Paisley College, High St., Paisley PA1 2BE, Scotland.
Add Multiple Tasks to Your Communication and Control Program

A special kernel lets your 8080 run multiple tasks concurrently

by Jerry Holter

Robotics, data communications, measurement and control, and computer music are only a few of the microcomputer programming applications that must respond to external real-time stimuli. Handling these stimuli is no problem if only one event occurs at a time and there is enough time between each event to do all the required computing for that task. But real-time problems are seldom so obliging. Often, the computer must handle several events concurrently.

This article describes one way to include concurrency in your programs, so that each simultaneous function can be written as a separate, straightforward task. You achieve concurrency by using a compact set of routines called a multitask kernel, to which each task speaks in a well-defined way. To demonstrate, I will present an 8080 kernel that supports multiple concurrent tasks in programs running under typical single-user operating systems.

A Split-Screen Display

First, let’s explore some multitasking concepts by taking a look at an example program. Suppose you would like to use your computer as a smart terminal for a remote system, but you have a tendency to forget the passage of time, thereby running up a gigantic bill for computer and telephone services. A possible solution is to display the current time in a large banner format on the upper one-third of the console screen and show the usual dialogue with the remote system on the lower two-thirds. Because you can assume that the processor and the console screen run much faster than the telephone modem, this goal appears reasonable.

Five tasks are chosen to run at the same time; these tasks send keyboard characters to the modem, receive modem input, periodically get the time of day, and display the two parts of the screen. The keyboard task can be written in pseudocode as:

```
KEYBOARD_TASK:
  begin
    repeat
      while no key hit
        SWAPOUT;
      get character from keyboard;
      while modem not ready for character
        SWAPOUT;
      send character to modem;
      until forever;
    end;
```

The routine that enables you to write this task as though it had exclusive use of the processor is called SWAPOUT. This kernel routine takes control from the calling task and gives it to another task. Thus, one way that the processor can be shared among concurrent tasks is by having them voluntarily relinquish control, with the understanding that they will soon get it back. Of course, the best time for a task to do this is when it is in a waiting mode.

The SWAPOUT routine demonstrates how multiple tasks are made to behave as concurrently executing processes. Each task is assigned its own data area, or stack frame. When SWAPOUT is called, the complete state of the calling task is saved; the state of the task includes the condition of its program counter, machine registers and flags, and everything already on its stack. Then, by switching the stack pointer to another stack frame, the next ready task is restored to the state in which it was preserved, and returned to execution.

Unlike the keyboard task, the other sample tasks (modem receive, time, and display) are not truly independent of each other. They need to communicate somehow; in particular, the display task needs to receive characters for display from the remaining two tasks. Moreover, it needs to know when characters are available. The other two tasks need to know when to send characters. I will explore these two closely related issues of task communication and syn-
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chronization further, but, for now, assume the existence of some kind of buffer mechanism between tasks. The remaining four tasks can then be sketched as follows:

MODM_RECEIVE_TASK:
begin
repeat
while the modem has no character
SWAPOUT;
get character from modem;
put character in bottom_buffer;
until forever;
end;

TIME_TASK:
begin
repeat
get time in banner form;
put time string in top_buffer;
DELAY(one minute);
until the end of time;
end;

TOP_DISPLAY_TASK:
begin
repeat
while top_buffer empty
SWAPOUT;
get character from top_buffer;
show character on top screen;
until forever;
end;

BOTTOM_DISPLAY_TASK:
begin
repeat
while bottom_buffer empty
SWAPOUT;
get character from bottom_buffer;
show character on bottom screen;
until forever;
end;

A new kernel routine, DELAY, is introduced in TIME_TASK. This routine allows you to postpone a task for a specified time, giving control of the microprocessor to the remaining tasks. Here, it triggers a new time display about once per minute. To implement the DELAY routine, the existence of some type of real-time clock is assumed, perhaps the same one used to handle the time of day. The clock handler calls the kernel routine TICK each time a tick (cycle) occurs. When the time specified to DELAY has elapsed, the delayed task is readied to continue execution.

The availability of a periodic clock interrupt that cycles every few milliseconds also raises the possibility of calling SWAPOUT from the interrupt
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handier. This technique (called timeslicing) would eliminate the need for each task to call SWAPOUT itself.

Some new problems would be introduced, however, because the order of task execution is harder to control. What's more, all parts of the system must now be reentrant; that is, they must not use memory cells that are accessible to other parts of the system, except explicitly for intertask communication. An important consequence of this situation is that runtime libraries and operating system calls must be reentrant, which they not always are. A more direct way to eliminate multiple calls to SWAPOUT involves the use of semaphores.

Semaphores

You might notice that in the sample keyboard task, the keyboard is checked many times before a character is finally typed. Calling SWAPOUT prevents getting hung up in a loop, but it seems a waste of microprocessor time to keep swapping KEYBOARD_TASK in and out of execution with nothing accomplished. A better method would forgo execution until a certain event occurs (a key is hit). This facility can be provided by a semaphore, a simple data structure used to signal the occurrence of events and to wait for them. The event associated with a semaphore is agreed upon by the tasks involved; the routines for using it are provided by the multitask kernel.

A semaphore is based on the idea of using a Boolean variable to communicate an event (for example, the real-time clock flip-flop). A way to suspend a task's execution has been added by the inclusion of a link field, which the kernel routines can use to build a list of tasks waiting for the event (see figure 1). This field takes care of one or more tasks that are anticipating an event. But what if lots of events are signaled before they can all be handled? Within reasonable limits, these events can be handled by a counting semaphore, a semaphore whose Boolean variable is replaced by a counter. Each time an event is signaled with nothing waiting for it, the counter is incremented. When a task finally gets around to checking the semaphore, the counter is decremented, and the task doesn't need to wait at all.

Using the new semaphore structure, you can rewrite the keyboard task:

```plaintext
KEYBOARD_TASK:
begin
    repeat
        WAIT(keyboard_hit);
        get character from keyboard;
        WAIT(modem_out_ready);
        send character to modem;
        until forever;
end;
```

The modem-receive task could undergo similar changes, with both tasks using the new kernel routine WAIT(semaphore). The address of the semaphore is passed to the kernel. If at least one event has occurred, WAIT returns immediately; otherwise, it postpones the task until a routine such as SIGNAL(semaphore) is called to signal the event. In the above example, the interrupt handler could do the signaling, or one task could be dedicated to checking all the devices and signaling the appropriate semaphores.

Intertask Communication

Now that you have semaphores to handle the synchronizing of tasks, you can build ways of moving data between tasks as well. Focusing on the passing of a single character, I will use a circular first-in/first-out (FIFO) buffer of the form shown in figure 2; in this buffer, characters are put in at TAIL and removed at HEAD, advancing these pointers with each access. What's needed is a way to indicate when the buffer is full and when it is empty; you will also want to suspend a task that can't access the buffer at these times.

Both of these needs are met by using a pair of counting semaphores, one to guard the input and one to guard the output. The count fields correspond to the count of characters put in and taken out, respectively. Initially, the input count is 0, the output count is set to the buffer size, and the buffer is empty. The following complementary routines can now be written to access the top and bottom screen buffers:

GET_ONE(buffer):
begin
    with the buffer specified, do
        WAIT(PUT_IN);
        get character at HEAD;
        advance HEAD;
        SIGNAL(TAKEN_OUT);
        return character to caller;
    end;
end;

PUT_ONE(character, buffer):
begin
    with the buffer specified, do
        WAIT(TAKEN_OUT);
        put character at TAIL;
        advance TAIL;
        SIGNAL(PUT_IN);
    end;
end;

Figure 1: The semaphore data structure consists of a count of the number of times the semaphore has been signaled with no tasks waiting and a link to a list of tasks waiting for signals.

Figure 2: The FIFO buffer. Characters are put into the buffer where TAIL points and removed at HEAD. After each access, the appropriate pointer is advanced; at the end of the buffer, the pointers are wrapped around to point to the first slot.
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The effect of these routines is to enable tasks to pass characters to other tasks without concern for whether they can be accepted at the moment; likewise, the accepting tasks need not worry about whether characters are available (SWAPOUT is unnecessary). Buffer-space housekeeping is done by the semaphore counts, and through the semaphore links, tasks are postponed if their requests cannot be honored.

Mutual Exclusion
The possibility of tasks interfering with each other may be important not only in conjunction with memory cells used by simultaneous tasks but also with any resource. In fact, the console screen is itself a single resource shared by two display tasks. What makes this condition a problem is that screen operations are divisible; that is, a single console function (such as positioning the cursor) might require several accesses (escape sequences). Each of these accesses might take enough time so that the microprocessor could be executing other tasks while waiting. Thus, the console-screen accesses constitute a critical region of the program—one that needs protection from use by more than one task at a time.

The mutual exclusion of tasks from a critical region can be handily accomplished using a semaphore. The count field of this semaphore takes on only two values: available (1) and reserved (0). A calling task waits at the entrance to the region if it is reserved; upon exit, the region is made available again. The semaphore is initially set to available (1). The following routine is passed either a displayable character or a special code requesting a control function, such as erase line or inverse video on/off:

SHOW CHARACTER(character, subscreen);
begin
    WAIT(available);
    if necessary, move cursor to new subscreen;
    send character or special sequence to screen;
    record new cursor position;
    SIGNAL(available);
end;
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The routine calls WAIT or SWAP-OUT between sending characters to the console device. Therefore, other tasks run but cannot enter the critical region until the first calling task is finished.

An 8080 Multitask Kernel

Listing 1 (page 458) shows a set of routines, called MTK80, written in 8080 code for the Digital Research MAC assembler. You can insert the routines into a program along with the included macroinstructions for convenient calling sequences (see listing 2, page 466). Except for the user macroinstructions, all labels include a nonalphabetic character to reduce conflicts with user symbols. If you use the DELAY call, a real-time (periodic) clock is also required.

If the conditional assembly control symbol INTS7 is true, interrupts are disabled on entry and enabled on exit from each kernel routine. This setup ensures that the kernel data structures cannot be accessed by more than one routine at a time (a simple form of mutual exclusion). If STAKICK is true, the stack pointer is checked to see if it is inside the current frame. If it intrudes upon a neighboring frame at the time it is checked, crucial data has likely been destroyed, so the kernel is abandoned.

The operation of the MTK80 kernel can be described from three perspectives: the states that tasks enter, the underlying data structure, and the function calls used.

Task States

The state diagram in figure 3 shows the possible states a task can be in (circles) and the routines used to make transitions (arrows) to other states. You would need one such diagram for each task to describe the condition of all tasks in a program. Only one task can be in the running state at a time, and, of course, it makes the function calls to change its own state or the state of another task.

The dormant state applies to tasks that might be in program memory but have no assigned stack frame. When a task initially starts, it is associated with a frame and given control. As the diagram shows, only a running task can stop its own execution altogether and become dormant again. It is not possible to terminate other tasks directly.

Text continued on page 467
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NOTE: The Smartmodem 1200B may also be installed in the IBM Personal Computer XT or the Expansion Unit. In those units, another board installed in the slot to the immediate right of the Smartmodem 1200B may not clear the modem; also, the brackets may not fit properly. If this occurs, the slot to the right of the modem should be left empty.

Circle 204 on inquiry card.
Tasks are dynamically associated with a stack frame when created.

The highest 2 bytes of each frame are used by the **?DELAY** and **?TICK** routines. Tasks of equal size are contiguous. This enables the previous byte pair, and the two bytes before that are used to save the stack pointer for that frame when the task is suspended.

Lists are maintained for ready and waiting tasks/frames, and available frames, as well as a pointer to the current task/frame.

Semaphores consist of a signal count byte followed by a two-byte queue link (list pointer). A fatal error exit address is passed to the initialization routine, for use when a stack frame overflow is detected. When a new task request fails for lack of available frames, or there are no ready tasks to execute, an idle loop is entered. From which no exit is possible unless an interrupt creates the missing frame.

If the assembly condition INTS? is true, interrupts are disabled upon entry to all routines, and re-enabled upon exit in the idle loop. Approx. memory requirements: code 750 bytes, data 14 bytes.

FALSE: EQU 0
TRUE: EQU not FALSE

INTS?: EQU TRUE ; Interrupts are in system (used by mk80.lib)

**MACLIB mk80** includes "mk80.lib" macros on first pass

### Data Area — Must be in RAM

- **?CUR**: DS 2 ; Pointer to current frame
- **?AVAIL**: DS 2 ; Head of list of available frames
- **?RDY**: DS 2 ; Head of list of ready frames
- **?PLAYED**: DS 2 ; Head of list of delayed frames
- **?SIZE**: DS 2 ; Saved frame size minus 2 — for overflow check
- **ERR?JMP**: DS 2 ; Fatal error jump address
- **?COUNT**: DS 2 ; Relative tick counter

### Code area — may be in ROM

- Initialize Multi-task kernel data structures. THE STACK POINTER IS CHANGED IN THIS ROUTINE. On return, the caller has a new frame.
- Not a trace remains of the old stack or registers. Enter with:
  - N=number of frames (must be at least 2),
  - D=Fatal error jump address.
- **MP**: EQU "INT0FF"
- **MP** = \texttt{INT0FF}
- \texttt{PUSH H}
- \texttt{LXI H, -2}
- \texttt{DAD D}
- \texttt{SHLD ?SIZE ; Save frame size-2}
- \texttt{XCHD}
- \texttt{SHLD ?RDY ; Set fatal error jump address}
- \texttt{POP DCX}
- \texttt{DCX D}
- \texttt{DCX D}

### Push Stuff

- \texttt{DCX D ; Set DE to pt to first link field when BC is added}
- \texttt{LXI H, 0 ; End link will be NIL}
- \texttt{SHLD ?RDY ; Init ready queue empty}
- \texttt{SHLD ?PLAYED ; Init delayed queue empty}
- \texttt{PUSH H}

### FR?LINK

- \texttt{DCX D ; Get ptr to "previous" frame}
- \texttt{DAD B ; Advance to next frame}
- \texttt{MOV H, E}
- \texttt{MOV D, O ; Set link field to "previous"}
- \texttt{DCX H}
- \texttt{PUSH H}
- \texttt{DCX A}
- \texttt{JNZ FR?LINK ; Last frame?}

### CHKOU

- \texttt{SHLD ?AVAIL ; Set head of available frame list}
- \texttt{POP H}
- \texttt{SHLD ?RDY ; Set ?CUR to remaining frame}
- \texttt{POP D ; Get caller's return address}
- \texttt{SPHL ; Give caller the current frame}
- \texttt{PUSH D ; Reserve SP-save field}
- \texttt{XCHD ; Get return address}
- \texttt{INT0 ; Return to caller (new a task)
Listing 1 continued:

```
; Get SP to new frame
INT 0
RET

; Terminate current task. Forget all registers and stack.
; Put stack frame on the available list; go to next ready task.
?TERM: INT 0

LHLD ?WAITL: Get ptr to available list
INC
XCHG
SHLD ?CUR: Get current frame ptr
SHLD ?WAITL: put it at top of available list. For convenience
MOV N.E
INX H
MOV N.D: Link to the rest of the list.
JMP ?NEXT: Get next ready task and resume it

; Check for signals at the semaphore pointed to by HL. If
; Signaled, acknowledge and return. Else suspend the current
; task on the semaphore's queue and go to the next ready task.
WAIT2: INT 0

PUSH PSW
MOV A, M
ORA A
JNZ ?ACK: Signaled?
?SAVE
CALL ?SHELVE: Save & check SP, get ?CUR in BC
POP H : Restore semaphore ptr
PUSH H
INX H
JMP ?NEXT: Activate next ready task

; Check if a semaphore at HL has been signaled; acknowledge if so.
; Returns non-zero if signaled.
WAIT3: INT 0

MOV A, M
ORA A
JNZ ?ACK: Signaled?
?SAVE
PUSH PSW: (Save status)
JZ NOTACK
?ACK
DCR M: YES. acknowledge
NOTACK: RESUME: Return to caller

; Suspend current task. Save regs, find next task, resume it. If
; there was only one ready task (the active one), it will be continued
SUSPND: INT 0

?SAVE
CALL ?SHELVE: Save & check SP, get ?CUR in BC
CALL ?APRDY: Add current frame pointer to sem. queue
JMP ?NEXT: Activate next ready task

; Real-time clock handler. Can be called, or use a jump at end of
; interrupt handler. Preserves all registers, and enables interrupts
; before returning (if INTS? is TRUE). Increments the relative tick
; count, and takes tasks off the top of the delayed list when their
; time is up.
?TICK: INT 0

PUSH PSW
?SAVE
CALL \1

; Get saved SP
MOV H.A
SPHL \1

; Switch SP to new frame
RE?STOR
; Retrieve registers
RE?SUME
; Resume previously suspended task

; "Flag" a semaphore pointer to by HL. If its count is non-zero,
; it's been signaled already - return, else signal it normally.
SIGM: INT 0
```
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(800) 222-8811
Listing 1 continued:

```assembly
INX H
MOV H, M
MOV L, A
CALL DBL?CP ; time is now?
PPOP H
JNZ TICKX
PUSH D ; (save tick count)
MOV E, M ; Yes, get next in list
INX H
MOV D, M
DCX H
XCHG
SHLD D7LAYED ; Make it first
MOV B, D
MOV C, E
CALL AP?RDY ; Append ready task to ready queue
POP D ; (restore tick count)
JMP TICK2LP ; Check for any more whose time is up

TICKX: RE?STOR

; Put caller to sleep for the number of ticks passed in HL, by
; inserting the current frame in the D7LAYED list in order of
; target times. Maximum delay is 65,536 ticks (when HL=0)

?DE?LAV, INT?OFF
PUSH PSW
?SA?VE
CALL ?SHELVE ; Save & check SP
POP D
PUSH D ; Get delay request
LXI H, D7LAYED ; point to delayed list
DELAY?L
PUSH H ; Save pointer
MOV A, M
INX H
MOV H, M ; Get link to next frame in list
MOV L, A
ORA H
JZ DELAY?L ; If none, go insert
PUSH H ; Save pointer
INX H
MOV H, M
CMP C, M ; Get delayed task target time
INX H
MOV B, M
LHLD ?COUNT ; Get current tick count
MOV A, C
SUB L
MOV A, B ; Subtract it from target
SUBB H
MOV M, A
CALL DBL?CP ; If GT, requested delay, go insert
POP H ; (restore link pointer)
JC DELAY?L ; throw away previous pointer
JMP DELAY?L ; Continue down the list
DELAY?L
MOV B, H
MOV C, L
LHLD ?COUNT
XTHL ; Calculate target tick count
XCHG
LHLD ?CUR ; Get pointer to calling frame

MOV M, E ; Set previous link to new frame
INX H
MOV M, D ; Get back target
I?CHO
MOV H, M ; Link new frame to next in list
INX H
MOV N, B
INX H
MOV M, E ; Set target time field in current frame
INX H
MOV A, D ; NEXT
JMP ; Resume execution of next ready task

; Initialize semaphore at HL to value in A, and set link to NIL.
; HL destroyed, A preserved.
?S?INIT INT?OFF
MOV M, A
INX H
MOV M, D
INX H
MV I, N
MV I, D
INT?ON
RET

; Save stack pointer, check for overflow, and return with BC=7CUR.
?SHEL?VE LXI H, 2
DAD SP ; Get SP (plus 2 for return addr)
ECHO
LHLD ?CUR ; Get current frame pointer
MOV B, H ; Save in BC
MOV C, L
DCX H
MOV M, D ; Save Stack pointer
DCX H
MOV M, E
IF STAK?CK
LHLD ?SIZE ; Get frame size (less 2 for return address)
DAD D ; Calculate saved SP + frame size
MOV A, B
CMP H
RC
JNZ ?ERR?OR ; ERROR
MOV A, C
CMP L
RC
endif

?ERR?OR INT?ON
LHLD ERR?JMP
PC?L

; A?PEND an item (frame link) to the end of a list. HL=p?r to the
; head of the list. BC=item address. HL, DE and A destroyed.
; AP?LP is entry point if item is also a list. Call AP?RDY to append
; a frame to the ready list
AP?RDY LXI H, RDY
AP?PEND XRA A
STAX B
INX B
STAX B ; item points to NIL
DCX B
AP?LP
MOV A, M
END OF LIST?
```

Listing 1 continued on page 466
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Listing 1 continued

JZ AP7X
MOV D, M
DCX H
MOV E, M
XCHD
AP7X:
JMP AP7LP
MOV M, B
yes, set end link to point to item
DCX H
MOV M, C
RET

Double precision compare (16-bit unsigned).
HL compared to DE. Accumulator destroyed.
Carry set if HL is greater than DE. Z set if equal.

Listing 2: This program sets up initial conditions for multitasking.

Initialize the multi-task kernel data structures, specifying the
beginning of the stack area, the number of equal sized stack frames
to be allocated, their size, and the fatal error jump address.
INITIN. MACRO stack, frames, frame@size, error@jump
LXI H, stack
LXI B, frame@size
MVI A, frames
LXI D, error@jump
CALL P?INIT
ENDM

Initialize a semaphore's count, and set its link to NIL (empty list).
INITSEM MACRO semaphore, value
LXI H, semaphore
MVI A, value
CALL P?INIT
ENDM

Create a stack frame for a new task, and place it into
execution. The new task will get a copy of the current registers
(except HL). The current task is placed on the ready list.
START MACRO new@task@addr
LXI H, new@task@addr
CALL P?SPAWN
ENDM

Assign the current stack frame to a new task, killing the old task.
The current registers are preserved (except HL).
TASK MACRO new@task@addr
LXI H, new@task@addr
JMP NEW@TSK
ENDM

End the current task entirely. Control goes to the next ready task.
STOP MACRO
JMP >TERM
ENDM

- Swap current task out of execution, placing it on
  the ready list. Control goes to the next ready task.
SNAPOUT MACRO
  CALL SUSPND
ENDM

- Place first waiter for a semaphore on the ready list.
  If none, increment the signal count.
SIGNL MACRO semaphore
  LXI H, semaphore
  CALL SIG?P
ENDM

- Signal a semaphore, with maximum count of 1.
FLAG MACRO semaphore
  LXI H, semaphore
  CALL SIG?F
ENDM

- Suspend task execution if and until semaphore has been signaled.
WAIT MACRO semaphore
  LXI H, semaphore
  CALL WAIT?S
ENDM

- If semaphore has been signaled, acknowledge and return non-zero.
CMWAIT MACRO semaphore
  LXI H, semaphore
  CALL WAIT?C
ENDM

- Get condition codes to non-zero if semaphore has been signaled.
CMSEM MACRO semaphore
  LDA semaphore
  BRA A
ENDM

- Suspend caller for the number of ticks specified.
DELAY MACRO ticks
  LXI H, ticks
  CALL ?DELAY
ENDM

- Real-time clock tick handler. Wake up tasks when it is time.
TICK MACRO
  CALL ?TICK
ENDM

- Macros for internal kernel use

?SAVE MACRO
  PUSH B
  PUSH D
  PUSH H
  ENDM

RE?STOR MACRO
  POP H
  POP D
  POP B
  ENDM

Listing 2 continued on page 467
Text continued from page 454

A task is in the blocked state when it is waiting for either a semaphore signal or a delay time-out. Only a running task can become blocked; the task is then out of contention for microprocessor time until the specified event occurs.

Tasks in the ready state are in contention for the microprocessor simultaneously (but are not running). Only one task can execute at a time; the remaining tasks are in line to run when given a chance. Tasks are made ready when an event is signaled, a delay times out, or the running task gives up control voluntarily. When more than one task is ready, the task that was presented to the kernel first will be executed.

Data Structure

The 8080 kernel is based on the data structure in figure 4; in this figure the RAM (random-access read/write memory) area pointed to by STACK is divided into frames of equal size. Several bytes in each frame are used to save the stack pointer for that frame (SP), link to other frames to form lists (LINK), and save the start-up time during delays (TIME). The remainder of each frame is used as a stack in the normal 8080 manner.

In figure 4, the queue heads shown are pointers to (possibly empty) lists of frames, strung together by their LINK fields. Lists are maintained of ready, available, and delayed frames (and thus of their associated tasks). There is also a pointer to the current frame (the running task). Frames not presently allocated to tasks are available for use by dormant tasks being initiated. In the ready list, the newest arrival is placed at the end of the list. The frame at the head of the list (the one that has been ready the longest) is the one to go when the microprocessor becomes free. All tasks have equal priority.

A semaphore is a 3-byte structure in memory: 1 byte contains the signal count and the other 2 point to a (possibly empty) list of tasks waiting for signals. Two representative semaphores are shown in figure 4. One of them has no waiters (a nil LINK) but can have a nonzero count; the other has a single frame on its wait list.
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You establish the data structure and error exit by using the macro-instruction INITMT (listing 2). The macroinstruction sets the ready and delayed lists empty, puts all frames but one on the available list, and makes the remaining frame the currently running one. When INITMT is called, the (hardware) stack pointer must be valid. The default operating system stack is valid and can serve as the stack pointer. On the return from INITMT, however, the state of the machine has been completely altered, and the calling task has become a task with a fresh stack.

Semaphores are initialized by the INITSEM macroinstruction, which sets the count field to the specified initial value and sets the wait queue to empty.

The START macroinstruction gets a frame from the available list and makes that frame the new running task, beginning its execution at the address supplied. The calling task is put on the ready list. An interesting result of the dynamic connection between executable code and stack frames is that, as long as there are available frames, the same piece of (reentrant) code can be alive in several incarnations at the same time! Because the task started gets a copy of the creator's registers, it might be handy to have more than one identical task active, each with different initial register contents. In this way, you could pass parameters to new tasks on start-up; you could also use this method in the split-screen example to reduce the two nearly identical subscreen tasks to one routine.

A special case of the START macroinstruction is the TASK macroinstruction, which terminates the calling task and starts the new one. It is equivalent to resetting the stack pointer to the top of the current frame and jumping to the new starting address.
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The STOP macroinstruction terminates a task by returning the task's frame to the available list. The first frame on the ready list is removed and is run.

SWAPOUT puts the currently running task at the end of the ready list, swapping it for the one at the top of the ready list. As with other functions that take the current task out of execution, SWAPOUT first pushes the return address and registers onto the stack, saves the stack pointer (at SP), and performs the optional stack overflow check. When a new current task is selected, its stack pointer is restored, followed by its register contents. It is then allowed to resume execution where it left off.

Using a semaphore, the WAIT macroinstruction enables a task to synchronize itself with an event. The complement of WAIT is the SIGNAL macroinstruction, which uses a semaphore to signal an event. If any tasks are waiting for the event, the first one is moved to the end of the ready list. Otherwise, the semaphore's count of unacknowledged signals is incremented. No check for overflow of this count is made (the maximum is 255). Another version of SIGNAL is FLAG, which works exactly the same way except that it never increments the count past 1. This behavior is appropriate for mutual exclusion semaphores and for preventing count overflow. Neither SIGNAL nor TICK takes the calling task out of execution.

The DELAY macroinstruction puts the calling task on the delayed list, thereby blocking it until the specified number of system clock ticks have passed. The delayed list is ordered according to the length of time requested, with the shortest time first. The proper placement of the calling task in the list is handled by DELAY, because this somewhat complex insertion needs to be done only once. The next ready task is then placed into execution.

DELAY uses a 2-byte counter register. Because this counter rolls over at 65,536, that value is the maximum number of cycles supported in one DELAY call. The register contains only a relative count that is incremented once by each call to TICK. Because the task with the shortest delay is at the top of the delayed list, TICK then compares the target wakeup time of that task with the current tick count. If any and all tasks whose time is up are appended to the ready
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Listing 3: This program illustrates how you can use MTK80 macroinstruction calls. This example, for use with a North Star Horizon, simply runs four tasks, each of which merely identifies itself when it runs.

```
ORG 100H
JMP MAIN

;-------------------
; INSERT THE KERNEL FILE mtk80.asm HERE.
;-------------------

; Kernel stack structure parameters.
Frames: EQU 6
FRBZ: EQU 64
ERR@JMP: EQU 0000H
Choose a place to jump on fatal error.

; North Star Horizon real-time clock equates.
RST2: EQU 26H
Choose clock interrupt at RST vector 2
ARM: EQU 00H
Clock interrupt are code
DISARM: EQU 40H
Clock interrupt disarm code
CLK@RST: EQU 50H
Clock flip/flop reset code
CLK@RPT: EQU 6
Clock 1/0 port

; CP/M equates.
Bолос: EQU 5
BDD call address
CON: EQU 11
Keyboard status check code
COUT: EQU 2
Console output code
EXIT: EQU 0
CP/M restart address

; Kernel stack and semaphore data area.
STACK: DS Frames,FRBZ
SEMA: DS 3

; Example main program.
MAIN: INITMAIN Stack, Frames, FRBZ, ERR@JMP
; Set up kernel
MVI A, JMP
STA RST2
LXI H, CLPRTINT
; Set clock interrupt handler jump vector
SHELD RST2+1
MVI A, ARM
OUT CLPRTINT
INITSEM SEMA.O
; Enable clock interrupts
START TASK1
START TASK2
START TASK3
START TASK4

; This task has nothing to do but wait to die
TASK4 WAIT SEMA
; Sleep until signaled
MVI A, DISARM
OUT CLPRTINT
JMP EXIT
; Disable clock interrupts
; Terminate the program

; Tasks 1-3 identify themselves by number at different intervals.
TASK1 DELAY 700
MVI E, '1'
CALL CONOUT
JMP TASK1

TASK2 DELAY 900
MVI E, '2'
CALL CONOUT
JMP TASK2

TASK3 DELAY 1100
MVI E, '3'
CALL CONOUT
JMP TASK3

; Clock interrupt handler.
CLPRTINT PUSH PSW
MVI A, CLPRTINT
; Clear the interrupt
OUT CLPRTINT
POP PSW
JMP ?TICK
; Activate delayed tasks whose time is up

; Send character in register E to the console screen
CONOUT MVI C, COUT
JMP BDDOS

END
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Jerry Holter (2329-B Hilgard Ave., Berkeley, CA 94709) is a senior engineer at Ampex Corporation in Redwood City, CA. He is involved with real-time microprocessor servo mechanisms.

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Jerry Pournelle's User's Column generates a lot of mail. In this space, Jerry will answer readers' questions on a regular monthly basis.

**The MULTICS Operating System**

Dear Jerry,

In your March column (“A User's View of Comdex,” page 44) you mentioned the concept of an Executive Secretary program that would allow interruption of an editing task in order to run another program without destroying the file being edited.

I, too, have wished for such a facility. Though I have not seen it on a micro, I can vouch for the fact that this facility is every bit the pleasure you anticipate. The Honeywell MULTICS operating system is so designed. In fact, it is possible to interrupt any program being run and return to it later (providing, of course, that you have altered none of the files being used by the interrupted program).

The MULTICS solution is quite elegant. When a command is typed into the terminal, it is interpreted by the command processor not as a program to execute but as a call to a (usually PL/I) procedure. Using predefined search rules, the procedure is located in the file system hierarchy and then actually called. (The syntax of commands even provides for the interpreter to pass text typed after the “command” or procedure name to be passed to the procedure as actual parameters.) Moreover, the entire system is constructed to allow unlimited recursion. Thus, no matter where you are, the command processor (also a PL/I procedure) may be called—hence, so can any procedure.

This method is not without cost. It is because of this feature that MULTICS is an incredible money and resource sink. Large amounts of virtual memory can be consumed when multiple users have a large call stack. But it is arguably the single best feature of MULTICS. It is interesting to note that although many features of Unix come from MULTICS, this one is not part of the Unix system. It is a shame that a cost-effective way to implement this feature could not have been found during the design of Unix.

James E. Densmore Jr. 503 Timber Lane Falls Church, VA 22046

*Instead of looking to Unix, I predict that concurrent CP/M-86 will enable us to write Executive Secretary for 8086 machines. . . . Jerry*

**Valdocs Revisited**

Dear Jerry,

In Response to “Epilogue: A Look at Valdocs” (August, page 442), most of your requests are valid. However, numbers 4, 5, and 7 are already implemented (version 1.16 as of June 1, 1983). In fact, #4 exists in every copy of the editor that you have ever seen, and it is documented. Also, top and bottom margins are changeable and always have been. However, only one set of top and bottom margins may be used in any one document (until version 2.0). If one needs to leave space on page 1 for a company logo, carriage returns work very nicely—after all, the editor is truly what you see.

Most of your other requests will have been implemented by version 2.0 of the editor. Of those listed, numbers 1, 2, and 3 will certainly be included. I'm not at liberty to reveal the release date of this product, but I can say soon.

Additionally, as you know, the perceived slowness of the editor is primarily a by-product of using a bit-mapped display. The benefits are obvious—multiple fonts, underlin-

*JRT Version 3.0*

Dear Jerry,

I thought you might be interested in my experience with JRT Pascal. I
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<td>7.90 5¼&quot; single-density soft sector</td>
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High-impact polycarbonate plastic and ten tabs combine with a handy pop-up latch to give you fast, easy retrieval of the disks you need. And clearly labeled spine helps you keep your floppies in order.
had a lot of trouble with version 2.x and was about to give up on the language entirely until I had occasion to use a friend's version 3.0. What a difference! I have no trouble compiling "standard" Pascal programs with the new version.

For example: I compiled and ran your matrix multiplication program flawlessly (it executed in 87 seconds); the same is true with Jim and Gary Gilbreth's Erastosthenes Sieve program (472 seconds) on my Osborne 1. What I am leading up to is this: why don't you and Alex give JRT version 3.0 a shot? I'd really like to see your matrix multiplication program (472 seconds) on my Osborne 33 Briarwood Court Walnut Creek, CA 94596

JRT version 3.0 does seem considerably improved over the earlier version. We'll have to examine it again. However, it is still nothing like standard, so programs written in JRT aren't likely to work with any other compiler. . . . Jerry

My dealer says (and one manual confirms) that I must buy Softcom to do this. Personally, I would much prefer to use Modem7 or some other utility, but at the moment I do not have a way to get a public-domain program into the Otrona format.

Is it necessary to have a modem-type utility (or Softcom by Otrona, at $150) to transfer files to Otrona disks? Tom Flagg 547 Tilden Ave. Teaneck, NJ 07666

We use the File Transporter from Workman and Associates. Modem7 is in the public domain; Workman has obtained permission to include it with the Transporter.

You could probably get Modem7 for the Otrona from a club or users group, but I don't know of one at the moment. . . . Jerry

Listing 1:

```
Program Silly (output):
BEGIN
  writeln( 'Hello, World' );
  writeln( 'Foo' );
  writeln( 'Hello again!' );
END (silly).

