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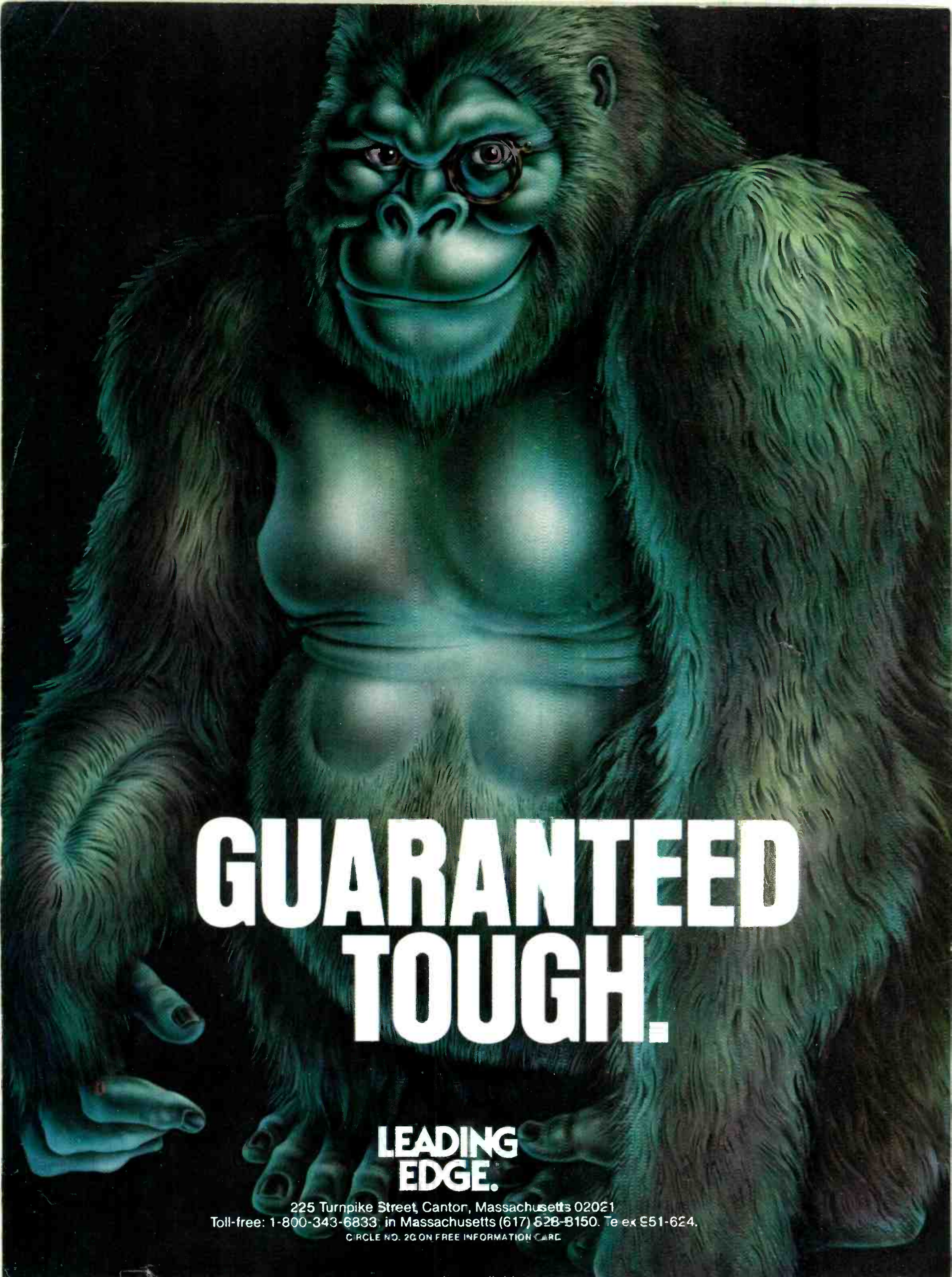

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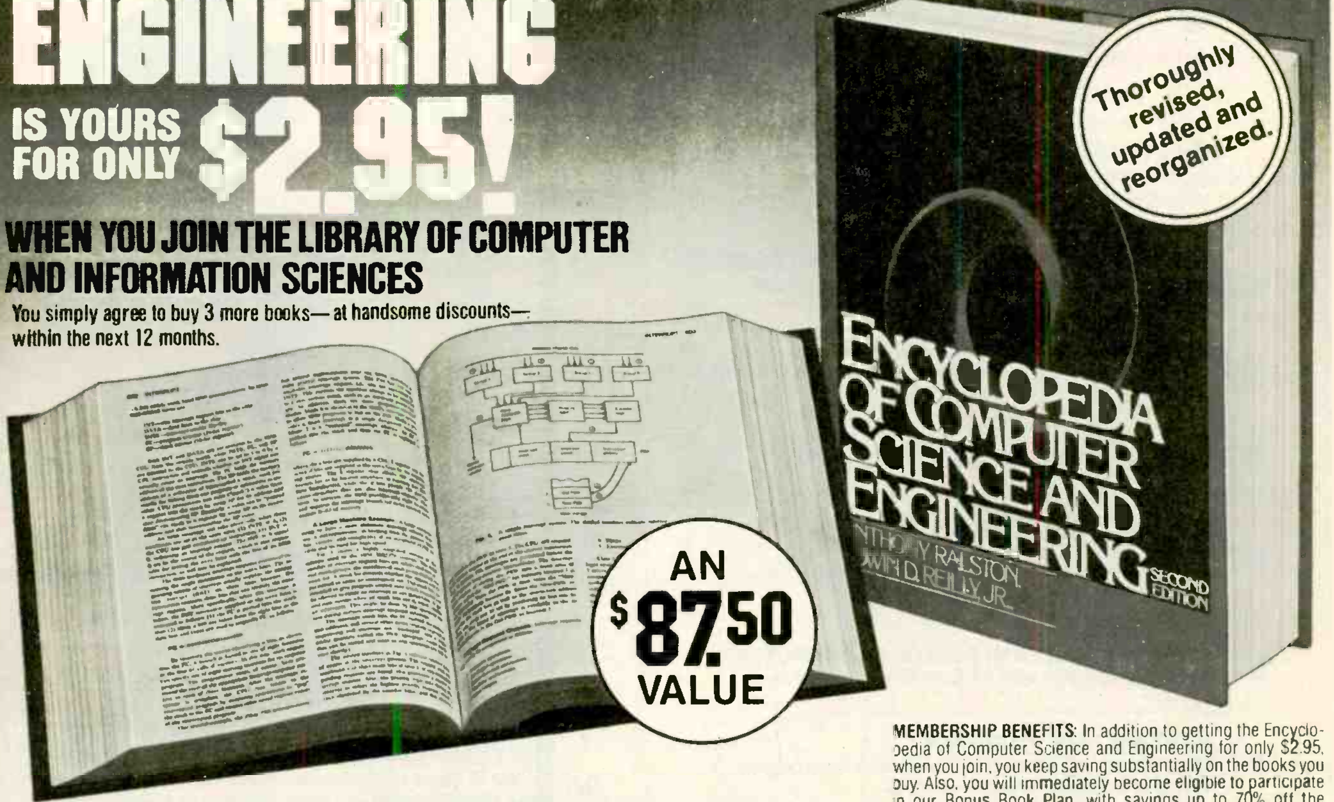

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Computers & Electronics

JANUARY 1984 VOLUME 22, NUMBER 1

FEATURE ARTICLES

COLUMNS

DEPARTMENTS

COVER PHOTOGRAPH BY GARRY HEERY

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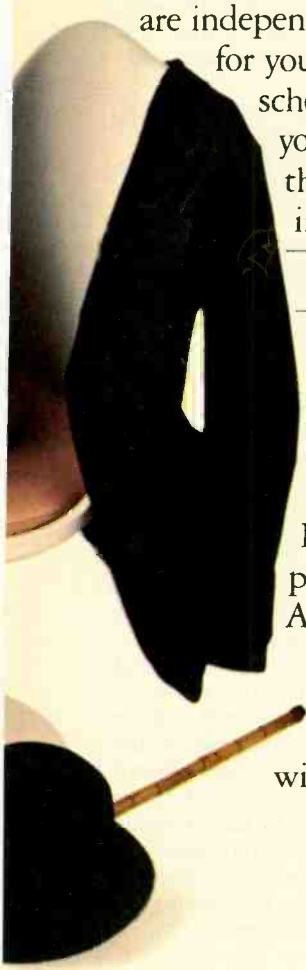

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EDITORIAL

And the [Computer] Beat Goes on

HERE it is fully two months before the New Year, though our production lead time forces me to write for our initial 1984 issue. As you all know by now, IBM's "Peanut" was unshelled as the "PC*jr*." A telephone call by an IBM representative alerted us to its public unveiling a day before it was to happen.

The happening was smoothly professional. A bevy of working PC*jr*'s were on hand, manned (womanned?) by IBM'ers who demonstrated how the machine performed with a handful of software packages developed outside the company. The color graphics were vivid and sharp; the wireless keyboard worked beautifully; and IBM should be pleased as punch by the attendant publicity, which it rightly earned.

Other computer makers should count their blessings, too. Firstly, the PC*jr* is not a low-cost machine. Thus, it is certainly not a mass-market system. Accordingly, you won't see this machine on the discount shelves of Toys 'R Us and other such mass merchandisers. IBM doesn't like to lose control, you know. So this leaves plenty of room for the Commodores, Apples, Radio Shacks, and others to compete. It also settles the stomachs of computer aftermarket makers who will, doubtlessly, introduce a host of devices to make the machine better, such as a substitute keyboard with better keypads.

The year 1983 might go down now as the year in which Christmas buying habits were ignored since PC*jr*'s won't be available until the first quarter of '84, and then not enough to satisfy demands. Coleco, too, appears to be looking toward the New Year for its biggest sales. As a result, one wonders how other personal computer sales will fare around the biggest traditional selling season? Will there be a really big freeze as buyers take a wait-and-see attitude?

None of the biggies in the home computer market have been knocked off, in my opinion, by the introduction of the Junior. Texas Instruments' 99/4A fell by the wayside before its debut. In fact, the machine was really terminal for a long, long time. Not because it is not a good computer. It's terrific! But it started life on the wrong side of the tracks. —an $1100 price tag for the basic machine, ultra-costly peripherals, an arrogant "we don't have to advertise, our name is Texas Instruments" attitude, and shutting out third-party hardware and software makers by not making an open bus available. It recognized its mistakes too late. Right now, the 99/4A is probably the buy of the decade.

So new microcomputer makers are entering the field, dropping by the wayside, and modifying their wares. The goal: a good slice of a projected $92-billion market in 1992.

Where does this leave you in making a personal-computer buying decision? Right in the middle, I'm afraid! This is a maturing market with all the attendant fluctuations. Innovative new products will constantly be introduced to tantalize you. This aside, you'll really have to decide which part of the market you should be in: office use, home use, travel use, school use. Reaching this conclusion is the easiest of all, of course. Beyond this point, there are numerous avenues to explore, which we will cover editorially as the months go buy.

The entry of the PC*jr* in 1984, however, adds an important element into the mix—another standard operating system. But a major one that will drive other computer makers to adopt it, just as the IBM PC small business computer forced others to follow suit in this field. And with the Junior's degree of upward compatibility with the more powerful, larger IBM PC, this could well lead the microcomputer industry closer to the single major operating system standard that's always been considered to be wishful thinking. Given this, I would guess that Japan would start moving in less costly home computers that are compatible with PC*jr*, abandoning the MSX standard they fostered.

Art Salsberg

LETTERS

COMPUPHOBIA

Your editorial on the fear of computers in the September issue was really to the point as far as I was concerned. It expressed most of the reasons I did not buy the computer system for which I went shopping last month.

There's no way I can spend that much money unless I know what I am buying. However, none of the employees of the four dealers I visited could speak about computers without throwing out meaningless (to me) jargon; none could tell me if Texas Instruments' computer could be used with the Com-Star printer; and none could tell me just what a specific item of software was about.—*Jim Hyde, Waycross, GA.*

PERFECT WRITER MEMORY

In your review of the Kaypro II computer in the June 1983 issue, it was stated that Perfect Writer's "virtual memory" feature enables the computer to handle word-processing files larger than its 64K memory. This is not true. Kaypro's version of Perfect Writer is capable of editing files no larger than about 50K or 50 pages (depending on your definition of a "page"). The practical limit—that is, the size that permits rapid editing, saving, etc.—is only 20 pages.—*A. S. Pfeffer, Kunming, Yunnan, People's Republic of China.*

MAIL-ORDER 2068

In the article on the Timex Sinclair 2068 computer (November, p. 69), it was stated that one mail-order house planned to offer the computer for $148.32. Whom did he have in mind? Sears Roebuck quotes me $179.99.—*S. S. Whiting, Pittsburgh, PA.*

Best Products, PO Box 25031, Richmond, VA 23260, Catalog page 386, #150002RDM.

PETER NERO

I enjoyed your article about Peter Nero and his use of a personal computer in his artistic and business life. You (and he) might be interested to know that there is, indeed, a Music Printing Option, which can be attached to the Synclavier II Digital Music System to produce printed scores from music played into the system's digital recorder through a real-time keyboard. The Synclavier II (New England Digital Corp., White River Junction, VT 05001) also includes a 16-bit, 128-Kb computer and a 640 × 480 video terminal.—*Frank Benoit, Boston, MA.*

H/Z AND IBM COMPATIBILITY

I was happy to see the review of the Heath-Zenith-100 in your October issue. This is an excellent machine that has been too long neglected in the press.

It should be noted that it is not true that the Zenith and IBM are totally software incompatible. The Zenith will read directories from all IBM disks that I have had a chance to try. It will read and can use all data files. Most programs require some modification. However, I have one program written for the IBM in compiled BASIC that the Zenith was able to run with no problems. Another IBM program written in Interpretive BASIC was run by the Zenith after first loading it into the IBM, then saving it in ASCII format.—*Erick Smith, Brooktondale, NY.*

OUT OF TUNE

In "A DC Motor Speed Controller" (October, p 57), Figs. 4 and 7 were inadvertently interchanged, as were Figs. 5 and 8.

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NEW PRODUCTS

HARD-DISK PORTABLE COMPUTER

Eagle's new Spirit XL combines a 10M hard-disk system with a portable computer that features IBM PC and XT compatibility. It incorporates extensive graphics, color monitor, enhanced standard IBM PC keyboard, 9" green video display screen, two serial and one parallel ports, 360K $5^1/_4$" floppy-disk drive, monochrome/color graphics display card with composite-video and RGB outputs, and four IBM PC-compatible hardware slots. The computer is built around the 16-bit 8088 processor and has a socket for an 8087 coprocessor option. It comes with 128K (expandable to 640K) of RAM. Display resolution is 640×200 pixels, and up to eight colors can be displayed on an optional monitor or eight levels of intensity on the built-in monitor. Also supplied with the less-than-33-lb portable are MS-DOS and CP/M-86. $4795.

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DAISY-WHEEL PRINTER

Data Terminals & Communications' DTC Style Writer daisy-wheel printer features a 35K (expandable to 67K) buffer and a multicopy mode that repeats printing of selected documents without having to reload the buffer from the computer. Features include: bidirectional printing; automatic proportional spacing; Centronics parallel interface; graphics plotting; two-color printing; momentary pause for paper, printwheel and ribbon changing; self-test diagnostic routine; and LED indicators for all error conditions. Options include a forms tractor, bidirectional cut-sheet feeder, 17 type fonts, buffer memory add-in, and a variety of interconnecting cables for most popular computers. $899. **Address:** Data Terminals & Communications, 590 Division St., Campbell, CA 95008.

HARD-DISK DESKTOP COMPUTER

Morrow's new Model MD11 desktop computer offers 11M of hard-disk and 400K of floppy-disk storage, full-size terminal, and eight software packages for just $2795. Hardware features of the single-board computer include: Z80 processor running at 4 MHz; 128K of RAM; 8K of ROM; 12" video screen (80 × 24 characters); parallel Centronics port; and three serial ports. Two of the serial ports are standard RS-232C configurations; the third can be either RS-232C or any of a number of special modes, including high-speed RS-432, or mainframe-compatible modes like HDLC, SDLC, or bisynchronous. Software packages supplied with the MD11 include: CP/M Plus; BASIC 80; BaZic (North Star compatible BASIC), New Word word processor; LogiCalc spreadsheet; Correct-It spelling checker; and Personal Pearl database manager.

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INTELLIGENT INTERFACE FOR COMMODORES

Limbic Systems' "Interpod" is an intelligent 6502-based transparent multiple interface that gives serial and parallel capabilities to VIC-20 and Commodore 64 computers. It allows the computer to communicate with all Commodore serial IEEE and IEEE-488, as well as RS-232, devices. It uses no computer memory, and use of the various I/O ports, including the cartridge slot, is not restricted. The device allows the computer to access from $\frac{1}{8}$M to 10M mass storage on floppy disks and hard-disk systems. Plugging Interpod into the serial port also allows users to compile BASIC programs on the Commodore 4040 and 8050 drives, using PET-SPEED, and gives the VIC-20 and C-64 the capability to communicate with IEEE-based voltmeters, plotters, and other A/D peripherals. $180. **Address:** Limbic Systems, Inc., 1056 Elwell Ct., Palo Alto, CA 94303.

BRIEFCASE-SIZE COMPUTER

The Xerox 1810 portable computer comes with 64K of RAM, 80 × 3-character LED display, 200K microcassette recorder, direct-connect modem, serial and parallel ports, output for video monitor, TV adapter, and slot for plug-in ROM cartridges. Software includes appointment calendar, clock with alarm, four-function calculator, text editor, electronic mail, and BASIC. The 8-bit computer is CP/M compatible and, with addition of an optional Xerox 1850 flat pack can be 16-bit CP/M-86 and MS-DOS compatible. Addition of the 1850 offers dual 500K IBM PC-compatible 5¼" floppy-disk drives, built-in modem, parallel and serial ports for a monitor, printer/plotter, data and power links, and a facility for using an optional four-color printer/plotter. The 1850 is supplied with 128K of RAM and is expandable to 512K. Options include the Xerox 1845 daul 5¼" disk drive expansion unit and a briefcase designed to accommodate the 1810 computer. $2195 for 1810, $2495 for 1850, $1195 for 1845, $325 for briefcase.

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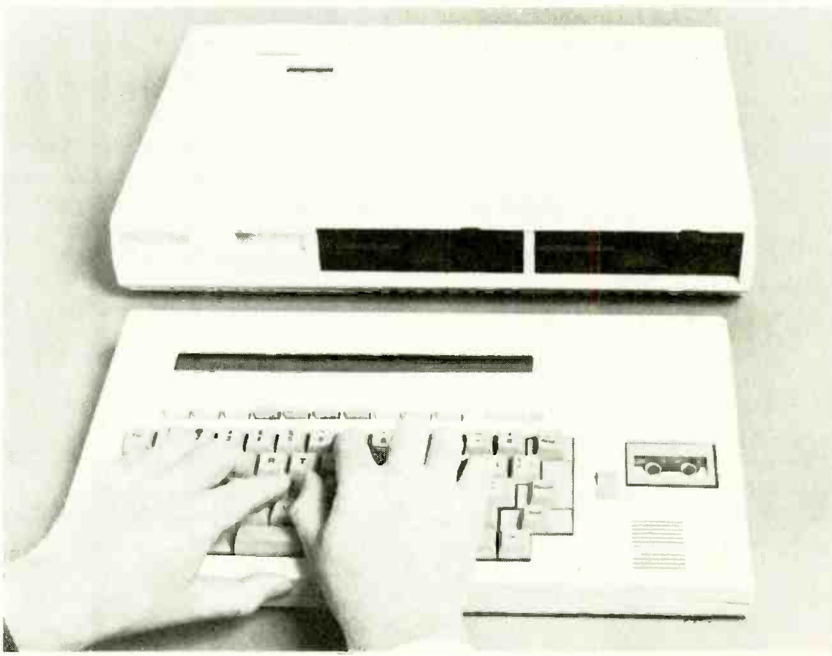

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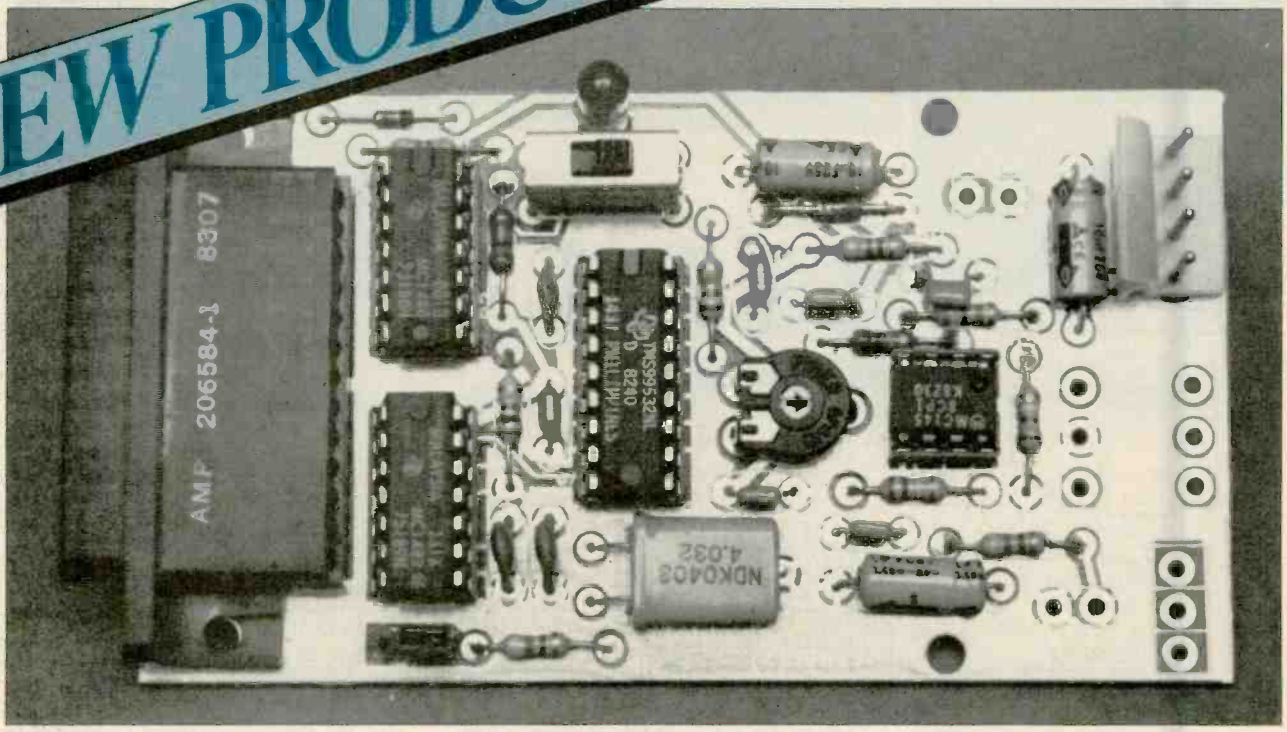

ORIGINATE/ANSWER MODEM

Micromint's build-it-yourself Model ECM-103 is a 300-bps modem kit based on the Texas Instruments TMS99532 FKS modem chip, which provides all the necessary modulation, demodulation, and filtering circuitry to implement a full-duplex serial asynchronous communications link. It requires no calibration or adjustments and uses no external filtering or frequency setpoint components. It lends itself to acoustic and direct telephone-line connection through an FCC-registered DAA. Connection to the DTE is via an RS-232C. $60. **Address:** Micromint Inc., 561 Willow Ave., Cedarhurst, NY 11516.

SOFTWARE SOURCES

Low-Cost Word Processor. Commodore Software's Easy Script 64 is a full-featured word-processing software package for the Commodore 64 and SX-64 portable color computers. Easy Script 64 has the ability to interface with Commodore's Easy Spell 64 spelling checker and to transfer words, phrases, and blocks of text from one location in a document to another. It can change display colors; do global/local hunt-and-find and search-and-replace; go directly to a specified line number; insert/delete characters, words, lines, and blocks; provide sound-effects prompts; print up to 240 characters per line; edit using a special function key; do superscripting and subscripting; and transfer words and phrases. $49.95.

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Apple-IBM Connection. Alpha Software has introduced a new version of its Apple-IBM Connection program that supports the Apple IIe and additional communications cards for the Apple II family. The program enables easy transfer of data files between the Apple II family and the IBM PC or PC-XT and is now compatible with the Apple Super Serial Card and the California Computer Systems CCS 7710 card. $250. **Address:** Alpha Software Corp., 12 New England Executive Park, Burlington, MA 01803.

Equation-Solving Software. Calcu-Plot is a new software package of mathematical utilities from Human Systems Dynamics that transforms complex equations into easy-to-read graphics for Apple II and IIe computers. The program accepts data from the keyboard, disk files, and even print format VisiCalc files. Solved equations can be plotted one at a time or in sets of two or three, all on the same graph. The program can create sequential disk files that can be used with all other software products offered by the company. To be able to use Calcu-Plot, the computer must have 48K of RAM, Applesoft in ROM, and one or two disk drives. $150. **Address:** Human Systems Dynamics, 9010 Reseda Blvd., Suite 222, Northridge, CA 91324.

CP/M- AND APPLE-COMPATIBLE PORTABLE

The Abacus portable computer from CompuSource comes standard with Apple and CP/M compatiblity and can optionally be made IBM PC compatible. Hardware features include: full-size keyboard with auto repeat, 64K of dynamic and 16K of static RAM, either one or two 5¼" floppy-disk drives, five Apple-compatible I/O slots (expandable to seven slots), game paddle port, composite-video and r-f outputs, and high- and low-resolution graphics. $1645 for single-drive unit, $1995 for dual-drive unit, $400 for IBM option.

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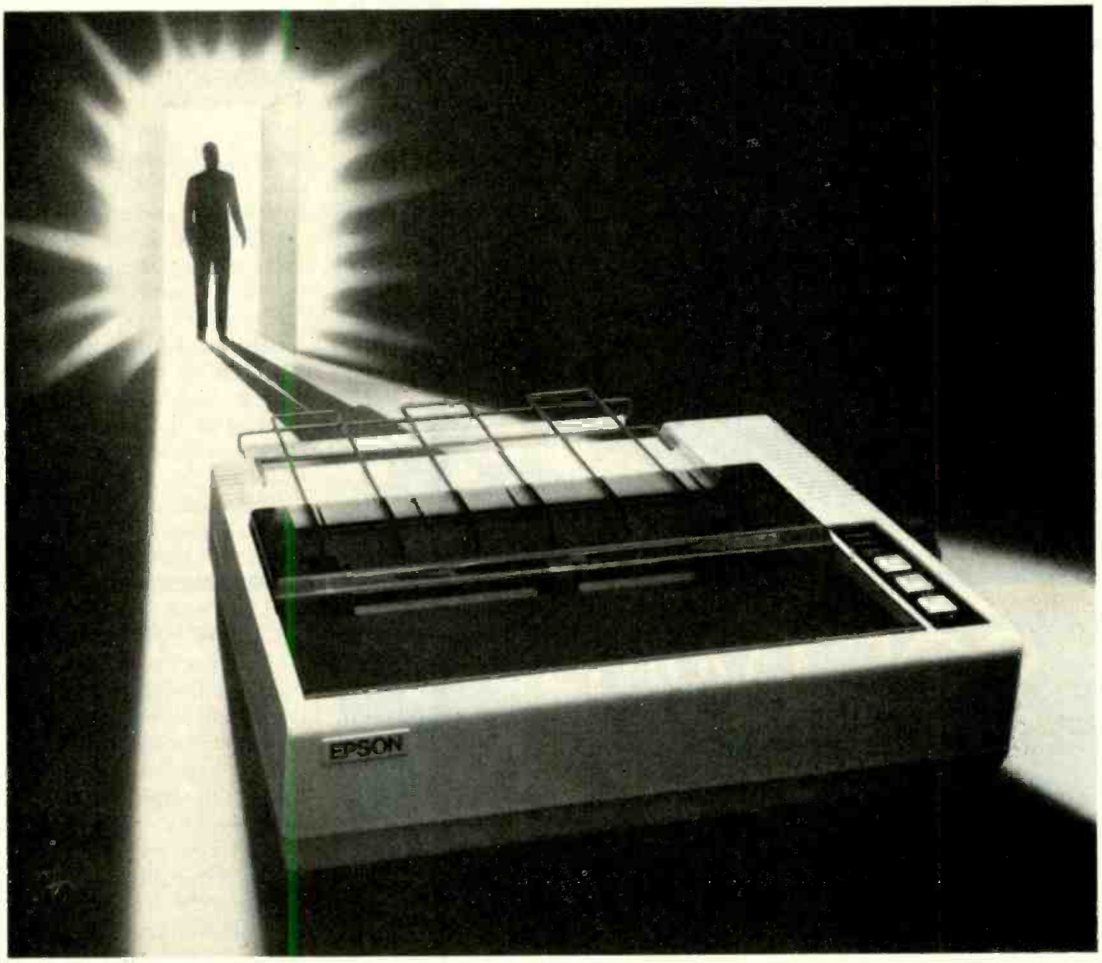
Introducing the new RX-80.



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NEW PRODUCTS

PROGRAMMABLE PORT EXPANDER

A low-cost RS-232C A-B-C-D switch that operates under software control or via manual override has been introduced by Digital Laboratories. The Model ESP-1 port expander creates four RS-232C serial ports from one and permits instant switching to different serial peripherals, using two-character instructions (prefix followed by a port designator). It switches four lines per port and can be cascaded to operate unlimited ports. The 8″ × 6″ × 1.8″ device consumes 5 watts. It comes with a 4-ft RS-232C DTE cable equipped with 25-pin connector. $395. **Address:** Digital Laboratories, Inc., 148 Linden St., Suite 105, Wellesley, MA 02181.

SOFTWARE SOURCES

Telecommunications Software. Source Telecomputing Corp. is marketing a new telecommunications software product called Sourcelink that simplifies use of its electronic service, The Source. The Sourcelink disk provides automatic dial-up and sign-on procedures; direct access to the various services on The Source, through the software or by programming the IBM PC's function keys; simultaneous capture of data from The Source into the **IBM PC's** memory or onto a disk; ability to turn on/off a printer while using The Source; and simplified transfer of data from IBM PC disks to files on The Source or from The Source files to the computer's memory or disks. Additional features include an editor; ability to automatically dial up as many as five other on-line services; and optional use of color graphics for IBM PCs equipped with 128K of RAM and 4- or 16-color graphics board. $149.95, includes membership to The Source.

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Precompiler for BASIC. Software 128's MetaBASIC is a comprehensive precompiler for interpreter BASIC. It permits large BASIC programs to be developed in modular fashion with "real" subroutine calls (not GOSUBS) to other BASIC program modules. Full argument passing is supported, and subroutines can be nested to any level. MetaBASIC also supports Named Global Common, Data Declaration, Structured Conditional Program Control, and Simplified File I/O using Record Data Constructs. Its Program Compression feature allows interpreter BASIC programs to be written in a structured fashion with liberal use of descriptive remarks without slowing program execution or making file sizes excessive. MetaBASIC is available for the **IBM PC** for both interpreter and compiler BASIC. $59. **Address:** Software 128, 363 Walden St., Concord, MA 01742.

English Tutor. T.H.E.S.I.S. has announced a new English grammar program for grades 2 through adult. A two-disk program can create students' disks for use in a variety of educational settings. The student disk can be used as a drill for any combination or all parts of speech and can be set to use a specified number of sentences in each session. Sentences can be modified by teacher or parent to match the reading level of the student. Students' results are stored on disk for viewing by teacher or parent. The program is written to work on **Apple II+** and **IIe** computers. $45.00 plus $3.00 S/H. **Address:** T.H.E.S.I.S., PO Box 147, Garden City, MI 48135.

(More on page 22)

VOLTAGE SPIKE PROTECTOR

General Electric's new Voltage Spike Protector is designed to protect sensitive electrical devices from the effects of high-voltage surges. Rated at 15 amperes, the single-outlet protector plugs between the device to be protected and any three-wire 117-volt ac power outlet. Protection is provided by a GE MOV varistor, which clamps the potential being delivered from the ac line to the device being protected to a safe level below 600 volts. Power from excessive voltage is harmlessly dissipated as heat. **Address:** General Electric Co., 316 E. 9 St., Owensboro, KY 42301.

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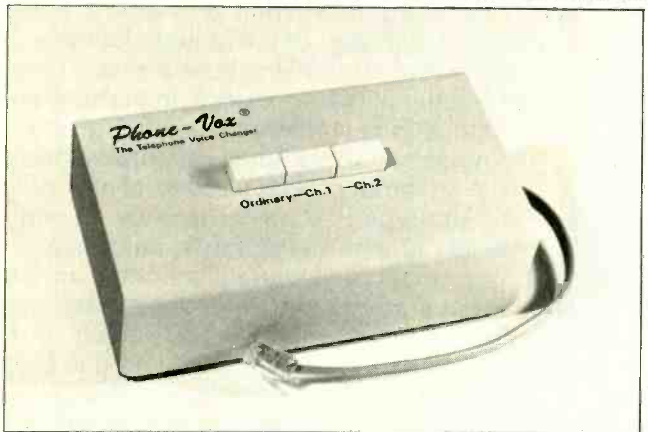

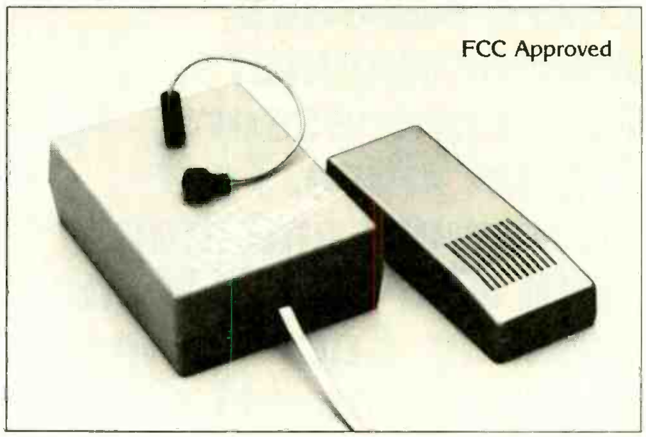

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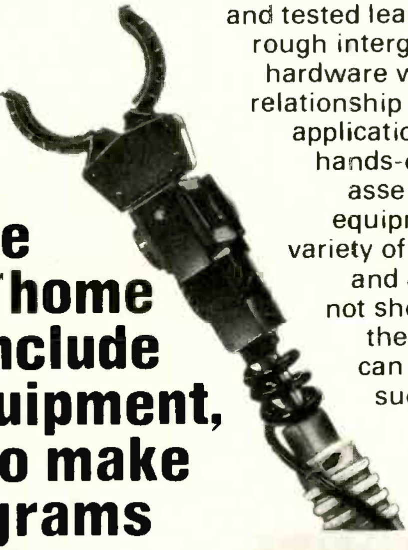

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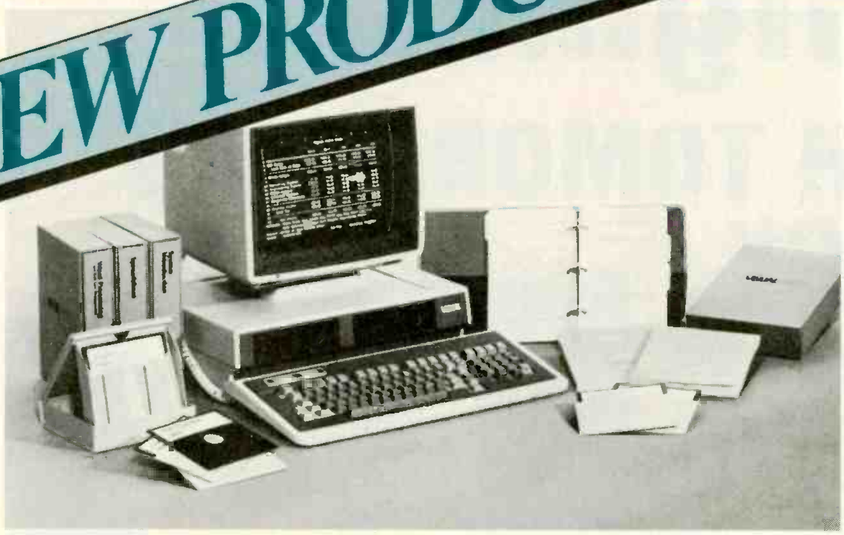

Executive Information Service. Compuserve, Inc. has introduced a package designed to offer the business executive total access to practical business information. The Executive Information Service features a comprehensive package of financial data, current news, decision-support research, and communications options. Among the features it offers are: updated price quotations on over 9000 security issues, information from Standard & Poor's on more than 3000 companies, access to the Official Airlines Guide Electronic Edition, access to the Associated Press Wire Service, electronic communications through Compuserve's InfoPlex Electronic Mail Service and the U.S. Postal Service's E-COM system, and Electronic Conferencing and Professional Forums, including a forum exclusively for **IBM PC** users. While the Executive Information Service can be accessed by most computer terminals and communicating word processors, Compuserve's Professional Connection software, for the **IBM PC,** provides a number of easy-to-use, menu-driven functions valuable to the first-time user. $150.

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The Model 1050 personal computer system from Visual Technology comes bundled with Multiplan, WordStar 3.3, MailMerge 3.3, DR-Graph graphics, GSX-80 graphics device driver, C BASIC, DEC VT-100 terminal emulator, and CP/M Plus software. It uses a Z80A system and 6502 display processors and comes with 96K (expandable to 160K) of RAM, 64K (expandable to 128K) of PROM, and 32K of display memory. Hardware includes: dual 400K $5\frac{1}{4}''$ disk drives; hi-res (640 × 300) bit-mapped graphics and 25 × 80-character monochrome display monitor; printer port; modem port; hard-disk expansion port; and detached typewriter-style keyboard. Options include a plug-in dual-port serial card and hard-disk system. $2695.

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The "Autocrat" from Bi-Comm Systems is a microprocessor-based unit that can be used to remotely control electrical devices through existing ac wiring. It is said to be compatible with almost any computing system and energy-management controllers equipped with RS-232C ports. Autocrat plugs directly into an ac outlet to transmit and receive signals over the power line. It can control up to 256 Leviton/BSR devices and is compatible with all BSR X-10 and Leviton CCS accessories. Included in the Autocrat is a battery-backed CMOS clock/calendar, firmware operating system in EPROM, and self-diagnostic routine. The device can operate as a stand-alone processor or a computer-controlled interface, or under telephone modem control. $485. **Address:** Bi-Comm Systems, 10 Yorkton Industrial Blvd., St. Paul, MN 55117.

TRANSPORTABLE COMPUTER

Radio Shack's new TRS-80 Model 4P is a compact transportable version of the company's Model 4 desktopper. It is totally compatible with all Model 4 programs and can run all Model III TRSDOS and LDOS disk programs (in Model III mode). It is also compatible with the CP/M Plus operating system offered by Radio Shack. The Model 4P comes with 64K of RAM (expandable to 128K), two built-in 184K double-density $5\frac{1}{4}''$ disk drives, 9″ hi-res 80 × 24 display. $1799.

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NEWS, VIEWS & GOSSIP/BY SOL LIBES

RUMORS & GOSSIP

▶ Expect Apple to introduce its long-awaited MacIntosh computer at its annual stockholder's meeting scheduled for this month. That is what they did last year when they announced the Lisa. . . . Hewlett-Packard is rumored to have dropped development of a 68000-based low-end microcomputer since introducing a unit that runs MS-DOS. . . . It is probable that IBM will produce 500,000 home computers this year. . . . IBM has reportedly ordered about a thousand 16032 chips from National Semiconductor for evaluation. The 16032 is National's new 32-bit microprocessor, which it expects to start sampling January 1. That means that IBM is wide open on which 32-bit micro to use. Intel 80386 samples are not expected for another 6 months yet. National claims the 16032 has the power of a VAX. . . . Sources report that Microsoft is developing a networking version of MS-DOS, to be called, you guessed it, "MS-Net". . . . The IBM XT is doing much better than expected and industry pundits estimate that IBM will need 1.8 million 10-Mb drives this year with most going to the XT. If true, it means that Seagate Technology, MiniScribe, and IMI are going to make a mint. . . . According to *Business Week* magazine, "IBM has already ordered enough components to build 2-million computers" this year. . . . According to Daniel H. Wilke, IBM PC manufacturing engineer, "a computer is made every 45 seconds."

APPLE DOINGS

▶ Among problems that Apple must address is that of Lisa compatibility and communications. The first part, Apple plans to handle by introducing a plug-in 8088 processor that will allow users to run MS-DOS and most PC-compatible software. This package is being developed by Apple for Microsoft. The second problem will be dealt with by the introduction, hopefully in the first quarter, of networking and communications controllers that will allow Lisas to talk to other micros and to mainframes. In another attempt at industry compatibility, Apple shut down its disk drive manufacturing and had decided to buy its drives outside.

Apple has also announced that it will increase the number of Lisa dealers from 130 to over 200. It is also expected that Apple will introduce a hard disk for the IIe and a plug-in board that will provide the unit with enhanced display features, such as windowing.

BATTLE OF THE OPERATING SYSTEMS

▶ According to John Rowley, President of Digital Research Inc., DRI currently has about 900 contracts with OEMs for CP/M (including both 8-bit and 16-bit systems), And industry estimates are that Microsoft has about 200 OEM contracts for MS-DOS. Further, Digital Research boasts that CP/M is now running on over 1.5-million computers worldwide. Similar estimates of systems running MS-DOS are less than half this number.

Digital Research is also known to be developing a new version of Concurrent CP/M-86, upgrading it to have many of the features of CP/M-80+, windowing, and the ability to run MS-DOS software. In the meantime, version 3.0 of MS-DOS, which Microsoft had promised to start shipping last fall, has been delayed. The new version of MS-DOS is expected to be compatible with Microsoft's Xenix multi-user system and concurrency (a la Concurrent CP/M-86).

In the meantime, Digital Research has introduced CP/M-80, which has the operating system and processor integrated on one chip. This is expected to be used by manufacturers of low-cost home computers.

QUOTATION OF THE MONTH

▶ "The shakeout of 1985 is happening now."

—Steve Jobs, Chairman,
Apple Computer Corp.

IBM DROPS 4" DISK DRIVE

▶ After nearly a year of trying to find OEM purchasers, IBM has given up on its 4" floppy-disk drive. The problem appears to be that the device did not use any of the current disk interface standards; and it was more expensive than the 5.25" drives.

IBM BOOSTS STAKE IN INTEL

▶ IBM bought another 1.71-million shares of Intel stock, bringing its interest in Intel up to 15.2%. It started with 12.5%, then boosted it to 13.7% before the latest purchase. Most of the shares were bought in blocks of 40,000 to 60,000. Under an agreement between the two companies, IBM can purchase no more than a 30% interest in Intel.

While on the subject of stakes, it should be noted that IBM also boosted its equity position in Rolm Corp. from 15% to 17.7%. Rolm makes sophisticated PBX systems. This apparently indicates IBM's intention to start actively competing with AT&T in this lucrative market. Why not? Isn't AT&T planning to jump into the computer business?

Along these lines there are rumors that, in the light of IBM's decision to drop the 4" floppy, it intends to buy into a disk maker such as either Seagate or Tandon. One question that comes to mind is why hasn't IBM bought into Microsoft?

PREDICTIONS

▶ Egil Juliussen of Future Computing, a market research firm, predicts that, by the end of the year, IBM will have 18% of the $2.9-billion home computer market, and by 1988 it will have 45% of the $5.9-billion home market. He said that distribution through mass merchandisers is required and over 10,000 locations are needed to be a leader in the home market.

CAN AT&T COMPETE WITH IBM?

▶ AT&T is expected to introduce a personal computer soon to compete head-on with IBM. It is expected to employ a 32-bit micro and run Unix with an emulator that will allow users to run MS-DOS software. According to International Resource Development, Norwalk, CT, a market research outfit, the software is being developed by Microsoft. The system is expected to be significantly more powerful than the XT. IBM will probably respond with price reductions on the XT and, later, with the introduction of a more powerful desktop based on a new 32-bitter.

ROBOT STANDARDS FOR LANGUAGE & SAFETY

▶ The Industrial Automation Planning Panel of the American National Standards Institute (ANSI) is pursuing the development of standards for robot programming languages and safety. The lack of language standards is currently making it difficult, if not impossible, to transport software and interface different robots in automated factories.

The National Bureau of Standards (NBS), which previously developed programming standards for CAD/CAM (Computer Assisted Design/Computer Assisted Manufacturing), is also working on a language standard for robotics.

In the area of robotic safety the Robot Institute of America (RIA) and the Underwriters Laboratories (UL) are both working on standards. Areas of concern include installation, programming/teaching, and maintenance.

