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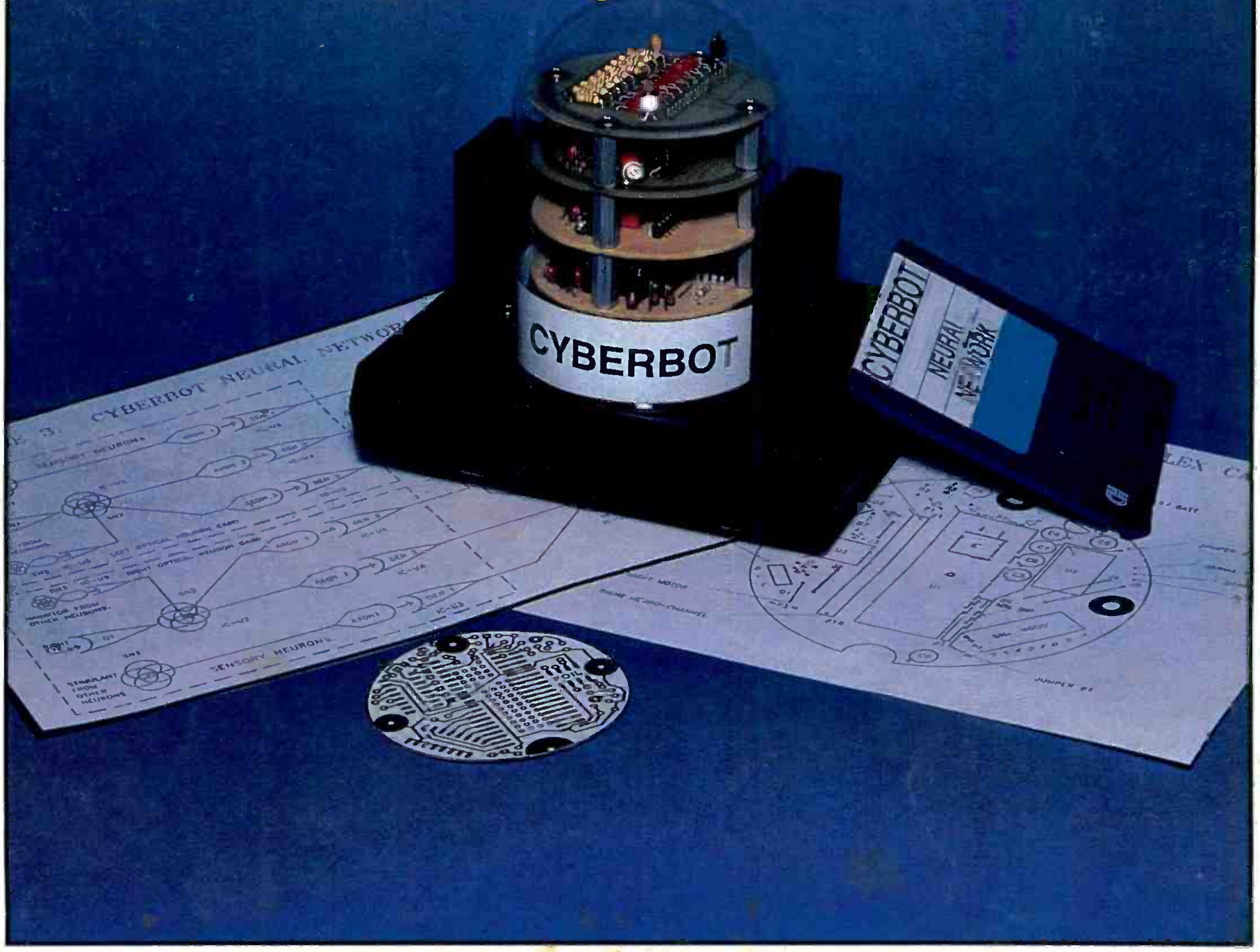

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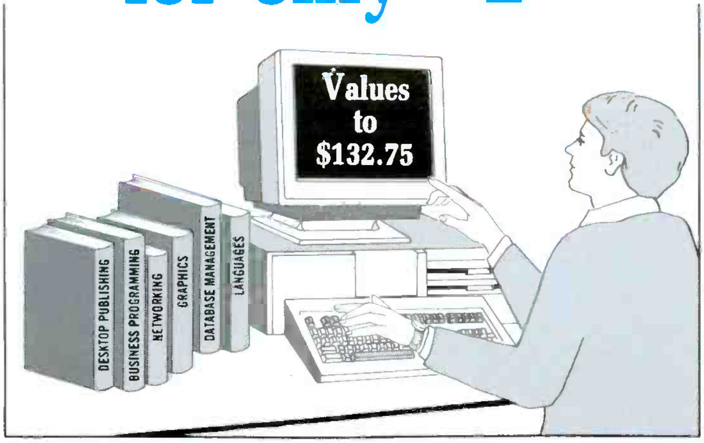

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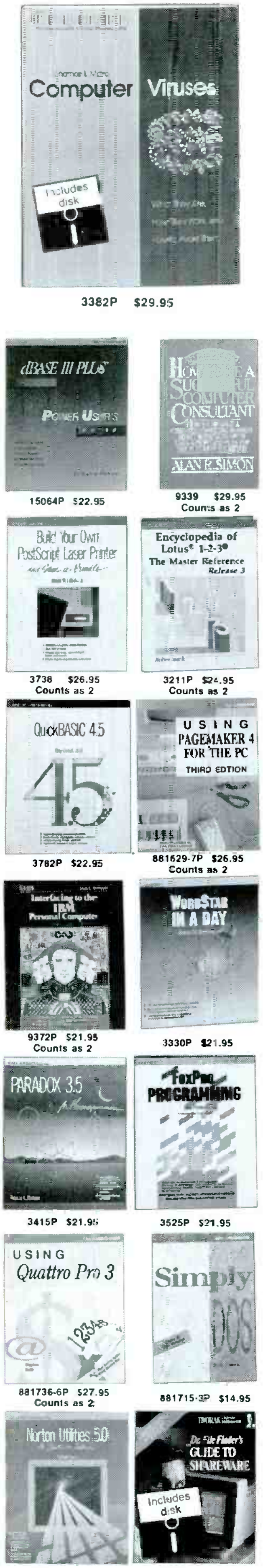

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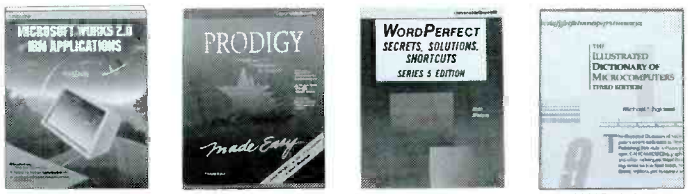

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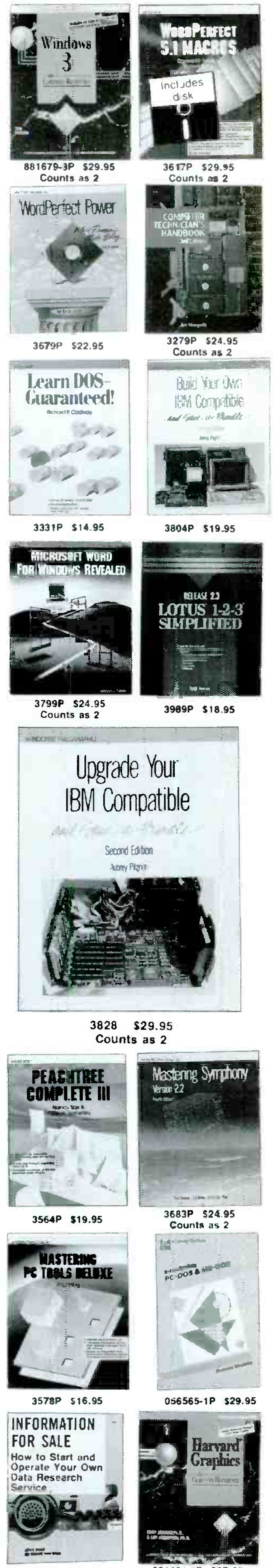

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ON THE COVER: A neural-network robot you can build "thinks" well enough to move about its environment.

A Brain In A Box

While digital computers are great number crunchers, with powerful computational abilities and superb accuracy, they have a long way to go to become brain-like systems that provide adequate responses to incomplete input information.

Artificial intelligence has been developing for many years now, but it's really still in its infancy. Nevertheless, it has been applied successfully to some extent in many control and pattern-recognition applications. I remember reviewing a word processor a few years ago that used a sort of AI to determine the word to be written when only the first few letters of the word were typed, for example.

Nick Goss's CyberBot construction project article in this issue provides you with a fundamental hardware/software platform with which to start experimenting in this area. It consists of an elementary neural network simulator that emulates the "reflexes" and "mood" of a mobile robotic device in reaction to light in terms of presence, absence or strength.

True neural networks consist of many interconnected processing elements that are more on the order of parallel distributed processors rather than the commonly used Von Neuman distribution. Accordingly, a neural network's speed would likely be measured in interconnections per second instead of the instructions per second used with digital computers.

There have been lots of fitful starts and stops in the neural-network field since the 1950s; great hopes and dashed expectations. Nevertheless, there are many hardware and software developers hard at work developing new neural networks that will hopefully be sufficiently low in cost and applied effectively.

Along these lines, Echelon Corp.'s (Palo Alto, CA) recently introduced Neuron chips appeared to be a step in the direction of off-the-shelf neural network chips. But although the product name appears so at first blush, it isn't. Actually, it's a microcontroller with versatile built-in input/output functions that contain three coupled processors. One of the I/Os has a transceiver port, and the chip contains a library of 25 I/O models. Such an embedded system could be part of a neural network, though, it seems.

We're all fascinated by the science-fiction concept of a (human-like) brain in a box, of course. Although strong efforts have been made to model a biological neural network in computer form, we're still in a very early stage. Furthermore, we don't yet know all about the inner workings of the human brain itself. Maybe we never will, but neurocomputing will, nevertheless, move forward as new technology and ideas appear on the scene, I believe.

With the powerful microcomputers in use today, we no longer have to wait on university research staffs to experiment with neural networks. There's a bevy of commercial products available to do this on everyday PCs, as well as experimentation projects, such as the device presented in this issue. Some neural-network MS-DOS software costs less than $100, in fact, such as *BrainMaker* from California Scientific Software, Sierra Madre, CA (telephone 818-355-1094) and, going up in price to $195, *NeuroShell* from Ward Systems Group, Frederick, MD (telephone 301-662-7950); a *Windows* version of the latter costs $295.

More Boosters

• I couldn't resist writing and telling you that you have my whole-hearted support with your new *ComputerCraft* publication. I have always been a hands-on, hardware-oriented type of hobbyist. In the past, I was generally more interested in analog electronics. My current interests are analog applications interfaced to digital microprocessors/microcontrollers. So it looks like *ComputerCraft* is a natural for me.

I would like to know *everything* you can tell me about microcontrollers from the ground up. I'm especially interested in '"rolling my own" equipment, but I also enjoy reading about what's available. Good luck, and keep those fantastic issues coming!