% Warning: Invalid variable or data type declaration
% Error: Syntax error - unrecoverable
```

My dealer says (and one manual confirms) that I must buy Softcom to do this. Personally, I would much prefer to use Modem7 or some other utility, but at the moment I do not have a way to get a public-domain program into the Otrona format.

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Toward Computer "Literacy"

Dear Jerry,

I'm considering buying our family's first personal computer, and I want to read about the latest applications and available products.

One question of particular importance concerns my two sons (ages 15 and 13) and their computer "literacy." We have read enough of your articles and other primers (e.g., Adam Osborne and Peter McWilliams) to realize how computer dumb we are. It will take some more research—and budget reviews—to determine what we buy. Before then I'd like my boys to get some "hands-on" education.

The local high school offers computer courses, but there's a catch. I hesitate to have my sons learn some fundamental aspects which, as you quoted Professor Dijkstra, would later have to be "unlearned." Should my sons, for example, learn BASIC and FORTRAN as their first languages? I want to encourage their enthusiasm for hands-on training, but I hesitate about the high school's curriculum. What are your views?

David E. Goode 6454 Dryden Dr. McLean, VA 22101

I don't see how anyone is harmed by learning BASIC, and your school's courses sound like a very good start. And although limited in scope, a Sinclair is a good machine to begin on. . . . Jerry
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The Handbook of Artificial Intelligence, Volume 2
Avron Barr and Edward Feigenbaum, eds.
William Kaufman Inc.
Los Altos, CA, 1982
428 pages, $35

Reviewed by
Henry W. Davis

The Handbook of Artificial Intelligence, a three-volume overview of artificial intelligence (AI), presents basic AI accomplishments and techniques so that people need not be specialists in the field to understand them. Volume 2 (discussed here) covers AI programming languages, AI applications to science, medicine, and education, and automatic programming.

(For a review of volume 1, see the July issue, page 460. Volume 3 will be reviewed at a later date.)

Volume 2's extensive bibliography (through early 1981) provides direction to basic material as well as research papers and is useful for novices and experts alike. The articles are carefully edited and work together quite well. Elaborate cross-referencing lets you skip to a specific topic of interest.

Languages
AI programming languages, the first topic in volume 2, have been heavily influenced by LISP, the dominant AI programming language today. It is therefore appropriate that the authors devote considerable effort to explaining the useful features of this language. Other influential languages covered are PLANNER, CONNIVER, QLISP, SAIL, POP-2, and FUZZY. PROLOG and LISP-machines are not discussed.

Early programming languages dealt mainly with useful ways to process numerical data. In contrast, LISP was developed to manipulate symbolic expressions, making it more suitable for the needs of AI programming.

LISP has endured as an important tool over the years for a number of reasons. First, its main data structure consists of multilevel lists, providing LISP with a powerful and flexible way to represent complicated knowledge, and LISP allows lists to change in structure and size during program execution. Furthermore, LISP's emphasis on recursion allows it to simplify the handling of many problems.

The control structure of LISP consists primarily of function composition. One effect is to encourage interactive development of complicated programs. Functions are easily replaced or enhanced on the spot.

LISP programs and data have the same syntax. Programs may pass other programs as data or read programs from a database. Such data may be executed by the receiving program because LISP supports a primitive function that is itself a LISP interpreter. Programs may construct other programs (and run them) and analyze situations, or themselves.

In PLANNER, a program's statements consist of "theorems" that describe strategies for achieving certain goals given a set of preconditions. Theorems also give contingency plans if specified situations arise. When a program is run, PLANNER searches through its database of assertions and theorems, attempting to solve a user-specified goal.

CONNIVER and QLISP extend this to give the user more control over the search process. QLISP's capabilities include resolution-based theorem proving, a powerful inference technique.

FUZZY allows the user to associate certainty values to assertions in the database. These numbers are manipulated as goals are sought from the database. Final conclusions also have measures of certainty associated with them.

Expert Systems
Expert systems (ESs) are programs that help solve complex, real-world problems in such areas as science, engineering, and medicine, thus minimizing the need for expensive human help. They work with large amounts of domain knowledge (facts and procedures, gleaned from human experts, that have proved useful in certain specialties) and several of these systems have a level of expertise comparable to or exceeding that of a good human professional.

The Handbook devotes a chapter each to ESs in science, medicine, and education. In no other single source can you find such a comprehensive overview of ES technology. Articles in these chapters cover noteworthy systems in each domain. Each article attempts to describe the problem, the knowledge used to solve it, the AI methods that were used to represent and manipulate that knowledge, the level of expertise obtained, and future prospects for the program and those methods.

A large variety of systems are described, usually with great clarity. (You may find it help-
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Science and Engineering

Science and engineering have historically been a favorite application domain for expert systems. The Handbook describes systems in chemistry, geology, mathematics, and database management. To give the flavor of the text, I'll discuss two of the chemical applications.

Current ES technology evolved from the DENDRAL project, started at Stanford University in 1965. The project was intended to show that algorithmic procedures that produce results exhaustively and at enormous expense could be augmented by the heuristic knowledge of experts to produce similar results at a fraction of the cost. From this highly successful project scientists isolated some key questions for what soon became ES technology: How does one obtain from human experts the large amounts of knowledge needed to simulate their expertise? How does one represent this knowledge? What are effective ways to manipulate and control the use of this knowledge?

Input to DENDRAL consists of the atomic constituents of a molecule along with mass spectrometric data. This information describes how molecules of a particular substance fragment when they are subject to intense heat. DENDRAL's output is a ranked list of possible structures for the molecule. Such information is extremely useful in many chemical applications but typically requires many man-hours of effort by experienced chemists.

In DENDRAL, expert knowledge about interpreting mass spectra is represented in rules, which are statements in the form "If a is true then take action b." Rules are used to build constraints on the set of molecular structures that might have produced the mass spectrum data. After a candidate list of molecular structures is generated, more rules are used to simulate or test the mass spectrum of each candidate so the list may be pruned and properly ranked. Many aspects of the DENDRAL program became common ingredients in later ESs: especially the "generate and test" paradigm and the use of rules to represent sophisticated human knowledge.

Another fascinating program that uses rules to represent complicated knowledge is Gelernter's SYNCHEN, developed at State University of New York at Stony Brook. The input to SYNCHEN is the structure of an organic molecule. The program seeks a sequence of reactions useful to the laboratory or industrial chemist for synthesizing the input molecule. A typical synthesis route consists of a chain of 3 to 20 reactions beginning with readily available compounds. Reactions are represented as rules. Starting with the goal molecule, rules are applied backwards in a heuristic search for shelf compounds. Finding workable synthesis routes is complicated for humans. Gelernter has had some success in automating it and his work looks very promising.

Medicine

Nearly a score of medical AI systems have been built since the mid-1970s; the Handbook surveys seven. Most of these systems focus on medical diagnosis. Typically the physician enters a patient's symptoms, laboratory data, and other findings in a dialogue with the computer. The ES infers a likely disease or combination of diseases, often explaining its reasoning. In some cases therapy is recommended. Today's systems operate in narrow areas of medicine such as bacterial infection or aspects of internal medicine. Some of them have received very favorable ratings compared with human experts.

In addition to diagnostic systems, ESs have been built for other medical purposes, such as drug-regimen determination.

The design techniques of AI medical systems vary considerably. Most of the knowledge-representation schemes described in volume 1 of the Handbook occur in one system or another. Search procedures are exhaustive rather than heuristic because of the small size of the databases and the potentially serious consequences of missing applicable information.

The items of knowledge used in medical reasoning are often, in fact, judgments. There may be competing evidence for and against a certain hypothesis. AI systems deal with this by attaching "weights" or "certainty factors" to information. For example, weights may be numbers between -1 and +1 where -1 means "known to be false" and +1 means "known to be true." Rules for combining weights are applied when the system must reason with uncertain knowledge. A hypothesis will be viewed as true when its weight exceeds some specified threshold.

Only one AI diagnostic system is reported to be in routine clinical use. However, several appear to be close to this stage. To account for this lack of use, many observers claim that physicians will not use computer diagnostic aids when they feel they are already performing adequately.

Education

Programs that interact directly with students in an effort to promote and control learning in a particular subject are called computer-aided instruction (CAI) and have their roots in the 1960s. In the first such programs, the student was typically given some instructional text (possibly on line) and then asked brief questions about it. The student's answers determined what further questions and text would be presented. The courseware author attempted to anticipate all patterns of wrong responses and use them to specify branches to appropriate remedial material. Some very sophisticated systems use this technique.

AI ideas of the 1970s have led to work on much more ambitious systems called knowledge-based or intelligent CAI (ICAI) programs. Such systems have three main components. The expertise module generates problems and evaluates the correctness of the student's solutions. In some cases this module reasons much like a conventional noneducational ES. The student model module maintains a representation of how well the student understands the skills being taught, plus related information (for example, student goals or what he or she tends to forget). The tutoring module integrates information from the other modules with teaching strategies to affect the learning process.

The Handbook describes eight ICAI systems in such varied areas as geography, medicine, electronics, programming, arithmetic, and university-level logic. In addition to their potential usefulness, these systems provide striking insight into the
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Automatic Programming

Automatic programming (AP) refers to a program or system of programs that enable users to specify a programming task to the computer on a very high level. This may mean that only the desired effect of the program is described (or partially described), or the intended effect and some of the methodology is specified. AP aims to allow the programmer to specify the task much the same way a manager specifies a task to a programmer.

At the foundation of AP is the idea that the program should know both the problem domain and the principles of programming so well that it can fill in the details. An ideal AP system should provide an efficient, correct program. Because much of today's software is costly and unreliable, the benefits of such goals are unquestionable.

Some impressive AP systems have been written within restricted problem domains. For example, George Heidorn's NLPS program determines the specifications for queueing problem simulations via an English dialogue with the user. It outputs programs written in GPSS. Systems with larger problem domains (for example, nonnumeric programming) are much less understood. In today's technology such systems work on only short programs in a few subclasses of their intended domain. We are a long way from being able to write an operating system via AP.

AP research falls into two major areas. One covers the specification problem, which is concerned with translating partial or ambiguous user input into complete and unambiguous specifications. A major obstacle to applying AP concepts to complex problems is determining a specification language that is easy to work with but forces users to be complete, consistent, and unambiguous. Such formal methods do not seem to reflect the way humans usually understand and describe programs. Some experimental systems have dealt with this by allowing users to describe their programs via some or all of the following: sample input-output pairs, traces (descriptions of how certain data structures change when certain decisions are made), English, and mixed-initiative English dialogue with the system. These are called informal specification methods. Systems using them must have knowledge of the problem domain and of programming concepts in order to make the transformation into complete specifications.

The other major area of AP research, the synthesis problem, is concerned, with generating the target program once a complete and unambiguous description of the specifications has been obtained. Several approaches have been undertaken. One of these is illustrated by the PECOS and LIBRA modules within Cordell Green's PSI system at Stanford University. PECOS contains hundreds of rules that may be applied to a program specification. Each rule alters the program, to varying extents, producing a refinement. Rules applied to refinements produce further refinements. By successive application of rules, PECOS attempts to move the original program specification into a target-language implementation. A rule may be applied only if its

“if condition” matches some part of the current refinement. Of course, sometimes several rules apply. This method generates a tree of refinements rooted in the original specifications. PECOS expands leaf nodes in that tree in its search for an implementation.

LIBRA, whose knowledge is also based on rules, analyzes and guides the development of the refinement tree to achieve an efficient implementation. Plausible implementation rules tell what type of data structures to use. Cost analysis rules estimate (with certainty factors) the expected efficiency of an implementation obtained by successive refinements of a given node. Other rules describe when to shift attention to different nodes in the tree.

The PSI system has been successful with a number of short programs in certain areas of nonnumeric computing.

Conclusion

No book is perfect, and volume 2 of the Handbook does have a few problems. Some articles on overlapping topics do not mesh well, and sometimes examples are not clear. I found five references in the text whose entries are missing from the bibliography. (The bibliography contains nearly 400 items.)

Overall, these problems are trivial and may be corrected when the Handbook is updated. Like Volume 1, this volume succeeds in explaining AI in a way that is useful to both novice and expert. Doubtless the Handbook will become a basic AI reference.

Henry W. Davis is a professor of computer science at Wright State University, Dayton, OH 45435.
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<td>Princeton Graphics</td>
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<td>ing value with library case and a ten year warranty.</td>
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<td>Star Micronics</td>
<td>120 CPS, Parallel</td>
<td>$149.00</td>
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<td>L-Q, 16 CPS, Parallel</td>
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Reviewed by
Thomas Clune

Any examination of FORTH quickly leads to Starting FORTH, written by Leo Brodie, a technical writer for FORTH Inc. (the Poly-FORTH people) and editor of FORTH Dimensions, the FORTH Interest Group publication. Starting FORTH is the only widely recommended book specifically on the language for two reasons. First, the book is authoritative and comprehensive; second, it has no real competition.

This is a serious and substantial work, but the first thing you notice is Brodie's cartoon illustrations throughout. What are they doing there? Alas, the answer is "Nothing." The line drawings do not help the reader at all. In fact, they are merely distractions. Similarly, Brodie suffers from the apparently universal characteristic of FORTH programmers, a propensity toward obvious puns.

Despite these irritations, the book is impressive. Encyclopedic in scope, it lists and illustrates the use of every standard FORTH word and catalog differences between FORTH dialects. As you'd expect from the author's background, the unique features of Poly-FORTH are especially well documented. Brodie clearly explains the reasons for deviations from and additions to the FORTH-79 standard. I particularly appreciated this feature: such explanations are unfortunately rare.

Further, the book is loaded with excellent hints and advice on working with FORTH. It also includes clear, brief expositions of such key FORTH concepts as factoring.

It includes much more, but that's the problem. By doing a bit of everything, Starting FORTH fails to do anything properly. It could be unbundled into two or three very good books on FORTH, but as a combination operator's manual, tutorial introduction, and programmer's handbook, it has no focus. The book's tone is predominantly tutorial, but it is too comprehensive to be a good FORTH tutorial. Yet as a reference book, it suffers from the tutorial motif. And it is indexed in the manner of a FORTH reference manual—by FORTH words only. As a result, if you're trying to track down that handy hint on loading a stubborn block, you won't get any help from the index.

Brodie appears to have tried to fill the void of published material on FORTH with this one book. The result is that the reader is more impressed with Brodie's understanding of FORTH than educated by his book. Not that the book is poorly written—in general, each subject is explained clearly and well. The problem is with the organization of the whole. The book needs a major editing job to give it focus, and it desperately needs a real index. Nonetheless, if you want to learn FORTH, you will need this book.

Thomas Clune is physical-chemistry laboratory coordinator for the Chemistry Department of Brandeis University, Waltham, MA 02154.
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Books Received


This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

BYTE's Bugs

A Word of Caution

Word has reached us that a bug may be lurking in listing 1 of James Folts's article "Cross-Reference Utility for IBM PC BASIC Programs" (August 1983 BYTE, page 378). In this program, line numbers are stored in integer variables to speed up processing. This, however, limits the line numbers to values no greater than 32767. To handle larger lines with this utility, drop the percent sign (%) from the variables LINE, NO% and LINE.REF% in line 6050 on page 382, change SPACE$(5) to SPACE$(6). Our thanks to James Folts for pointing out this potential problem.
Introducing a sensible solution to the problems of dBASE II.

<table>
<thead>
<tr>
<th></th>
<th>dBASE II</th>
<th>The Sensible Solution</th>
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<tbody>
<tr>
<td>Records Per File</td>
<td>65,535</td>
<td>999,999</td>
</tr>
<tr>
<td>Maximum Record Size</td>
<td>1,024 bytes</td>
<td>1,536 bytes</td>
</tr>
<tr>
<td>Fields Per Record</td>
<td>32</td>
<td>384</td>
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<tr>
<td>Key Fields Per File</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Number of Files</td>
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<tr>
<td>Simultaneously Accessible</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Number of Screens Per Program</td>
<td>Limited by system memory</td>
<td>Limited only by system storage</td>
</tr>
<tr>
<td>Data Dictionary</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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Users of the Texas Instruments TI-58/59 can join an independent club dedicated to the use of TI-manufactured hand-held computers and calculators. The club produces a newsletter, *TI PPC Notes*, and welcomes all former members of the TI-supported PPX-59 club. Membership is $25 a year and includes the newsletter. Contact PPC Publications, POB 1421, Largo, FL 34294.

**North Star Notes Via Polaris**

The North Star Computer Society (NSCS) produces a monthly newsletter, *Polaris*, that is dedicated to exchanging information about North Star computers, software, and peripherals. The group of professionals and hobbyists meets on the third Wednesday of each month at 7:30 p.m. Dues are $24 a year. For details, write to NSCS, POB 311, Seattle, WA 98111.

**Computers in Schools**

The Timex/Sinclair Educators' Users Group of Texas Wesleyan College, in cooperation with Timex Computer

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For more information, contact the following organizations: **IBM PC Users in Boca Raton** - A computerized bulletin board is available for meetings and business at the College of Boca Raton's South Florida IBM Personal Computer Users Group. Interested parties can contact Wyatt Bell, College of Boca Raton, 3601 North Military Trail, Boca Raton, FL 33431, (305) 994-0770, ext. 83 or ext. 14.

**Tidewater of Virginia Beach** - The Tidewater Commodore Users Group (TCUG) invites anyone interested in Commodore computers or in computing to inquire further. Contact Tidewater Commodore Users Group, 4917 Westgrove Rd., Virginia Beach, VA 23455.

**Indianapolis Group for the IBM PC** - The IBM PC Users Group, a nonprofit organization, meets on the fourth Monday of each month at 7 p.m. at the Computerland store in Indianapolis, Indiana. Members have access to a library of disks, books, and magazines as well as the information from monthly newsletters. Individual membership is $15; family memberships are $20. For more information, contact Davie Reed, IBM PC Users Group, POB 68271, Indianapolis, IN 46268.

**Smart Users Group** - The Santa Monica Area TRS-80 Users Group (SMARTUG) meets on the third Wednesday of each month at 7 p.m. at the Senior Citizens Center in Santa Monica, California. For further details, contact SMARTUG, 1433 11th St., #3, Santa Monica, CA 90401, or call (213) 394-5997.

**Long Live FolkLife** - The Folklife Terminal Club, a Commodore users group, maintains a software library of more than 5000 public-domain programs. Any interested Commodore owners and users can contact the Folklife Terminal Club by writing to POB 2222, Mount Vernon, NY 10551.

**Focus on Basis** - A national users group has been formed for the Basis computer. Participants will share knowledge and skills. For information, contact Ms. Barbara Thomas, Suite 320, 100 Almeria Ave., Coconut Grove, FL 33134.

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For the IBM PC users interested in occupations and research to share software and information, the Occupational Therapy Microcomputer Club Journal is available. The club was formed to support all people in the legal community, including students, alumni, and lawyers, in their use of computers. Membership costs $5. Contact the Law School Computer Group, Southern Methodist University School of Law, Dallas, TX 75275.

The NCR Users Form Global Cooperative is an independent cooperative of NCR users. The organization provides such services as technical and software exchanges, product reviews, and a journal called the NCR Monthly. Membership is $92 in the U.S.; foreign rates vary. For further details, contact NCR World Inc., POB 399, Cedar Park, TX 78613, or call (512) 250-9023.

The Transportation Communication group, UPCIT, explores the use of computers in analyzing, graphing, or transmitting data related to transportation operations, rates, costs, or markets. For further details, contact Arthur Todd, Lincoln Electric Co., 22801 St. Clair Ave., Cleveland, OH 44117, or call (216) 481-8100.

The Midwestern Chronicle is the newsletter produced by the Greater Cleveland PC Users Group, which meets the first Saturday of every month at 2 p.m. at the Beachwood Public Library in Beachwood, Ohio. Anyone interested is invited to attend meetings designed to educate members in the capabilities of the IBM PC and similar microcomputers.

Users of the Texas Instruments TI-58/59 can join an independent club dedicated to the use of TI-manufactured hand-held computers and calculators. The club produces a newsletter, *TI PPC Notes*, and welcomes all former members of the TI-supported PPX-59 club. Membership is $25 a year and includes the newsletter. Contact PPC Publications, POB 1421, Largo, FL 34294.

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Clubs and Newsletters

Corporation, produces a quarterly newsletter, The TEC News, dedicated to the application of low-cost computers to educational settings. Each edition will contain a theme section, a teacher-report section, and an applications section that provides lesson plans, programming tips, and ideas. The newsletter is free to educators. For information, write to M. Mark Wasicsko, School of Education, Texas Wesleyan College, Fort Worth, TX 76105.

A Free HUG Membership

The Schenectady HUG (Heath Users Group) meets on the third Wednesday of each month at 7:30 p.m. to promote familiarity with hardware and software relating to the Heath H-89, H-8, HOOS, and the CP/M operating systems. Membership is free as no newsletter is produced, although the group is available via a bulletin-board service, for which there is a $10 user's fee. Further information is available from Walter Whipple at (518) 385-5660, or write to Schenectady HUG, c/o T. Budge, 715 Sanders St., Scotia, NY 12302.

Clubs and News Notes

The Silicon Valley Color Computer club (SVC) for users of the TRS-80 Color Computer now meets on the first Tuesday of each month at 7:30 p.m. in the Dysan Auditorium at 5201 Patrick Henry Drive in Santa Clara, California. Write to Silicon Valley Color Computer Club, POB 61593, Sunnyvale, CA 94088. (For the first mention of this club, see February 1983 BYTE, page 444).

Subscribers to Interactive Video Technology, a newsletter produced by Heartland Communications (233 Sunrise Dr., Shreve, OH 44676), can now access all back and future issues via Newsnet, an electronic information and retrieval service (March 1983 BYTE, page 491). Article submissions are welcome to The I/O Connector, the newsletter produced by the San Diego Atari Computer Enthusiasts (SD-ACE), 533 S. Baltimore Dr. #39, La Mesa, CA 92041 (January 1983 BYTE, page 469).

The Connecticut IBM Personal Computer Users Group meets on the fourth Tuesday of each month at 6 p.m. Contact Davis or Sherry Foulger, POB 291, New Canaan, CT 06840, (203) 744-4002.

Bug In Board

A bug popped up in William Barden's article "A General-Purpose I/O Board for the Color Computer?" June 1982 BYTE, page 260). Substitute pin 32 (CTS+) for pin 36 (SCS+) on the Color Computer I/O bus. The board is now addressed with hexadecimal C000, 1, 2, and 3 instead of the addresses hexadecimal 3FFF, 1, 2, and 3. Using the SCS+ signal for the device selection does not enable the 8255 at the proper time because the SCS+ signal is not developed from the E clock. The E clock should be used together with an I/O device address for proper I/O device operation.

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Accounts Receivable, an open-item, accounts-receivable system for small-business accounting. It includes customer maintenance, transaction processing, reports and printouts, utilities, and end-of-period processing. For the Apple II; floppy disk, $39.5. Broderbund Software Inc., 1938 Fourth St., San Rafael, CA 94901.

Bop-a-Bet, an educational game for children ages 5 to 8. By moving around a high-resolution maze and selecting letters in sequence, children develop the alphabetizing skills needed in effectively using libraries, dictionaries, and encyclopedias. For the Apple II, II Plus, and IIE; floppy disk, $27.95. Sierra/On-Line Inc., Sierra/On-Line Building, Coarsegold, CA 93614.

Computer SAT, a software/textbook package that leads the student step by step through the complete Scholastic Aptitude Test preparation process. The package pinpoints student strengths and weaknesses, gives immediate feedback, and prepares a study plan to improve scores. No previous computer experience needed. For the Apple II, II Plus, and IIE; floppy disk, $79.95. Harcourt Brace Jovanovich, 1250 Sixth Ave., San Diego, CA 92101.

Crypto-Cube, an educational word puzzle for children ages 8 and up. Spark an interest in spelling and word recognition as players try to identify the missing letters of words in a variety of graphic formats. For the Apple II Plus and IIE; floppy disk, $39.95. Designware Inc., 185 Berry St., San Francisco, CA 94107.

Diskinvoice System, an invoicing/accounts-receivable program that can handle the billing for the small businessperson who sends fewer than 300 invoices per month. It allows easy customizing and back-up; also available in Spanish. For the Apple II, II Plus, and IIE; floppy disk, $35. Broadway Software, Suite 136, 642 Amsterdam Ave., New York, NY 10025.

Disk Protection Program, a locking program for software developers. This inexpensive, easy-to-use program disables list, reset, catalog, and save from pirates. For the Apple II Plus; floppy disk, $45. The Zivy Co., MPO Box 1616, Niagara Falls, NY 14032.


Dragon's Keep, an educational adventure game for children ages 7 and up. Children develop reading comprehension as they rescue 16 animals through reading maps, identifying details, making inferences, and drawing conclusions. For the Apple II, II Plus, and IIE; floppy disk, $29.95. Sierra/On-Line Inc. (see address above).

Early Games for Young Children, nine educational games for children ages 2½ to 6. Children can learn to match numbers and letters, count blocks, add and subtract stacks of blocks, work with the alphabet, type names, compare shapes, and draw pictures in color without supervision. For the Apple II; floppy disk, $29.95. Counterpoint Software Inc., Suite 140, Shepard Plaza North, Minneapolis, MN 55426.

Early Games Music, four educational music games for children ages 4 to 12 that teach basic music skills and music notation in colorful high-resolution displays. For the Apple II Plus and IIE; floppy disk, $29.95. Counterpoint Software Inc. (see address above).

Easel Ease, a full-screen, high-resolution graphics package that lets you create pictures using colors, patterns, and brushes. It includes menu-driven features, save options, and single-keystroke controls. For the Apple II Plus; floppy disk, $24.95. Watermark Inc., Department PC, POB 481, Melbourne Beach, FL 32951.

 Fontrix, an extended-screen graphics system. This multi-purpose graphics package includes a font editor, graphic writer, character generator, and a graphics dump. You can design, create, typeset, and print in a variety of formats. For the Apple; floppy disk, $75. Data Transforms, Suite 106, 616 Washington St., Denver, CO 80203.

Function Plotter, an educational mathematical tool. This tamper-proof program will graph a user-specified function over any chosen domain. You can change either the domain or the displayed range and overlay any number of functions on the same set of axes. For the Apple II Plus and IIE; floppy disk, $29.95. J.L. Hammett Co. Inc., Microcomputer Division, Hammett Place, Braintree, MA 02184.

Hi-Res Versatile Calculator (HVC), an RPN (reverse Polish notation) calculator that combines the functions of a scientific calculator with a programmer's calculator. It operates in four bases, contains over 50 functions, and features standard ASCII tables. For the Apple II, II Plus, IIE, and III; floppy disk, $59.95. Tackaberry Software, POB 2857, Ormond Beach, FL 32074.

Learning with Leeper, four educational games for preschoolers. Dog Count is a counting game; Balloon Pop is a shape-matching game; Screen Painting is creative play; and Leap Frog develops eye-hand coordination. For the Apple II, II Plus, and IIE; floppy disk, $34.95. Sierra/On-Line Inc. (see address above).

Master Math, an educational math program for high school students that covers algebra, trigonometry, geometry, statistics, and basic accounting. For the Apple II, II Plus, and IIE; six floppy disks at $30 each or the set for $150. PMI Inc., High St., POB 87, Buckfield, ME 04220.

Pascal Source, nine game and utility programs that include Art, Tower, Splitfile, Art 2, Format, Graftools, Testgt, Shape, and Trek. Includes all source code. For the Apple II; floppy disk, $15. Mark Watson, 535 Mar Vista Dr., Solana Beach, CA 92075.

Police Artist, a program of three games for children ages 7 and up that draws over 1 million faces. You pick a culprit's face from a police lineup and reconstruct it piece by piece, or create your own faces. For the Apple II, II Plus, and IIE; floppy disk, $34.95. Sir-Tech Software Inc., 6 Main St., Ogdensburg, NY 13669.
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Wizplus, a utility program for the Wizardry adventures that lets you quickly change, restore, add to, modify, recover, or move any of your characters, their equipment, spells, or treasures. No more frustrating games where the wizard always wins. Now you have a chance. For the Apple II Plus; floppy disk, $39.95. Datamost Inc., 8943 Fullbright Ave., Chatsworth, CA 91311.

Trekking, a competitive game that allows you to explore the galaxies and planets of the universe. For the Apple II; floppy disk, $49.95. Broderbund Software Inc., 1938 Fourth St., San Rafael, CA 94901.