NBS, RIA and UL are all members of ANSI's panel.

RANDOM NEWS BITS

▶ Move over Gucci and Gloria Vanderbilt! Make way for the "Apple Collection" of clothes and gifts bearing the Apple insignia. Items range from low-cost bumper stickers and cocktail napkins all the way up to a $900 windsurfer bearing the Apple logo. . . . Atari has reportedly laid off another 380 staffers in a continuing shift of manufacturing to offshore. . . . Binary Star Inc., Bellevue, WA, claims to have developed a high-brightness flat color display panel with almost unlimited area and pixel density using straightforward digital raster scanning. Initial use is expected to be in a three-dimensional display for the military and CAD applications, with possible later use in TV. . . . IBM has begun letting software-only stores sell IBM brand software. The first such chain (32 stores) is Software Centres International of Los Angeles. . . . There are now over 800 PC dealers in 26 countries outside North America. . . . Judging by companies exhibiting at trade shows, training of end users is becoming a big business, with close to a dozen companies already getting into the action.

How Computers Create Color

THE NTSC (National Television Systems Committee) method of transmitting and receiving color TV has been around for a few decades and has proved to be reasonably good in reproducing color TV images.

Until the introduction of video games and personal computers, all using digital techniques, color TV and color video monitors operated only with analog signals. Since analog and digital techniques are different, circuit designers had to develop new concepts to provide interfaces between the digital circuit and the analog color system to "fool" the latter into thinking that it was receiving an analog color signal instead of a stream of digital pulses.

Different techniques are used by various manufacturers. This piece will cover color circuits used within the popular Apple II computer, as an example. The technique is contained in U.S. Patent 4,278,972, "Digitally Controlled Color Signal Generation Means For Use With Display" by Stephen G. Wozniac, assigned to Apple Computer Co.

The Apple II has two color modes—HIRES (high resolution) and LORES (low resolution). Each will be covered in turn.

High Resolution. A pixel is a picture element that appears on the screen as a small dot. HIRES specifications call for a picture that is 192 pixels high by 280 pixels wide. However, the latter number is not quite correct.

As shown in Fig. 1, a single horizontal line can be divided into 280 "cells," each occupied by a single pixel. However, the pixel, being slightly smaller than the cell, can be either centered completely within its cell or it can overlap the adjacent pixel cell. Thus, it is possible to have up to 560 pixel positions on a single horizontal line. In fact, in the monochrome mode, that is exactly how many pixels there are.

In the HIRES color mode, the circuit is designed so that any one data byte poked by BASIC or machine language into the pertinent screen location contains the binary signals to form either of two sets of colors. One set consists of violet, green, black or white, while the other set can be selected from blue, orange, black or white. However, you cannot use colors from both sets in the same byte.

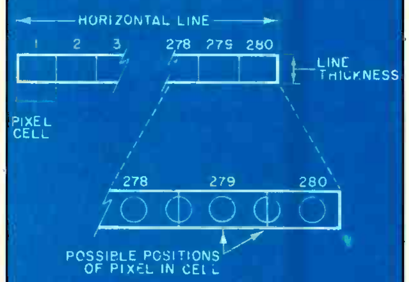

Fig. 1. A pixel can be centered in its cell or can overlap the adjacent pixel cell.

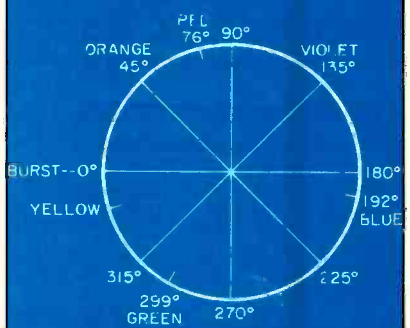

Fig. 2. Each color is a certain number of degrees from reference.

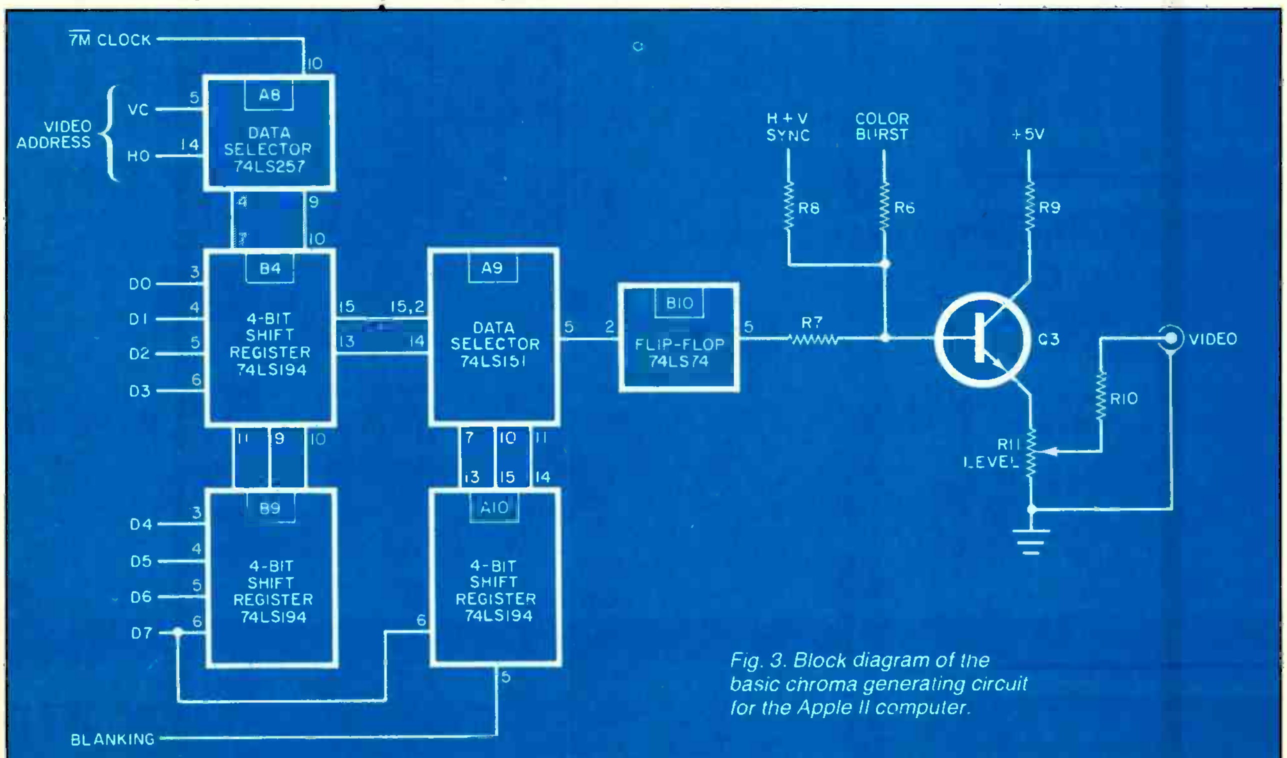

Fig. 3. Block diagram of the basic chroma generating circuit for the Apple II computer.

HIRES Circuit Operation. Before we discuss the basic chroma generating circuit within the Apple II, observe from the vector diagram of Fig. 2 how the various colors in the NTSC color system are defined. Note that all colors are referenced as "so many degrees" offset from the 3.579545-MHz reference burst that establishes the 0-degree point. Circuitry within the TV receiver or monitor creates the vector pattern. In reality, the various colors blend smoothly into each other and there is no sharp demarcation between colors (as in a rainbow or prism). Color saturation is a function of the pulse duty cycle, as will be explained further along.

The basic chroma generating circuit for the Apple II is shown in Fig. 3. The letter and number in each logic block indicates the IC's physical location on the Apple II motherboard in case the reader wants to use a scope to observe actual circuit operation.

Let us start with the violet color. As shown in Fig. 4, this color is generated by having 10101010 (85 decimal, 55 hex) present on the D0-D7 data lines. Note that, in this and the following discussions, the LSB (least significant bit) starts the single-file "parade" of binary bits exiting from the shift registers. Note also that, before clocking, the D0 bit is always present at the register output.

The two 4-bit shift registers (*B4* and *B9*) are interconnected to form one 8-bit register. As the data selector (*A8*) clocks the composite 8-bit shift register, the alternating pattern of 1s and 0s is shifted out—LSB first—to be applied to data selector (*A9*). Figure 4 shows that this particular square-wave pattern is delayed by 135 degrees from the reference burst. According to the chroma phase diagram of Fig. 2, 135 degrees is the required angle for violet.

For blue, the 8-bit shift register is provided with 10101011 (213 decimal or D5 hex) on the D0 through D7 data lines as shown in Fig. 5. Note that the low-order seven bits for blue are the same as the low-order seven bits for violet (10101010 vs. 10101011). The difference is in the bit on the D7 line. For violet, it is a 0; and for blue, it is a 1.

As shown in Fig. 3, data selector *A9* is driven from register *B10* when bit D7 appears as a logic 1. This causes the data selector to switch its input from the 8-bit shift register to the output of flip-flop *A11*, as in Fig. 5. Observe that the 8-bit shift register data is also coupled to flip-flop *A11*, which when clocked at a 14-MHz rate produces a delay equivalent to 90 degrees of phase shift.

Thus, the violet waveform at 135 degrees is delayed a further 90 degrees, producing 225 degrees (blue). Therefore, the difference between violet and blue is the extra 90 degrees of phase shift produced by the action of the logic-1 bit on the D7 line.

A little study will show how the other colors can be produced by changing the data byte on the D0 through D7 lines, and noting the action when flip-flop *A11* is turned on when bit 7 is a 1.

If the D0 through D7 lines contain all zeros, black will be produced since the 8-bit shift register output is always low (with *A11* activated, the output is still low). If the D0-D7 lines contain all ones, output of the 8-bit shift register remains high—even with *A11* turned on by the high at D7—thus producing white.

Low Resolution. The LORES mode uses the same hardware as HIRES but it is software switched into the arrangement shown in Fig. 6. The major change is that shift registers *B4* and *B9* now form two 4-bit registers instead of a single 8-bit device as used in HIRES. Each is selected by data selector *A8*.

Unlike the single dot pixels used in the HIRES mode, each LORES pixel is actually a block that is four scanning lines high and seven dots long, with each pixel stored as 4 bits. Data lines D0 through D3 feed shift register *B4* to determine one pixel, while data lines D4 through D7 feed shift register *B9* to create the other pixel. Thus, the 8-bit data bus generates two pixels.

The two shift registers actually generate four pixels (on even and odd bytes) with each addressed via the four combinations of the H0 and VC signals applied to register *A10* (Fig. 6). The VC signal changes every four scanned lines, while the H0 signal changes every 978 nanoseconds. These signals, along with the blanking signal applied to register *A10*,

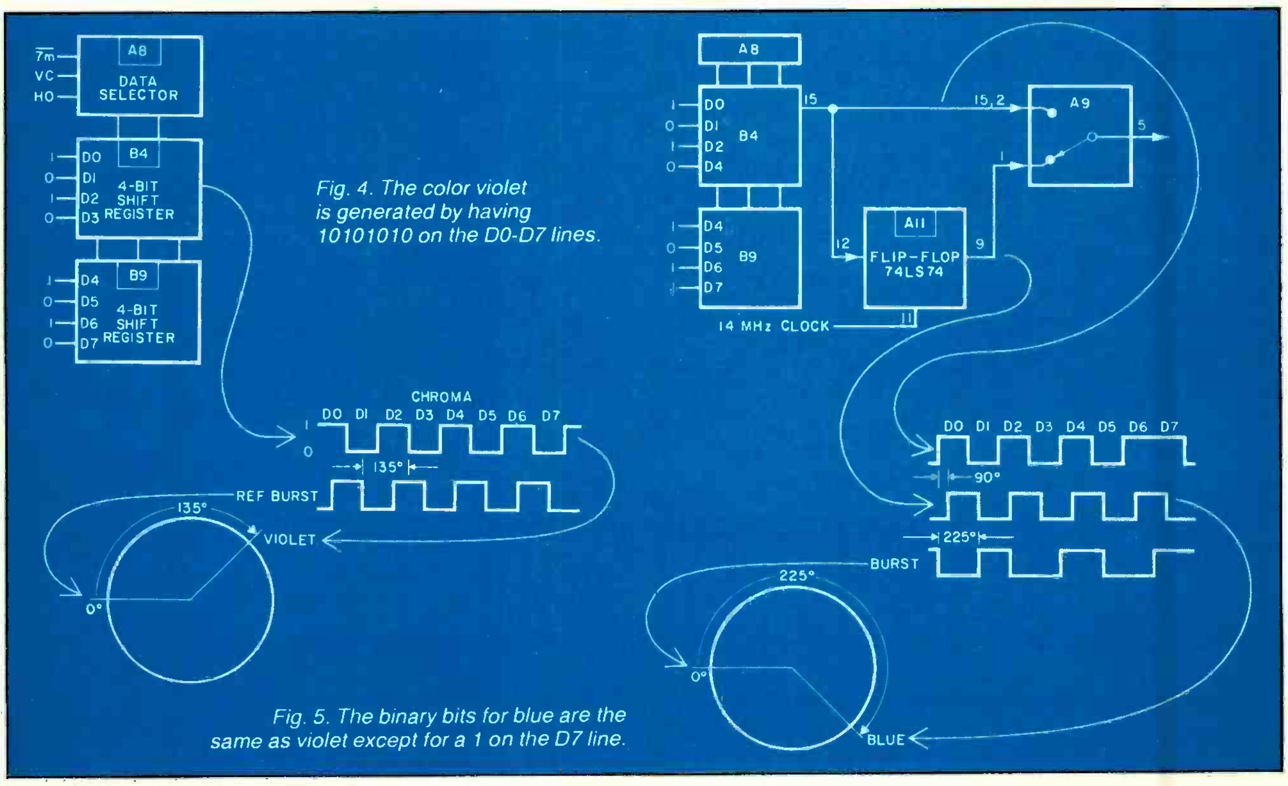

Fig. 4. The color violet is generated by having 10101010 on the D0-D7 lines.

Fig. 5. The binary bits for blue are the same as violet except for a 1 on the D7 line.

determine which pixel passes through data selector *A9* at any particular time.

Now, let us see how LORES color is created using the partial logic arrangement shown in Fig. 7. The output of the selected 4-bit shift register (*B4* and *B9*) is passed to two circuits—data selector *A9* (Fig. 6) and the video output circuit, and then back to the bottom of the 4-bit shift register (Fig. 7). Thus, as the shift register is clocked, the data present on data lines D0(D4) through D3(D7) circulates through the register. While this is going on, the H0 and VC lines are selecting the desired "pixel."

As shown in the waveforms of Fig. 7, for "plain" green, the waveform is displaced 315 degrees from the reference. The waveform that generates dark green is not a square wave, but has a 25% duty cycle (it spends ¾ of its time at logic 0, which is essentially black). The fact that the waveform is at 270 degrees still makes it green, but a little darker since, besides the 25% duty cycle, it is also closer to blue on the phase diagram of Fig. 2.

On the other hand, note that the waveform for light green spends ¾ of its time at the logic 1 level. Since logic 1 is white, the greenish color is diluted. Thus, you can see how a change in duty cycle changes the saturation (density) of a color.

Obviously, all 0s on the data lines produces black, and conversely, all 1s generates white. This means that a double-frequency square wave (1010 on the data lines) produces grey.

If you now go back to either Fig. 3 or Fig. 6, you will note that, after leaving flip-flop *B10*, the chroma information is matrixed into emitter follower *Q3* along with the horizontal and vertical sync signals and the 3.579545-MHz reference burst.

Due to the limited bandwidth of the *Q3* circuit, the interconnecting cable, the r-f modulator if used, and when coupled with the restricted bandwidth of the TV receiver, the higher frequencies that form the sharp corners of the square wave are lost. This makes the edges of the square waves round off, making them look somewhat "sine-ish," and thus acceptable for the NTSC system. Note also that, although the horizontal and vertical sync signals generated by the Apple are not exactly as specified by NTSC, they are close enough so that the bulk of TV receivers and video monitors will lock to them. ◇

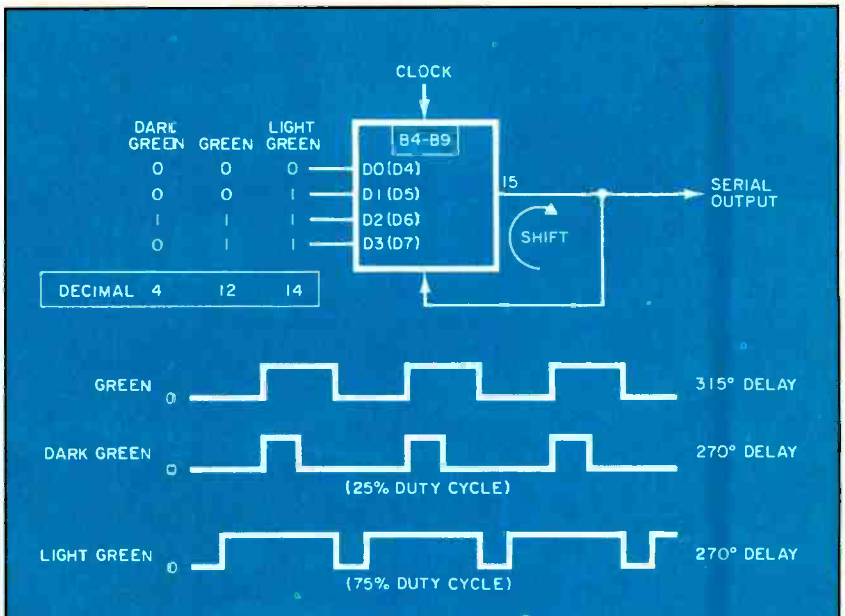

Fig. 7. Plain green is displaced 315° from the reference.

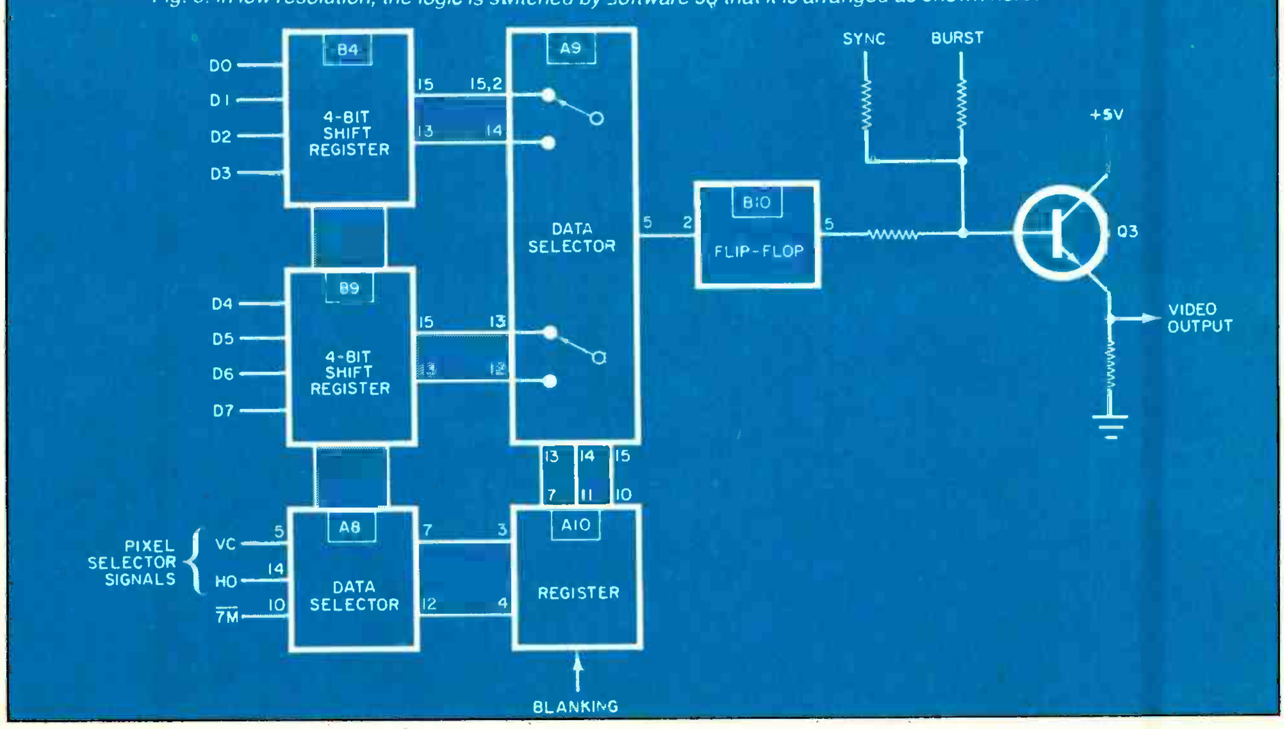

Fig. 6. In low resolution, the logic is switched by software so that it is arranged as shown here.

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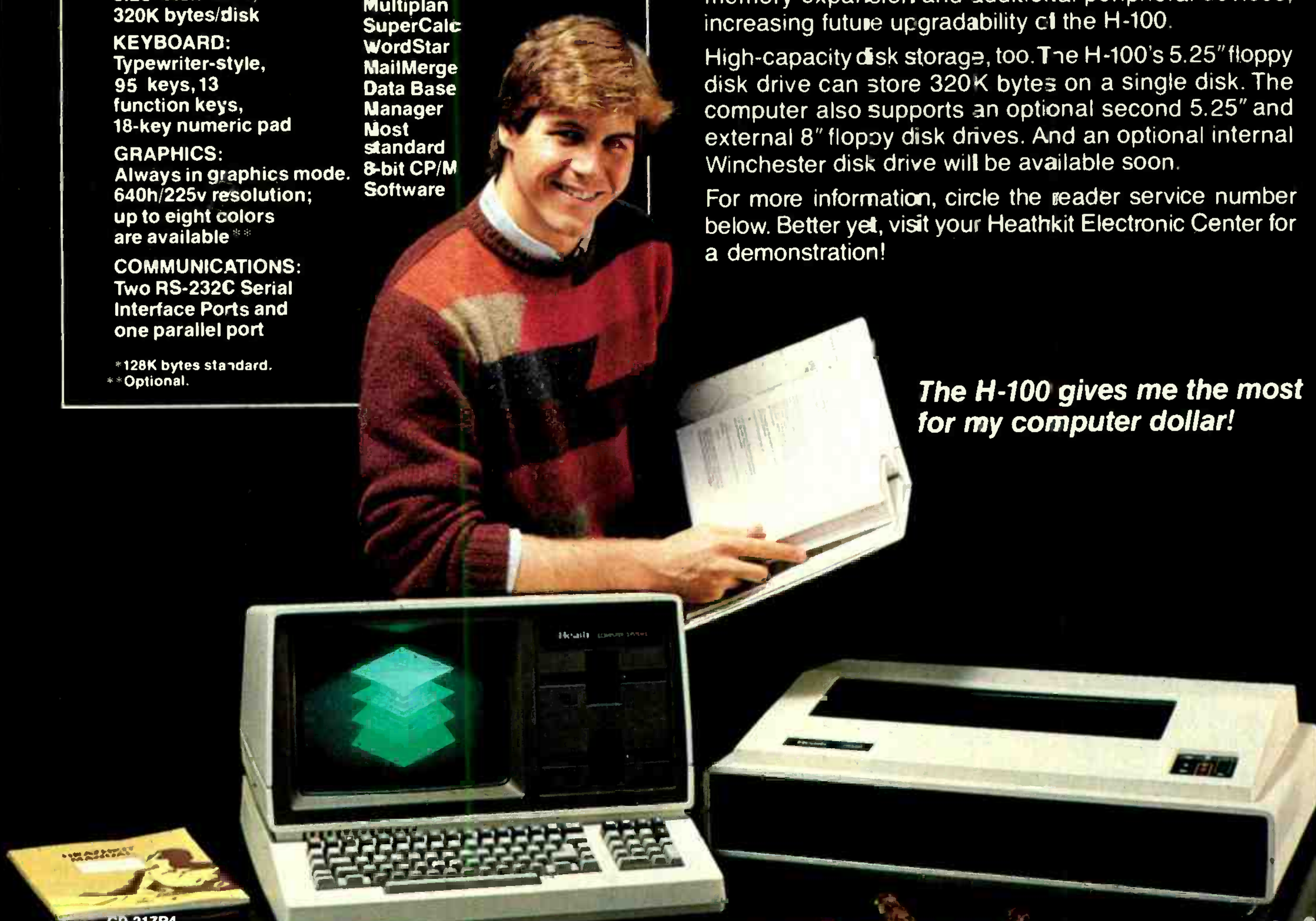

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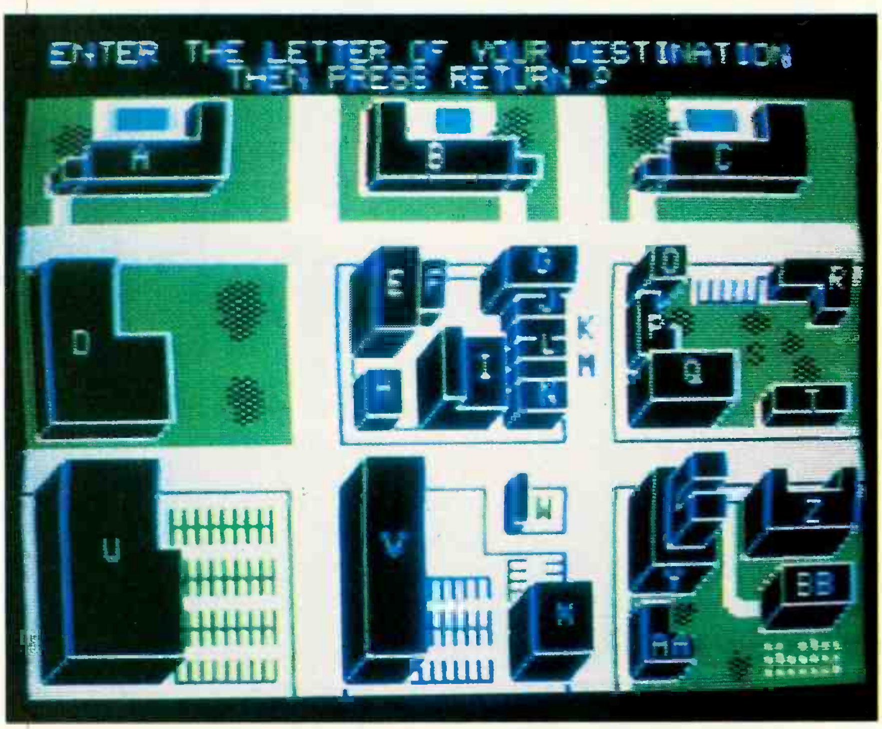
COMPUTER VIDEO GAMES

Hands-On Reviews of Recently Released Game Software

GATEWAY TO APSHAI

ROM Cartridge for Atari 400/800
Epyx Computer Software, 1043 Kiel Ct., Sunnyvale, CA 94089; 408-745-0700.

Graphics ★★★★
Gameplay ★★★★
Sustained Interest ★★★★
Type: Joystick action/maze/adventure game
Memory Required: Resident ROM



Some of the graphics for "Murder by the Dozen" are fascinating.

Once again, we're presented with an adventure game-maze combination from Epyx, this time on a plug-in ROM cartridge. The object of the game is to complete all eight levels, scoring as many points as possible along the way. You complete a level by moving your hero through a maze of dungeons, fighting off monsters and avoiding traps, while picking up treasures to score points.

This is also a time-oriented game; if you haven't finished in 6.5 minutes, your hero is automatically transported to the start of the next deeper level. If that sounds like you're getting a freebee, forget it. Your five lives won't last long enough to run the clock out unless you decide to pace the floor in just one dungeon.

I found that keeping the game in the "fight" mode (selected with the "Start" key) helps to save a little time in doing battle with the several types of monsters encountered. Otherwise, the monster can get a couple of hits on you while you take your hand off the joystick to press the "Start" key. These monsters include such unlikely creatures as the Mamba Snake, the Ghouls and the Slime Mold (called "Fungus" on the screen).

By hitting the "Select" key, you can retrieve a set of keys from your bag to open locked dungeon doors that bar your progress with annoying frequency. That means getting out of the fight mode, which inevitably lays your hero open to danger.

During the game, when you use the Select key, you can check on such things as your status: strength, agility, luck, health, etc. You will also be able to see a full inventory of the treasures, spells, and useful objects that you're carrying.

Gateway has eight levels, 16 dungeons on a level, and about 60 rooms in each dungeon. That's a whopping 7500 different rooms for you to explore, which is a tall order no matter how much time you have.

The automatic screen scrolling is effortless and smooth, which means that the Epyx programmers have fine-tuned this particular aspect of the maze. This is an especially good game for adventure and maze game lovers. It has so many convolutions and twists and turns that it should be good for many an evening of enjoyment.

MURDER BY THE DOZEN

Diskette for Apple, Commodore 64 and IBM PC
CBS Software, One Fawcett Pl., Greenwich, CT 06836; 203-622-2500.

Graphics ★★★★
Gameplay ★★★★
Sustained Interest ★★★★
Type: Keyboard mystery game
Memory Required: 48K

Mystery lovers rejoice! This latest entry in the convoluted pathways of computerized sleuthing is a combination text game with some throwaway graphics that help give you proper perspective. Some of the graphics are just window dressing; others, like the three-dimensional city map, are a pleasure and joy for computer nuts like me.

There are 12 possible cases; you pick the one you want to work on. They're all murders, and some are rather improbable.

CBS has supplied a mountain of documentation: a detective (instruction) manual, a book of clues that tells you the meaning of clue numbers that appear on the screen, a special printed pad to keep track of the case, and a confidential book of solutions.

The game is really designed more as a parlor exercise with up to four players matching wits with one another. It's exceptionally well done, intriguing, and one of the better text-style mystery computer games we've seen.

B.C.'S QUEST FOR TIRES

Diskette or ROM cartridge for Atari 400/800
Sierra On-Line, Inc., Sierra On-Line Bldg., Coarsegold, CA 93614; 209-683-6858.

Graphics ★★★★
Gameplay ★★★
Sustained Interest ★★★
Type: Joystick action game
Memory Required: 32K

If you follow the comic strips, you're familiar with B.C. and star character Thor who is always riding on his uniwheel. The graphics and animation of this game—actually designed by the comic strip's creator, Johnny Hart, are true to the sense and feel of the newspaper version.

Thor is at once comical and semi-tragic as he rides his wheel across the country to try to rescue Cute Chick, who's being held a prisoner by a dinosaur. The trip is loaded with hazards: boulders and craters to be jumped over, tree limbs to duck under, a river to cross by hopping stepping-stone fashion across turtle's backs. And on the other side awaits arch enemy Fat Broad with her club ready to do Thor in.

Then comes the lava pit, which our hero can cross by grabbing onto Dooky Bird's legs. Then there are a rushing, dangerous downhill sprint, crossing a ravine, ducking a volcanic eruption, and finally one more river to cross just before the dinosaur cave. Can Thor finally save Cute Chick from her fate? It all depends on your skill.

HARD HAT MACK

Diskette for Apple II
Electronic Arts, 2755 Campus Dr., San Mateo, CA 94403; 415-571-7171

Graphics ★★★★+
Gameplay ★★★★+
Sustained Interest ★★★★
Type: *Two-button joystick or keyboard strategy/action game*
Memory Required: 48K

When we see a game with the Electronic Arts logo, we expect excellence, and Hard Hat is no exception. This is a multilevel, get-through-the-task-and-avoid-being-killed kind of game. If you have an analog joystick with two firing buttons, it goes a bit easier and faster.

Mack is trying to work on his construction job—putting steel girders into place and then riveting them. But he has two enemies and several on-the-job hazards. The first enemy is called OSHA (that Federal safety agency that finds danger in *every* job situation) and the second is a vandal. If Mack runs afoul of either one, he loses a life.

He can also get hit by runaway hot rivets that fall and bounce down the screen, and he can fall off a girder. He has an elevator to help him get between construction levels on the screen. So much for the dangers in the first level.

The second level gets harder. Mack has to jump on conveyers and ride a girder up into the stratosphere to collect tool boxes. He has to avoid his usual enemies plus added dangers.

In the very difficult third level, Mack has to collect all the steel blocks and drop them through holes in the girders into the rivet machine. There's an elevator in this level that Mack can use, and he has to watch for the port-a-potti. There are three more levels, but we aren't good enough to see them yet.

In Level 2, Hard Hat Mack rides a girder to the top to collect tool boxes.

OIL'S WELL

Diskette for Atari 400/800
Sierra On-Line, Inc., Sierra On-Line Bldg., Coarsegold, CA 93614. 209-683-6858.

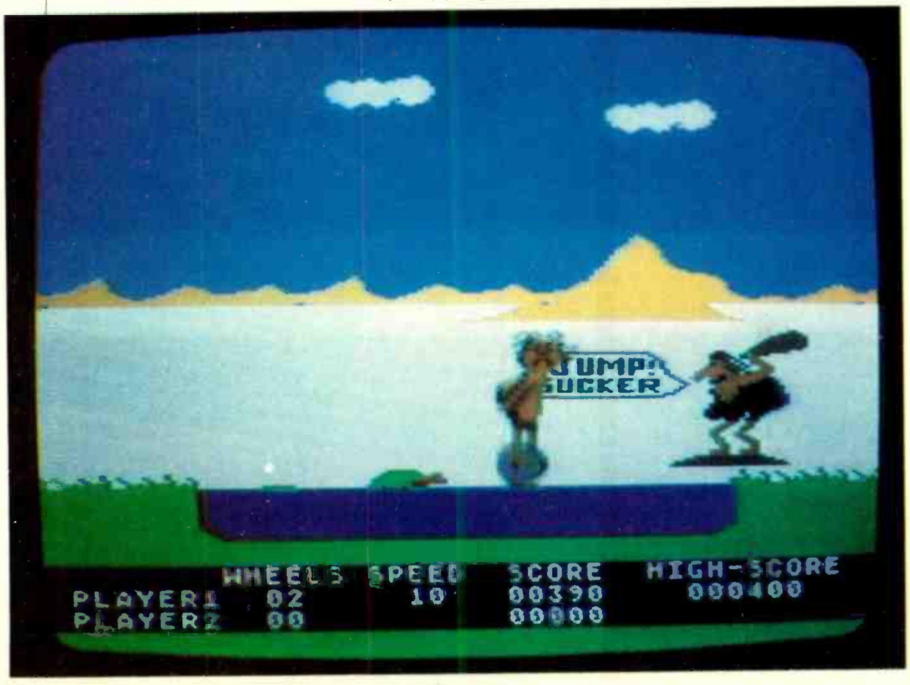
Graphics ★★★★
Gameplay ★★★★
Sustained Interest ★★★★
Type: *Joystick action game*
Memory Required: 32K

This is another one of those games inspired by Pac-Man, but in our opinion, it's much more original and interesting than most of the copycats. You have to go after the oil field with a drill bit that looks very much like old Pac-Man himself, but he's attached to a pipeline that snakes around mazelike shafts and passageways gobbling up oil "pellets", oozies and goblets.

There are land mines which can destroy the bit but not the pipe. The oozies—of which there are plenty, will destroy your extended pipe if you let them get near it. The only defense is to retract to the wellhead in a hurry with the firing button on the joystick.

This is a high-speed, high-skill game, and certainly one of the better of the twitch variety that we've seen recently.

Thor has to cross a river by hopping from one turtle's back to another.

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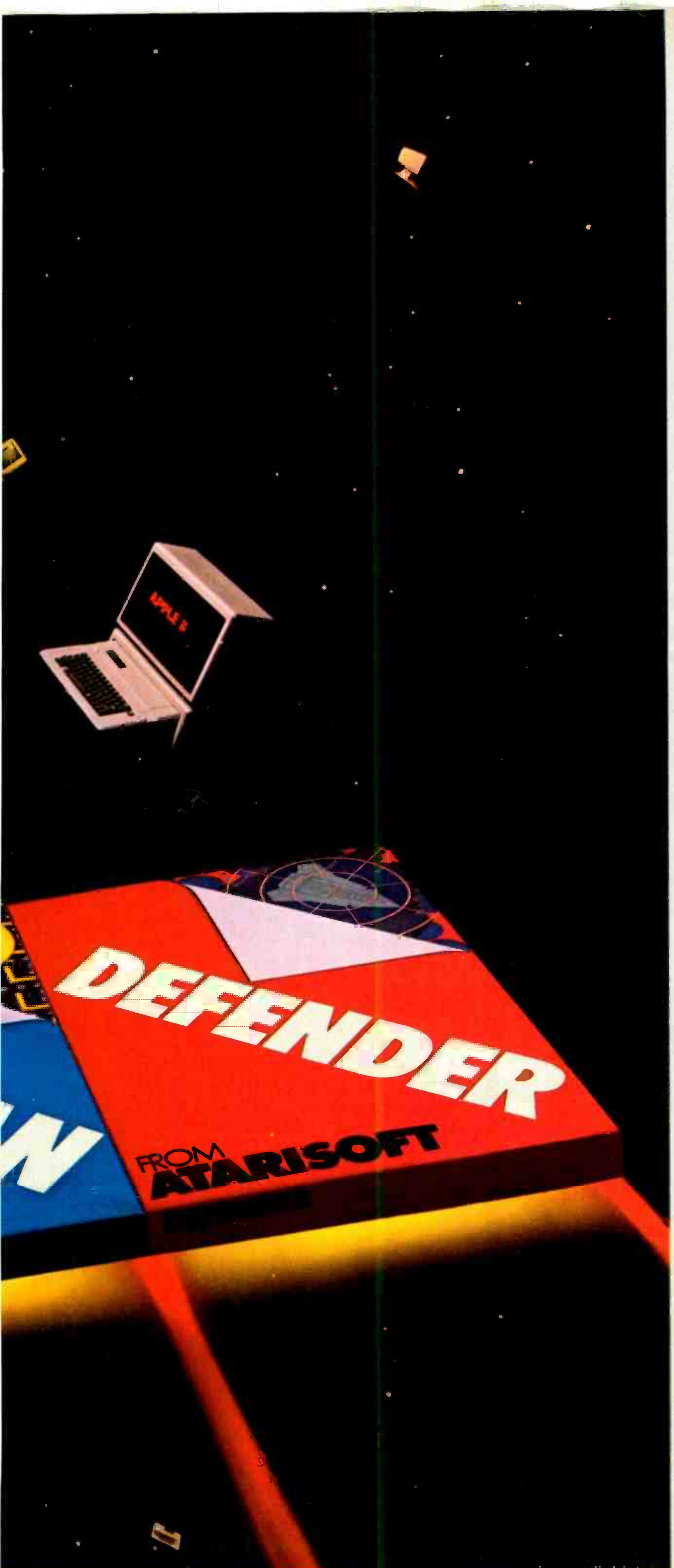
APPLE II
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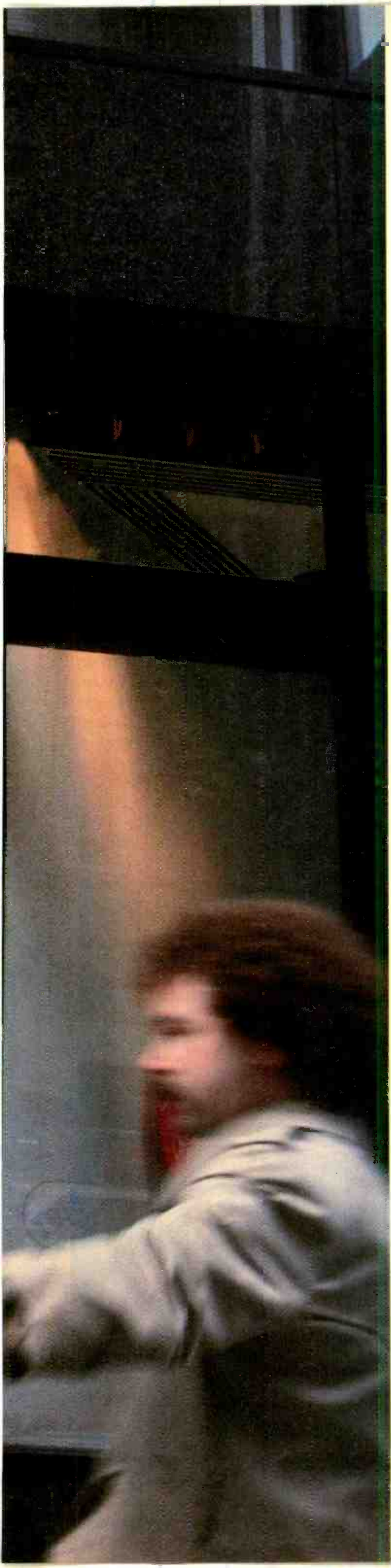

INSIDE STORY

IBM's Peanut: A PC in a Junior-size Package

Offering upward compatibility with the PC, jr reveals some surprizes, including a cordless keyboard
By George Mitchell

THE long-awaited IBM home system is here and it sports some interesting surprises.

Although the new system was long-ago dubbed the Peanut, supposedly the internal IBM code name for the project, the name being used is the PC*jr*. And, not so surprisingly, the name pretty much tells the tale—though it is certainly not a precise chip off the old block.

For example, the PC*jr* still uses the IBM PC's Intel 8088 microprocessor operating at 4.77 MHz and the DOS 2.1 in the disk-oriented version, which is a new generation of PC-DOS utilized on the larger machines.

Even with the similarities in processor and operating system, however, there are a number of differences between the IBM PC and PC*jr*. Specifically, the latter is designed to work with a standard home television set, has a cordless keyboard, and uses a desktop transformer for power, much like an Atari 800 does. Other features of the system include:

- 64K bytes of dynamic RAM, expandable to a maximum of 128K. Of this, 16K is dedicated to the video buffer.
- 64K bytes of ROM, containing power-on diagnostics, cassette BASIC interpreter, cassette operating system, I/O drivers, dot patterns for 256 characters in graphics mode, and a diskette bootstrap loader.
- Two ROM cartridge program slots.
- A cassette interface.
- Interfaces for adding joysticks, modem, light pen, and I/O expansion.

In addition, the system console, which measures 13.9" × 11.4" × 3.8" and tips the scale at less than 6 lb without disk drive (9 lb with a single drive), includes individually keyed connectors on the rear panel for attaching a variety of I/O devices.

The "entry" unit, without disk drives but with 64K of memory, cordless keyboard, transformer, and two cartridge slots, is expected to carry a price tag of $669. To attach the unit to your color television set, add another $30 for the connector cable. What you then have is a cassette-based BASIC system that is capable of displaying 40 characters on the screen and up to 16 colors.

Adding additional functions costs more, of course. For example, expect to pay in the neighborhood of $1269 for the "enhanced" system that includes 128K of main memory and a 360-Kb disk drive. Cost will be higher, though, to make it all happen for this option-laden machine. So add $30 for a TV set connector, $175 for a thermal printer, etc., etc. You can add other items such as a joystick, internal modem, carrying case, adapter cable for an IBM color display, and a keyboard cord. Generally speaking, you will have more than

Using infrared communication, the keyboard is said to be able to be used 20 ft away from the base unit.

$1900 invested in the machine if you purchase everything, excluding software, firmware, and color display.

The Keyboard's Cordless. One of the exciting features of the PC*jr* is its keyboard. Measuring approximately 13½" × 6½" × 1" and weighing 25 oz with 4 AA batteries, the keyboard features a typewriter-style 62-key layout, cursor-key control cluster, and a single function key.

Although the keyboard looks standard enough, it communicates with the system through two infrared-emitting diodes. The keystrokes are encoded with pulse-modulation techniques, which are then detected by the base unit.

IBM claims that the keyboard can be used 20 feet away from the base unit and that it has a wide 60-degree arc of operation. Physical obstacles will block the signal of course.

You don't have to rely on the IR link, however. IBM provides, at additional cost, a cable connection. This cable not only provides power to the keyboard but establishes a serial link for the encoded data by disengaging the battery power and IR link. IBM says that this option must be used when more than one unit is used in the immediate area to avoid interference.

Because the PC*jr* keyboard differs greatly from the standard PC keyboard, aside from its much smaller size and slightly-sculpted, Chiclet-like keys, IBM allows emulation via SHIFT CONTROL keys. It's claimed a user can then do everything on the PC*jr* that he does on the larger PC keyboard. To facilitate this, cardboard overlays are offered for the PC*jr* keyboard. These are designed to be written or typed on so that specific application overlays can be created. Basically, this seems to be a cheap solution to what will probably be a very complex problem for serious users. Letters and numbers aren't marked directly on keys, by the way.

Apparently, the reason for the cordless keyboard is that positioning of the control section can be more flexible when used in the home and for playing games. However, some observers think that this foreshadows the IBM office communication system. The keys are supposedly full-travel types with membrane contacts.

Memory and Display Can Be Expanded. The very basic PC*jr* comes with 64K of built-in dynamic memory and the ability to display 40 characters. Expanding both is handled via the memory and display expansion option, which you can expect to pay around $140 for.