Steve Hassenfritz
Hazelwood, MO

• I have read with interest *ComputerCraft*. This is just the type of magazine I have been looking for. Most computer magazines are too esoteric or devoted entirely to software to be practical to most home or hobbyist computer owners. Yours has the right mix of editorial and hands-on articles. Your article on the Parallel I/O Port is especially timely since I am building several speech-related projects and the typical serial port interface is just too slow.

Jon Taylor
Andover, MA

• Today, I picked up my first copy of *ComputerCraft* magazine. I was enthused that, finally, someone is willing to publish a magazine devoted more to the nuts-and-bolts end of the computer field at a level of one with some electronics understanding. The field is overly glutted with magazines devoted to the business user of equipment and software, and rarely is seen an article on the electronics of computers. Even rarer is a construction article. Anyway, I wish you good luck in making a go of *ComputerCraft*. I hope you remain oriented toward the technical, hardware and construction areas of computers.

Charles I. Knowlton
Rocky Mount, NC

• This is another letter of congratulations for the new direction the now-defunct *Modern Electronics* has taken with the emergence of *ComputerCraft*. Finally, a magazine I enjoy and can benefit from, from cover to cover!

I agree wholeheartedly with author Adolph A. Mangieri in the August Letters column. This periodical came as a pleasant surprise to me as well. Having been hardware hacking for 25 years, I've seen many magazines come and go. I was glad to see some of the heavyweights returning to regular columns, and even though I'm a seasoned electronics technician, I still need some basic refreshers once in a while. So I still read all of the articles aimed at the newcomer.

You seem to have reached the perfect mix of articles, from novice to expert. So far, every issue of *ComputerCraft* has been timely and informative and will be worthy additions to my back-issue library, with the likes of *Kilobaud, Byte, Creative Computing* and other SIG publications.

Considering the price-to-performance ratio, you're charging too little, in my opinion. I look forward to new issues more so than any other publication!

Gary L. Parker
Cumberland, ME

• The first few months' issues of *ComputerCraft* that I found were what I've been looking for. So I decided to subscribe. Don't get away from the electronics side of things and do more software reviews. I'd like to see competent electronics articles, and if you do software reviews, make them on diagnostics and test packages. A plus to your publication is that you have Hardin Brothers included. Have him write the technical hardware articles that I used to read in *PC Resource*.

Michael Leonard
Lincoln, NE

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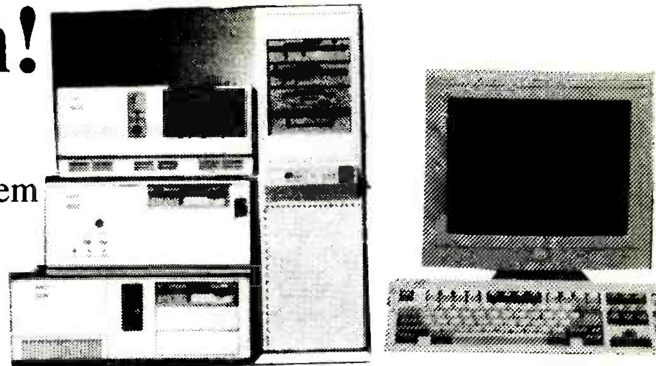

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Help. What started as dial-a-porn with "900/976" telephone numbers has spread into more mundane areas, including computer-oriented ones. Among them is The Help Network, a Houston, TX-based "900" service that offers technical support to software users. More than 30 popular software packages are supported, including WordPerfect, Lotus 1-2-3, dBASE, Quattro, and Ventura Publisher, Microsoft Works; C, Basic, Fortran, Pascal and Unix languages, too; as well as DOS. Cost is $2 for the first minute, and $1.50 per minute thereafter. This is added to the user's regular phone bill, of course.

The Network's number is 1-900-884-HELP. If outgoing calls are blocked to 900 phone numbers, the service can be reached at 713-526-5903. The latter is cheaper, too--$1.25 per minute using a credit card. According to the company, the average call lasts less than five minutes.

Computer User Growth. A new survey by the U.S. Census Bureau, based on 1989 figures, indicates that 75-million Americans use computers, according to a report by I&M Communications, Cambridge, MA. This figure sounds quite high: nearly 1 of every 3 people? Another reported statistic from the survey indicates that almost 25% of home computer users also own modems.

Relating to telecommunications, the Videotex Industry Association reports that there are about 2-million subscriptions to on-line services. On the assumption that there are multiple users for each subscription, this was extrapolated to be a market of about 8-million people. The count here is questionable, though, even assuming the multiple-user figure, since many users subscribe to more than one on-line service, which considerably reduces the people count; one sub equals less than one person.

Multimedia Communications Chip. Yamaha's Systems Technology Division (San Jose, CA) introduced the first single-chip multimedia communications device, the FAX VOdem(tm). It combines data, fax/ADPCM voice and caller identification. Its controller chip (GTM407) offers external EPROM addressing capabilities up to 128K. Its 16550 UART interface is compatible with DOS, OS/2 and UNIX com1-com4 software. Associated firmware allows V.42bis data compression/V.42 error correction.

The controller has built-in power-down circuitry with a shutdown mode, as well as an automatic power-up mode without losing the Hayes AT command set. Additionally, firmware provides an automatic fax/data/voice switch. The system is capable of transmitting and receiving up through 9600 bps, and the 0.8-micron CMOS chip uses only 300 mW when active via a +5V power supply and less than 1 mW in standby. Given its small footprint, minimal power needs and versatility, it's a natural for use as an internal modem with notebook and laptop PCs.

Cheap Water Quest. Silicon Valley, home to so many of our semiconductor makers, is thirsting for less costly water, which plays such a large role in fabricating chips. There's a long-term water shortage in the valley, even though heavy winter rain put off immediate concerns. Recycling costs are very high due to the need for very pure water, but it may be the best alternative if water costs, now $1.50 per gallon from the city, continue to increase. So look for higher prices down the line.

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6264-15	1.40
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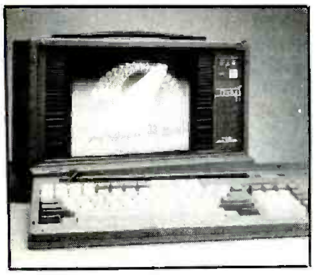
CIRCLE NO. 104 ON FREE INFORMATION CARD

Five-Slot PC Portable

Dolch Computer Systems introduces the SX-20C, a 20-MHz 386SX portable computer with five uncommitted, full-sized ISA slots. Also, the unit includes 2M of RAM (expands to 16M) and a 40M hard drive. The SX-20C comes



standard with a bright-red gas-plasma display, providing 16 shades of gray scale at 640 × 480 VGA resolution. Dolch offers an optional active matrix thin-film transistor LCD flat panel that has a palette of 24,389 colors. The unit sports a full-sized 101-key keyboard, 1.44M floppy drive and a 225-watt power supply. Measuring 16″H × 9.5″W × 7.8″D, the SC-20C weighs 18 lb. $5,995.

CIRCLE NO. 5 ON FREE CARD

Hi-Res Color Hand Scanner

The Marstek ColorArtist is a hand scanner with an 18-bit-per-pixel display resulting in 262,144 color combinations. ColorArtist also provides a

full 400-dpi-gray-scale resolution for text or line-art. *RainbowPaint*, a high-end color paint and imaging software package is bundled with the ColorArtist. $695 for IBM/compatibles; $100 more for Mac version.

CIRCLE NO. 6 ON FREE CARD

Diagnostic Software

DiagSoft has new releases of its IBM/compatible diagnostic software for users at all levels. *QAPlus/fe-tech* is a self-booting program for power users and service technicians that can pinpoint problems down to the component level. Additionally, the program suggests possible solutions to be considered. The new release now incorporates *Power Meter* (a program designed to benchmark and compare the performance of IBM/compatible computers) and *QAClean* (a disk-drive head cleaning system).

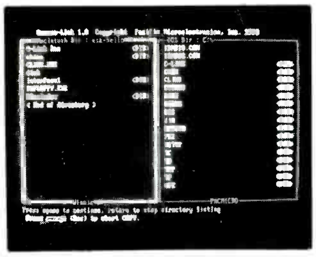
QAFloppy, a floppy-disk-drive alignment system is now bundled with *QAPlus/fe-tech*. Service technicians can run tests remotely when *QSPlus* software is installed on a computer along with such remote communications packages as *Carbon Copy* or *PC Anywhere*. Over 60 tests plus summary printouts are available from the software. Test "scripts" can be custom-written that permit continuous testing through the program's loopback capability.

DiagSoft recommends that only experienced computer technicians use *QAPlus/fe-tech* ($500) since the program has the capability of low-level formatting a hard drive. *QAPlus/fe* ($350) is the same program without *QAFloppy*. For end users, DiagSoft offers *QAPlus* Version 4.52 ($160). It has many of the same diagnostic capabilities as the field-engineer versions, but it lacks the capability to destroy data. It is also more user-friendly with pull-down menus, mouse support and plain English descriptions of errors and possible solutions.

CIRCLE NO. 7 ON FREE CARD

Speaking To Macs

Mac-In-Dos from Pacific Micro now has the capability to format Macintosh diskettes on an IBM/compatible disk drive. In addition to formatting Mac disks, the program allows exchange of text, binary and graphic files between Mac and DOS systems. No special cables or hardware are needed. The program shows listings of two directories of files side-by-side on the

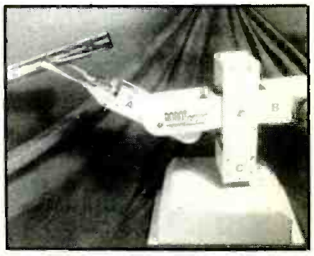


screen. On one side are the Mac files resident on the Mac disk; on the other side are DOS files. Files are simply copied from one side to the other. Conversions take place rapidly and almost automatically. Because there are three parts to a Mac file, tutorial notes pop up with prompts during Mac-to-DOS conversions. The user selects the appropriate level of conversion for the situation. In a DOS-to-Mac conversion, a dummy Mac file is created and the DOS file is simply copied into it. *Mac-In-Dos* comes on a 1.44MB IBM-type floppy diskette. $200.

CIRCLE NO. 8 ON FREE CARD

Robot Arm

Promotional Technologies has a robotic arm device designed for hobby and educational use. The robot arm features all-metal construction and four stepper motors for movement. It can be controlled manually, using an optional joystick control panel available from Promotional Technologies. For computer control, the robot arm is designed to be used with A-Bus



computer interface products, also available from Alpha Products. $1,495 (without controller).

CIRCLE NO. 9 ON FREE CARD

Free Catalogs

The Heath Company offers a new "HomeWorks by Heathkit" catalog that features a new line of computer application training courses. Courses covered are *WordPerfect*, *Windows*, Lotus *1-2-3*, *Word for Windows*

and *AutoCAD*. The 40-page catalog also introduces six new home-study video courses that can be used to learn important electronics concepts. A student workbook is included with each video to reinforce learning. Courses can be obtained by calling 800-44-HEATH.