Suspended, an interactive game (see description under Apple). For the Atari 400/800; floppy disk, $49.95. Infocom, 55 Wheeler St., Cambridge, MA 02138.

Ultra Disassembler, a utility package that lets you recreate source code. This labeling disassembler handles DOS files and code. Output code may be written to video display, printer, or disk file. For the Atari 400/800/1200; floppy disk, $49.95. Adventure International, POB 3435, Longwood, FL 32750.

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ACNAP, an AC networking-analysis program. This electronic-circuit program can handle circuits as large as 70 components. It is optimized for speed and can analyze a five-node, ten-component circuit in less than one second. For CP/M-based systems; floppy disk, $39.95. BV Engineering, POB 3351, Riverside, CA 92519.

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Data VU, a database-management system. Four features include an automatic form generator, a relational database manager, a report-generator program, and an automatic menu generator. It can be used for personal or small-business purposes. For CP/M-based systems; floppy disk, $149. Thinkers Soft Inc., POB 221, Garden City, NY 11530.

Personal Pearl, an information-management system. This relational database and form/report program generator is designed for the novice user. Create input and output forms and reports and define simple or complex relationships. For CP/M-based systems, floppy disk, $295. Pearlsoft, POB 13850, Salem, OR 97309.

Suspended, an interactive game (see description under Apple). For CP/M-based systems; floppy disk, $59.95. Infocom, 55 Wheeler St., Cambridge, MA 02138.

XREF, a cross-reference program for Microsoft BASIC that is written in Pascal. You enter certain headings to the command tail. For CP/M-based systems; floppy disk, $50 (preferably converted to South African Rand). Barxact Computer Systems (Pty.) Ltd., POB 785150, Sandton, 2146, South Africa.

Commodore

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Disk Support, a 1K-byte machine-language extension program that adds 12 new commands to the computer. The user can save, save with replace, load, verify, delete, and rename disk files with just two keystrokes. For the Commodore 64 and VIC-20; floppy disk, $14.95. H & H Enterprises, 5056 North 41st St., Milwaukee, WI 53209.

Info-Manager, an information-management system designed to keep records of any nature in the home or small business. You can store and selectively print address lists, expense records, bills due, mailing labels, and many other files. For the Commodore 64; floppy disk, $39.95. Pyramid Software International, Suite A, Department 300, 30 Fairfax St., San Rafael, CA 94901.

Space Sentinel, an arcade-type game. As an orbiting space sentinel you must protect Earth from aliens’ heat missiles before the polar ice caps melt and cause floods. Joystick required. For the Commodore 64; floppy disk, $29.95. Talcove & Familian Co. (see address above).

Suspended, an interactive game (see description under Apple). For the Commodore 64; floppy disk, $49.95. Infocom, 55 Wheeler St., Cambridge, MA 02138.

Utility File, an energy-consumption data-processing
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program that calculates, displays, files, and prints a variety of data for designated units in such resources as electric, water, gas, oil and propane. For the Commodore 64 and VIC-20; cassette, \$29.95. Fabtronics, 51 Quarry St., Brockport, NY 14420.

The Wizard & The Princess, a graphics adventure game in which you must storm into the evil wizard's castle, defeat the dragon guarding the gate, find your way through the passage, and rescue the princess. On your way out you must slay the troll before your mission is a success. For the Commodore VIC-20; cassette, \$14.95. Melbourne House Software Inc., Department CS, 347 Reedwood Dr., Nashville, TN 37217.

**IBM Personal Computer**

Crypto-Cube, a word-puzzle game (see description under Apple). For the IBM Personal Computer; floppy disk, \$39.95. Designware Inc., 185 Berry St., San Francisco, CA 94107.

Financial Management TK Solver Pack. This program includes such topics as compound interest, net present value, level debt service, cost of equity capital, analysis of financial statements, stock-option pricing, bond swaps, convertible debt, and bond-refunding decisions. To be used in conjunction with TK Solver (\$299). For the IBM Personal Computer; floppy disk, \$100. Software Arts Inc., 27 Mica Lane, Wellesley, MA 02181.

Intellicom, an intelligent communications processor. This package provides computer-to-computer communications from terminal-termination and file-transfer standpoints. It supports several file-transfer protocols that facilitate the transmission of binary and ASCII data. For the IBM Personal Computer; floppy disk, \$49.95. Computer Toolbox, 1325 East Main St., Waterbury, CT 06705.

Mailcom, an E-COM mailing program. With a personal computer, modem, and this package, you can send out more than 2000 letters for 26 cents each from home or office via the Postal Service's E-COM System. The Post Office will print, fold, stuff, and seal computer-originated mail and guarantees delivery within 48 hours. For the IBM Personal Computer; floppy disk, \$195. Digisoft Computers, 1501 Third Ave., New York, NY 10028.

Media Magician, a disk-editing utility for binary and ASCII codes. You can modify disks by byte, string, or sector. The program brings you to any sector on a disk and displays up to 256 bytes of that sector at a time. It also provides ASCII code and updates representations of each byte. For the IBM Personal Computer; floppy disk, \$48.50. Photon Software, 636 120th Ave. NE, Bellevue, WA 98005.

Mystery Message, an interactive-game program. You must guess answers to 500 items as quickly as possible. This program stimulates concentration, recall, and retention skills for all ages. For the IBM Personal Computer; floppy disk, \$34.95. Social Systems Corp., Suite 28, 1621 Fulton Ave., Sacramento, CA 95825.

PC-Link, a terminal-emulation package that lets an IBM Personal Computer function like a Digital Equipment Corporation VT100 terminal. It allows transfer of ASCII program and data files between IBM PC and DEC computers. For the IBM Personal Computer; floppy disk, \$40. Screenware Corp., POB 3662, Nashua, NH 03061.

Personal Investment Analysis, an investment-decision program. All the information you need to perform accurate analyses for such investments as convertible bonds, mortgage loans, interest rates, retirement funding, and tax-free securities. Requires no prior computing experience. For the IBM Personal Computer; floppy disk, \$60. Wiley Professional Software, John Wiley & Sons, 605 Third Ave., New York, NY 10158.

Personal Pearl, an information-management system (see description under CP/M). For the IBM Personal Computer; floppy disk, \$295. Pearsoft, POB 13850, Salem, OR 97309.

Plot, a mathematical-graphing program. You can plot and process data and/or curves described by mathematical functions. This program allows switching back and forth between linear, semi-log, and double-log scales; calculating and plotting inverse relationships, power, and linear functions of data points. Color-graphics adapter required. For the IBM Personal Computer; floppy disk, \$29.95. Non-Linear Products, POB 14755, Minneapolis, MN 55414.

SSPLOT, a data-plotting program that generates plots on screen and can print pie charts, bar graphs, histograms, line plots, and scatter plots using files created by Visicalc and saved in DIF (Data Interchange Format). For the IBM Personal Computer; floppy disk, \$45. Stanford Software, 585 Singley Dr., Milpitas, CA 95035.

**Heath/Zenith**

Games #1, a collection of five games that includes Gomoku, Concentration, Maze-Dash, Solitary, and Barricade. For the Heath/Zenith Z-89; floppy disk, \$29.95. Interactive Micro Systems, POB 21007, Columbus, OH 43221.

Quizzer, an educational program that asks a student a series of practice questions in such formats as true/false, fill in the blank, or multiple choice. It can talk when used with the Votrax Type 'n Talk. For the Heath/Zenith Z-89; floppy disk, \$19.95. Interactive Micro Systems (see address above).

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Dealer Inquires Invited

Circle 198 on inquiry card.
Software Received

analysis program (see description under CP/M). For the TRS-80 Models I and III; floppy disk, $39.95. BV Engineering, POB 3351, Riverside, CA 92519.

Cards, an instructional program that enables you to program your own card games and gives hints on the graphics you'll require. For the TRS-80 Color Computer; cassette, $8. William Noggle, 2413 Kenwood Ave., San Jose, CA 95128.

Clean Slate, a word-processing package. This documented software contains a text editor, terminal communications capabilities, a form-letter generator, and handles assembly source code. For the TRS-80 Models I and III; floppy disk, $79.95. Howard W. Sams & Co., 4300 West 62nd St., Indianapolis, IN 46268.

Conquest of Kzirla, a high-resolution graphics game. As a warrior in the mythical kingdom of Kzirla, you are faced with the challenge of conquering the evil wizard Kolobarr in his dangerous dungeon. For the TRS-80 Color Computer; cassette, $21.95. Rainbow Connection Software, 3514 6th Place NW, Rochester, MN 55901.

Exams, a word-processing system designed to prepare examinations efficiently. It allows fast creation, modification, and storage of multiple-choice or true/false questions. Neatly formatted tests with answer keys are the final product. For the TRS-80 Model III; floppy disk, $69.95. Microsoft Software Services, POB 776, Harrisonburg, VA 22801.

Hidden BASIC 1.0, a utility program designed to protect BASIC programs. Several commands will cease to execute without affecting the speed or ability of your programs. For the TRS-80 Color Computer; cassette, $19.95. Spectrum Projects, 93-15 86 Dr., Woodhaven, NY 11421.

Rainbow-Writer, a general-purpose screen formatter that lets you write text in high-resolution graphics. It also features underline, subscript, superscript, scroll protect, and more. For the TRS-80 Color Computer; cassette, $29.95. Rainbow Connection Software (see address above).

Suspended, an interactive game (see description under Apple). For the TRS-80 Model III; floppy disk, $49.95. Infocom, 55 Wheeler St., Cambridge, MA 02138.

Zaxxon, an arcade-type game. Unique color graphics surround you as you pilot your aircraft through a simulated battlefield with enemy aircraft, fuel tanks, concealed missiles, anti-aircraft tanks, and nerve-shattering sound effects. The final showdown is a confrontation with the deadly robot Zaxxon. For the TRS-80 Color Computer, floppy disk, $39.95. Datasoft Inc., 9421 Winnetka Ave., Chatsworth, CA 91311.

Timex/Sinclair

Arcade Games Package. Two BASIC program listings, Tic Tac Toe and Tank Zap, each with varying levels of difficulty. For the ZX81 and TS1000 computers; two listings, $3. Florida Creations, Department P, POB 16422, Jacksonville, FL 32245.

Music/Sounds Package. Five BASIC program listings and directions for broadcasting music and spaceship noises to a nearby radio. It controls the radio-frequency interference generated by the computer.
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Software Received

For the ZX81 and TS1000; five listings, $3. Florida Creations (see address above).

Other Computers

K-Fix v. 2.1, a program that modifies the Kaypro II to shut off the disk drives when not in use, extinguish the drive lights when not being accessed, and allows you to set the default serial data rate. For the Kaypro II CP/M; floppy disk, $29.95. Maplesoft Inc., Suite 100, 49 Ascot Dr., Fredericton, NB E3B 6G1, Canada.

Manykey, a utility package that lets you define control-number keys and CP/M or Wordstar arrow keys for each disk. This package allows each .COM file to define its own arrow and control-number keys.

For the Osborne 1; floppy disk, $20. Compumagic Inc., POB 780, Severn, MD 21144.

Swords & Serpents, an arcade-type game. You're the White Knight exploring a maze-like dungeon. Avoid danger and protect a friendly wizard until he can learn the spells to save you both. For the Mattel Intellivision; cartridge, $39.95. Imagica, 981 University Ave., Los Gatos, CA 95030.


This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and [where appropriate] the alternate forms in which they are available.

BYTE's Bits

Software for Schools

Silicon Valley Systems is giving away more than $100,000 worth of its word-processing and educational software to public schools. For further information on how schools can obtain some of this software, contact Peggy Johnson, Assistant to the President, Silicon Valley Systems, 1625 El Camino Real, Belmont, CA 94002.
A Colorful Introduction to Computers

Here's a fun and educational coloring book to introduce your home computer to the youngest members of your family. The Magic Machine explores the excitement and wonder of computers from a young child's point of view. Theodore Cohen's story, written for beginning readers, answers many of the basic questions children ask about the magic machines that are coming into our homes in ever-growing numbers, and Jacqueline Bray's line drawings capture the vivid and often funny images that arise from the inquisitive minds of children as they seek to understand the world around them. Packaged complete with its own set of crayons, The Magic Machine will help children appreciate computers even before they are old enough to begin using them.

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I Speak BASIC to My Apple™ (Jones) teacher's manual #6165, $17.45; student text #6175, $8.45.
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I have been trying to locate technical information that will assist me in developing some electronic-measuring devices. I am a fisheries biologist and amateur engineer and machinist. I want to design and build equipment that will allow me to measure small fish automatically and record the lengths with my computer. I also want to fit automated measuring capabilities to some machine tools so that I can have real-time measurements as I work and know precise tool positions. Once I have this capability, I want to move into numerical control and some robotic applications.

I would like to try using magnetic strips coded with distance information attached to the machines' ways, then use a reading head attached to the moving element of the machine. The reading head would feed into a processing unit with a digital readout. I have seen a picture of an electronic vernier caliper that operates on this principle but have not been able to get any details of the actual working elements.

Your assistance in locating technical information or people to contact is greatly appreciated.

Greg L. Young
Juneau, AK

One of the simplest yet most sophisticated techniques devised for electronic measuring is the use of a TV camera. By digitizing a video image of a part or surface, measurements to thousandths of an inch are possible. I have seen units that can inspect complex mechanical parts in seconds, and give a list of all dimensions measured, the allowable range for each dimension, and a flag against any dimension that is not within the spec. Here are some companies that make such products. . . . Steve

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Concord, MA 01742
(617) 371-0104

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Rte. 128 and Brimbal Ave.
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Vestigial-Sideband Filter

Dear Steve,

I am constructing a microcomputer system using Motorola's 6847 VDG (video-display generator) and 1372 TV Modulator. Motorola's documentation on the VDG 6847 interface is quite clear; however, I found the information provided for the 1372 and TV interface is too general. Specifically, the 1372's output is fed into the TV set (probably to the antenna) with a vestigial-sideband filter. Can you tell me what this filter is? I would greatly appreciate it.

Richard F. Man
Medford, MA

A television signal is generated in a manner similar to that of a standard AM (amplitude modulation) sound broadcast, and the video signal consists of two sidebands and a carrier. To conserve spectrum bandwidth and to reduce the problems associated with wide bandwidth transmissions, one sideband is removed. However, filters to completely remove this sideband (for single-sideband transmission) must have a very sharp cutoff frequency and not change the phase or amplitude of the remaining sideband. Such filters are difficult to construct and expensive. As a compromise, most, but not all, of one sideband is removed. This method is known as vestigial-sideband operation.

A vestigial-sideband filter also removes second harmonic effects and other spurious noise. The output of the MC1372 is essentially a double-sideband signal, and the vestigial filter is used to "trim" the signal to fit the bandwidth of the television receiver. . . . Steve

---

High-Resolution Storage

Dear Steve,

We would like to know if anyone makes a video camera with interface that will let you copy records and files to be recorded on the computer disk for later recall and reproduction through a printer or plotter. We wish to reduce our records to a computer library with indexing capabilities.

Eugene Manzo
Miami, FL

Many video camera systems on the market allow image storage, but it is important to choose one with high resolution in order to store a complete page of text. The higher the resolution, the sharper the image and the greater demands on memory.

For example, 1024 by 1024 pixels would be the minimum resolution, and higher values are preferred. But one frame at this size requires 128K bytes.

Some companies making such equipment include:

Datacopy
1070 East Meadow Circle
Palo Alto, CA 94303
(415) 493-3420

Imaging Technology Inc.
400 West Cummings Park, Suite 4350
Woburn, MA 01801
(617) 938-8444

Eikonix Corporation
23 Crosby Dr.
Bedford, MA 01730
(617) 275-5070

Quantex Corporation
252 North Wolfe Rd.
Sunnyvale, CA 94086
(408) 733-6730

You might also want to consider using a laser-type videodisc with a personal computer to provide random access. The major problem here is getting the information onto the laser disc. Refer to the June 1982 BYTE for more information. . . . Steve

---

VIC-20 Expansion

Dear Steve,

I have a Commodore VIC-20. Is there a company that manufactures an expansion module that would provide a 40- or 80-column video output?

Robert J. Kakoczki
White Cloud, MI

Quantum Data Inc. makes a series of cartridges for the VIC-20, among which is a card that will display 80 columns of...
The card optionally features 16K bytes of memory and a programmable ROM socket. It comes set for 40 columns that can be displayed on a TV set. For 80 columns, a change inside the cartridge is made. A video monitor must be used with any 80-column display because the bandwidth of an ordinary TV is not adequate. Contact Quantum Data Inc., 3001 Redhill Bldg., Suite 105, Costa Mesa, CA 92626, (714) 966-6553.

Data 20 Corporation also makes a set of cards for the VIC that includes a Video Pak 80-column expansion card with additional memory and free word-processing software. Contact Data 20 Corporation, 23011 Molino Parkway, Suite B10, Laguna Hills, CA 92653, (714) 770-2366.

Voiceprints
Dear Steve,
I am writing in reference to your articles in BYTE on voiceprints. I have been thinking along these lines in an attempt to build a system to help deaf people learn to speak. I think if you could display correct voiceprints on a monitor for the deaf person to duplicate, it would facilitate their efforts to speak.

I have an Apple II system and some experience in programming in BASIC. I have heard some rumors about systems that have already been designed, but I have not been able to get any real information. Do you know of anyone I could contact about this subject? Any information or advice on how to proceed would be greatly appreciated.

Thank you for your consideration.
Dale Sarver
Ridgefield, WA

Many companies are actively pursuing speech recognition, but I am not sure how many are using the voiceprint concept. Most are concentrating on the recognition of specific words by an unlimited number of users. I am listing below some companies engaged in speech recognition. Write them for further information. . . . Steve

Ben Franklin Industries
Casey Creek, KY 42723
(606) 787-5002

Covox Company
675-D Conger St.
Eugene, OR 97402
(503) 342-1271

Excalibur Technologies
800 Rio Grande Blvd. NW,
Suite 21
Albuquerque, NM 87104
(505) 242-3333

Hitachi
175 Crossways Park West
Woodbury, NY 11797
(516) 921-7200

Interstate Electronics
POB 3117
Anaheim, CA 92803
(714) 635-7210

NEC America
532 Broad Hollow Rd.
Melville, NY 11747
(516) 752-9700

Votan
26046 Eden Landing Rd.
Hayward, CA 94545
(415) 785-8060

IMSAI Repair
Dear Steve,
I have an IMSAI VDP-44 in need of repair. To have this done locally, I need schematics and possibly an equipment manual. What is the address of the company that bought out IMSAI?
Is it worth the trouble to fool with this machine? After numerous phone calls, the closest repair available seems to be Computerland in Chicago. J. R. Weistart Rochester, NY

Microsystems magazine features advertisements by a company that has taken over the line of IMSAI computers. Perhaps they have a repair facility to service your unit. Write or call them at

IMSAI Computer Division
Fischer-Freitas Corporation
910 81st Ave., Bldg. 14
Oakland, CA 94621
(415) 635-7615

As to whether it is worth fixing, that is a question you must answer. Weigh the cost of repair to your total investment. If you were happy with the unit before it malfunctioned, then repair it and keep going. If you were unhappy, here is the excuse that you need to buy a new one.

Good luck. . . Steve

---

Protecting ZX81 Programs

Dear Steve,

I've had a Sinclair ZX81 computer for about six months and have written a lot of my own programs. Is there any way to prevent someone from being able to display the listing of a program? That is, is there any way you can make a program on tape “run-only”? Any help you can give me on my problem would be greatly appreciated.

Greg E. Sedbrook
Del Rio, TX

The easy way to protect programs from being listed in BASIC is to have the program disable the LIST command. This is easy for computers that have the BASIC in RAM but very difficult if it is in ROM (like your ZX81). I am not aware of a simple way to defeat this command.

Writing your program in machine language will certainly solve the problem. A BASIC program can be written to give title and credits. Then call a USR command to run your machine-language program. This will make it more difficult to copy. . . Steve

---

Getting Ready for April 15

Dear Steve,

I have a Timex/Sinclair 1000 computer and would like to know if anyone has written a program for it to prepare income tax returns. I know it’s been done for other computers.

Also, do you know if anyone has written about converting Sinclair BASIC to other BASICS. There is a book to convert between Apple, PET, and Radio Shack; but it does not mention your computer. A general reference for converting between BASIC versions is The BASIC Handbook by David A. Lien, published by ComputerSoft Publishing. It describes the similarities and differences between versions of BASIC, gives sample programs, and tells you what to do if your BASIC lacks a particular feature. It should be of great help to you.

I have not seen an income tax program for the Timex/Sinclair 1000. There have been many articles written for such programs,
so it should be an easy matter to convert one for your computer. One such article appeared in the March 1980 issue of Microcomputing magazine on pages 42-47. "Income Tax Consultant" by William P. Van Horn describes a tax preparation program that can serve as a model for your computer. . . .Steve

Apple Equipment and the Commodore 64

Dear Steve,

Commodore says that the 6510 processor in its 64 is an improved version of the 6502. If this is true, can I interface the 64 to an Apple II expansion bus? If I do so, can I use Apple-compatible peripheral devices with it? If so, how? Is there any way I could use Apple II software?

Joshua Putnam
Burton, WA

The 6510 microprocessor used in the Commodore 64 is an improved version of the 6502. It features additional input/output lines and shares the same instruction set as the 6502. Apple-compatible peripheral devices, in theory, should work with the Commodore, but some significant differences must be addressed.

1. Many Apple peripheral cards have an onboard ROM that contains software to drive the hardware. These ROMs contain calls to Apple routines in the monitor and other areas not common to the 64. Hence the ROMs may have to be changed.

2. The Apple bus has some built-in decoding known as Device Select signals, which activate the card when a particular area in memory is addressed. No separate address decoding is on the card (usually), and you must add this to work with the 64.

3. Apple uses a different phase of the system clock than the 64 (1 instead of 2). This may create some timing problems on some cards.

Each card must be considered separately for compatibility. It may be possible to create a universal Apple interface for the 64, but an in-depth study of the software and hardware differences is required. . . .Steve

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

Ask BYTE
do Steve Clarica
POB 582
Glastonbury CT 06033

If you are a subscriber to The Source, chat with Steve (TEC317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.
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September 1983

September
Continuing Engineering Education, Washington, DC. Two of the courses offered this month are "Programming in the C and Unix Environment" and "Graphical Data Analysis." Fees range from $625 to $855. For a full schedule, contact Douglas Green, Continuing Engineering Education, George Washington University, Washington, DC 20052, (800) 424-9773; in the District of Columbia, (202) 676-8512.

September-October
Computer-assisted Manual Writing, various sites throughout the U.S. This one-day seminar is designed to teach attendees how to produce good software manuals. The sponsor will demonstrate a software package for automated documentation development called Manual Maker. The fee is $195. For further information, contact Promptdoc, 833 West Colorado Ave., Colorado Springs, CO 80905, (303) 471-9875.

September-November
Computer Showcase Expos, various sites throughout the U.S. This popular show will bring together hardware and software manufacturers, dealers, and consumers of small computer systems. For further details, contact the Interface Group, 160 Speen St., POB 927, Framingham, MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

September-November

September-December
Intensive Seminars for Professionals, various sites throughout the U.S. This conference provides a forum for learning about advanced technical topics. Seminars in management and such technical areas as speech recognition and synthesis, control theory, fundamentals of computer graphics, and microprocessor interfacing. In-house presentations can be arranged. For a descriptive catalog outlining seminars, locations, and fees, contact Irene Parker, McGraw-Hill Seminar Center, Suite 603, 331 Madison Ave., New York, NY 10017, (212) 687-0243.

September-December
James Martin Seminars and Seminars of Excellence, various sites throughout the U.S. and Canada. A brochure describing these data-processing and computer-related seminars, contact Technology Transfer Institute, 741 10th St., Santa Monica, CA 90402, (213) 394-8305.

September-December
Seminars for Professional Development, various sites throughout the U.S. Databyte Research Corporation offers more than 35 professional development seminars in such areas as personal computers, data communications, systems and software, and office automation. Complete outlines and schedules are available from Datapro Research Corp., 1805 Underwood Blvd., Delran, NJ 08075, (800) 257-9406; in New Jersey, (609) 764-0100.

September-December
Software Workshops in MMFSFORTH, Boston metropolitan area. These workshops are public versions of the professional training Miller Microcomputer Services (MMS) offers to client companies in support of the MMFSFORTH product line. A variety of topics and skill levels are covered. Full details are available from Miller Microcomputer Services, 61 Lake Shore Rd., Natick, MA 01760, (617) 653-6136.

September-January 1984
Technology Opportunity Conference, various sites throughout the U.S. The conference focuses on the convergence of optical storage, videodisc, and computer technologies. For full details, contact Technology Opportunity Conference, POB 14817, San Francisco, CA 94114, (415) 626-1133.

September 21-14
The American Data Services (ADS) Users Seminar, Marriott Resort, Lincolnshire, IL. This seminar focuses on the ADS inventory-management system. A procedural cost system for hospital departments will be introduced. Contact Sharon Spencer, American Data Services, Suite 210, 900 North Shore Dr., Lake Bluff, IL 60044, (312) 295-6850.

September 12-14
Discovery '83: Computers for the Disabled, Leamington Hotel, Minneapolis, MN. This conference provides a forum for learning about ad-

September 13-15
AUTOFACT Europe Conference and Exhibition, Palexpo Exhibition Center, Geneva, Switzerland. This conference, cosponsored by the Society of Manufacturing Engineers (SME) and the Institution of Production Engineers of London, England, will focus on the technologies of automated and computer-integrated manufacturing for European production. Technical sessions will explore both theory and applications strategies. A complementary products display will be featured. Contact the Society of Manufacturing Engineers, Public Relations Department, One SME Dr., POB 930, Dearborn, MI 48121, (313) 271-0777.

September 12-15
Midcon/83 and Mini/MicroMidwest/83, Chicago, IL. Topics on the professional program include computer simulation, energy management, laser applications, and printed-circuit-board technology. An exhibit area is planned. For further information, contact Electronic Conventions Inc., 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965.

September 13-15
Peripherals '83, Moscone Center, San Francisco, CA. Full details are available from Cahners Exposition Group, Cahners Plaza, 1350 East
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September 13-15

September 13-16
Understanding Microprocessor-based Equipment and Troubleshooting Seminar, Washington, DC. Top topics include TTL and CMOS logic devices, architecture of computer systems, test equipment, and digital troubleshooting. Contact is $900. For more information, contact Micro Systems Institute, Garnett, KS 66032, (913) 898-6152.

September 14-16
Euromicro '83, Madrid, Spain. The ninth annual Euromicro symposium will cover microprocessing and programming. Speeches will address economic and social aspects of microprocessors and trends in VLSI (very-large-scale integration) technology. Tutorials, seminars, and an exhibition are planned. The highlight of this event is the Euromouse contest, in which mechanical mice race around a maze. A complete program is available from Euromicro, TH Twente, POB 217, Department INF, Room A312, 7500 AE Enschede, The Netherlands; tel: (31) (33) 338799; Telex: 44200 TES.

September 15-16
The Second Annual Indiana Computer Expo, Convention Center, Indianapolis, IN. This exposition is designed for business end users interested in mini- and microcomputers, software, word processing, graphics, services, and peripherals. Contact Ernie Kerns & Associates, Trade Show Department, Suite 201, 2555 East 55th Place, Indianapolis, IN 46220, (317) 259-8111.

September 15-16
The Second Annual Twin Cities Computer Show and Software Exposition, Minneapolis Auditorium, Minneapolis, MN. This show features more than 350 displays of microcomputers, accessories, peripherals, publications, services, and software. General admission is $5 for adults and $3 for children. Contact Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (800) 841-7000; in Massachusetts, (617) 739-2000.

September 16-18
Computex, Seattle Center Exhibition Hall, Seattle, WA. This show will feature personal computer hardware, software, and services available for a variety of applications. Presentations and seminars on how to buy a personal computer and users' effectiveness with children will be offered. Contact Tom Ickeda, Computex Inc., Suite 302, 909 Northeast 43rd St., POB 45218, Seattle, WA 98105, (206) 633-3247.

September 16-18
The First Annual Heart of Texas Computer Show, Convention Center, San Antonio, TX. This show will emphasize small-business systems, financial and inventory control, farm-business, education, and personal computing needs. More than 200 hardware, software, and peripheral vendors will display their wares. Show details are available from Robin G. Mann, Heart of Texas, POB 12094, San Antonio, TX 78212, (512) 226-4636.

September 16-18
Great Southern Computer & Electronics Show '83, Memorial Coliseum, Jacksonville, FL. Computers, electronics, and information services will be featured. Contact Great Southern Computer & Electronics Shows, POB 655, Jacksonville, FL 32201, (904) 384-6440.

September 17-18
Carleton University Computer Fair '83, Carleton University campus, Ottawa, Ontario, Canada. Exhibits, lectures, and auction of used and hard-to-find electronic materials will be featured. Admission to all events is free. Information is available from the IEEE Student Branch, Faculty of Engineering, Carleton University, Ottawa, Ontario K1S 5B6, Canada.

September 18
Computer Swap Meet, Exhibition Hall, Sarasota, FL. This event is sponsored by the Institute of Computer Management (ICM), a nonprofit corporation designed to enhance the mental skills of the physically disabled. Items relating to computers will be sold. Admission is free. Contact the ICM, 3803 Prairie Dunes Dr., Sarasota, FL 33583, (813) 924-7105.

September 19-21

September 19-22
Computer Literacy Week, New York City Hilton. More than 35 sessions on such topics as how to help managers grow accustomed to computers and how to use microcomputers as a training medium highlight this conference. Workshops, hands-on seminars, and an exhibition hall will be featured. For a brochure, contact Susan Jones, Conference Management Corp., 17 Washington St., POB 4990, Norwalk, CT 06856, (203) 852-0500.

September 19-23
The Ninth World Computer Congress—IFIP '83, Paris, France. This event, sponsored by the International Federation for Information Processing (IFIP), is held in conjunction with SICOB, the major French computer exposition. Formal papers and panel sessions will cover such areas as computer hardware and software, theoretical foundations of information processing, networks, and communications. For full program details, contact the U.S. Committee for IFIP '83, Dorn Computer Consultants, 25 East 66th St., New York, NY 10028, (212) 427-7460.