This module enables you to have a 625 x 480 resolution, 80 columns, and up to six pages of display memory. Moreover, an additional 64K of 150-nanosecond dynamic RAM is added. The board plugs into a 44-pin connector on the system board. This connector is the only I/O expansion on the system board.

You can probably expect a variety of manufacturers to offer multifunction boards to fit this connector by the first quarter of this year. But be aware that the electrical power to the PC*jr* is minimal. A single 60-VA transformer supplies the power, and extending the memory beyond 128K would severely drain its capabilities. Additionally, little space is available inside the system unit, and stacked boards won't fit.

Interestingly, the PC*jr* doesn't provide you with as much usable memory as you may wish, as you can see in Table I. Notice that only 112K bytes maximum is available, due to the 16K required for the video buffer. And when using the new DOS 2.1 only 82K bytes is available. As a result, many programs that work on a full-sized PC won't fit. However, IBM has modified some (EasyWriter 1.15 and most of the PFS software) to work in the limited memory.

Although there is little space inside the system cabinet, IBM has designed an internal 300-bps auto/answer auto/dial modem. This plugs into a special connector on the system board, and the telephone jack extends from the rear. Since the modem does employ serial signals and uses the interrupt structure of the PC*jr*, the connector may offer add-

APPLE'S MACINTOSH OFFERS MORE FOR LESS

If you're not an IBM fan and like the Apple world, the MacIntosh personal computer is just a month away.

According to sources close to the company, Apple's latest entry is expected to be unveiled at the annual stock holders' meeting in early January.

The machine, which features Lisa-like functions such as the mouse cursor controller, uses a 68000 processor, has dual 5¼" standard disk drives rather than the unreliable Twiggy drives, includes a 7"(diagonal measurement) monochrome integrated CRT, and provides composite video output for use with a color monitor or television.

The full-size typewriter keyboard, although not cordless, may be easier to use than any other machine offered in its price class. (You can probably expect to pay less than $3000 for the MacIntosh when it finally appears on the market.)

As enticing as MacIntosh sounds, it, too, may have some shortcomings. Specifically, it may be lacking in software. To date, not enough has been developed for Lisa, so why should MacIntosh have great early software support? It seems that most programming shops are tuned in to creating products for the 8088 CPU rather than the 68000.

However, it is believed that MacIntosh may have a heads-up chance at getting software by offering more than just an Apple operating system. You might expect to see Digital Research's CP/M-68K and VisiCorp's Visi-On on the machine. In addition, it appears that Microsoft is preparing to offer its popular Multitool series on the machine.

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on makers a solution as to where to plug things in.

Cartridges Add Programs. Following an Atari- and TI-like concept, the PC*jr* also comes equipped with two 28-pin ROM cartridge slots.

The cartridges include a number of games, educational software, and, apparently, an IBM logo. You can look for: Monster Math, Animation Creation, Bumble Games, Juggles' Butterfly, Turtle Power, Personal Communications Manager, and Casino Games, to name a few. Cartridge BASIC is also available as an option for $75.

There are expected to be about 50 cartridges available by the time you read this, and an equal number of disk- based software packages.

DOS 2.1, a Better O/S. Once you tire of using the PC*jr* as a cassette-based system (1500-baud transfer is used on the cassette) or cartridge system, you will more than likely upgrade to a disk-based system.

You can choose to use one single drive in concert with cartridge BASIC and the cassette O/S to maximize system operation and minimize cost. (IBM does not presently offer an outboard second drive, though the system is said to be able to support it with the proper controller electronics to go with it.) You can upgrade the entire system by adding serial and parallel adapters, a thermal printer, and a host of other options.

Once you've added everything, you have a fairly complete system, though only a one-drive system. And DOS 2.1 completes the picture. The $65 O/S comes with a user's guide and a DOS reference manual.

Like previous versions, DOS 2.1 operates on all prior PC models, but earlier versions of DOS don't work on the PC*jr*. The new version works with either single- or double-density disk drives, can support a hard disk (an option that may come for the PC*jr*).

One aspect of DOS 2.1 to be considered is that it has higher memory requirements than previous versions (about 12K bytes more than 1.1). In addition, it supports graphics screen dump to the printer, global file name searches, and supports multiple-disk I/O memory buffers to speed disk performance.

TABLE I—MEMORY USAGE

	Memory Used	Total System Memory Approx. Remaining User Memory 64K	128K
Video buffer	16K	48K	112K
Cassette BASIC (ROM)	4K	44K	108K
DOS	24K	24K	88K
Cartridge BASIC (w/o DOS)	6K	42K	106K
Cartridge BASIC (with DOS)	30K	18K	82K

You can also have job stream command sequences, and support current date and time in directory entries. Further background operations such as file print are included, and you can divert parallel printer output to serial.

The basic commands of DOS 2.1 are similar to previous versions, with some added functions and commands to ease its use, as shown in Table II.

Generally speaking, the use of DOS 2.1 and the cordless keyboard may be the real hallmarks of the system. The rest is almost pedestrian.

Setting Up. Setting up the PC*jr* is fairly simple. You can use the keyboard cable or operate in a cordless mode. You can then connect the system console to either your color TV, a standard composite video monitor, or, through a $20 adapter cable, the IBM color display via a plug on the rear of the system console. If you plan anything serious, you should probably consider getting the higher-class display. The popular BMC color monitor will work nicely, I believe. Be aware, however, that, if you plan to have sound effects, you do need the television receiver since the system uses the speaker in the TV set. If you want the better display *and* sound, you'd have to kludge up a speaker on the system console.

The 2-lb, 13-oz desktop stepdown transformer is plugged into a connector at the rear and supplies power to the entire system.

Once you have everything plugged in and turned on, you're greeted with the IBM logo and 16 color bars. While this screen is being displayed, the system is self-checking, and a single beep and change to BASIC 1.1 signifies that everything is operating correctly.

You can choose to run Keyboard Adventure, which is built into the system ROM. This is entered by tapping the escape key during the system start-up sequence. This program uses a cartoon character to take you through the use of the keyboard.

Early Conclusions. The PC*jr*, finally emerging out of the swell of rumors under the guise of "Peanut," is a classy home personal computer. Sure there's a list of wish-it-hads that could be made; but, price aside, it's an impressive package—for the home, that is, not for heavy small-business use. After all, it would be unfair to compare, say, a student's home electric typewriter with a heavy-duty office typewriter.

Nonetheless, the keypads, though operating smoothly, are not a touch-typist's delight owing to their size and shape. The same could be said for keys of some very fine electric typewriters, too. Further, people who aren't proficient typists might find the absence of markings directly on the keys disconcerting. Instead, they're marked on the keyboard's base. Apparently, the anticipated use of a variety of keyboard overlays led IBM to make this decision (each key can be programmed for special applications). Furthermore, it would have been nice to have a numeric keypad.

TABLE II—DOS COMMANDS

Function	DOS Command or Utility
Configuration File (CONFIG. SYS)	BREAK=ON/OFF BUFFERS= DEVICE= FILES=
Substitute diskette drive assignments	ASSIGN
Batch file support	.BAT
Check for Ctrl/Break Interrupt	BREAK
Check diskette or fixed disk	CHKDSK
Clear screen	CLS
Compare files	COMP
Copy files	COPY
Set date	DATE
Set time	TIME
Delete files	DEL, ERASE
List directory	DIR
Compare diskettes	DISKCOMP
Copy diskette	DISKCOPY
Format diskette or fixed disk	FORMAT
Graphics screen dump	GRAPHICS
Set display or printer options	MODE
Remark within batch file, then wait	PAUSE
Print files in "Background"	PRINT
Change DOS prompt	PROMPT
Recover file	RECOVER
Remark from batch file	REM
Rename a file	RENAME, REN
Transfer DOS to another diskette or fixed disk	SYS
Set time of day	TIME
Display file contents	TYPE
Display DOS version	VER
Write-verify data to diskette	VERIFY
Display disk(ette) label	VOL
Line editor	EDLIN
Load, alter, display/execute files	DEBUG
Link-edit a compiled program	LINK
Change directory	CHDIR
Substitute screen & keyboard	CTTY
Convert .EXE files to .COM format	EXE2BIN
Search for string in file	FIND
Create a sub-directory	MKDIR
Pause after displaying screenful	MORE
Specify directory paths	PATH
Remove directory	RMDIR
Set environment	SET
Sort data	SORT
Display directory paths	TREE
Initialize a fixed disk	FDISK
Backup fixed disk files to diskette	BACKUP
Restore files from diskette to fixed disk	RESTORE

Color video quality of a model demonstrated was excellent, with 16 individual colors in medium-resolution and four colors in high-resolution.

When we get our hands on a *jr* for a reasonable period of time, we'll get more details on it for you. Meanwhile, I'd liken this machine to Cadillac's "Cimarron" small automobile. It will compete at the top of the nonbusiness personal computer area. Other less prestigious machines will get you there also, of course. ◊

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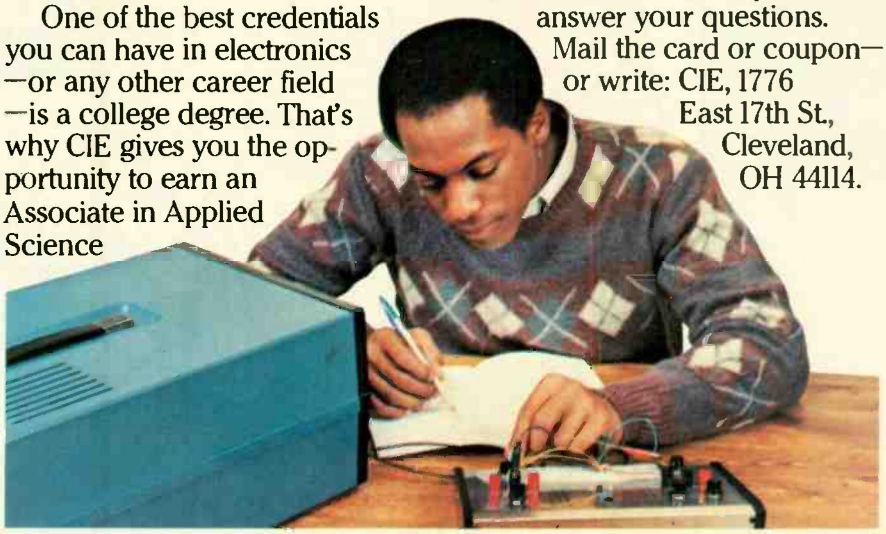

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CompuScan/2100

BEARCAT SCANNING RECEIVER

INTERFACING microcomputers to external equipment is commonplace. Every so often, though, an exciting new application comes along. This is the case with the Bearcat CompuScan/2100 scanning receiver system from the Electra Company. Electra, which produced the first scanning receiver radio in 1968, has interfaced a high-quality scanner to a Commodore-64 personal computer (and plans to do the same with other popular micros). The result is a scanning receiver system with capabilities well beyond those available on current top-of-the-line scanners.

For those not familiar with scanners, this type of receiver can tune in the Public Service bands such as local Police and fire calls, mobile telephone conversations, weather broadcasts, marine radiotelephone, and many other kinds of transmissions. Scanning usually consists of establishing frequencies that are monitored in sequence by the receiver. If a signal is picked up, the receiver broadcasts it until it is over; then it continues on, jumping from one frequency to the next until it finds another active transmission. The cycle then repeats itself.

Combining a microcomputer with a scanner

By Joe Desposito

The $10\frac{1}{4}$" x $9\frac{1}{2}$" enclosure houses receiver and CPU.

The number of frequencies that can be monitored at one time with a scanner is typically less than ten, although some top-of-the-line models scan as many as 50. In contrast, the CompuScan system can monitor 200 frequencies at a time. Additionally, it displays pertinent information about the frequency (such as its source of transmission), and maintains a log of selected frequencies.

CompuScan can receive frequencies in the following ranges:

30- 50 MHz Low-Band VHF (FM)
118-136 MHz Aircraft (AM)
144-148 MHz 2-M Amateur (FM)
148-174 MHz High-Band VHF (FM)
421-450 MHz 70-cm Amateur (FM)
450-470 MHz UHF Band (FM)
470-512 MHz UUHF-T Band (FM)

The CompuScan scanning receiver system includes the receiver, a whip antenna and cable, interface cable, software on $5\frac{1}{4}$" disk, and power supply. To run the system reviewed here, you need a Commodore-64 microcomputer, whose keyboard is used as the front-end tuning selector, and one disk drive. Suggested retail price of the system is $499.95.

Hardware. The Bearcat CompuScan/2100 system includes a state-of-the-art scanning receiver that operates under microprocessor control. Patented features such as track tuning, enhance scanner sensitivity. A block diagram of the microprocessor control section is shown in Fig. 1.

A modest $10\frac{1}{4}" \times 9\frac{1}{2}" \times 2\frac{1}{4}"$ enclosure houses both receiver and microprocessor circuitry. The microprocessor is a Z-8 with an on-board UART. The unit interfaces to the host computer through an RS-232 port that provides TTL compatible signals as well as true RS-232. An RS-232 interface cable that plugs into the user port of the Commodore 64 is included with the package. Also included is a system disk, and ac adapter.

Four auxiliary outputs on the receiver permit the user to connect accessories such as an audio tape recorder to the receiver. One of the outputs connects to a normally open relay that closes when a signal is present. The other three outputs each provide 200 mA current sink capacity (to ground) under various control conditions.

Supplied with the receiver is a telescoping whip antenna (with base) and 20' of RG-58 cable. The antenna can be easily maneuvered in a room for maximum response. The receiver has an internal speaker, and volume and squelch controls. If desired, the speaker and controls can be disabled and replaced by comparable external devices.

Software. CompuScan software is completely menu driven. The system comes up in "Standby" mode, which presents five options to the user: Manual, Scan, Search, Quit, and Zero.

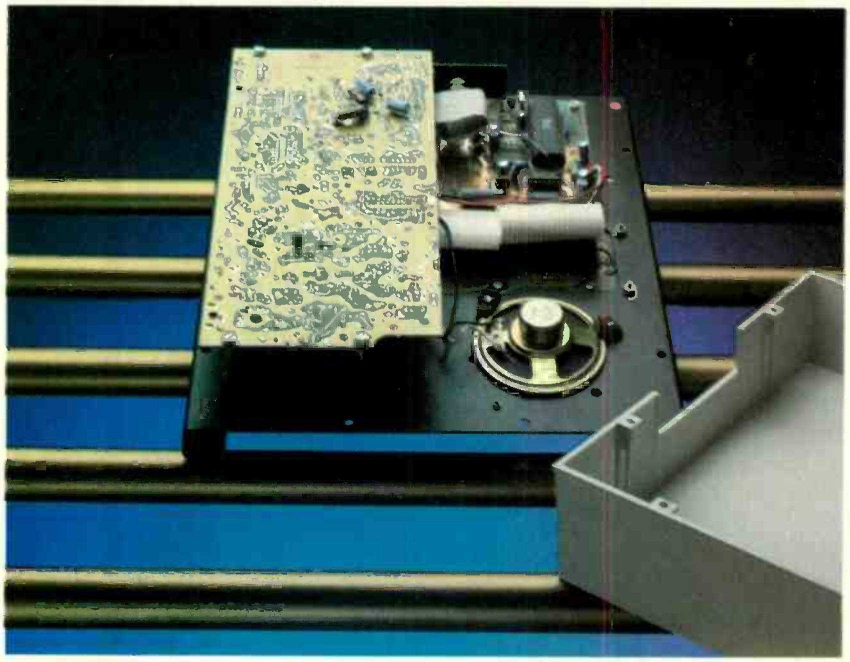
Manual mode is selected by pressing M on the keyboard. This brings up a display of "Bank 1" that contains channels 1 to 20, plus additional information for each channel (Fig. 2). The information indicates whether or not a channel is locked out, a delay is set, or the auxiliary bits are set. To select a channel from bank 1 (or any other bank), you just enter the channel number. To change to a different bank, press C, and then enter the appropriate bank number.

When you select a channel, the receiver automatically tunes to the frequency and broadcasts a signal if it is present. A screen appears, too, showing corresponding channel data (Fig. 3). If you are entering information for the first time, you must input the frequency first. Once the frequency is entered, you may then input additional information

On the bottom are the RS-232 port and accessory connector.

that pertains to it. LOCK OUT causes the scanner to pass over the frequency when in the scan mode. DELAY causes the receiver to remain tuned to a given channel in scan mode about two seconds following the loss of signal on that channel. This feature is useful for transmissions that are followed by a response on the same frequency. COUNT keeps track of the number of times a frequency is found to have a signal present during a scan sequence. Selecting this option zeroes the count.

Choices 5 through 8 of the channel data menu allow you to set the auxiliary bits. These bits refer to special control signals present at the accessory jack on the bottom of the receiver. AUX 1 activates built-in relay contacts when set and a signal is present. This is useful for connecting a cassette tape recorder to the scanner. When AUX 2 is set and a signal is present, it sinks 250 mA (max) for controlling external devices such as alarms. AUX 3 and AUX 4, when set, sink 200 mA whenever a channel is sampled



Interior of the scanner shows the main and CPU boards.

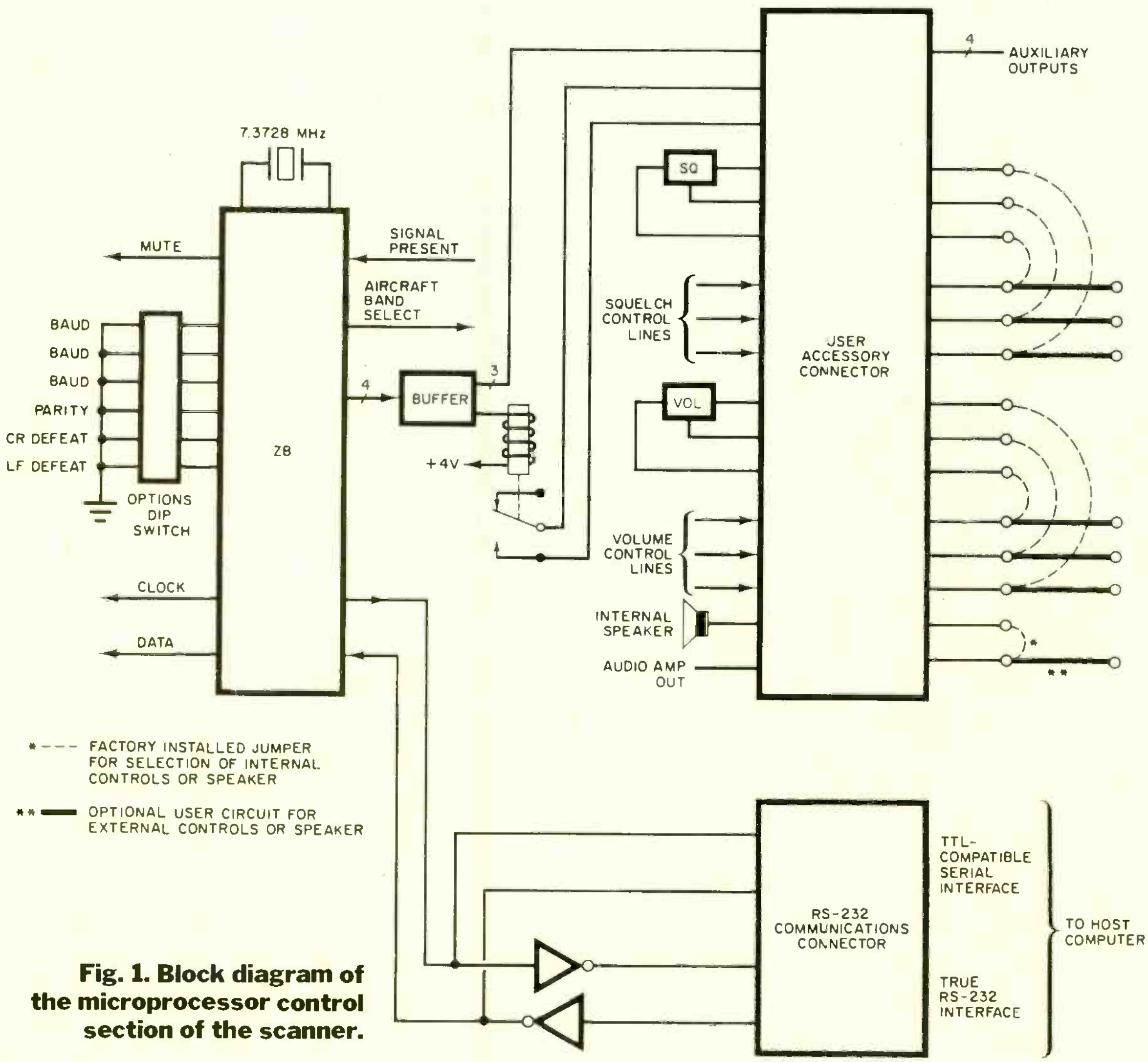


Fig. 1. Block diagram of the microprocessor control section of the scanner.

Fig. 2. Display of Bank 1 shows channels 1 to 20.

Fig. 3. When a channel is selected, its data appears.

(a signal need not be present). These bits are useful for antenna switching.

With the MEMO feature, you can insert up to four lines of information about a channel. Information might include the source of the broadcast, names, telephone numbers, codes, required procedures, etc.

From Manual mode, you may select up to three "Priority" channels. Priority operation causes CompuScan to monitor the channels regardless of what the user may be doing otherwise. If CompuScan picks up a signal while scanning or searching, it will also sample the priority channels at approximately 2-second intervals. If a signal appears on a priority channel, CompuScan switches the broadcast to that signal.

Scan mode is the "business" mode of CompuScan and can be entered from either standby or manual modes. You may choose the number of banks you wish to scan (10 banks of 20 channels each are available). Channels within each bank can be skipped over during the scanning process by choosing the lockout feature while in manual mode.

Once you start scanning, a graphic appears on the screen that shows you the channels being scanned. For example, when the receiver scans channels 1 through 20, the screen looks like the one shown in Fig. 4A. An L beneath a channel number means that the channel is locked out; an asterisk means that the channel has been sampled, and no signal was found. If a signal is present on a channel, the screen changes to that shown in Fig. 4B. It shows the channel, its frequency, and any information about the channel that was included when first stored. If the channel loses its signal, the receiver automatically begins scanning again. If you want to interrupt the process, you may do so with one of the five options shown at the bottom of the screen (Fig. 4B).

Search mode allows you to search for active frequencies between upper and lower limits that you enter. The frequencies that you enter must be valid ones, which means that they must lie within the band limits of the receiver (Fig. 5).

There is one other search feature that I didn't review, but which will be included in the final product. It's called the Search/Store/Count feature. In effect, the system in this mode does not stop and transmit a signal. Instead, it pauses momentarily and stores the frequency. When through with the search, the system displays the number of frequencies stored. Also, you can step through the frequencies to get a count of how often each was encountered during the search. If the frequency is of interest to you, you can automatically store it in a data bank.

The final two options of the Standby Menu are Zero and Quit. CompuScan automatically counts how many times a signal is present on a frequency during scan mode and displays a running total on the channel-data screen. Zero allows you to zero these counts for *all* channels stored in the system. When you are through operating the scanner, Quit closes all the files.

There are a few other noteworthy features of the software. Whenever you make an improper entry, the screen blinks in red. This gives you a quick visual feedback that an error has been made. If you load the software and forget to turn the receiver on, NO RESPONSE comes up on the display. This is a reminder to turn the receiver on.

All the data you enter is stored on the system disk. Thus, there is no need for a separate data disk. The program itself is written in BASIC. A spokesman for Electra indicated that the program could have been written in machine code to achieve optimum performance. However, it was decided instead to allow users access to the code if they wanted to modify it in any way. The complete program listing in BASIC is available from Electra. The listing is well commented and contains a cross-reference table.

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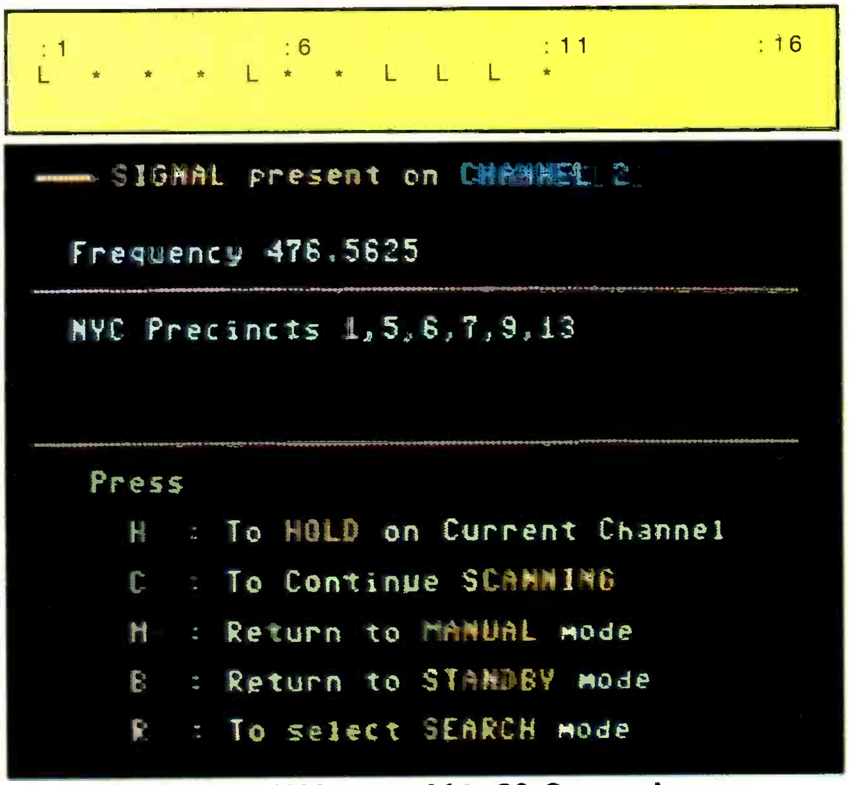


Fig. 4. At top (A) is scan of 1 to 20. Screen changes to (B) below if a signal is present on a channel.

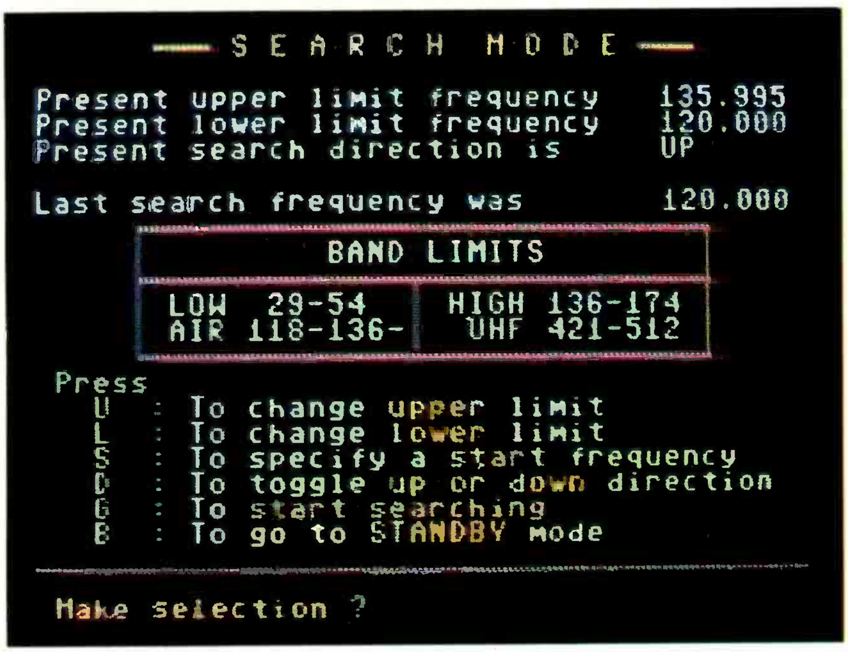


Fig. 5. This screen shows band limits of frequencies.

Using CompuScan. Initial setup of the CompuScan receiver is fairly simple. A cable must be connected between an RS-232 connector on the underside of the receiver and the user port of the Commodore-64. The receiver also connects to a telescoping whip antenna with a 20′ length of RG-58 cable. Then all you have to do is plug the ac adapter into a wall socket and plug its jack into the receiver. This procedure has to be done only once and it can be left as is thereafter.

Loading the program takes a little over a minute. When you run it, data on the disk is loaded into RAM. This takes another $1\frac{1}{2}$ minutes or so. The software comes up in standby mode, which is a menu that allows you to enter any of the other modes of the system. When you first use the system, you must enter manual mode and load frequencies into the data banks. If you're not familiar with the frequencies to tune to in your area, there are publications available to find out what they are. Electra publishes a pamphlet that lists local frequencies and who is transmitting on them. They also publish the "Betty Bearcat" frequency directory for different regions of the U.S. Your local dealer can help you find this information.

Once you've loaded the frequencies into the data banks, you can switch into scan mode. You can scan all or some of the data banks by listing the appropriate bank numbers, which the program queries you for. Any channels within the banks that you don't want scanned must be locked out while in manual mode. A typical frequency that you would want to lock out is the weather broadcast. Since this is a continuous broadcast, the scanner would never leave the station once it tuned it in. After you've determined the banks you want to scan, you press G and the scanner begins operation.

The procedure just outlined is the basic scanner operation; but there are other options, too. Suppose you wanted to listen to the weather channel. You can call the station up by inputting its channel number while in manual mode. You might also be interested in searching for active frequencies in your listening area. If you were interested in the aircraft band, you would enter frequencies between 118 and 136 MHz while in search mode. The scanner would then search between the frequency boundaries you entered, and broadcast whatever it found.

User Comments. I used the CompuScan scanning receiver with a Commodore-64. Setting up the hardware was straightforward and easily done. Loading the software, however, presented a problem. It appears that Commodore is having compatibility problems with its disk drives. For example, a disk that runs on one 64 drive might not run on another. After trying a few different disks, however, the programs did run. One other small problem appears to have its roots in the architecture of the Commodore-64.

When data is being loaded from the disk into RAM there are sometimes delays of a few seconds or more right in the middle of an operation. For example, if the frequencies of bank 1 are being listed on the screen, the computer sometimes stops in midstream. After a few seconds, it resumes the listing. This is because the Commodore-64 has no provision for dimensioning strings. Thus, RAM is allocated for storage and then must be re-allocated once the area is filled.

Loading frequencies into the data banks is a little time consuming, but it's done only once. Besides loading the frequencies, it's wise to insert a memo so that you can later recall who transmits the frequency. You'll have to experiment with the frequencies in your area to find those that will provide the information that you're interested in.

Once into the scan mode, I found reception to be quite good. Sometimes the receiver gets stuck on a station that's not transmitting anything intelligible. But the software allows you to press C to continue scanning. If this happens during every scan cycle, you can omit the frequency entirely or just lock it out by switching back to manual mode and making the adjustments.

TECHNICAL SPECIFICATIONS
BEARCAT COMPUSCAN/2100 SCANNING RECEIVER

R-f sensitivity:	30-50 MHz: 0.6 μV 118-136 MHz: (AM): 1.0 μV 144-148 MHz: 0.6 μV 148-174 MHz: 0.6 μV 421-450 MHz: 1.0 μV 450-470 MHz: 1.0 μV 470-512 MHz: 1.0 μV
Squlch sensitivity:	Equal or better than specified under r-f sensitivity
I-f selectivity:	-60 dB @ ±25 kHz
Audio output:	1 W rms, 10% THD (max.) into internal speaker. 2 W rms, 10% THD (max.) total (internal and 8-ohm external speakers or 8-ohm external only)
Scan speed:	15 channels/second nominal during any bank. 100 ms to change banks. 60 ms additional to bank change when priority is programmed.
Channel capacity:	200 (10 banks, 20 channels each)
Memo capacity:	4 lines, 30 characters each available for each of the 200 channels.

Conclusions. The marriage of a scanner receiver and a personal computer adds a great deal of utility to the receiver. I was able to enter any frequencies I wanted, limited only by the frequency range of the receiver. The receiver scans up to 200 frequencies at a time, and can store them to disk with any relevant information. This is certainly a quality improvement over any scanning receiver on the market today. Additional search features and access to control signals make the combination of computer and scanner even more attractive.

But as with all marriages, sometimes there are problems. The problem with the Commodore-64 disk loading is something to watch out for.

Some obvious software utility is missing, too. For example, there is no provision to output stored frequencies to a printer. Though a user has access to the code and might indeed insert this feature, it really should be provided.

Overall, I think that the Bearcat CompuScan receiver is a fine product. For the scanner enthusiast it offers features that have been unavailable up to now. For the computer enthusiast it offers an exciting new add-on product that could develop into a lifetime interest. ◇

WHAT'S NEW IN THE CP/M WORLD?

The state of CP/M: an up-to-date look at microcomputing's most widely used disk operating system

By Josef Bernard

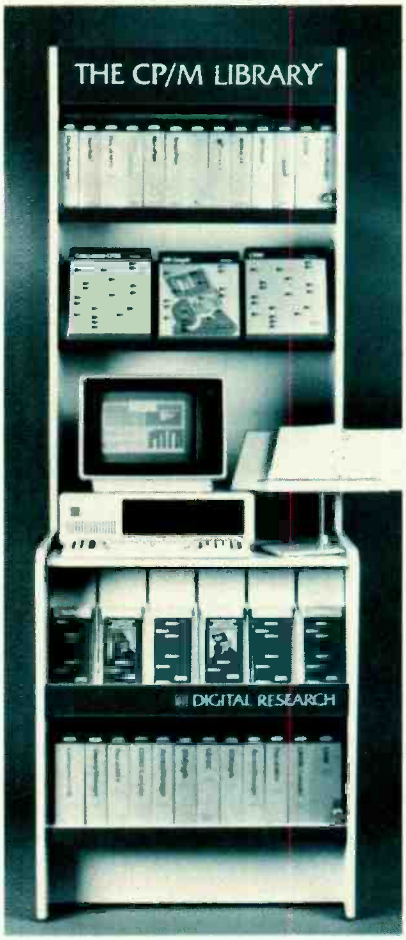
THE most prevalent disk operating system in use today is the one known as CP/M. If you are using a computer other than the IBM PC or one of its work-alikes, you are almost certainly using CP/M. If you own an Osborne, a Kaypro, a Morrow, or any one of a number of medium- to high-end 8-bit systems designed for serious use, you are using CP/M.

Even if you own an Apple or a TRS-80, or another computer that originally came with a different operating system, you may very well now be using CP/M. Why is it that this "antique" of an operating system—it's been available for microcomputers for over eight years—is still so much in use . . . and why is it that even many brand new systems use it in preference to another?

Certainly there are operating systems that are more manageable than CP/M, that offer more features, and that are easier to understand. How does CP/M manage to hold on and, perhaps more important, why is it likely to be with us for a long time to come despite MS-DOS and its derivatives?

A Little Background. CP/M, which stands for Control Program for Microcomputers, was created as a programmer's tool. It was never intended to be "user friendly." Evidence of this is found in the utilities, like ED, ASM, and DDT that are included as part of the standard CP/M package. These utilities are intended for the creation and debugging of assembly-language programs—certainly not the purpose for which you bought *your* computer. It's probably fair to say that most present-day owners of CP/M systems never even bother to run these utilities. Still, they are supplied with every CP/M disk and we may be able to understand why a little later.

CP/M was created in the early 1970s by Gary Kildall to fill a need he had for a disk operating system to assist him in his work. At the time he was with Intel Corporation, the company that produced the first microprocessors. There were other disk operating systems around (after all, it was IBM that had developed the floppy disk), but they were tailored to much larger and more complex computers than Gary was using. What he needed was a simple tool to allow him to work with his little 8-bit microprocessor, not some 32-bit giant. Thus came about CP/M. Kildall later left Intel and formed his own company, Digital Research, Inc., to distribute CP/M as well as develop and market new CP/M products.



Digital Research markets much more than CP/M.

When the first disk drives for microcomputers arrived on the market, most of them came with their own proprietary operating systems. Notable among these were the NorthStar DOS (which still has a small but ardent following today) and PTDOS from the now-defunct Processor Technology, a pioneer in microcomputers. Some of these disk operating systems were good and some were awful. All, though, shared a common flaw. They could be used only with the specific systems they came with and, worse, programs written to run using one operating system were totally incompatible with computers using another.

All disk drives require a piece of hardware called a controller, which is an interface between the computer and the drive. Before the days of all-in-one computers, the controller was supplied as a plug-in board, and was usually sold together with the disk drive and operating system. This was probably the first example of bundled software for microcomputers. (The word-processing and spreadsheet packages included in the price of many computers now are current-day bundled software.)

As the microcomputer industry grew, some companies began selling controller boards that were not associated with a specific computer or disk drive. The majority of these were intended for computers using the S-100 bus. These computers consisted generally of a cabinet, a power supply, and a motherboard carrying a hundred control, data, and address lines into which could be plugged an assortment of CPU (microprocessor) boards, memory boards, input/output boards, etc. Among the etceteras were disk-controller boards.

Given the general nature of the S-100 systems, it was only natural that the disk operating systems provided for S-100 controller boards also be as nonspecific as possible. Under these circumstances, CP/M was the ideal candidate. The rest is history.

A Universal DOS. Virtually all of the early—and most of the current—disk operating systems were intimately tied into the computer system for which they were intended. For example, PTDOS, mentioned earlier, could be used only on Processor Technology computers, and only with the disk drives offered by that company. It was an excellent operating system, but could be used by relatively few. Similarly, the NorthStar DOS was intimately linked to the NorthStar controller board, and would work with no other. Not so CP/M.

In designing CP/M, Gary Kildall made it independent of any particular computer or controller board. Of course, certain parts of CP/M has to be compatible with the computer system it was being used with, but these parts were supplied in a form that could be altered by a manufacturer or knowledgeable computer user to conform to his own equipment. That is probably one strong reason for the assembly-language utilities that are still provided with the operating system. Not only did you get the DOS, but you also get the tools you needed to tailor it to your requirements.

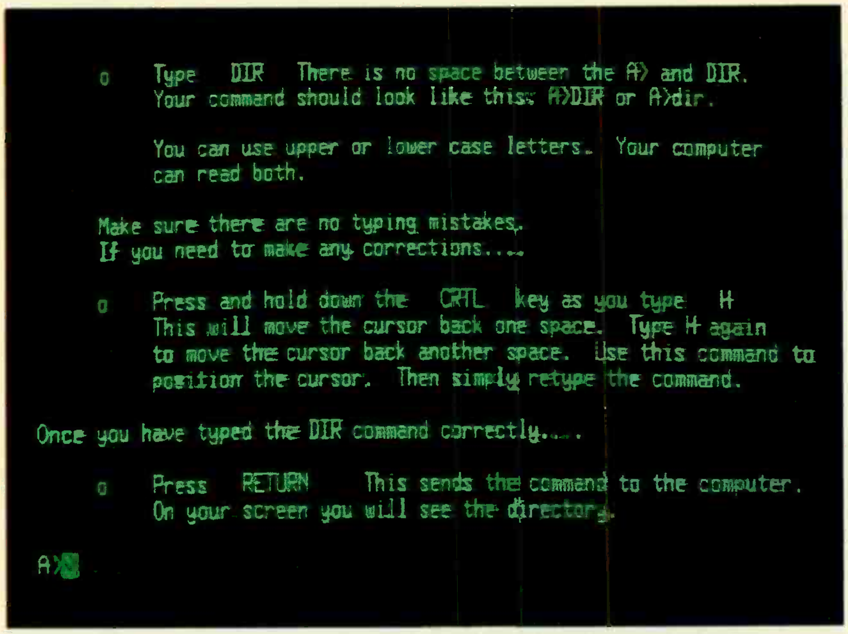
CP/M's universality is due largely to the fact that it is formed of modules. The most important of these is the BIOS, or Basic Input/Output System. It is the portion of the CP/M that controls the disk drive, and that allows the computer to communicate with the outside world through terminals, printers, and other peripheral devices.

The portion of the BIOS that controls the disk drive must be tailored specifically to the disk controller and to the physical drive itself. Once that is done, though, little more work need be performed on it. This is because CP/M uses a number of what are termed *function calls.*

Each function call performs a specific task, like reading the directory of files (programs or assemblages of data) that are contained on the disk, opening or closing files (very important to keep various programs and data files from intermingling and turning into valueless garbage), and controlling the flow of information between the computer and various peripherals.

Every function call is assigned a number, and, to use one, all that is necessary is to refer to its number. So, a programmer does not have to write a series of routines to get data into or out of the computer, or to read it from or write it to the disk. All he has to do is use the appropriate function call. This may seem unimportant, but the effect it ultimately has on the programs you use is significant.

The other concept that makes CP/M



ATI's CP/M course builds confidence in using the DOS.

so convenient, and its use so widespread, is the one of *logical devices.* As opposed to a physical device, like a specific printer or console device (usually a terminal), a logical device is more a generalization of a device type. The most frequently encountered logical device in CP/M is the LIST device, which is generally a printer. The particulars of the various physical devices are described in the BIOS for a particular system, and they are then referred to by their logical names.

An intimidating message from CP/M.

Instead of writing a program that instructs the computer to send its output to a Diablo Model 1650 serial-interfaced using XON/XOFF protocol and connected to the port designated "2F," all the programmer has to do is instruct the program to output the data to the LIST device. The BIOS takes care of all the detail work.

That's all well and good for the programmer, but how does it benefit you?

Transportability. The significance of CP/M's BDOS (Basic Disk Operating System) and BIOS is that, once they are configured for a particular computer system, virtually *any* program written to run under CP/M can make use of them to run on any CP/M system without modification! This ability to go from one system to another without having to customize a program for each one is called *transportability.*

For the programmer, this means that he does not have to write a separate version of his program for each computer he intends it to run on. The use of function calls and logical devices makes a single version almost universal.

For you, it means that almost any CP/M-compatible program you choose is guaranteed to run on your system. Furthermore, because CP/M is so convenient for programmers to use (and because the greater the number of systems their programs can run on, the more they will sell) there are well over 2000 pieces of CP/M-compatible software for you to choose from!

(Compare this to the fact that many programs written to run on IBM's Personal Computer under PC-DOS—IBM's version of MS-DOS—will not run on other MS-DOS-based computers. When you look at the ads for PC-like computers, read the fine print; you'll see what we mean.)

Fear of CP/M. If CP/M is so wonderful, why is there so much trepidation about using it? Most people who purchase CP/M-based systems seem afraid even to concede its existence, and are content to run the 'Stars, 'Calcs, and other applications programs it supports.

Part of the desire to avoid contact with CP/M is probably due to its history. In its early days, CP/M frequently was supplied unconfigured, in skeletal form, and required someone with extensive assembly-language-programming experience and an intimate knowledge of how the hardware of a system should be organized to get it running. Coupled with that was a thick and nearly incomprehensible set of manuals that even experienced programmers puzzled or wept over at times. Furthermore, when a CP/M system was successfully configured, the novice computer user still had to refer to those impossible manuals if he wanted to get anything done, even if it was only copying a file from one disk to another.

Another factor stems from one of man's earliest instincts: fear of computers. Even though they may have been persuaded to purchase, and even use, them fairly regularly, many people are scared to get more involved with computers than they have to. Perhaps it's the idea of irretrievably losing data, or maybe it's just the thought that "If I touch the wrong key, the thing'll blow up!"

In truth, it's very hard to break a computer. If you hit the wrong key you may cause the computer to do something you don't expect it to, but it's not going to blow up. And if you are working with a disk you've set aside for practice purposes, you're not going to lose any irreplaceable data or programs.

Finally, there's the "who-needs-it" syndrome. You've learned how to use your word processor, so what else do you have to know? Though computers and operating systems are becoming more and more "transparent," letting you concentrate on the work you bought the computer for, one day you may find out what you have to know . . . the hard way.

Fortunately, using and learning about CP/M is a lot easier than it used to be. First, almost every CP/M computer sold today comes with the operating system already installed. Moreover, if special printers or other peripherals have to be added, there are usually utilities supplied by the computer manufacturer that make their installation about as easy as selecting items from a menu.

Additionally, the latest manuals from Digital Research are easier to understand. Finally, a number of book and software publishers have hopped on the CP/M bandwagon with titles intended to help you fathom the intricacies of what may be the world's most popular but least-understood disk operating system.

Almost every major publisher has at least one book on the shelves with a title like "The Complete CP/M User's Guide" or "Three Weeks to Better CP/M." There are books written for experienced programmers and books written for complete neophytes. A trip to a nearby computer or book store will give you a chance to examine a variety of works on the subject, and you can select the one(s) that you feel most comfortable with.

An interesting entry at the software level is a training course on disk from ATI (American Training International, Inc., 3800 Highland Avenue, Suite 300, Manhattan Beach, CA 90266). The disk comes with a rather skimpy manual and, in fact, does not go into many aspects of CP/M itself. Despite those shortcomings, though, it is an amazingly powerful learning tool, especially for those who suffer from a "what-if-I-break-the-computer" complex.