CIRCLE NO. 10 ON FREE CARD

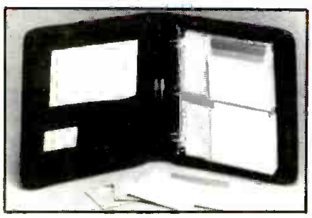
Techni-Tool's newest catalog lists more than 18,000 items in 248 pages and representing over 850 manufacturers. Products range from

electromechanical and assembly devices to electronic, telecommunication and field-service tool kits.

CIRCLE NO. 11 ON FREE CARD

Shielded Disk Carrier

Amherst's new Disk Manager, a high-capacity diskette carrier and organizer, features an integral-shield construction. It can accommodate up to 48 disks of either 3½" or 5¼" sizes. Disks are carried in anti-static loose-



leaf-style pages, and a cache page holds four disks. Its three-ring binder is useful for carrying documentation, too. Pockets are provided to store business cards, pencils, etc. The portfolio-style product features a zippered closure. Typical users are software developers, service technicians and other professionals who routinely carry a large number of disks. $60.

CIRCLE NO. 12 ON FREE CARD

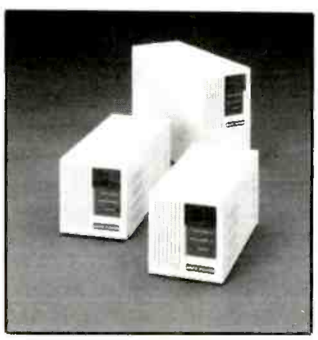
Theft Alarm

Sonicpro offers two versions of its personal computer theft alarm. One version is in a self-contained case that attaches to the outside of a computer case. The other is a card that plugs into a standard ISA slot (there's no electrical connection to the bus). Each version has a keypad that arms and disarms the alarm, and each is said to tolerate normal jostling that's to be expected on a desktop. Pick up the unit, though, and the alarm emits an ear-piercing howl. $59.

CIRCLE NO. 13 ON FREE CARD

New UPSs

SAFE POWER 650, 800 and 1,200 are three new UPS models from Acme Electric. These units address the needs of larger workstations and network file servers. Model 650 provides complete protection for a fully configured AT or 386 model and provides up to 10 minutes of continuous power. The model 800 meets the demands of larger micros, network file servers with multiple external hard drives. Finally, the model 1200 provides equipment and data protection for local-area networks



with multi-user applications and provides up to 45 minutes of run time based on system configuration. Prices start at $300.

CIRCLE NO. 14 ON FREE CARD

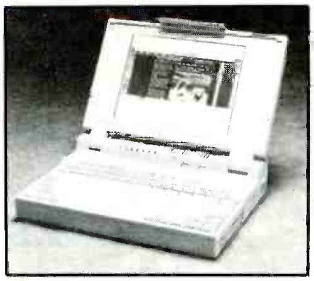
New Computer Operation & Programming Course

The Cleveland Institute of Electronics now offers a new home-study course, "Computer Operation and Programming." It is a laboratory-intensive program that includes assembly-language programming, operation of a microprocessor-based computer system and a microprocessor training laboratory. It was designed to provide a strong electronics background, along with an understanding of computer languages and programming applications.

The course is said to prepare individuals who successfully complete it to be able to troubleshoot electronic circuitry, diagnose and repair front-end computer problems and understand and apply popular high-level programming languages, BASIC and C languages.

CIRCLE NO. 15 ON FREE CARD

Notebook Computer



The new Goldstar GS620 386SX 20-MHz notebook computer weighs in at 6.2 pounds with rechargeable battery and features a supertwist VGA LCD screen and a 40M hard drive. A 1.44M floppy drive and 2M RAM are standard. Battery life is specified at 2.5 to 3 hours, and recharge time is 1.5 hours with the ac adapter. The GS620 features a full 81-key keyboard with F11 and F12 support, an auto-resume mode, a one-year limited warranty, and DOS. Expansion slots are provided for a 2,400-bps modem, FAX modem, and memory expansion. $3,095.

Goldstar is also shipping the GS319 desktop 25-MHz 386SX (AMD chip set) machine with static RAM cache, VGA/SVGA support and 2M RAM. Other features include a 1.2M floppy drive, five expansion slots, bays for up to three additional drives and an enhanced 101-key keyboard, as well as the standard ports. $2,495; $1,995, 20-MHz Model GS318E; $1,595, 16-MHz Model GT316M.

CIRCLE NO. 17 ON FREE CARD

Tandy's Multimedia Computers

Tandy now offers fully configured Multimedia 80286-, 80386SX- and 80386DX-based computers. The heart of these new offerings is a proprietary CD-ROM drive (the CDR-1000) that has been optimized for multimedia use. Tandy recently invited the press to private demonstrations of the new drive. In one demonstration, a 10-MHz 286 machine equipped with the new drive sat side-by-side with a 25-MHz 386 box equipped with a standard CD-ROM, with all other factors equal. Identical CDs were placed in both drives. The video in the 286 was noticeably superior to that of the 386. On the 286, animation was smooth and natural looking, while the 386's video was jerky and inconsistent. Prices start under $3,000 for complete systems. Upgrade paths are available, too. The CDR-1000 is available with a proprietary controller and sound system board. The board includes programmable audio mixer, microphone circuitry, stereo amplifier and several other features. $800 (internal CDR-1000); $900 (external CDR-1000).

CIRCLE NO. 19 ON FREE CARD

The Master IC Cookbook

By Clayton L. Hallmark & Delton T. Horn

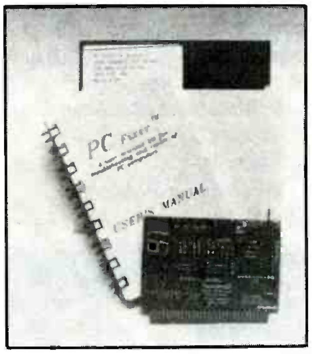
(Tab Books. Soft cover. 568 pages. $22.95.)

This second edition provides most essential data on TTL, CMOS, special-purpose CMOS, memories, op amps, audio amps, r-f devices and other linear devices. All chips listed were still available as of early 1991, but it is a rapidly changing market with obsolete devices going out of production on a regular basis. Block diagrams and pinout information are included for all devices listed. Necessary external components are shown with some complex special-purpose ICs.

The authors provide significant operating parameters (for instance, maximum supply voltage) for components where they feel this is necessary. ICs are listed in numerical order within each category, which makes it easy to locate a particular IC. Finally, there is a glossary of the technical terms used in the book. Useful for the tinkerer and experimenter; the service technician, too, may find it useful.

PC Diagnostic Kit

PC Fixer from Sibex is a combination hardware and software tool for diagnosing and repairing hardware and firmware failures in an IBM/compatible computer. It is designed for use by computer users and service technicians alike. PC Fixer provides a fast, economical means of diagnosing problems ranging from simple misplaced jumpers to dead motherboards. PC Fixer includes a circuit card for testing motherboard problems, diagnostic software program and detailed user manual. Detected problems are read out as numbers on a dual-digital display on the card. Each number is cross-referenced in the manual to a detailed discussion of the problem and the steps necessary to make repairs. $120.



CIRCLE NO. 18 ON FREE CARD

68HC05/68HC11 Emulators Feature Symbolic Debugging

TECI's TECICE-HC05 and TECICE-HC11 are PC-based terminal emulators for the 68HC05 and 68HC11 single-chip controllers. Features include symbolic debugging that allow symbolic names for variables, a macro/record routine, user reset with breakpoint that allows testing of sophisticated routines, view mode that permits viewing of up to 10 variables, trace mode that logs and displays the program counter value after each instruction, and automatic clock switching for emulating very slow speeds without slowing down PC communications. Includes a cross-assembler, power supply, emulation pad and enhanced terminal-emulator program. Requires only a computer with a serial communication port, terminal program and an RS-232 cable. $1,070 to $1,245.

CIRCLE NO. 20 ON FREE CARD

New ZSoft Paintbrush

ZSoft's Publisher's *Paintbrush* Version 2.0 is a full-featured paint and image-processing program designed for use with *Windows*. Images can be scanned or created from scratch. Image control features include multiple views, 24-bit true color capability, accessible tools, device independence and virtual memory support. The user can blend and soften colors, equalize the dynamic range of an image, remove spots to clean up an image, sharpen the edges of an image to bring out hidden detail, and customize a photograph with "motion blur," embossing and smoothing.

Paint tools include paintbrush, paint roller, hollow/filled box, rounded box, ellipse, polygon, eraser, hand, eye dropper, spray can, scissors and gadget box, lasso, text, color replacer, clone and line and curve. *Publisher's Paintbrush* exploits *Windows* Help facilities to the fullest, offering single-line, context-sensitive help on-screen at all times. A click of the mouse button delivers a rich Help subsystem that is complete with word-search and indexing capability. $495.

CIRCLE NO. 21 ON FREE CARD

The PC User's Guide

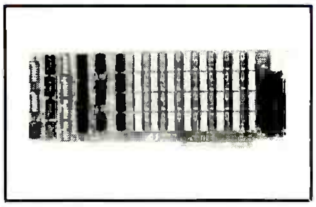
By Nick Anis and Craig Menefee
(Dvorak Osborne/ McGraw-Hill. Soft cover. 725 pages. $29.95.)

Here is a wealth of clearly written and very useful information for the newcomer to DOS and IBM/compatibles. Additionally, the intermediate user will benefit from much of the material, particularly the clear explanations and examples for most DOS commands. For the power user, it might possibly serve as a secondary reference, but other reference books are more complete and offer more depth for advanced users.

The first 300 pages of the book are concerned with basics, ranging from choosing which computer to purchase to unpacking and setting up a computer to which software to buy. The balance of the text concerns itself with DOS, BASIC, hard drives, troubleshooting tips and "tweaking" the system for better performance. The writing style is crisp and easy to understand without "talking down" to the reader. "READ.ME" sections are sprinkled through the book and serve the same functions as sidebars in magazine articles. The graphics and drawings are excellent and could be of particular interest to someone who is making first contact with the "innards" of a computer.

If you are a seasoned "applications user" and want an easy-to-read overview of the computer, or you need a clear and concise reference for DOS commands, you should consider adding *PC User's Guide* to your library. If you are already a power user, it's unlikely you will get $30 of insight from this particular book.

PC Switch Card



The 32 Switch Reed Relay Card from AccuSys is a new eight-bit computer plug-in card for any IBM/compatible computer that sports 32 switches. Each relay can accommodate analog or digital signals with ease and can handle signals up to the 100-volt (10-watt) level. Even high-level languages, such as dBASE, can easily turn any of the relays on or off. Since there's no address limit to the number of boards that can co-reside in a single PC, the number of control connections is limited only by the number of slots available. $395.