September 20-21
Data Storage 83, Marriott Hotel, Santa Clara, CA. This international forum covers industry issues and areas of change in data-storage equipment and applications. The
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September 20-22
Caribbean Informatics '83, San Juan, Puerto Rico. This is the first major international exhibition and conference to be held in the Caribbean area. For further details, contact Informatics '83, Suite 219, 3421 M St. NW, Washington, DC 20007, (703) 920-9595.

September 20-23
Understanding Microcomputer-based Equipment and Troubleshooting Seminar, Boston, MA. For details, see September 13-16.

September 21-22
Business-Expo, Boston, MA. This exposition serves as a showcase for office equipment ranging from computers to coffee machines. More than 20 seminars are planned. Address inquiries to Business-Expo, 702 East Northland Towers, 15565 Northland Dr., Southfield, MI 48075, (313) 569-8280.

September 22-23
Computers in Construction, San Francisco, CA. This seminar is designed to assist construction management firms and contractors in acquiring computer systems. The fee is $425. Contact CIP Information Services Inc., 1105-F Spring St., Silver Spring, MD 20910, (301) 589-7933.

September 22-24
The Second Annual Rocky Mountain Computer Show and Software Exposition, Merchandise Mart, Denver, CO. This show features displays of computers, video games, software, accessories, publications, services, and peripherals. For information, contact Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (800) 841-7000; in Massachusetts, (617) 739-2000.

September 26-28
Macon '83, Kansas City, MO. This electronic show and convention explores such topics as aerospace electronics, computer peripherals, laser technology, and personal computing. Contact Electronic Conventions Inc., 8110 Airport Blvd., Los Angeles, CA 90045, (213) 772-2965.

September 26-29
The World of CAD/CAM, Boca Raton Resort Hotel, FL. This seminar provides an overview of how manufacturing will change as the automated factory becomes a reality. It will consist of four one-day presentations in computer-aided engineering, design, manufacturing, and computer-integrated manufacturing. For a brochure, write or call the Center for Manufacturing Technology, 4170 Crossgate Dr., Cincinnati, OH 45236, (513) 791-8801.

September 26-30
Compon Fall '83, Marriott Crystal Gateway Hotel, Arlington, VA. The theme of this show is "Delivering Computer Power to End Users." It features technical papers and panel sessions that address a variety of computer and computer-network issues. It is sponsored by the Institute of Electrical and Electronics Engineers (IEEE) Computer Society. For more information, contact Compon Fall '83, POB 639, Silver Spring, MD 20901, (301) 589-8142.

September 26-30
Expo Beirut '83, Beirut, Lebanon. This is Lebanon's first international reconstruction/development exposition and conference after eight years of civil war. Topics to be covered include construction, transportation, communications, agriculture, computer hardware and software, metallurgy, textiles, and automated equipment. Further details are available from Show-Tech International Inc., 950 Third Ave., New York, NY 10022.

September 26-30
International Conference on Networks and Electronic Office Systems, University of Reading, Berkshire, England. The conference program comprises formal lectures and discussions. For additional information, contact the Conference Secretariat, Institution of Electronic and Radio Engineers, 99 Gower St., London WC1E 6AZ, England; tel: 01 388 3071.

September 28-29
Ottawa Computer and Office Automation Show, Civic Centre, Ottawa, Ontario, Canada. For details, contact Industrial Trade Shows of Canada, 20 Butterick Rd., Toronto, Ontario M8W 3Z8, Canada, (416) 252-7791.

September 28-October 2
The Sixth Personal Computer World Show, Barbican Centre, London, England. This show, one of the largest computer shows in Great Britain, is sponsored by Personal Computer World magazine. Business, scientific, technical, and educational uses of microcomputing will be featured as well as hobbyist and home-based systems. For information, contact Tim Collins, Montbuid Ltd., 11 Manchester Square, London W1M 5AB, England; tel: 01 486 1951; Telex: 24591.

September 29-October 1
CP/M '83 East, Hynes Auditorium, Boston, MA. For information on this conference and exposition of CP/M-based software, contact Northeast Expositions Inc., 826 Boylston St., Chestnut Hill, MA 02167, (800) 343-2222; in Massachusetts, (617) 739-2000.

September 29-October 2
Computers in Health Care '83: A Symposium and Exhibition, Sacramento, CA. This symposium and exhibition explores the role of computers in hospitals, physician and dental offices, rehabilitation centers, long-term care facilities, home-health agencies, pharmacies, and mental-health settings. Contact Eskaton Health Corp., Community Services Division, 1501 El Camino Ave., Sacramento, CA 95815, (916) 927-5722.

October 1983
October 1
The Third Annual Microcomputers in Education Conference, Dutchess County Community College, Poughkeepsie, NY. Dr. Delores Shanahan, an innovator in the field of special education and computers, will speak at this event sponsored by the Microcomputer Educator Group. Details are available from Dr. Florence Staats, Office of Community Services, Dutchess County Community College, Pendell Rd., Poughkeepsie, NY 12601, (914) 471-4500, ext. 240.

October 2-5
Computer Systems Exposition, MGM Grand Hotel, Las Vegas, NV. This exposition will be held in conjunction with the annual meeting of the National Association of Convenience Stores. Hardware and software will be displayed, and computer consultants will be on hand to
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answer questions. For details, contact the National Association of Convenience Stores, Suite 809, 5201 Leesburg Pike, Falls Church, VA 22041, (703) 578-1800.

October 2-6
The Annual Meeting of the American Society for Information Science - ASIS-83, Crystal City Hyatt Regency, Arlington, VA. The theme for this meeting is "Productivity in the Information Age." Papers, special-interest sessions, information briefings, an information-science theater, and demonstrations will be featured. Further information is available from Edmond Sawyer, ASIS Headquarters, 1010 Sixteenth St. NW, Washington, DC 20036, (202) 659-3644.

October 2-7
HP 3000 IUG International Conference, George Hotel, Edinburgh, Scotland. This conference, sponsored by the HP 3000 International Users Group (IUG), is made up of technical sessions and tutorials on data-processing management, data communications, and applications in business, manufacturing, and engineering for users of Hewlett-Packard 3000 business computers. Contact the Conference Manager, HP 3000 IUG, 289 South San Antonio Rd., Los Altos, CA 94022, (415) 941-8440.

October 3-5
SNA Architecture and Implementation, Holiday Inn, Park Center Plaza, San Jose, CA. This seminar provides the working knowledge needed to design SNA (system-network architecture) networks and evaluate SNA-compatible products. Examples of how various protocols are used to control communications will be provided. Other topics include SNA functional layering and network elements. The fee is $5650. Full details are available from Communications Solutions Inc., 992 Saratoga-Sunnyvale Rd., San Jose, CA 95129, (408) 725-1568.

October 6-6
The Southwest Computer Conference, Tulsa, OK. The theme for this conference is "Managing Information Technology in the 80s." Computer hardware and software will be exhibited. Contact the Southwest Computer Conference, POB 950, Norman, OK 73070, (405) 329-3660.

October 6-5
CompuSource '83, Red Lion Inn and Convention Center, San Jose, CA. Original equipment manufacturers and sophisticated end users are offered a look at products and technologies reflecting the latest advances in the computer industry. This conference will feature technical sessions and more than 100 exhibits. Details are available from Norm DeNardi Enterprises, Suite 204, 289 South San Antonio Rd., Los Altos, CA 94022, (415) 941-8440.

October 6-7
Computers in Construction, Atlanta, GA. For details, see September 22-23.

October 6-8
The Second New Jersey Business Computer Show, Holiday Inn (North), exit 14 of the New Jersey Turnpike. This business show features small business systems, desktop computers, word processors, software, and accessories. For further information, contact the Kengore Corp., POB 13, Franklin Park, NJ 08823, (201) 297-2526.

October 6-11
Japan Electronics Show '83, Osaka International Trade Fair Grounds, Osaka, Japan. This show will cover a range of consumer and industrial electronic products and components. For information, contact the Japan Electronics Show Association, 24 Mori Building 11F, 3-23-5, Nishi-Shinbashsi, Minato-ku, Tokyo 105, Japan; tel: (03) 433-7751.

October 7
Computer Graphic Networks and Standards, Washington, DC. New directions in integrated voice, data, text, graphics, and image networking for information imaging and market trends for the next five years are some of the topics to be explored at this seminar. The fee is $250. Contact Mike Nolan, Computer Technologies Department, Printing Industries of America Inc., 1730 North Lynn St., Arlington, VA 22209.

October 7-9
Great Southern Computer & Electronics Show '83, Convention Center, Orlando, FL. For details, see September 16-18.

October 8-9
The Tidewater Eighth Annual Computer Convention, Hamfest, Electronic Flea Market, Pavilion, Virginia Beach, VA. Dealers, an electronics flea market, displays, and forums highlight this event. Admission is $4 for both days. For tickets and general information, call or write Jim Harrison, 1234 Little Bay, Norfolk, VA 23503, (804) 587-1695.

October 8-10
PC '83, Bayside Exposition Center, Boston, MA. This conference and exposition features IBM Personal Computers and compatible equipment. A seminar program will explore applications, provide technical information, and offer general sessions designed to show ways to get the most from their IBM PC. For details, contact Northeast Exhibitions, 822 Boylston St., Chestnut Hill, MA 02167, (800) 841-7000; in Massachusetts, (617) 739-2000.

October 10-12
Online '83, Palmer House, Chicago, IL. The fifth annual Online conference and exposition features introductory and advanced technical sessions, panel discussions, workshops, seminars, and addresses. The role of microcomputers and software for database searching, storage, creation, and communications will be emphasized. Registration information is available from Online Inc., 11 Tannery Lane, Westport, CT 06883, (203) 227-8466.

October 10-13
Information Management Exposition and Conference: Info '83, New York City Coliseum. Hardware and software exhibits and conference sessions will revolve around the theme "Tying the Information System to the Business Plan." A number of the conference sessions will deal with decision support systems. For complete details, contact the Marketing Manager, Info '83, 706 Third Ave., New York, NY 10017, (212) 661-8410.

October 10-14
Defense Computers--Graphics--DCG '83, Convention Center, Washington, DC. Sessions and tutorials will complement this conference and exposition about computers and graphics for the defense community. For more information, contact DCG '83, Suite 333, 2033 M St. NW, Washington, DC 20036, (202) 773-9556.
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October 11-12
Computer-aided Design Conference—CADCON East ’83, Boston, MA. This conference consists of technical programs and exhibitions organized exclusively for computer-aided-design engineers. More information is available from Morgan-Grampian Expositions Group, 2 Park Ave., New York, NY 10016, (212) 340-9760.

October 11-13
Southwest Semiconductor & Electronics Exposition—SSE ’83, Civic Plaza Convention Center, Phoenix, AZ. Approximately 200 suppliers of equipment, materials, and services used in the electronics industry will attend this show. A technical conference will be held. Contact Cartlidge & Associates Inc., Suite 205, 4030 Moopark Ave., San Jose, CA 95117, (408) 554-6644.

October 12-21
The Sixth International Trade Exhibition on Office Organizational Systems, Office Furniture, and Office Aids—Systemtechnika ’83, Vassilievsky Ostrov Exhibition Centre, Leningrad, Union of the Soviet Socialist Republics. On display will be communications systems, microfilming equipment and systems, data-processing equipment, and computers. Contact Düsseldorfer Messgesellschaft mbH—NOWEA-Central Division—Foreign Fairs, Düsseldorf Exhibition Centre, 4000 Düsseldorf 30, Federal Republic of Germany; tel: (02 11) 45 60-1.

October 13-14
Computers in Construction, Chicago, IL. For details, see September 22-23.

October 13-15
Edutech/East ’83, Civic Center, Philadelphia, PA. For-merly called Ed Com, this conference and exposition is designed for educators at all levels. Presentations will address such topics as computer-aided instruction, administrative uses of computers, classroom management, programming, research applications, authoring languages, and literacy. The format includes workshops, seminars, demonstrations, hands-on sessions, discussions, and micro courses. Hardware, software, and publishing companies will exhibit their wares. Contact Carol Houts, Judco Computer Expo Inc., Suite 201, 2629 North Scottsdale Rd., Scottsdale, AZ 85257, (800) 528-2385; in Arizona, (602) 990-1715.

October 14-15
Computers and Reading/Learning Difficulties, Dallas, TX. Workshops, hands-on exhibits, and speakers will explore such topics as using computers in learning disability classrooms and evaluating software. This program is designed for all education levels. For information, contact Frost Conference Management, Department I, 1070 Crowns Nest Way, Richmond, CA 94803, (415) 222-1249.

October 16-17
The Fifth Annual Hong Kong Consumer Electronics Show, New World Hotel and Regent Hotel, Hong Kong. For details, contact IBS Trade Fair Ltd., 17th Floor, Tung Sun Commercial Centre, 200 Lockhart Rd., Hong Kong; tel: 5-732988-9; Telex: 63037 HKIBS HX.

October 16-18
Texas Association for Educational Data Systems 1983 Convention, Austin Hilton Hotel, Austin, TX. The theme for this year’s convention is “Computer Literacy.” The keynote speaker will be Captain Grace Hopper of the U.S. Navy. Information may be obtained from Tom Hopper, Northside ISD, 5900 Evers Rd., San Antonio, TX 78238, (512) 618-8330, ext. 212.

October 17-19
The Eighth Conference on Local Computer Networks, Minneapolis, MN. The theme for this conference is “Practical Applications and Issues in Local Computer Networks.” Papers and tutorials will address such issues as users’ versus manufacturers’ needs, public versus private networks, software, and VLSI (very-large-scale integration). Contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901.

October 17-21
Systems 83, Munich, West Germany. Computers, peripherals, and software will be displayed by more than 600 firms from 35 nations. For additional information, contact Kallman Associates, 5 Maple Court, Ridgewood, NJ 07450, (201) 652-7070.

October 18-20
The Fourteenth Annual International Test Conference, Frankfurt Plaza Hotel, Philadelphia, PA. For information, contact the Conference Registrar, POB 371, Cedar Knolls, NJ 07927, (201) 267-7120.

October 18-21
HP 3000 IUG 1983 International Conference, Hyatt Regency Hotel, Fort Worth, TX. This conference features technical sessions and tutorials for users of the Hewlett-Packard 1000 family of realtime engineering and scientific computers. Contact the Conference Manager, HP 3000 IUG, 289 South San Antonio Rd., Los Altos, CA 94022, (415) 941-1943.

October 18-21
The Third Symposium on Microcomputer and Microprocessor Applications—µP ’83, Hotel Duna Intercontinental and the Hungarian Academy of Sciences, Budapest, Hungary. The conference language will be English. Full details are available from Mrs. I. Bába, Scientific Society for Telecommunication, POB 451, H-1372 Budapest, Hungary; tel: (36) 1 113-027; Telex: MTE52 25-5792.

October 19-20
Calgary Computer & Office Automation Show and Conference, Roundup Centre, Calgary, Alberta, Canada. For details, contact Industrial
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October 19-21
The Fourth Canadian Symposium on Instructional Technology, Westin Hotel, Winnipeg, Manitoba, Canada. This symposium, designed for education and training professionals and those interested in computer-aided learning, will explore the theme "Computer Technologies for Productive Learning." Topics on the agenda include computer awareness and literacy in schools and society, systems technology, and computer-aided training and retraining for business, industry, and government. A products exhibition will be held. Contact Ken Charbonneau, Conference Services Office, National Research Council, Ottawa, Ontario K1A 0R6, Canada, (613) 993-9009; Telex: 053-3145.

October 19-21
IDATE-The Fifth International Conference, Montpellier, France. The theme for this conference, sponsored by the International Telecommunication Union, is "Picture Networks." Topics of interest include network functioning and areas of applications, economics and law relating to the visual media, network languages, and languages on the networks. The conference language is French. For further details, contact Francois Rabaté, Responsable Scientifique, Journées Internationales 1983, IDATE-Bureaux du Polygone, 34000 Montpellier, France; tel: (33-67) 65 48 48; Telex: IDATE 490 290.

October 19-21
The National Software Show, Trade Show Center, San Francisco, CA. Full details are available from Ragging Bear Productions Inc., Suite 175, 21 Tamal Vista Dr., Corte Madera, CA 94925, (800) 752-2300; in California, (415) 924-1194.

October 19-21
SIBEC—Info Expo, Palais des Congres, Montreal, Canada. Exhibits related to the computer and office automation industries will be held. An international lineup of speakers has been invited. Contact Informatique Quebec (Info Expo) Ltee, 1057 Avenue Laurier Ouest, Outremont, Quebec H2V 2L2, Canada, (514) 270-5481; in the Toronto area, call (416) 281-3459.

October 19-22
Management Executives Conference, The Breakers, Palm Beach, FL. The "Third Industrial Revolution" is the theme for this conference sponsored by the American Society of Mechanical Engineers (ASME). Management experts will speak on such topics as executive effectiveness and management for international competition. Complete conference details are available from Wendy Morris, ASME, 34 East 47th St., New York, NY 10017, (212) 705-7788.

October 19-22
Percompasia 83—The Second South East Asian Personal Computer Hardware & Software Show & Conference, World Trade Centre, Singapore, Republic of Singapore. This show is devoted to all aspects of personal computing. Further details are available from Overseas Exhibition Services Ltd., 11 Manchester Square, London W1M 5AB, England; tel: 01 486 1951; Telex: 24591.

October 23-26
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October 24-26
The Annual Conference of the Association for Computing Machinery-ACM '83, Sheraton Centre Hotel, New York, NY. Exhibits of computer hardware and software and paper sessions will focus on the conference theme, "Extending the Human Resource." The emphasis will be on theory and practices of personal computing. Highlighting the conference will be the Fourth International Computer Chess Championships. For details, contact Thomas A. D'Auria, Assistant Commissioner, City of New York, Computer Service Center, 11th Floor, 111 8th Ave., New York, NY 10011, (212) 620-5055.

October 25-27
Andean Informatics '83, Bogota, Colombia, South America. This is the first major international exhibition and conference to be held in the Andean region. For details, contact Informatics '83, Suite 219, 3421 M St., NW, Washington, DC 20007, (703) 920-9595.

October 25-28
Working Conference on Prototyping, Brussels, Belgium. This conference will focus on the user-oriented development of information systems supported by prototyping. Research and technical papers will be presented. The sponsor is the Commission of the European Communities. For information, contact Reinhard Budde or Heinz Zuelighoven, GMD-IST Postfach 1240, Schloss Birlingenhofen, D-5205, St. Augustin 3, West Germany; tel: 02241/14-2440; Telex: 8 89 469 gmd d.

October 26-28
Developing Long-Range Systems Strategies, Sheraton Hotel, Washington, DC. This is part of the George Washington University Executive Systems Forum series. Contact the Conference Manager, U.S. Professional Development Institute, 1805 Powder Mill Dr., Silver Spring, MD 20903, (301) 445-4400.

October 27-28
Computers in Construction, Washington, DC. For details, see September 22-23.

October 28-30
Applefest, Moscone Center, San Francisco, CA. More than 300 displays and booths of Apple computer equipment and accessories will be featured. Seminars, panel discussions, conferences, and workshops will be held. Details are available from Northeast Expositions Inc., 822 Boylston St., Chestnut Hill, MA 02167, (800) 343-2222; in Massachusetts, (617) 739-2000.

October 30-November 2
DPMA Baltimore '83, Convention Center and Hyatt Regency Hotel, Baltimore, MD. The theme for this conference, sponsored by the Data Processing Management Association (DPMA), is "Information on the Firing Line." Seminars, workshops, general sessions, and product displays will be featured. For details, contact Jim Osowski, DPMA International Headquarters, 505 Busse Highway, Park Ridge, IL 60068, (312) 825-8124.

October 31-November 3
International Conference on Computer Design-VLSI in Computers, Rye Town Hill-
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Don't fall off the edge! If networking—we mean real local area networking of numerous PC's, running multiple operating systems without modification to "off the shelf" software, having concurrent file sharing, default file locking, extensive data security and more—sounds exciting to you, call us for a demonstration so you can discover your options. ShareNet/VAST will take you out of the "flat" bounded network world and into the boundless universe of networks that work.

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ton, Port Chester, NY. This conference will cover the VLSI (very-large-scale integration) aspects of the interaction between fabricators and systems designers in various aspects of the integration between fabricators and systems designers in hardware, software, and reliability in computers. Contact the IEEE Computer Society, POB 639, Silver Spring, MD 20901.

October 31 - November 4
Welcome to the World of Personal Computing, Washington, DC. This is a comprehensive introduction on how to use microcomputer technology in business, industry, and government. The workshop agenda offers six modules ranging from user productivity to software reliability. For details, contact Keston Associates, 11317 Old Club Rd., Rockville, MD 20852, (301) 881-7666.

November 1983

November 1-2
The Annual Fall Conference of the Iowa Association for Educational Data Systems, Des Moines, IA. "Quality Software for the 80s: Development, Selection, and Usage" will be the focus of more than 40 sessions presented during this conference. Three preconference workshops will be held on October 31. For details, contact Phillip J. Berrie, Educational Services Division, Heartland AEA 11, 1932 Southwest Third St., Ankeny, IA 50021.

November 1-3
Western Design Engineering Conference, Convention Center, Los Angeles, CA. Short courses on the agenda include "Principles of Robotics for Engineers," "Effective Project Management," and "Programming Personal Computers." Many of the 12 short courses will provide hands-on experience. An exhibition area will be featured. Contact the Marketing Director, Western Design Engineering Show, 708 Third Ave., New York, NY 10017, (212) 661-8410.

November 2-4

November 2-4
The First Annual Computer Vertical Market Conference, Meadowlands Hilton, East Rutherford, NJ. This conference, sponsored by Frost and Sullivan, will explore the impact of the new integrated software approaches and the importance of maintenance and support functions.

November 3-6
The 1983 National Home Electronics Show, Arlington Park Exhibition Hall, Arlington Heights, IL. This show covers electronic equipment and technology ranging from home computers to telecommunications security systems. It's produced by Lincoln Merchandising Co. Inc., 1417 Milwaukee Ave., Chicago, IL 60622, (312) 276-2819.

November 5-6
The Fourth Annual San Diego Computer Fair, Scottish Rite Center, San Diego, CA. This fair features a computer and peripheral games contest, commercial displays, and user group displays.

November 7-11

November 8-10

November 8-11
Wescon and MicroWest 83, San Francisco, CA. A conference and exposition, Wescon covers a broad range of topics, including artificial intelligence, computer peripherals and simulation, and robotics. MicroWest serves the original equipment manufacturer community by exploring peripherals, processors, data communications, and software.

November 9-10
Business-Expo, Philadelphia, PA. For details, see September 21-22.

November 9-15
Interkama 83, Düsseldorf West Germany. This exhibition is designed for the instrumentation and automation industries. It's expected to attract more than 1000 exhibi-
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The accompanying chart summarizes the speeds. (Notice that at 10 Pitch and 80 Columns, Speed is 275 Lines per Minute).

<table>
<thead>
<tr>
<th>Printing speeds (cps)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Pitch</td>
<td>500 cps</td>
</tr>
<tr>
<td>12 Pitch</td>
<td>540 cps</td>
</tr>
<tr>
<td>Enhanced</td>
<td></td>
</tr>
<tr>
<td>Proportional</td>
<td>275 cps</td>
</tr>
<tr>
<td>10 Pitch</td>
<td>250 cps</td>
</tr>
<tr>
<td>12 Pitch</td>
<td>300 cps</td>
</tr>
<tr>
<td>Condensed</td>
<td></td>
</tr>
<tr>
<td>15 Pitch</td>
<td>375 cps</td>
</tr>
<tr>
<td>16.4 Pitch</td>
<td>410 cps</td>
</tr>
<tr>
<td>Dual Pass Correspondence Quality</td>
<td></td>
</tr>
<tr>
<td>Proportional</td>
<td>110 cps</td>
</tr>
<tr>
<td>10 Pitch</td>
<td>100 cps</td>
</tr>
<tr>
<td>12 Pitch</td>
<td>120 cps</td>
</tr>
</tbody>
</table>

10 Pitch Printing Speed (lines/minute)

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| 80 Columns | 275 lpm |
| 132 Columns| 180 lpm |

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November 15-17
SNA Architecture and Implementation, Sheraton Rolling Green Inn and Conference Center, Boston, MA. For details, see October 3-5.

November 17-19
Ed-Com/Fall '83, Los Angeles, CA. This conference and exposition offers demonstrations, seminars, hands-on sessions, panels, and micro courses that address, evaluate, and analyze the development of computers in education. Hardware, software, and publishing companies will display items of interest. Contact Carol Houts, Judco Computer Expos Inc., Suite 201, 2629 North Scottsdale Rd., Scottsdale, AZ 85257, (800) 528-2355; in Arizona, (602) 990-1715.

November 17-19
The Fifth Annual Northeast Computer Show and Software Exposition, Hynes Auditorium, Boston, MA. This end user computer show offers nearly 500 displays of computers, peripherals, accessories, and software. More information is available from Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, (800) 841-7000; in Massachusetts, (617) 739-2000.

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<table>
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<tr>
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<th>PUT PRICES IN CHECK</th>
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<tr>
<td><strong>CARTRIDGE RIBBONS FOR</strong></td>
<td><strong>CARTRIDGE RIBBONS FOR</strong></td>
</tr>
<tr>
<td><strong>APPLE PRINTERS</strong></td>
<td><strong>EPSON</strong></td>
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<tr>
<td><strong>NEC 8023A</strong></td>
<td><strong>MX-80 MX-100</strong></td>
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<td><strong>C. ITOH PROWRITER</strong></td>
<td><strong>$6.99 EA.</strong></td>
</tr>
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<td><strong>$7.99 EA.</strong></td>
<td><strong>$9.95 EA.</strong></td>
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<td><strong>$86.29 DOZ.</strong></td>
<td><strong>$75.49 DOZ.</strong></td>
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<td><strong>$107.46 DOZ.</strong></td>
<td><strong>MAXELL</strong></td>
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<td><strong>DISKETTES</strong></td>
<td><strong>5¼&quot; SINGLE SIDE</strong></td>
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<tr>
<td><strong>5¼&quot; SINGLE DENSITY</strong></td>
<td><strong>DUAL DENSITY</strong></td>
</tr>
<tr>
<td><strong>MD-1</strong></td>
<td><strong>$29.90 10 PACK</strong></td>
</tr>
<tr>
<td><strong>INNOVATIVE CONCEPTS</strong></td>
<td><strong>DISKETTE STORAGE BOXES</strong></td>
</tr>
<tr>
<td><strong>FLIP‘N’FILE</strong></td>
<td><strong>5¼&quot; - BLUE OR BEIGE</strong></td>
</tr>
<tr>
<td><strong>DISC STORAGE BOX</strong></td>
<td><strong>$2.49 EA.</strong></td>
</tr>
<tr>
<td><strong>HOLDS UP TO 60 DISKETTES</strong></td>
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</tr>
<tr>
<td><strong>5¼&quot; 8&quot;</strong></td>
<td><strong>LIBRARY CASE SET</strong></td>
</tr>
<tr>
<td><strong>$24.95 EA.</strong></td>
<td><strong>CONTAINS 5 BRIGHT COLORS</strong></td>
</tr>
<tr>
<td><strong>$29.95 EA.</strong></td>
<td><strong>5¼&quot; 8&quot;</strong></td>
</tr>
<tr>
<td><strong>$24.99 10 PACK</strong></td>
<td><strong>$19.95 SET OF 5</strong></td>
</tr>
<tr>
<td><strong>DUAL SPOOL RIBBONS FOR</strong></td>
<td><strong>$23.95 SET OF 5</strong></td>
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<tr>
<td><strong>OKIDATA PRINTERS</strong></td>
<td><strong>LABEL SPECIAL</strong></td>
</tr>
<tr>
<td><strong>MEMOREX DISKETTES</strong></td>
<td><strong>$2.99 (5K MIN)</strong></td>
</tr>
<tr>
<td><strong>5¼ SINGLE-SIDE - DUAL DENSITY</strong></td>
<td><strong>(5K MIN)</strong></td>
</tr>
<tr>
<td><strong>$24.99</strong></td>
<td><strong>$39.95 EA.</strong></td>
</tr>
<tr>
<td><strong>PROTECTALL LINE VOLTAGE</strong></td>
<td><strong>WITH FREE LIBRARY CASE!</strong></td>
</tr>
<tr>
<td><strong>SURGE SUPPRESSOR</strong></td>
<td><strong>SPECIFY BLUE OR BEIGE</strong></td>
</tr>
<tr>
<td><strong>(SIX OUTLET)</strong></td>
<td><strong>MOST RIBBONS AVAILABLE IN COLORS TOO!</strong></td>
</tr>
<tr>
<td><strong>$39.95 EA.</strong></td>
<td><strong>CALL OR WRITE FOR OUR SUPPLIES CATALOGUE</strong></td>
</tr>
<tr>
<td><strong>WABASH DISKETTES</strong></td>
<td><strong>ON ORDERS UNDER $14.00 PLEASE ADD $3.00 FOR SHIPPING</strong></td>
</tr>
<tr>
<td><strong>5¼ SINGLE-SIDE SINGLE DENSITY</strong></td>
<td><strong>MINIMUM RIBBON ORDER 30 EA. OR 1 DOZEN</strong></td>
</tr>
<tr>
<td><strong>$10 FOR $19.99</strong></td>
<td><strong>WITH FREE LIBRARY CASE!</strong></td>
</tr>
<tr>
<td><strong>LABEL SPECIAL</strong></td>
<td><strong>SPECIFY BLUE OR BEIGE</strong></td>
</tr>
<tr>
<td><strong>$2.99</strong></td>
<td><strong>MOST RIBBONS AVAILABLE IN COLORS TOO!</strong></td>
</tr>
<tr>
<td><strong>$39.95 EA.</strong></td>
<td><strong>CALL OR WRITE FOR OUR SUPPLIES CATALOGUE</strong></td>
</tr>
<tr>
<td><strong>TOLL FREE 800-343-7706</strong></td>
<td><strong>ON ORDERS UNDER $14.00 PLEASE ADD $3.00 FOR SHIPPING</strong></td>
</tr>
<tr>
<td><strong>IN MASS 617-963-7694</strong></td>
<td><strong>MINIMUM RIBBON ORDER 30 EA. OR 1 DOZEN</strong></td>
</tr>
<tr>
<td><strong>PHONES OPEN 9AM-6PM EASTERN TIME</strong></td>
<td><strong>WITH FREE LIBRARY CASE!</strong></td>
</tr>
<tr>
<td><strong>548 BYTE September 1983</strong></td>
<td><strong>SPECIFY BLUE OR BEIGE</strong></td>
</tr>
</tbody>
</table>
An Operations Research Scheduling Program

A microcomputer-based scheduling algorithm can be an aid in managerial decision making

by Walter A. Stark Jr. and Richard A. Reid

In the field of operations research (OR), practitioners develop analytical procedures that can help managers improve their decision-making capabilities. Many OR techniques provide assistance in solving day-to-day operational problems, such as establishing collection routes, designing nutritional menus, scheduling aircraft and crews, locating offshore oil-drilling platforms, and determining the number of toll operators needed. Some of the more common OR models that have been recently discussed in the microcomputer trade press include linear programming, network analysis, queuing, and routing solutions (see references 1, 4, 8, and 9).

Sequencing and scheduling problems illustrate the short-term planning concerns for which OR techniques have been developed. These techniques have been used for a variety of scheduling problems, including the determination of the processing order for jobs by various machines in a facility and the resultant schedule for each machine, the sequence by which customer orders are picked in an electronics distribution center, and the establishment of a sequence by which customer audits are completed in an accounting firm.

Many of these OR methods contain recipes, or algorithms, for solving problems. Although not difficult conceptually, these algorithms often require extensive calculations that, when performed manually, are tedious and subject to error. However, these algorithms appeared to be well within the capabilities of a modest-sized microcomputer, and we were intrigued by the challenge of executing and applying some of these algorithms using an Apple computer. Various job-sequence algorithms or heuristics have been implemented on large computer systems (see reference 5). However, it seemed appropriate to consider implementing a flow-shop scheduling problem on a microcomputer for two main reasons. First, a microprocessing system at the scene of management action is more likely to be used than a terminal connected to a firm's mainframe because the practice-oriented manager feels less threatened and more in control relative to the smaller system. Second, the total investment in a microcomputer system is commensurate with the job required; extensive number-crunching, graphical displays (such as that required in PERT charting), and database management should be left to the larger centralized systems.

In this article, we will describe and illustrate an efficient method for determining a good sequence for processing a set of jobs or customers, each of which has different characteristics or makes different demands on the various organizational resources.

The Problem

At this point, a simple example will clarify terminology to be introduced later and show how proper scheduling can save time and, presumably, money. Suppose you operate a successful specialty car-painting shop whose reputation for attention to detail and superb paint jobs is spreading. The following are general operations in the normal sequence of your special paint job: removal of...