The disk simulates the CP/M environment. As you progress through the lessons, it looks and feels as though you are using CP/M; but it is all really an illusion created by the program. You get nowhere near the *real* CP/M your system is running.

If you make a mistake, the worst that happens is that the program (metaphorically) slaps your hand and makes you do it again until you get it right. By the time you've finished the course, you may not be an expert on CP/M, but you'll be comfortable with it and able to learn more about it on your own.

Power! is utility for CP/M that makes it easy to use.

8 Bits/16 Bits. It is interesting to look at what 16-bit computers offer that 8-bit ones don't. It is generally assumed that more bits make a better computer, but that is not necessarily the case.

What are the advantages of a 16-bit computer over an 8-bit one? The answer usually given is speed and the ability to address larger amounts of memory (needed for large programs and for manipulating large amounts of data). Some might also mention the color and graphics capabilities of most of the 16-bit machines.

To tackle the last point first, many 8-bit computers—even the lowly VIC 20—have color and graphics capability. The resolution of some 8-bit systems even approaches that of the 16-bitters. And, if high-resolution, full-palette color is required, there are add-on boards and systems for 8-bit computers that make machines like the IBM PC's abilities look insignificant.

As for memory size, the 8088 microprocessors used in almost all 16-bit computers can address about 1 megabyte (one million bytes) directly. While that figure may make the Z80's 64 thousand bytes of addressable memory look paltry in comparison, it should be noted that several schemes are routinely used in 8-bit systems to extend their capacity that far and beyond.

Finally, there is speed. For most purposes, 8-bit systems already operate as fast as necessary, and may even have some speed in reserve. After all, how many people can type faster than their computers? The advantage of 16-bit CPUs is their ability to cope with larger chunks of data, primarily numbers. However, although the 8088 is a 16-bit CPU internally, it is essentially an 8-bit device as far as the rest of the computer system is concerned. All its 16-bit data transfers to and from memory, for example, have to be broken up into two 8-bit operations. That slows it down considerably. Actually, in running a given program, many 8-bit systems, running theoretically more slowly than the 16-bit systems they were being compared to, have been demonstrated to run that same program more quickly than their 16-bit competitors!

State of CP/M. If CP/M is so wonderful, what's all the to-do about the MS-DOS family? Why doesn't CP/M dominate the 16-bit computer world, as it does the 8-bit computer world?

Part of the answer lies, unfortunately, in intercorporate politics, and that's a subject we'll leave for another time. Actually, there is a 16-bit version of CP/M called CP/M-86 that competes with MS-DOS; but, largely because of its originally high price, it has found little acceptance.

At the CP/M 83 East show held in Boston last fall, not much new in the way of CP/M hardware and software was shown. There were a few new computer systems, but nothing out of the ordinary. Most of the new CP/M software shown was of interest to people who wished to upgrade at the system, rather than the application, level.

Embarassingly, in fact, two of the most interesting new pieces of (application) software, OZ, a business management system from Fox & Geller, and an improved spreadsheet program, SuperCalc3 from Sorcim, were shown running on 16-bit IBM PCs! The CP/M versions, we were told, would be available early in 1984.

Does this mean that 8-bit CP/M is dead? Not by a long shot! First, there exists a large established base of 8-bit computers. It would be unrealistic to assume that the owners of all those systems would discard them overnight in favor of 16-bit machines. CP/M applications software will still be written for them.

CP/M is not dead—by a long shot.

Second, many of the new computers being introduced, as well as some of the current best sellers, use 8-bit microprocessors. Even some of the 16-bit systems include a second, 8-bit Z80 CPU and the CP/M operating system. This would seem to indicate recognition that CP/M is still a strong force in the software industry.

Nor has Digital Research dropped out of the 16-bit arena. Although its CP/M-86 seems to have missed the boat, with MS-DOS in its various versions dominating the market, there also exists a 16-bit version of CP/M called Concurrent CP/M. It allows a 16-bit computer to run several programs simultaneously, and there were numerous programs being run under Concurrent CP/M at the Boston show.

The ideal computer has often been conceived of as being able to supply any kind of information at any time. If, for example, you were writing a letter on your word processor and needed to look up a name and address to include in it, you would like to be able to find that information without having to leave the word-processing program.

With most operating systems in use today, you would have to save the portion of the letter you had already written on disk, exit the word-processing program, run your database program, make a note of the name and address, then restart the word processor and insert that information.

With an operating system like Concurrent CP/M, you could have both programs running at the same time (together, perhaps, with a communications program that could automatically download the closing stock-market prices for your later perusal) and simply "glance" from one to the other.

Most popular applications programs can now run under Concurrent CP/M, and the list is growing almost daily.

In answer to the question; "What is the state of CP/M?" the answer is that, despite rumors to the contrary, it's still in very good health and continuing to flourish. ◇

C&E Interviews Digital Research

At the CP/M83 East show held in Boston last fall, COMPUTERS &ELECTRONICS had the opportunity to interview Gary Kildall, the developer of CP/M and founder (and now Chairman of the Board and Chief Executive Officer) of Digital Research, Inc., and John Rowley, President and Chief Operating Officer of the company. Following are some excerpts from that interview. The two are not identified individually in their remarks.

C&E: Here you are with CP/M and CP/M-86, and there's Microsoft with MS-DOS. What do you think is going to happen?

DRI: That's a question I get asked a lot. At any point in time in the evolution of CP/M there's been a competitor of some sort. It could be Unix. . . . In the early days it was Oasis. There's always somebody out there competing with you. I think it's pretty clear that PC-DOS is the competition, incidentally, not MS-DOS.

C&E: What's the difference between the two?

DRI: I don't think most people understand that those are two different areas of competition. PC-DOS is sold in quite large quantities because of IBM. MS-DOS is not anywhere near as much a competitor for us. In terms of volume it's less than half of what CP/M-86 is. So we don't view MS-DOS as major competiton. PC-DOS is the major competition.

C&E: What about CP/M versus PC-DOS? That's the real issue.

DRI: We started out originally with the idea that CP/M-86 was an entry-level operating system for 16-bit microcomputers because where our marketing has always been is the office-oriented systems. We've sold mainly to Fortune 5000 or Fortune 1000 companies. The orientation we've had from the beginning was to go toward Concurrent CP/M. That was the original design for 16-bit machines, because that's the operating system that more closely matches the capabilities of 16-bit machines. Once you've used a system like Concurrent CP/M, an operating system like CP/M-86 or PC-DOS is pretty primitive. Concurrent CP/M is really the focus of the 16-bit processors and there is no competition for that at all. We see a very strong growth now through CP/M-86 to Concurrent CP/M and to the networking systems. That's what the strategy's been all along.

C&E: So CP/M-86 is more or less an interim operating system.

DRI: Well, in fact, it is. It's a starter system. The idea is if you have a small memory system and you want to be able to get as much functionality as you can in it, then you can use CP/M-86. It is a starter system in that, as you add more memory and more peripherals and so forth, then the growth is into Concurrent.

That's always been the strategy, and it's paying off quite nicely out there right now because, to get some product differentiation and to do some of the things that are necessary in systems like data communications, manufacturers are realizing they have to have something like Concurrent.

C&E: What's the software base like currently?

DRI: Anything that runs under CP/M-86 will run under Concurrent. There are quite a large number of packages [that run] under CP/M-86. We have our own CP/M Library, with 20 of the most popular titles, and we're going to be increasing that significantly. The independent software vendors are lining up something on the order of 500 packages to run under CP/M-86. There could easily be well over 1000 applications right now.

C&E: Will they all run concurrently?

DRI: Sure. Concurrent CP/M has all the file protection needed to keep those programs from interfering or working with one-another's data files. That's a major feature of Concurrent. It also has significant compatibility.

Incidentally, there's a difference between running concurrently and using Concurrent CP/M, just like there is in local area networks. (You can use them for file transfer and as a distributed operating system, which are two different things.) What we're seeing now is vendors using Concurrent to do multiprocessing in one environment. That is, data communications linked up, say, with word processing.

C&E: Getting back to our original question—what about CP/M versus MS-DOS?

DRI: The question is really much larger. If you take a look at those two—CP/M-86 and MS-DOS—where our competition likes to focus, there's a heated battle there. But if you take it to Concurrent, there's no battle at all. We'll be retailing four different versions of Concurrent. When manufacturers start bundling CP/M-86 and/or MS-DOS, it will be just like having a button on the machine—an ON button. Turn it on and you're in CP/M or MS-DOS. Now they're looking for product differentiation, and Concurrent is really the only significant product differentiator right now for personal computing.

C&E: You're getting more into retailing products now, aren't you.

DRI: Yes, there's a whole retail program and, talking about the CP/M Library, we have a whole manufacturing facility that I don't think any of the other microcomputer manufacturers have.

C&E: At several of the press conferences we've attended here, we've noticed that a lot of the new software is running under MS-DOS or PC-DOS, though this is a CP/M show. It almost looks as though CP/M is being ignored.

DRI: Well, that's clearly not the case. Certainly by far the majority of the packages running down at the show are CP/M based.

You shouldn't be surprised by that, though, if you think about it. The thing that's confusing is that, when you said PC-DOS, that should not be surprising because the IBM PC is absolutely the number-one seller; it drags the most software. So if we were not Digital Research—if we didn't have operating systems and were just coming out with applications—the first market we would probably go to would be IBM. We'd program some unique application and put it on PC-DOS.

Back in the 8-bit heyday, people would go to Apple DOS. But there was no confusion. They'd go to Apple DOS and then they'd come to CP/M. They found that all the popular Apple applications were on CP/M. And, there were many popular CP/M applications that might not have gotten to Apple DOS. That's why 1 out of 5 Apples gets sold with CP/M.

C&E: What about the 8-bit versus 16-bit situation? Where do you see things going?

DRI: There's sort of a stratification of computer systems. There are the $500-$1000 machines, there are the portables and the nonportable 8-bit machines that have been around for some time; there's a variety of 16-bit machines, and there's also the 16-bit IBM generic-type machine. Then you get into the high-performance 16-bit machines and the minis.

"If we were not Digital Research . . . we would probably try the IBM market first."

What has happened is that the 8-bit market is essentially CP/M. The low-end machines are either CP/M or emulations of CP/M machines of some sort (basically because CP/M is a good design for that type of machine). The portables are a mixture of 8- and 16-bit machines, typically, again because all the 8-bit machines are CP/M machines. The 16-bitters are mixtures using CP/M-86 or MS-DOS. The IBM generic types are often MS-DOS because what they're trying to do is emulate PC-DOS . . . as best they can. But the others tend to be Concurrent CP/M to get the product differentiation and to get the growth back because they're not interested in the IBM. Their idea is to get some other product that's different and better than what's around. The future systems that are being designed are all basically (designed for) Concurrent, because they have no choice. The new OEMs [Original Equipment Manufacturers] are looking at Concurrent, not strictly MS-DOS or CP/M.

C&E: Do you see a future for 8-bit machines?

DRI: Oh yes, definitely!

C&E: We mean not only at the low end, but at higher levels.

DRI: Yes. you see, 8-bit machines are very inexpensive to build; and, as a result, they're probably going to be less expensive as an overall computer system. For most people's requirements, they do a fine job. If you take a look at most of the programs running on 16-bit machines, they're running in a 64K area anyway; most compilers don't even generate code for outside of a 64K region. And if you're talking about assembly language, with 64K you can rule the world!

That, together with the fact that in a 16-bit machine the code is not nearly as dense as 8-bit code. There's probably a 20 to 100% difference in the size of the assembly-language code, which means that there's basically no reason for them [8-bit machines] to go away.

A number of new 8-bit machines are just starting to really build up their sales. Finally, some programs which are among the classics on a Z80, 6-MHz device, run faster there than on an IBM PC. Literally, if you push the buttons at the same time, you'll end up faster on your 8-bit machine. A lot of the 16-bit mystique is related to the marketing field . . . 16 is bigger than 8. That's not to say that there's anything wrong with the 16-bit direction. There are lots of applications, for example, like DR Logo, that wouldn't have been developed for an 8-bit processor because they require large memory areas. But that's a different kind of function.

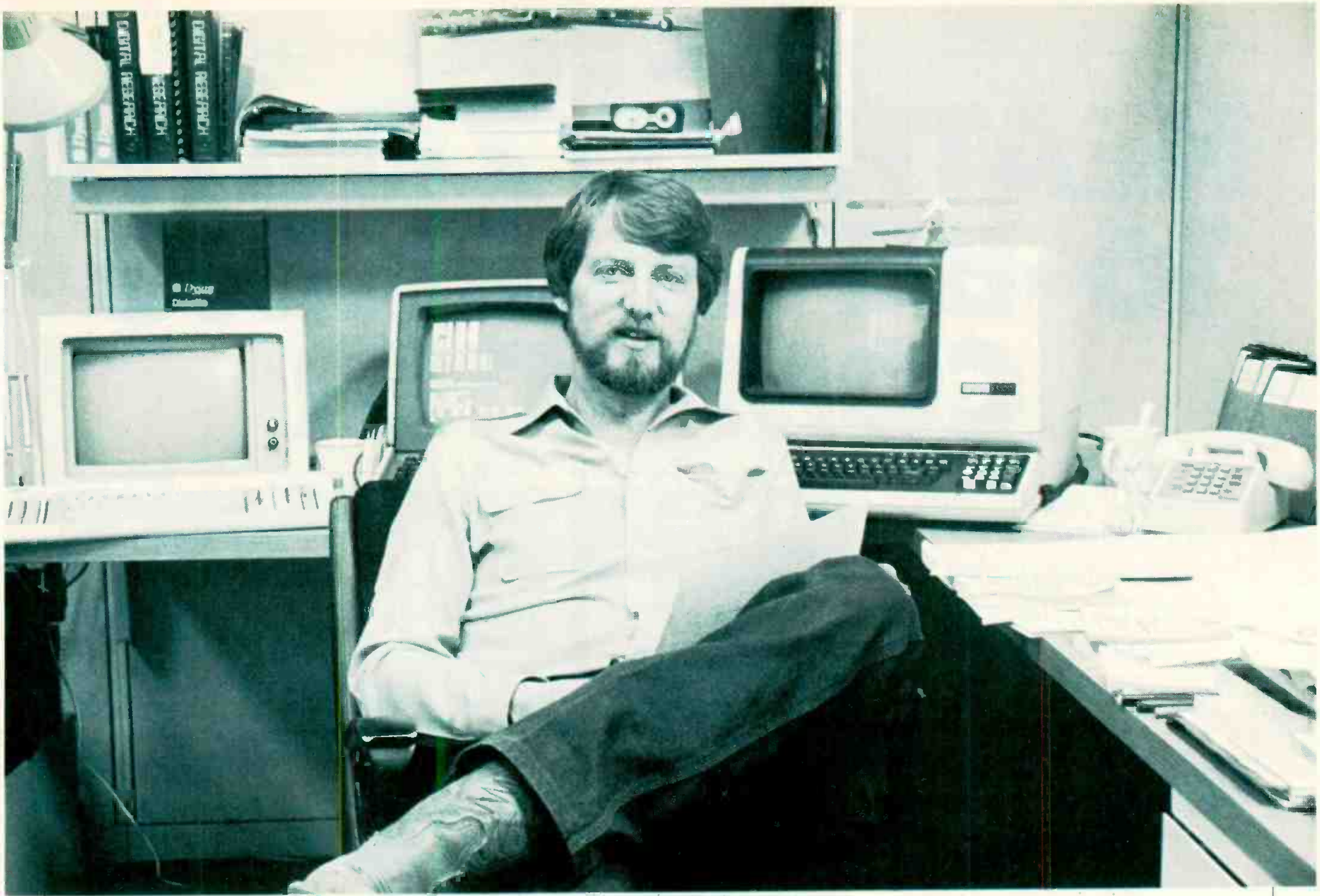
C&E: Do you have any opinions about the MSX "standard" for BASIC?

DRI: Well, the Japanese do believe in standards because they have a manufacturing country. So if they can get into high-volume production (that's why they're so intrigued with CP/M), they endorse the standards. But if you ask the manufacturers, they do not endorse MSX. In fact, the JEDA, which Microsoft tried to have endorse MSX, has said formally that it does not endorse it. However, they do endorse the concept of standardization. It started out with a bang; but in general, the large companies are not endorsing it as a standard.

The reason is that it isn't a viable alternative for standardization in home computing. You really need an operating system [rather than a language].

C&E: Where does DRI stand on this matter?

DRI: We've introduced, in Europe and Japan, a derivative of CP/M called per-



Gary Kildall, creator of CP/M and founder of Digital Research

sonal CP/M, which is not available in the States yet, but will be later this fall. So we have that, and some other technologies related to providing, first of all, an environment that is friendly and very usable in the home.

Obviously CP/M itself was written much more for programmers . . . not for my 11-year-old son. Personal CP/M is a derivative of CP/M which has a much more user-friendly interface and is just very much more consumer-oriented. But it still carries the compatibility at the BDOS level—at the system-call level—of CP/M so that, if you did want to run some CP/M-based software, that's fine—there's no problem. You could run CP/M-based software or you could write new applications and you'd have a different user interface.

C&E: This is not available in this country yet.

DRI: No, but we're working with other companies and . . . you'll hear about it later this fall. But in discussing MSX you almost have to discuss this particular alternative because, in reality, in Japan, the three largest manufacturers have already gotten involved . . . at the low end . . . and here in the US, I think you'll see the same thing. You'll see a variety of the home computer manufacturers in the US take that derivative of CP/M as an operating system.

C&E: What else do you have in the works?

DRI: We are working with Zilog and some of the silicon manufacturers to move CP/M right into the Z80 architecure so if you buy a Z80, you'll get CP/M because it'll be on a single chip. The whole thing has become an integral part of how you construct a home computer. There's also some associated technology that allows us to bring home computer applications . . . but we can't talk about that yet.

C&E: Do you think you'll find a big market down at the level of machines like the Spectravideo, Adam, and the Commodore computers?

DRI: I think the whole idea of our Consumer Division is to get into those markets where we haven't really been before. The Consumer Division's first product—DR Logo—is already out and, as things open up—like the Adam and the Commodore 64—we intend to have products that will facilitate each one of these. We will have products that consumers can buy through mass-merchandising channels.

C&E: For example?

DRI: DR Logo is a product where sales volumes are going to be extremely high. If we look at the DR Logo Learning Library—that is an associated learning library of Logo-based software—we would say that 80% of the revenues of Digital Research will come through it and will be brought back either to the consumer or the educational/institutional segment. We've got some things going that you'll be hearing about in the next three to six months. They'll just keep rolling out.

C&E: Digital Research products have not previously been noted known as particularly user-friendly. Is DR Logo going to be different?

DRI: We had an on-line help facility in DR Logo to begin with; it was using abbreviated help commands. Now we basically have the entire reference manual available as an on-line help facility. If you hit HELP, you don't even have to go into the manual any more.

C&E: Do you have any final comments?

DRI: The main thing for COMPUTERS & ELECTRONICS is probably that you're going to find that computers in the home are going to be a lot more environmental-sensitive. Home computers are going to be operating controllers and be out into the homes a little bit more than just as a keyboard and display. That's definitely going to be exciting over the next two years . . . and we're definitely going to be in the middle of it. ◇

NEW HEATHKIT/ZENITH 16-BIT LEARNING COMPUTER

Powerful, expandable semi-kit combines with educational course for "hands-on" self instruction

By Joe Desposito

The ET-100 breadboard can be used to perform experiments.

BUILD-it-yourself microcomputers, so prevalent in the mid-to-late 1970's, have now almost vanished from the scene. But the big daddy of the electronic kit business, the Heath Company, continues to support such products. Its latest kit computer, the ET-100 Learning Computer, is a 16-bit trainer that can be expanded into a full-blown system.

The Learning Computer consists of a cassette-based 16-bit computer with detached keyboard, and a top-mounted experimental breadboard. The computer trainer is fully functional in its basic configuration and needs only a video monitor for display and standard cassette tape recorder for data storage. (Alternatively a TV set and optional modulator can be used for the display.) Suggested retail price of the ET-100 Learning Computer kit is $999.95 ($1499.95 factory assembled).

With the ET-100, you can learn the fundamentals of 16-bit microprocessors (specifically Intel's 8088 CPU) and assembly-language programming. The breadboard atop the main unit gives you access to the 8088 for interfacing the computer to the outside world.

Unlike some kit computers, this one doesn't really have to be built from scratch—the main logic board and keyboard come pre-assembled and tested. Though this might offend some purists, it should encourage those who are somewhat gun-shy (solder, that is).

Here then, is an over-the-shoulder view of what it takes to build a 16-bit microcomputer (circa 1983) accompanied by a review of the product as trainer.

Electronic Assembly. A computer kit usually conjures up visions of microprocessor, RAM, and support chips by the truckload. Not so with the ET-100. There are three printed-circuit boards to assemble: the breadboard, keyboard logic, and power supply, but notably missing is the main logic board.

The main logic board for the ET-100 is so complex that it is assembled and tested at Heath. This may steal away some kit-building glamour, but it most certainly avoids major problems in getting the computer to work. The keyboard, too, comes wired, though the keyboard logic board does not.

Building a Heathkit is an exercise in organization. You're expected to set aside a workplace for the project and to have the proper tools needed for the job. Since correct soldering techniques are so important to success, the assembly manual reviews them for you. I used three soldering devices during the project: a 25-W pencil iron for IC and other semiconductor soldering, a 40-W pencil iron for general-purpose soldering, and a 140-W gun for heavy duty work. Confident but realistic, I also kept a de-soldering bulb close at hand.

Soldering components to the breadboard, keyboard logic, and power supply pc boards is straightforward. Assembly instructions have you soldering components to the board one section at a time. When each section is finished, there is a checklist of commonly made errors. These include unsoldered connections, poor solder connections, and solder bridges, plus correct installation of ICs, tantalum capacitors, diodes, and resistor packs. I'm usually very careful when I build a kit, so I considered skipping these checks. But after finding two capacitors soldered in place in the wrong direction, I was glad I didn't. Skipping checks might save time initially, but could prove to be disastrous at the end.

Most of the cables are constructed from scratch. This means cutting wires to size, stripping the ends, soldering them to spring connectors, and then inserting them in socket shells. I found this to be the most tedious part of the kit construction.

Mechanical Assembly. There is as much, if not more, time spent on mechanical assembly of the ET-100 as there is on electronic assembly. Even the solderless breadboards come disassembled! You have to push many, many metal connectors into plastic holes to complete the assembly.

A piece of advice on mechanical assembly is in order here. If you intend to build the ET-100, purchase a few ice cube trays. Then when you have to sort the myriad screws and hex nuts included with the kit, you'll be well prepared. This will help you immensely when a 6-32 × ⅝" black screw (rather than 8-32 × ⅜") is called for, or when it's necessary to distinguish between a #6 fiber flat washer and a #6 shoulder washer.

If you're not familiar with press-in nuts, you'll get ample opportunity to learn about them. These nuts must be placed over holes in the plastic enclosure, heated with a soldering gun, and pressed into the holes once the plastic begins to melt.

Final Checkout. After what Heath figures to be about nine hours of construction, you'll be ready to test the final product. (Why did it seem more like 18 hours to me?) The initial tests are resistance checks and voltage measurements. If you successfully build the power supply, you'll find ±5 V and ±12 V in the appropriate places. Then it's just a matter of whether the keyboard and main logic board will function properly. Since the main logic board is preassembled and checked, there's a good chance the system will work. Mine did the first time, and that's a good feeling.

```
;LABEL/  OPCODE/  OPERANDS/
;NAME    DIRECT.  ARGUMENT

         ORG      00FFH

NUMBER   EQU      0FF00H

         MOV      AX,NUMBER
         MOV      CX,VAR
         ADD      AX,CX
         MOV      STORE,AX
         HLT

VAR      DW       00FFH
STORE    RW       1

         END
```

Fig. 1

The Working Unit (Hardware). When you hear the term "microcomputer trainer," you usually think of a unit with a hex keypad for program and data entry. The ET-100 is very different in this respect—it uses a full-size keyboard. The keyboard is detachable and connects to the computer through a coiled wire. The computing unit is distinguished by three solderless breadboards sitting on top of it that are used for microprocessor interfacing experiments.

The keyboard has 95 full-travel keys, which includes a standard (QWERTY) alphanumeric keyboard, as well as separate numeric keypad. The keyboard generates a full 96-character ASCII set that can be displayed in 24 80-character lines on a video monitor, or in 20 40-character lines on a standard TV set (using an optional modulator). There are four cursor-control keys, 13 function keys, and assorted others. Some of the special keys are delete or insert a character, delete or insert a line, line feed, and fast repeat. Line feed moves the cursor to the next line, but has no effect on the entry of a command or instruction. All keys will repeat when pressed and held down; the fast repeat key is used to increase the repeat speed.

Inside the keyboard enclosure is an 8021 keyboard encoder, which is a dedicated 8-bit microprocessor with internal RAM and ROM. It decodes the keyboard matrix and communicates with an 8041 Universal Peripheral Interface (UPI) on the main board through the coiled cord. The 8041 is also a dedicated 8-bit microprocessor with internal RAM and ROM. When a key is pressed, the 8021 sends the code to the 8041. The 8041 then generates an interrupt to tell the CPU that a key has been pressed. The CPU accesses the 8041 and the ASCII code is put on the data bus.

The computer contains the main logic board, power supply, fan, interface connectors, and breadboard. On the main logic board is Intel's 8088 microprocessor, 16K RAM (expandable to 64K on board), 32K ROM, and 2K video RAM. Also on the main board are an 8255 programmable peripheral interface (PPI) and 68A45 cathode-ray-tube controller (CRTC), among other things. Part of the PPI's parallel ports are used by the system and part are routed to the breadboard for experiments. Video display is controlled by the CRTC. It generates the addresses needed to refresh the screen and also generates the horizontal and vertical sync pulses.

The power supply produces +5 V dc at 6 A, +12 V dc at 1 A, and −12 V dc

TECHNICAL SPECIFICATIONS
HEATHKIT ET-100 16-BIT LEARNING COMPUTER

Central processor unit:	Type iAPX 88/10 (8088)
Clock rate:	5 MHz
On-board memory:	16K RAM (expandable to 64K)
User memory (incl. EA-100):	Expandable to 192K
ROM space:	One 64K page; 32K for monitor, editor, etc.; 16K reserved for MTR-100 ROM.
Video RAM:	2K
Video controller:	68A45 CRTC
Display format:	24 rows of 80 char. or 20 rows of 40 char.
Character type:	5X9 dot matrix; 8X10 dot matrix graphics
Character set:	96 ASCII characters; 32 graphics
Keyboard:	95 keys: 61 alphanumeric; 16 function and control; 18 numeric and control.
Serial I/O:	RS-232 (DCE)
Baud rate:	300, 600, 1200, 2400, 4800, 9600, default baud rate 4800
Cassette data rate:	300 baud
Primary power:	100 W
Keyboard dimensions:	18¼"W × 3½"H × 7¼"D
Main unit dimensions:	18¼"W × 4½"H × 12½"D
Weight:	21 lb

```
              EQUATE                                   SOURCE
              VALUE            PROGRAM                 PROGRAM
                               IN HEX CODE
MEMORY        FF00                             NUMBER  EQU    H
ADDRESSES
           00FF B800FF                                 MOV    R
           0102 2E8B0E0E01                             MOV    R
           0107 03C1                                   ADD    X
           0109 2EA31001                               MOV    X
           010D F4                                     HLT

           010E FF00                           VAR     DW     H
           0110                                STORE   RW     1

                                                       END

        END OF ASSEMBLY.  NUMBER OF ERRORS:   0
        USE FACTOR:  1%

        >■
```

Fig. 2

at 500 mA for the system. There is also power available at the breadboard (+5 V dc at 1 A, +12 V dc at 500 mA, −12 V dc at 100 mA, and −5 V dc at 100 mA), which is independently regulated from the logic board supply for protection. Line filtering is provided by a capacitor and toroid inductance combination to remove or reduce "noise" from the power line.

At the rear of the computer are the connectors supplied with the standard ET-100: a composite video output, RS-232 port, and cassette I/O. Also on the rear panel are a 110-V ac line, cord,

```
O D I T S Z A P C          | FFF0   01 01 01 01
0 0 0 0 0 0 0 0 0          |        01 01 01 01
                           | FFF8   01 01 01 01
AX= 0000                   |        01 01 01 01
BX= 0000                   | 0000 →00 00 00 00
CX= 0000                   |        00 00 00 00
DX= 0000                   | 0008   00 00 00 00
                           |        00 00 00 00
SP= 0400     | Break Pt.   | 0010   00 00 00 00
BP= 0000     |             |        00 00 00 00
SI= 0000     |             | 0018   00 00 00 00
DI= 0000     |             |        00 00 00 00
             |             | 0020   00 00 00 00
CS= 0280     |             |        00 00 00 00
DS= 0300     |             | 0028   00 00 00 00
SS= 03C0     |             |        00 00 00 00
ES= 0300     |             | 0030   00 00 00 00
IP= 0000     |             |        00 00 00 00
-----------------------------------------------
: ■
```

Fig. 3

on/off power switch, and fuse compartment for a 1.5-A slow-blow fuse. A LOW/NOR switch permits compensation for consistently low line voltage by connecting to a tap on the power transformer in the LOW position.

The breadboard, which takes most of the top of the computer, can be used to perform experiments with the ET-100. The large center area consists of three solderless breadboards (one removable). There are several smaller breadboard blocks, which connect to specific places inside the console. The *Power* block supplies ±5 and ±12 V dc. The *Address* and *Data* blocks give you access to A0 through A19 and D0 through D7 of the 8088 CPU. The *PPI* block allows you to access the 8255A Programmable Peripheral Interface. Since some parts of the PPI are used by the system, you must be careful not to program any part of the chip that you can't access. The *System* block consists of the reset line, a 60-Hz output, a 5-MHz system clock output, and a light-pen input to the CRTC for light-pen experiments. The *MPU* block contains several lines that are available from the 8088. All access lines are buffered to protect the 8088 microprocessor from damage.

The Working Unit (Firmware). The system firmware includes a 16K ROM that contains an assembler and a 16K ROM that contains a monitor, editor and debugger. The monitor is in control of the system when you turn it on. Through it you can gain access to the assembler, editor and debugger. You can also run, save, load and list programs, among other things.

The ET-100 assembler is based on the CP/M-86 assembler. You can assemble a program from source code created with the monitor's editor, or from source code saved on cassette tape or downloaded from the RS-232 port.

To gain an idea of how the system works, let's suppose you wanted to enter a program into the computer. After turning on the computer, you would be greeted with a prompt that looks like a "greater than" symbol (>). To get into the editor, you simply type EDIT and press RETURN. Once in the editor, you type your program in assembly language. A typical program to add two numbers is shown in Fig. 1. After typing in the program, a CTRL Z will allow you to exit the editor.

At this point you can assemble the program by typing ASM86 and pressing RETURN. The assembled version of the program of Fig. 1 is shown on Fig. 2. Any errors in the code are noted at the bottom of the display. To correct an error, you must return to the editor and make the correction, then return to the assembler and reassemble the program.

Once assembled, the program can be loaded into the debugger. You enter this mode by typing DEBUG at the monitor prompt. The debugger allows you to

Simple, even for adults.

load a program, single step through it while watching register and memory contents, and change the program if necessary. The debugger display is shown in Fig. 3. The nine *Flag* registers are shown across the top left, the contents of each register are shown on the left side of the screen, and the contents of memory are shown on the right side of the screen. Debugger commands are entered at the bottom of the screen. When you're satisfied that your program will run correctly, you can exit the debugger by typing, Q, and then use

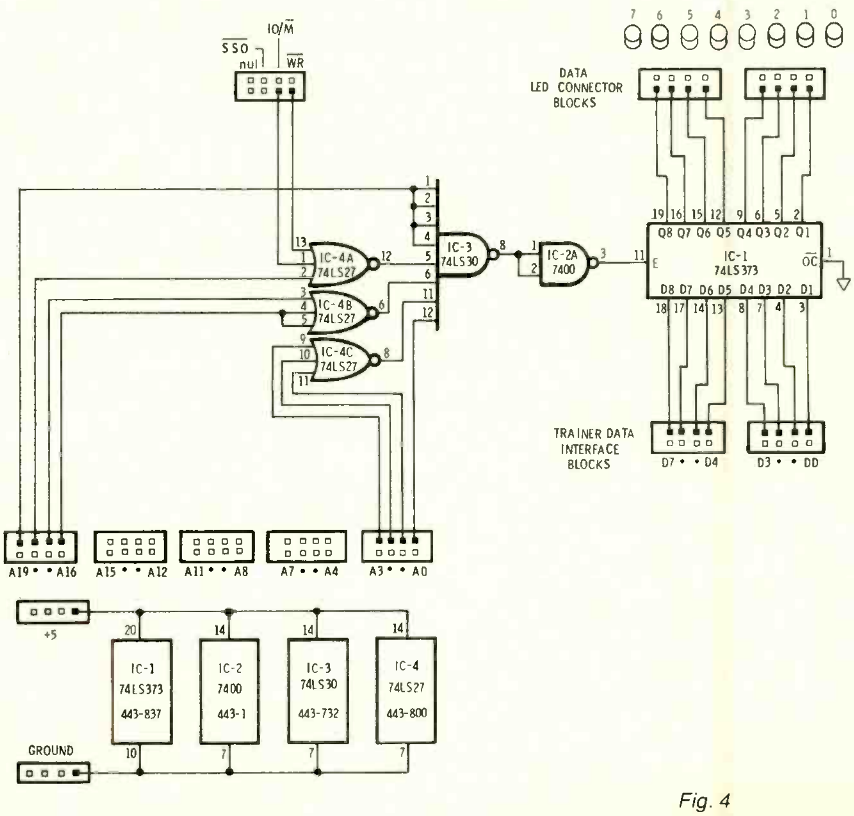


Fig. 4

With 3M diskettes, your computer never forgets.

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monitor commands to run the program, save it to tape, or print it out.

Using the ET-100. The ET-100 can be used for learning to program the 8088 in assembly language (as shown above), or it can be used to learn the basics of hardware interfacing to a microprocessor. A typical experiment that uses both hardware and software techniques is interfacing the microprocessor to an external data display.

Figure 4 is a circuit diagram that shows the ET-100 breadboard connections to the address lines, data lines, and $IO/\overline{M}$ and $\overline{WR}$ control lines of the 8088. This circuit can be used with a program that will alternately turn all of the data LEDs on and off (Fig. 5).

In operation, bistable octal latch *IC1* is enabled whenever a decoded address is accessed. Any data appearing on the data lines at that time is latched into *IC1*. Since the output control pin ($\overline{OC}$) of *IC1* is tied to ground, the data LED will follow the latched data level of the output pin it is connected to.

This simple experiment shows how the 8088 can be interfaced with the outside world with the ET-100. Extending this experiment, one could envision actuating a display for an operator to read, or sending a digital control signal to an electromechanical device.

Documentation. The ET-100 comes complete with an assembly manual and user's manual. The assembly manual takes you step by step through the construction and testing of the ET-100. The user's manual provides a description of the system, and all the technical data you'll need. For the hardware, there are data sheets and schematics. For software, there are the commands for the editor, monitor, and debugger, plus a complete description of the 8088 instruction set.

The Microprocessor Course and System Expansion. There are two ways to enhance the value of your ET-100. First is with the "Advanced Microprocessors" individual learning program that sells for $99.95. This 1200-page book is a complete training course for 16-bit microprocessors. Although Heath uses the term "advanced," the course also covers the fundamentals of microprocessors, programming and interfacing.

The other way of enhancing the ET-100 is to expand it into a disk-based 16-bit computer system. An expansion accessory kit priced at $1299.95 ($1999.95 factory assembled and tested) adds features that include 128K RAM, a 320K disk drive, and bit-mapped video. The system can then run all current 16-bit software under the Z-100 operating system, Z-DOS (MS-DOS), including such programs as Multiplan, WordStar, Lotus 1-2-3, and PeachText. Further system expansion is also possible to add more memory (192K), color graphics, and dual drives. Even after it is fully upgraded, however, the ET-100 can be returned to its training mode with a simple keyboard command.

```
CP/M ASM86 1.1   SOURCE: SOURCE.A86

                          ;LABEL/  OPCODE/  OPERANDS/
                          ;NAME    DIRECT.  ARGUMENT

  8000                    LED_ADR  EQU      8000H
  0001                    LED_OFF  EQU      1

 0000 B80080                       MOV      AX,LED_ADR
 0003 8ED8                         MOV      DS,AX
 0005 BB0100              START:   MOV      BX,LED_OFF
 0008 33C0                         XOR      AX,AX
 000A 8807                         MOV      [BX],AL
 000C E80C00        001B           CALL     DELAY
 000F BB0100                       MOV      BX,LED_OFF
 0012 B0FF                         MOV      AL,0FFH
 0014 8807                         MOV      [BX],AL
 0016 E80200        001B           CALL     DELAY
 0019 EBEA          0005           JMPS     START

 001B B90400              DELAY:   MOV      CX,4
 001E BB08CF              REPEAT:  MOV      BX,53000
 0021 4B                  AGAIN:   DEC      BX
 0022 90                           NOP
 0023 75FC          0021           JNZ      AGAIN
 0025 E2F7          001E           LOOP     REPEAT
 0027 C3                           RET

                                   END


END OF ASSEMBLY.  NUMBER OF ERRORS:   0
USE FACTOR: 16%
```

Fig. 5

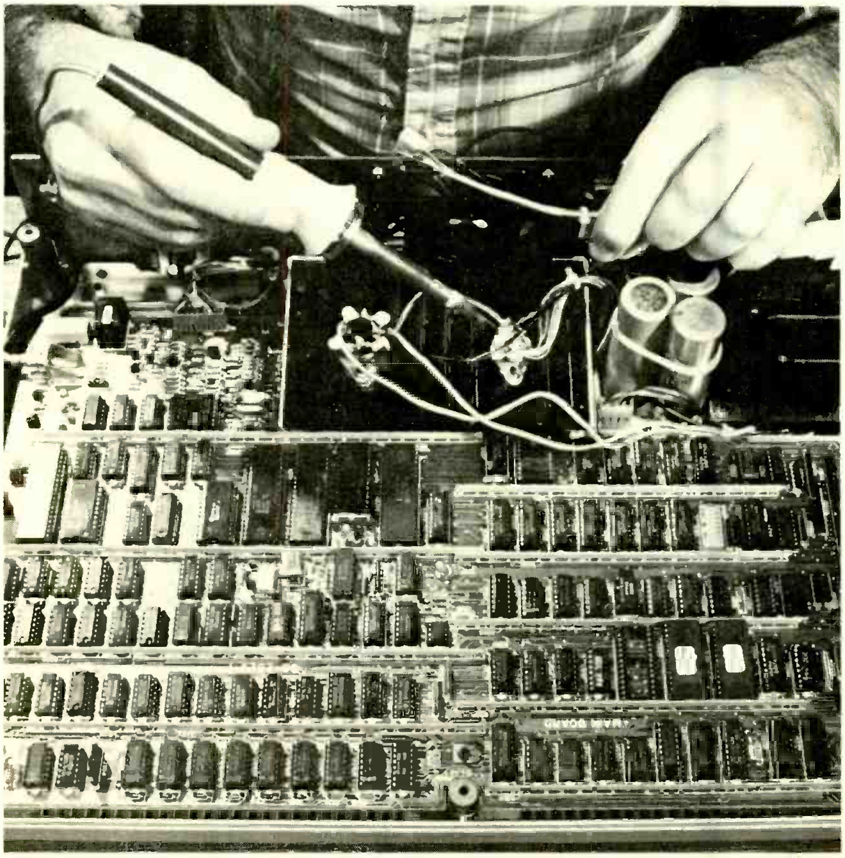
Conclusion. If you've ever built a Heathkit, you're aware of the incredible care this company takes in guiding you through the construction of a project. All you have to do is cooperate by extending some care on your own part to have a successful kit-building experience.

Kit builders might regret that so much of the kit is pre-assembled, but it's clearly a case of the technology outdistancing the skills of the kit-building enthusiast. Though much of the kit building tasks are mundane, it does give you a good understanding of the construction and interconnection techniques used.

I think the ET-100 is an excellent learning tool. With it a person can gain an in-depth understanding of the 8088 CPU, one of the most popular microprocessors available today. Though much more expensive than some 8-bit microprocessor trainers, the ET-100 gives one a handle on a microprocessor that's most often found in new business-oriented personal computers. This fact and its expandability feature make the price, in my opinion, less of a factor in the buying decision.

A good review should highlight both the positive and negative features of a product. However, I feel hard-pressed to find anything that disturbs me about the ET-100. ◇

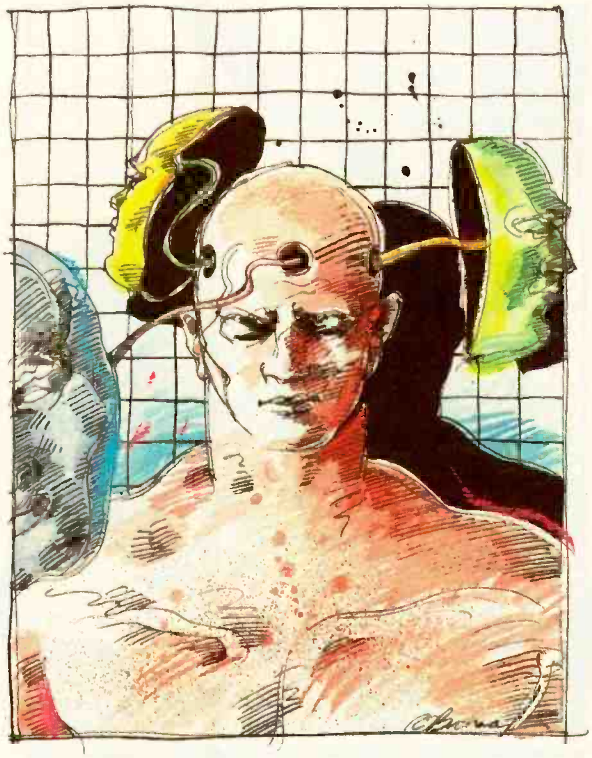
With a pre-assembled breadboard, soldering is minimal.



Getting Started in PERSONAL COMPUTING

FOR new readers who have not yet joined the computer revolution, this is your invitation to a learning adventure that will prime you for a smooth entry into home or business computing.

The personal computer has had an ever-growing influence on our everyday lives in business, in education, and in the home. It's helping businessmen to plan, forecast, and generally manage their enterprises; educators to more effectively motivate and teach students from elementary school to graduate-level school; and home users to become computer literate, keep track of family finances, and play action games in full color with sound effects.



The most popular uses of personal computer systems are in the areas of word processing, financial spreadsheets, database management, games, education, and telephone communications with data banks and other computers.

The manner in which you perceive a personal computing system depends largely on what you know—and don't know—about computing in general. Therefore, we've geared this introductory-level article toward demystifying personal computer hardware and software terms.

By Alexander W. Burawa

How a Computer Works

All computers, regardless of how simple or complex they are, have in common three major sections: input/output (abbreviated I/O), memory, and processor. Without any one or more of these sections, no computer is complete, nor can it operate in any meaningful way. Although I/O, processor, and memory are usually combined within a computer, each has a separate and distinct function.

To help make sense of the various sections that make up a personal computer (indeed, *any* computer) and to explain their purposes and importance to the computing process, you should understand what a computer is and what it does. There is nothing really mysterious or magical about a computer, nor are you required to know every technical detail of its design or operation to be able to use its processing power.

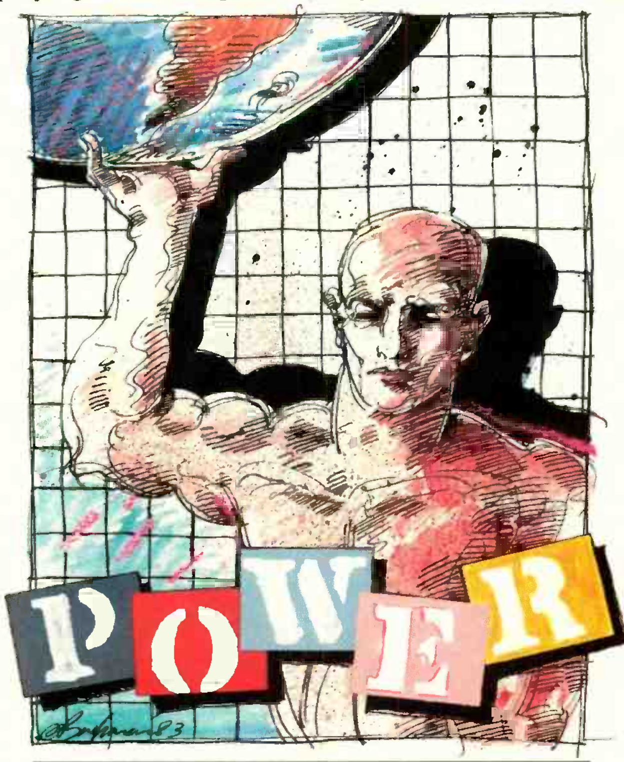
In very basic terms, a computer is an information or data processor. It takes information fed into it from the outside world, through the input portion of the I/O section, and does whatever it has been programmed to do with the information. Then, after processing the information according to the detailed instructions in a program, the computer sends the results back to the outside world through the output portion of the I/O section. This information is presented in the form the user can understand and may be displayed on the TV-like screen of a video display monitor or printed out on paper.