CIRCLE NO. 22 ON FREE CARD

Faster CD-ROM

Hitachi's CDR-1700S and CDR-1750 CD-ROM drives have improved random-access times to less than 320 ms. The 1700S is FCC Class B certified, and certification for the 1750 is pending approval. Both stand-alone units have a low-profile design and eight-unit daisy-chaining capability. A patented Hitachi double-door mechanism even prevents dust from entering the caddy slot. Another feature detects contaminants on the optical pickup lens and automatically cleans the lens upon disk ejection. Both offer audio output, life-extending sleep mode and three-way caddy ejection. $995, CDR-1700S; $895, CDR-1750S.

CIRCLE NO. 23 ON FREE CARD

Cyberbot: A Neural-Network Robot
Part 1

Experiment with basic neural networks by building this cybernetic photovore

In the past few years, much advanced research in the computer-science field has been directed at innovative logic systems called "neural networks." The Cyberbot project detailed here gives you an opportunity to begin experimenting in a field that's still in its infancy. It will start you on an early road to working with artificial intelligence.

CyberBot allows you to work with a unique "digital-over-analog" network. You'll construct hardware that can "think" well enough to move around its environment using CyberBot's neural network and drive mechanism. Like you and I, the device is affected by changes in "brain chemistry," which cause our "moods" to change. It's this susceptibility to changes in mood that makes neural networks so attractive to scientists.

Some Background

Neural Networks refer to systems of active logic devices called "neurons." These devices are called neurons because of their similarity to biological counterparts in living biological organisms.

In carbon-based systems like you and me, neurons are cells that make up the brain, spinal cord and nerves. Each cell body contains a nucleus, several dendrites and an axon. Dendrites, really a part of each neuron, act as receptors (like a radio receiver) that receive signals from other neurons. Axons, also a part of the neuron, act as transmitters (like a radio transmitter).

Consider for a moment that your brain is composed of more than 10-billion individual neurons. (Experts disagree over the exact number; some believe that perhaps as many as 100-billion neurons may be more typical.) Most neurons in your brain are connected to numerous other neurons by using their dendrites and axons. You might, therefore, be inclined to jump to the conclusion that the brain is constructed like an extremely large gate array. Not so.

The beauty of our biological neural-network brain is that connections between dendrites and axons (called synapses) aren't binary (on/off) in nature. Rather, data in the form of electrical impulses are transferred through a chemical neuro-messenger. In this manner inter-neuronal information transfer can be moderated over a large area of the brain by sim-

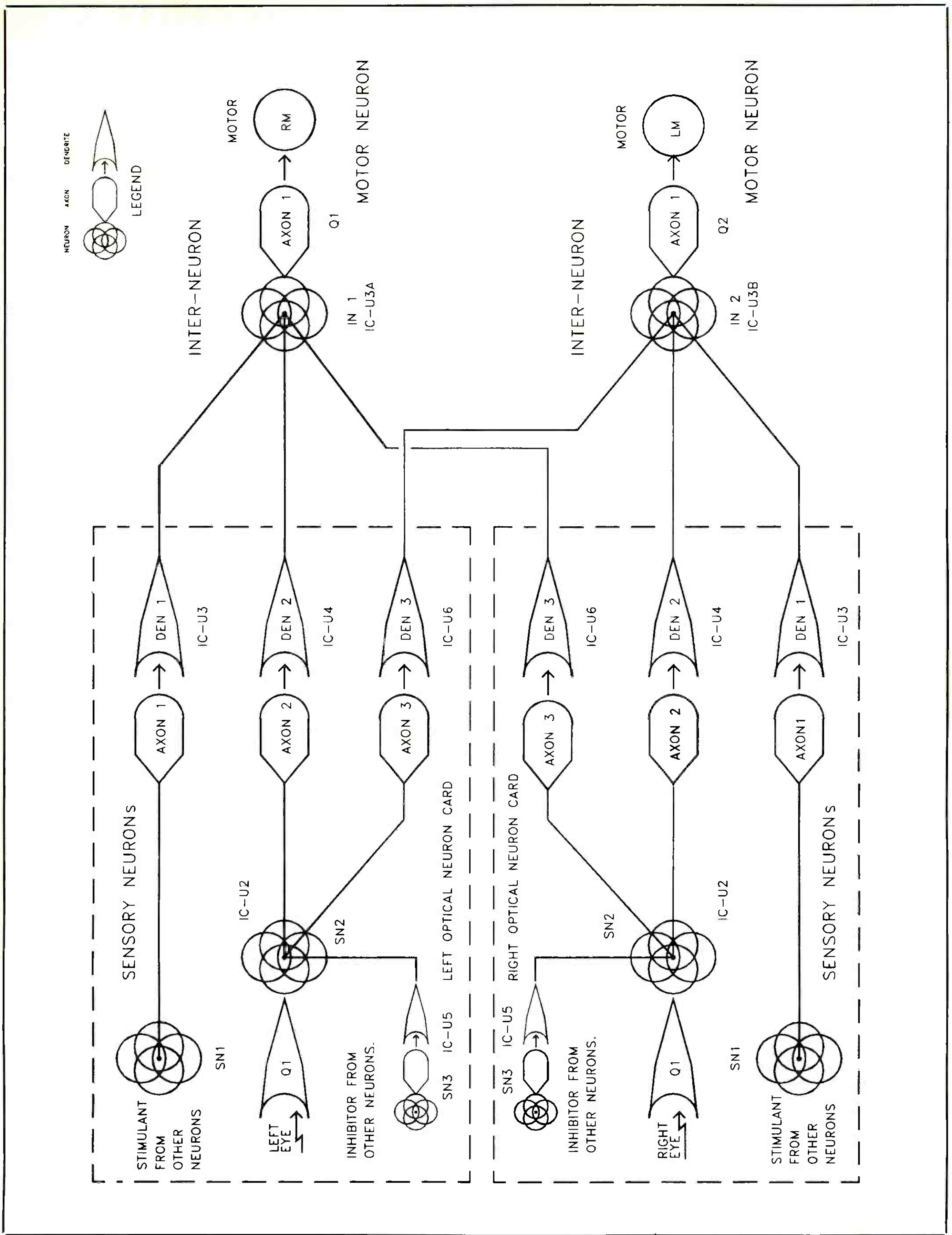


Fig. 1. Schematic diagram of CyberBot's Neural Network.

ply changing the "chemistry." When researchers and doctors speak of "brain chemistry," they're usually referring to the neuro-chemicals that affect our "moods" and overall thought processes.

Sensitivity of the dendrite (radio reception) can be manipulated by the neuron to set predetermined "thresholds" for transfer of data from a particular axon to a particular dendrite. It's also of interest to note that there are basically three types of neurons: sensory neurons that sense electrical changes in the system, inter-neurons that interconnect the system and perform most of the logic functions and motor neurons that stimulate action in the biological organism.

For these and other reasons, computer scientists are extremely optimistic that neural networks (based in silicon and other semiconductor materials) will prove as successful as their biological counterparts. While there will always be a strong niche for the conventional sequential computers of today, the future of true artificial intelligence (AI) would seem to lie in neural networks.

Meet CyberBot

CyberBot is a curious photovore (something that feeds on or is attracted to light) that doesn't mind letting you into its head, quite literally. All the various neuronal characteristics found in biological brains can be emulated by hardware and software in CyberBot.

To demonstrate the neural network's power, we needed a form that would be easy to relate to and understand. To keep things simple, we gave CyberBot one set each of sensory neurons, inter-neurons and motor neurons. If you want to expand CyberBot's neural-net, we provided a modular "stack"-type architecture and some bread-boarding space on the printed circuit cards.

To let you interact with CyberBot, we placed a microprocessor on the Mood and Reflex circuit card. This microprocessor will let you do the following:

(1) Configure CyberBot to desire to seek light.

(2) Configure CyberBot to desire to avoid light

(3) Configure CyberBot to be indifferent.

(4) Change the level or intensity of these desires.

(5) Change "brain chemistry" levels to evaluate their effect on the behavior of CyberBot.

(6) Create self-initiated action.

(7) Create self-inhibitory action.

(8) Create psychotic behavior.

You might say, "Well, I can write a microprocessor program that will do those things." Yes, but the real beauty of CyberBot is that the neural network itself creates the behavior, *not* the microprocessor. The microprocessor is included only as an interface between you and the neural network. Let's get started by looking over the actual CyberBot neural network topology.

This time around, we'll focus on how CyberBot's circuitry works. Next month, in the conclusion of this article, we'll present construction details for the project and discuss how to use it.

CyberBot Neural Network

Figure 1 illustrates a neural schematic diagram of the CyberBot system. The two boxes on the left side of the drawing represent the Right and Left Eye Sensor Neuron Cards. If you look at Fig. 2, you'll see the correlation between the neural and the electronic schematic diagrams.

Start with light entering Left Eye neural receptor phototransistor *Q1*. The output from *Q1* is used to directly drive Sensory Neuron SN2, identified as *U2*. SN2 outputs a neural potential from 0 to 5 volts along the Axon 2 and Axon 3 paths to form synapses with Dendrite 2 and Dendrite 3. Axons, as you recall, transmit information from the nucleus of a neuron to the dendrite of another neuron. Such is the case between Neuron SN2 (Sensory Neuron) and Neuron IN1 (Inter-Neuron).

Whereas information flow across a brain's synapses is controlled by neuro-messenger chemicals, this action, as well as dendritic sensitivity, is handled in Cyberbot by a special integrated circuit called an EEPOT. When used in conjunction with an operational amplifier configured as a dc summing device, these EEPOTs form the heart of our neural network.

Notice on the right side of Fig. 3 that LM358 dual operational amplifier *U3* directly drives MJE3055 npn power transistors *Q1* and *Q2*. These transistors make up the control circuit that switches the right and left traction motors on and off. By turning only one motor on at a time, you can control the direction in which CyberBot moves. With both motors powered, Cyberbot moves forward.

Resistors *R4* and *R7*, both 100 ohms in value, limit the base-emitter current of *Q1* and *Q2*. Notice also that the traction motors use their own 3-volt power source, supplied by two C-size cells. These cells are connected in series between motors and ground to the Mood and Reflex Card through a spade lug bolted to 1" aluminum stand-offs.

Note in Fig. 4 that the motors are configured back-to-back and share the same +3-volt power-supply line. The heart of the neural network resides in *U3*, which is configured as a dc summing amplifier. That is, a positive dc voltage applied at the non-in-

PARTS LIST

Optical Neuron Circuit

Semiconductors
Q1—FPT-100 npn silicon phototransistor
Q2—VN0300 hex field-effect transistor
U1—78L05 fixed +5-volt regulator
U2—LM358 dual operational amplifier
U3,U4,U5,U6—X9103 EEPOT (Xicor)

Capacitors
C1—1-µF, 16-volt tantalum
C2—10-µF, 16-volt tantalum

Resistors (¼-watt, 5% tolerance)
R1—1,000 ohms
R3—100,000 ohms
R4—10,000 ohms
R5—2,200 ohms
R6,R7,R8—22,000 ohms
R2—1-megohm pc-mount trimmer potentiometer

Miscellaneous
P1A—18-pin male strip connector
P1B—18-pin female strip connector
Printed-circuit board; 9-volt alkaline battery and snap connector; 4-40 × ½" female tapped standoffs (3); hookup wire; solder; etc.