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trim parts, stripping (to the bare metal) of all paint, finishing body work, painting and buffing, and final reassembly after touch-up operations. Normally, your shop does no major body work, although occasionally such work is done for special customers. There are thus six possible operations including major body work. The elapsed time, in hours, for completion of each of these operations is the process time. What's more, zero process time is allowable; for example, most jobs require no major body work. Also, on occasion, a low-budget job comes through in which the paint is not stripped. In this case, the sanding is done during the body-finishing operation.

Now, imagine that five cars arrive for painting. Each is a job. Based on years of experience, the shop foreman estimates the times for each job, as shown in Table 1. Given these times and a desire to complete all jobs in the shortest possible time, the objective is to determine the best sequence in which to complete all the jobs.

At first glance, it is not immediately obvious that any job sequence is the most efficient. In order to manage this situation, you need to present a schedule that shows the start and finish times for each job at each work station. Such a schedule is shown in Table 2 for the sequence of jobs given in Table 1.

The cumulative elapsed time for all five jobs is 79 hours. Because we assume you don't fire workers in between operations, the total number of hours paid equals the number of workers (at all operations) multiplied by the total elapsed time. For one worker per operation, you pay for $6 \times 79 = 474$ hours total operations time. Summing the actual hours worked (16 in major body work, 11 in trim removal, 17 in stripping, 64 in finishing, 14 in painting, and 8 in reassembly) yields a total of 130 hours. Thus, the idle time of workers (and/or machines) is $474 - 130 = 344$ hours. Indeed, most of the time the workers are idle! This situation assumes that an idle worker at one operation cannot be used to reduce the time required on another operation; that is, you have a union shop. Moreover, technological specifications require that each job have the same sequence of machine operations.

Using techniques that are described later, a suitable reordering of the jobs reduces the total elapsed time by 54 hours, or $6 \times (79 - 70)$, for a new total operations time of 420 hours; idle time now becomes $420 - 130 = 290$ hours. Not only are labor costs reduced by 11 percent, but also the overall fraction of idle time is lowered. Furthermore, in searching for a better sequence, you have identified two sequences having the same low total operations time. Having two or more good job sequences allows the foreman some discretion in granting job priorities, arranging machine maintenance, or workers' vacations, and the like, while at the same time maintaining the best possible schedule.

How do you begin to approach the search for an optimum job sequence? Considerable effort has been expend-

---

**Table 1: An example of how a scheduling algorithm works, we'll use a specialty car-painting shop where five cars have to be painted. An entire paint job is made up of six processes. Here are estimates of how long each process will take for each car.**

<table>
<thead>
<tr>
<th>Job</th>
<th>Major Body Work</th>
<th>Trim Removal</th>
<th>Paint Strip</th>
<th>Body Finish</th>
<th>Paint</th>
<th>Reassembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corvette</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>12</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Daytona</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>20</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Turbo-ZX</td>
<td>16</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cobra</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>16</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

**Table 2:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Corvette</th>
<th>Daytona</th>
<th>Turbo-ZX</th>
<th>Rabbit</th>
<th>Cobra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Body Work</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Trim Removal</td>
<td>4</td>
<td>3</td>
<td>16</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Paint Strip</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Body Finish</td>
<td>12</td>
<td>20</td>
<td>10</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>Paint</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Reassembly</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Process-Time Estimates (in hours) for Specialty Paint Shop**

*Note: The cumulative elapsed time for the sequence of jobs given in Table 2 is 130 hours, the minimum possible value. All other sequences result in a higher total elapsed time.*
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ed to develop an understanding of the scheduling problem, which is at best frustrating and at worst totally intractable. Under certain conditions, however, the problem can be solved, or at least a nearly optimal solution can be obtained. It is noteworthy that these special solutions can be implemented on a microcomputer (in this case, a 48K-byte Apple II Plus).

Some Definitions
To understand the problem and the programmatic approach to the solution more clearly, a few definitions are helpful (see also reference 6):

Sequencing is the order in which objects are placed for processing by an organization. Job sequencing involves the time ordering of jobs through one or more processing centers so that specific performance measures, such as minimal idle times or timely deliveries, are achieved. Variation in job sequence can produce significant differences in costs and productivity. The sequential arrangement of start and finish times of various jobs on machines is termed a machine loading schedule. A schedule can be generated for a given machine only after the job processing sequence has been determined. In preparing the schedule, note that a machine cannot be used until it is free and that a given operation of some job cannot be started until the prior operation for that job is completed.

Jobs represent customer orders, and machines involve processes that must be performed on customer orders. In other words, a job represents a total effort, the result of which is used to satisfy a customer's need. A machine provides processing capability for the job effort and can perform one or more operations, but only one at a time. Acts performed by machines are needed to complete the job. In this sense, machines are not necessarily always mechanical devices; they can be human beings performing a strictly manual operation such as visual inspection. The order in which a job must proceed through various machines is referred to as technological ordering. And, as mentioned previously, the time spent on a machine to perform a given operation is called the process time for that operation.

In the most general case, without any job technological order specified, for $N$ jobs and $M$ machines, there are $(M!)^N$ possible sequences. (For a given job with $M$ machines, there are $M$ ways to choose the first machine operation, $M-1$ ways to choose the second, etc., so that the total number

<table>
<thead>
<tr>
<th>Schedule of Operations</th>
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<tbody>
<tr>
<td><strong>Job</strong></td>
<td><strong>Major Body Work In</strong></td>
</tr>
<tr>
<td>Corvette</td>
<td>0</td>
</tr>
<tr>
<td>Daytona</td>
<td>0</td>
</tr>
<tr>
<td>Turbo-ZX</td>
<td>0</td>
</tr>
<tr>
<td>Rabbit</td>
<td>16</td>
</tr>
<tr>
<td>Cobra</td>
<td>16</td>
</tr>
</tbody>
</table>

Table 2: A sample schedule of operations. The numbers listed show at which hours a given car enters or leaves a particular process. First, the Corvette enters the trim-removal process and the Turbo-ZX enters the major body work process. After four hours, the Corvette leaves trim removal and enters the paint strip process while the Daytona enters trim removal. The process continues until after 79 hours the last car, the Cobra, leaves the reassembly process.
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of possible sequences for machine ordering is $M(M-1)(M-2)\ldots = M!$. The combination of job sequences is an exponential function resulting in $(M!)^N$ possible job-machine sequences. The number of possible job sequences, therefore, quickly becomes very large. For example, if $M = N = 4$, the number of possibilities is about $3.3 \times 10^5$; for $M = N = 5$, the possible sequences total nearly $2.5 \times 10^{10}$. Thus, complete enumeration and evaluation of all job sequences becomes impractical for most real problems, and operations researchers seek cost-effective limits in searching for good job ordering.

Although the general problem remains intractable, operations researchers have developed efficient procedures for certain special cases, which result from adding simplifying assumptions to the general problem in order to create a more limited perspective. You can then solve the subproblem mathematically. For the special problem treated here, the crucial assumption made is that the technological ordering for all jobs considered is the same. In other words, each job goes through exactly the same ordered sequence of machine operations (remember that some operations can have zero process time). This enabling assumption results in what is known as the flow-shop scheduling problem in contrast to job-shop scheduling, in which each job might have different technological ordering (see reference 6). With the same sequence of operations for each of $N$ jobs, the number of possible orderings of jobs becomes $N!$. Now, if $N = 5$, for example, $120$ (or $5 \times 4 \times 3 \times 2 \times 1$) job sequences have to be examined to find the optimum sequence.

Method

The flow-shop scheduling problem assumes that you know or can determine processing times for each of $N$ jobs on $M$ machines (these times could represent average values). Moreover, the best job sequence is assumed to require the least total facility processing time to complete all jobs. By definition, total facility processing time is equal to total machine-operating time plus total machine-idle time. Because total machine-operating time is fixed for a given set of jobs, minimizing total facility processing time also minimizes total machine-idle time.

The approach for solving this problem was first developed by S. M. Johnson (reference 7), extensively explored by R. A. Dudek and R. M. Ghar (reference 3), and popularized by R. E. D. Woolsey and H. S. Swanson (reference 10). The procedure coded here is based on the heuristic presented by R. Hesse and R. E. D. Woolsey (reference 5).

Simply described, for $N$ jobs processed first on Machine A and then on Machine B, the Johnson algorithm requires finding the shortest processing time in the set of times for both machines. If that time is for Machine A, then that associated job is scheduled first; if for machine B, the associated job is processed last. The associated job is then removed from consideration. Next, the selection process is repeated, but this time the algorithm schedules the job having the next-shortest time either as early as possible or as late as possible according to the next-shortest time on Machine A or Machine B, respectively. This job is then removed from consideration, and the process is continued for the remaining jobs until all jobs are scheduled.

To illustrate, suppose we have five jobs with the following process times (in hours):

<table>
<thead>
<tr>
<th>Job</th>
<th>Machine A</th>
<th>Machine B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job 1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Job 2</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Job 3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Job 4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Job 5</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

The optimal sequence is Job 1-3-5-4-2. The shortest time on any machine is 1 hour (Job 2, Machine B). Hence, according to the algorithm, Job 2 is scheduled last. Job 2 is then eliminated from further consideration. The next-shortest time is 2 hours for both Jobs 1 and 4. Job 1 is scheduled...
as the first job (the 2-hour time is on Machine A); Job 4 is scheduled next to last because its 2-hour time is on Machine B. After removal of these two jobs from consideration, Jobs 3 and 5 remain to be scheduled. The next-shortest time is 3 hours (Job 3, Machine A). Thus, Job 3 is scheduled as early as possible, after Job 1. Job 5 remains to be scheduled between Job 3 and Job 4.

This algorithm forms the heart of the machine-scheduling program presented in listing 1. A formal proof of the algorithm can be found in S. M. Johnson's original paper (see reference 7). However, intuitively, you can see that the last job (N) cannot be finished earlier than the time required to process each job on Machine A, plus the time necessary to complete the second operation of the last job. Similarly, the last job cannot be completed sooner than the time to process each job on Machine B, plus any time delay before Machine B can begin processing. Moreover, the minimum delay is just the time required to process the first job (1) on Machine A. The minimum total time, $T_{\text{min}}$, is thus bounded by the larger of the following two inequalities:

$$T_{\text{min}} \geq \sum_{j \text{ jobs}} t_{1j} + t_{2N}$$

or

$$T_{\text{min}} \geq t_{11} + \sum_{j \text{ jobs}} t_{2j}$$

where $t_{1j}$ and $t_{2j}$ are the process times on Machine A and Machine B, respectively, for job j; $t_{2N}$ thus represents the operation time on Machine B for the last job N, and $t_{11}$ represents the operation time on Machine A for the first job.

The sums are fixed values, independent of job sequence; therefore, the only way to influence the overall time is by choosing $t_{1j}$ or $t_{2N}$ to be as small as possible. Thus, the job with the smallest $t_{1j}$ is scheduled first, and the job with the smallest $t_{2j}$ is scheduled last. The remaining jobs are scheduled by extending the application of this logic.

The rationale underlying this procedure is to place jobs having short

Listing 1: An Applesoft BASIC program using a scheduling algorithm. The program can be used for an operation using any number M of processes or machines.

1000 REM MACHINE SCHEDULE
1010 REM COPYRIGHT 1981, W. A. STARK
1020 REM
1030 REM M-MACHINE SCHEDULING
1040 REM USING QUICK & CLEAN JOHNSON
1050 REM ALGORITHM
1060 REM
1070 DIM K(20,20), M(20)
1080 DIM A(20), B(20), C(20)
1090 DIM S(20,20), SE(20,20), MT(20)
1100 DIM T1(20,20), T2(20,20)
1110 DIM S(20,20), T2(20,20), T1(20,20)
1120 DIM K(20)
1130 REM
1140 GOTO 1730
1150 REM
1160 REM SUBROUTINE PAUSE
1170 REM
1180 PRINT "PRESS SPACE BAR TO CONTINUE"
1190 CV = PEEK(37)
1200 GET CV
1210 VTAB(CV)
1220 PRINT SP(38);**
1230 RETURN
1240 REM SUBROUTINE ENABLE PRINTER
1250 REM SUBROUTINE TO ENABLE PRINTER
1260 REM DISABLES THE AID BOARD SLOT 2
1270 REM
1280 REM SUBROUTINE TO END PRINTING
1290 REM
1300 CALL (768)
1310 PRINT CHR$(17)
1320 REM
1330 REM DEFEAT 40 COLUMN WINDOW
1340 POKE 33, 33
1350 RETURN
1360 REM SUBROUTINE TO END PRINTING
1370 REM
1380 REM ENABLE PRINTER
1390 REM RESTORE 40 COLUMN WINDOW
1400 POKE 33, 33
1410 RETURN
1420 REM SUBROUTINE SCHEDULE
1430 REM CATALOGS IN / OUT
1440 REM SCHEDULES FOR MACHINES
1450 REM
1460 REM T1(1,1) = 0.0
1470 T1(1,1) = 0.0
1480 FOR M = 1 TO NM
1490 T2(J,M) = T2(J-1,M) + M(C(J),M)
1500 IF M = NM GOTO 1550
1510 T1(J,M) = T2(J-1,M)
1520 T1(J,M) = T2(J-1,M)
1530 NEXT M
1540 NEXT J
1550 T1(J-1,M) = T2(J-1,M)
1560 FOR J = 2 TO NJ
1570 NEXT J
1580 T1(J-1,M) = T2(J-1,M)
1590 T1(J-1,M) = T2(J-1,M)
1600 NEXT J
1610 REM
1620 REM SCHEDULES FOR MACHINES
1630 FOR M = 2 TO NM
1640 T1(J,M) = T2(J,M)
1650 IF T2(J,M) > T2(J,M - 1) THEN T1(J,M) = T2(J,M - 1)
1660 T2(J,M) = T1(J,M) + M(C(J),M)
1670 NEXT M
1680 NEXT J
1690 RETURN
1700 REM
1710 REM ******** MAIN ********
1720 REM
1730 HOME: PRINT "PRINT"
1740 REM

Listing 1 continued on page 558
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processing times on the first machine early in the sequence so that the second machine can be put to use as soon as possible. At the end of the sequence, the situation is reversed. In particular, those jobs with short processing times on later machines are placed at the end of the sequence so that all machines finish all job processing at approximately the same time.

The Johnson algorithm provides an optimum schedule for the two-machine problem and for special three-machine situations. Extending the algorithm to M-machine situations produces a good, but not necessarily optimal, solution. However, experience shows that of the N! possible job sequences, some of the M - 1 sequences uncovered using the extended algorithm are optimal or near optimal.

You extend the algorithm to M machines by first applying the Johnson two-machine algorithm to the first (1) and last (M) machine operations in order to obtain a feasible job sequence. Next, by using the sum of the job processing times for the first two (1 + 2) and the last two \((M - 1) + M\) machine operations, you can determine another sequence. The process is continued \(M - 1\) times, applying the Johnson algorithm successively to the sum of the first \(j\) processing times and to the sum of the last \(j\) processing times, where \(j\) runs from 1 to \(M - 1\).

This procedure yields \(M - 1\) job-order sequences. The sequence having the least total facility processing time may be selected as best. An advantage of the Johnson algorithm over other flow-shop techniques, such as the Gupta algorithm (see reference 5), is that several sequences are determined for consideration. Having these alternative sequences allows the scheduling manager some viable options if such factors as priority jobs, machine maintenance, or workers’ vacations need to be considered.

The Program
Listing 1 shows the implementation of the Johnson scheduling algorithm on an Apple II Plus 48K-

<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1750</td>
<td>PRINT TAB(10);&quot;MACHINE SCHEDULE&quot;</td>
</tr>
<tr>
<td>1760</td>
<td>PRINT TAB(7);&quot;COPYRIGHT 1981, M A STARK&quot;</td>
</tr>
<tr>
<td>1770</td>
<td>FOR T = 1 TO 2000</td>
</tr>
<tr>
<td>1780</td>
<td>NEXT T</td>
</tr>
<tr>
<td>1790</td>
<td>PASS = 0</td>
</tr>
<tr>
<td>1800</td>
<td>HOME ; PRINT ; PRINT</td>
</tr>
<tr>
<td>1810</td>
<td>REM</td>
</tr>
<tr>
<td>1820</td>
<td>REM ; DESCRIPTION</td>
</tr>
<tr>
<td>1830</td>
<td>PRINT &quot;M-MACHINE SCHEDULING&quot;</td>
</tr>
<tr>
<td>1840</td>
<td>PRINT &quot;USING THE JOHNSON QUICK &amp;&quot;</td>
</tr>
<tr>
<td>1850</td>
<td>PRINT &quot;CLEAN ALGORITHM.&quot; ; PRINT</td>
</tr>
<tr>
<td>1860</td>
<td>PRINT &quot;PROGRAM CAN BE USED FOR&quot;</td>
</tr>
<tr>
<td>1870</td>
<td>PRINT &quot;UP TO 15 JOBS AND 20&quot;</td>
</tr>
<tr>
<td>1880</td>
<td>PRINT &quot;MACHINE OPERATIONS.&quot; ; PRINT</td>
</tr>
<tr>
<td>1890</td>
<td>PRINT ; FLASH ; PRINT &quot;NOTE!&quot; ; NORMAL</td>
</tr>
<tr>
<td>1900</td>
<td>PRINT &quot;------------------------------------------------------------------------------------------------&quot;</td>
</tr>
<tr>
<td>1910</td>
<td>PRINT &quot;COMPLETE ALL DATA ENTRIES&quot;</td>
</tr>
<tr>
<td>1920</td>
<td>PRINT &quot;BY HAVING THE RETURN KEY&quot;</td>
</tr>
<tr>
<td>1930</td>
<td>PRINT &quot;------------------------------------------------------------------------------------------------&quot;</td>
</tr>
<tr>
<td>1940</td>
<td>GOSUB 1960; REM ; PRINT CHOICE</td>
</tr>
<tr>
<td>1950</td>
<td>BOTO 2070</td>
</tr>
<tr>
<td>1960</td>
<td>PRINT ; PRINT</td>
</tr>
<tr>
<td>1970</td>
<td>PRINT &quot;FOR HARD COPY OUTPUT, TYPE P:;&quot;</td>
</tr>
<tr>
<td>1980</td>
<td>PRINT &quot;(BE SURE PRINTER IS READY)&quot;</td>
</tr>
<tr>
<td>1990</td>
<td>PRINT &quot;OTHERWISE, TYPE AN N&quot;</td>
</tr>
<tr>
<td>2000</td>
<td>INPUT TT6</td>
</tr>
<tr>
<td>2010</td>
<td>IF TT6 = &quot;N&quot; THEN TT6 = 0; RETURN</td>
</tr>
<tr>
<td>2020</td>
<td>IF TT6 = &quot;P&quot; THEN TT6 = 1; BOTO 2050</td>
</tr>
<tr>
<td>2030</td>
<td>PRINT ; PRINT &quot;TYPE P OR N, PLEASE&quot;</td>
</tr>
<tr>
<td>2040</td>
<td>PRINT ; BOTO 2060</td>
</tr>
<tr>
<td>2050</td>
<td>GOSUB 7160; REM ; PRINTER DRIVER</td>
</tr>
<tr>
<td>2060</td>
<td>RETURN</td>
</tr>
<tr>
<td>2070</td>
<td>HOME ; VTAB 5</td>
</tr>
<tr>
<td>2080</td>
<td>DISPLAY = 0</td>
</tr>
<tr>
<td>2090</td>
<td>INPUT &quot;TYPE NUMBER OF JOBS *;IIJ</td>
</tr>
<tr>
<td>2100</td>
<td>VTAB 10</td>
</tr>
<tr>
<td>2110</td>
<td>INPUT &quot;TYPE NUMBER OF MACHINES * ;NN</td>
</tr>
<tr>
<td>2120</td>
<td>REM</td>
</tr>
<tr>
<td>2130</td>
<td>REM ; INPUT JOB DESCRIPTIONS AND</td>
</tr>
<tr>
<td>2140</td>
<td>REM ; MACHINE OPERATIONS</td>
</tr>
<tr>
<td>2150</td>
<td>HOME</td>
</tr>
<tr>
<td>2160</td>
<td>PRINT &quot;BEGIN BY DESCRIBING MACHINE&quot;</td>
</tr>
<tr>
<td>2170</td>
<td>PRINT &quot;OPERATIONS. THESE OPERATIONS ARE&quot;</td>
</tr>
<tr>
<td>2180</td>
<td>PRINT &quot;ASSUMED TO BE SEQUENTIAL.&quot;</td>
</tr>
<tr>
<td>2190</td>
<td>PRINT</td>
</tr>
<tr>
<td>2200</td>
<td>FOR H = 1 TO NN</td>
</tr>
<tr>
<td>2210</td>
<td>PRINT</td>
</tr>
<tr>
<td>2220</td>
<td>PRINT &quot;TYPE A DESCRIPTION OF OPERATION I * ;M</td>
</tr>
<tr>
<td>2230</td>
<td>PRINT &quot;(USE UP TO 7 CHARACTERS)&quot;</td>
</tr>
<tr>
<td>2240</td>
<td>INPUT M(H)</td>
</tr>
<tr>
<td>2250</td>
<td>IF LEN(M(H)) &lt; 7 THEN CY CY - 1</td>
</tr>
<tr>
<td>2260</td>
<td>PRINT</td>
</tr>
<tr>
<td>2270</td>
<td>PRINT &quot;USE ONLY 7 CHARACTERS, PLEASE&quot;</td>
</tr>
<tr>
<td>2280</td>
<td>PRINT</td>
</tr>
<tr>
<td>2290</td>
<td>PRINT</td>
</tr>
<tr>
<td>2300</td>
<td>NEXT J</td>
</tr>
<tr>
<td>2310</td>
<td>HOME</td>
</tr>
<tr>
<td>2320</td>
<td>PRINT &quot;NOW BRIEFLY (6 CHARACTERS OR LESS)&quot;</td>
</tr>
<tr>
<td>2330</td>
<td>PRINT &quot;DESCRIBE EACH JOB, AND THE TIME&quot;</td>
</tr>
<tr>
<td>2340</td>
<td>PRINT</td>
</tr>
<tr>
<td>2350</td>
<td>PRINT</td>
</tr>
<tr>
<td>2360</td>
<td>FOR I = 1 TO NJ</td>
</tr>
<tr>
<td>2370</td>
<td>PRINT</td>
</tr>
<tr>
<td>2380</td>
<td>J0(J(J)) = LEFTS(J0(J), 6)</td>
</tr>
<tr>
<td>2390</td>
<td>PRINT</td>
</tr>
<tr>
<td>2400</td>
<td>PRINT &quot;FOR THIS JOB, ENTER THE TIME&quot;</td>
</tr>
<tr>
<td>2410</td>
<td>PRINT &quot;(TO THE NEAREST TENTH UNIT)&quot;</td>
</tr>
<tr>
<td>2420</td>
<td>PRINT &quot;RE:0 D FOR EACH OF THE&quot;</td>
</tr>
<tr>
<td>2430</td>
<td>PRINT &quot;OPERATIONS LISTED BELOW.&quot;</td>
</tr>
<tr>
<td>2440</td>
<td>PRINT</td>
</tr>
<tr>
<td>2450</td>
<td>PRINT</td>
</tr>
<tr>
<td>2460</td>
<td>PRINT &quot;(USE THE SAME TIME UNITS)&quot;</td>
</tr>
<tr>
<td>2470</td>
<td>PRINT</td>
</tr>
<tr>
<td>2480</td>
<td>PRINT</td>
</tr>
<tr>
<td>2490</td>
<td>FOR N = 1 TO NM</td>
</tr>
<tr>
<td>2500</td>
<td>CV = PEEK(37) + 1</td>
</tr>
<tr>
<td>2510</td>
<td>IF CV &gt; 23 THEN CV = CV - 1</td>
</tr>
</tbody>
</table>
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Listing 1 continued:

3290 PRINT TAB(6);‘SPC(6);‘V1(1);‘V6(1);‘V1(1);‘V6(1);‘V1(1);‘V6(1)
3300 NEXT J
3310 IF TTY = 1 THEN GOSUB 1370: REM - PRINT INHIBIT
3320 PRINT: PRINT: GOSUB 1140: REM - PAUSE
3330 HOME: PRINT TAB(17):‘INITIAL‘KK = 0
3340 GOSUB 5850: REM - PRINT SCHEDULE
3350 HOME: PRINT: PRINT
3360 BT = NN:‘T2(NJ,NH)
3370 DISPLAY = 0
3380 FLA& = 1
3390 GOSUB 8510: REM - IDLE TIME CALC
3400 GOSUB 1140: REM - PAUSE
3410 IF NK = 2 GOTO 3580
3420 HOME: PRINT: PRINT
3430 IF NK = 2 GOTO 3580
3440 PRINT "TO VIEW ALL LOADING SCHEDULES AS"
3450 PRINT "SEQUENCES ARE DETERMINED,
3460 PRINT "TYPE AN A"
3470 PRINT "TO VIEW ONLY THE BEST SCHEDULE(S)",
3480 PRINT "TYPE A B."
3490 PRINT "(ONE MAY RETURN LATER TO REVIEW •
3500 PRINT "ALL SCHEDULES)"
3510 PRINT: PRINT "A OR B"
3520 INPUT D$1
3530 IF D$1 = "A" THEN DISPLAY = 1: GOTO 3580
3540 IF D$1 = "B" GOTO 3580
3550 PRINT: PRINT "TYPE A OR B, PLEASE!"
3560 INPUT N$1
3570 GOTO 3500
3580 FOR KK = 1 TO NK - 1
3590 RPT = 0
3600 GOSUB 2070: REM - SET UP FOR 2-MACHINE
3610 GOSUB 2420: REM - 2 MACHINE ORDERING
3620 IF RPT = 1 THEN GOSUB 4910: REM - FILTER
3630 GOSUB 1450: REM - CALCULATE SCHEDULE
3640 IF FLA& = 0 GOTO 3720
3650 IF NK = 2 GOTO 3700
3660 IF TTY = 0 GOTO 3700
3670 GOSUB 1250: REM -PRINT ENABLE
3680 GOSUB 5130: REM -PRINT SCHEDULE
3690 GOSUB 1370: REM -PRINT INHIBIT
3700 GOSUB 4670: REM -PRINT OPTIMAL ORDER
3710 GOSUB 5560: REM - PRINT SCHEDULE
3720 GOSUB 4500: REM - IDLE TIME CALC
3730 IF FLA& = 0 GOTO 3760
3740 GOSUB 1160: REM - PAUSE ROUTINE
3750 IF RPT = 1 GOTO 3960
3760 MEIT KK
3770 IF NK = 2 GOTO 3700
3780 GOSUB 4940: REM - FIND SMALL IDLE TIME
3790 IF TTY = 0 GOTO 3960
3800 GOSUB 1250: REM -PRINT ENABLE
3810 GOSUB 5130: REM -PRINT SCHEDULE
3820 PRINT
3830 GOSUB 1370: REM -PRINT INHIBIT
3840 FOR LL = 0 TO L
3850 KK = KK LL
3860 DISPLAY = 0
3870 IF TTY = 1 THEN GOSUB 1250
3880 IF TTY = 1 THEN GOTO 33;40: HOME : POKE 33,33
3890 HOME: PRINT: PRINT
3900 PRINT "A GOOD JOB SEQUENCE IS:"
3910 PRINT
3920 PRINT "ORDER JOB NAME FINISH TIME"
3930 PRINT
3940 IF NK = 2 THEN RETURN
3950 RPT = 1: GOTO 3600
3960 MEIT LL
3970 GOSUB 1250: REM - REPEAT?
3980 DM FLA& GOTO 4010,4030
3990 PRINT: PRINT "GOODBYE!!!": PRINT
4000 GOTO 4050
4010 FLA& = 0: HOME
4020 GOSUB 1960: GOTO 2680
4030 FLA& = 0: HOME
4040 GOTO 4040
4050 END

Listing 1 continued on page 564
## LSI 11/23 PLUS COMPUTERS WITH UP TO 4 MEGABYTES RAM MEMORY

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl-103</td>
<td>DESKTOP COMPUTER — Complete computer system enclosed within a VT103 video terminal with LSI 11/2 and 64KB Memory</td>
<td>$3100.00</td>
</tr>
<tr>
<td></td>
<td>With LSI 11/23 and 256KB Memory</td>
<td>$4100.00</td>
</tr>
<tr>
<td></td>
<td>With LSI 11/23 PLUS and 1 Megabyte Memory</td>
<td>$5395.00</td>
</tr>
<tr>
<td>Cl-11/23 AC</td>
<td>LSI 11/23 CPU with MMU, 256KB byte RAM Memory, Power supply, 8x4 backplane, in a rack mountable chassis</td>
<td>$2675.00</td>
</tr>
<tr>
<td></td>
<td>Same with LSI 11/23 PLUS and 1 Megabyte Memory</td>
<td>$4395.00</td>
</tr>
<tr>
<td>Cl-11/03 LK</td>
<td>LSI 11/2 CPU with 64K byte RAM Memory, Power supply, 8x4 backplane in a rack mountable chassis (KEV11)</td>
<td>$1845.00</td>
</tr>
<tr>
<td>Cl-520</td>
<td>10 Megabyte Winchester with 2 Megabyte 5½” floppy RX02/RL02 or RX50/WD50 emulation</td>
<td>$3995.00</td>
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</table>

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Listing 1 continued:

4060 REM ****************************
4070 REM SUBROUTINE COMBINE
4090 REM COMBINES DATA FOR INPUT
4100 REM TO JOHNSON TW0-MACHINE
4110 REM QUICK AND CLEAN ALGORITHM
4120 REM
4130 FOR J = 1 TO NJ
4140 A(J) = 0  B(J) = 0
4150 NEXT J
4160 FOR M = 1 TO KK
4170 FOR J = 1 TO NJ
4180 A(J) = A(J) + \( M(J, W) \)
4190 B(J) = B(J) + \( W(J, M) - M + 1 \)
4200 NEXT J
4210 NEXT M
4220 RETURN
4230 REM ****************************
4240 REM SUBROUTINE FOR JOHNSON
4250 REM TWO MACHINE QUICK & CLEAN
4260 REM
4270 NF = 0 NL = NJ J = 0
4280 Go SUB 4550 ; REM -FIND MAX ELEMENT
4290 FOR J = 1 TO NJ
4300 C(J) = NJ + 1
4310 NEXT J
4320 IF J = 1 THEN FL = 1
4330 NEXT J
4340 RETURN
4350 REM : ELIMINATE DONE JOBS
4360 FOR J = 1 TO NJ
4370 IF A(J) = 0 THEN FL = 1
4380 NEXT J
4390 IF J = 1 THEN FL = 1
4400 IF A(J) = 0 THEN FL = 1
4410 IF B(J) = 0 THEN FL = 1
4420 NEXT J
4430 IF J = 1 THEN FL = 1
4440 IF J = 1 THEN FL = 1
4450 IF J = 1 THEN FL = 1
4460 IF J = 1 THEN FL = 1
4470 IF J = 1 THEN FL = 1
4480 IF J = 1 THEN FL = 1
4490 IF J = 1 THEN FL = 1
4500 IF J = 1 THEN FL = 1
4510 IF J = 1 THEN FL = 1
4520 IF J = 1 THEN FL = 1
4530 RETURN
4540 REM ****************************
4550 REM SUBROUTINE MAXIMUM
4560 REM
4570 REM DETERMINES MAXIMUM ELEMENT
4580 REM OF TWO ARRAYS A,B
4590 REM
4600 LA = A(1)
4610 FOR J = 1 TO NJ
4620 IF A(J) > LA THEN LA = A(J)
4630 IF B(J) > LA THEN LA = B(J)
4640 NEXT J
4650 RETURN
4660 REM ****************************
4670 REM SUBROUTINE OUTPUT ORDER
4680 REM
4690 REM PRINTS JOB SEQUENCE
4700 REM
4710 IF TTY = 1 THEN GOSUB 1250
4720 IF RPT = 1 GOTO 4800
4730 HOMF : PRINT : PRINT
4740 IF NH > 2 GOTO 4870
4750 PRINT "AN OPTIMAL SEQUENCE IS: *" ; GOTO 4770
4760 PRINT "A POSSIBLE SEQUENCE IS:" ; GOTO 4770
4770 PRINT
4780 PRINT "ORDER JOB NAME FINISH TIME*"
4790 PRINT
4800 FOR J = 1 TO NJ
4810 GAP = J
4820 IF J > 9 THEN GAP = 2
Listing 1 continued on page 566

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Listing 1 continued:

4030 L1 = LEN (J(J(J(J)))
4040 L2 = 18 - L1 - LEN ( STR ( INT (T2(J,J,J)))
4050 PRINT TAB(6);P;SPC(6);J(J(J(J));SPC(L2);T2(J,J,J))
4060 NEXT J
4070 IF TTY = 1 THEN GOSUB 1370: REM END PRINT
4080 PRINT: GO SUB 1160: REM - PAUSE
4090 RETURN
4100 REM
4110 REM "CHECKS FOR DUPLICATE"
4120 REM "POSSIBLE SEQUENCES"
4130 REM
4140 REM
4150 REM "FLAG = 1"
4160 REM
4170 IF NM = 2 THEN RETURN
4180 IF KK < 2 THEN RETURN
4190 IF K = 1 TO KK - 1
4200 IF NFLA6 = 0 GOTO 5070
4210 IF NM = 0 THEN FLAG = 0
4220 FOR J = 1 TO K
4230 IF NFL = 0 THEN IF SEQUENCE DIFFERS FROM PREVIOUS SEQUENCES
4240 REM "POSSIBLY CORRECT"
4250 REM "PROVIDES FOR CORRECTIONS"
4260 REM "TO INPUT DATA"
4270 REM
4280 REM
4290 REM
4300 REM
4310 REM "ENTER JOB ": INPUT J
4320 REM "NOW ENTER NEW JOB DESCRIPTION AND TIMES FOR ALL MACHINE OPERATIONS."
4330 REM "SEPARATE NAME AND TIMES WITH SLASHES"
4340 REM "("/
4350 REM "DO YOU WISH TO SCHEDULE" 5350 REM "DATA?"
4360 REM "V OR N?"
4370 REM "PLEASE"
4380 REM "DO YOU WISH TO MODIFY EXISTING DATA?"

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Listing 1 continued:

6360 PRINT TAB(4)"(I)C(J)
6370 FOR N = NB TO NF
6380 VTAB(C(N)+1)
6390 CH = 5 + 2 * (N - NS) $ SP
6400 VTAB CH
6410 PRINT SPCC(S1(N)); INT(T1(J,N)+.5); SPCC(S2(N)); INT(T2(J,N)+.5)
6420 NEXT J
6430 CV = CV + K2; VTAB CV
6440 NEXT J
6450 GOSUB 1160; REM - PAUSE ROUTINE
6460 IF NF = NH AND GOTO 6490
6470 NS = NF + 1
6480 BDTO 5950
6490 RETURN
6500 REM ******************************************************
6510 REM SUBROUTINE IDLE TIME
6520 REM
6530 REM Calculates cumulative
6540 REM total of time machines
6550 REM are idle.
6560 REM
6570 L = 10.10 = 0.5
6580 OT = NM * T2(M,N,M)
6590 IF OT > BT THEN BT = OT
6600 TL = LEN ( STRA ( INT (DT(I))))
6610 IT(KK) = INT ((DT(I) - MT(MM + 1)) $ P + Q) / P
6620 IF FLAG = 0 THEN RETURN
6630 HOME
6640 IF TTY = 1 THEN GOSUB 1250; REM -PRINT ENABLE
6650 PRINT
6660 PRINT "Tab(3)"; "Performance characteristics for*
6670 IF KK < > 0 GOTO 6700
6680 PRINT "Tab(101)"; "Initial sequence*
6690 GOTO 6740
6700 IF NM < > 2 GOTO 6730
6710 PRINT "Tab(101)"; "Optimal sequence*
6720 GOTO 6740
6730 PRINT "Tab(12)"; "This sequence*
6740 GOSUB 5130; REM - DASHLINE
6750 PRINT ";"
6760 PRINT "Total facility processing time *
6770 PRINT ";"; INT (T(N,M)) + SPCC (1) "unit";
6780 SI = TL - LEN ( STRA ( INT (MT(MM + 1))))
6790 PRINT
6800 PRINT "Total machine processing time *
6810 PRINT ";"; SPCC (S1); MT(MM + 1); SPCC (1) "unit"
6820 PRINT
6830 SI = TL - LEN ( STRA ( INT (IT(KK))))
6840 PRINT "Idle machine time *
6850 PRINT ";"; SPCC (S1); IT(KK); SPCC (1) "unit"
6860 PRINT
6870 IF TTY = 1 THEN GOSUB 1370; REM - PRINT INHIBIT
6880 RETURN
6890 REM ******************************************************
6900 REM SUBROUTINE SHORTEST SEQUENCE
6910 REM
6920 REM Selects shortest sequences
6930 REM of those sequences
6940 REM Suggested by Johnson
6950 REM Algorithm.
6960 REM
6970 IF N = 0 TO MM - 1
6980 IF IT(N) < BT THEN BT = IT(N)
6990 NEXT N
7000 IS = -1
7010 KK = 0
7020 IF IT(KK) = BT THEN IS = KK
7030 IF KK > = (NM - 1) GOTO 7050
7040 KK = KK + 1; GOTO 7020
7050 KL(O) = IS
7060 L = 1
7070 FOR N = 0 TO IS - 1
7080 IF IT(N) < BT GOTO 7110
7090 KL(L) = L
7100 L = L + 1
7110 NEXT N
7120 LM = L - 1

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Circle 263 on inquiry card.

Circle 230 on inquiry card.

Circle 323 on inquiry card.

Listing 1 continued on page 572
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Listing 1 continued:

7130 RETURN
7140 REM *************
7150 REM PARALLEL DRIVER ROUTINE
7160 REM *************
7170 REM FOR USE WITH EPSON PRINTER,
7180 REM AND S60/410 BOARD INSTALLED
7190 REM IN APPLE SLOT #2.
7200 REM
7210 REM TO INITIALIZE THE DRIVER,
7220 REM RUN THIS SUBROUTINE:
7230 REM CALL(769)
7240 REM
7250 REM TO ENABLE THE PRINTER:
7260 REM PRINT CHR$(177)
7270 REM POKE 33, 33
7280 REM
7290 REM THE POKE COMMAND ALLOWS
7300 REM LENGTHS GREATER THAN 40.
7310 REM IS NOT REQUIRED FOR SHORTER
7320 REM LINES.
7330 REM
7340 REM TO DISABALE THE PRINTER:
7350 REM PRINT CHR$(191)
7360 REM POKE 33, 40
7370 REM
7380 REM THE POKE RETURNS THE APPLE
7390 REM TO A FULL SCREEN.
7400 REM
7410 REM TO EXIT THE PRINTER DRIVER:
7420 REM P800
7430 REM
7440 RESTORE
7450 FOR N = 0 TO 89
7460 NP = 768 + N
7470 READ P
7480 POKE NP,P
7490 NEXT N
7500 DATA 169,255,141,162,192,169
7510 DATA 128,141,160,192,169,60
7520 DATA 141,161,192,141,163,192
7530 DATA 169,27,133,54,169,3
7540 DATA 133,55,76,141,88,3
7550 DATA 32,240,253,173,88,3
7560 DATA 201,141,206,12,173,87
7570 DATA 3,141,89,9,169,13
7580 DATA 32,61,3,96,32,61
7590 DATA 3,208,89,3,240,236
7600 DATA 96,73,0,141,162,192
7610 DATA 141,60,141,161,192,73
7620 DATA 8,141,163,192,173,163
7630 DATA 192,41,128,240,249,173
7640 DATA 162,192,76,132,141,8
7650 REM
7660 REM DRIVER IS SET UP FOR A
7670 REM 132 CHARACTER LINE.
7680 REM FOR A DIFFERENT LENGTH LINE
7690 REM POKE 955, NL WHERE NL IS
7700 REM IS THE DESIRED LINE LENGTH.
7710 RETURN
7720 REM *************
7730 REM SUBROUTINE DISPLAY
7740 REM
7750 HOME; PRINT: PRINT
7760 PRINT TAB(3);"BECAUSE THERE ARE MORE THAN"
7770 PRINT TAB(3);"FOUR MACHINES, SEVERAL SCREENS"
7780 PRINT TAB(3);"OP INFORMATION WILL BE PRESENTED"
7790 PRINT TAB(3);"FOR EACH OF THE VARIOUS DISPLAYS."
7800 PRINT TAB(3);"PLEASE FOLLOW THE DIRECTIONS"
7810 PRINT TAB(3);"AT THE BOTTOM OF EACH DISPLAY"
7820 PRINT TAB(3);"TO GET SUBSEQUENT SCREENS"
7830 IF PASS = 1 THEN 7870
7840 PASS = 1
7850 GOSUB 1160: REM - PAUSE
7860 RETURN
7870 FOR T = 1 TO 2500
7880 NEXT T
7890 RETURN
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<tr>
<th>TRANSMISSION TIMES**</th>
<th>Std. Tel Rate (7am-1pm)</th>
<th>Cost</th>
<th>Dis. Tel Rate (1pm-6pm)</th>
<th>Econ Tel Rate (6pm-7am)</th>
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<tr>
<td>1 MINUTE</td>
<td>$2.37</td>
<td>$1.78</td>
<td>$1.42</td>
<td></td>
</tr>
<tr>
<td>3 MINUTES</td>
<td>$5.03</td>
<td>$3.78</td>
<td>$3.02</td>
<td></td>
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<tr>
<td>6 MINUTES</td>
<td>$9.02</td>
<td>$6.78</td>
<td>$5.42</td>
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</tr>
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Text continued from page 558:
byte system (cassette). It is worthwhile to make a few comments regarding program flow, limitations, and operations.

We set up the conversational, interactive program for as many as 15 jobs with as many as 20 machine operations. In principle, more machine operations could be used, and, indeed, more jobs could be added if the DIM statements were changed. However, due to the Apple's vertical display limitation, the various schedules would be confusing in these instances.

We marked the program subroutines with asterisks in listing 1 and included a brief description of subroutine operation at the beginning of each subroutine listing. Also, within the listing, each call to a subroutine indicates, by a following REM statement, what the called subroutine does.