To be able to take in the desired information, the computer must have some convenient means for loading (entering) the data. This may be a typewriter-like keyboard, a disk or cassette-tape drive, or some other mechanism that can be used for entering data and instructions. Frequently, more than one entry device is used, such as a keyboard and a disk drive; new data is fed in from the keyboard, while the program that is to process it might come from a preprogrammed magnetic disk.

Once information is fed into a computer, the processor acts upon it according to the steps detailed in the program. To be able to operate efficiently, a place inside the computer is used to store the data and instructions until needed by the processor and any intermediate results of processing. This is the task of the memory section.

Finally, a video display screen or a hard-copy printer is fed the results of processing through the output portion of the computer's input/output section.

Information processing inside a computer can have any number of meanings, depending on the applications software (program) being used. In word processing, for example, the processing function executes commands that allow you to change characters, words, and even whole blocks of typed-in copy; formats letters and reports to give them a professionally finished appearance; and performs any number of editing operations available with the software package. Another program might allow you to alphabetize long lists of names or words or place in order numerical data. Yet another program might permit you to quickly and accurately perform mathematical computations in the sciences and engineering. From the foregoing, it's obvious that "processing" is a catch-all term that refers to the multitude of data and information manipulations available with a given software applications package.



In basic terms a computer takes information from the outside world and processes it.

All data and instructions entered into a computer are manipulated according to a precise set of instructions detailed in a computer program. As data and instructions are entered—whether by running a magnetic disk or tape with the program already on it or by keying in your own program—they're stored in memory until needed by the processor. Intermediate results of manipulations are stored in memory, too, at locations different from those used for data and instructions.

There's nothing arbitrary or random in the way in which the computer's processor assigns memory locations to the data and instructions fed to it. The processor manages its memory by assigning data and instructions to specific blocks of memory for instant recall.

Whatever form of information processing is performed, at some point in the program you want the results in a form you can use. In the case of word processing, this will usually be a document or letter printed out on paper. It's the task of the output portion of the computer's I/O section and a hard-copy printer (a peripheral that's not part of the computer's basic system) to provide the results of word processing and many other forms of processing. In many cases, however, you may want a nonpermanent output, in which case, the results of processing may be displayed on the system's video display screen instead of being printed out on paper.

Now that we've introduced the basic sections that make up even the most elementary of computers, let's look at each section in greater detail.

Input Devices

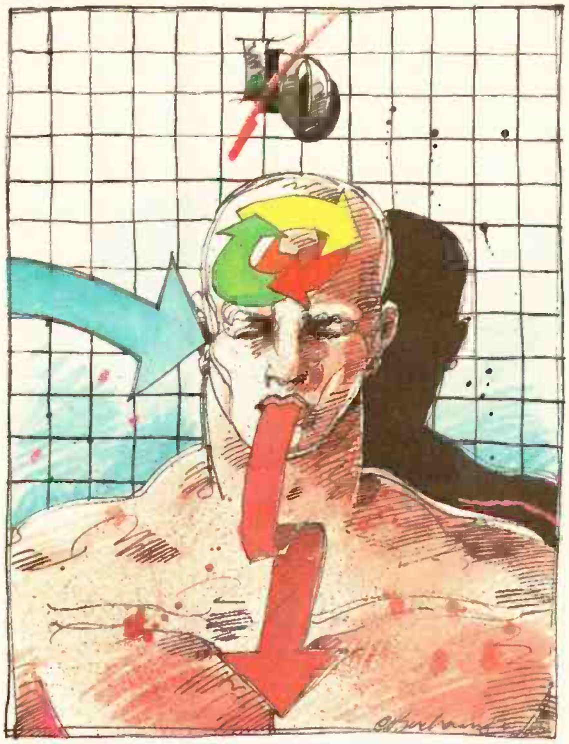
A common data-entry (input) device for modern computers takes the form of a standard QWERTY typewriter-like keyboard that has the usual alphabetic, numeric, and punctuation keys. To these are added the special-character and special-function keys required by and unique to computing. Though such a keyboard is the most common entry device used in computing, it's only one of many input devices available.

Computers can also obtain data from other computers over the telephone lines, using a device called a "modem" (more about this later). They can also obtain what they need from magnetic tape in any number of guises ranging from an audio cassette, to a solid-state cartridge, to disks that superficially resemble audio records. Yet another input device, very popular with computers with games-playing capabilities, is the so-called "joystick," which is used for controlling the action of video games and sometimes for much more serious applications. There are also a number of other specialized input devices, such as the light pen and the barcode reader that "reads" optical coding, and analog-to-digital (A/D) converters that feed such nondigital information as temperature, pressure, weight, etc., into the computer after converting it to a form the computer can use. And information can be entered by vocalizing it—speaking to a computer equipped with an electronic "ear."

We'll discuss input (and output) devices in much greater technical detail in a later section. For now, to understand how computers do what they do, it's enough to know that the input/output section is a major and very important part of any computer system. It's this I/O section that makes it possible for us to communicate and interact with the computer.

Output devices are usually grouped with input devices, since both are managed by the same section in the computer. Output devices, such as the printer and video display unit are required only after information has been processed within the computer. The video display unit, however, is also used to display data as it's being entered from the keyboard and instructions from programs being used, as well as for display of output information.

Before we get too deep into a discussion of output devices, however, let's take a look at the processor and memory sections, which are next in the computer flow.



The I/O section makes it possible for us to communicate with the computer

The Processor

In a very real sense, the processor is the "brain" of the computer, since it orchestrates the flow of data into and out of the computer's memory section and from and to the outside world, in addition to actually processing of data. This device goes by a number of names, all of which refer to the same thing. Among the names in common use are "central processing unit" (commonly abbreviated CPU) and simply "processor." In the case of the personal computer, another name commonly used is "microprocessor," which is derived from the *micro*scopic size of its *processor* circuits.

For the sake of efficiency, the processor accepts instructions and other information several bits at a time in parallel chunks. One could say that it takes a "bite" at a time, except that in computing the spelling is "byte." Just how many bits at a time it can handle is called the processor's word size, which has a direct influence in determining how powerful a given processor is and, thus, the power of the computer in which it's used.

The microprocessor is actually a miniature computer in its own right. It's made from a single integrated-circuit (IC) "chip" on which are thousands of basically very simple on/off circuits that act like switches. Though these circuits are very simple individually, they're combined in complex arrangements and there are so many of them that the microprocessor, in all its designs, is among the most complex devices ever created by human ingenuity. With all this complexity and power, the typical microprocessor is a very low-cost device. In fact, the more popular microprocessors in current use average only a few dollars each to manufacture.

As we've already mentioned, the word size of a microprocessor determines just how powerful in terms of processing the device can be. The first microprocessors, introduced in the early 1970s, handled 4-bit words and, consequently, were known as 4-bit processors. By 1975, when personal computing made its debut, the word size had increased to 8 bits, with the introduction of Intel's popular 8080, followed by Motorola's MC6800 microprocessors and Mostek's 6502 devices. Today, the most popular processors used in personal computers are still 8-bit devices. However, a new generation of 16-bit microprocessors will likely surpass them in the business-oriented computer area.

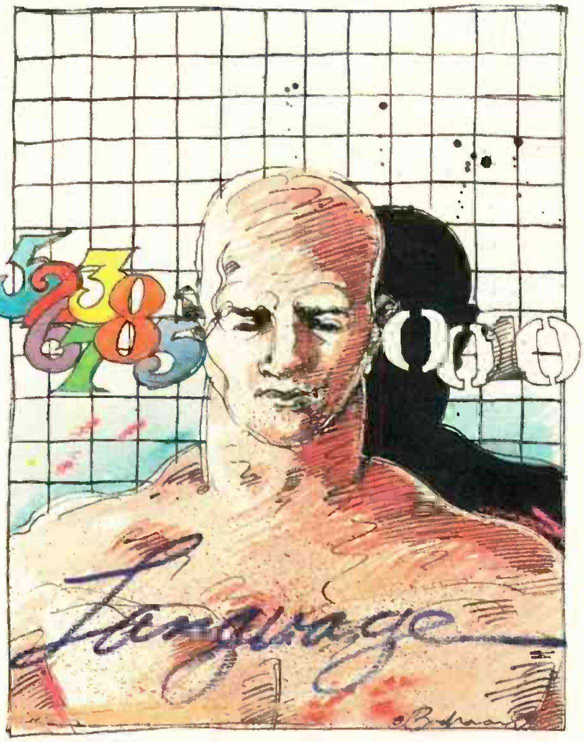
There are a few different types of microprocessors in current use in personal computers. Each is more or less incompatible with all the others. Furthermore, even the same types cannot often use the same software because each design has its own special approach to processing information.

Understanding how computers work and the task of the processor requires some understanding of how programs (the processor's instructions) are stored in the computer's memory. A computer stores its instructions and data at locations in memory called "addresses."

When the processor needs the contents stored in a particular location, it sends the location's address out over its bus, along with a signal that tells the memory system that the processor wants to "read" the contents at that address. Since the processor reads several bits of data simultaneously, that's also the manner in which it's stored in the computer's memory section.

The retrieved data can be either an instruction or a number. If it's an instruction, the processor performs the required operation and then sends out a new address call to memory to retrieve the next instruction or piece of data. This process continues until the entire program stored in memory has been executed.

Sometimes, an instruction, such as a mathematical operation, requires a number to be processed. In a stored-program computer, that number is usually located in memory at a location immediately following the location of the instruction. At other times, the data immediately following the instruction is another address in memory where the number can be found, instead of the number itself. In any case, it's the processor's task to interpret each instruction, sending out new addresses to memory, which, in turn, sends back more instructions and data to be processed.



A computer "thinks" only in terms of 1s and 0s

The concept of stored programs, in which all of a processor's instructions are stored in sequential addresses in memory and intermixed with numbers, is common to all modern computers. The steps performed are very similar to those in an ordinary calculator, which accepts a number and then an instruction, such as + for addition or × for multiplication, and then another number, followed by another instruction, such as = to obtain the result.

The major difference between how a computer and a calculator perform a mathematical operation is significant. In a computer, instructions and numbers are stored in memory and are automatically "fetched" when needed. In a calculator, on the other hand, numbers and instructions are entered one at a time by hand. More advanced "programmable" calculators operate in a manner similar to a computer in performing mathematical operations, but the computer extends the concept to include handling of nonmathematical symbols as well.

A computer, "thinks" only in terms of 1s and 0s. You might wonder, then, how it's able to extend its processing power to manipulate letters and numbers. To understand this process requires a closer look at a byte. To simplify this discussion, we will limit it to 8-bit processors, which handle 8-bit bytes.

Since each of the eight bits in a byte can be either a 1 or a 0, there are a total of 256 different possible bytes. This number is derived from the fact that the number of different combinations of a string of a binary number "n" bits long is 2^n. Thus, a byte has 2^8, or 256, different possibilities.

With 256 possible variations, one byte is assigned to each upper- and lower-case letter of the alphabet and one each for the ten digits (0 through 9). The remaining 194 bytes are assigned to punctuation, graphics, and special characters. Thus, while the bit is the basic unit of information, the 8-bit byte is used to represent numbers and letters. For microcomputers, this is based on the widely accepted ASCII (American Standards Committee for Information Interchange) correspondence between bytes and the symbols they represent. It's important to note that this correspondence, while useful for translating between bits and the more familiar symbols we commonly use in everyday language, isn't the only meaning given to a byte.

Within the processor itself, bytes often represent instructions the processor must execute and for which the ASCII code doesn't apply. The kind of instructions a processor follows gets us to the very core of the processor itself, which is made up of an *arithmetic logic unit* (abbreviated ALU), a control section, and various kinds of single- and multiple-byte storage locations called *registers*. The storage registers aren't part of the computer's user memory; rather, they're located within the processor itself.

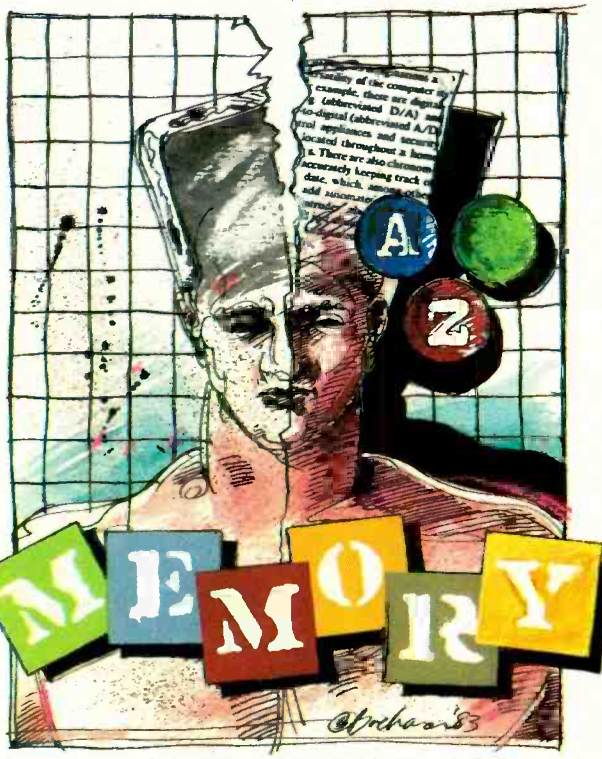
In a typical processor instruction cycle, as mentioned above, an address is sent out to memory to retrieve an instruction stored in a specific location (address). To send out the address, the processor loads it into a one-byte memory called the *address counter*.

How does the processor know at what address to look for an instruction? When the processor is first powered up, the address counter contains all 0s. This means that the processor expects to find its very first instruction in the computer's memory at address 0000. From here, the address counter keeps incrementing, or adding one

or more to its own value, to locate each successive address at which it expects to find succeeding instructions. Additionally, certain instructions used to modify the address counter cause the processor to look in different areas of memory for instructions. These are called *jumps* or *branches* and are part of a programmer's strategy in writing programs.

Wherever it comes from, the instruction arriving on the data bus enters the processor's instruction register (IR), which stores it for decoding by the processor's control section. The control section is the actual "brain" of the processor. It's the responsibility of this section to interpret each instruction and to orchestrate the other parts of the processor into action at the proper time.

In some cases, an instruction might simply fetch a number or letter from memory so that the next instruction can send it out to a printer or video monitor. In other cases, the instructions use the arithmetic logic unit to perform mathematical and/or logic operations. Logic operations combine bytes of data according to certain rules to produce a desired result. Frequently, the result is redeposited in memory for later use by still another instruction that "writes" data back into the computer's memory.



RAM is used to temporarily store data, while ROM has data permanently stored

The Memory

Once a computer accepts the data and instructions fed into it through the input portion of the I/O section, it either stores it for later use or processes it immediately. Storage, which is the function of the memory section of the computer, is required to hold the computer's applications program and other information.

Memory devices for computers to store data and programs are available in many different configurations. The capacity of its memory system is often used as the yardstick by which a computer's processing power is measured. The more memory a computer has, the larger the program it can accommodate. In fact, many applications programs can operate only in those computers that have at least a certain amount of user memory available. Computers with very little memory may not have enough memory capacity to run word-processing, data-base management, and other highly sophisticated software and, thus, are "underpowered" in this respect.

Computer memory is generally divided into two categories. One is *working memory* (frequently referred to as *user RAM*) and preprogrammed *ROM*. The other is so-called *mass memory*.

Working Memory can be thought of as an arrangement of "bins," each of which can store one and only one byte of information. Each of these bins has a unique numbered "address." The bins are subdivided into a set number of slots, the number reflecting the number of bits that make up the computer's word size. In an 8-bit computer, each memory bin has eight slots to accommodate the eight 1s and 0s that make up its word size. Each slot in the memory bin accommodates only one 1 or 0. No two locations in memory can have the same address, but two or more addresses (memory locations) can have the same character programmed into them.

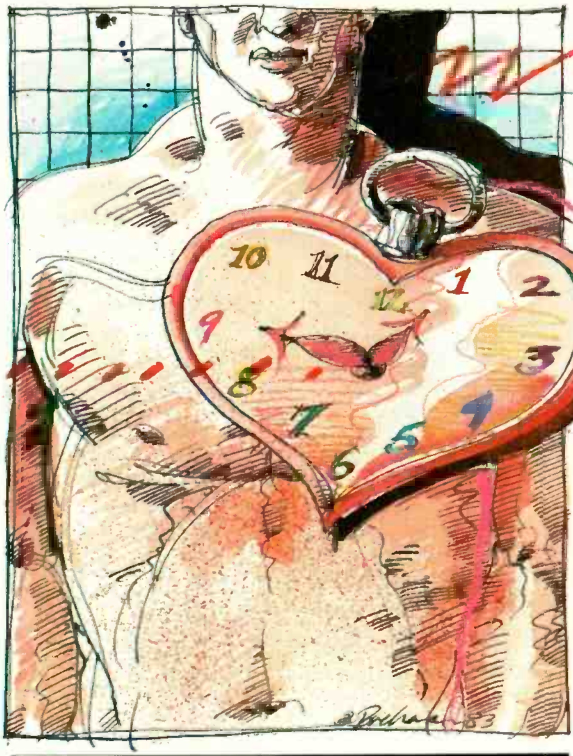
When the computer's processing section requires a specific piece of information from memory, it looks up the location's address and goes directly to that location to fetch the data it needs. It doesn't have to step through each location in memory between the last location addressed and the current location to be addressed in order to arrive where it wants to be. Instead, it "jumps" directly to the location being called. This ability to jump directly to any location in memory gives the computer's processor the ability to *randomly* access any given address; for this reason, the arrangement of address locations is called *random-access memory* and is commonly abbreviated *RAM*.

In most computers, the majority of working memory is user RAM, but a portion of working memory is almost invariably set aside for a different kind of memory called *read-only memory*, which is commonly abbreviated *ROM*. As is the case with RAM, ROM locations in memory can be accessed randomly. However, since ROM contains programming that must be executed in a specific sequence, access to its memory locations isn't usually random; thus, ROM isn't considered to be *random-access* memory.

There's one major difference between RAM and ROM—RAM is used to *temporarily* store data until needed, while ROM has data *permanently* stored in it. When a computer is through using data in RAM, the data can be erased and replaced with new data. Not so with ROM; whatever data is preprogrammed into ROM isn't ordinarily erasable by the computer user. Hence, RAM can be thought of as a blackboard that can be used and erased over and over, each time with different information. ROM, on the other hand, is more like a typewritten page that's nonerasable and always contains the same information.

Another important difference between RAM and ROM has to do with the data retentivity of the two different types of memory. Data stored in RAM is *volatile*, which means that it remains in memory only as long as power is applied and hasn't been interrupted. Any interruption in power to RAM will erase whatever data was stored; this data is then irretrievably lost. On power-up, the computer's RAM memory will have nothing in it. ROM, by contrast, is a *nonvolatile* memory system; anything programmed into it as it's delivered from the factory will remain in it, regardless of whether or not power is applied.

RAM and ROM are all-electronic devices. They're actually integrated-circuit (IC) chips, like the microprocessor. These solid-state devices, along with the input/output and processor sections, make up part of what is termed the computer's *hardware*. (The ROM can also be thought of as being software in the sense that it contains program data necessary to the functioning of the computer. In fact, because the programmed ROM shares many of the characteristics of both hardware and software, it's frequently called "firmware."). Because they're totally electronic devices that directly connect to the computer's processor section via a metal-conductor data bus, they can transfer data at almost the speed of light.



If a program is stored on a thirty-minute tape, it might take 30 minutes just to locate it.

Mass Memory is one step removed from the computer's processor and is available to the processor only by first passing through working memory.

Mass-memory storage is a relatively low-cost approach to meeting the large data needs of a computer. It's usually composed of a magnetic material that can have recorded on it the desired information. There are two basic magnetic-media mass-storage devices in common use in personal computing systems. These are standard cassettes and disks.

The cassette medium is the least expensive form of mass storage ($50 to $150). Though it can store large masses of data, it's not very practical for serious computing. Compared to disk media, cassette storage is relatively unreliable, slow in operation, and lacking in flexibility. It's mentioned here only to inform you that it exists and offers a low-cost introduction to mass storage.

The next step up in the mass-storage medium is the so-called "floppy disk" and its drive. As its name implies, the floppy storage medium is in the form of a flexible disk of thin Mylar on both sides of which is deposited a coating of magnetic-oxide that serves as the recording medium. Depending on the type of disk drive and the type of disk being used, one or both sides are accessible for program and data storage. The floppy disk gets its name from the nature of the storage medium, which is very flexible (or, in the modern idiom, "floppy") when not housed inside its nonremovable protective plastic jacket.

Floppy disks are available in a number of sizes, ranging from the 8″ diameter floppy, to the $5\frac{1}{4}$″ minifloppy, to the 3″ to 4″ microfloppy. Each size disk is designed for a specific drive type and is incompatible with the others. In terms of storage capacity, 8″ floppy disks can store considerably more data than can $5\frac{1}{4}$″ minifloppies. The microfloppy has a storage capacity the equal of $5\frac{1}{4}$″ minifloppies, due to much tighter manufacturing and operating-control tolerances.

Floppy disks are capable of storing information ranging from 80,000 bytes (abbreviated 80K) in older $5\frac{1}{4}$″ drives to in excess of 1-million bytes (abbreviated 1M) in the newest drives, depending on media size and whether or not the disks and drives are single- or double-sided. As a rule, double-sided disks can store two or more times the program and data information than can be stored on single-sided disks of the same density.

For much greater storage capacity, it's necessary to step up to hard-disk systems, which can store anywhere from 5-million bytes on up to and beyond 160-million bytes of program and data information.

The storage medium inside hard-disk drives (frequently called "Winchester" drives) consists of rigid, or "hard," metal disks on which is deposited the magnetic-oxide recording material. The disks themselves are sealed inside dust-proof chambers.

The need for mass memory is basically one of economics. Fast, immediately accessible working memory is expensive, not only in terms of the cost of the devices themselves but also in terms of the space they require inside the computer and in power consumption. ◇

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AN ATARI TAPE INTERFACE

A simple FSK interface permits loading and storing programs on a conventional cassette recorder

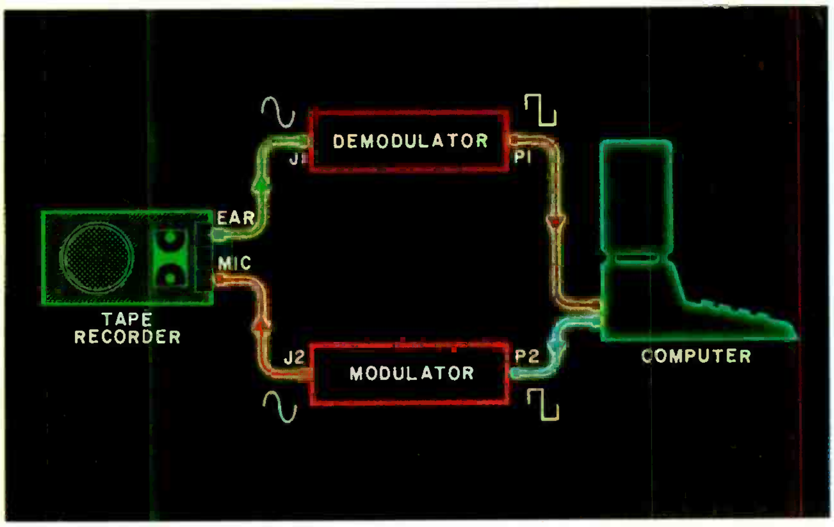


Fig. 1. Basic setup of the tape interface.

By Randy Carlstrom

ONE thing you learn quickly when you become a member of the computer revolution is that, while your computer's initial purchase price may have been dirt-cheap, the other things you need to make it useful—like a cassette recorder or disk drive, printer, and other peripheral devices—generally cost far more than you'd expect. The computer itself may turn out to be the least expensive part of your system, and it becomes a case of the tail wagging the dog.

It is difficult to justify purchasing a peripheral that costs more than the computer with which it was designed to operate. Having purchased an Atari 400 computer for less than $80 (including an Atari rebate) from a local hobby-and-toy store, I couldn't quite bring myself to pay more for the data recorder than I had for the computer. If you belong in the same category and own a standard cassette player/recorder of decent quality, or if you already own an Atari recorder and find that it's not quite as reliable as you'd like it to be, read on—for less than $20 you now have access to the wealth of Atari cassette programs.

Circuit Description. The Atari data recorder differs from a conventional audio cassette recorder because the frequency-shift keyed (FSK) modulator circuit is incorporated into its design, rather than being an integral part of the computer, as is usually the case. This article describes a simple single-chip FSK interface, designed to operate with the Atari computers, based on the Exar XR-2211 integrated circuit. This interface will permit loading and storing programs using a conventional cassette tape recorder.

Basic operation of the FSK tape interface is shown in Fig. 1. The modulator section accepts digital pulses from the computer (representing the program or data in the computer that is in the process of being stored) and converts them into audio tones, which are readily "stored" by a tape recorder. In the case of the Atari computers, a logic 1 is represented by a 5327-Hz tone and a logic 0 by a 3995-Hz tone. The demodulator section performs the reverse operation. It accepts the recorded data tones from the tape player and translates them back into their original binary format. The resulting pulses are then sent on to the computer for final processing. (If this sounds strangely similar to a modem, it's because the two are almost identical in operation. The only difference is that the tones are sent between a computer and tape deck via a cable, rather than back and forth over telephone lines.)

A block diagram of the XR-2211 integrated circuit is shown in Fig. 2. The small, numbered circles are the package pin leads. This versatile device contains an input preamplifier, a voltage-controlled oscillator (VCO), two phase detectors, two voltage comparators, and a reference voltage source. These functional blocks are internally connected to

"Peripherals may wind up costing more than the computer itself."

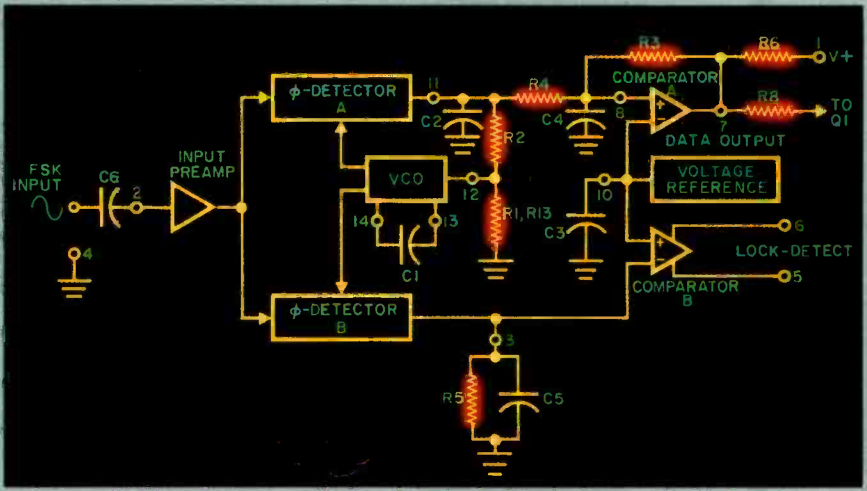


Fig. 2. Block diagram of the XR-2211 integrated circuit.

form a phase-locked loop (PLL).

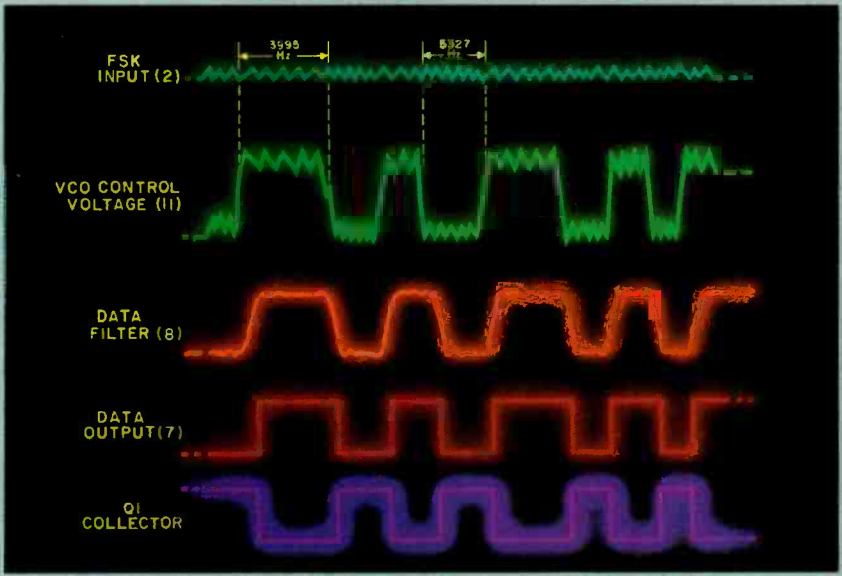
When a signal of sufficient amplitude is present at the FSK input (pin 2), the loop formed by phase detector A, *R2*, and the VCO attempts to track the input frequency. If the input signal is within the capture range of the PLL (the range of frequencies over which the loop can lock in), the VCO will track any small changes in the input frequency. The resulting changes in the VCO control voltage at the output of the phase detector (pin 11) are filtered by *C2* and the data filter, *C4* and *R4*. This signal is a facsimile of the original data and is amplified and shaped by comparator A. Inverter *Q1* provides the proper data polarity for the computer. Typical waveforms are shown in Fig. 3.

Phase detector B, filter *C5* and *R5*, and comparator B form a lock-detection circuit. Any time the input signal falls outside the PLL's capture range (or if the input signal is lost), pin 6 of comparator B is low. This pin is usually connected directly to the FSK demodulator's output (pin 7) to prevent chatter, should the PLL become unlocked.

The input preamplifier is actually a limiting amplifier that is able to accommodate a wide range of input signal levels. Ten millivolts rms is sufficient to cause limiting, but signals as large as 3 V rms can be used. This makes the PLL relatively immune to the volume (gain) setting of the tape recorder.

A schematic of the complete project is shown in Fig. 4. Resistors *R9* and *R11* form a 40-dB attenuator betweeen the computer's FSK output and *J2*, which connects to the microphone input of the recorder. Approximately 10 mV rms is delivered to *J2* during program save operations, providing the proper recording level for most recorders. The value of *R9* can be changed (or it can be removed) if necessary to suit the requirements of your tape recorder.

Fig. 3. Timing diagram for the circuit shown in Fig. 4.



Construction. The cassette interface can be built using any convenient construction technique and can be housed in its own enclosure or mounted inside the computer's case. If the latter method is chosen, two holes must be drilled in the case for mounting *J1* and *J2*. The five power and I/O connections from the interface board can be soldered directly to the mounting pins of the computer's serial I/O connector. (This eliminates *P1*, and the serial I/O connector is left free for use with other peripherals.) However, this method is recommended only for the skilled and/or dauntless since the computer's warranty is automatically voided.

Alignment and Operation. One adjustment is necessary to ensure reliable operation of the interface. It involves setting the free-running frequency of the PLL's VCO. The following steps outline the procedure:

1. Connect an ohmmeter between pin 12 of *IC1* and ground. Adjust *R13* until the ohmmeter indicates approximately 21 kilohms, then disconnect the ohmmeter.

2. Connect a shielded cable from the earphone or speaker jack of a cassette recorder to *J1* (EAR) of the interface. Place a program tape in the recorder and rewind it completely. If the interface wasn't installed inside the computer, make certain plug *P1* is plugged into the computer's serial I/O connector at this time. Turn on the computer power.

3. Press the PLAY button on the recorder. The first 10 seconds or so of the tape should consist of a steady 5327-Hz tone, which can be verified by listening to the television speaker. During this period, adjust *R13* so that pin 11 of *IC1* is −2.6 V with respect to pin 10. If you don't have access to an ohmmeter or voltmeter, you can center *R13* and slowly adjust it until the program loads suc-

cessfully through the interface.

Operation of the cassette interface is similar to that of the Atari data recorder. Programs can be loaded by following the instructions that accompany the program cassette. As a program is loaded, you will hear a buzzing sound from the television speaker. This is normal and indicates that the Atari is happy with the data it is receiving from the tape recorder. When saving programs on tape, follow the instructions given with the programming language used. Remember to press the RECORD button on the recorder.

If the interface was aligned properly as outlined above, programs should load very reliably, since this interface has proven to be more reliable than the Atari 410 data recorder. If you experience any problems, adjust the recorder's volume and/or tone controls. If that doesn't help, the recorder may not be quite up to par, in which case a good tape-head cleaning may be in order.

Errors occurring at the beginning of a loading sequence can often be attributed to leaving an insufficient amount of tape leader before the actual data began on the tape. (The computer doesn't really begin accepting data from the recorder until approximately 5 to 10 seconds after the computer's RETURN key has been pressed.) A tape that refuses to load past a certain point (usually at the same point and somewhere in the middle) is a classic example of the "bargain-tape syndrome." Some cheaper tapes often contain "dead spots" where the FSK signal drops out momentarily—a phenomenon almost certain to succeed in confusing your computer.

Bit-Copying Tapes. It is a simple matter to make backup copies of any of your tapes using the cassette interface and the circuit shown in Fig. 5. This circuit simply remodulates the serial data stream from the demodulator, bit by bit, and consequently doesn't care if the program is BASIC, machine language, or even copy-protected. A second tape recorder "listens in" on *J3* while the first recorder is playing the original program tape through *J1* (Fig. 6).

"So," you say, "why not just patch two recorders together to duplicate tapes?" This method will work, in general, if you use a good quality recording to start with. However, it has been the author's experience that many of the commercially available cassettes tend to degrade with time, especially those that are favorites of the family and are constantly being used and abused. You can be sure that a "patched" duplicate made from such marginal tapes will be even more marginal!

It is recommended that the alignment of the modulator circuit in Fig. 5 be performed with a frequency counter. With the counter connected to pin 2 of *IC2*, short pin 9 to ground and adjust *R18* for 3995 Hz. Remove the short from pin 9 and adjust *R20* for 5327 Hz. (Note that the computer must be turned on to make these adjustments.) If you don't have access to a frequency counter, you can use the following alternate procedure:

1. With a jumper wire or shielded cable, connect *J3* of the modulator to *J1* of the demodulator.

2. Short pin 9 of *IC2* to ground and adjust *R18* until pin 11 of *IC1* is +2.6 V

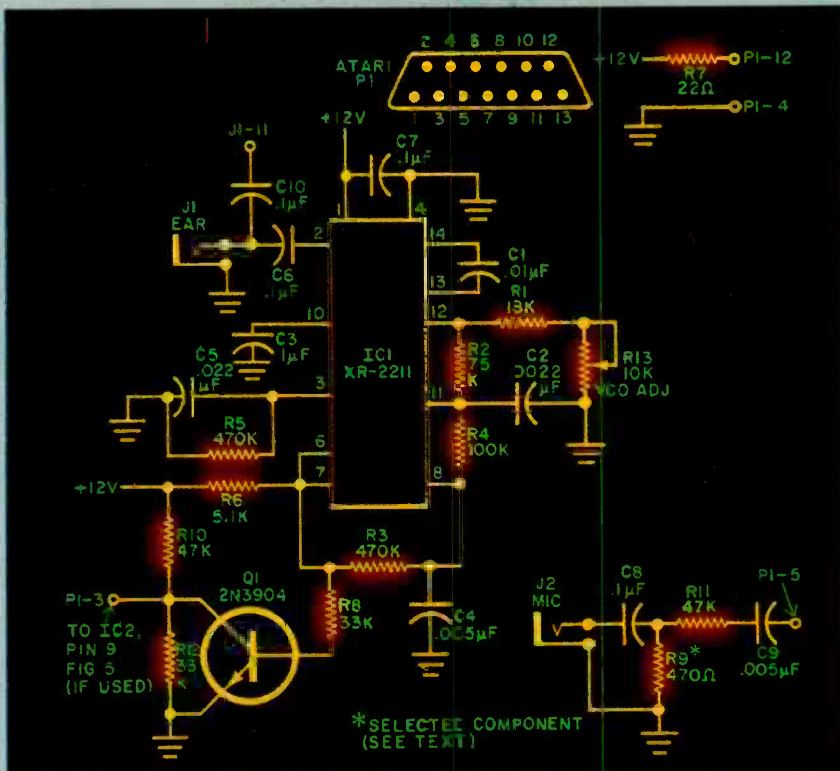


Fig. 4. Schematic of the interface. The wiring side of P1 is shown.

PARTS LIST

- C1,C12—0.01-µF, 5% polyester capacitor
- C2—0.0022-µF ceramic capacitor
- C3,C6,C7,C8,C10,C14—0.1-µF ceramic capacitor
- C4,C9—0.005-µF ceramic capacitor
- C5—0.022-µF ceramic capacitor
- C11,C15—1-µF electrolytic or tantalum capacitor
- C13—10-µF electrolytic or tantalum capacitor
- IC1—XR-2211 FSK demodulator/tone decoder (Exar)
- IC2—XR-2206 function generator (Exar)
- J1,J2,J3—Miniature phone jack
- P1—13-pin Atari mating plug
- Q1—2N3904 npn transistor

The following are ¼-W, 5% carbon resistors unless otherwise specified:

- R1—18 kilohms
- R2—75 kilohms
- R3,R5—470 kilohms
- R4—100 kilohms
- R6,R21,R22—5.1 kilohms
- R7—22 ohms
- R8,R12,R15,R23—33 kilohms
- R9,R16—470 ohms (selected, see text)
- R10,R11—47 kilohms
- R13,R18,R20—10-kilohm trimmer potentiometer
- R14—200 ohms
- R17—20 kilohms
- R19—15 kilohms
- Misc.—Suitably etched and drilled pc board or perf board; IC sockets; 5-conductor cable; solder; enclosure; etc.

***Note:** The following are available from RC Systems Inc., 121 W. Winesap Rd., Bothell, WA 98012: Kit of parts for cassette interface/duplicator, including etched and drilled pc board, No. AK-1, for $29.95. Also available separately from the same source: Kit of parts for cassette interface only, No. AK-2, for $19.95; etched and drilled pc board for interface/duplicator, No. AB-1, for $5.00; etched and drilled pc board for cassette interface, No. AB-2, for $4.00; XR-2211 IC for $5.25; XR-2206 IC for $5.00; Atari 13-pin mating plug, No. AP-1, for $6.50. Please include $1.75 shipping and handling on all orders. Washington state residents, add 7.8% sales tax.*

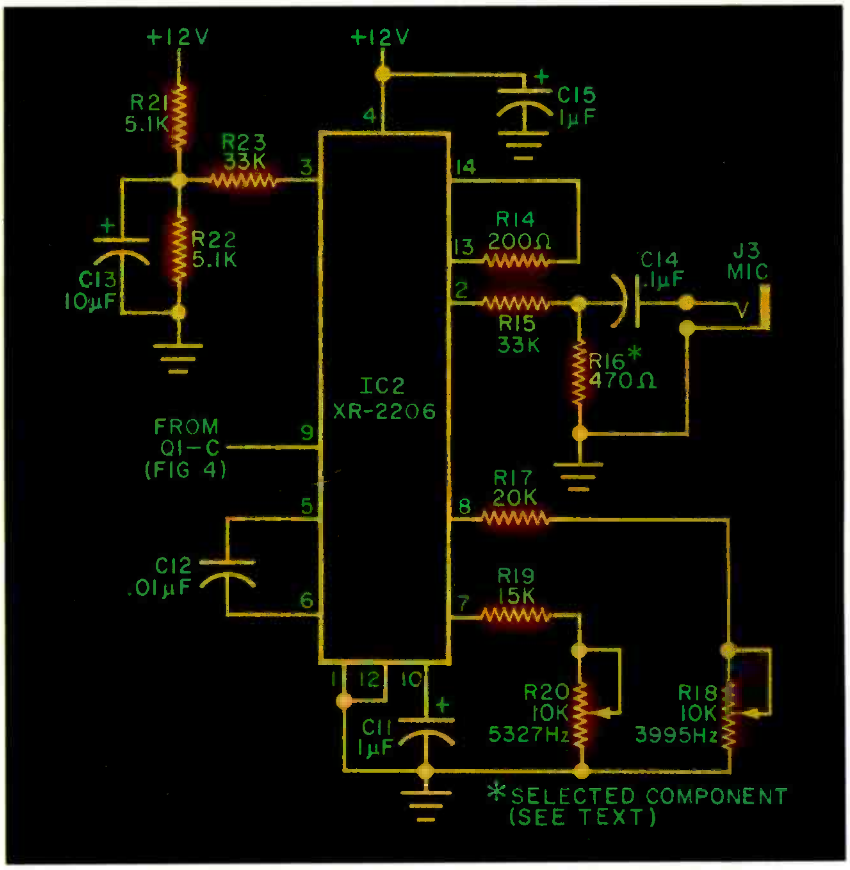


Fig. 5. Schematic of a circuit to remodulate the serial data.

with respect to pin 10.

3. Remove the short from pin 9 and short the base of *Q1* (the lead that connnects to *R8*) to ground.

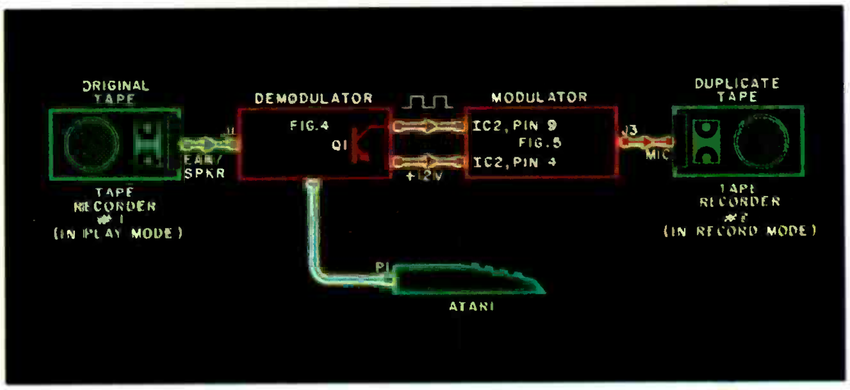
4. Adjust *R20* until pin 11 of *IC1* is −2.6 V with respect to pin 10. Remove the short from *Q1* and the connection between *J1* and *J3*.

Since *IC1* is acting as a frequency discriminator during these adjustments, the accuracy of these adjustments will depend on how accurately *R13* was set. The value of *R16* sets the recording level at *J3*, which may need to be selected to suit the drive requirements of the second recorder.

The operation of the demodulator is not affected in any way by the modulator and can remain connected permanently. In fact, it's a good idea to have the computer load the original tape during the duplication process. If the original tape loads successfully, you can be reasonably certain the duplicate copy is accurate.

The remodulation process does a marvelous "cleanup" job of marginal tapes. In fact, I use my duplicates all the time, saving the originals for backups. Also, I don't get so upset now if my recorder gets hungry and chews up a $40 game cassette! ◇

Fig. 6. Modulator and demodulator interconnections.



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Assembly Language Primer for IBM PC:

Featuring the 8088 Microprocessor

Learning and using assembly language

By Robert Lafore

INTRODUCTION

ASSEMBLY language has the reputation of being difficult to learn; especially from the pages of a magazine. We think this reputation is largely undeserved, and that assembly language can be taught as simply and easily as other languages such as BASIC and Pascal. In the following article, we present assembly language for the absolute beginner: the person who has never programmed in assembly language before.

This article is excerpted from the forthcoming *Assembly Language for the IBM PC,* a Waite Group book by Robert Lafore. (As you may recall, Mr. Lafore and Mr. Waite wrote *Soul of CP/M,* serialized in these pages in 1983.) This new book is a complete introduction to 8088 assembly language and forms part of an integrated series of **New American Library** language books on the IBM PC issued under the dual *Plume/Waite* imprint.

How is it possible to teach assembly language so simply? Mr. Lafore makes use of several innovative techniques. First, by basing his work on the IBM PC, he ensures that everyone will be working with exactly the same equipment. Books which attempt to teach assembly language for a particular *microprocessor chip* must be excessively vague about the actual commands used to perform a given operation, since the same chip can be used in many different machines.