Note: See Note at end of Mood & Reflex Circuit Parts List for details on ordering a kit of parts and individual items.

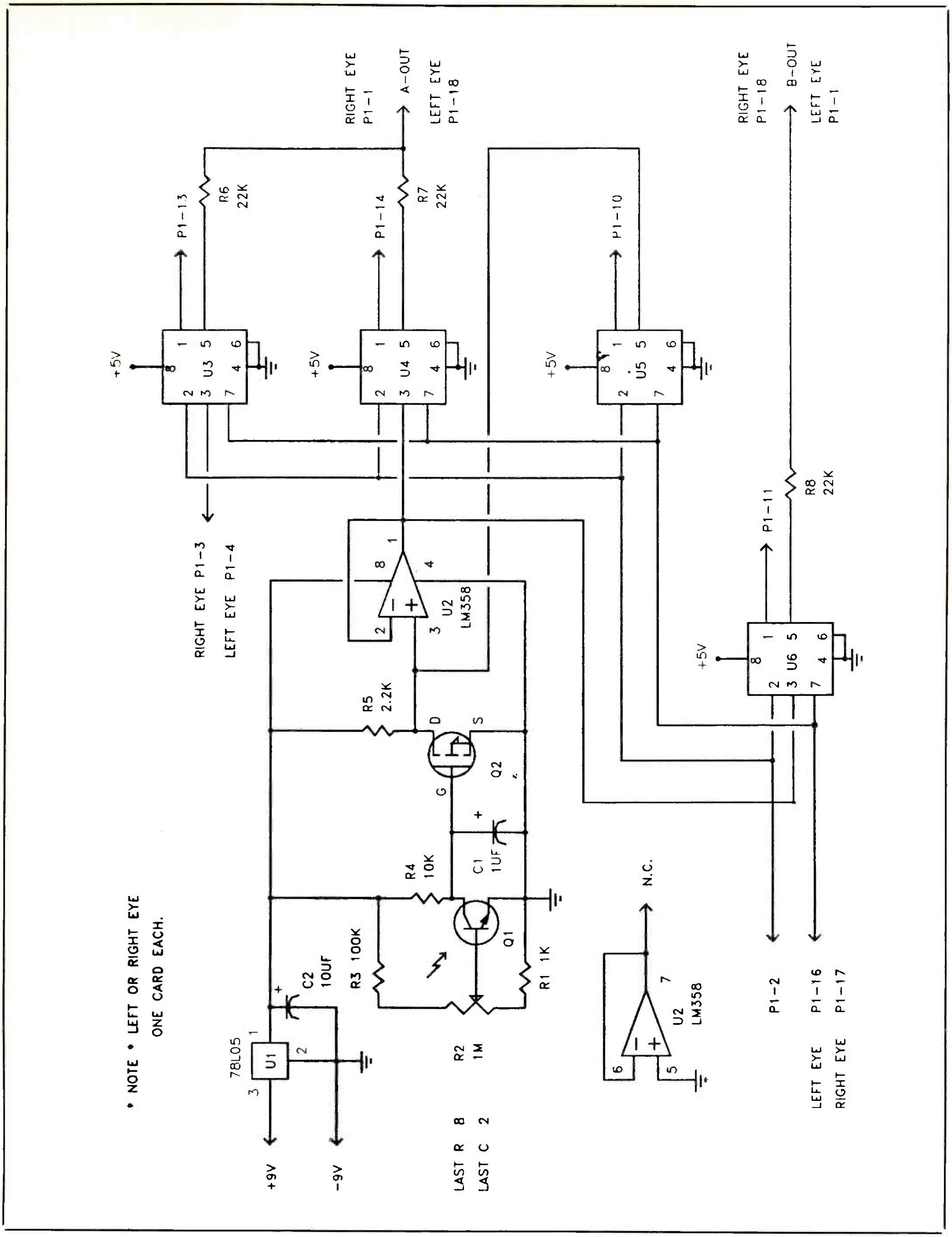


Fig. 2. Schematic details of the Optical Neuron Card circuitry.

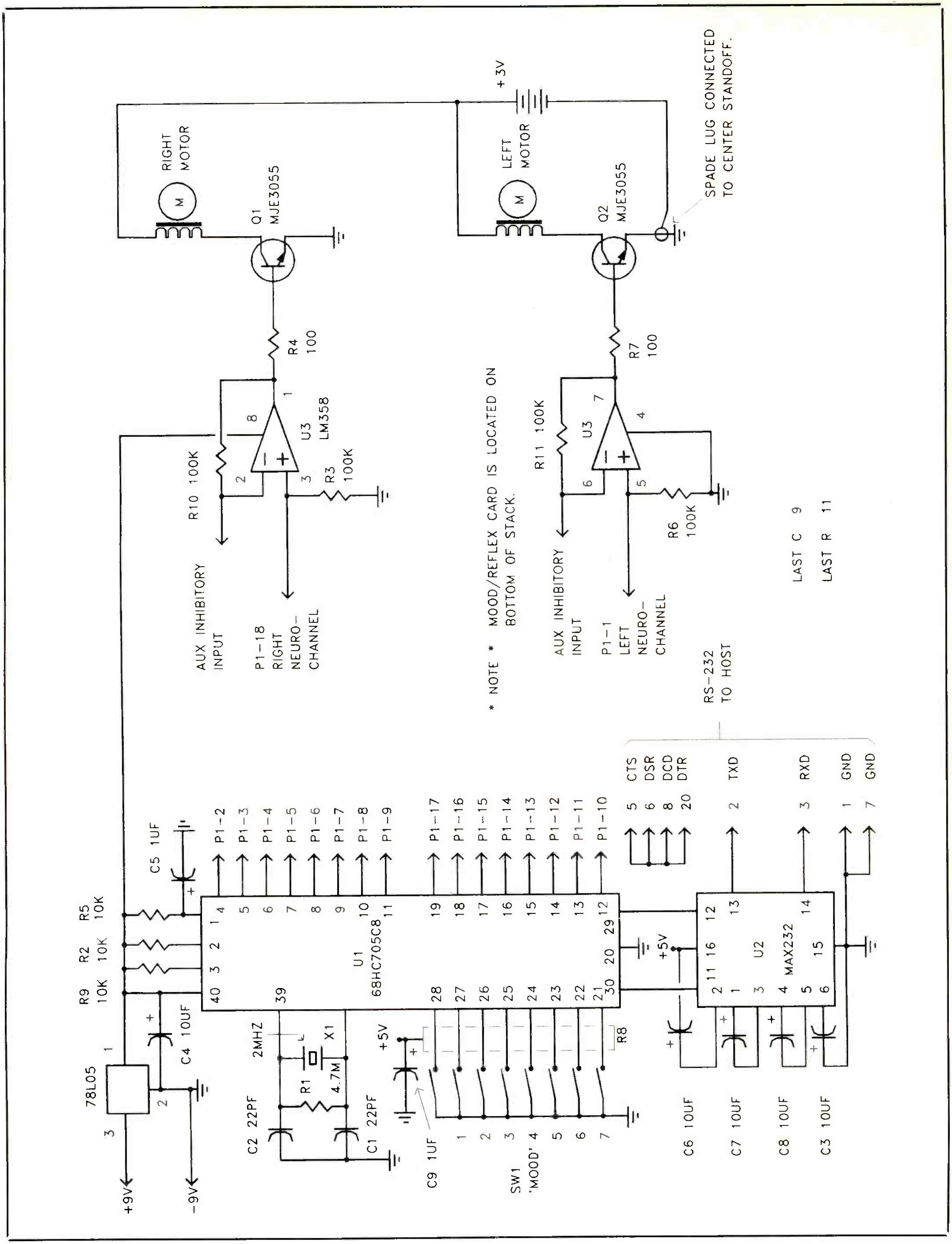
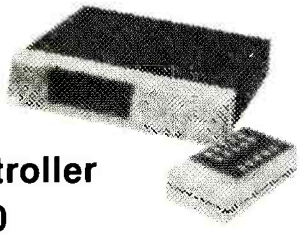


Fig. 3. Schematic details of the Mood and Reflex circuitry.

CATV DESCRAMBLERS



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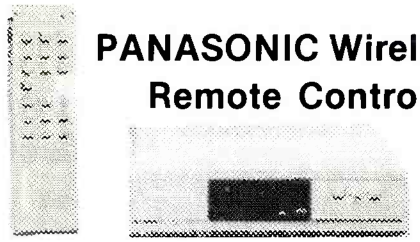

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PARTS LIST

Mood & Reflex Circuit

Semiconductors
Q1,Q2—MJE3055 npn power transistor
U1—MC68HC705C8S microprocessor
U2—MAX232 RS-232 interface
U3—LM358 dual operational amplifier
U4—78L05 fixed +5-volt regulator
Capacitors
C1,C2—22-pf ceramic disc
C3,C4,C6,C7,C8—10-μF, 16-volt tantalum
C5,C9—1-μF, 16-volt tantalum
Resistors (¼-watt, 5% tolerance)
R1—4.7 megohms
R2,R5,R9—10,000 ohms
R3,R6,R10,R11—100,000 ohms
R4,R7—100 ohms
R8—10,000-ohms SIP resistor network
Miscellaneous
P1A—18-pin male strip connector
SO1—40-pin DIP IC socket
SW1—Eight-position DIP switch
XTAL—2.00-MHz crystal
Printed-circuit board; 9-volt alkaline battery and snap connector; female 4-40 × 1″ tapped standoffs (3); hookup wire; solder; etc.

Note: A complete kit of parts for the CyberBot project can be obtained for $99.95 from U.S. Cyberlab, Inc., Rte. 2 Box 284, West Fork, AR 72774 (501-839-8293). Also available from the same source are: a kit containing ready-to-wire Mood/Reflex Card, Optical Neuron Cards (two) and Monitor Card, $19.95; traction drive/base assembly kit, $39.95; preprogrammed MC68HC705C8S microprocessor and source-code documentation, $24.95; Cyber Programmer Development system with software and instructions, $89.95; glass Cyber dome, $12.95. Add $4.95 for P&H (no extra charge for COD orders placed by phone). Arkansas residents, please add state sales tax.

verting (+) input of the op amps causes a proportional positive voltage to appear at the device's output.

Combinations of positive voltages applied to pins 1 and 18 of connector *P1* (Right Neuro-Channel and Left Neuro-Channel) are summed to form a composite voltage that, in turn, is applied to *Q1* and *Q2*. With no voltage present at either Neuro-Channel input, neither motor will turn. However, when Neuro-Channel inputs rise above 1.5 to 2 volts, the respective motor will begin to turn.

Although the current model of CyberBot doesn't use the Auxiliary Inhibitory Inputs at pins 2 and 6 of *U3*, we should consider their action. Positive voltages applied to these inputs are subtracted rather than added to the output voltage. In this manner, other sensory or inter-neurons can "inhibit" the action of a particular neuron. Just remember that a dc voltage applied to either the Right or Left Neuro-Channel input will cause the associated motor to turn.

With the Right Neuro-Channel stimulated, CyberBot turns right. With the Left Neuro-Channel stimulated, CyberBot turns left. With both Neuro-Channel inputs stimulated, Cyberbot moves straight forward.