Basically, the program flow consists of data input (beginning at line 2090) with a following sequence for correcting errors (line 5120). Performance characteristics including total facility processing time, total actual machine time, and idle time are calculated for the initial job order before the program begins the search for better sequences.

The subroutine at line 4180 is the Johnson Two-Machine Quick and Clean Algorithm. (A “clean” algorithm is guaranteed to generate an optimal solution; see reference 10.) The algorithm as coded has a slight bias: In case of a tie between jobs for the smallest operations time, the job later in the initial order is the one assigned first. Similarly, if a job that is ready for assignment has equal times on Machine A and Machine B, it is scheduled as early as possible. According to strict application of the Johnson algorithm, equal times may be decided arbitrarily because the resulting total facility processing time will remain the same. Should you care to modify the selection criteria, you must manipulate lines 4340 through 4350. Alternatively, if you change the input data by a fractional amount, the program might produce a different schedule that presents an option to the programmed tie-
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<th>VA 212 PA</th>
<th>HAYES 1200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front-panel operation</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Dial-tone and call-progress detection</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Permanent telephone-number storage</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Automatic redial and linking</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Security feature</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Synchronous operation</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Built-in telephone jack</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Complete diagnostic test features</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>

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And there are only two machines, the program exercises the Johnson algorithm, determines the optimum sequence, prepares the machine loading schedule, and calculates the performance characteristics of the optimum sequence. If there are more than two machines, the program searches through the M - 1 two-machine problems according to the procedures outlined in the Method section (page 555).

When the search is completed, you are presented the best (i.e., having the shortest total facility processing time) sequence (or sequences) for consideration. Again, performance characteristics are computed, and the machine loading schedule (to the nearest whole time unit) is available for examination and rumination. At this point, the manager can either work on a new series of jobs or return to modify the data of the original set of jobs. The latter permits the manager to test the sensitivity of the recommended job sequence to small changes in expected process times for various jobs. An examination of alternative job sequences with similar performance characteristics provides an opportunity for the manager to explicitly consider other factors, such as priority jobs or machine maintenance requirements.

Note that the program has an optional print capability. In particular, it is set up to allow printed output using an Epson printer and an SSM AIO board. Obviously, modifications to the printer driver at lines 7060 through 7620 are necessary for other printers and interfaces.

Partial output for the paint shop example is shown in listing 2. Two job sequences (Rabbit, Cobra, Corvette, Daytona, then Turbo-ZX; Rabbit, Cobra, Daytona, Corvette, then Turbo-ZX) have the minimum idle time (290 hours) of those sequences that were examined. Both represent equally good job process sequences, and the corresponding loading schedules are determined by the program. Although the machine loading schedules are presented only as video output, the output for the two good sequences is shown in tables 3...
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Listing 2: A partial listing of the output from the program in listing 1 using the paint shop example. The initial sequence and four possible sequences are shown. The two sequences with the least amount of idle machine time (290 hours) are then listed as good job sequences.

**INITIAL SEQUENCE**

<table>
<thead>
<tr>
<th>ORDER</th>
<th>JOB NAME</th>
<th>FINISH TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CORVET</td>
<td>26</td>
</tr>
<tr>
<td>2</td>
<td>DAYTON</td>
<td>48</td>
</tr>
<tr>
<td>3</td>
<td>TURBOZ</td>
<td>57</td>
</tr>
<tr>
<td>4</td>
<td>RABBIT</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>COBRA</td>
<td>79</td>
</tr>
</tbody>
</table>

**PERFORMANCE CHARACTERISTICS FOR INITIAL SEQUENCE**

- **TOTAL FACILITY PROCESSING TIME = 474 HOURS**
- **TOTAL MACHINE PROCESSING TIME = 130 HOURS**
- **IDLE MACHINE TIME = 344 HOURS**

**A POSSIBLE SEQUENCE IS:**

<table>
<thead>
<tr>
<th>ORDER</th>
<th>JOB NAME</th>
<th>FINISH TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>COBRA</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>RABBIT</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>DAYTON</td>
<td>54</td>
</tr>
<tr>
<td>4</td>
<td>CORVET</td>
<td>64</td>
</tr>
<tr>
<td>5</td>
<td>TURBOZ</td>
<td>75</td>
</tr>
</tbody>
</table>

**PERFORMANCE CHARACTERISTICS FOR THIS SEQUENCE**

- **TOTAL FACILITY PROCESSING TIME = 450 HOURS**
- **TOTAL MACHINE PROCESSING TIME = 130 HOURS**
- **IDLE MACHINE TIME = 320 HOURS**

**A POSSIBLE SEQUENCE IS:**

<table>
<thead>
<tr>
<th>ORDER</th>
<th>JOB NAME</th>
<th>FINISH TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RABBIT</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>CORVET</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>COBRA</td>
<td>39</td>
</tr>
<tr>
<td>4</td>
<td>DAYTON</td>
<td>61</td>
</tr>
<tr>
<td>5</td>
<td>TURBOZ</td>
<td>70</td>
</tr>
</tbody>
</table>

**PERFORMANCE CHARACTERISTICS FOR THIS SEQUENCE**

- **TOTAL FACILITY PROCESSING TIME = 420 HOURS**
- **TOTAL MACHINE PROCESSING TIME = 130 HOURS**
- **IDLE MACHINE TIME = 290 HOURS**

**A GOOD JOB SEQUENCE IS:**

<table>
<thead>
<tr>
<th>ORDER</th>
<th>JOB NAME</th>
<th>FINISH TIME</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>RABBIT</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>CORVET</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>COBRA</td>
<td>39</td>
</tr>
<tr>
<td>4</td>
<td>DAYTON</td>
<td>61</td>
</tr>
<tr>
<td>5</td>
<td>TURBOZ</td>
<td>70</td>
</tr>
</tbody>
</table>

**PERFORMANCE CHARACTERISTICS FOR THIS SEQUENCE**

- **TOTAL FACILITY PROCESSING TIME = 420 HOURS**
- **TOTAL MACHINE PROCESSING TIME = 130 HOURS**
- **IDLE MACHINE TIME = 290 HOURS**

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and 4. You can use the start and finish times for each job at the machine stations to identify idle times. You can plan the reassigning of idle employees and the scheduling of equipment maintenance during idle periods.

Now you can use other criteria to distinguish between the two sequences. For example, suppose the owner of the Ferrari Daytona was a valuable customer and required the finished car as soon as possible. The Daytona could be delivered 12 hours earlier using the second good sequence. The Corvette job then suffers a 20-hour delay, but the total processing time remains at 420 hours.

Conclusions

We have presented a microcomputer-based scheduling algorithm that can be helpful in identifying job sequences that minimize total facility processing times. Analyses to determine the effects on schedules and performance characteristics of changes in the machine operations time are easily obtained. In taking this approach to the flow-shop problem, we assumed that processing sequences were identical for all jobs, process times for each job on each machine were able to be determined, and all jobs arrived simultaneously.

We developed this approach as an aid in managerial decision making, which is the goal of applied operations researchers.

References


Walter A. Stark Jr. (275 Kimberly, White Rock, Los Alamos, NM 87544) currently manages the isotope heat source research and development at a Los Alamos National Laboratory nuclear-processing facility. Richard A. Reid (The University of New Mexico, Robert O. Anderson Schools of Management, Albuquerque, NM 87131) teaches operations management and quantitative analysis.
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The only peripherals required are a video monitor and a cassette tape recorder. In kit form, the ET-100 costs $999.95. Factory-assembled and tested, it's $1499.95. The complete self-instruction course is $99.95. The upgrade kit is priced at $1299.95 or $1999.95, assembled and tested. For full information, write to Heathkit/Zenith Educational Systems, Heath Co., Department 150-125, Benton Harbor, MI 49022. Circle 650 on inquiry card.

Dual-Processor Multiuser System Eyes Business Market

At CP/M '83 East in Boston later this month, Compupro will unveil the Multipro Model MP 10, a four-user microcomputer capable of simultaneous 8/16-bit program execution yet priced at less than $1800 per workstation. The Model MP 10 is aimed at businesses seeking to run their databases on a system more powerful than a personal computer network. It supports communications and word and data processing through a shared database, which, in turn, provides access to information more rapidly than through a network.

In a standard MP 10 configuration, each workstation has access to a dedicated 64K-byte Z80B processor for 8-bit programs. The central processor, an 8-MHz 8088, and its 1 megabyte of main memory are dynamically allocated to each user, with the Z80B functioning as a terminal handler for running 16-bit tasks. The multiprocessor design is said to make all system resources potentially available to each workstation at any time while allowing operators to run an 8- or 16-bit program. Concurrent operation is provided under a Compupro-enhanced MP/M operating system.

Key hardware features include five serial ports, a modem connector, a Centronics-type printer port, 384K bytes of solid-state disk memory, and dual 5¼-inch floppy-disk drives with 1.6 megabytes of formatted storage capacity. The case measures 7 by 17 by 21 inches. Bundled with the MP 10 are a menu-driven electronic spreadsheet, a word processor, and database-management software.

Mass storage options include an external 2.4-megabyte dual 8-inch floppy-disk drive subsystem and an internal 5¼-inch Winchester hard-disk drive with 40 megabytes of storage. Other options include an 8-MHz 8087 coprocessor, up to 4 megabytes of solid-state disk emulator, and a network interface.

The MP 10 is the first in a series of high-performance business computers departing from Compupro's traditional S-100 bus architecture. Its base price is $4995, excluding terminals. For full details, contact Compupro, 3506 Breakwater Court, Hayward, CA 94545; (415) 836-0909. Circle 651 on inquiry card.
What’s New?

PORTABLE COMPUTERS

Nicad Batteries Power Portable for Half a Day

Self-contained rechargeable nicad batteries power the UDI-500 portable computer for up to 12 hours. Mass storage is provided by dual 3½-inch 322K-byte micro disks that feature DMA data transfer and automatic power down to conserve power. The UDI-500 comes with two CMOS central processors and two DOSes: the 280 with CP/M 2.2 and the RCA 1805 with MicroDOS. Standard features include 64K bytes of RAM, 2K bytes of video RAM, an accessory slot for a 300-bit-per-second [bps] modem, an 8-line by 40-character LCD display, a 59-key keyboard with 6 soft function keys, a Centronics-type parallel connector, and an RS-232C serial port with data rates ranging from 50 to 19,200 bps. The UDI-500 measures 11 by 13 by 3½ inches and weighs 12½ pounds.

Some of the software packages available for the UDI-500 are BASIC-80, CBASIC, a spreadsheet, and a text processor. Hardware options include double-sided 737K-byte disk drives, a 1200-bps modem, up to 256K bytes of RAM, and an internal AC power supply. For more information, contact Universal Data Inc., M-15, 3960 Ortonville Rd., Clarkson, MI 48016, (800) 521-1056; in Michigan, [313] 625-0158.

Circle 652 on inquiry card.

QWERTY keyboard with an integral keypad and an RS-232C port for communications. A Centronics parallel port lets you use the FP-200 with a printer or plotter, and its I/O port provides for future expansion. A cassette port allows you to load and store programs. RAM memory is expandable to 32K bytes.


Circle 653 on inquiry card.

16-Bit Portable Bundled with Software

The 16-bit 8088-based portable Columbia VP is bundled with 15 business and professional applications packages, including MS-DOS, MS-BASIC, communications, accounting, and the Perfect Writer and Perfect Filer. This 128K-byte IBM PC-compatible weighs 30 pounds and comes with two 5½-inch half-height floppy-disk drives handling 320K bytes of data. Its green phosphor, 9-inch display offers full graphics capabilities: 640 by 200 or 320 by 200 pixels in an 80- or 40-column by 25-line format. The VP's 83-key keyboard is IBM-standard.

Interfaces include parallel and serial ports, eight-level priority interrupt and DMA controllers, and an IBM PC-compatible expansion slot. RAM memory is expandable to 256K bytes, and a socket for an 8087 coprocessor is provided.

The Columbia VP costs $2995. For additional information, contact Columbia Data Products Inc., 9150 Rumsey Rd., Columbia, MD 21045, (301) 992-3400.

Circle 654 on inquiry card.

Your Passport to Portable Computing

The Anderson Jacobson Passport comes with 256K bytes of RAM, two 320K-byte disk drives, and a 7-inch amber screen. The IBM PC-compatible Passport uses an Intel 8088 microprocessor operating at 4.77 MHz. It offers 20K bytes of display RAM and 8K bytes of ROM for diagnostics and general I/O routines. The 84-key detachable keyboard has 10 function keys and a numeric pad. The alphanumeric screen format is 25 by 80. Greek, foreign language, mathematics, and line-drawing symbols are among the 256 characters available. Display attributes include underline, blink, intensity, reverse video, subscript, and superscript. A parallel printer port is provided, and the Passport's RS-232C port offers programmable asynchronous data rates ranging from 50 to 19,200 bps.

Circle 655 on inquiry card.

Notebook Computer

Casio has introduced the Model FP-200 notebook computer. Containing 8K bytes of RAM and 32K bytes of ROM, the FP-200 offers a 20-column by 8-line display that can handle both data and graphic information. It has a full-sized QWERTY keyboard and an RS-232C port for communications. A Centronics parallel port lets you use the FP-200 with a printer or plotter, and its I/O port provides for future expansion. A cassette port allows you to load and store programs. RAM memory is expandable to 32K bytes.


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Circle 653 on inquiry card.
What's New?

110 to 19,200 bps and synchronous bpsync and bit-oriented protocols (100,000 bps maximum). A built-in, 300-bps Bell 103J-compatible modem with auto-answer capabilities is standard. The 20-pound Passport is supplied with MS-DOS, Multiplan, text editing, communications, relational database, and executive desk software.

Two versions are available. The first, which costs approximately $4500, has two disk drives, parallel and serial ports, battery-backed time and date clock, the modem, and software. The second version is a single-disk model with dual I/O ports and operating system software. It's priced in the low-$3000 range. For complete particulars, contact Anderson Jacobson Inc., 521 Charot Ave., San Jose, CA 95131, (408) 286-7960.

Circle 655 on Inquiry card.

Portable Computer with Network Capabilities

The TeleTote I may be the first portable computer with network capabilities. An optional RS-422A network port is all that's needed to link the TeleTote I with a Televideo network for access to shared files, printers, and electronic mail.

The basic TeleTote has a 9-inch video display with 640 by 240 high-quality graphics resolution and 24-line by 80-character format. Mass storage is in the form of a single 368.6K-byte (formatted) 5¼-inch floppy-disk drive. Additional hardware includes a Zilog Z80A, 64K bytes of RAM, a mouse port for quick cursor manipulation, two RS-232C printer/modem ports, and telephone connections. Supplied software is made up of the CP/M operating system, the GSX-80 graphics extension, and word processing, spreadsheet, and graphics packages. The 25-pound TeleTote is software- and media-compatible with the 8-bit Televideo TS803 desktop computer.

TeleTote's RAM memory is expandable to 128K bytes and a second floppy-disk unit is available for $449. The network option costs $495. A mouse costs $99. The TeleTote I costs $1499. A two-drive version is priced at $1899.

Contact Televideo Systems Inc., 1170 Morse Ave., Sunnyvale, CA 94086, (408) 745-7760.

Circle 656 on Inquiry card.

DesktoP Performance in Portable

The Jonos C2100 portable computer is said to offer the performance characteristics typically associated with desktop computers. This 25-pound machine, built around a Z80A central processor, comes with 64K bytes of dual-ported RAM, two RS-232C ports, and a pair of 3½-inch 322K-byte (formatted) Sony micro-floppy-disk drives. Its 92-key detachable keyboard features an IBM Selectric-style layout and a full numeric cluster as well as an entry key and 10 function keys. A 9-inch P-31 phosphor screen provides a 25-line by 80-character format. For expansion, an integral compartment for a third disk drive and five STD bus cards slots are available. The basic unit comes with such software as CP/M, Spellbinder, Multiplan, and BASIC-80. It costs $399.5 from Jonos Ltd., 920-C East Orange-thorpe, Anaheim, CA 92801, (714) 999-6661.

Circle 657 on inquiry card.

PC-5000 Runs on Batteries or AC Power

Sharp Electronics' PC-5000 portable computer operates from a rechargeable built-in battery or from an AC adapter. The basic 11-pound PC-5000 comes with 128K bytes of RAM, a typewriter-style keyboard, 128K bytes of bubble-memory storage, and an 8-line by 80-character LCD display with a bit-mapped graphics capacity of 640 by 80 dots. A character set containing 256 characters and symbols is provided. The unit is programmed in BASIC.

A wide assortment of options are available, including a high-density dot-matrix thermal impact printer, a 10-key modem/auto-dialer, disk drives, and three-octave sound capabilities. Initial software offerings on bubble-memory software cartridges include a word processor, spreadsheet, database manager, and an executive planner. The basic PC-5000 costs $2500. For full details, contact Sharp Electronics Corp., Systems Division, 10 Sharp Plaza, POB 588, Paramus, NJ 07652.

Circle 658 on Inquiry card.
The Star-Lite HD20 is an 8080A computer with a built-in 20-megabyte hard-disk drive. A 8080A computer running CP/M 2.2, the HD20 has 64K bytes of RAM, 183K bytes of floppy-disk storage, a 9-inch 24 by 80 green screen, and a detached keyboard with 26 user-programmable function keys. Display attributes include half-intensity, underlining, blinking, and reverse video. Single serial and Centronics-type parallel ports are provided.

Three 8-bit bus slots are opened for expansion. Bundled with the HD20 is word processing, spreadsheet, modem, and accounting software. It weighs 34 pounds and measures 7% by 16% by 16% inches.

The suggested retail price for the HD20 is $499.95. Further information is available from Computershop Inc., 139 First St., Cambridge, MA 02141, (617) 661-3723.

20 Megabytes of Hard-Disk Storage in Portable

Computer with Bubble Memory

The Teleram 3000 portable computer weighs 9 pounds and is small enough to rest comfortably in your lap. Principal specifications are 64K bytes of RAM, 4K bytes of ROM, 128K or 256K bytes of nonvolatile bubble memory, an RS-232C interface, and a flat-panel LCD display with a 4-line by 80-character format. The 3000 has a typewriter-style keyboard with numeric and cursor keypad and 16 software programmable function keys. The CP/M 2.2 operating system is standard. It's powered by an internal rechargeable battery.

Options include floppy-disk drives, a text/graphics display, networking, and communication interfaces.

The basic Teleram costs $2495. With 256K bytes of bubble memory, it's $2995. For details, contact Teleram Communications Corp., 2 Corporate Park Dr., White Plains, NY 10604, (914) 694-9270.

Circle 660 on inquiry card.

Large Memory, Math Processor in Portable

The Sord M23P portable computer weighs 9 pounds and can be tucked into carry-on luggage. A 8080A-based computer, the M23P has an Am9511 arithmetic processor, 128K bytes of RAM, and two 3•1/4-inch 290K-byte microfloppy-disk drives. Two 25to 19,200-bps RS-232C serial ports, a Centronics-compatible parallel port, and three bus slots compose the M23P's I/O section. With the addition of an acoustic coupler, the M23P can send or retrieve data. Featured software includes Sord's Pan Information Processing System (PIPS), which has simplified commands for making tables, classifying data, searching, arranging information, performing calculations, and creating graphs. BASIC, UCSD Pascal, FORTRAN, a word processor, and an assembly-language debugger are standard. When equipped with a 12-inch green or a 14-inch color monitor, the M23P offers a 25 by 80 display format. Color capacities include 640 by 256-dot graphics and 8 colors.

Options include the SB-80 operating system and a dot-matrix or daisy-wheel printer. The list price is $2185. Add $195 for the...

PORTABLE PC-RELATED PRODUCTS

Check and Budget Program for HX-20
Data-Check, a check and budget program for the Epson HX-20, has been announced by Datacount. This program maintains a checking account with budgets and reconciliation and allows up to 20 user-defined categories. Budget reports include analysis of month- and year-to-date performance. Transactions can be summarized by category, and Data-Check can print balances and outstanding transactions. When used with the HX-20's microcassette drive, this program also provides extensive file-handling abilities. It can accommodate 125 transactions with the 16K-byte HX-20 and 1000 transactions with the 32K-byte version. Data-Check resides in RAM, so you can access its features at any time.

This program is also available for the Radio Shack Model 100 and the NEC 8201. For full details, contact Datacount Inc., Suite 820, 516 Southeast Morrison St., POB 14706, Portland, OR 97214, (503) 232-0490. Circle 663 on inquiry card.

Magazine for Kaypro Users
Pro = Files is a bimonthly magazine for users of Kaypro computers. Written for both the novice and the experienced Kaypro user, Pro = Files has a full range of departments, features, and news on Kaypro-related and industry topics. Regular departments include letters to the editor, a question-and-answer column, technical tips, and short summaries of new products and applications. Pro = Files will be distributed free of charge for one year to new Kaypro owners. Subscriptions for current owners began with the premiere issue, June 1983. Details are available from Kaypro Corp., 533 Stevens Ave., Solana Beach, CA 92075, (619) 481-3424. Circle 664 on inquiry card.

Software and EPROM Programmer for HHC
Quasar has announced snap-in software capsules and an EPROM programmer for its HHC (hand-held computer). The software capsules include a programmer's aid, statistics and budget programs, and a poker/blackjack game. Prices range from $25 to $80. The EPROM programmer can be used to custom program capsules for the system. It costs $295. For full details, contact Quasar Co., 9401 West Grand Ave., Franklin Park, IL 60131, (312) 625-0020. Circle 665 on inquiry card.

Stand for Portables
A stand from Icarus Systems lets you adjust the viewing angle of your portable computer console up to 25 degrees. The stand is constructed of heavy-gauge aluminum alloy and is painted with a scratch-resistant, baked urethane enamel. Currently, versions are available for the Compaq, Kaypro II, Osborne Executive, and Zorba. The retail price is $69.95, plus shipping. Dealer inquiries are invited. Contact Icarus Systems, Suite 14-325, 2303 North 44th St., Phoenix, AZ 85008, (602) 945-3993. Circle 666 on inquiry card.

Computer Backpack
The Compupak backpack makes it possible to transport portable computers on foot for blocks or miles. The water-proof nylon pack is similar to the type used by cross-country backpackers. Its frame is made of welded aluminum with crossbar reinforcing and padded shoulder straps and waist belt.

Compupak will accommodate most portable computers. It costs $139, plus $10 shipping. It's available from Sage Designs, 6035 Ocean View Dr., Oakland, CA 94618, (415) 654-1619. Circle 667 on inquiry card.

PRINTERS

Wide-Carriage Printers
Two versions of the MT 180 wide-carriage printer are available from Mannesmann Tally. The MT 180I features high-speed 132-column printing for accounting, report, or spreadsheet preparation. The MT 180L has letter-quality capabilities. When in the letter-quality mode, these dot-matrix printers operate at 40 cps. For report preparation, they run at 160 cps.

Both versions feature a 15-inch carriage and 132-character print line. A user-selectable compressed print option provides up to 264 columns of data on a single line. Output formats, such as right-margin justification, automatic centering, print pitch, and proportional spacing, can be set directly from front-panel controls or through the computer. These printers come with internal software that integrates text with graphics printing in the same document. A single lever controls switching from single cut-sheet to tractor feed. Both serial and parallel in-

What's New?
interfaces are standard.
The MT 1801 and the
180L will work with such
16-bit computers as the
IBM Personal Computer
and the DEC Rainbow and
with 8-bit computers, in-
cluding the Apple II and
Osborne. The MT 1801
costs $998, and the 180L is
priced at $1098. For more
information, contact Man-
nesmann Tally Corp., 8301
South 180th St., Kent, WA
98032, (206) 251-5503.
Circle 668 on Inquiry card.

Under-$700 Daisy-Wheel
Comrex International
has announced an under-
$700 daisy-wheel printer
capable of producing letter-
quality copy. The Comriter
CR-II features such word-
processing functions as
superscript, subscript, back-
space, underline, boldface,
double strike, and propor-
tional spacing. Its 5K-byte
buffer, capable of storing
up to three pages of data,
lets you reproduce original
and multiple copies of a
document stored in it. The
average print speed is 12
cps (approximately 140
words per minute). Print
motion is bidirectional and
logic seeking. The print
wheel is ASCII-standard
with 96 petals. The ribbon
is a Brother-compatible cas-
ette-type. Centronics and
RS-232C interfaces are
available.

Options include tractor
feed, color print ribbons,
a cut-sheet feeder, and inter-
changeable print wheels
compatible with the Com-
riter CR-4. For more infor-
mation, contact Comrex
International Inc., 3701
Skypark Dr., Torrance, CA
90505, (203) 373-3280.
Circle 669 on inquiry card.

Dual-Interface Letter-Quality Printer
The TP-II, a letter-quality,
dual-interface printer has
been introduced by Smith-
Corona. The TP-II daisy-
wheel printer has a 10/12
pitch 93-character ASCII
print wheel with reverse
slash, brackets, approx-
imate sign, vertical line, up-
arrow, and greater- and
less-than symbols. TP-II can
accommodate X/On, X/Off,
ETX/ACK, and hardware
handshake protocols. A
self-test switch, auto-
matic underscore, pro-
grammable margins and
tabs, and a 256-character
buffer are standard. It uses
ribbon cassettes, and RS-
232C and Centronics ports
are built in.

A tractor feed attach-
ment is available for $149.
The TP-II costs $895. For
details, contact Smith-
Corona, 65 Locust Ave.,
New Canaan, CT 06840,
(203) 972-1471.
Circle 670 on inquiry card.

Petite Alphanumeric
Printer
Syntest Corporation’s
SP-400 alphanumeric ma-
trix printer measures a mere
8 by 4.45 by 2.7 inches.
Capable of producing
high-quality 40-column
printouts on thermal paper,
the SP-400 has switch-sele-
cetable data rates from 50
to 9600 bps and selectable
stop bits and parity. Input is
RS-232C or 20-mA loop. A
40-character buffer and a
LED for low paper indica-
tion are standard. Printing
speed is 1 line per second.

The SP-400 is $285 in
quantity. The single-unit
price is $365. Both prices
include power supply.
Contact Syntest Corp., 169
Millham St., Marlboro, MA
01752, (617) 481-7827.
Circle 671 on inquiry card.
Organize and Store Text by Menu

Questext III version 3.5 is a general-purpose system for organizing, communicating, and storing textual information by menu. Produced by Information Reduction Research, Questext is suitable for such applications as computer-aided instruction, electronic publishing, executive scheduling, and classroom blackboarding. It's entirely menu-driven and said to be learnable in one session.

Questext organizes text into tree-like menu structures and executes machine code. Standard features include easy updating, cursor editing, error trapping, simple English-language commands, Help and Show facilities, and file controls. Print capabilities include screen, text, and outline dumping, continuous or page formats, and variable indentation. Questext can read and write text compatible with Wordstar.

Questext runs on the IBM Personal Computer, Osborne I, Xerox 820, Morrow Micro Decision, Apple II CP/M, Kaypro, and 56K-byte CP/M systems. An 8-inch single-density disk is offered. A 24-line by 80-column ASCII terminal is required. A full system capable of accommodating 99 lines per menu, up to 6000 screens, and 32,700 records costs $299.95, including a self-teaching disk with sample applications. A mini version with 6 lines per menu, up to 40 screens, and 500 records is available for $49.95. The manual alone is $29.95. Original equipment manufacturer and dealer inquiries are welcome. For further information, contact Information Reduction Research, 1538 Main St., Concord, MA 01742, (617) 369-5719.

Circle 673 on Inquiry card.

Educational Software Available

Edusoft offers 17 educational software packages for Apple, Atari, and Radio Shack TRS-80 users. For young children, Alphabet Song and Count provide practice in learning the ABCs and numbers. Elementary school students can gain mathematics mastery with Addition, Multiplication, and Division Drills, and older students can explore computer programming through the Simulated Computer program. For teachers, Edusoft offers Gradebook.

Most Edusoft programs cost $24.95. For a free catalog, contact Edusoft, POB 2560, Berkeley, CA 94702, (800) 227-2778; in California, (415) 548-2304.

Circle 675 on Inquiry card.
What's New?

Get the Draw on Graphics
Micro-Labs' Draw is a graphics and text-editing package for creating pictures or designing graphics screens on Radio Shack TRS-80 Model IIs equipped with the Grafyx Solution Board. Containing nearly 10,000 instructions, this machine-language program lets you set, clear, or complement points, lines, circles, or boxes. Point sizes can be changed at any time, the entire screen can be reversed or shifted in any direction, and sections of the screen can be filled in with patterns. When a picture is completed, it can be saved on disk or tape or printed. Draw uses single-letter commands.

Draw costs $39.95, which includes 12 high-resolution pictures and a manual. Contact Micro-Labs Inc., 902 Pinecrest, Richardson, TX 75080, (214) 235-0915. Circle 676 on inquiry card.

Modula-2 Compiler for CP/M
A Modula-2 compiler for 60K-byte CP/M systems will be available from JRT Systems on October 1. Derived from Pascal, Modula-2 lets you develop large programs made up of small modules that are kept in a program library. You can modify any module without affecting its relationship to the rest of the program because each module is divided into a definition part and an implementation part. Modula-2 features type checking between separately compiled program segments and low-level facilities for direct access to hardware and for circumventing strong type checking. It has multiprogramming abilities and procedure variables for program control.

Modula-2 was designed by Niklaus Wirth, creator of the Pascal language. Its suggested retail price is $100. An IBM Personal Computer version is in development. Contact JRT Systems Inc., 45 Camino Alto, Mill Valley, CA 94941, (415) 388-9670. Circle 677 on inquiry card.

Project Grapher Without Additional Hardware
The Harvard Project Manager lets IBM PC users develop project plans graphically without requiring special graphics hardware. HPM, based on CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique), employs the PC character set to construct the graphical elements for project management. It takes user-specified tasks, subprojects, and job milestones and draws a project “roadmap” on the PC’s video display. Projects can be depicted as a bar chart showing when each task begins and ends. Task duration units can range from minutes to years. Costs are user-specified. As the project definition is refined, HPM continually recalculate and displays total project costs and duration. The project’s critical path is displayed at all times. Other features include dynamic partitioning of the display screen into several functional windows, temporary displays of information, two-dimensional scrolling, and the ability to produce high-resolution hard copy.

HPM will also run on such IBM PC-compatible machines as the Compaq and Hyperion. The suggested price is $395. Contact Harvard Software Inc., Harvard, MA 01451, (617) 456-3400. Circle 678 on inquiry card.

Keyboard Programmer
AS-Key is a keyboard software package that lets you program special keys on the North Star Advantage. With AS-Key, you can define the 107 special-key combinations on the Advantage as any standard ASCII character or sequence of characters. Eight local functions are provided, including the ability to send keyboard messages to a printer for the setting of special modes.
What's New?

AS-Key, which costs $250, works with CP/M 2.2 or MS-DOS. It's distributed to North Star dealers through Northern Lights Computers, 1832 2nd St., Berkeley, CA 94710, (415) 540-6162. Circle 679 on Inquiry card.

Utilities for IBM PC Programmers

Power Pac I, the first in a series of IBM PC utility packages from Monument Computer Service, contains three programs: Formatted Lister, Diskmod, and BASIC Variable Cross-Reference. Formatted Lister lets you define headings, page numbers, margins, and line spacing for BASIC source-code listings. Diskmod provides a means for reading and inspecting disk sectors and has a full-screen editor that allows you to modify disk data in either hexadecimal or ASCII code. With BASIC Variable Cross-Reference, you can prepare listings of line-jump references and lists of variables and their use within programs. Also, it can analyze up to 10 programs simultaneously and prepare documented listings and internal programming references.