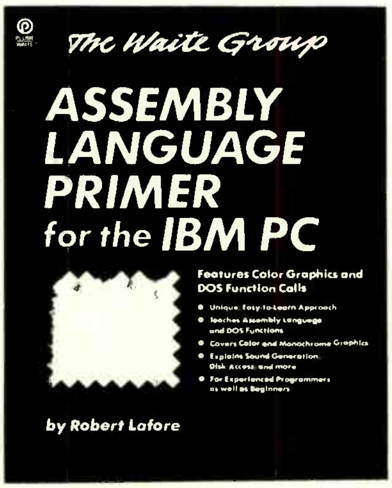
Assembly Language for the IBM PC also uses the "miniassembler" built into the DEBUG program. This feature provides a greatly simplified entry into assembly language, since the reader need not start off by learning the complexities of the full-scale IBM Macro-Assembler program. Finally, by making use of the powerful *DOS functions* built into the operating system, the book can start out with programs that are very short and simple, but that nevertheless accomplish significant tasks. As you will learn, programming through DOS functions is *the* professional approach; it means your programs will work on all computers that run a version of the popular MS-DOS operating system.

For those of you who have always wanted to learn assembly language, but have not known how to begin, this is your chance!

ASSEMBLY LANGUAGE is always the fastest and most powerful language for a given computer. It is essential in programs where pure speed of operation is important, such as graphics, sorting, and sustained number-crunching. It is also the only language that can make use of *all* of a particular machine's hardware features. With higher-level languages, such as BASIC or Pascal, the programmer is always insulated from the computer by the language itself—he can only do what the writers of the language decided he should be able to do, so inevitably he cannot tap the full power of the computer.

For these reasons, many types of programs—such as operating systems, compilers, word processors, and graphics programs—are almost always written in assembly language. If you want to do this sort of programming, then you need to know assembly language.

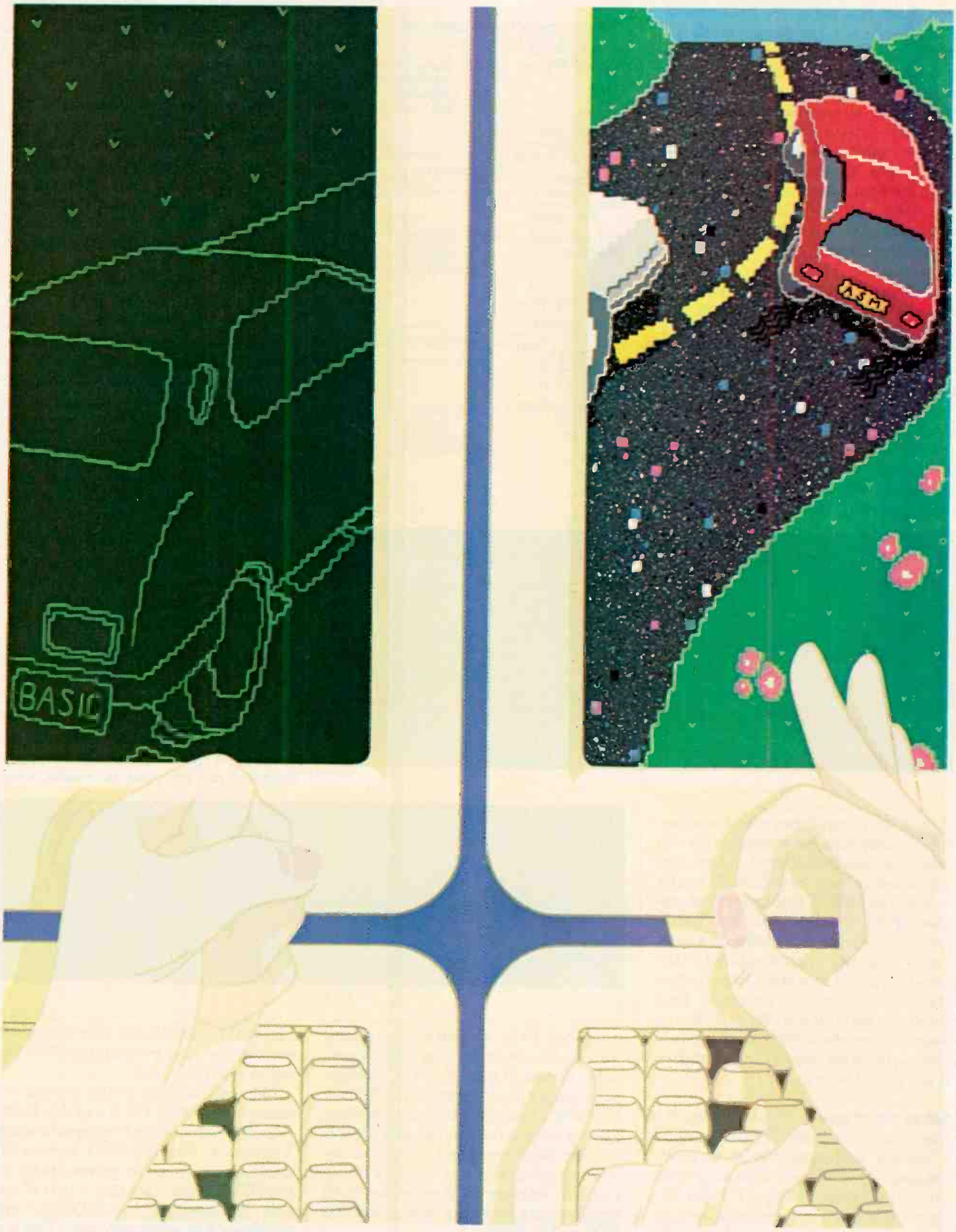
But assembly language is not only practical, it is also a fascinating and rewarding field of study. Because it is so close to the physical reality of the computer, everything you do in assembly language is the result of the way the computer operates, not the way designers of a higher-level language decided to do things for the sake of ease and convenience.



We can think of higher-level languages as being like stodgy luxury sedans: they're comfortable and easy to use, but the steering is imprecise, the suspension insulates you from the feel of the road, and if you try to push them too fast they slide into the ditch.

Assembly language, on the other hand, is the sports car of computer languages. In a sports car you're close to the road, the steering, brakes and gears are light and precise, and the car is built for speed and efficiency. It may not be as comfortable as a sedan, but it's fast and, more important, it's fun to drive.

Is Assembly Language Hard to Learn? Unfortunately, assembly language has developed the reputation of being difficult to learn. Many people—



Assembly language is the sports car of computer languages. . . . It may not be as comfortable as a sedan but it's fast and it's fun to drive

even those who had no trouble learning a higher-level language such as BASIC—think that assembly language is somehow beyond them. This belief is fostered by many assembly-language books which, strange as it may seem, appear to be written with the assumption that the reader already knows about the subject. For instance, many assembly-language books start off by listing and describing all of the scores of microprocessor instructions. As a result, most readers give up before finishing the text.

We believe that assembly language, in spite of its reputation, is actually not much harder to learn than any other computer language, provided it is presented so you do not feel overwhelmed at the beginning. It's this sort of easy, step-by-step presentation that will be used in this series.

The series is intended primarily for the person who has no previous acquaintance with assembly language: the rank beginner. However, it will also benefit the programmer who knows assembly language for a microprocessor other than the 8088 described here, and who wants to learn how the 8088 works.

Why the 8088? There are several reasons. First, because it's the microprocessor used in the IBM PC, a computer enjoying unprecedented sales growth, as well as work-a-like computers such as Compaq, Columbia Data Products and others. Second, if you want to learn about the new 16-bit technology, the 8088 chip in such computers is the ideal device to use.

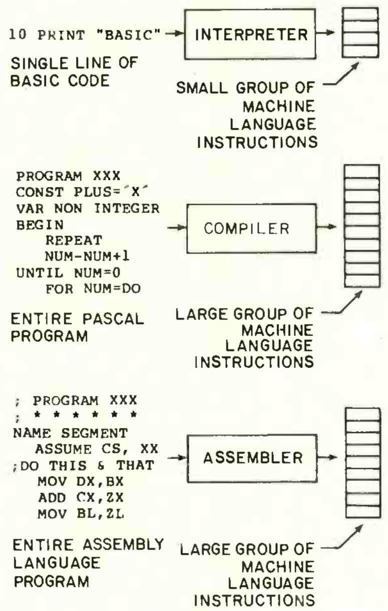


Fig. 1

```
A>debug
-d100
04B5:0100  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0110  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0120  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0130  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0140  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0150  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0160  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0170  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
-_
```

Fig. 2

```
-d100
04B5:0100  03 EB 42 90 75 03 EB 41-90 20 30 2C 30 38 3C 0A   .kB.u.kA. 0,08<.
04B5:0110  73 34 52 8B D3 9F 03 DB-03 DA 03 DB D1 DE 9E D1   s4R.S..[.Z.[Q^.Q
04B5:0120  D6 8A D0 B6 00 9F 03 DA-D1 DE 9E D1 D6 5A E8 21   V.P6...ZQ^.QVZh!
04B5:0130  00 72 0A 2C 30 72 04 3C-0A 72 D3 41 4A 8A C7 0A   .r.,0r.<.rSAJ.G.
04B5:0140  C0 C3 9F 41 4A 9E F9 C3-E8 05 00 75 01 C3 EB F8   @C.AJ.yCh..u.Ckx
04B5:0150  8A C5 0A C1 75 01 C3 49-42 8B F2 AC 24 7F 0A C0   .E.Au.CIB.r,$..@
04B5:0160  F9 75 01 C3 3C 0C F9 75-01 C3 3C 0A F9 75 01 C3   yu.C<.yu.C<.yu.C
04B5:0170  3C 1A F9 75 01 C3 72 01-C3 F5 C3 A9 46 00 00 00   <.yu.Cr.CuC)F...
```

Fig. 3

What You'll Need. This is very much a hands-on series. Although you can gain a general understanding of assembly language by reading it without a computer at your disposal, you'll be far better off if you have a computer on your desk before you start to read. As with other languages—both human and computer—it's only through practice that real mastery is achieved.

We'll assume therefore that you have access to an IBM PC using PC-DOS or to another 8088-CPU based computer using MS-DOS. (Virtually everything we'll do can be done under either operating system. From now on, though, we'll speak only in terms of the PC and PC-DOS.) You'll need at least one floppy-disk drive. You won't be able to use a cassette-based computer, since the assembler program and various other pieces of software we'll make use of all require a disk operating system like PC-DOS or MS-DOS.

How much memory do you need to create assembly-language programs? That depends on which assembler you want to use. When you buy the standard IBM Macro Assembler for the PC, you actually get two assemblers in the same package: ASM and MASM. MASM stands for "Macro ASseMbler," and is a full-scale assembler with all the bells and whistles. If you use it, you'll need a minimum of 96K of RAM.

ASM, which is sometimes called the "Small Assembler," is a more modest version of MASM. It will run in a 64K system if you are using PC-DOS Version 1.0 or 1.1. However, if you are using DOS Version 2.0, then you will need a minimum of 96K, with 128K being preferable if you get into writing long programs.

You can use any video display you like, since the concepts we'll explain here don't require the use of color. However, all the examples we'll give are based on an 80-column display. If you are using only 40 columns, you will need to do a little mental reformatting to compare the printouts here with those on your screen, but that should not pose a major problem.

It's very nice, but not absolutely necessary, to have a printer when writing assembly-language programs. A printed listing is convenient for debugging and for following the overall operation of a program, but a printer is like a house in the country: If you have one, you'll love it, but if you don't, you'll get along just fine anyway.

You'll find the Technical Reference Manual for your computer extremely useful. It's packed full of details about the computer's operation, and many of those details will become important to us as we explore the things assembly language can do. And, of course, keep handy the manuals for your assembler and for the other programs we'll be using to create our own.

You can use any of the current releases of PC-DOS: 1.0, 1.1, or 2.0. However, there are some advantages to using Version 2.0. First, PC-DOS Version 2.0 contains a very useful enhancement to the DEBUG program that is part of the disk operating system (DOS), and which we'll be using quite a bit. This is a "mini-assembler," built right into DEBUG. The first assembly-language programs we write will be created with DEBUG's mini-assembler rather than the more cumbersome ASM or MASM. You can also use older versions of DE-

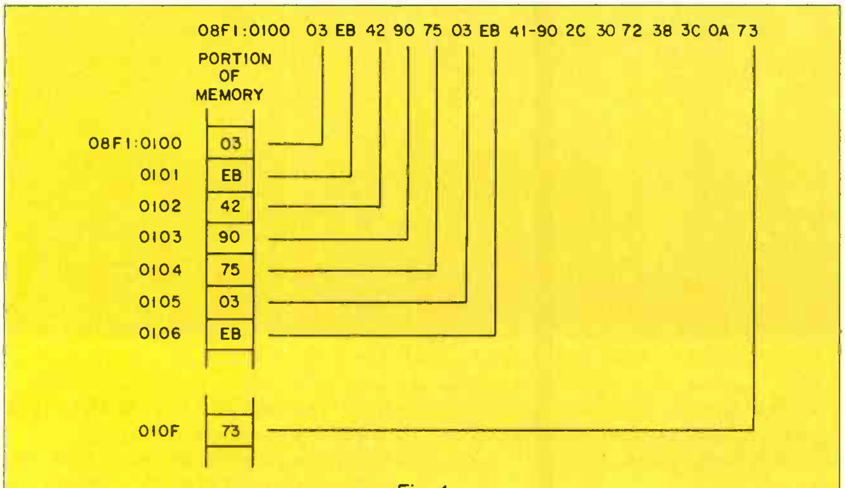


Fig. 4

BUG that do not contain the mini-assembler (we'll show you how), but it will be easier if you have it.

Three of the utility progams that come with PC-DOS are essential to following the lessons we're going to present. The first is DEBUG, which we've already mentioned. It's used to monitor, debug and edit assembly-language programs. Learning how to use it is vital to an understanding of assembly language.

The second utility is LINK, a program used to change an intermediate form of assembly language programs, call OBJ (for OBJect) files, into an executable program called an EXE file. (We'll explain these terms as we go along.)

The last is EXE2BIN, which converts EXE (EXEcutable) files to COM (COMmand) files. COM files are another, somewhat simpler, form of executable program.

Finally, once we start writing longer assembly-language programs, you'll need some sort of word processor to create what are known as the source files. These are text files, just like letters or other documents, but they contain the assembly-language instructions that will later be assembled for use by the microprocessor.

PC-DOS comes with a text editor called EDLIN (for EDit LINes). Though it's possible to use EDLIN to create assembly language source files, its limitations will become apparent as your programs become longer, and you'll probably want a good word processor anyway.

Assembly Language. Let's start by talking about assembly language in general—how it differs from higher-level languages such as BASIC—and about the operation of an assembler and how it differs from the interpreter or compiler used in higher-level languages.

If you're familiar with a higher-level language such as BASIC or Pascal, you know that there is a certain level of abstraction involved in program statements in these languages. A BASIC statement such as:

```
LET A=3
```

is operating on an abstract level. That is, we don't usually know, or *need* to know, where in the computer "A" is, or what changes are taking place in the computer when A is assigned the value of 3. This is because higher-level languages are oriented toward the handling of numbers with algebra-like formulas. Programmers using higher-level languages need that abstraction; they *want* to be insulated from what's really going on inside the computer so they can concentrate on the formulas.

In contrast, assembly language operates on a very concrete level. It deals with bits, with bytes, with *words* (two bytes side-by-side), with *registers*—which are physical places in the microprocessor where bytes and words are stored—and with memory locations, which have specific numerical addresses and specific physical locations in the memory chips inside the computer.

What Does an Assembler Do? If you've written programs in BASIC, you're familiar with the two-step process involved: First you write a group of BASIC program statements that make up a program; then later, when you execute the program, these statements are "interpreted" or changed into *machine-language* instructions that are executed by the microprocessor.

This process in BASIC is made to appear "invisible" to the user. The individual program lines are interpreted one at a time, and the resulting machine-language instructions for each line are executed by the microprocessor before the next line is interpreted. (Figure 1 shows how this works.)

In compiled languages such as Pascal, things are handled a little differently. The user first creates a *source file*, which is a text file of the entire program. This is then changed into machine-language instructions by a *compiler* program. (Actually, a utility called a *linker* is used too, but we'll ignore it for the moment.) In a compiled language the entire program is transformed into machine language all at once.

Assembly language resembles a compiled language more than it does an interpreted language such as BASIC. An assembly-language source file consisting of the text of the program is first created. This is then assembled into machine language by an *assembler* program. The assembler performs a process very similar to that of a compiler except that—as we'll see a little later—there is a far closer correspondence between an assembly-language instruction and a machine-language instruction than there is between a Pascal statement and the group of machine-language instructions that result from it.

What we've just described is the traditional way of transforming an assembly-language program into machine language instructions. To start with, however, we're going to use a different approach; we're going to use the mini-assembler in DEBUG. Using DEBUG, it's almost as easy to create and run short assembly-language programs as it is to create and run interpreted programs.

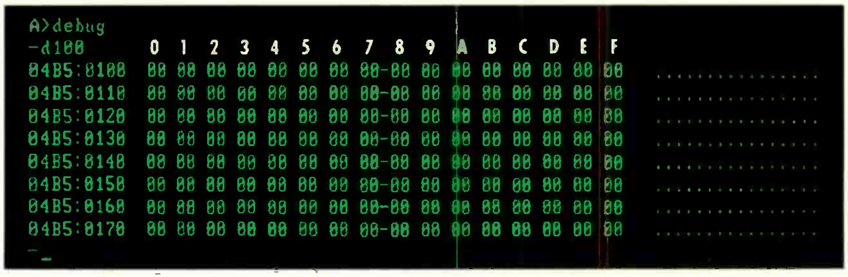


Fig. 5

DEBUG vs. an Assembler. There are

several reasons why we've decided to start with DEBUG rather than with ASM or MASM. First, DEBUG is a much easier program to operate than the others. To type in and execute a program using DEBUG requires calling up only DEBUG itself, a simple process. Using an assembler, on the other hand, involves using a text editor, the assembler itself, a linker program called LINK, and often another program called EXE2BIN. Each of these programs requires a rather complex series of commands to make it work. We figured you'd have enough on your mind being introduced to a new computer language without having to learn how to operate all those other programs at the same time.

DEBUG's second advantage is that programs written with it require less "overhead" memory than those written with an assembler. This overhead comes in the form of program statements that must appear in the ASM source file, but are not necessary in DEBUG. (Don't worry if you don't understand what's meant by some of the terms we've used. Everything will be explained eventually.) The reason these additional statements are necessary in the assembler is difficult to explain at this point, so let's just say that by using DEBUG you avoid having to start your day with a lot of incomprehensible program lines.

Third, using DEBUG puts you in closer contact with what is *really* going on in your computer than using an assembler does. DEBUG has features that make it possible to get down to the most fundamental level of your computer's operation (short of opening up the cover and probing about with logic probes and oscilloscopes). Sooner or later, if you write programs in assembly language, you're going to have to understand this fundamental level and learn to use DEBUG; so now seems like a good time to start.

Of course, as we'll find out later, an assembler has all sorts of powerful features that make it indispensable for long programs, but for the moment, DEBUG will do just fine. Table I summarizes the advantages and disadvantages of DEBUG and assemblers.

```
A>debug
-f120 14f ff
-d100
04B5:0100  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0110  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0120  FF FF FF FF FF FF FF FF-FF FF FF FF FF FF FF FF   ................
04B5:0130  FF FF FF FF FF FF FF FF-FF FF FF FF FF FF FF FF   ................
04B5:0140  FF FF FF FF FF FF FF FF-FF FF FF FF FF FF FF FF   ................
04B5:0150  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0160  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0170  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
-_
```

Fig. 6

Window of the Soul. An old saying has it that "the eyes are the windows of the soul."

We might say that DEBUG is the window of the 8088's soul. Besides being useful for assembling programs, DEBUG is also used to examine and modify the contents of memory locations; to load, store, and start programs; and to examine and modify registers. In other words, DEBUG is designed to put us in touch with various physical features of the PC-DOS or MS-DOS computer.

Before we write our landmark, first-ever 8088 assembly-language program, we're going to get to know our way around DEBUG; rev it up, so to speak, find out where the controls are, and taxi it out of the hangar and around the runway. Then we'll be ready for takeoff.

```
A>debug
-f100 117 61
-f178 17f 24
-d100
04B5:0100  61 61 61 61 61 61 61 61-61 61 61 61 61 61 61 61   aaaaaaaaaaaaaaaa
04B5:0110  61 61 61 61 61 61 61 61-00 00 00 00 00 00 00 00   aaaaaaaa........
04B5:0120  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0130  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0140  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0150  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0160  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0170  00 00 00 00 00 00 00 00-24 24 24 24 24 24 24 24   ........$$$$$$$$
-_
```

Fig. 7

Getting DEBUG Rolling. All right, let's leap into the cockpit, get a firm grip on the keyboard, and get DEBUG rolling! We'll assume that you have a disk with DEBUG on it inserted into drive A, and that the "A>" prompt is waiting for your next move. (If you have a Winchester disk you'll have to make sure that DEBUG has been copied to it, and you'll also have to imagine a "C>" whenever you see "A>" here.) DEBUG is one of the programs provided on the "system disk" that contains your computer's operating system.

Following the DOS prompt, enter the program name "DEBUG". (When we tell you to "enter" something here, we mean to type the "something" and then press the ENTER key just to the left of the numeric keypad on the PC's keyboard.)

When DEBUG is loaded into the computer it will display its prompt, a single dash ("–"), which tells you that it's ready to listen to what you have to tell it.

The "D" Command. You can tell DEBUG what to do by typing in single-letter commands, usually followed immediately by one or more numbers. When we refer to these single-letter commands here we'll usually use upper-case letters, like "D," to make them stand out. However, when you type them in you can use either upper or lower case. For example, enter the letter "d" followed by the digits "1" "0" "0". You should see a display like the one shown in Fig. 2.

Wow! Look at all those numbers! What does it all mean? First of all, you may not see all zeros on your display as we show here. What the "D" command has done is to "dump" or display a portion of your computer's memory on the screen. Each pair of numbers represents one byte, or eight bits, of data stored in a particular memory location. If your

TABLE I—ADVANTAGES AND DISADVANTAGES

DEBUG
Easy to run
Low-overhead programs
Close to the machine
Not so versatile
Good on short programs

Assembler
Hard to run
More program overhead
Isolated from the machine
Very versatile
Good on long programs

computer's memory happened to have other data in it before you loaded DEBUG, it will appear here when you type "D", so you may well see all sorts of junky-looking numbers, like those in Fig. 3.

All the numbers there are in hexadecimal form. In fact, hexadecimal is the only numbering system DEBUG knows about, so if you aren't already acquainted with this way of representing numbers, now is the time to find out about it. A good discussion of numbering systems appeared in the December 1983 issue of COMPUTERS & ELECTRONICS.

Let's adopt this convention: Hexadecimal numbers—except for those in program listings or where the context makes clear what they are—will be followed by the small letter "h" to distinguish them from decimal numbers. Decimal numbers—again, unless the context makes it clear—will be followed by a small "d". Numbers from 0 to 9 are the same in both systems, so they don't really need a distinguishing letter, although they sometimes will have one for consistency. Of course, since DEBUG speaks *only* hexadecimal (hex for short), it doesn't use an "h" on its displays, and you should not put one after hexadecimal numbers you type in as DEBUG commands.

It requires two hexadecimal digits to represent an 8-bit byte of data. This two-digit hex number can range in value from 00h to FFh (0d to 255d). Thus, all the two-digit numbers in Fig. 3 fall into this range. There are 16 of these numbers on each line of the display. The dashes in the middle of the display are placed there for clarity, to separate the eight left-hand bytes on the line from the eight right-hand bytes.

Addresses. The numbers in the column at the left of Figs. 2 and 3 (like 08F1:0120) are the *memory addresses* of the bytes of data displayed. Each byte shown in the dumps occupies a specific address, as illustrated in Fig. 4.

The vertical column to the left represents an actual section of your computer's memory. Note how the byte in each memory location corresponds to a particular number in the DEBUG dump shown in Fig. 3.

Each address consists of two numbers separated by a colon. The number to the right of the colon (like 0100) is called the *offset address*, and for our purpose is the only portion of the address we'll be concerned with. The number to the left of the colon is called the *segment address*, and is used when addressing very high (above 64K) memory locations. Since our programs are not going to be anywhere near that large, we can safely ignore it.

Notice how each offset address (we'll just refer to them as addresses from now on, since we will not be using the segment portion) in the left-hand column of a DEBUG dump ends with a zero. If you're familiar with hexadecimal numbers you should understand why this is so. There are 16d, or 10h, bytes in each line, so when you've counted from 0h to to Fh, you're ready to increase the ten's (actually sixteen's) column by one, since 10 is the number that comes after F in hex. So we display 16d (10h) bytes, and then move down one line, increment the address by 10h, and display 10h more bytes. The display would be easier to read and understand if it had the 1's column values of the address printed across the top, as shown in Fig. 5, but it doesn't.

Anyway, it should be clear that the first byte on the top row is at memory location 0100, the next is at 0101, the next at 0102, and so on. Similarly, the first byte on the second row is at 0110, the second at 0111, etc.

The "F" Command. Want to see the display change? An easy way to do this is to use DEBUG's "F" or FILL command. This command fills a part of memory with a particular hex number.

To use FILL, you enter "f" followed immediately by three numbers separated by spaces. The first of these numbers is the address where you want to *start* filling, the second is the address where you want to *stop* filling, and the third is the constant (from 00h to FFh) that you want the locations from the first address to the second to be filled with. Notice that while the data to be filled in consists of two-digit hex numbers (representing bytes), the addresses are four-digit hex numbers. Of course, you don't need to type leading zeros, so you can type fewer than four digits for the addresses when appropriate, as it is here. At the DEBUG prompt ("–") enter this:

```
f 120 14f ff
```

The first "F" (remember, it can be upper or lower case) is the FILL command. It is followed by, respectively, the starting address of the fill, the ending address of the fill, and the value (FFh) that will be used. When you hit ENTER, nothing appears to happen. To see what's changed, you have to dump the same part of memory again. A dump of locations 100h through 170h is shown in Fig. 6.

Look at that! All the memory locations between 120h and 14Fh are now filled with FF, just as you specified with the "F" command. As for the rest, if you started out with numbers other than zero in memory, they'll still be there instead of the zeros shown in the dump.

ASCII Codes. You may be wondering about all the little dots and odd characters on the right-hand side of the dump display. These are the characters (like "A", "B", and so on) that the numbers to the left represent. The number that represents a particular character is called its *ASCII value.* (ASCII stands for "American Standard Code for Information Interchange.") As you probably know, the ASCII code is the normal way to represent characters in a computer's memory.

Since neither 00 nor FF represents a printable ASCII character, the positions in the ASCII display corresponding to those numbers are filled with dots, which indicate "no printable character." (If your computer's memory was filled with junk rather than all zeros to begin with, some of the numbers—20h through 7Eh—may have represented printable characters.) To see the character display change, along with the numbers, let's try filling in parts of memory with numbers that we know represent characters.

Enter the following three DEBUG commands (the "–" is, of course, DEBUG's prompt):

```
-f100 117 61
-f178 17f 24
-d100
```

You'll get the display shown in Fig. 7. The character corresponding to 61h is a small "a," and 24 hex is the code for the dollar sign, "$." We can see them both as numbers, and to the right as characters.

So far we've talked about how assembly language differs from higher-level languages, and also explained something about the operation of the DEBUG utility program. You may find it useful at this point to experiment a bit with DEBUG. Try filling in different constants to see how they look when you dump them. Examine different parts of memory. (You may be surprised at what you find!) You'll be using DEBUG a great deal as we go on, and you should feel comfortable with it.

Your First Program. Although you're now going to write your first assembly-language program, you don't know assembly language yet. There will be many aspects of the process that won't seem completely clear to you. Don't worry about this! Our approach is to show you first *what* something looks like, and afterwards explain *why* it looks that way and *how* it works.

By moving in this direction, from the concrete to the abstract, rather than the other way around, we hope to avoid the sort of academic theory-oriented descriptions that leave most readers confused, bored, and frustrated. Instead, you'll first get the *feeling* of the process (the roar of the motor and the rush of the wind in your hair, to return to our earlier flying analogy); later we'll explain what happened.

Different DOSs. There's a small problem we'd better deal with right away. This has to do with which version of DOS you're using. As noted previously, the DEBUG in DOS Version 2 (that is, Versions 2.0 and later) contains a built-in mini-assembler that will help in the creation of assembly-language programs. The DEBUG in DOS Version 1 (Versions 1.0 and 1.1) does not have this capability, so for those readers using this version we need to take a slightly different tack.

We'll handle the situation in the following way. We'll first explain how to type in a program if you're using DOS Version 1. Even if you have Version 2, you should read this part, try it out, and understand it. There are two good reasons for this. The first is that you will be introduced to a new DEBUG com-

```
-e100       <---you enter this
04B5:0100 61._
 :     \      /:\
 :      \      :________ the cursor will wait here for you to
segment  \                type in a two digit number
address   \
doesn't        offset address is the same as what
matter         you typed in
```

Fig. 8

```
-E100
04B5:0100 61.b2  61.1  61.b4  61.2  61.cd  61.21  61.cd  61.20
                :     :      :      :      :      :      :      :
- <---DEBUG     \_____________________________________/        :
      prompt     press space bar following these numbers    press ENTER
                                                             following
                                                             last number
```

Fig. 9

```
-a100
08F1:0100 mov dl,1    \
08F1:0102 mov ah,2     \____ enter these lines
08F1:0104 int 21       /
08F1:0106 int 20      /
08F1:0108         <------simply press ENTER here
-_ <--------------now you're back in DEBUG
```

Fig. 10

```
-d100
04B5:0100  B2 01 B4 02 CD 21 CD 20-61 61 61 61 61 61 61 61   2.4.M!M aaaaaaaa
04B5:0110  61 61 61 61 61 61 61 61-00 00 00 00 00 00 00 00   aaaaaaaa........
04B5:0120  FF FF FF FF FF FF FF FF-FF FF FF FF FF FF FF FF   ................
04B5:0130  FF FF FF FF FF FF FF FF-FF FF FF FF FF FF FF FF   ................
04B5:0140  FF FF FF FF FF FF FF FF-FF FF FF FF FF FF FF FF   ................
04B5:0150  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0160  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00   ................
04B5:0170  00 00 00 00 00 00 00 00-24 24 24 24 24 24 24 24   ........$$$$$$$$
```

Fig. 11

mand: the "E" (for Enter) command. The second is that, after you've typed in the program using "E," you'll be better able to appreciate how lucky you are to have DOS Version 2, with its advanced version of DEBUG and its mini-assembler.

Using the "E" Command. Now we'll create an assembly-language program using DEBUG's "E" command. (The term "assembly language" is actually not quite right in this particular instance, as we'll see later on, but that needn't concern us now.) If you have DOS Version 1, this is the *only* way to use DEBUG to create a program. If you have Version 2, you should follow along anyway, typing in the commands.

The purpose of the "E" command is to enter a byte (or bytes) of data into memory. It's like the "F" command, except that you can enter a series of *different* bytes; they don't all have to have the same value, as they do with "F."

The series of bytes we're going to enter with "E" will constitute our program. To insert this program into memory, when you see the DEBUG prompt, you enter the command "E," followed immediately by the address where you want the program to go. In our case, we're going to put it at location 100h, so we enter "e" followed by "100." The program will respond by printing out the address, followed by its current contents, as shown in Fig. 8.

As shown there the content of location 100 happens already to be 61h, since that's what we put there with the "F" command earlier. However, it doesn't really matter what was there before: The important thing is that we're going to put it there now.

To "enter" a two-digit hex number into this location we type the number followed by—*not* the ENTER key—the *space bar*. The space bar has the effect of entering a number into one memory location and then advancing to the next one. The ENTER key, on the other hand, enters the number and then terminates the entire "E" command and returns us to the DEBUG prompt. After you have entered a number and pressed the space bar, the command will then print out the old contents of the next location and wait for you to type in the new contents.

The series of hexadecimal numbers we want to type in is the following:

```
B2
 1
B4
 2
CD
21
CD
20
```

These are the numbers that constitute our program. Type each number, press the space bar, type the next number, and so on. After you've typed in all eight numbers, the screen should look like Fig. 9 (minus our comments, of course).

Note that if you don't type any number at all before hitting the space bar, the byte in that location will remain unchanged, as you will discover if you make a typing mistake.

After you type the last number, press ENTER to tell DEBUG you're through. This should cause the DEBUG prompt ("–") to reappear.

If you make a mistake at any time, just press ENTER to get back to the DEBUG prompt and start over.

You've now placed your program in the computer's memory, from location 100 to location 107, using the "E" command. We'll explain how to execute, or "run," the program in a moment.

Using the "A" Command. Here's where you DOS Version I users become, briefly, just spectators. You should read through this section so you know what you're missing and, more important, because future program descriptions are going to be based on the "A" command approach outlined here. You'll need to know both approaches so you can use "E" even though we're talking about "A"; that is, translate our descriptions of the "A" approach into operations with "E." This won't be as difficult as it probably seems, so read on. (Or, better yet, hurry out and buy a copy of DOS Version 2.)

The "A" command accomplishes the same thing as the "E" command. Therefore, it is putting the bytes that constitute our program into memory—but it does so in a different way.

When we use the "A" command we don't insert hexadecimal bytes into memory directly. Instead, we type in a series of *mnemonic* symbols. ("Mnemonic" simply means "easy to remember." The idea is that these symbols are supposed to be easier to remember than the hexadecimal numbers they represent.) These codes are two- or three-character names that stand for certain assembly-language *instructions.* The instruction tells the microprocessor *what operation is to be done.* The instruction mnemonic is usually followed by a space and then by some letters and numbers that indicate what the operation is to be done *to.*

Expressed in mnemonic symbols, our program looks like this:

```
mov dl,1
mov ah,2
int 21
int 20
```

```
-u100,106 <---- you enter this

08F1:0100 B201      MOV    DL,01   \
08F1:0102 B402      MOV    AH,02    :____ the program prints
08F1:0104 CD21      INT    21       :     out all this
08F1:0106 CD20      INT    20      /
-_
```

Fig. 12

It looks short, but absolutely incomprehensible, doesn't it? That's all right, it won't be long before you can churn out this kind of thing in your sleep. We're going to type in this program, then dissect it a little and see if we can get a feel for how the "A" approach differs from the "E" approach, and for what assembly language is all about.

Enter the letter "A," followed by the address where you want the program to start. Here's a rule you should remember: *Programs written in DEBUG should always start at 100h.* The reasons for this will become clear later when we talk about the difference between COM files and EXE files.

When you enter "A" followed by an

address, DEBUG will automatically echo the address:

```
-a100
08f1:0100 -
```

DEBUG will then sit there waiting for you to type in the mnemonic codes for your program.

On the first line, enter "mov dl,1". That's "mov" as in the first three letters of "move," followed by a space, which is important, then "dl,1". with the *letter* "l", followed immediately by a comma and the *number* "1." Don't confuse letters and numbers. The screen should now look like this:

```
08F1:0100 mov dl,1
08F1:0102_
```

You've just typed your first line of assembly language!

The assembler is waiting for line two. Enter "mov ah,2". Then the third line, "int 21" and the fourth, "int 20".

After you've finished these four lines, you're done. So when the program says:

```
08f1:0108
```

you simply press ENTER to let it know you're through assembling this program and want to get back to DEBUG's prompt. Your screen should then look like Fig. 10.

So you now have two different ways to enter your program, depending on which version of DOS you have. In either case the program itself should be sitting in memory, waiting to be executed. There's a lot to say about the relationship between these two approaches to putting a program into memory, but if you're a real red-blooded programmer you can't wait to run the program. Let's do that first, and talk later.

Running the Program. What does the program do? Does it balance your checkbook? Calculate accounts receivable? We're afraid it's not as ambitious as that. Let's see what happens when we run it. To execute the program we use the "G" (for "Go") command. Simply enter the letter "g." It's not followed by any numbers (at this time). This will cause the program to be executed, just as entering "RUN" does in BASIC, and you'll see a little happy face on the screen smiling at you. Isn't that the cutest thing you ever saw? (No? Well, what did you expect from an 8-byte program?)

If you didn't get a happy face, you probably made a mistake typing in the program. It's easy to mistype something, what with all the numbers and unfamiliar symbols. Start with the "E" or "A" command and try again.

Unfortunately, mistakes in assembly-language programs can have more serious consequences than those in higher-level languages like BASIC. In higher-level languages the interpreter or compiler usually protects the operating system from the consequences of errors in programming by keeping your machine running and displaying something like, "Error in line 2034."

In assembly language, however, there is no such protection. Assembly language is the most fundamental level of the machine. There is nothing on a "supervisory level" overseeing the assembly-language program, as the interpreter or compiler does in higher-level languages. So if you make a mistake in assembly language it is woefully easy to "crash" your operating system—that is, alter parts of it in memory so that it no longer works and you need to reset the entire computer, either by hitting the ALT, CTRL, and DEL keys simultaneously or, in even worse cases, by turning the entire computer off and then on again. But all this is academic. You're never going to make a programming error! Are you?

Figure 11 shows the results of dumping locations 100 through 170 using the "D" command. And there, in the first eight locations, from 100 to 107, is our program. You can see this by comparing the numbers on the display with those typed in using "E." Our program has overlayed the 61s that were there before.

The symbols at the right—2.4.M!M—are meaningless. They just happen to be the ASCII equivalents of the numbers that make up the program.

What Assemblers Really Do. If you typed in the program using "E," you probably aren't too surprised to see these numbers reappear when you look in memory with "D." After all, you entered the numbers into memory, and there they are, just where you put them.

But how did they get there if you used the "A" command? You typed in mnemonic instructions and, lo and behold, there are the numbers sitting in memory. What's happened here is what this series is all about: The "A" command *assembled* the mnemomic instructions into hex numbers. This is the function of an assembler; both of DEBUG's mini-assembler that you invoke with the "A" command and of its large-scale relatives ASM and MASM. We'll have more to say about this later. First let's look at our program from another perspective.

The "U" Command. There's a more elegant and useful way to look at our program than by using "D" as we did above: the "U" command. We've assembled our program with "A" or typed in the pre-assembled hex numbers with "E." Now let's use the "U" command to *unassemble* it. "U" is the opposite of the "A" command. Where "A" takes us from symbolic mnemonic codes to the hex digits of machine language. "U" takes us from hex digits back to mnemonic codes. (Actually, the usual word for "unassemble" is "disassemble.")

To "unassemble" your program, enter "U," followed by the address where you want to start disassembling, then a comma, and then the address where you want to *stop* disassembling, as you see it in Fig. 12.

"U" shows the program in *both* hex codes and mnemonic instructions, all nicely arranged for you to admire! Thus the new number B201 is the machine-language equivalent of the assembly language statement "MOV DL,01," and so on for the other instructions. As before, the numbers on the left, such as "08F1:0100' " are the addresses of the locations occupied by the program. There's an address printed for each instruction, and since each of the instructions happens to occupy just two bytes, the addresses are all even numbered: 100, 102, 104, and 106.

Machine Language and Assembly Language. The hex numbers on the left in the "U" listing in Fig. 12 are what is called *machine language.* These numbers occupy specific memory locations, and the 8088 microprocessor looks in these locations, takes the numbers out of them, figures out what they mean, and executes them. These numbers are called "machine language" because it's the *machine*—the microprocessor—that understands them and operates on them. As far as we humans go, such numbers are hard to understand and virtually impossible to remember. For a human to decipher a program written entirely in hex numbers requires the most masochistic form of mental discipline, while the microprocessor chip, no larger than a fingernail, handles it easily. It is perhaps better not to dwell on the philosophical implications of this.

Take heart, however. The mnemonic instructions in the column on the right in the listing are *not* comprehensible to the microprocessor, clever though it may be. They form what is properly called "assembly language." And while you may not understand them now, you will when you finish reading this material.

If you want to pursue learning assembly language with the IBM PC, additional articles that build on this one can be read in upcoming issues of our sister publication, *PC* magazine. ◇

Converting Programs for VIC-20, PET, and C-64 Computers

Using a few tricks and knowing what can and cannot be done allow you to make your programs transportable

By Ron Gunn

QUESTIONS often fly at our local Commodore-user meetings regarding the interchangeability of VIC, PET, and Commodore-64 programs. We've found out a lot and this article will supply precise answers to many of those questions, since the programs are quite transportable once you know the rules. Now you can renumber your VIC or C-64 program on a nearby PET, and then run it. Additionally, you can find out when it's practical to permanently convert that great game or utility and when it's not. For now, let's see what works and what doesn't.

[*Editor's Note:* The ROM sets in some Commodore computers may be different from those in the ones used by the author. This may result in different memory locations being used for certain functions. If you encounter difficulties, try peeking memory locations around the ones suggested to see what happens as you change modes. This can tell you a lot.]

The first thing to realize is that PET, VIC, and C-64 programs use different parts of memory. This is why a VIC program seems to disappear when you load it into a PET. It is not really gone; it's still there if you know where to look. PET programs start at location 1024 in memory; C-64 programs start at 2048; and, just to make it interesting, VIC programs can start at 4096, 1024, or 4608. What does all of this mean to you?

You can use the above numbers to tell the PET where to look for the program. VICs and C-64s don't need to be told because they have been set up to do the correct thing automatically when programs load in. To run a C-64 or VIC program on a PET, use the following procedures: If it's a C-64 program, type the following line onto the screen and press RETURN.

```
POKE 2048,0:POKE 41,8
```

The C-64 program can now be loaded, listed, manipulated, saved, and even run. Once the PET knows where it's located, all is well.

The same is true of a VIC program, except that some guesswork may be required. Use one of the following three lines to load your VIC program into your PET:

```
POKE 4096,0:POKE 41,16
POKE 1024,0:POKE 41,4
POKE 4608,0:POKE 41,18
```

The first line locates a program saved from a plain 5K VIC, the second line locates a program saved when the VIC has a 3K expander installed, and the third line locates a program saved from a VIC with 8K or more of expansion memory working. Use only one of these lines at a time, then try a load and see what's there. You can't hurt anything from the keyboard, so if you guess wrong, just try again.

The second line above represents the normal state of the PET when it's turned on, so if you haven't poked the PET yet, it's still in that state. Use that second line when you want it to find PET programs after you've already entered one of the others. (Or you can turn it off to reset.)

Color. Color characters can be transferred between the VIC and C-64 and show up in screen listings on all three computers. When running, the PET simply ignores them. You can add color symbols if you're using a VIC or C-64, but they don't even exist on the PET keyboard. If you intend to do some color editing on a PET, then add a line to the VIC or C-64 program while it's in that computer:

```
9998 PRINT"12345678"
```

The statement at 9998 is an example of an unused line—one that isn't intended to be a functional part of a program. Be sure to hold the CTRL key down while typing in the numbers within the quotes. You will get a set of weird reverse characters, the ones that invoke color. Use this line within quotes in PRINT statements on the PET. Whenever you need a color character, just type the line number you will need instead of 9998 and then edit around these color characters you can't type in.

You will need a list of the colors those weird characters represent. If you use the numerical sequence above, they will stand for black, white, red, cyan, purple, green, blue, and yellow. If you want more colors, then continue on. Once you have typed "12345678" with the CTRL key held down, then do it again with the COMMODORE key held down. You will get eight more symbols that represent, in sequence, orange, brown, light red, gray 1, gray 2, light green, light blue, and gray 3. Now you will be sure to have plenty of color in that converted program.

Here's an example: Your C-64 program is in a PET and you want to edit in a print statement that says "HOLD IT" in red. It will become line 1212. Go to line 9998 and neatly type 1212 over the 9998. Press RETURN. This will replicate line 9998 at 1212. With the new line at 1212, delete everything inside the quotes except the third weird character, which is the symbol for red. Add the rest of the new line. The result will be:

```
1212 PRINT"[RED]HOLD IT"
```

Remember, too, the pokes that control the screen background colors. For a white screen, for instance, you would "POKE 53281,1" on your C-64; and you would "POKE 36879,27" on your VIC.

Sound. This is the one area where the three computers are the least compatible. That's the bad news. The good news is that the computers usually ignore each other in the sound areas, so few unexpected crashes occur. You are looking at PET sound programming when you see POKE at locations 59464 and 59466 in a program. VIC programs will have a sound POKE at 36874 through 36878. The significant sound capabilities of the C-64 are accessed through a POKE at locations 54272 through 54296.

Each computer has a different ability to create sound, so when you are considering a program conversion, you are limited to finding out what the original sound was and where it was, and then finding substitute coding for it. The one constant thing is that the original coding will not produce what you want.

In the PET, sound is usually produced by manipulating the CB2 line of the user port. This is single-channel sound and it has to be turned off within the program before the program ends. The VIC has three channels of sound with relatively coarse adjustments available. The C-64 supports elaborate control of its three sound channels. Sound for both VIC and C-64 stops when you hold down the RUN/STOP key and press RESTORE.