Figure 2 represents one eye of two circuits that are required for a complete CyberBot unit. Light falling onto the active surface of *Q1* saturates this silicon phototransistor, causing its collector voltage to drop as light intensity increases.

To make CyberBot's "Neural Eye" practical, it's necessary to adjust the threshold of the "Eye" to light. This is accomplished by trimmer potentiometer *R2*. In conjunction with 100,000-ohm resistor *R3* and 1,000-ohm resistor *R1*, forward bias for the base-emitter junction can be adjusted over a wide range. CyberBot was designed to be used in a darkened room. Consequently, the Eye Neuron is adjusted accordingly.

Notice that the collector of *Q1* connects directly to VN0300 hex FET *Q2*. Current is sourced into the gate of this device by resistor *R4*. Pull-up for the drain output is provided by 2,200-ohm resistor *R5*. The more light that strikes *Q1*, the lower the collector voltage of this transistor. In turn, the lower the collector voltage of *Q1*, the higher the drain voltage of *Q2*, due to the inverting action of the transistor.

The VN0300 is a very-high-gain

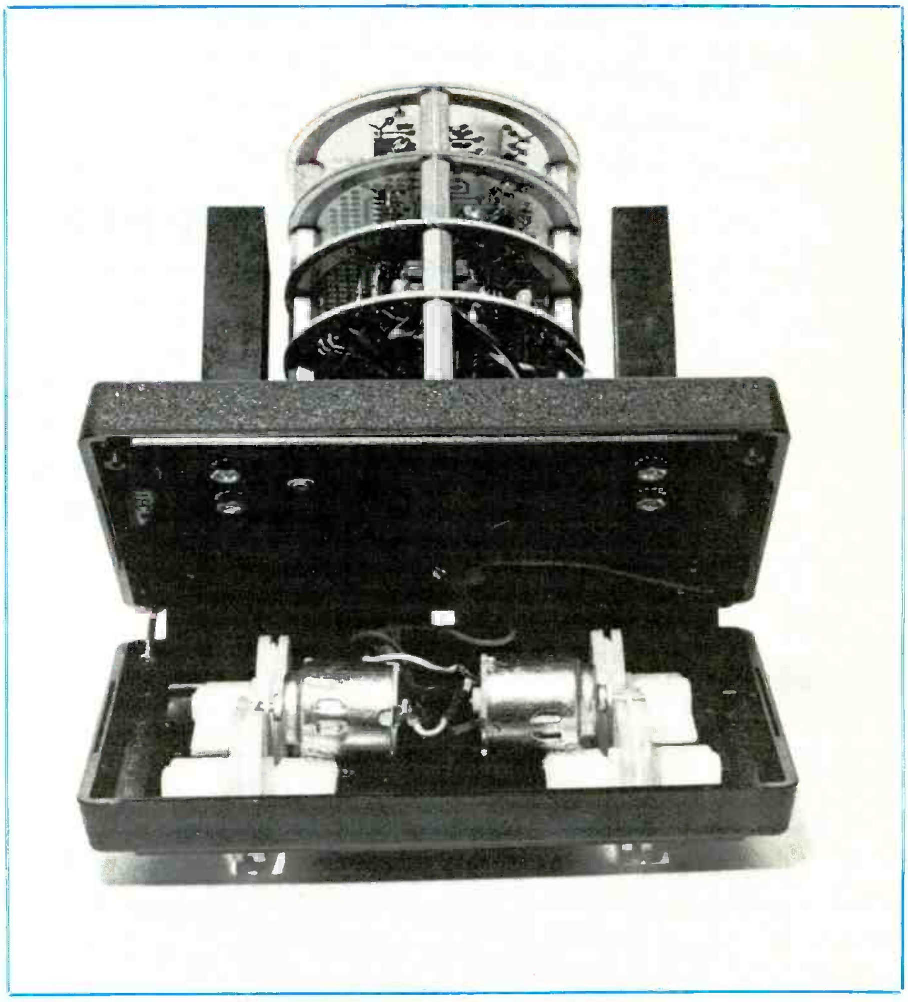

Fig. 4. Interior view of CyberBot's drive motor/wheel assembly.

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LS9200	TOSHIBA	670 nm	3 mW	85 mA	2.3v	49.99
LS9201	TOSHIBA	670 nm	5 mW	80 mA	2.4v	59.99
LS9211	TOSHIBA	670 nm	5 mW	50 mA	2.3v	69.99
LS9215	TOSHIBA	670 nm	10 mW	45 mA	2.4v	109.99
LS3200	NEC	670 nm	3 mW	85 mA	2.2v	79.99
LS022	SHARP	780 nm	5 mW	65 mA	1.75v	19.99
SB1053	PHILLIPS	820 nm	10 mW	90 mA	2.3v	9.99

Dynamic RAMS

STOCK #	DESC.	SPEED	1-24	25-99	100+
41256-60	256K x 1	60 ns	2.59	2.46	2.21
41256-80	256K x 1	80 ns	2.19	2.08	1.87
41256-100	256K x 1	100 ns	1.99	1.89	1.70
41256-120	256K x 1	120 ns	1.89	1.80	1.62
41256-150	256K x 1	150 ns	1.79	1.70	1.53
511000-70	1 meg x 1	70 ns	5.49	5.22	4.70
511000-80	1 meg x 1	80 ns	5.29	5.03	4.53
511000-10	1 meg x 1	100 ns	5.09	4.84	4.36
514256-70	256K x 4	70 ns	6.49	6.17	5.55
514256-80	256K x 4	80 ns	6.09	5.79	5.21
514256-10	256K x 4	100 ns	5.69	5.41	4.87
541000-80	4 meg x 1	80 ns	26.99	25.64	23.08
544256-80	1 meg x 4	80 ns	31.99	30.39	27.35

EPROMS

STOCK #	SPEED	1-24	25-99	100+
2716	450 ns	3.29	3.13	2.82
2732	450 ns	4.19	3.98	3.58
2732A	250 ns	3.29	3.13	2.82
2764	250 ns	3.49	3.32	2.99
2764A	250 ns	3.09	2.94	2.65
27128	250 ns	4.79	4.55	4.10
27C128	250 ns	4.79	4.55	4.10
27256	250 ns	4.59	4.36	3.92
27C256	250 ns	4.29	4.08	3.67
27512	250 ns	5.49	5.22	4.70
27C512	250 ns	5.49	5.22	4.70
27C1024	200 ns	10.99	10.44	9.40
27C2048	200 ns	21.99	20.89	18.80

LASER TUBES

STOCK #	WAVELENGTH	OUTPUT POWER (MIN.)	OUTPUT POWER (MAX.)	BEAM DIAM.	BEAM DIVERG.	POLARI-ZATION	OPERATING VOLTAGE	OPER. CURR.	FIRING VOLT.	MIN. SERIES RES.	SIZE D X L (IN MM)	WT. (GM.)	BRH CL.	PRICE 1-9	10+
LT7770	543nm (Green)	0.5mW	1.0mW	0.71mm	≤ 1.2 mrad	random	1750v ± 110v	6.5 mA	≤ 8 kV	81k Ω	37 x 350	200	II	799.99	749.99
LT7650	632.8nm (Red)	0.5mW	2.0mW	0.49mm	≤ 1.7 mrad	>100:1	1000v ± 100v	3.5 mA	< 7 kV	68k Ω	25 x 146	70	IIIa	529.99	479.99
LT7656	632.8nm (Red)	0.5mW	2.0mW	0.34mm	≤ 2.4 mrad	random	1050v ± 100v	2.8 mA	≤ 8 kV	82k Ω	22.5 x 118	60	IIIa	134.99	124.99
LT7655	632.8nm (Red)	0.5mW	2.0mW	0.49mm	≤ 1.7 mrad	random	1000v ± 100v	3.5 mA	≤ 7 kV	68k Ω	25 x 150	70	IIIa	144.99	134.99
LT7655S	632.8nm (Red)	1.0mW	2.0mW	0.49mm	≤ 1.7 mrad	random	1000v ± 100v	3.5 mA	≤ 7 kV	68k Ω	25 x 150	70	IIIa	159.99	144.99
LT7632	632.8nm (Red)	1.2mW	3.0mW	0.61mm	≤ 3.0 mrad	random	1300v ± 100v	3.5 mA	≤ 7 kV	81k Ω	20 x 210	70	IIIa	249.99	229.99
LT7621S	632.8nm (Red)	2.0mW	5.0mW	0.75mm	≤ 1.2 mrad	random	1300v ± 100v	5.0 mA	≤ 7 kV	68k Ω	30 x 255	140	IIIa	204.99	191.99
LT7634	632.8nm (Red)	2.0mW	5.0mW	0.75mm	≤ 1.2 mrad	>500:1	1300v ± 100v	5.0 mA	≤ 7 kV	68k Ω	30 x 255	140	IIIa	209.99	194.99
LT7621MM	632.8nm (Red)	5.0mW	15mW	1.0mm	≤ 2.5 mrad	random	1250v ± 100v	6.5 mA	≤ 7 kV	68k Ω	30 x 255	140	IIIb	359.99	334.99
LT7627	632.8nm (Red)	5.0mW	15mW	0.80mm	≤ 1.1 mrad	random	1900v ± 100v	6.5 mA	≤ 8 kV	81k Ω	37 x 350	200	IIIb	369.99	344.99
LT7628	632.8nm (Red)	5.0mW	15mW	0.80mm	≤ 1.1 mrad	>500:1	1900v ± 100v	6.5 mA	≤ 8 kV	81k Ω	37 x 350	200	IIIb	389.99	364.99
LT7627MM	632.8nm (Red)	10mW	30mW	1.2mm	≤ 4.0 mrad	random	1750v ± 100v	6.5 mA	≤ 8 kV	81k Ω	37 x 350	200	IIIb	479.99	444.99

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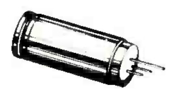

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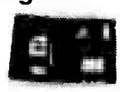

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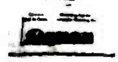

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device and provides a nice "snap-action" output. LM358 dual op amp *U2* is configured as a voltage-follower to help buffer the drain of *Q2* and provide sufficient drive for EEPOTs *U4* and *U6*.

Now for the fun part of the circuit: EEPOTs *U3* through *U6*. (EEPOTs are a trademark of the Xicor Corp., and designate the company's version of a digitally controlled potentiometer.) Inside each of these integrated circuits is a seven-bit counter, programmable control and power-on detector circuit, nonvolatile memory, 1-of-100 digital wiper position decoder, some transfer logic and precision resistor array.

That's a lot of circuitry to have in an eight-pin mini-dip IC package. For the time being, however, let's pretend that each of EEPOT is simply a trimmer potentiometer. Visualize the top of the pot connected to pin 3 of the device, ground connected to pin 6 and the wiper connected to pin 5. As a matter of fact, you may want to pencil-in a pot symbol on Fig. 2.