Minimum requirements are 64K bytes of memory and a printer. Power Pac I costs $79.95. For details, contact Monument Computer Service, Village Data Center, POB 603, Joshua Tree, CA 92252, (619) 365-6668. Circle 680 on Inquiry card.

Microgrids Offer High Resolution

Microgrid digitizer systems are plug and I/O compatible with other Summagraphics digitizers, including ID, Supergrid, and Summagrid. Six tablets, ranging in size from 12 by 12 inches to 42 by 60 inches, compose this series. Each features resolution of up to 1000 points per inch, ±0.010-inch accuracy, a single controller/interface board, a single-board printed-circuit grid, dual RS-232C interfaces, and an 8-bit parallel interface. A choice of transducers is offered so that the Microgrid can be tailored to meet specific applications needs. Transparent self-rest and interactive terminal diagnostics are built in.

Minimum requirements are 64K bytes of memory and a printer. Power Pac I costs $79.95. For details, contact Monument Computer Service, Village Data Center, POB 603, Joshua Tree, CA 92252, (619) 365-6668. Circle 680 on Inquiry card.

Buffer Gobbles Data as Fast as It Comes

Consolink's Microspooler accepts information as fast as your computer can output and holds it in memory until your printer is ready. With this device, you can store sentences, paragraphs, and data from different programs, compile them, and print a finished document. Microspooler can function as an interface between noncompatible computers and printers because it's available in any combination of parallel and serial I/O ports. Other standard features include multiple-copy functions, and a pause button. Microspooler will also receive data from a telephone modem or a remote input terminal.

The basic Microspooler contains 16K bytes of memory and an LED display that indicates the amount of memory in use and how much data is yet to be printed. Options include memory expansion of up to 64K bytes and serial interfacing capabilities. The suggested retail price for the parallel-to-parallel interface unit is $199. For full particulars, contact Consolink, 1840 Industrial Circle, Longmont, CO 80501, (303) 651-2014. Circle 682 on Inquiry card.
What's New?

IEEE-488 Line Output Module
A 64 digital line output module that's IEEE-488 bus-compatible is available from Connecticut Microcomputer. Busster 864 accepts commands and data from any computer with an IEEE-488 interface. This unit processes information through its IEEE port and then activates 1 to 64 digital TTL-level lines, effectively increasing a computer's interfacing capabilities while reducing overhead. Busster can be programmed through BASIC commands from the host computer. Available from stock, Busster 864 costs $495. Contact Connecticut Microcomputer, 36 Del Mar Dr., Brookfield, CT 06084, (203) 775-4595.

VIC-20 Expansion Device
The RAMmaster 32 for the Commodore VIC-20 has been announced by Mosaic Electronics. RAMmaster expands the VIC's memory to 37K bytes and features a built-in expansion port, pause and write-protect switches, and a relocatable memory block. A disable switch that permits cartridge removal without turning off the computer is standard. The suggested retail price for RAMmaster is less than $150. Further information is available from Mosaic Electronics, POB 708, Oregon City, OR 97045, (800) 547-2807; in Oregon, (503) 655-9574.

EPROM Emulator/Programmer
You can program or emulate such chips as the 2756, 2716, 2732, 2732A, 27128, and 68764 with Mosaic's Empron-1 EPROM emulator/programmer board. The Empron-1 does not use system memory space. It uses only eight I/O ports. An 8-inch single-sided single-density disk controls all programming and emulation functions. Programming is accomplished by an on-board or an external zero-insertion force socket. Programming voltages are developed on the card, and personality changes are software-switched. A ribbon cable connects the Empron-1 and the target processor.

Options include a buffered emulation cable and an adapter module for emulating multiple EPROMs. The software disk will run with CP/M, MP/M, or CDOS. Contact Maco, 427 Perymont, San Jose, CA 95125, (408) 998-1655.

Digital Oscilloscope, Data Acquisition for Apple
Applescope from RC Electronics contains all the hardware and software necessary to convert your Apple or Franklin into a multipurpose digital-storage oscilloscope and data-acquisition system. System highlights include the ability to acquire consecutive points on a single sweep, shiftable trigger position within a signal sweep, automatic test and measurement, waveform storage and retrieval on a floppy disk, hard-copy output, real-time voltage measurement, external trigger, 4-channel software support, pretrigger viewing, single sweep or continuous trace, and addition, subtraction, inversion, multiplication, and conversion of input waveforms. It uses the display monitor to graph digitized input signal on a 280-by-160-dot grid. Three lines of text at the bottom of the screen display status. Applescope can acquire and store several screen displays for each sweep (up to 64 in the DMA mode) and permits the screen to be scrolled through the acquired signal trace.

System hardware includes an A/D converter, DMA controller, buffer memory, and programmable timing logic. Two versions are offered: the D2, a two-board, dual-channel 8-bit system, and the HR14, a 14-bit single-channel system with 12-bit absolute accuracy. Options include probes and specialized software packages. The Applescope D2 costs $795. The HR14 begins at $995 per channel. Complete Applescope packages start at $4895, including a computer. For full ordering and product specifications, contact RC Electronics Inc., 5386-D Hollister Ave., Santa Barbara, CA 93111, (805) 964-6708.

Circle 684 on Inquiry Card.
Switch Lets 8 Units Interact Simultaneously

Digital Laboratories markets a line-controlled general-purpose switch that lets up to 8 nonmedia-compatible devices share resources. The Micro-Matrix II allows multiple conversions and broadcasting between any combination of RS-232C- and 20-mA-compatible devices. This Z80-based unit stores up to 16 frequently used 8 by 8 connection matrices, which can be accessed and routed by simple codes. It can be operated by a standard video terminal or through computer control. Software modification between computers is not required.

The Micro-Matrix II costs $995. For more information, contact Digital Laboratories Inc., 600 Pleasant St., Watertown, MA 02171, (617) 924-1680.

Voice-Recognition System for Apple

An Apple-compatible voice-recognition board that lets you input commands and repetitive data through a microphone is available from Voice Recognition Systems. When AVIM (Apple Voice Input Module) receives your verbal commands, it responds with any sequence of preprogrammed keystrokes you wish. Its resident 8K bytes of memory can store up to 80 voice-command/keyboard response sets, and additional command sets can be stored on disk. It's supplied with a menu-driven utility for creating commands. The utility disk is also preprogrammed with command vocabularies for Visicalc, Wordstar, List Handler, BASIC, and seven other programs. AVIM connects through any RS-232C port. Among AVIM's pertinent hardware specifications are a Motorola 6803 synthesizer, proprietary analog chips for signal processing, and a 16-channel audio-spectrum analyzer that determines strategies for voice-pattern recognition and storage.

Options include a remote FM microphone for cordless operation, appliance on/off relays, and a number of software packages. The retail price is $950. A $75 adapter is required for the Apple IIe. IBM Personal Computers and S-100 bus versions are in development. For full details, contact Voice Recognition Systems, 550 Battery St., San Francisco, CA 94111, (415) 788-2007.

Multifunction Subsystem Adds Speech

The CMJ-IF multifunction subsystem plugs into the cartridge slot on the Radio Shack TRS-80 Color Computer or the TDP-100. Available from Magnum Distributing, the CMJ-IF expands your computer by providing a speech synthesizer accessible from BASIC, two parallel ports, 4K or 8K bytes of EPROM or ROM space, two countertimers, a serial communications port, and an extender port for accessing a disk controller or ROM pack without disconnecting the subsystem. CMJ-IF is priced at less than $200. For additional information, contact Magnum Distributing Inc., 1000 South Dixie Highway #3, Pompano Beach, FL 33060, (305) 785-2002.

Nine Display Formats for the Apple

Videx's Ultraterm video card gives your Apple II Plus, lle, or III a high-quality 8- by 12-dot character matrix with a flicker-free display. Nine software-selectable formats allow as many as 4096 characters to be displayed. Format modes include 40 by 24, 80 by 24, 80 by 32 with interfacing, 128 by 32 for expanded spreadsheet visuals, and 160 by 24. Video attributes, also software-selectable, include bright, dim, standard or alternate character sets, normal, and inverse.

Ultraterm costs $379. Its interleaved mode requires a monitor with high-persistence phosphor. Contact Videx Inc., 897 Northwest Grant, Corvallis, OR 97330, (503) 758-0521.

Circle 688 on inquiry card.

Circle 689 on inquiry card.
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What's New?

MASS STORAGE

HP-Compatible Winchester

The Series 3000 line of Winchester hard-disk subsystems from Bering Industries is designed for Hewlett-Packard computers. This 12-member family offers storage capacities of 5, 10, and 15 megabytes and an average transfer rate of 174,000 bytes per second. The 8085 microprocessor and the 2900 bit-slice chip are integrated with the controller and a 5-bit error-correction-code circuit is built into added data integrity. Storage can be partitioned into formatted blocks.

The Series 300 is hardware-, software-, and media-compatible with such HP technical and personal computers as the HP1000, Series 80, and 64000 development systems. Connection is via the HP-IB; no hardware or software modifications are required.

The Series 3000 can be equipped with a variety of options, including integral 3½-, 5¼-, or 8-inch floppy-disk drives. Other options include a multiport feature, an intelligent controller for local backup, and disk-sharing capabilities. Series 3000 prices range from $2860 to $4260. For complete product descriptions, contact Bering Industries Inc., 747 East Brokaw Rd., San Jose, CA 95112, (408) 298-8552.

Circle 691 on inquiry card.

Disk Subsystems for OEM Market

PH-Associates' Mark line of disk subsystems for OEMs have a 30-millisecond average access time. Capacities of 20, 33, and 46 megabytes are available. Said to be identical in size to the standard 5 1/4-inch floppy-disk drive, these subsystems come with a smart controller featuring intelligent formatting and automatic sectoring. The transfer rate is 5 megabits per second, and the line interfaces to S-100, Z80, Apple, IBM Personal Computer, Radio Shack TRS-80, and many 8-bit parallel computers.

The Mark is available as a complete subsystem assembled into either a standalone or rack-mountable chassis or as part of an existing chassis. OEM quantity one prices begin at $3000. Contact PH-Associates, 8720 Old Courthouse Rd., Vienna, VA 22180, (703) 281-5762.

Circle 692 on inquiry card.

Dual-Mode Streaming Tape Backup

The 20-megabyte Syrgen Image streaming cassette-tape backup for the IBM PC XT gives you a choice of two backup modes: Preserve and Filesave. Preserve saves a volume of disk data and restores it on another disk. It has a catalog utility that lists all the files by tape file identification, and size. Filesave allows individual files or groups of files to be saved from hard disk to the tape, and vice versa. Its catalog utility lets you see all the files on tape, a specific range of files, or a particular file.

Image provides complete archival backup of hard-disk information at the rate of 2.5 megabytes per second. Compatible with CP/M-86 and PC-DOS, this subsystem comes with a controller, electronics, and drive mechanics. Word processing, database management, spreadsheet, and other demonstration software are supplied with Image. It costs $995, which includes interface card, cables, and the software. Contact Sysgen, 47853 Warm Springs Blvd., Fremont, CA 94539, (415) 490-6770.

Circle 693 on inquiry card.

Intelligent Drives for Atari 400/800

Trak's single-density AT-D1 and double-density AT-D2 intelligent drive systems work with Atari 400/800 computers. These drives feature an onboard microprocessor, programmed memory, and a digital track counter. Standard controls include a pressure-sensitive control panel that provides information on system activity through read/write indicators, a touch-sensitive write-protect switch for securing data, and an intelligent controller interface for a Centronics-type parallel printer.

These drives have half-height mechanisms with steel-band head positioning and direct-drive beltless DC motors. Track-to-track access time is 5 milliseconds. The AT-D1 costs $499. For full details, contact Trak Microcomputer Corp., 1511 Ogden Ave.,
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PORTABLE MINICASSETTE FOR FIELD WORK

The LG-P compact portable minicassette system is manufactured by Analog & Digital Peripherals. This microprocessor-controlled unit is designed for field and factory personnel needing means for loading and storing programs at remote sites. Standard features include 96K bytes of storage per tape, multiple file/tape abilities, switch-selectable data rates of 150 to 9600 bps, double-buffered I/O, terminal and modem ports, and automatic error checking and retry. It has a self-contained operating system, a transparent standby mode between terminal and modern, and the ability to handle ASCII or binary codes. Its manual controls are read and write block or file, stop, skip, and backwards.

The LG-P comes in a shock-mounted briefcase measuring 7 1/4 by 5 by 9 1/2 inches. Standard RS-232C and 20-mA current loop interfaces are offered. The single-unit price is $639. Quantity discounts are available. Contact Analog & Digital Peripherals Inc., 815 Diana Dr., Troy, OH 45373, (513) 339-2241.

Circle 695 on inquiry card.

CANADIAN PAYROLL SYSTEM

Arctic Data Corporation’s Canadian payroll accounting system works with computers running CP/M and OS65/U operating systems. This package uses menu-driven prompts to guide operators through all phases of installation, operation, and report generation. It can print payroll summaries, input registers, employee lists, and payroll stubs. It supports up to nine user-defined deductions and four rate categories per employee. Payrolls can be calculated concurrently for hourly, salaried, and piecework paid employees. Salary personnel files can be password protected. Further facilities permit issuing cash advances, bonuses, and lump-sum payments. This system can handle government-supplied forms. Union and job costing versions are available. Dealers and interested end users can receive complete details from Arctic Data Corp., 1839 1st Ave., Prince George, British Columbia, V2L 2Y8, Canada.

Circle 696 on inquiry card.

REMOTE LINE MONITOR

The RLM 2000 remote line monitor from RAD Computers Ltd., permits EIA status and line data streams to be transmitted from remote data links to a central site for analysis. This system is made up of a master unit at a central site and a slave unit that can be connected over communication lines and controlled by the master. The slave scans the transmit and receive lines, control signals, and control clocks, and control signals. It transmits data to the master via low-speed channels using an error-checking algorithm for data integrity. The master unit receives and stores data in its 1K- to 16K-byte memory. Data is then re-

stored and transferred to monitoring equipment for analysis. The slave is programmed through a standard ASCII terminal connected to the master.

Other products from RAD include short-haul modems and automatic cable testers. For more information, contact RAD Computers Ltd., 8 Hanechoshet St., Ramat-Hachayal, Tel Aviv 69710, Israel; tel: (03) 494511; Telex: 35517.

Circle 697 on inquiry card.

WINCHESTERS AND FLOPPIES STANDARD

The Orion VI series of microcomputers from Dy-4 Systems offers two types of Winchester hard-disk drives combined with an 8-inch double-sided double-density floppy-disk drive. The Orion VI-A comes with a 35.6-megabyte (formatted) 8-inch Winchester, and the Orion VI-B is equipped with a 5-, 10-, or 20.8-megabyte 5 1/4-inch Winchester. Both systems feature STD bus architecture, a 280A microprocessor, 64K bytes of RAM, 4K bytes of EPROM, and CP/M.

A 12-slot card-cage option for the VI-B allows for up to 9 user card slots. Additional options include RS-232C and parallel ports, color graphics, and floating-point mathematics. Contact Dy-4 Systems Inc., 888 Lady Ellen Place, Ottawa, Ontario K1Z 5M1, Canada; (613) 728-3711.

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Ejecutivo magazine is designed for Latin American business people who want to know more about computers and information-processing equipment. It offers reports on industry trends, trade happenings, new products and services, and profiles of names in the news. Current circulation of this Spanish-language, four-color journal is 40,000. For information, contact Ms. M. Morelli, Ostwaldstrasse 6, 5300 Bonn 1, West Germany; tel: (228) 612807. In the U.S., Johnston International, 386 Park Ave, S. New York, NY 10016, (212) 689-0120. Circle 700 on inquiry card.

Printer Flows at 37 cps

The Flowriter RP1300 operates at 37 cps and offers character pitches of 10, 12, and 15 cpi and proportionally spaced type styles. This bidirectional printer with optimized print-head movement comes with an 8K-byte buffer, graphics capabilities, and such print enhancements as underline and boldface. Standard features include external forms control, multicolor print, self-test, automatic linefeed, paper and ribbon sensors, and a print wheel with the full 96-character ASCII set and 28 special symbols. Flowriter can print an original plus six copies. Interfaces are serial RS-232C, IEEE-488, or Centronics parallel. Options include a variety of typefaces, tractor feed, and a keyboard for communications. A 60-cps version is available. Contact Appropriate Technology Ltd., 2-4 Canfield Place, London NW6 3BT, England; tel: 01-328 7272; Telex: 264538 SSE G. Circle 699 on inquiry card.

K-Fix Patches Kaypro CP/M

Maplesoft’s K-Fix version 2.1 is designed to correct several unpopular traits of the Kaypro II. K-Fix alters the Kaypro’s CP/M system so that it turns off the drive motors when they are not in use, extinguishes the drive lights except for when a read or write is occurring, and sets the power on/reset default serial data rate to any of the 16 values supported by the Kaypro.

K-Fix is written in assembly language and is recopyable with COPY and SYSGEN utilities. The distribution disk contains KFIX.COM, the source code (KFIX.ASM), and a boot-up message advising users how to proceed. It costs $29.95 (in Canada, $35), which includes a manual containing a fully commented source-code listing. Order K-Fix from Maplesoft Inc., Suite 100, 49 Ascot Dr., Fredericton, New Brunswick, E3B 6G1, Canada. Circle 700 on inquiry card.

VisiCalc Subject of Two New Works

Two recent releases from Osborne/McGraw-Hill focus on VisiCalc's VisiCalc spreadsheet program. 54 VisiCalc Models: Finance-Statistics-Mathematics by Robert H. Flast is a collection of ready-to-run VisiCalc programs that address common business, mathematical, and statistical problems. It's written for both beginners and seasoned VisiCalc users. The price is $15.95. In The VisiCalc Program Made Easy, David M. Castlewitz presents a series of hands-on lessons that introduce users to VisiCalc's program format and commands. Numerous examples and exercises help even first-time users achieve desired results. It costs $12.95. Contact Osborne/McGraw-Hill, 2600 Tenth St., Berkeley, CA 94710. (415) 548-2805. Circle 702 on inquiry card.

Guide to Osborne

Purported to provide all the operational requirements needed to wrest the best from your Osborne 1, Using the Osborne Personal Computer is a Van Nostrand Reinhold publication. Author Kenniston W. Lord offers easy-to-use applications that can save business people time and money. Methods of entering, sorting, and presenting information are explained, and graphics techniques for business reports are described. Discussions cover data and programs running under the CP/M operating system and explain how printer graphics are used. Other topics addressed include defining media files and reading and writing to magnetic media. Numerous projects are provided to further refine programming skills.

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MODEL III/4 Internal Two Drive Kit: Includes controller board, dual drive mounting bracket, dual power supply, all hardware cable, and connectors (gold plated) & TEC Drive...

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CLRCLE 152 on inquiry card.
What's New?

Components Catalog
A free, illustrated 80-page catalog of semiconductors, memories, microprocessors, and passive electronic components is available from Active Electronics. Also covered are computer systems and peripherals. Contact Active Electronics, POB 8000, Westborough, MA 01581, (800) 343-0874; in Massachusetts, (617) 366-0500.

Online Data Directory
Profiles of 291 online services are contained in a 52-page directory produced by Data Decisions. Online Services covers databases in 15 categories, such as distribution, education, banking and finance, medical/health, government, and agriculture. Service reports provide information on the primary function of the company, application and industry emphasis, application languages and program development aids supported, and access schemes permitted. Other features include a quick-reference and summary index classifying the listings by industry and a miscellaneous section of databases.


Single-Board Computer
Automatically Boots DOS
The ID-80 from Advanced Data Processing Systems automatically boots a control program or DOS when powered up. This single-board computer comes with a floppy-disk controller, two RS-232C serial ports, three parallel ports, and 64K bytes of dynamic RAM. It features an onboard terminal that uses VT-52 control codes and outputs composite video in an 80-column by 24-row format. Characters are formed in a 9 by 12 matrix, and custom fonts are user-programmable. A semigraphics mode allows the generation of 32 graphics characters. For storage, the ID-80 can handle two single- or double-density, single- or double-sided 5¼-inch floppy-disk drives or up to four single- or double-sided, single-density 8-inch drives. A 2K-byte character generator and 2K bytes of video memory are standard.
In single units, the ID-80 costs $598. For further information, contact Advanced Data Processing Systems, POB 10417, San Jose, CA 95137, (408) 446-9332.

Unisystem-PC is PC-compatible
Compatible with the IBM Personal Computer, the Unisystem-PC is produced by International Systems Marketing. This 16-bit 8088-based machine is outfitted with 256K bytes of memory, dual 720K-byte floppy-disk drives. 8K bytes of EPROM, two RS-232C...
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32K S-100 EPROM CARD

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USES 2716's
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SPECIAL: 2716's EPROM's (48K NS) Are $4.95 Ea. With Above Kit.

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2. Allow up to 32K of software on line!
3. IEEE S-100 Compatible
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THE NEW ZRT-80

CRTC TERMINAL BOARD!

A LOW COST Z-80 BASED SINGLE BOARD THAT ONLY NEEDS AN ASCII KEYBOARD, POWER SUPPLY, AND VIDEO MONITOR TO MAKE A COMPLETE CRT TERMINAL. USE AS A COMPUTER CONSOLE OR WITH A MODEM FOR USE WITH ANY OF THE PHONE-LINE COMPUTER SERVICES.

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64K SS-50 STATIC RAM

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48K KIT

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SUPPORT ICS + CAPS $18.00
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ports, a parallel printer port, and a video monitor with a 25 by 80 format. Video attributes include uppercase and lowercase characters, underline, blink, reverse image, and high-intensity characters. Eight levels of interrupts are provided. Word processing, communications, and electronic spreadsheet software are standard. The operating system is MS-DOS.

Up to 1 megabyte of internal memory, a color graphics monitor, and an 8087 coprocessor are among the options. The UniSystem-PC begins at $2595. Details are available from International Systems Marketing Inc., Jackson Place South, Suite 6, 932 Hungerford Dr., Rockville, MD 20850, (301) 279-5775.

Circle 708 on Inquiry card.

Encore 8- or 16-Bit Performance

Ithaca Intersystems’ Encore can be configured as either an 8- or 16-bit system with a variety of storage devices. The 8-bit Z80B Encore runs Digital Research’s CP/M or MP/M II operating systems, and the 16-bit Z80000 system is provided with Microsoft Xenix. Standard features include a 10-slot motherboard, modified 5-100 circuit boards, and two or more mass-storage units. The storage options offered are 5½- and 8-inch floppy-disk drives and 5½-inch hard-

What's New?
disk drives with capacities of up to 31 megabytes. Prices for 8-bit Encores begin at $4995. Complete details are available from Ithaca Intersystems Inc., 200 East Buffalo, POB 91, Ithaca, NY 14851, (607) 273-2500.

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True Three-dimensional Modeling System

Intek’s Diplomat is a Z80-based peripheral controller for intelligent communication between microcomputers, peripherals, and printers. A software-controlled switchbox, Diplomat can accommodate a group of devices, regardless of whether serial or parallel, providing that at least one of the units is computer input. Technical features include 16K bytes of RAM, 16 data rates (8 hardware- and 8 software-selectable) from 50 to 19,200 bps, an internal printer driver, automatic bidirectional printing with optimized throughput, sheet-feeder and graphics modes, word-processing features, and RS-232C, Centronics parallel, Qume, and Diablo interfaces. Its switch-selectable protocols are NEC 7710, Diablo 630, IBM PC/Epson, Qume Sprint 5, and Atari. Other specifications include vector plotting, remote diagnostics, reprint of up to 8000 copies, clear error, adjustable tabbing, and an audible alarm.

Options include 64K bytes of memory. Retail prices range from $595 to $895, depending on the amount of memory and desired configuration. Contact Intek, 780 Charcot Ave., San Jose, CA 95131, (408) 946-9041.

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Intelligent Communication Controller

ElectroNews Inc. is a computer-accessed interactive news and advisory service. This service produces up-to-the-minute reports on such financial subjects as securities, precious metals, real estate, interest rates, and inflation as well as advice from leading financial and investment experts. Subscribers are able to interact with the system posing questions that help them make personal investment strategies.

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BYTE September 1983 603
Modem with Processor-Controlled Auto-Dial

Bytcom's Autodial 212AD is a full-featured Bell 212A-compatible modem with a microprocessor-based auto-dial circuit. It provides 0 to 300 bps and 1200 bps full-duplex transmission of data over a switched network. Its non-volatile memory can store nine 40-digit telephone numbers and names and can be activated by terminal key or computer control. System features include integral voice/data transfer switch; software disconnect; remote boot capabilities; 16-character answer back; redial, linking, and continuous redial until connected; secondary dial-tone detect for PBX dialing; a help menu; and interchangeable Touch-Tone, Pulse, or blind dialing within a stored number sequence to allow pulse-circuit users to dial over MCI and Sprint lines. The terminal interface is RS-232C, and the telephone line interface is RJ11 or RJ45.

The Autodial 212AD modem costs $595. Contact Bytcom, Suite H, 2169 Francisco Blvd., San Rafael, CA 94901, (800) 227-3254; in California, (415) 485-0700. Circle 713 on inquiry card.

Computer Cleaning Aids

A line of computer cleaning products is marketed by Automation Facilities Corporation. The line includes a disk-drive cleaning kit, a compressed-air sprayer, a static sprayer, a solvent, presaturated cleaning pads, and lint-free wiping materials. For a product catalog, contact Automation Facilities Corp., 3916 State St., Santa Barbara, CA 93105, (805) 687-7040. Circle 715 on inquiry card.

Microprocessor Handles Keyboard Functions

A single microcomputer controller handles all the functions of the 8000 Series keyboard. This 95-key system offers a standard 53-key typewriter arrangement, a left-hand 10-key function keypad, and 13 numeric keys on the right-hand side. Across its top are 19 special-function keys. All keycaps are non-glare two-shot molded sculptured style. Four versions of the 8000 Series are available, with prices beginning at $170. Contact George Risk Industries Inc., GRI Plaza, Kimball, NE 69145, (308) 235-4645. Circle 716 on inquiry card.

Card Cage Ready for Projects

The MB6AF-PS6 is an STD bus-compatible modular card-cage assembly from Computer Dynamics. It consists of an integral six-slot motherboard, cage, power supply, and fan. The bottom plate is removable for flat mounting within an enclosure. The connectors feature gold-plated contacts, and the chassis is made of anodized aluminum with nylon card guides spaced at 0.5 inches. In single units, the MB6AF-PS6 costs $395. Contact Computer Dynamics Inc., 105 South Main St., Greer, SC 29651, (803) 877-7471. Circle 717 on inquiry card.

Suppressor Responds In Less Than 60 Picoseconds

The Power Sentry-2 transient suppressor and line conditioner from Surgeonics responds to voltage transients in less than 60 picoseconds. It comes with a built-in RF filter that's designed to attenuate RF noise and dissipate high-speed, high-energy transients for increased reliability. Key specifications include energy dissipation of more than 1.1 megawatts, 156 V RMS (220 peak) ±10% clamping voltage by means of a two-stage system, and a nominal line voltage of 120 V, single phase at 50 or 60 Hz. Further details are available from Surgeonics Ltd., 155 Kisco Ave., Mount Kisco, NY 10549, (914) 241-3202. Circle 718 on inquiry card.

Where Do New Products Items Come From?

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VIDEO TERMINAL BOARD 82-018

This is a complete stand alone Video Terminal board. All that is needed besides this board is a parallel ASCII keyboard, standard NTSC monitor, and a power supply. It displays 80 columns by 25 lines of UPPER and lower case characters. Data is transferred by RS232 at rates of 110 baud to 9600 baud — switch selectable. The UART is controlled (parity etc.) by a 5 pos. dip switch.

Complete source listing is included in the documentation. Both the character generator and the CRT program are in 2716 EPROMS to allow easy modification to your needs.

This board uses a 6502 Microprocessor and a 6545-1 CRT controller. The 6502 runs during the horz. and vert. blanking (45% of the time). The serial input port is interrupt driven. A 1500 character silo is used to store data until the 6502 can display it.

Features
- 6502 Microprocessor
- 6545-1 CRT controller
- 2716 EPROM char. gen.
- 2716 EPROM program
- 4K RAM (6116)
- 2K EPROM 2716
- RS232 I/O for direct connection to computer or modem.
- 80 columns x 25 line display
- Size 6.2" x 7.2"
- Output for speaker (bell)
- Power +5 700Ma.
- +12 50Ma.
- -12 50Ma.

This board is available assembled and tested, or bare board with the two EPROMS and crystal.
Assembled and tested
#82-018A $199.95
Bare board with EPROMS and crystal
#82-018B $89.95
Both versions come with complete documentation.

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IBM Personal Computer

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<tr>
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<th>Model</th>
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<td>Color IV (RGB Analog input)</td>
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<td>USI</td>
<td>Amber Monitor</td>
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Quadrant

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<tr>
<th>Brand</th>
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<td>TG Joystick</td>
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<td>Microsoft 64K Ramcard</td>
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<td>Hayes Smartmodem 1200</td>
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<td>Quadrum Multifazer w/Power Supply</td>
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<td>System Monitor Card</td>
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<td>VanWriter Graphical Tablet</td>
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Printers

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<td>Diablo</td>
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Circle 434 on inquiry card.
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THE CCT EXCLUSIVE WARRANTY

With any system we build, we provide, in writing, an unconditional 12 month direct warranty on the entire system, including mainframe, boards, drives, power supplies, cabling and peripherals! We offer guaranteed 24 hour in-house repair and/or replacement with just a toll-free phone call. We can offer this, since we are so sure of our level of quality and reliability. It’s great to know that in the event of a problem, you’re not out all business waiting on service turnaround. We deliver!

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M-Drive CP/M W/RAM Punched-$49 * Disk 1w/CP/M-$499 * M-Drive-H/512K-$1299
CPU 8086/88-$319 * CPU 8087-$519/10MHz-$599 * CPU 68K-$1079/10MHz-$599 * CPU-Z-$249
Disk 1-$359 * Disk 2-$599 * Disk 28K/100K-$359 * Disk 3000-$699
RAM 12 (12MHZ)-$399 * RAM 16 (12MHZ)-$399 * RAM 21 (128K)-$399 * RAM 22 (256K)-$1899
Interfacer 1-$299 * Interfacer 2-$299 * Interfacer 35 3+$399 3+$599 * Interfacer 4+$399
System Support 1-$299 * Enclosure 2-Desk-$599/Rack-$649 * 20 Slot Motherboard-$210
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Call for CBC Boards — New Releases — Operating System Modus/Updates

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CPU M 80-$399 * CP/M 80-$150 * CP/M 8-16/$799 * CP/M 68K-$279 * Forth 88K-$1699
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24 Megabyte hard/floppy
CCT/ Fujitsu/ Mitsubishi ultra-system
23 meg. hard disk next to 1.2 meg. 8" DDSF floppy drive. Includes disk 2 board set, all cabling, A&T, formatting, burn-in. Ready for any CompuPro system:

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TXS-200K Kit $175.95
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IO-1015A A & T $245.00
I/O-5 — SSM Microcomputer