Screen Size. The Commodore 64 and the PET both have the same 40-column screen width and 24-line screen height. Screen output written for one will fit the other exactly. The VIC screen is 22 columns wide by 23 lines high and will handle about half a screenful of information from the other machines in its own way, with wild wraparounds and strangely linked lines. Reading VIC material on a C-64 or PET yields a well-formatted output along the left half of the screen.

To properly read screen displays from the other machines on your VIC, you will have to do modifications to your screen-print statements. A quick and dirty method is to create these lines in the program:

```
9996 GET Z$: IF Z$="" THEN
     9996
9997 RETURN
```

Put a new line in the original program at every half-screen of information:

```
1291 GOSUB 9996
```

This will force the display to stop until you tap a key. All of this is shown in Table I. While the original screen formatting won't be preserved, at least you'll get to see most of it.

Function Keys. These keys are unique to the VIC and C-64 and do not exist on the PET. The values they return are CHR$(133) through CHR$(140) on both machines. These values are consecutive, so unshifted function keys F1, F3, F5, and F7 will return values of 133, 134, 135, and 136. There is no key on the PET that will return these values, so a trick is in order.

Find the places in a VIC or C-64 program where CHR$ values between 133 and 140 are used. That's where the function keys are detected. For operation on a PET, let's use the numbers 1 through 8 as substitute function keys. Since the number 1 is actually CHR$(49), we can make a substitution in the program. If the program says:

```
220 IF A$=CHR$(133)
```

and we change it to:

```
220 IF A$=CHR$(49)
```

then we can dummy up the number keys to operate the program. With this kind of change, the number keys will act like the function keys in the original VIC/C-64 program.

This example of use of the function keys

```
2000 GET A$:A=ASC(A$)-132
2010 ON A GOTO
     2050,2060,2180,3500
```

would convert to:

```
2000 GET A$:A=ASC(A$)-48
2010 (no change)
```

Here, the first function key would be converted to a value of 1 in variable A because it has a value of 133, and 132 is subtracted from it. This would send program execution to line 2050. After the conversion, the number 1 would send program execution to line 2050.

Upper- and Lower-case. Many programs will initialize the UPPER/LOWER or UPPER/GRAPHICS mode while setting up. Table II shows the numbers you can use to make the appropriate conversions.

You can confirm these values yourself. Try this one on your VIC. Enter: PRINT PEEK(36869) RETURN. Now press SHIFT/COMMODORE key to change character sets, and enter the PRINT PEEK statement again. The number in 36869 should originally have been 194. Then it should have changed to 192.

Screen Manipulations. Some programs bypass the programmable cursor movements and poke directly to the screen memory. This is done for convenience and speed. Screen memory starts at 32768 on the PET and 1024 on the C-64. In the VIC, the screen memory locations vary for different amounts of memory. A good description of how to find the screen memory is in the VIC manual.

To avoid confusion in converting a program that pokes values directly into the screen memory, convert it on the original machine to accept an offset from the "start of screen" location. On a PET, for example, set a variable SC=32768. Now use SC in all screen poke calculations and debug the program. When it works, set SC=1024 and load it into a C-64.

You will need the description in the VIC programmer's manual to simplify the job of POKEing the VIC screen. You will rapidly find out why some software written for the VIC doesn't work when extra memory is switched in.

Automatic Conversion. It is possible and, in fact, practical to make a program conversion that will work on two machines. This could even be automatic if the program could sense which machine it was running on. Consider the following:

```
9991 SC=1024: IF
  PEEK(62006)=73 and
  PEEK(41)=4 THEN SC=32768
```

This sets the beginning of screen-memory variable SC to the start of a C-64 screen. If two conditions are met that are true in 4.0 PETs, then the start of the screen variable is one the PET can use. This program can poke to either a PET or a C-64 screen. Moreover, now that the identification has been made, all kinds of adjustments can occur. The correct upper-case or graphics poke can be made, the correct sound code switched in, and so on.

For example: The program is running in a C-64, and line 9991 has just executed, so SC=1024. Program execution continues at line 9992:

```
9992  IF SC=1024 THEN POKE
      53281,1: POKE
      53272,21:
      S=1: GOTO 9994
9993  POKE 59468,12:S=0:REM
      LINE 9992 IF C-64, 9993
      IF PET—VARIABLE S SETS
      SOUND
9994  (next actual line in
      program)
```

Random Tidbits. A PET with a Programmer's Toolkit installed can load VIC or C-64 programs directly into the PET's normal program area starting at location 1024. Simply type NEW and then APPEND. This may be necessary in the case of large C-64 programs since all of the PET's memory is then utilized.

VIC and PET data handling on cassette is excellent. If you are having data (or program) problems with your cassette, have the head aligned at 10 kHz using a standard audio test tape. Timing problems cause C-64 handling of cassette data to be shaky. If you have to work with large amounts of data, use a disk, which is very reliable.

Long Lines. You may be aware of the VIC's 88-character (4 × 22) line length. Will VIC programs with lines this long fit into a PET or C-64, both of which have 80-character program lines? The answer is yes, they *will* fit, and the excess won't be unceremoniously dumped into that great bit-bucket in the sky. There is one limitation: The PET and C-64 screen editors won't handle more than 80 characters, so you've got to be tricky in editing the longer VIC lines in those machines.

There are two things to do: Read the section of the VIC manual that shows how to abbreviate BASIC keywords with a letter followed by a shifted second letter, and then use this shorthand to create lines of 80 characters or less. Such lines will expand to more than two lines on the 40-character screen when listed, which is all right. They must be entered on two lines, however, or the wraparound past the second line will disappear.

The following example will make this clearer. Consider this VIC line:

```
30440  CLOSE2:CLOSE3:
       PG$="":RESTORE:
       AT=PEEK(1):INPUTB$:
       PRINTRIGHT$(C$,3):
       FORI1=0TO1250
```

This line is 85 characters. Let's say that you are editing it on a C-64 and you want to change the 1250 to 1750. If you simply edited the change, the last few characters would be over the editor's 80-character limit, and those characters would be lost. Try it and you'll see. Now try reentering the line this way:

```
30440  CL[shift-O]2:CL
       [shift-O]3:PG$=
       "":RE[shift-S]:
       AT=P[shift-E](1):
       INPUTB$:?R[shift-I]
       (C$,3):F[shift-O]
       I1=0TO1750
```

Agreed, this is shifty, but when you enter the above with single-shifted characters in place of the brackets, the line will be only 65 characters and will fit easily within the two-line limit. Try it, then list it. The listed version will run over onto a third line on the screen. The loop value will be 1750. The impossible edit has just been made.

Conversions to Avoid. There are times when the chances for a successful conversion are less than if you were to rewrite the program from scratch. Let's

TABLE I

```
1200 PRINT''THIS TEXT IS FORMATTED TO PRINT OUT ON''
1210 PRINT''THE FORTY COLUMN SCREEN OF A PET OR''
1220 PRINT''COMMODORE-64. IF IT IS PRINTED ON A''
1230 PRINT''VIC, THEN HALF OF IT WILL SCROLL OFF''
1240 PRINT''THE SCREEN BEFORE YOU CAN READ IT.''
1250 PRINT''THE WAY TO STOP THIS IS TO ADD A LINE''
1260 PRINT''AT THE HALF SCREEN POINT THAT HOLDS''
1270 PRINT''THE REST UNTIL YOU TAP A KEY. YOU''
1280 PRINT''MUST HAVE ADDED TWO LINES: 9996/9997''
1290 PRINT''FIRST. THESE LINES WOULD JUST ABOUT''
1291 GOSUB 9996:REM LINE ADDED FOR VIC OPERATION ***
1300 PRINT''FILL A VIC SCREEN NOW, AND NEEDED TO''
1310 PRINT''BE STOPPED BY THE ADDED LINE 1291''
1320 PRINT''TO STOP IT FOR READING. NOW, YOU MAY''
1330 PRINT''NOT NEED THIS TRICK IF YOU ARE AN''
1340 PRINT''EXCELLENT SPEED READER, BUT THE REST''
1350 PRINT''OF US SURE DO!''
```

TABLE II

	PET	VIC	C-64
UPPER/LOWER	POKE 59468,14	36869,194	53272,23
UPPER/GRAPHICS	POKE 59468,12	36869,192	53272,21

identify these turkeys so you won't waste a lot of time.

Be sure that all of the program you are converting is practical to replace. If it has machine-language sections and you aren't interested in machine-language programming, then avoid it. If you are interested in machine language, then by all means give it a try, as the conversion of existing routines is one of the very best ways to learn any kind of programming.

If the program runs on a C-64 and uses sprites for graphics, then you won't be able to duplicate them in any VIC or PET program. Any substitute you come up with will be much slower and will move around in increments of one character, not one pixel. On the other hand, the use of sprites in a program converted for use on a C-64 may allow for significant enhancement. This is well worth doing, and there is always extra room in a C-64 when any VIC or PET program is loaded in.

If the program features sound, then be prepared to rewrite the whole thing. There is virtually nothing that will transport from machine to machine. Atari 800 sound programs would be just as close!

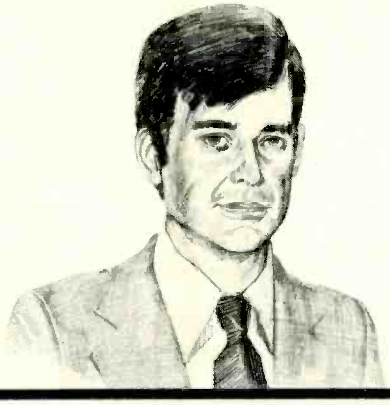
If the conversion is to a VIC, then the limited size of the VIC's screen must be considered. Watch out for one other quirk also: The VIC screen editor will wrap up to four lines together. This is because of the 88-character VIC logical line and is due to a system bug. This then produces blank lines that you didn't program in and don't want. To avoid this, only print lines on the screen that are less than 22 characters long. Any character in the 22nd space sets the wraparound and brings on the problem. The screen is small enough already without the extra blank lines.

Simple Conversions. If a program performs lots of calculations—trig functions like SIN or TAN, string manipulations like LEFT$ or RIGHT$, math functions like LOG or EXP, useful things like RND, DEF FN or the clock, TI$—these are identical for all the machines and will run perfectly on any one. The only exception is the RND function (often used in games) where the seed may have to be changed. If you start with the same "random" sequence each time and your program has the command RND(1) in it, then change it to RND(−1) and a truly random sequence will be delivered each time in all three machines.

If you have data stuffed everywhere in floating point, integer, or string-subscripted arrays, then convert with confidence. These arrays are very powerful ways of handling data and will look like A(X) or B%(X,Y) or C$(X,Y,Z) or even D(X,Y,Z,T). All of these machines handle these important arrays in the same way and your data and results will be identical.

You may wish to temporarily stuff a program from one type of Commodore computer into another just to take advantage of enhancements it might have like RENUMBER, FIND, or REPLACE. Or, your objective may be to permanently convert a program running on one of these machines to work on another. The information above will show you how to do this.

Some conversions are simple, and the information above may lead you to them right away. Others are more difficult and a cost-to-benefit analysis is very much in order. Don't forget to consider the added knowledge that you will gain from doing the job. If you have the interest, then converting something that already works so that it will work on some other machine is one of the best ways to learn any phase of programming. ◇



Rediscovering the Transistor
Low-Budget Radio Control
Output Interface for a Digital Timer

By Forrest M. Mims, III

CHANCES are the last circuit you assembled used one or more integrated circuits and few, if any, transistors. That's because falling prices and a wealth of functions have made integrated circuits so pervasive that circuits employing discrete transistors alone are fast becoming rare.

Nearly all the circuits I design and build use integrated circuits. However, while writing a new book last summer (*"Getting Started in Electronics,"* Radio Shack, 1983), I was reminded that there remain many simple applications for which individual transistors are ideally suited.

In this column we'll examine several simple but very useful transistor circuits you may have overlooked in favor of more complicated integrated circuit versions. We'll also compare a few transistor circuits with versions made with IC's to determine if the transistor versions are indeed simpler.

Next, we'll experiment with an inexpensive radio control module kit with many possible applications. Finally, we'll greatly expand the capabilities of a midget digital timer by adding a do-it-yourself output interface.

Rediscovering the Transistor

With the availability of literally hundreds of different kinds of integrated circuits, it's common to design even the simplest circuit around one or more IC's when a transistor or two would suffice. For example, the usual way to drive a meter or trigger a relay in response to a changing voltage or current is to use an operational amplifier or comparator. Often the same function can be performed with one or two transistors.

Another common example is the pulse generator. Most designers use a timer, such as the popular 555 or a pair of cross-coupled gates, when a simple pulse generator is required. Often, however, a simple two-transistor circuit will perform the same function with fewer components.

Let's look at several practical examples of how a simple transistor circuit can provide some or all the functions of an integrated circuit version. I think you'll agree with me that simple transistor circuits still have an important role to play in electronics today.

Moisture Detection Circuits. If asked to design a moisture detection circuit, the typical design engineer will use an op amp or comparator as the principal active circuit element. Figure 1 shows a much simpler approach.

The ultra-simple circuits in Fig. 1 each use a single bipolar transistor as the active element. Most common silicon npn small-signal transistors (2N2222, 2N3904, etc.) can be used.

The moisture meter can be used to measure the level of moisture in a flower pot or in garden soil. Probes can be made from nails or, even better, stainless steel wire. The circuit is calibrated by adjusting *R2* for a meter reading of 1 milliampere when the soil moisture is at the desired level.

The moisture-activated relay in Fig. 1 is a modified version of the moisture meter. The relay is actuated when the moisture level exceeds the level determined by *R2*. If you replace the sensor probes with a circuit board upon which has been etched an interlacing, comb-like grid, the circuit will be actuated when a rain-drop bridges the gap between the two foil patterns.

It's interesting to compare these circuits with integrated versions. The most obvious difference is cost. A suitable transistor can be purchased for under 15 cents if you're willing to pay a dollar or two for a bag of a dozen or more.

Another advantage of the transistor version is simplicity. A transistor has only three connection leads, while connections must be made to at least five of the eight pins of a typical op amp. Furthermore, since most transistors are equipped with leads rather than pins, the transistor moisture detection circuits can be easily assembled on a perforated board the size of a postage stamp.

Finally, at least one of the transistor circuits can be powered by a pair of penlight cells. (The relay circuit requires more voltage to drive the relay.) Though CMOS op amps that can be powered by as little as a volt or two are available, they are far more costly than a single transistor.

A Two-Transistor Metronome/Tone Source. Figure 2 shows a simple metronome circuit that, together with its two transistors and a speaker, includes only

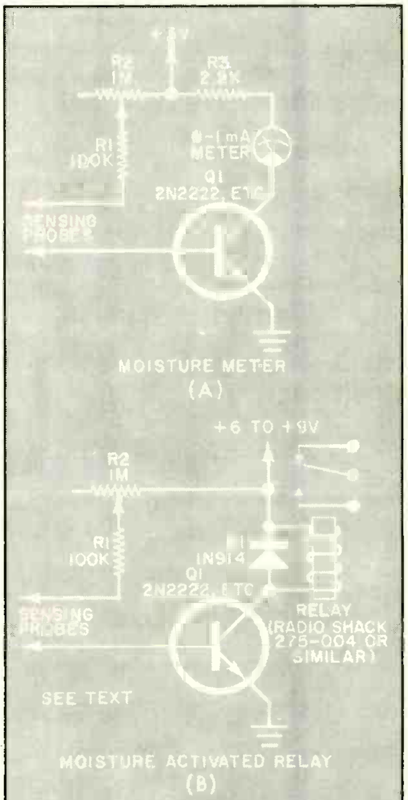


Fig. 1. Transistorized moisture sensing circuits.

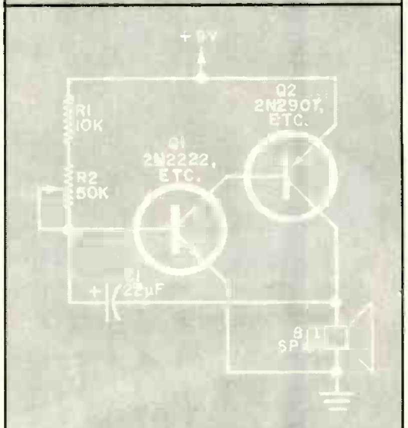


Fig. 2. Simple but effective two-transistor metronome.

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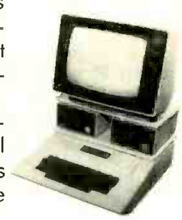

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six components. Ordinarily the ubiquitous 555 timer is used to make a simple circuit like this. However, the 555 version also requires six components (assuming it, too, employs a resistor in series with its frequency-control potentiometer).

Many common silicon switching and small-signal transistors can be used for *Q1* and *Q2* in Fig. 2. The click rate can be adjusted by adjusting *R1* or changing *C1's* value. Since the transistors have leads rather than pins, it's easy to build this circuit on a small perforated board.

FET Electrometer. The electrometer in Fig. 3 is a good circuit to try on a dry winter day. Though it uses only four components, its meter will indicate the presence of static charges up to several feet away. The circuit I tried, for instance, can detect from several feet away the presence of a plastic comb which I charged by stroking through my hair. Even *very* small movements of the charged comb will cause the meter needle to respond in kind. Potentiometer *R2* allows the circuit to be calibrated.

You can make a permanent version of the electrometer to check for the presence of static electricity near computers and other devices that can be affected by electrostatic discharges. For best results, install the circuit in a plastic box. A circuit board will not be necessary, since the leads of the FET and *R1* can be soldered directly to the meter and the potentiometer. *Q1* should be placed near the top portion of the box. A short, stubby "antenna" wire should extend from the top of the box.

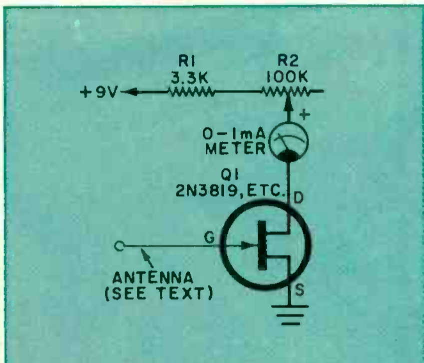


Fig. 3. Schematic of an ultra-simple FET electrometer.

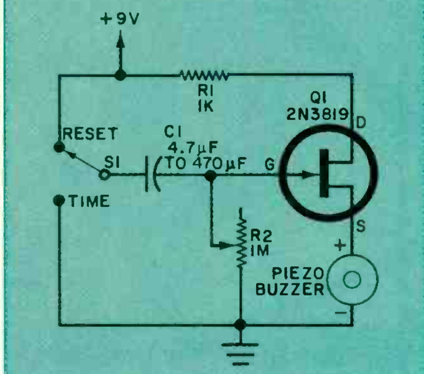


Fig. 4. Schematic of a single-FET timer circuit.

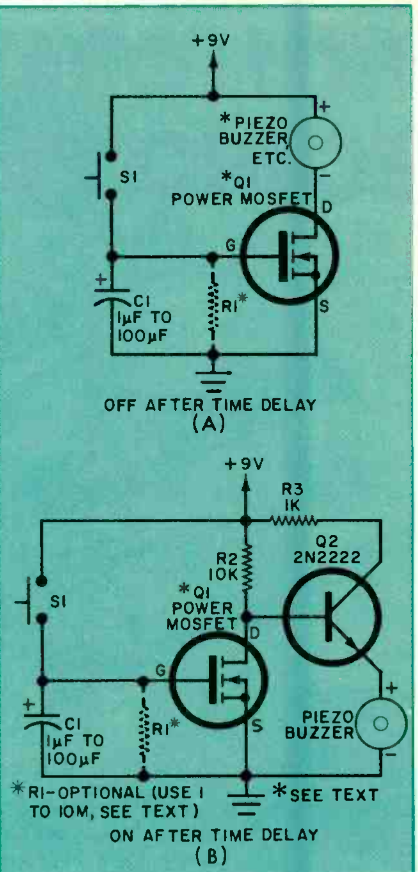


Fig. 5. Two power MOSFET timer circuits.

More sophisticated electrometers can be made with CMOS op amps. But they are more costly, trickier to design, and harder to construct. For a simple indication of the presence of static electricity, the ultra-simple single FET circuit in Fig. 3 may be a better choice.

A FET Timer. When faced with the need to design a timer, I inevitably use a 555 or its CMOS counterpart, the 7555. For brief timing durations of a few minutes, the simple FET circuit in Fig. 4 may be a better choice. Certainly, it's simpler, easier to build, and less expensive.

In operation, when *S1* is switched to RESET, *C1* is charged to near the power supply voltage through *R2*. When *S1* is switched to TIME, *C1* is slowly discharged through *R2*. Eventually, the voltage on *C1* falls low enough to allow *Q1* to switch on, thus allowing the piezoelectric buzzer to sound.

Power MOS Timers. VMOS, TMOS, DMOS, and other MOSFET power transistors can be used to make more effective, longer duration timing circuits than the simple FET version in Fig. 4. Thanks to the ultra-high-impedance input of the MOSFET, time delays of up to half an hour or even longer are possible. And, again, the necessary circuitry is simpler than an IC version using the 555, 7555 or similar timer chips.

Figure 5 shows two simple timers in which a power MOSFET (*Q1*) plays the key role. *Q1* can be a VN10, VN67, IRFD-1Z3 or other common power MOSFET.

The circuit in Fig. 5A is an "Off After Delay" timer. In operation, the piezoelectric buzzer is normally off. When *S1* is momentarily closed, however, *C1* is charged, thus switching on *Q1* and the buzzer. When *C1* eventually discharges through natural leakage paths, transistor *Q1* switches off and silences the buzzer.

Very long time delays are possible when *C1* has a high capacity. For best results, use a capacitor having a very low-loss dielectric. To control the timing cycle, you can add a resistor across *C1*. This resistor, *R1*, will provide a discharge path for the charge on *C1*.

Figure 5B is a modified version of the circuit in Fig. 5A. Here a bipolar transistor (*Q2*) inverts the switching status of *Q1*, thus providing an "On After Delay" operating mode. In this case, the piezoelectric buzzer sounds *after* the time delay is complete.

Though I used a piezoelectric buzzer in both circuits in Fig. 5, you can use a relay, small lamp, motor, portable radio or other device. In any case, do *not* exceed the power rating of *Q1* in Fig. 5A or *Q2* in Fig. 5B. The latter circuit includes a series resistor (*R3*) to limit current through *Q2* and the piezoelectric buzzer. If it's necessary to reduce the drive current in the circuit in Fig. 5A, insert an appropriate series resistor between the positive supply and the controlled device.

Low-Cost Radio Control

Ever since I began experimenting with aerial photography from kites and balloons, I've maintained an active interest in low-cost radio-control equipment. In a previous installment of "Experimenter's Corner" in this magazine (January 1983), I described in some detail two moderately priced radio-control systems with which I've experimented. I also related how I used a simple radio-control system salvaged from a toy car as well as standard radio-control systems to control an airborne Kodak disc camera.

After experimenting with various kinds of radio-control systems, I found that those having both a crystal-controlled transmitter *and* receiver are far more reliable than those in which only the transmitter is crystal controlled. Generally, the cheap systems used in radio-controlled toy cars do *not* have a crystal-controlled receiver.

My preference for crystal-controlled receivers is due to the serious noise and interference problems that often occur. Since a non-crystal-controlled receiver is broadly tuned, it may detect signals from CB radios and other sources being broadcast on nearby frequencies.

Though the commercial radio-control systems having crystal-controlled receivers are generally far superior to their non-crystal-controlled counterparts, there are some applications in which interference may not pose a serious problem. In these cases, if you have a need for a very low-cost radio control system, you may wish to consider a pair of pre-assembled remote control modules recently offered for sale by Radio Shack (catalog number 277-1012). These circuits appear very similar to those used in inexpensive radio-controlled cars.

The modules, which are sold together, include a crystal-controlled transmitter and a non-crystal-controlled receiver. The transmitter board is 1" wide and 3.6" long. The receiver board is 1.4" wide and 3" long. Both modules are powered by a 9-volt battery. In addition, the receiver requires a pair of 1.5-volt cells if the circuit is to drive the two small dc motors for which purpose it was originally designed.

Figure 6 is a block diagram showing both the transmitter and receiver. The transmitter consists of a 27.145-megahertz crystal-controlled oscillator which drives a single-stage radio-frequency amplifier. A two-transistor multivibrator modulates the amplifier with several switch-selectable combinations of audio-frequency control signals.

Figure 7 shows the circuitry of the

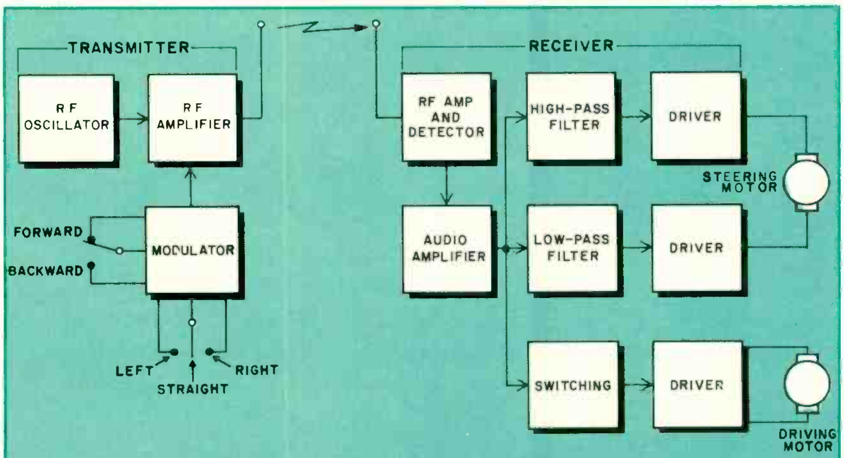


Fig. 6. Block diagram of remote-control module pair.

transmitter's oscillator *(Q2)* and r-f amplifier (*Q1*). Transformers *T1* and *T2* can both be adjusted for peak operating performance. For simplicity, Fig. 7 shows the audio-frequency modulator as a function block. I'll have more to say about the modulator later.

The receiver consists of an inductively-tuned (non-crystal) radio-frequency amplifier and detector followed by a stage of audio-frequency amplification. Two filters and a network of output driver transistors complete the circuit.

In its intended operating mode, the receiver's output stages are connected to two small dc motors. One motor, the one which propels the toy car, is always on when the receiver is on. It propels the car in a forward direction when the transmitter signal is tone-modulated. When the carrier from the signal is not modulated, the motor's direction of rotation is reversed, and the car is propelled backwards.

The second motor controls the direction of travel. It steers the car either left or right, depending upon which of two modulation frequencies is selected.

Figure 8 is a simplified view of one of the two receiver's motor drive circuits. Depending upon the control signals at the inputs to each output stage, the polarity of the voltage at output terminals A and B is reversed. See the truth table in Fig. 8 for details.

Incidentally, the circuit in Fig. 8 can be implemented with power MOSFETs. I once described one way this can be done in a "Project of the Month" column for this magazine (October 1982).

Modifying the Transmitter. In this month's lead topic I discussed the advantages of using discrete transistors rather than integrated circuits in some simple circuits. Radio Shack's radio-controlled modules, however, go too far. Both circuits use transistors exclusively, the receiver having 18 of them!

Although both the transmitter and receiver work well, I decided to modify the transmitter to permit transmission of a much wider range of carrier signals. I also designed a relatively simple circuit that replaces the mechanical switches used to control the carrier tone with logic signals. The external modulator circuit shown in Fig. 9 illustrates the latter circuit.

Though the transmitter's on-board, two-transistor multivibrator can be modified, I chose to use a 555 timer IC. This is a good example of where an IC

Q1	Q2	Q3	Q4	A	B
ON	OFF	ON	OFF	+	–
OFF	ON	OFF	ON	–	+

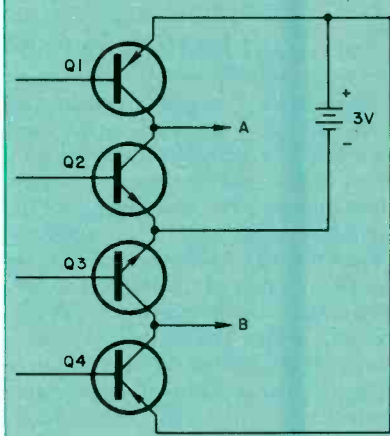


Fig. 8. Receiver polarity reversal output stage.

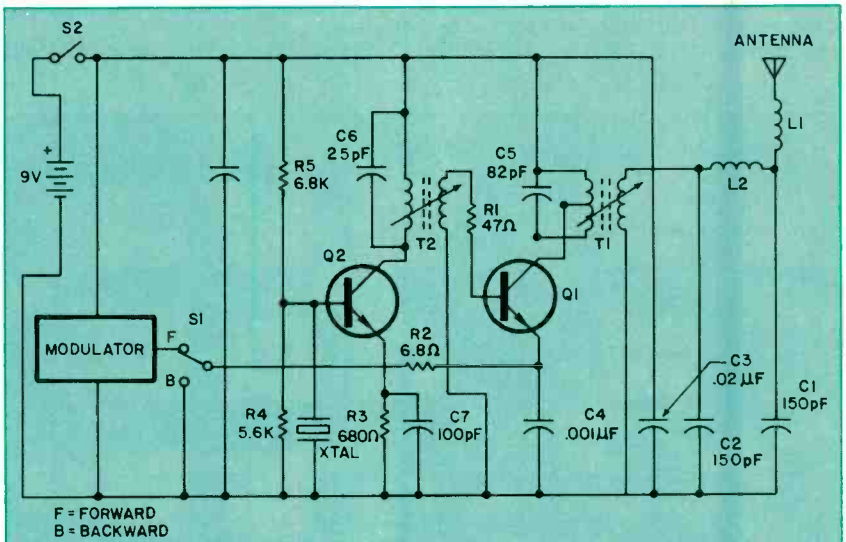


Fig. 7. Radio Shack remote-control transmitter.

provides more versatile operation than a transistor version.

In operation, the 555 oscillates at a frequency determined by *R2* and *C1*. Logic signals at inputs A and B determine which of two values of *R1* is selected, thereby controlling the modulation frequency. The output from the modulator (pin 3 of the 555) should be connected directly to the 68-ohm resistor shown as *R2* in the circuit diagram supplied with the transmitter module. Use the transmitter's 9-volt battery to power the circuit.

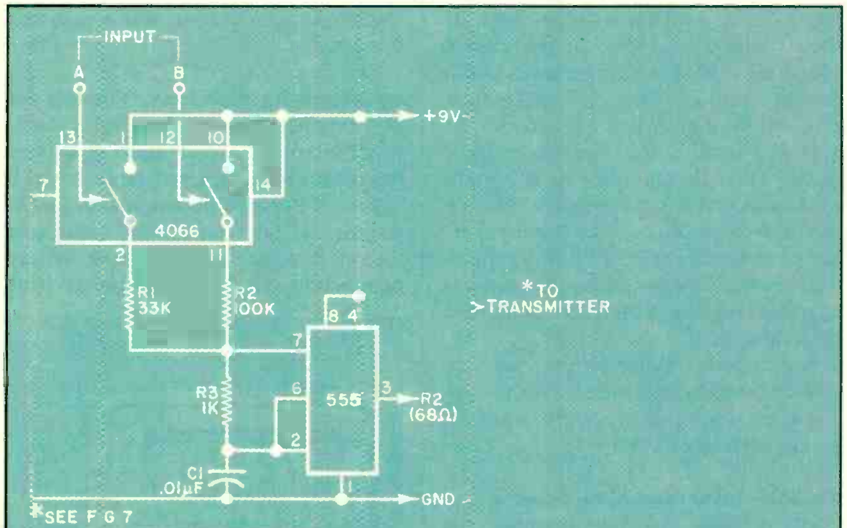
You can easily modify the modulator circuit in Fig. 9 by changing the values of *R1, R2*, and *C1*. For fast carrier-frequency changes, you can substitute potentiometers for *R1* and *R2*. The receiver can also be modified.

Modifying the Receiver. Though the Radio Shack receiver was designed to drive small dc motors, it will also drive other devices. Figure 10, for example, shows how it can be used to drive a pair of *tricolor* LEDs.

It's very simple to connect the LEDs to the receiver module. Be sure to use the two series resistors to limit the current to the LEDs to a safe value.

The truth table in Fig. 9 shows the various color and on-off combinations of the two LEDs for all four logic combinations that can be applied to inputs A and B. Of course, the LEDs will also respond to the various control combinations available from the unmodified transmitter.

Going Further. If you're interested in



INPUT		RCVR OUTPUT	
A	B	M1	M2
L	L	—	RED
L	H	—	GREEN
H	L	RED	GREEN
H	H	RED	GREEN

Fig. 9. External modulator circuit for radio-control transmitter.

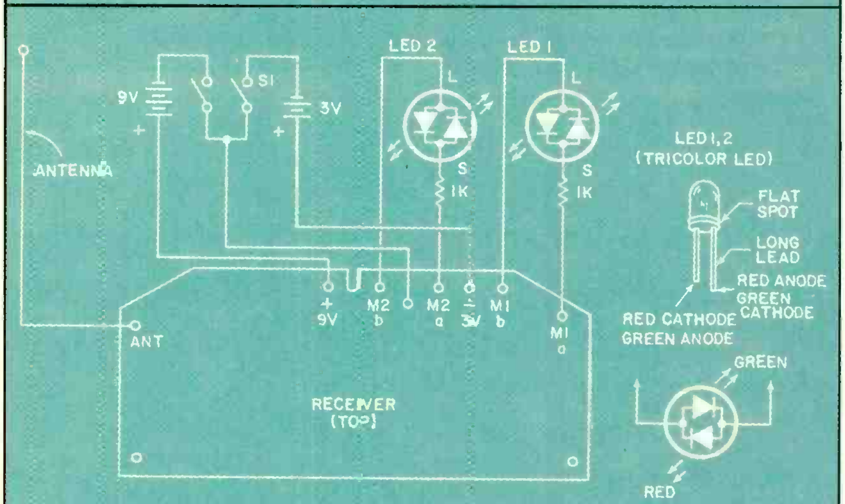


Fig. 10. How to connect LEDs to the receiver.

experimenting with these low-cost radio-control units, by now you may have already thought of other possible modifications. Besides electronic modifications and enhancements, you can physically modify the circuits so they will better fit a pair of small enclosures.

The transmitter is particularly well-suited for physical modification since the carrier modulator and r-f oscillator are at opposite ends of the circuit board. It's a simple matter to cut the board in half and mount the r-f oscillator section on a separate board upon which you can then assemble an IC modulator like the one in Fig. 9. Or you can stack the two halves of the existing board to form a more compact transmitter assembly.

Summing up, this pair of radio-control modules offers many possibilities for experimentation. Be sure to keep in mind the limitations of the receiver and the low power of the transmitter. For applications requiring more range and better noise and interference immunity, spend more money and buy a system that's completely crystal-controlled and includes on-board noise rejection circuitry.

Adding an Output Interface to a Digital Timer

One of the handiest gadgets in my office is a West Bend Electronic Timer™. This compact, crystal-controlled device is a digital countdown timer that sounds an alarm at the conclusion of a preset, user-programmable interval. The interval can range from 1 second to 99 minutes and 99 seconds.

Figure 11 is a pictorial view of the timer's front panel. The unit is operated by keying in the desired interval and pressing START. When the count reaches 00M 00S, the timer emits a rapid series of attention-getting chirps. The chirps will sound for one minute or until the STOP/RESET key is pressed.

The countdown can be halted temporarily by pressing STOP/RESET. The countdown will resume when START is pressed. Pressing STOP/RESET twice clears the display to 00M 00S.

Adding Output Leads. On the back of the timer is a handy clip that allows the unit to be attached to a belt or pocket. It also functions as a desk stand. A magnet in the clip permits the timer to be temporarily attached to a metal surface.

Just below the bottom of the clip is a small Phillips screw. When this screw is removed, the back panel of the timer can be gently pried away from the front panel by inserting a flat screwdriver blade in the continuous, thin slot that separates the two panels. Be sure to pry along the bottom slot near the screw hole to avoid breaking the plastic snap retainers on the inside, upper edge of both panels.

After you lift the back panel away, temporarily set aside the power cell. Note the wires leading to a cylindrical component in the back panel. This is the piezoelectric alerter. The volume of sound that can be delivered by an alerter so small is truly remarkable.

Use a grounded or battery powered soldering iron to remove both alerter leads from the circuit board. Wrap appropriately colored lengths of wrapping wire around the exposed wires of each lead, solder in place, and then solder the two pairs of connection wires back to their original locations on the circuit board. Be sure to solder the leads to the correct locations, for if their polarity is reversed the alerter will not sound.

Drill a small hole in the timer's back panel. Then thread the two wrapping wire leads through the hole and replace the back panel. Be sure the battery contacts are properly aligned *before* replacing the screw. (You can see the contacts by removing the battery cover on the back panel.)

Replace the battery (plus polarity side up) and check the timer for proper operation. Now you are ready to assemble the interface circuit.

An SCR Interface. The timer alarm signal consists of approximately eight bursts per second of 125-microsecond pulses having a 2.4-volt peak-to-peak amplitude. The pulses have a frequency of 4 kilohertz. Figure 12 shows a simple SCR interface that switches on upon arrival of the first pulse and remains on until manually reset.

The SCR alone can control loads up to its rated capacity. I used a relay to provide isolation between the timer and the load and to increase the circuit's switching power. *D1* reduces the possibility of 8-Hz chatter while the timer's alarm is sounding. *D2* protects the SCR from reverse voltage developed across the relay's coil when the reset switch is opened.

Not all SCR's will be reliably triggered by the timer's alarm signal. I had good results with Motorola's SCR1128 and Radio Shack's 276-1067.

Incidentally, you're on your own when you modify a manufactured electronic device such as this timer! Any warranty may be voided. And you must exercise caution to avoid damaging the timer's internal circuitry. You *must* also use caution and follow appropriate safety requirements should you use the modified timer to control line-powered devices.

Interface Applications. You can use the modified timer to control a darkroom enlarger, outdoor lighting, battery chargers, appliances, radios, and television sets. For best results, install the interface and relay on a small board and mount it adjacent to a 9-volt battery holder in a suitable enclosure. Provide

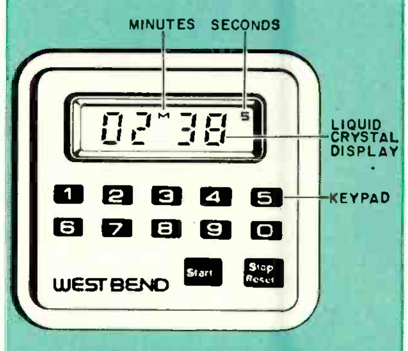


Fig. 11. Front panel of West Bend timer.

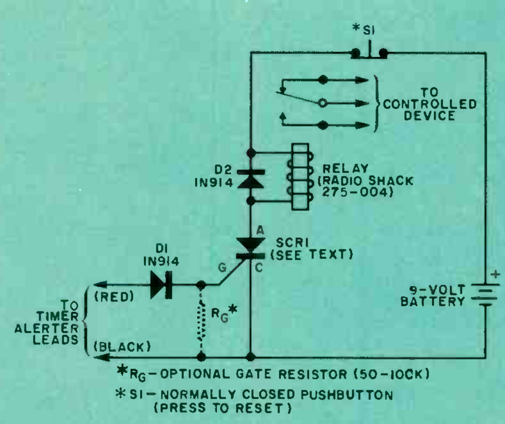


Fig. 12. Output interface circuit to connect to the timer alerter.

suitable plugs and jacks for connecting the timer to the interface and the interface to the device being controlled.

The timer can be clipped to a suitable shoulder or extension on the interface enclosure. Alternatively, you can use adhesive-backed squares of hook and loop fasteners. This will allow you to remove the timer when it's not being used to control the interface.

WARNING: You *must* follow safe wiring procedures if you use this circuit to control devices powered by the household line. Insulate *all* exposed connections. Do *not* exceed the contact ratings of the relay. The timer and interface should *not* be used for any application in which a circuit malfunction might cause injury to people or property.

Going Further. The timer I used is made by The West Bend Company (Box 1976, West Bend, WI 53095). I purchased mine at a department store for about $12.

Recently I've seen advertisements from three other companies showing timers having an almost identical appearance to the West Bend unit, but selling for as much as $29.95! You may be able to modify these and other digital timers with the help of the circuit in Fig. 12. In any case, shop around for the best buy. You may save more than enough to pay for the interface circuit . . . and possibly enough to buy a second timer!

A New Fiber-Optic Breakthrough

For the past decade, several major telecommunications companies and laboratories have engaged in an unofficial contest to establish a world record for the transmission of lightwave communications through the longest length of uninterrupted optical fiber. The signal must not be boosted along its path by the use of lightwave repeaters or regenerators.

The winner of this contest changes every few months and sometimes more often than that. The previous champion, Bell Laboratories, held the record for four months. Recently, however, scientists at Japan's Nippon Telegraph and Telephone announced a new record at a Tokyo conference on lightwave communications. The Japanese scientists successfully transmitted a 445.8-megabits-per-second signal through an optical fiber 134 kilometers (83.27 miles) long!

The optical source for this latest telecommunications achievement was a state-of-the-art distributed-feedback laser emitting at a wavelength of 1.53 micrometers in the near-infrared. At this wavelength, the optical fiber used in the demonstration had an optical attenuation of only 0.23 dB/km.

Incidentally, while the Japanese record may stand for a while, it will inevitably fall before the onslaught of new technological advances. Though the eventual distance record for conventional sources and fibers may not far exceed the recent Japanese figure, new sources and fibers designed to operate farther into the infrared may eventually provide repeaterless links of up to a thousand miles or more!

Device Developments

An Integrated Tone Ringer. Motorola has introduced the MC34012 tone ringer IC, the latest in a rapidly growing family of chips designed for telephone applications. The MC34012 permits the heavy and bulky electromechanical bell assembly in a conventional telephone to be replaced by a piezoelectric alerter.

In operation, the MC34012 is powered by the ac ring signal transmitted through the telephone line. The chip rectifies this signal and generates a square wave that drives the alerter. The chip's internal oscillator and frequency dividers provide a 12.5-Hz warble and tones that alternate between a high and low frequency. The sound volume can be adjusted by means of an external potentiometer between the chip and the alerter.

Telephone circuitry and equipment must be highly reliable and remain unaffected by voltage transients that may arrive through the telephone line. The MC34012 incorporates an internal SCR that fires when the on-chip voltage regulator draws more than 50 milliamperes, thereby protecting the chip's input circuitry.

Though primarily intended for telephone applications, the MC34012 would make an ideal sound generator chip for any kind of electronic, audible warning device. Three different versions of the chip in 8-pin miniDIP packages are available: 400/500 Hz, 800/1000 Hz, 1600/2000 Hz.