Output pin 1 of *U2* is connected directly to the top of the pots in *U4* and *U6*. The internal potentiometer resistance of these devices is 10,000 ohms. So, in effect, we have two 10,000-ohm pots connected in parallel across the output of *U2*. Now imagine that each of the pots was turned all of the way down (off). The wiper of the pots then would be at ground and wouldn't see any output voltages coming from output pin 1 of *U2*.

Assume for a moment that both pots are set all the way up. This effectively connects the wipers of both pots directly to the output of *U2*. Consequently, any voltage that appears on pin 1 of *U2* also appears at the wipers of both pots. This action is the essence of the neural network "mood" and "threshold" control scheme.

Rather than having to physically turn trimmer pots on the printed circuits, CyberBot permits the control microprocessor to automatically adjust the configuration of the neural network—in real-time. By digitally "cross-wiring" (using software to control and set *U4*) the Left Eye Neuron to the Right Neuro-Channel and the Right Eye Neuron to the Left Neuro-Channel, you can cause CyberBot to turn into the direction from which an external light source is emanating.

For example, if you use a flashlight in a darkened room, CyberBot will follow you around using its neural network for control. To make things interesting, you can set (digitally move the wiper) the EEPOT to its mid-range position and reduce the amount of "desire" CyberBot has for light. As you can see, CyberBot in its simplest software configuration is a photovore.

This configuration is selected by setting position 0 of DIP switch *SW1* to ON. From Fig. 3, you can see that the autonomous mode "moods" are all selected by directly jamming data into microprocessor *U1*.

An internal microprogram automatically "configures" CyberBot for a particular mood of interest. This is accomplished by bringing pin 2 of all EEPOTs high or low to increment or decrement the wipers. Individual ICs are addressed using their own separate inputs clocked at pin 1 of each. Additionally, the microprocessor can select or deselect the Left or Right Eye Neuron EEPOTs, permitting independent programming of the eyes.

Before moving on to actual mood control of CyberBot, you should look over the rest of the circuitry associated with the Eye Neurons.

As you know from the foregoing, *U4* allows CyberBot to behave as a Photovore. Should you want to change CyberBot from a Photovore to a Photophobic, you'd utilize *U6*. Notice that *U6* (the same as *U4*) is connected to the same Neuro-Channel, rather than the opposite channel. When the wiper of *U4* is turned all the way down and the wiper of *U6* is instead turned all the way up, CyberBot will *avoid* light by darting away from any source of light.

The degree of aversion to light can be controlled by varying the position of *U6*'s wiper. This is automatically accomplished by setting position 1 of *SW1* to ON and position 0 to OFF.

Next, to experiment with inhibitory behavior, *U5* is used to suppress the action of the Eye Neuron by shunting the drain of *Q2* to ground through the wiper. In this manner, the effects of CNS (Central Nervous System) depressants can be emulated and observed.

Finally, U3 is attached directly to one of the output lines on the microprocessor. This allows the control microprocessor to directly stimulate the Right or Left Neuro-Channel. Accordingly, this permits CyberBot to wander around looking for light, or it can be used to induce psychotic behavior in CyberBot.

Now let's look at the left side of Fig. 3 in more detail. The control microprocessor used is a Motorola 68HC705C8 running at 1 MHz. This particular crystal frequency was selected as a timing reference for internal baud-rate generators used in conjunction with RS-232 interface *U2*. This Maxim IC synthesizes all required positive and negative voltages for our host-computer interface.

The real strength of CyberBot is in its ability to be directly interfaced with your host computer. Running Cyberlab software, you'll be able to control every aspect and parameter of the robot's neural network. (Also, if you're interested in developing your own microprocessor code, an inexpensive 68HC705C8 development system is available from the source given in the Parts List).

The Monitor Card provides a convenient way for you to "watch" CyberBot's thinking process. Eighteen separate "poly" LEDs indicate activity on every pin of the *P1* bus. Current-limiting resistors bias each LED at about 1 milliampere to conserve battery life. Transistors *Q1* and *Q2* isolate the Left and Right Neuro-Channels and drive their respective LED indicators. The Monitor Card receives its +9-volt power from the Eye Neuron Card located directly beneath it when the project is assembled.

Next month, we'll detail how to build CyberBot and explain its actual operation. ■

Nick Goss

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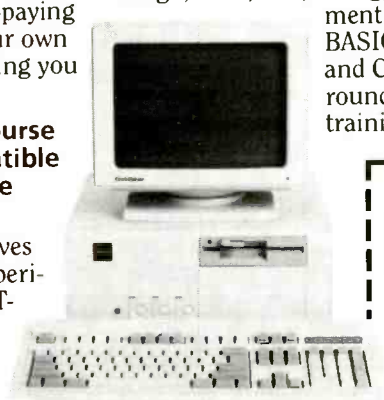

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Adding a Real-Time Clock

A look at two ICs you can use to add timekeeping to applications that require this feature

Many microcomputer circuits require a real-time clock that keeps track of seconds, minutes, hours, days, months and even years. Your personal computer probably includes such a clock that it uses for, among other things, dating its files. Other uses for real-time clocks are in circuits that perform operations at specified intervals, maybe every 5 minutes or hourly or daily or on the first of the month, or whatever. For example, a data logger might record the time and date of each measurement or the times when selected events are detected.

Often, a special clock IC is dedicated to keeping "real time," which frees the microprocessor so that it can perform other tasks. Many clocks perform functions beyond simple timekeeping, such as generating periodic interrupts or acting as a "watchdog" that resets the microprocessor in case of program crashes.

Of the many real-time clock ICs available, two full-featured ones are Dallas Semiconductor's DS1286 Watchdog Timekeeper and the 68HC68T1 Real-time Clock, the latter available from Motorola and Harris Semiconductor (formerly GE/RCA). Both perform similar functions, but the 1286 uses an eight-bit parallel interface, while the 68HC68T1 uses a serial interface.

In this article, I'll describe the features of both ICs. I'll also give circuit and code examples and tips on implementing a real-time clock in circuits of your own design.

Why Real-Time Clocks?

Most microprocessors require a master clock to sequence their operations. In fact, without a master clock, the microprocessor will do nothing at all. The clock signal is generated by a crystal or other oscillator that connects to the microprocessor via its XTAL inputs.

While the master clock provides an essential timing reference, it has no inherent ability to keep track of "real-world" time. Though many microcomputer ICs have programmable timer and clock circuits built into them, they're typically just variations of the master clock, perhaps divided down to a lower frequency.

When timing requirements are simple, embedded clocks may be adequate. But writing a program that counts clock cycles and keeps track of units from seconds on up to years may be more than you care to do. Also, a complex timekeeping program requires more microprocessor time to maintain the clock, leaving less time for other functions.

A solution lies in real-time clock/calendar ICs. These are specialized devices that free the microprocessor from having to keep real time. When time or date information is needed, the microprocessor needs only read it from the clock IC.

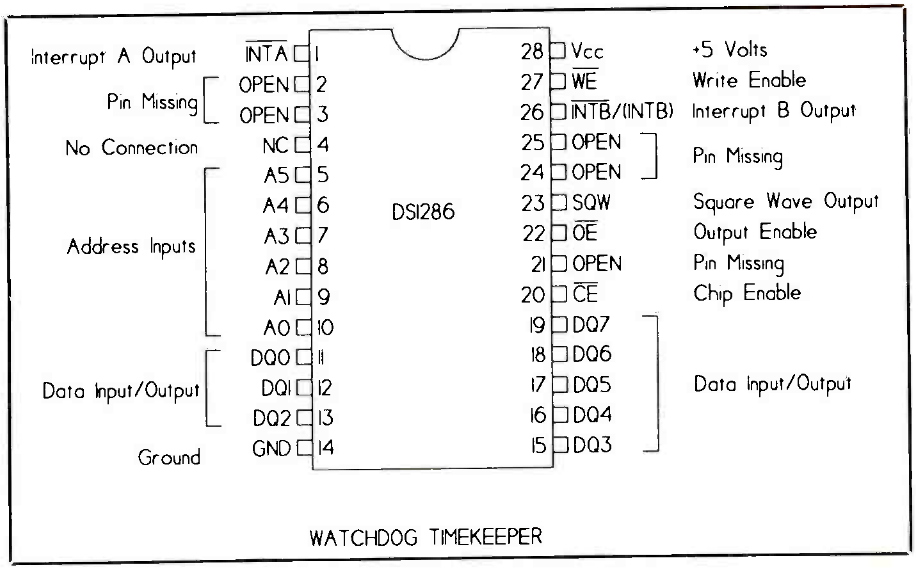


Fig. 1. Dallas Semiconductor's DSS1286 Watchdog Timekeeper keeps track of the time and date and generates periodic and watchdog alarms. It contains its own timing reference and lithium backup power.

Watchdog Timekeeper

Dallas Semiconductor's DS1286 Watchdog Timekeeper, shown in Fig. 1, is easy to use because it contains its own quartz crystal timing reference, as well as a lithium cell for backup power. Once you initialize the clock and calendar and start the oscillator, the clock keeps time for 10 years or more, whether or not an external power source is present.

The 1286 contains a series of registers, or memory locations, that store time, date, alarm and configuration information. This IC is accessed like byte-wide RAM, with an access time of 150 nanoseconds.

Current time and date can be read from the 1286 in hundredths of seconds, seconds, minutes, hours, day of the week, date of the month and year—a pretty complete list. Months of different lengths and even leap years are handled automatically. Clock accuracy is better than ±1 minute per month at 25°Celsius.

Outputs of the 1286 include an interrupt that can be programmed to occur whenever the time and/or day match stored values. A second output generates an interrupt if the 1286's watchdog register isn't accessed periodically. This feature can be used to reset a microprocessor automatically if a misbehaving program "crashes" the microprocessor, causing it to stop accessing the watchdog register. The 1286 also has 1,024-Hz square-wave output and 50 bytes of nonvilatile user RAM available for any use.

To accommodate its crystal and power source, the 1286 uses a 28-pin encapsulated DIP (dual in-line package) that's somewhat taller than other DIP ICs.

Figure 2 details the functions of the 1286's registers. These registers store time, date, configuration and status information. To initialize the clock/calendar, you write the current time and date into Registers 0, 1, 2, 4, 6 and 8 through A and then start the clock by clearing EOSC (Bit 7 of Register 9).

Time and date values are stored in binary-coded decimal (BCD) format. In BCD, a four-bit nibble represents one decade, and nibbles greater than 9 (1001) aren't allowed. Fig. 3 shows numbers expressed in decimal, BCD and binary. Some values in the 1286 don't require a full eight bits.

decimal	BCD	binary
0	0000 0000	0000 0000
1	0000 0001	0000 0001
2	0000 0010	0000 0010
3	0000 0011	0000 0011
4	0000 0100	0000 0100
5	0000 0101	0000 0101
6	0000 0110	0000 0110
7	0000 0111	0000 0111
8	0000 1000	0000 1000
9	0000 1001	0000 1001
10	0001 0000	0000 1010
11	0001 0001	0000 1011
.	.	
.	.	
.	.	
19	0001 1001	0001 0011
20	0010 0000	0001 0100
.	.	
.	.	
.	.	
29	0010 1001	0001 1101
30	0011 0000	0001 1110
.	.	
.	.	
.	.	
99	1001 1001	0110 0011

Fig. 3. In binary-coded decimal, each four-bit nibble represents one decade of values: 1s, 10s, etc.; 0 to 9, BCD and binary are identical.