Two serial & 3 parallel ports, 110-19 2K baud
IO-1015A A & T $285.00
INTERFACER 4 — CompuPro
3 serial 1 parallel, 1 Centronics parallel
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MEM-561525 56K kit $225.00
MEM-641525 64K kit $265.00
Assembled & Tested add $30.00

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MBS-121A A & T $89.95
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CPU-30201A A & T $199.95

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CPU-30500C 3/6 MHz $374.95

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SFC-5505/5042F CP/M 3.0 with VF-2 $129.95

2422 DISK CONTROLLER — C.C.S.
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IDO-12000K Kit with 8 & after PROM $299.95
IDO-12090A A & T with 8 & after PROM $325.00
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MEM-95530A A & T with software $248.95

PB-1 — SSM Microcomputer
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MEM-95510A A & T with manual $216.00

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EME-115100 8 receptacle $69.85

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Computer Products
4901 West Rosecrans Ave. Hawthorne, California 90250
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**Printers On Sale!**

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>380Z by D.T.C.</td>
<td>$995.00</td>
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<tr>
<td>PRD-11000 380Z printer</td>
<td>$1195.00</td>
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<tr>
<td>PRA-11000 Tractor option</td>
<td>$169.95</td>
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<tr>
<td>PRA-11200 Cut sheet folder</td>
<td>$39.95</td>
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**IBM PC™ Add-ons**

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
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<tbody>
<tr>
<td>QUADLINK Apple emulator for IBM PC</td>
<td>$849.95</td>
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<tr>
<td>PRA-11000A</td>
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<tr>
<td>PRA-11000B</td>
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</tr>
</tbody>
</table>

**Video Monitors**

**LOWEST PRICE! DAISY WHEEL PRINTER - TTX**

The new TTX Daisy wheel printer is compact, versatile and inexpensive—everything you've been waiting for in a letter quality printer.

It has a low-profile, contemporary design, and requires 20% to 50% less desk space than most other daisy wheel printers. Other features include dual interface (RS232 and centronics parallel), built-in adjustable pivot forms guide, and compatibility with Wordstar print control commands, including underline, bold print, super and sub-script, etc.

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$179.95

Dual 8" Slimline Sub-systems
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$879.00
END-000844 A & T w/2 SS DD Drives
$885.00
END-000845 Kit w/2 SS DD Drives
$1060.00
END-000846 DS DD Drives
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We brought out a major manufacturer's overspill, and we are passing the savings on to you! Single sided double density, package of 10
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MSF-10801R $189.00 ea 2 for $378.00 ea
Shugart SA-10851R Double sided, double density
MSF-10851R $490.00 ea 2 for $980.00 ea
Tandem TM 848-1 Single sided, double density thin-line
MSF-554981 $395.00 ea 2 for $790.00 ea
Tandem TM 848-2 Double sided, double density thin-line
MSF-108492 $495.00 ea 2 for $990.00 ea
Shugart SA 801R Single sided, double density
MSF-10801R $189.00 ea 2 for $378.00 ea
NEC FD 1158 Double sided, double density thin-line
MSF-811165 $450.00 ea 2 for $900.00 ea
NEC FD 1164 Double sided, double density thin-line
MSF-811164 $500.00 ea 2 for $1000.00 ea

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MSM-551001 $225.00 ea 2 for $450.00 ea
Shugart SA 400L Single sided, double density 40 track
MSM-10400 $234.95 ea 2 for $469.90 ea
Tandem TM 190-2 Double sided, double density 48 TPI
MSM-551002 $259.00 ea 2 for $518.00 ea
MPI 652 Double sided, double density 48 TPI can be substituted for CDC
MSM-155205 $275.00 ea 2 for $550.00 ea
MPI 851 Single sided, double density 48 TPI
MSM-155100 $209.00 ea 2 for $418.00 ea
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MSM-155300 $285.00 ea 2 for $570.00 ea

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MMA-508 Holds 50 8" diskettes
$24.95

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80 column x 24 line video card for Apple II addressable 255 status flags, normal/ inverse or high/low video. 128 ASCII characters. upper and lower case, 7 x 9 dot matrix with true descenders. CP/M, Pascal & Fortran compatible. 50/60 Hz. 100/60 columns selection from keyboard. Best 80 column card!
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**DT1057** Digitalker®............. $24.95 ea.

**QUALITY COMPONENTS AT AFFORDABLE PRICES!**

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<table>
<thead>
<tr>
<th>Part No.</th>
<th>Qty</th>
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**SOLDERTAIL STANDARD (TIN)**

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**WIRE WRAP SOCKETS (GOLD LEAD)**

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**SOLDERTAIL (GOLD STANDARD)**

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**74HC HIGH-SPEED CMOS**

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**PROGRAMMABLE ARRAY LOGIC (PALS)**

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**LINEAR**

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<tr>
<td>CD4069</td>
<td>100</td>
<td>$0.05</td>
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</table>

**Circle 239 on inquiry card.**
**PRINTERS**

- **$269** Star Gemini

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- **$795** Wyse 109

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- PERSPECT Spectrum (84-255K)
- PLANTONICS Color plus Card
- MAGNUS Board (256-512K)
- P/N 656 64K w/ functions
- Disklink Apple Card
- RIZON PC/XT2A Modern I/O
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  - 80:60, 80:40, 80:30, 40:30, 40:20, 40:10
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- Color matches Apple
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270-DAM 5.35
270-DAR 5.35
270-SAIO 5.35
270-SAIO/1 5.35
270-SAIO/2 5.35
270-SAIO/3 5.35
270-SAIO/4 5.35
270-SAIO/5 5.35
270-SAIO/6 5.35
270-SAIO/7 5.35
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SAT 10:00 A.M.-1:00 P.M.

Circle 154 on inquiry card.

SYTE September 1983 633
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#### DISK DRIVES

<table>
<thead>
<tr>
<th>Type</th>
<th>Price</th>
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<tbody>
<tr>
<td>MF + DDS (6 slot M/B)</td>
<td>699.00</td>
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<td>MF + DDB (6 slot M/B)</td>
<td>749.00</td>
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<tr>
<td>MF + DD12 (12 slot M/B)</td>
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#### DISK DRIVE CABINETS

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<tr>
<td>5/&quot; DDS/5/&quot; DSDD</td>
<td>399.00</td>
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<tr>
<td>5/&quot; DDS/5/&quot; DSDD 220v</td>
<td>448.00</td>
</tr>
</tbody>
</table>

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  - Apco 15½" 480i: 179.00

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<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
</table>
| **OKIDATA**        | Microline 93A  
  - 160 cps  
  - 15" Carriage  
  - Very Close to Letter Quality |
|                    | $ 799                                                                       |
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  - More Storage  
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| **Tandon for IBMPC** | TM 100-2A  
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  - 2, 320K Disk Drives  
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  - Color Card  
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| **Franklin**       | Starter System  
  - Franklin Ace 1000 w/64K  
  - Amber Monitor  
  - Disk Drive (Slimline) & Controller |
|                    | $ 1195                                                                      |
| **Commodore**      | Commodore 64  
  - 1525 Graphic Printer  
  - 1541 Disk Drive (1)  
  - 1701 Color Monitor |
|                    | $ 999                                                                       |
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<table>
<thead>
<tr>
<th>Company</th>
<th>Model</th>
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<td>Ace 1200 w/ drive</td>
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<td>1600-12 520K Drives</td>
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### IBM PC Accessories

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### VIDEO DISPLAY MONITORS

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### DISK DRIVES

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<td>Data 20</td>
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### DISK DRIVES FOR APPLE & FRANKLIN

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<td>Sup-S Controller</td>
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<td>51/4&quot; Disks Verbatim</td>
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<td>Raritan Systems</td>
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<td>Apple Mate</td>
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### MODEMS

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<td>Hayes Micro Computer</td>
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<td>J-Cat 300 baud</td>
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<td>Apple Cat II</td>
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### LOW PRICED

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<th>Company</th>
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<tr>
<td>Advanced Access</td>
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<tr>
<td>All Products Have 90 Day to 5 Yr. Warranty</td>
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### COMPUTER COMPONENTS UNLIMITED

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<thead>
<tr>
<th>Company</th>
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<td>IBM PC Accessories</td>
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<tr>
<td>VIDEO DISPLAY MONITORS</td>
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<td>DISK DRIVES</td>
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<tr>
<td>MODEMS</td>
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### NEW RETAIL STORE

<table>
<thead>
<tr>
<th>Details</th>
<th>Location</th>
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<tbody>
<tr>
<td>11976 Aviation Blvd</td>
<td>Inglewood, CA 90304</td>
</tr>
<tr>
<td>P.O. Box 1936</td>
<td>Hawthorne, CA 90250</td>
</tr>
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### 800-847-1718 OUTSIDE CALIFORNIA

<table>
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<tr>
<th>Details</th>
<th>Location</th>
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<tbody>
<tr>
<td>Technical &amp; Customer Service</td>
<td>(213) 219-0808</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Item Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>8&quot; Shugart 3800/3800 Assm.</td>
<td>$369.00</td>
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<tr>
<td>8&quot; Shugart 8080 Double Sided 1.2 Mag.</td>
<td>$457.00</td>
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<tr>
<td>8&quot; Quantum 10/10 Megabyte Winchester - Two Platters</td>
<td>$156.50</td>
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<td>8&quot; Quantum 10/10 Megabyte Winchester - Four Platters</td>
<td>$265.30</td>
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<tr>
<td>8&quot; Quantum 10/10 Megabyte Winchester - Six Platters</td>
<td>$359.00</td>
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<td>8&quot; Quantum 10/10 Megabyte Winchester - Eight Platters</td>
<td>$499.30</td>
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<tr>
<td>8&quot; Quantum 10/10 Megabyte Winchester - Ten Platters</td>
<td>$699.00</td>
</tr>
</tbody>
</table>

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On assembled and tested cabinets.

One year parts and labor on these dual drive cabinets, complete with power supplies, A.C. and D.C. cables, 50 pin data cables (vertical only) and complete mounting hardware.

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The fifty-five dollar 8" Power Supply is back!

WONDERFUL SMARTMODEM! 8" Power Supply is back!

For 8" Floppies

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<tbody>
<tr>
<td>T-1000</td>
<td>$295.00</td>
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<td>T-1000-32</td>
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<td>T-1000-44</td>
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PM-1300 MODEMS

For 6 to 22 Slots

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<tbody>
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</tr>
<tr>
<td>S-1000</td>
<td>$995.00</td>
</tr>
</tbody>
</table>

CUSTOMER SERVICE HOTLINE 1 - (714) 898-5525
CUSTOM COMPUTER SYSTEMS by XOR

Why do companies like I.B.M. Corp., Micro-System Corporation, Samsung Elec., Hitachi Space Center, Edwards A.F.B., Motorola Corp., Raytheon, and Pacific Technology buy products from us? Maybe it's our full 1 year parts and labor warranty on all XOR O.E.M. products. It could be our state of the art technology, or even the factory direct sales and service. We think it's our custom computer systems with over 1000 possible configurations. If you don't see it advertised, call us today, chances are we can custom build the system you need.

**MICRO MANAGERS: POWERFUL, PORTABLE, AND AFFORDABLE**

- **5½" Z-80A 64K CP/M System**
  - Dual Floppy 375K 85/DD 40 Track
  - Dual Floppy 735K 85/DD 40 Track
  - Prices: $1445.00

- **5½" Hard Disk with ½ Height Floppys**
  - 5 Megabyte Hard Disk w/375 Floppy
  - 6 Megabyte Hard Disk w/750 Floppy
  - Prices: $1750.00

- **2.4 Meg DS/DD 8" CP/M System**
  - System with Dual 85/DD 1.2 Megabyte
  - Prices: $1795.00

- **THE BASIC PROFESSIONAL FLOPPY, HARD DISK AND TAPE BACKUP**

- **THE OFFICE MASTERS! REMOVABLE CARTRIDGE DISK SYSTEMS**

- **THE BUSINESS PROFESSIONALS: HARD DISK MULTI-USER SYSTEMS**

---

**FREE U.S. MICRO SALES SOFTWARE GIVEAWAY!**

Order any system below and get all of the following software and manuals absolutely FREE! CP/M Operating System, Perfect Writer, Perfect Speller, Perfect Mailer, Perfect Calc, AND an eight module business accounting package by BUSINESSMASTER INCLUDING: A/R order entry, A/P purchase orders, G/L Payroll, Mailing List, Fixed Asset Accounting, Inventory (RAW), and inventory regular goods. AND multi-user systems also include Digital Research's MP/M and Link-80 software. $1685.00 value.

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**FREE MULTIPLE USER CARTRIDGE DISK SYSTEM**

For users who need multi-user removable cartridge disk for ease and what you want to automate your office or small business, with all the software packages you need, with each user having direct access to one cartridge, one copy of the database in effect. Each user terminal will work with the user parts and the disk as stated below and free of charge. Cost: $5,995.00.
SBC 300
Z-80 Single Board Computer
- Fully complies with IEEE 996 (5100) Bus Standard
- 2-656 CPU 4 or 6 MHz
- 64 KBytes of RAM with parity
- 2 to 16 K Bytes 8 bit expandable CPU
- 24 bit addressing to 16 MBytes
- Full SASI Port with 8 bit I/O data bus
- Full Programmable Communications Options
- Dual Synchronous Full-Duplex Channels
- Supports CP/M Plus, MPM, and TURBO
- Permanent Master or Slave
- Two Full Duplex Serial Ports
- Asynchronous, synchronous, or HDLC
- Software selectable baud rate
- Full duplex, up to 1 Mbit/sec in asynchronous mode
- 6, 7, or 8 bits data characters
- Stop bits 1, 1.5, 2
- Parity - off, even, or none
- Error detection - parity overrun, CRC framing
- Hard Disk
- All receive characters
- Ready when Ready with Buffer Backup

Part No. Description List Price
BUSB330051 6 Sync serial (A/T) $955.00 $84.90
BUSB330052 6 Sync serial (SO) $705.00 $87.90

VERSAFLOPPY III
Floppy and Hard Disk Controller
- 8-1600 (5100) compatible
- Supports 5.25" or 8" drives
- Plastics back box data separation
- Supports 5.25" Winchester drives
- Complete error checking
- 2x40 sector buffer
- Data transfer of up to 51mbytes/sec

Part No. Description List Price
BUSB893010 V-R3 Disk Controller (A/T) $950.00 $950.00
BUSB893011 W-R4 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893011 W-R5 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893011 W-R6 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893011 W-R7 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893011 W-R8 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893011 W-R9 Disk Controller (A/T) 3.5" $950.00 $950.00

VERSAFLOPPY II/696
Floppy Disk Controller
- 8-1600 (5100) compatible
- Concurrent support of 4 drives of 5.25" or 8"
- Double density formats
- Separate connections for 5.25" and 8" drive cables
- Single and double sided disk drive capability
- CRC error code checking
- Placed keyed disk data separator

Part No. Description List Price
BUSB389299 V-R3 Disk Controller (A/T) $950.00 $950.00
BUSB389300 W-R4 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB389301 W-R5 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB389302 W-R6 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB389303 W-R7 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB389304 W-R8 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB389305 W-R9 Disk Controller (A/T) 3.5" $950.00 $950.00

SOFTWARE-CP/M PLUS™ 3.0
SYSTEM REQUIREMENTS AND OS INSTRUCTIONS:
CP/M 3.0 requires a minimum of 112K bytes of system RAM partitioned into 128K words for operation. Memory size parameters are communicated to the OS by means of selections in the CONFIG.COM file. The OS is divided into two modules, the main portion that resides in the common memory, and the loaded portion that acquires the upper area of RAM (just below the common area). The common area must be at least 4K for CP/M to be compatible with the distribution configuration.

Part No. Description List Price
BUSB893011 W-R3 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893012 W-R4 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893013 W-R5 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893014 W-R6 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893015 W-R7 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893016 W-R8 Disk Controller (A/T) 3.5" $950.00 $950.00
BUSB893017 W-R9 Disk Controller (A/T) 3.5" $950.00 $950.00

ROM DISK 128
Program Accelerator
- 8-1600 (5100) compatible
- 10 KBytes of storage per board
- Uses 16 users shared 2764 or 2732 type PROMs
- S/4 boards required on a 256K bus
- Standard PROMs supported
- Faster than a floppy disk drive
- Ideal for environments with mechanical drives not practical
- CP/M and MP/M+ installable

Part No. Description List Price
BUSB929011 ROM DISK 128 PROMS (A/T) $350.00 $350.00
BUSB929012 PROM DISK Manual $350.00 $350.00

RAM DISK 256
Program Accelerator
- 8-1600 (5100) compatible
- 16K bytes of sequentially accessed memory
- On-board transparent net (only when the M1 signal is disabled)
- Faster than a floppy disk drive
- PC/AT program included (with configured the RAM DISK-256 looks like a single density 8" disk drive)
- Source code libraries included
- On-board dynamic RAM controller
- Electronic drive offers the use of four boards in the same address range to be accessed giving you up to 1 MByte of storage
- Asynchronous bus operation and uses the LINT line only
- 1 Year Warranty

Part No. Description List Price
BUSB929011 ROM DISK 256 PROMS (A/T) $750.00 $750.00
BUSB929012 PROM DISK Manual $350.00 $350.00
CPU BOARDS

- **68K - 60000 16 bit CPU**
  - Price: $595.00
- **68K - 6000 10 MHz CPU**
  - Price: $510.00

CO-PROCESSOR 8068/8087

- **68K 8 BIT**
  - Price: $595.00
- **8087**
  - Price: $100.00

DISK CONTROLLER CP/M 2.2

- **CP/M 2.2**
  - Price: $299.00

COMPUTER HARDWARE

- **SUPER SALE PRICE: $99.00**
  - 64K 10MHz LOW POWER S-100 IEE/STATIC RAMS
  - **64K 8 BIT**
    - Price: $299.00
  - **64K 8 or 32K 16 BIT**
    - Price: $325.00

STORAGE 5-100 MOTHERBOARDS

- **S-100 MOTHERBOARDS**
  - Price: $125.00

INTERFACER 1

- **INTERFACER 1**
  - Price: $295.00

INTERFACER 2

- **INTERFACER 2**
  - Price: $295.00

INTERFACER 3

- **INTERFACER 3**
  - Price: $295.00

INTERFACER 4

- **INTERFACER 4**
  - Price: $295.00

INTERFACER 5

- **INTERFACER 5**
  - Price: $295.00

MPX CHANNEL BOARDS

- **MPX CHANNEL BOARDS**
  - Price: $295.00

RETAIL STORE PHONE NUMBERS:

- **PRIORITY ONE ELECTRONICS**
  - (Chatsworth): (213) 709-5464
  - (Irvine): (714) 660-1411

Address: 9th St. Deering Ave., Chatsworth, CA 91311
### S-100 TO "REAL WORLD" INTERFACE PRODUCTS

<table>
<thead>
<tr>
<th>Port Number</th>
<th>Description</th>
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<td>BUGC1973</td>
<td>remote temperature sensor (1 lb)</td>
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<td>BUGC3121</td>
<td>remote humidity sensor (1 lb)</td>
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<td>BUGC3125</td>
<td>remote moisture sensor (1 lb)</td>
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<td>BUGC3126</td>
<td>remote smoke detector alarm (2 lbs)</td>
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<tr>
<td>BUGC5001</td>
<td>remote controller circuit board</td>
<td>$49.95</td>
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</tr>
</tbody>
</table>

**Air Conditioning & Heating Duct Valves**

- BUGC8097: 7" diameter valve (1/2") | $7.95
- BUGC8098: 7" diameter valve (3/4") | $7.95
- BUGC8099: 10" diameter valve (3/4") | $10.95
- BUGC8102: 10" diameter valve (2") | $15.95
- BUGC8105: 20" diameter valve (2") | $10.95
- BUGC8110: 24" diameter valve (2") | $14.95

**64 PIN CABLE ASSEMBLIES**

- BUGC1094: 64 pin single ended 4" long (2 lbs) | $29.95
- BUGC1095: 64 pin single ended 10" long (3 lbs) | $29.95
- BUGC1096: 64 pin single ended 20" long (6 lbs) | $49.95

**5-100 CLOCK/CALIBRATION BOARDS**

- BUGC2001: With alarm circuit | $29.95
- BUGC2003: With timer board | $29.95
- BUGC2010: Software for ICO101 board | $34.95

### S-100 DATA SCIENCE

#### 5-100 SBC BOARD

- BUGC1029: SBC 8040 8/4 MHz with 2708 RAM | $295.00
- BUGC1030: SBC 8040 8/4 MHz with 2708 RAM | $295.00
- BUGC1031: SBC 8040 8/4 MHz with 2708 RAM | $295.00

**CPU 2 or 4MHz**

- BUGC1032: CPU 2 or 4MHz with 2708 RAM | $295.00
- BUGC1033: CPU 2 or 4MHz with 2708 RAM | $295.00
- BUGC1034: CPU 2 or 4MHz with 2708 RAM | $295.00

**INTERCONNECTION MICRO SYSTEMS**

- ZM10 DMA SBC & ZM10 SLAVE 8-100 IEC/IEC SPARES - 1 YEAR WARRANTY

**DUAL V/8 SBC 8040 SLAVE**

- BUGC1035: V/8 SBC 8040 SLAVE | $295.00
- BUGC1036: V/8 SBC 8040 SLAVE | $295.00
- BUGC1037: V/8 SBC 8040 SLAVE | $295.00

**DUAL V/8 SBC 8040 SLAVE**

- BUGC1038: V/8 SBC 8040 SLAVE | $295.00
- BUGC1039: V/8 SBC 8040 SLAVE | $295.00
- BUGC1040: V/8 SBC 8040 SLAVE | $295.00

**DUAL V/8 SBC 8040 SLAVE**

- BUGC1041: V/8 SBC 8040 SLAVE | $295.00
- BUGC1042: V/8 SBC 8040 SLAVE | $295.00
- BUGC1043: V/8 SBC 8040 SLAVE | $295.00

**TELETEK SOFTWARE**

- Software with no programming compensation included | $29.95

**HARD DISK/CARTIDGE TAPE CONTROLLER**

- BUGC1044: Hard Disk/Tape controller 4MHz | $795.00
- BUGC1045: Hard Disk/Tape controller 6MHz | $795.00

**RETAIL STORE PHONE NUMBERS:**

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DOUBLE DENSITY DRIVES!
FOR ONLY
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- Double Sided/Double Density Drives — 768 Kbytes of Storage
- QUEST BOOKKEEPER® Software included
- PERSONAL PEARL® data base manager
- 2 Serial Ports and 1 Parallel Port — simultaneous connection to terminal, printer and modem

The MD3 is a complete computer system (hardware and software) developed to satisfy the needs of the millions of small, independent businesses with fewer than 50 employees and annual sales under $5 million. These businesses need a computer that is easy to use, provides a wide variety of functions, including word processing, financial planning and forecasting, information management, mailing lists, a good general bookkeeping system, and most important of all — is affordable! That's the MD3!

HARDWARE

The Micro Decision® is a 4 MHz Z80A based computer with 64K of memory and an on-board disk controller. The two 5.25" double-sided density half height floppy disk drives supply an impressive 384K of storage capacity. There are two RS232 serial ports and one Centronics style parallel port for direct connection to a terminal, modem, printer, or just about any other peripheral you may need.

TERMINALS

Choose one of two terminals with the purchase of your MD3. Each is designed to meet the needs of the typical microcomputer user. The Micronet® is a standard model with a built-in monitor and keyboard, and the Micronet® II is a more advanced model with a built-in terminal, printer, and modem.

SOFTWARE

The MD3 comes complete with 9 software packages that would cost as much as the whole system if purchased separately. The highlight of this software package is

<table>
<thead>
<tr>
<th>SOFTWARE</th>
<th>PROGRAM</th>
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<tbody>
<tr>
<td>QUEST BOOKKEEPER®</td>
<td>Financial accounting</td>
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<tr>
<td>PERSONAL PEARL®</td>
<td>Data management</td>
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<tr>
<td>GENERAL LEDGER SYSTEM</td>
<td>Accounting and invoicing</td>
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<tr>
<td>DETAILED LEDGER AND INVENTORY</td>
<td>Inventory management</td>
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<tr>
<td>ACCOUNTING</td>
<td>Tax preparation</td>
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<tr>
<td>PERSONAL ACCOUNTING</td>
<td>Personal finance management</td>
</tr>
<tr>
<td>INVENTORY CONTROL</td>
<td>Inventory control</td>
</tr>
</tbody>
</table>

NEW LOWER PRICES ON MD2, ALSO!!

MD2 W/250K Disk Drives (Sh. Wt. 28 lbs.) $995.00
MD2 W/MDT20 Beige terminal (Sh. Wt. 34 lbs. & 27 lbs.) $1395.00
MD2 W/MDT20 Black terminal (Sh. Wt. 34 lbs. & 27 lbs.) $1395.00

20 ips LETTER QUALITY

Ideal Companion to Your Micro Decision!

The MORROW DECISION MD3000 provides all of the features that you would expect in a letter quality printer. Features such as

- 20 ips (Stahman last print speed)
- Bi-Directional printing
- 17" paper width paper capacity
- Prints up to 5 part forms
- Front panel controls of PAUSE, FORM FEED, TOF, E1-E6
- POWER, ALERT and PRINT ON front panel indicators
- Very quiet operation
- Optional tractor feed

<table>
<thead>
<tr>
<th>PRINTER OPTIONS</th>
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<tr>
<td>Single type 13 million characters</td>
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<tr>
<td>Multitype edition</td>
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<tr>
<td>Print wheel</td>
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<td>Courier 10 point</td>
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<tr>
<td>Courier 12 point</td>
</tr>
<tr>
<td>Proportional</td>
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<tr>
<td>Script style</td>
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</table>

GEMINI 10X & 15

OKIDATA

MANNESSMANN TALLY

LETTER QUALITY DOT MATRIX PRINTER

<table>
<thead>
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<th>PRINTER CARTS</th>
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<tbody>
<tr>
<td>Single type 13 million characters</td>
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<td>Proportional</td>
</tr>
<tr>
<td>Script style</td>
</tr>
</tbody>
</table>

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Circle 365 on inquiry card.
$175.00 each
CALL for 10+
ORDER NOW AND SAVE!
BUY DRIVE & CABINET TOGETHER AND SAVE!!
DUAL 8" SIEMENS FDD1008
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AND INTERNAL POWER CABLES
(Save $30.00 for shipping)

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Prices Subject to Change

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30
different

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14" x 26" SHEET 12.00
12" x 13" SHEET 8.00

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½ Mb Storage 1 Mb Storage
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80 Track - 96TPI
6 ms — track to track
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65A55 ACA 1.5MHZ 2.95
0220/0820 PIA 2.95

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2112L 450NS-LP 1.49
2112 460NS 1.99
2114 460NS .99
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1793 16.95
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CRTS27 9.95
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PLEASE USE YOUR CUSTOMER NUMBER WHEN ORDERING"
"TERMS: For shipping include $3 for UPS Ground or $13 for UPS Blue Label Air. Items over 5 pounds require additional shipping charges. Foreign orders include sufficient amount for shipping. There is a $10 minimum order. Bay Area and Los Angeles Counties add 6% Sales Tax. Other California residents add 8% Sales Tax. We reserve the right to substitute manufactures. Not responsible for typographical errors. Prices are subject to change without notice. We will match or beat any competitor’s price provided it is not below our cost.

Circle 240 on Inquiry card.
## 4164 64K DYNAMIC RAMS $5.95

### STATIC RAMS

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Quantity</th>
<th>Price</th>
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Circle 243 on inquiry card.
FOR SALE: IMSAI 22-40 slot 5-100 system, IEEE-486 compatible. Front panel, 64k static 200MHz RAM, 280, and 8080 processor cards, 2302 video signal card, Accutronics 120 disk controller, and two disk drives. CPM BIOS and all necessary disk utilities included. Excellent starter system working 12000 time. You shop or deliver within 75 miles. A. L. Bertens, 611 Victoria Terrace, Paramus, NJ 07652. (201) 660-0175.

WANTED: Apple II Plus-compatible software to swap. I am particularly interested in utilities and educational programs (including CPM). Send a list of your programs and/or a disk of your more advanced programs. I will promptly return the same with some of my programs. Ursula Sueisch, 1414 Northwest Green Circle, Conway, SC 29526. (803) 746-5259.

FOR SALE: Equipment left over from several large club projects. 49 2520 TRS-80 (almost new), 20 D-100 plus 280 type IBM 8024L (at 12), 95-B inch disk IBM disks at 12:17 DEC tape reels in cassette at 13. 3040 Payten, 3880 Phinney Dr, Farmington, OH 44144.

FOR SALE: Radio Shack MicroDisk Drive (cat no. 26-114A) is in excellent condition $100 or best offer. Richard Havener, 575 Stoughton Ave, Stafford, CA 95339. (209) 377-0480 after 5:30 m.

FOR SALE: North Star 14MB hard disk drive with North Star 14MB DOS. No bad spots. Less than a year old. $150. John Scraff, 417 West 1st, Sarasota, FL 34241, (941) 387-2273 days and 387-3798 evenings CT.

FOR SALE: ASR 33 with manuals. Hardly used 1200 pay shipping on delivery. Also, two Processor Technology 16K RAM boards, modified to 4K each (low price) each 50. M. Gilbert, 154 Munson Ave, West Hempstead, NY 11552. (516) 486-0367.

WANTED: I am writing a book about software. Seeking unique or specialized software like manufacturing robots and general business software. Send SAPE. Anthony Klosky, 1529 North Hide St., Chicago IL 60627.

FOR SALE: M-401C/1SR handheld computer calculator system including printer, code word adder, card reader, timer module, PRG, ROM, STAS, Extended functional memory, and many hardware extras. All like new. Much software included. (scientific/medical applications) and documentation from HP and a PCQ 14 inch hard drive $375 or best offer including shipping. Will consider sale by the piece: S. J. Davidson, 901 E St., Philadelphia, PA 19147. (215) 928-1551 or 682-6544.

WANTED: Used computer system, complete with display screen, printer, and software for word processing, etc: J. Leonard, 1702 Avonade Ave., Riverside, NY 11571. (212) 548-6325.


WANTED: Need information on the IMSAI MDC Disk Controller card, especially schematic, I/O board, and CPU board. David Schiller, 3023 Avon Rd, Bethlehem, PA 18018.

WANTED: Send a list of your Apple programs and I will send you mine. I am mainly interested in entertainment software. Please include a SASE. Greg Burns, 240 West Rd., New Canaan, CT 06840.

FOR SALE: Kaypro II computer, software and manuals included.

FOR SALE: Zenith Data Systems 2-100, brand new in the box, all software, 1-100 basic operation manual, 2-100 brand new in the box, all software, 1-100 basic operation manual, 2-100 brand new in the box, all software, 1-100 basic operation manual, 2-100 brand new in the box, all software, 1-100 basic operation manual, 2-100 brand new in the box, all software, 1-100 basic operation manual, 2-100 brand new in the box, all software, 1-100 basic operation manual, 2-100 brand new in the box, all software, 1-100 basic operation manual.

FOR SALE: Dynabase DB 1B1 and DB 1B2. Physical dual disk, two blank floppy disks, SSD, DB 8 Hayes Metromonad, software included over 30 CP/M discs. MS/DOS, MS/DOS, MS/DOS, MS/DOS.

June BOMB Winners

Readers lauded the User's Column this month with first place going to Jerry Pournelle's "Zenith Z-100, Epson QX-10, Software Licensing, and the Software Piracy Problem." Dr. Pournelle wins $100. Second place and $50 goes to Steve Clarica for his article entitled "Use ADPCM for Highly Intelligible Speech Synthesis." Tim Paterson takes third place with "An Inside Look at MS-DOS," an overview of the popular operating system.

Correspondence

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<th>Description</th>
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TRS-80 Model 4 is the Logical Choice. For performance and price, our Model 4 desktop computer is the professional approach to improving your productivity. It has features built-in that cost extra in other computers—features that will make your job a lot easier.

**Designed to Make Hard Work Easy.** The easy-to-read 80-character by 24-line display and 64,000-character memory make Model 4 perfect for complex spreadsheet analysis. To speed operations, our "MemDisk" emulates a super-fast disk drive in memory for keystroke-quick responses instead of time-consuming disk access. A built-in print spooler lets you work on one job while printing another.

**Versatile and Powerful.** We designed Model 4 to be completely compatible with our existing line of word processing, time management, electronic filing—in fact, all TRS-80 Model III software. And soon you’ll be able to choose from thousands of CP/M*-based programs.

See It Today. Get a demonstration of the TRS-80 Model 4 (Cat. No. 26-1069) at your nearest Radio Shack Computer Center, participating store or dealer. Be sure to ask about our leasing, training and service plans, too.

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