When this chip reaches the experimenter market, it should be reasonably priced because it sells for only $1.24 in quantities of 100. As soon as I can obtain a sample, I'll experiment with it and relate the results in a future column. ◇

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SN7428N	14	.59
SN7430N	14	.25
SN7432N	14	.29
SN7437N	14	.25
SN7438N	14	.29
SN7439N	14	.59
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.69
SN7447N	16	.69
SN7448N	16	.69
SN7450N	14	.19
SN7451N	14	.19
SN7453N	14	.19
SN7454N	14	.19
SN7459N	14	.25
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SN7476N	16	.35
SN7479N	14	4.95
SN7480N	14	.89
SN7482N	14	1.49
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.79
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.89
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74104N	14	1.19
SN74105N	14	1.19
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.69
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
SN74144N	24	3.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59
SN74156N	16	.59
SN74157N	16	.59
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.59
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.95
SN74170N	16	1.29
SN74172N	24	4.95
SN74173N	16	.69
SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
SN74177N	14	.69
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	1.19
SN74184N	16	2.49
SN74185N	16	2.49
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.89
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	2.49
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

74LS00	14	.25
74LS01	14	.25
74LS02	14	.29
74LS03	14	.25
74LS04	14	.35
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.29
74LS20	14	.29
74LS21	14	.29
74LS22	14	.29
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.39
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	14	.75
74LS51	14	.25
74LS54	14	.25
74LS55	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.89
74LS125	14	.59
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.89
74LS139	16	.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.29
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS166	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.95
74LS190	16	.89
74LS191	16	.89
74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.49
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

74S/PROMS*

74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S74	14	.55
74S85	16	2.49
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	1.19
74S175	16	1.19
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49
74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
74S258	16	1.19
74S260	14	1.19
74S280	14	1.95
74S287*	16	1.95
74S288*	16	1.95
74S373	20	2.49
74S374	20	2.49
74S387*	16	1.95
74S471*	20	5.95
74S472*	20	4.95
74S473*	20	4.95
74S474*	24	4.95
74S475*	24	4.95
74S570*	16	2.95
74S571*	16	2.95
74S572*	18	4.95
74S573*	18	4.95
74S940	20	2.49
74S941	20	2.49

CA—LINEAR

CA3010H		1.35
CA3039H		1.35
CA3046N	14	1.35
CA3059N	14	2.95
CA3060N	16	2.95
CA3065E	14	1.49
CA3080E	8	.89
CA3081N	16	.99
CA3082N	16	1.19
CA3083N	16	1.49
CA3086N	14	.69
CA3089N	16	1.69
CA3096N	16	1.49
CA3130E	8	.89
CA3140E	8	.79
CA3160H		1.95
CA3161E	16	2.95
CA3162E	16	6.95
CA3189E	16	1.59
CA3401N	14	.59

CD—CMOS

CD4000	14	.29
CD4001	14	.29
CD4002	14	.29
CD4006	14	1.19
CD4007	14	.29
CD4009	16	.59
CD4010	16	.59
CD4011	14	.29
CD4012	14	.29
CD4013	14	.39
CD4014	16	1.19
CD4015	16	.39
CD4016	14	.49
CD4017	16	1.19
CD4018	16	.99
CD4019	16	.59
CD4020	16	1.19
CD4021	16	1.19
CD4022	16	1.19
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
CD4027	16	.45
CD4028	16	.69
CD4029	16	1.29
CD4030	14	.39
CD4034	24	2.49
CD4035	16	1.49
CD4040	16	1.19
CD4041	14	1.19
CD4042	16	.89
CD4043	16	.79
CD4044	16	.79
CD4046	16	1.19
CD4047	14	1.29
CD4048	16	.59
CD4049	16	.39
CD4050	16	.39
CD4051	16	.99
CD4052	16	.99
CD4053	16	.99
CD4056	16	2.95
CD4059	24	7.95
CD4060	16	1.49
CD4066	14	.59
CD4068	14	.39
CD4069	14	.29
CD4070	14	.39
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	1.19
CD4078	14	.49
CD4081	14	.29
CD4082	14	.29
CD4093	14	.49
CD4098	16	1.95
CD4506	16	1.19
CD4507	14	1.19
CD4508	24	3.95
CD4510	16	1.29
CD4511	16	1.19
CD4512	16	1.19
CD4514	24	2.49
CD4515	24	2.49
CD4516	16	1.19
CD4518	16	1.19
CD4519	16	.59
CD4520	16	1.19
CD4526	16	1.49
CD4528	16	1.49
CD4529	16	1.69
CD4543	16	1.95
CD4562	14	6.95
CD4566	16	1.39
CD4583	16	2.49
CD4584	14	.69
CD4723	16	1.19
CD4724	16	1.19
MC14409	16	13.95
MC14410	16	13.95
MC14411	24	11.95
MC14412	16	13.95
MC14419	16	7.95
MC14433	24	13.95
MC14538	16	1.19
MC14541	14	1.19

(More in Catalog)

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MICROPROCESSOR CHIPS

Part No.	**Pins	Function	Price
CDP1802	40	CPU	$2.95
MCS6502	40	MPU w/Clock	5.95
MCS6502B	40	MPU w/Clock at 3MHz	9.95
MC6802CP	40	MPU w/Clock and RAM	7.95
6809	40	CPU—8-bit (Internal Clock) 1MHz	14.95
INS8035N-6	40	MPU—8-bit (6MHz)	5.95
INS8039N	40	CPU-Sgl chip 8-bit (128bts, Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	9.95
INS8070N	40	CPU (64 bytes RAM)	29.95
INS8073N	40	CPU w/Basic Micro Interpreter	29.95
P8085A	40	CPU	4.95
8086	40	CPU 16-bit 5MHz	24.95
8088	40	CPU 8/16-bit	29.95
8155	40	HMOS RAM I/O Port Timer	6.95
8748	40	HMOS EPROM MPU	24.95

Z80, Z80A, Z80B, Z8000 SERIES

Z80	40	CPU (MK3880N)(780C) 2MHz	$3.95
Z80-CTC	28	Counter Timer Circuit	3.95
Z80-DART	40	Dual Asynchronous Rec./Trans.	10.95
Z80-DMA	40	Direct Memory Access Circuit	9.95
Z80-P10	40	Parallel I/O Interface Controller	3.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	12.95
Z80-S10/1	40	Serial I/O (Lacks DTRB)	12.95
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80 S10/9	40	Serial I/O	12.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	4.49
Z80A-CTC	28	Counter Timer Circuit	4.95
Z80A-DART	40	Dual Asynchronous Rec./Trans	9.95
Z80A-DMA	40	Direct Memory Access Circuit	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB bonded)	12.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	12.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80A-S10/9	40	Serial I/O	12.95
Z80B	40	CPU (MK3880N-6) 6MHz	9.95
Z80B-CTC	28	Counter Timer Circuit	12.95
Z80B-DART	40	Dual Asynch. Receiver/Transmitter	19.95
Z80B-P10	40	Parallel I/O Interface Controller	12.95
Z8001	48	CPU Segmented	44.95
Z8002	40	CPU Non-Segmented	34.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

6500/6800/68000 SERIES

MC6502A	40	MPU with clock and RAM (2MHz)	6.95
MC6520	40	Peripheral Inter. Adapter	4.95
MC6800	40	MPU	2.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6809E	40	CPU (1MHz) External (Locking)	14.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	2.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	9.95
MC6850	24	Asynchronous Comm. Adapter	3.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	7.95
MC68000L8	64	MPU 16-Bit (8MHz)	49.95
MC68488P	40	General Purpose Inf. Adapter	9.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Int	9.95
MCM68764	24	64K EPROM (450ns)	24.95
SY6522	40	Peripheral Inter. Adapter	7.95

8080A SERIES

INS8080A	40	CPU	2.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	6.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	2.95
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	3.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.95
DP8307	20	8-bit Bi-Directional Receiver	2.95
DP8308	20	8-bit Bi-Directional Receiver	2.95
DP8310	20	Octal Latched Peripheral Driver	4.95
8741	40	8-bit Univ. Peripheral Interface	29.95
8755	40	16K EPROM with I/O	24.95

DISK CONTROLLERS

INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	29.95
FD1793	40	Single/Double Density (True)	29.95
FD1795	40	Dual Density/Side Select (Inv.)	29.95
FD1797	40	Dual Density/Side Select True	29.95
6843P	40	Floppy Disk Controller (1MHz)	29.95

SPECIAL FUNCTION

DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	8.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64 digit RAM & Direct LED Drive w/N Buss Int	5.95
COP470N	20	32-seg VAC Fluor. Drvr (20-pin pkg.)	3.25
IDM2909AJC	28	Microprocessor Sequencer	7.95
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	**Pins		Price
1103	18	1024x1 (300ns)	.99
4027	16	4096x1 (250ns)	2.49
4116N-2	16	16,384x1 (150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1 (200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1 (250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1 (150ns)	6.95 - 8/49.95
4164N-200	16	65,536x1 (200ns)	5.95 - 8/44.95
MM5261	18	1024x1 (300ns)	.49 - 8/1.95
MM5262	22	2048x1 (365ns)	.49 - 8/1.95
MM5270	18	4096x1 (250ns) MK4096	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MM5290-2	16	16,384x1 (150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1 (200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1 (250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1 (200ns)	1.69

STATIC RAMS

1101	16	256x1 (650ns)	1.49
2101	22	256x4 (450ns) 8101	2.49
2102	16	1024x1 (350ns)	.89
21L02	16	1024x1 (450ns) L.P.	1.49
2111	18	256x4 (450ns) 8111	2.95
2112	16	256x4 (450ns) MOS	1.95
2114	18	1024x4 (450ns)	1.49 - 8/9.95
2114L	18	1024x4 (450ns) L.P.	1.95 - 8/13.95
2114-2	18	1024x4 (200ns)	1.75 - 8/11.95
2114L-2	18	1024x4 (200ns) L.P.	2.25 - 8/14.95
2147	18	4096x1 (70ns)	4.95
2148	18	1024x4 (70ns)	4.95
TMS4045	18	1024x4 (450ns)	3.95
TMS40L47-45	20	1024x4 (450ns)	2.95
5101	22	256x4 (450ns) CMOS	2.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-3	24	2048x8 (150ns) CMOS	5.95
HM6116-4	24	2048x8 (200ns) CMOS	4.95
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	5.49
HM6264P-15	28	8192x8 (150ns) CMOS	39.95
27LS00	16	256x1 (80ns) L.P.	9.95
7489	16	16x4 (50ns) 3101	2.25
74C920	22	256x4 (250ns)	3.95
74C921	18	256x4 (250ns) CMOS	3.95
74C929	16	1024x1 (250ns) CMOS (6501)	3.95
74C930	18	1024x1 (250ns) CMOS (6518)	3.95
74S189	16	16x4 (35ns) 93405	1.95
74S200	16	256x1 (80ns) 93410	3.95
74S206	16	256x1 (60ns) 93411	3.95
74S289	16	16x4 (35ns) 3101	2.25
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25

PROMS/EPROMS

1702A	24	256x8 (1us)	4.95
2708	24	1024x8 (450ns)	3.95
2708.5	24	1024x8 (550ns) SM00246	2.95
TMS2516	24	2048x8 (450ns) 2716	5.95
TMS2532	24	4096x8 (450ns) NMC2532	6.95
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TMS2716	24	2048x8 (450ns) 3 voltage	9.95
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2732	24	4096x8 (450ns)	6.95
2732A-3	24	4096x8 (300ns)	7.95
2732A-4	24	4096x8 (450ns) 21V	6.95
2732Q-4	24	4096x8 (550ns)	5.95
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2764-4	28	8192x8 (450ns)	9.95
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MM52040	24	512x8 (1us)	4.95
MCM68764	24	8192x8 (450ns)	24.95
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74S188	16	32x8 PROM O.C. (6330-1)	1.49
74S287	16	256x4 PROM T.S. (6301-1)	1.95
74S288	16	32x8 PROM T.S. (6331-1)	1.95
74S387	16	256x4 PROM O.C. (6300-1)	1.95
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22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.46	.42	.39
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LP

SG

ST

WW

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28 pin SG	.81	.76	.72
36 pin SG	1.09	1.03	.97
40 pin SG	1.21	1.14	1.08

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20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
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74C173	16	1.19
74C174	16	1.19
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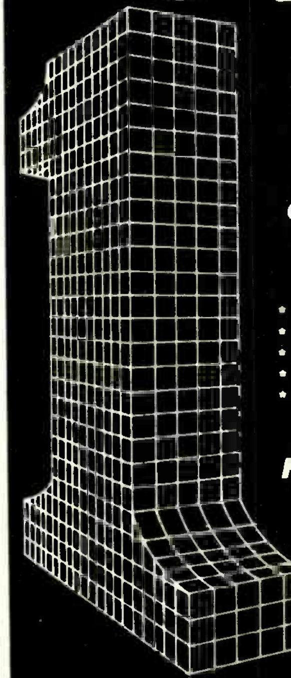

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11304	18	.73	.66	.55
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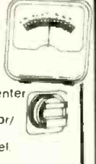
11204	18	.18	.17	.15
11205	20	.20	.18	.16
11206	22	.22	.20	.18
11207	24	.24	.22	.20
11208	28	.28	.26	.25
11209	40	.40	.37	.33

EKI KITS
come with all parts necessary to assemble!
- Stock No. 88844 TV Jammer Kit "wipes out" your TV screen .... $ 7.71
- Stock No. 88850 Whooper Alarm Kit makes a great alarm or siren..... $11.33

MANY, MANY MORE KITS AVAILABLE IN FULL LINE CATALOG

ELPAC POWER SUPPLIES - DC/DC CONVERTERS

SINTEC Stock No. 300 MW Type	ELPAC No.	Input Voltage (VDC)	Output Voltage (VDC)	Output Current (MA)	Dimensions (HxWxD) in Inches	Price
13825	CB3801	3.0-7.0	12±0.6	0-25	.48x.51x3.05	$ 7.95
13826	CB3811	3.0-7.0	-12±0.6	0-25	.48x.51x3.05	7.95
13827	CB3802	3.0-7.0	15±0.7	0-20	.48x.51x3.05	7.95
13828	CB3812	3.0-7.0	-15±0.7	0-20	.48x.51x3.05	7.95
13829	CB3804	3.0-7.0	28±0.7	0-10	.48x.51x3.05	7.95
13830	CB3814	3.0-7.0	-28±0.7	0-10	.48x.51x3.05	7.95
1.5 W TYPE:						
13831	CL3801	4.0-7.0	12±0.6	125	.651x1.2x1.77	$24.95
13832	CL3811	4.0-7.0	-12±0.6	125	.651x1.2x1.77	24.95
13833	CL3802	4.0-7.0	15±0.7	100	.651x1.2x1.77	24.95
13834	CL3812	4.0-7.0	-15±0.7	100	.651x1.2x1.77	24.95
13835	CL3804	4.0-7.0	28±1.4	50	.651x1.2x1.77	24.95
13836	CL3814	4.0-7.0	-28±1.4	50	.651x1.2x1.77	24.95
13825-1	DATA SHEET FOR DC/DC CONVERTERS					.25

Special of the Month!
INDUCTION AMMETER


No direct electrical connections—the current-carrying conductors are simply slipped into channels on the back of the meter. The magnetic field set up by the current actuates the moving magnet mechanism. The dual scale is for zero center ranges 75-0-75 and 400-0-400, and is suitable for monitoring both the alternator/generator and starter of a motor vehicle. Metal case and bright chrome plate bezel.

Stock No.	Price
13734	$7.50

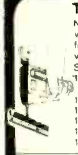
OPCOA
Single Digit Displays - Common Cathode

LEFT DECIMAL POINT — RIGHT DECIMAL POINT

Stock No.	Color	1	100
12082	Red	$1.12	$ .99
12085	Green	1.84	1.63
12087	Yellow	1.92	1.70
12089	Orange	2.08	1.84

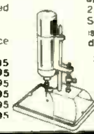
Right Angle Socket for Above Displays

Stock No.	1	100
11010	$1.24	$ .99

The Battery Just Wrap™ Tool


New battery powered tool wraps insulated wire around .025" square posts without need for pre-cutting and pre-stripping. Complete with bit and 100 ft 30 AWG wire.

Stock No	Description	Price
13340	Battery just-wrap tool with bit and 100 ft 30 AWG wire	$49.95
13341	Replacement bit	9.95
13342	100 ft. blue replacement wire	6.95
13343	100 ft. white replacement wire	6.95
13344	100 ft yellow replacement wire	6.95
13345	100 ft red replacement wire	6.95

MINI-DRILL


This portable hand drill is appropriate for circuit board drilling. Runs at 2,500 RPM on 4 "AA" batteries (not included). Supplied with one .039 dia. drill bit. Drill stand is designed like a drill press for precise hole drilling.

Stock No	Description	Price
13346	Hand drill with .039 dia bit (no batteries)	$24.95
13347	Replacement bits 2 each of .040 and .060 dia	5.95
13348	Drill stand	13.95

PIN FORMING TOOL
puts IC's on their true row to row spacing. One side is for .300 centers. Flip tool over for devices on .600 centers. Put device in tool and squeeze.

ONE TOOL DOES 8 thru 40 PINS!

NEW! ANTI-STATIC MODEL Stock No. 10200 $14.95
Stock No. 11059 $12.95

OK MACHINE AND TOOL

IC INSERTION/EXTRACTION KIT
Includes DIP IC extractors and inserters to accommodate all ICs from 14 to 40 pins. Tools that engage conductive surfaces are CMOS safe and include grounding lugs. Stock No. 13309 **$37.74**

SOCKET WRAP ID
DIP socket sized plastic panels with numbered holes in pin locations. Slip onto socket before wire wrapping to identify pins. Also write on them for location, IC part number, function, etc. Simplifies initial wire wrapping, troubleshooting and repair.

13295	14 pin
13296	16 pin
13297	18 pin
13298	20 pin
13299	22 pin
13300	24 pin
13301	28 pin
13302	40 pin
13303	96 pin

$1.82 per pack

IC EXTRACTOR
One-piece, spring steel construction. Will extract all LSI, MSI and SSI devices with 8 to 24 pins.
Stock No. 13313 **$2.10**

OPTEL LCD's with pins
Stock No. 47005
Stock No. 47006
Stock No. 47007

Stock No.	Description	1	10
47005	3½ dig, .5"	$ 5.95	$ 5.50
47006	4 dig, .5"	5.95	5.50
47007	4 dig., .7"	11.90	11.00

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INTEGRATED CIRCUITS

7400 TTL · 74LS00 TTL · 74S00 TTL · 4000 CMOS · Linear · 74C00 CMOS · A/D & D/A · Micro · Interface · Memory

TEXAS INSTRUMENTS I.C. SOCKETS

Body — 94 V-O polyester with Copper Alloy contacts. Accommodates standard IC leads up to .014" thick and .025" wide. Contact is designed and oriented to the insulator to grasp the broad "face" of the IC lead allowing for low insertion and high retention forces. Socket is designed to achieve maximum density on boards.

SOLDER TAIL DIP SOCKETS

- Single beam
- Low profile
- YOUR CHOICE: TIN OR GOLD* (Minimum 10 microinch gold inlay on gold sockets)

TIN PLATED SOLDER TAIL Min 200 Microinches Tin, -40° to +70°C

Part No	Description	1	10	100
C8908	8 pin solder tail, tin	13	1.15	10.50
C8914	14 pin solder tail, tin	15	1.45	12.00
C8916	16 pin solder tail, tin	17	1.60	13.00
C8918	18 pin solder tail, tin	20	1.90	17.00
C8920	20 pin solder tail, tin	23	2.10	20.00
C8922	22 pin solder tail, tin	25	2.25	21.00
C8924	24 pin solder tail, tin	28	2.50	24.00
C8928	28 pin solder tail, tin	32	2.90	27.00
C8940	40 pin solder tail, tin	46	4.20	39.00

GOLD INLAY SOLDER TAIL Min 10 Microinches Gold, -65° to +125°C

Part No	Description	1	10	100
C9808	8 pin solder tail, gold	34	3.20	30.00
C9814	14 pin solder tail, gold	44	4.20	40.00
C9816	16 pin solder tail, gold	50	4.70	45.00
C9818	18 pin solder tail, gold	57	5.40	52.00
C9820	20 pin solder tail, gold	.63	5.90	57.00
C9822	22 pin solder tail, gold	70	6.60	64.00
C9824	24 pin solder tail, gold	76	7.20	70.00
C9828	28 pin solder tail, gold	.79	7.50	73.00
C9840	40 pin solder tail, gold	1.12	9.90	97.00

WIRE WRAP DIP SOCKETS

- Standard profile
- Universal mounting and packaging capabilities
- Contacts accommodate .015" through .021" rec. or round dual-in-line leads
- Wire wrap posts held to true position of .015" providing a true position of .020" on boards for efficient automatic wire wrapping
- YOUR CHOICE: TIN OR GOLD* (Minimum 10 microinch gold inlay on gold sockets)
- TEXAS INSTRUMENTS QUALITY

TIN PLATED WIRE WRAP Min 200 Microinches Tin

Part No	Description	1	10	100
C8108	8 pin wire wrap, tin	.38	3.60	34.00
C8114	14 pin wire wrap, tin	.50	4.90	48.00
C8116	16 pin wire wrap, tin	57	5.60	55.00
C8118	18 pin wire wrap, tin	.69	6.70	65.00
C8120	20 pin wire wrap, tin	76	7.50	74.00
C8122	22 pin wire wrap, tin	83	8.20	81.00
C8124	24 pin wire wrap, tin	91	8.90	88.00
C8128	28 pin wire wrap, tin	1.04	10.30	102.00
C8140	40 pin wire wrap, tin	1.42	13.90	138.00

GOLD INLAY WIRE WRAP Min 10 Microinches Gold

Part No	Description	1	10	100
C9108	8 pin wire wrap, gold	59	5.80	57.00
C9114	14 pin wire wrap, gold	79	7.80	77.0
C9116	16 pin wire wrap, gold	85	8.40	83.00
C9118	18 pin wire wrap, gold	99	9.80	97.00
C9120	20 pin wire wrap, gold	1.19	11.80	117.00
C9122	22 pin wire wrap, gold	1.29	12.80	127.00
C9124	24 pin wire wrap, gold	1.39	13.80	137.00
C9128	28 pin wire wrap, gold	1.69	16.80	167.00
C9140	40 pin wire wrap, gold	2.29	22.80	227.00

TEXAS INSTRUMENTS GOLD EDGEBOARD CONNECTORS

Solder Tab · Solder Eye · Wire Wrap

RELIABLE, COST EFFICIENT CONTACT DESIGN

H4 SERIES .100" x .200" EDGEBOARD CONNECTORS

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4116 200 nsec 16,384x1 D Ram

Prime Parts As Low As $1.365 Each.

Part No.	8	32	128	512	1024
4116N ND	15.12	57.12	216.00	806.40	1397.75
5290N ND	15.12	57.12	216.00	806.40	1397.75
Price Each	1.89	1.785	1.68	1.575	1.365

NSC Data Books

Book Title	Part No.	Price
1982 Transistor Databook	9070B	$ 6.00
1981 Logic Databook	9054B	9.00
1982 Linear Databook	9068B	12.00
1980 Interface Databook	9064B	6.00
1980 Memory Book	9059B	6.00
1982 COPS Microcontroller Data Book	9069B	8.50
1979 Special Function Databook	9057B	6.00
NSC 800 Microprocessor Family Handbook-1981	9053B	5.00
Linear Applications Handbook	9062B	16.00
Microprocessor Applications in Business, Science and Industry	9055B	4.00
1980 Audio/Radio Handbook	9085B	5.00
Voltage Regulator Handbook-1982	9063B	7.00

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DIGI-KEY now has an expanded line of Panasonic Ceramic Disc Capacitors, including (listed after NPO banner)

NPO TYPE

For Complete Specs on Physical Size and Electrical Characteristics, consult your *FREE* DIGI-KEY Catalog.

Part No	Cap.	Volt.	10	100	1,000
P4000	10 pf	500	75	6.49	48.71
P4002	15 pf	500	75	6.49	48.71
P4003	18 pf	500	75	6.49	48.71
P4004	22 pf	500	75	6.49	48.71
P4005	27 pf	500	75	6.49	48.71
P4006	33 pf	500	75	6.49	48.71
P4007	39 pf	500	75	6.49	48.71
P4008	47 pf	500	75	6.49	48.71
P4009	56 pf	500	75	6.49	48.71
P4010	68 pf	500	84	7.23	54.22
P4011	82 pf	500	84	7.23	54.22

See The DIGI-KEY Catalog For Low OEM Prices On Disc Capacitors

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$ 10.00-$25.00	Add $0.75	$ 100.00-$249.99	Less 10%
$ 25.00-$49.99	Add $0.50	$ 250.00-$499.99	Less 15%
$ 50.00-$99.99	Add $0.25	$ 500.00-$999.99	Less 20%
$100.00 & Up	No Charge	$1000.00 & Up	Less 25%

4164 64K DYNAMIC 200 NS $5.95

TMM2016 2KX8 STATIC 200 NS $4.15

STATIC RAMS

2101	256 x 4	(450ns)	1.95
5101	256 x 4	(450ns) (cmos)	3.95
2102-1	1024 x 1	(450ns)	.89
2102L-4	1024 x 1	(450ns) (LP)	.99
2102L-2	1024 x 1	(250ns) (LP)	1.49
2111	256 x 4	(450ns)	2.49
2112	256 x 4	(450ns)	2.99
2114	1024 x 4	(450ns)	8/9.95
2114-25	1024 x 4	(250ns)	8/10.95
2114L-4	1024 x 4	(450ns) (LP)	8/12.95
2114L-3	1024 x 4	(300ns) (LP)	8/13.45
2114L-2	1024 x 4	(200ns) (LP)	8/13.95
TC5514	1024 x 4	(650ns) (cmos)	2.49
TC5516	2048 x 8	(250ns) (cmos)	9.95
2147	4096 x 1	(55ns)	4.95
TMS4044-4	4096 x 1	(450ns)	3.49
TMS4044-3	4096 x 1	(300ns)	3.99
TMS4044-2	4096 x 1	(200ns)	4.49
MK4118	1024 x 8	(250ns)	9.95
TMM2016-200	2048 x 8	(200ns)	4.15
TMM2016-150	2048 x 8	(150ns)	4.95
TMM2016-100	2048 x 8	(100ns)	6.15
HM6116-4	2048 x 8	(200ns) (cmos)	4.75
HM6116-3	2048 x 8	(150ns) (cmos)	4.95
HM6116-2	2048 x 8	(120ns) (cmos)	8.95
HM6116LP-4	2048 x 8	(200ns) (cmos)(LP)	5.95
HM6116LP-3	2048 x 8	(150ns) (cmos)(LP)	6.95
HM6116LP-2	2048 x 8	(120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8	(300ns) (Qstat)	34.95
HM6264	8192 x 8	(150ns) (cmos)	49.95

LP = Low Power   Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1	(250ns)	1.99
UPD411	4096 x 1	(300ns)	3.00
MM5280	4096 x 1	(300ns)	3.00
MK4108	8192 x 1	(200ns)	1.95
MM5298	8192 x 1	(250ns)	1.85
4116-300	16384 x 1	(300ns)	8/11.75
4116-250	16384 x 1	(250ns)	8/11.95
4116-200	16384 x 1	(200ns)	8/12.95
4116-150	16384 x 1	(150ns)	8/14.95
4116-120	16384 x 1	(120ns)	8/29.95
2118	16384 x 1	(150ns) (5v)	4.95
MK4332	32768 x 1	(200ns)	9.95
4164-200	65536 x 1	(200ns) (5v)	5.95
4164-150	65536 x 1	(150ns) (5v)	6.95
MCM6665	65536 x 1	(200ns) (5v)	8.95
TMS4164-15	65536 x 1	(150ns) (5v)	8.95

5V = single 5 volt supply

EPROMS

1702	256 x 8	(1us)	4.50
2708	1024 x 8	(450ns)	3.95
2758	1024 x 8	(450ns) (5v)	5.95
2716	2048 x 8	(450ns) (5v)	3.95
2716-1	2048 x 8	(350ns) (5v)	5.95
TMS2516	2048 x 8	(450ns) (5v)	5.50
TMS2716	2048 x 8	(450ns)	7.95
TMS2532	4096 x 8	(450ns) (5v)	5.95
2732	4096 x 8	(450ns) (5v)	4.95
2732-250	4096 x 8	(250ns) (5v)	8.95
2732-200	4096 x 8	(200ns) (5v)	11.95
2732A-4	4096 x 8	(450ns) (5v) (21vPGM)	6.95
2732A	4096 x 8	(250ns) (5v) (21vPGM)	9.95
2732A-2	4096 x 8	(200ns) (5v) (21vPGM)	13.95
2764	8192 x 8	(450ns) (5v)	9.95
2764-250	8192 x 8	(250ns) (5v)	14.95
2764-200	8192 x 8	(200ns) (5v)	24.95
TMS2564	8192 x 8	(450ns) (5v)	17.95
MC68764	8192 x 8	(450ns) (5v) (24 pin)	39.95
27128	16384x8	(300ns) (5v)	29.95

5v = Single 5 Volt Supply   21vPGM = Program at 21 Volts

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		9	8,000	83.00
PE-14T	X	9	8,000	119.00
PE-24T	X	12	9,600	175.00
PL-265T	X	30	9,600	255.00
PR-125T	X	25	17,000	349.00
PR-320T	X	42	17,000	595.00

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3.579545	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

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AY5-1013	3.95
AY3-1015	6.95
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TR1602	3.95
2350	9.95
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8038	3.95

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TMS99532	29.95
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MC3470	4.95
MC3480	9.00
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95H90	7.95
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MM5375	4.95
MM58167	12.95
MM58174	11.95
MSM5832	3.95

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AY5-3600	11.95
AY5-3600 PRO	11.95

74LS00

74LS00	.24	74LS173	.69
74LS01	.25	74LS174	.55
74LS02	.25	74LS175	.55
74LS03	.25	74LS181	2.15
74LS04	.24	74LS189	8.95
74LS05	.25	74LS190	.89
74LS08	.28	74LS191	.89
74LS09	.29	74LS192	.79
74LS10	.25	74LS193	.79
74LS11	.35	74LS194	.69
74LS12	.35	74LS195	.69
74LS13	.45	74LS196	.79
74LS14	.59	74LS197	.79
74LS15	.35	74LS221	.89
74LS20	.25	74LS240	.95
74LS21	.29	74LS241	.99
74LS22	.25	74LS242	.99
74LS26	.29	74LS243	.99
74LS27	.29	74LS244	1.29
74LS28	.35	74LS245	1.49
74LS30	.25	74LS247	.75
74LS32	.29	74LS248	.99
74LS33	.55	74LS249	.99
74LS37	.35	74LS251	.59
74LS38	.35	74LS253	.59
74LS40	.25	74LS257	.59
74LS42	.49	74LS258	.59
74LS47	.75	74LS259	2.75
74LS48	.75	74LS260	.59
74LS49	.75	74LS266	.55
74LS51	.25	74LS273	1.49
74LS54	.29	74LS275	3.35
74LS55	.29	74LS279	.49
74LS63	1.25	74LS280	1.98
74LS73	.39	74LS283	.69
74LS74	.35	74LS290	.89
74LS75	.39	74LS293	.89
74LS76	.39	74LS295	.99
74LS78	.49	74LS298	.89
74LS83	.60	74LS299	1.75
74LS85	.69	74LS323	3.50
74LS86	.39	74LS324	1.75
74LS90	.55	74LS352	1.29
74LS91	.89	74LS353	1.29
74LS92	.55	74LS363	1.35
74LS93	.55	74LS364	1.95
74LS95	.75	74LS365	.49
74LS96	.89	74LS366	.49
74LS107	.39	74LS367	.45
74LS109	.39	74LS368	.45
74LS112	.39	74LS373	1.39
74LS113	.39	74LS374	1.39
74LS114	.39	74LS375	.95
74LS122	.45	74LS377	1.39
74LS123	.79	74LS378	1.18
74LS124	2.90	74LS379	1.35
74LS125	.49	74LS385	3.90
74LS126	.49	74LS386	.45
74LS132	.59	74LS390	1.19
74LS133	.59	74LS393	1.19
74LS136	.39	74LS395	1.19
74LS137	.99	74LS399	1.49
74LS138	.55	74LS424	2.95
74LS139	.55	74LS447	.95
74LS145	1.20	74LS490	1.95
74LS147	2.49	74LS624	3.99
74LS148	1.35	74LS640	2.20
74LS151	.55	74LS645	2.20
74LS153	.55	74LS668	1.69
74LS154	1.90	74LS669	1.89
74LS155	.69	74LS670	1.49
74LS156	.69	74LS674	14.95
74LS157	.65	74LS682	3.20
74LS158	.59	74LS683	3.20
74LS160	.69	74LS684	3.20
74LS161	.65	74LS685	3.20
74LS162	.69	74LS688	2.40
74LS163	.65	74LS689	3.20
74LS164	.69	81LS95	1.49
74LS165	.95	81LS96	1.49
74LS166	1.95	81LS97	1.49
74LS168	1.75	81LS98	1.49
74LS169	1.75	25LS2521	2.80
74LS170	1.49	25LS2569	4.25

6800

68000	59.95
6800	3.95
6802	7.95
6803	19.95
6808	13.90
6809E	19.95
6809	11.95
6810	2.95
6820	4.35
6821	3.25
6828	14.95
6840	12.95
6843	34.95
6844	25.95
6845	14.95
6847	11.95
6850	3.25
6852	5.75
6860	9.95
6875	6.95
6880	2.25
6883	22.95
68047	24.95
68488	19.95

8800 = 1MHZ

68B00	10.95
68B02	22.25
68B09E	29.95
68B09	29.95
68B10	6.95
68B21	6.95
68B40	19.95
68B45	19.95
68B50	5.95

68B00 = 2 MHZ

8200

8202	24.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8237-5	21.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	79.95
8272	39.95
8275	29.95
8279	8.95
8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
8287	6.50
8288	25.00
8289	49.95

Z-80

2.5 Mhz

Z80-CPU	3.95
Z80-CTC	4.49
Z80-DART	10.95
Z80-DMA	14.95
Z80-PIO	4.49
Z80-SIO/0	16.95
Z80-SIO/1	18.95
Z80-SIO/2	16.95
Z80-SIO/9	16.95

4.0 Mhz

Z80A-CPU	4.95
Z80A-CTC	4.95
Z80A-DART	11.95
Z80A-DMA	16.95
Z80A-PIO	4.95
Z80A-SIO/0	16.95
Z80A-SIO/1	16.95
Z80A-SIO/2	16.95
Z80A-SIO/9	16.95

6.0 Mhz

Z80B-CPU	11.95
Z80B-CTC	13.95
Z80B-PIO	13.95
Z80B-DART	19.95
Z80B-SIO/2	39.95

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68047	24.95
8275	29.95
7220	99.95
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CRT5037	49.95
TMS9918A	39.95
DP8350	49.95

6500

6502	4.95
6504	6.95
6505	8.95
6507	9.95
6520	4.35
6522	7.95
6532	9.95
6545	22.50
6551	11.85

2 MHZ

6502A	6.95
6522A	9.95
6532A	11.95
6545A	27.95
6551A	11.95

3 MHZ

6502B	14.95

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1771	16.95
1791	24.95
1793	26.95
1795	49.95
1797	49.95
2791	54.95
2793	54.95
2795	59.95
2797	59.95
6843	34.95
8272	39.95
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7403	.19	74132	.45
7404	.19	74136	.50
7405	.25	74143	2.95
7406	.29	74145	.60
7407	.29	74147	1.75
7408	.24	74148	1.20
7409	.19	74150	1.35
7410	.19	74151	.55
7411	.25	74153	.55
7413	.35	74154	1.25
7414	.49	74155	.75
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7425	.29	74163	.69
7427	.29	74164	.85
7430	.19	74165	.85
7432	.29	74166	1.00
7437	.29	74167	2.95
7438	.29	74170	1.65
7442	.49	74173	.75
7445	.69	74174	.89
7446	.69	74175	.89
7447	.69	74177	.75
7448	.69	74181	2.25
7451	.23	74184	2.00
7473	.34	74185	2.00
7474	.33	74191	1.15
7475	.45	74192	.79
7476	.35	74193	.79
7482	.95	74194	.85
7483	.50	74195	.85
7485	.59	74197	.75
7486	.35	74198	1.35
7489	2.15	74221	1.35
7490	.35	74246	1.35
7492	.50	74247	1.25
7493	.35	74259	2.25
7495	.55	74273	1.95
7497	2.75	74276	1.25
74100	1.75	74279	.75
74107	.30	74366	.65
74109	.45	74367	.65
74116	1.55	74368	.65
74121	.29	74393	1.35
74122	.45		

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LM301	.34	LM340 (see 7800)		LM566	1.49	LM1558H	3.10
LM301H	.79	LM348	.99	LM567	.89	LM1800	2.37
LM307	.45	LM350K	4.95	NE570	3.95	LM1812	8.25
LM308	.69	LM350T	4.60	NE571	2.95	LM1830	3.50
LM308H	1.15	LM358	.69	NE590	2.50	LM1871	5.49
LM309H	1.95	LM359	1.79	NE592	2.75	LM1872	5.49
LM309K	1.25	LM376	3.75	LM709	.59	LM1877	3.25
LM310	1.75	LM377	1.95	LM710	.75	LM1889	1.95
LM311	.64	LM378	2.50	LM711	.79	LM1896	1.75
LM311H	.89	LM380	.89	LM723	.49	ULN2003	2.49
LM312H	1.75	LM380N-8	1.10	LM723H	.55	LM2877	2.05
LM317K	3.95	LM381	1.60	LM733	.98	LM2878	2.25
LM317T	1.19	LM382	1.60	LM741	.35	LM2900	.85
LM318	1.49	LM383	1.95	LM741N-14	.35	LM2901	1.00
LM318H	1.59	LM384	1.95	LM741H	.40	LM3900	.59
LM319H	1.90	LM386	.89	LM747	.69	LM3905	1.25
LM319	1.25	LM387	1.40	LM748	.59	LM3909	.98
LM320 (see 7900)		LM389	1.35	LM1014	1.19	LM3911	2.25
LM322	1.65	LM390	1.95	LM1303	1.95	LM3914	3.95
LM323K	4.95	LM392	.69	LM1310	1.49	LM3915	3.95
LM324	.59	LM393	1.29	MC1330	1.69	LM3916	3.95
LM329	.65	LM394H	4.60	MC1349	1.89	MC4024	3.95
LM331	3.95	LM399H	5.00	MC1350	1.19	MC4044	4.50
LM334	1.19	NE531	2.95	MC1358	1.69	RC4136	1.25
LM335	1.40	NE555	.34	MC1372	6.95	RC4151	3.95
LM336	1.75	NE556	.65	LM1414	1.59	LM4250	1.75
LM337K	3.95	NE558	1.50	LM1458	.59	LM4500	3.25
LM337T	1.95	NE561	24.95	LM1488	.69	RC4558	.69
LM338K	6.95	NE564	2.95	LM1489	.69	LM13080	1.29
LM339	.99	LM565	.99	LM1496	.85	LM13600	1.49
						LM13700	1.49

H = TO-5 CAN T = TO-220 K = TO-3

RCA

CA 3023	2.75	CA 3082	1.65
CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85
CA 3160	1.19		

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
75494	.89		

BI FET

TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
LF357	1.40		

CMOS

4000	.29	4528	1.19
4001	.25	4531	.95
4002	.25	4532	1.95
4006	.89	4538	1.95
4007	.29	4539	1.95
4008	.95	4541	2.64
4009	.39	4543	1.19
4010	.45	4553	5.79
4011	.25	4555	.95
4012	.25	4556	.95
4013	.38	4581	1.95
4014	.79	4582	1.95
4015	.39	4584	.75
4016	.39	4585	.75
4017	.69	4702	12.95
4018	.79	74C00	.35
4019	.39	74C02	.35
4020	.75	74C04	.35
4021	.79	74C08	.35
4022	.79	74C10	.35
4023	.29	74C14	.59
4024	.65	74C20	.35
4025	.29	74C30	.35
4026	1.65	74C32	.39
4027	.45	74C42	1.29
4028	.69	74C48	1.99
4029	.79	74C73	.65
4030	.39	74C74	.65
4034	1.95	74C76	.80
4035	.85	74C83	1.95
4040	.75	74C85	1.95
4041	.75	74C86	.39
4042	.69	74C89	4.50
4043	.85	74C90	1.19
4044	.79	74C93	1.75
4046	.85	74C95	.99
4047	.95	74C107	.89
4049	.35	74C150	5.75
4050	.35	74C151	2.25
4051	.79	74C154	3.25
4053	.79	74C157	1.75
4060	.89	74C160	1.19
4066	.39	74C161	1.19
4068	.39	74C162	1.19
4069	.29	74C163	1.19
4070	.35	74C164	1.39
4071	.29	74C165	2.00
4072	.29	74C173	.79
4073	.29	74C174	1.19
4075	.29	74C175	1.19
4076	.79	74C192	1.49
4078	.29	74C193	1.49
4081	.29	74C195	1.39
4082	.29	74C200	5.75
4085	.95	74C221	1.75
4086	.95	74C244	2.25
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
4502	.95	74C908	2.00
4503	.65	74C909	2.75
4508	1.95	74C910	9.95
4510	.85	74C911	8.95
4511	.85	74C912	8.95
4512	.85	74C914	1.95
4514	1.25	74C915	1.19
4515	1.79	74C918	2.75
4516	1.55	74C920	17.95
4518	.89	74C921	15.95
4519	.39	74C922	4.49
4520	.79	74C923	4.95
4522	1.25	74C925	5.95
4526	1.25	74C926	7.95
4527	1.95	74C928	7.95
		74C929	19.95

74S00

74S00	.32	74S168	3.95
74S02	.35	74S169	3.95
74S03	.35	74S174	.95
74S04	.35	74S175	.95
74S05	.35	74S181	3.95
74S08	.35	74S182	2.95
74S09	.40	74S188	1.95
74S10	.35	74S189	6.95
74S11	.35	74S194	1.49
74S15	.35	74S195	1.49
74S20	.35	74S196	1.49
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74S30	.35	74S201	6.95
74S32	.40	74S225	7.95
74S37	.88	74S240	2.20
74S38	.85	74S241	2.20
74S40	.35	74S244	2.20
74S51	.35	74S251	.95
74S64	.40	74S253	.95
74S65	.40	74S257	.95
74S74	.50	74S258	.95
74S85	1.99	74S260	.79
74S86	.50	74S273	2.45
74S112	.50	74S274	19.95
74S113	.50	74S275	19.95
74S114	.55	74S280	1.95
74S124	2.75	74S287	1.90
74S132	1.24	74S288	1.90
74S133	.45	74S289	6.89
74S134	.50	74S301	6.95
74S135	.89	74S373	2.45
74S138	.85	74S374	2.45
74S139	.85	74S381	7.95
74S140	.55	74S387	1.95
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L = TO-92

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DP8304	2.29
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	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
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7812	+12 VDC	276-1771	1.59
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7905	−5 VDC	276-1773	1.59
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4011	276-2411	.79
4013	276-2413	.99
4017	276-2417	1.49
4023	276-2423	.99
4049	276-2449	.99
4066	276-2466	.99

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With Pin-Out and Specs

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7404	276-1802	.79
7408	276-1822	.79
7447	276-1805	1.19
7490	276-1808	.89

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MPS222A	NPN	276-2009	.79
PN2484	PNP	276-2010	.89
MPS3904	NPN	276-2016	.69
TIP31	NPN	276-2017	.99
TIP3055	NPN	276-2020	1.59
MPS2907	PNP	276-2023	.79
MJE34	PNP	276-2027	1.49
2N3053	NPN	276-2030	.89
MPS3638	PNP	276-2032	.79
TIP120	NPN	276-2068	1.29
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2N4401	NPN	276-2058	.59
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LM339	(Quad)	276-1712	1.49

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2.2	35	272-1435	.59
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22	16	272-1437	.79

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10	35	272-1013	.59
22	35	272-1014	.69
47	35	272-1015	.69
100	35	272-1016	.79
220	35	272-1017	.89
470	35	272-1018	.99
1000	35	272-1019	1.59
2200	35	272-1020	2.49
3300	35	272-1021	2.99
4700	35	272-1022	3.59
470	50	272-1046	1.59
1000	50	272-1047	1.99
2200	50	272-1048	3.49

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µF	WVDC	Cat. No.	Each
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470	16	272-957	.89
1000	16	272-958	.99
4.7	35	272-1024	.49
10	35	272-1025	.59
22	35	272-1026	.69
47	35	272-1027	.69
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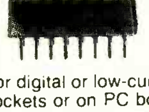
C 

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330	271-1315	47k	271-1342
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1k	271-1321	100k	271-1347
1.8k	271-1324	220k	271-1350
2.2k	271-1325	470k	271-1354
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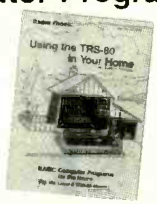

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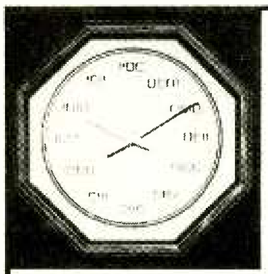

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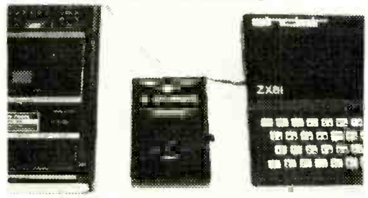

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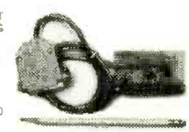

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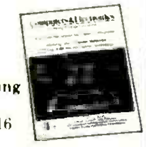

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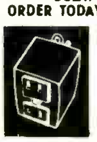

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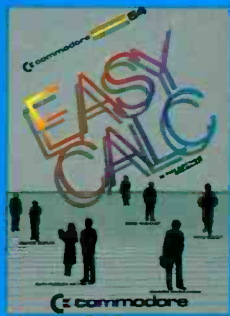

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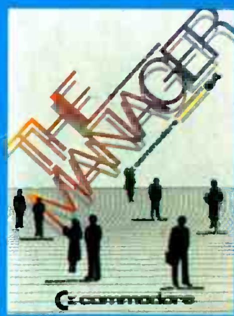

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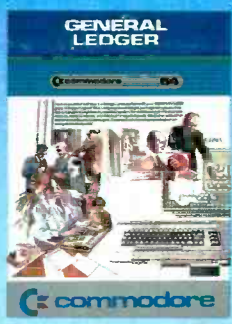

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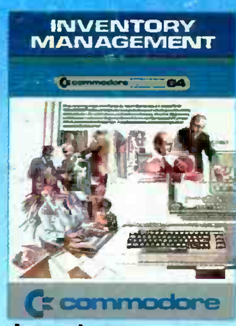

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