	ADDRESS	BIT NUMBER 7	6	5	4	3	2	1	0
clock, calendar, time-of-day registers	0	0.1 SECONDS				0.01 SECONDS			
	1	0	10 SECONDS			SECONDS			
	2	0	10 MINUTES			MINUTES			
	3	M	10 MIN. ALARM			MINUTES ALARM			
	4	0	12/24	10 AM/PM	10 HR	HOURS			
	5	M	12/24	10 AM/PM	10 HR	HOUR ALARM			
	6	0	0	0	0	0	DAYS		
	7	M	0	0	0	0	DAY ALARM		
	8	0	0	10 DATE		DATE			
	9	EOSC	ESQW	0	10 MO	MONTHS			
	A	10 YEARS				YEARS			
command register	B	TE	IPSW	IBH/LO	PU/LVL	WAM	TDM	WAF	TDF
watchdog registers	C	0.1 SECONDS				0.01 SECONDS			
	D	10 SECONDS				SECONDS			
user registers	E ⋮ 3F								

EOSC - enable oscillator
ESQW - enable square wave out
TE - transfer enable
IPSW - interrupt switch
IBH/LO - interrupt B high/low
PU/LVL - pulse/level interrupts
WAM - watchdog alarm mask
TDM - time-of-day alarm mask
WAF - watchdog alarm flag
TDF - time-of-day alarm flag

TIME OF DAY ALARM MASK BITS

MIN	HR	DAY	ALARM FREQUENCY
1	1	1	ONCE PER MINUTE
0	1	1	WHEN MINUTES MATCH
0	0	1	WHEN HOURS AND MINUTES MATCH
0	0	0	WHEN HRS. MINS. AND DAYS MATCH

Fig. 2. The DS1286 contains 14 registers that store time, date, configuration and status information. Also available are 50 bytes of nonvolatile user RAM.

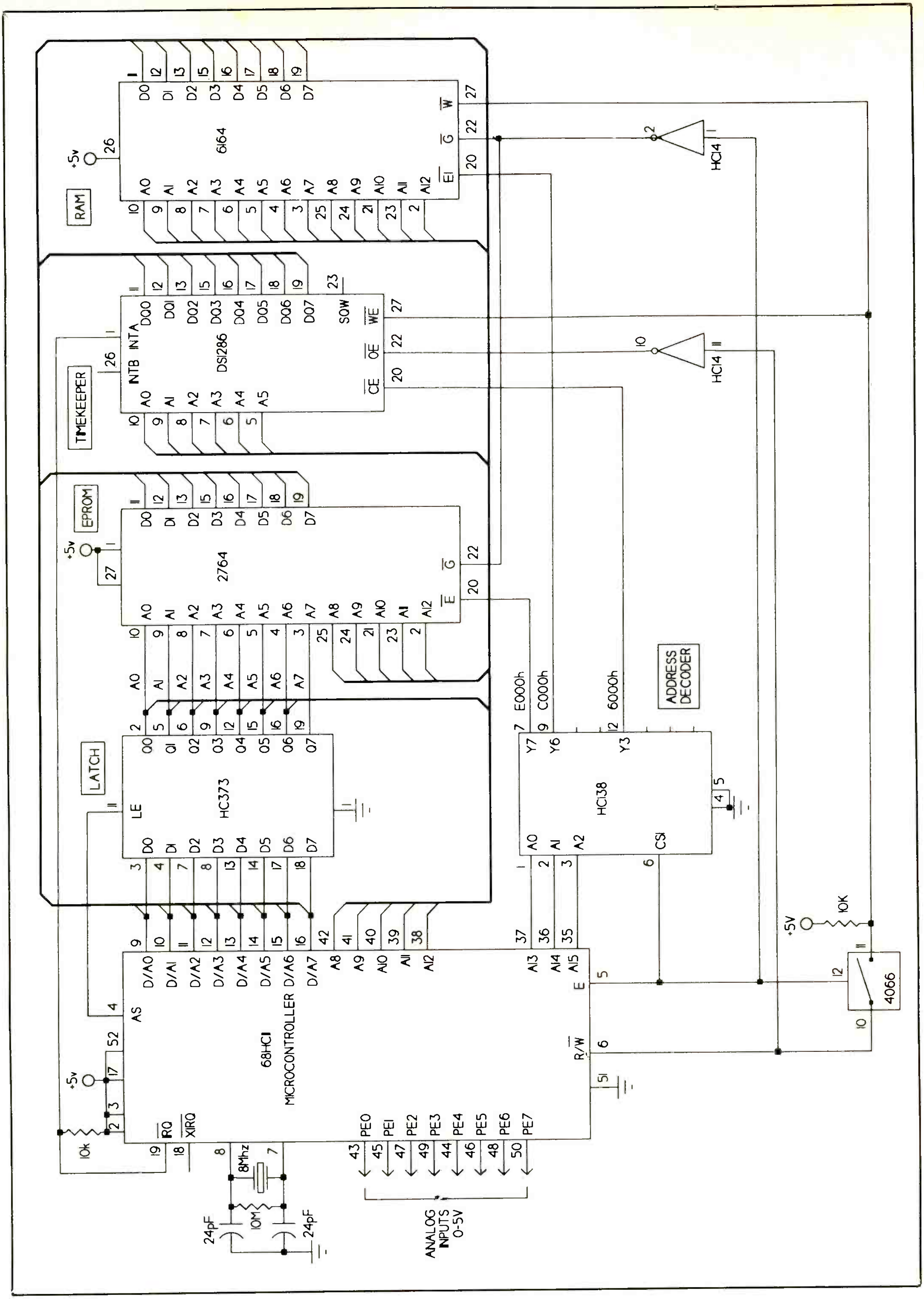
Since the number of the month can't be greater than 12, only five bits are needed to store this value.

To generate an interrupt at a specific time, you select an alarm frequency by setting or clearing three mask bits (Bit 7 of Registers 3, 5 and 7) and storing the desired alarm values in Bits 0 through 6 of these registers. For example, to generate an interrupt at 3:15 daily, the following values would be stored:

Register	Mask Bit	Alarm Data
3		001 0101 (15 min)
5		000 0011 (3 hrs)
7		don't care (days)

If you want an alarm frequency other than daily, hourly or on the minute, there are a couple of ways to achieve this. For an alarm every 10 minutes, you could generate an interrupt once per minute and ignore nine out of ten interrupts. If this seems wasteful, you can update the alarm minutes to the next desired value after each interrupt.

Using the example of an interrupt every 10 minutes, you'd set the mask bits for "when minutes match" (0-1-1) and start out by storing 0 in Register 3, which causes an interrupt to occur on the hour. When the interrupt does occur, you'd add 10 to Reg-



RAM
6164
+5v
TIMEKEEPER
DS1286
EPROM
2764
LATCH
HC373
ADDRESS DECODER
HC138
E000h
C000h
6000h
HC14
4066
10K
68HC11
MICROCONTROLLER
8Mhz
10M
24pF
10k
ANALOG INPUTS 0-5V

Fig. 4. The 1286 timekeeper is interfaced to a microcontroller much like RAM or EPROM. This example uses Motorola's HC11 evaluation board as a base for the circuit.

ister 3 to schedule the next interrupt for 10 minutes after the hour. By continuing to add 10 to Register 3 after each interrupt and returning to 0 on a count of 60, you end up with an interrupt every 10 minutes.

Figure 4 shows a 1286 interfaced to a 68HC11 microcontroller, using Motorola's HC11 evaluation board as a base for the circuit. (For more information on the HC11 evaluation board, see the June 1991 issue of *ComputerCraft*.) The pinout of the 1286 closely matches the standard 28-pin static RAM pinout, and circuit connections are similar. In fact, with a couple of modifications, I was able to test the 1286 by plugging it into the spare RAM socket on the evaluation board. Address decoding places the 1286 at 6000h.

To permit different connections from those on the evaluation board, I lifted pins 26 and 23 on the 1286. Actually, since sockets are cheaper than ICs, I plugged the 1286 into a socket and carefully bent the two legs on the socket outward and then plugged the socket into the evaluation board. This arrangement allowed me to clip jumper leads onto the lifted legs and route these signals as desired.

Listing 1 shows example code for the Fig. 4 circuit to initialize the clock/calendar, generate an alarm every 10 minutes for an hour and on each alarm, store readings from the HC11's eight-channel analog-to-digital (A/D) converter in the 1286's user RAM. The programs were written using Motorola's freeware BAS11 BASIC interpreter for the 68HC11, available from the company's BBS. (This and other sources are listed at the end of this article.)

As Fig. 2 shows, many of the registers in the 1286 have multiple functions. In Register 9, Bits 0 through 4 store the current month, Bit 6 enables the square-wave output, Bit 7 enables the clock and Bit 5 is always 0.

For situations like this, a programming technique called masking allows you to read and write to selected

Listing 1. BAS11 Program for Initializing 1286 and Sample HC11's A/D Converter's Outputs Every 10 Minutes for an Hour.

```
10 REM **********demo of DS1286 clock/calendar IC**********
20 REM written in BAS11 for 68HC11
30 REM assumes DS1286 is at $6000-$603f
40 REM BAS11 conventions: $ = hexadecimal
50 REM / = integer division; \ = remainder division
60 REM ***********initialize and start clock****************
70 POKE ($6009,$80):REM set 1286 reg. 9, bit 7 to stop clock
80 REM get time and date for initializing
90 INPUT "year (0-99)",YR
100 INPUT "month (1-12)",MO
110 INPUT "day of month (1-31)",DM
120 INPUT "day of week (1-7)",DW
130 INPUT "24-hr (0) or 12-hr (1) clock",TT
140 IF TT=0 THEN 180
150 INPUT "hour (1-12)",HR
160 INPUT "AM (1) or PM (0)",AP
170 GOTO 190
180 INPUT "hour (0-23)",HR
190 INPUT "minutes (0-59)",MN
200 INPUT "seconds (0-59)",SC
210 HS=0:REM hundredths of seconds
220 REM convert values to BCD and store in DS1286
230 POKE ($600a,(YR/10)*16+YR\10)
240 POKE ($6008,(DM/10)*16+DM\10)
250 POKE ($6006,(DW/10)*16+DW\10)
260 POKE ($6004,(HR/10)*16+HR\10+AP*$20+TT*$40)
270 POKE ($6002,(MN/10)*16+MN\10)
280 POKE ($6001,(SC/10)*16+SC\10)
290 POKE ($6000,HS)
300 POKE ($600b,$c8):REM configure int. A as TOD, low level
310 INPUT "Press 0 and <RET> to start clock",A
320 REM store MO and clear register 9, bit 7 to start clock
330 POKE ($6009,(MO/10)*16+MO\10)
340 REM ************display current time and date***********
350 POKE($600b,$48):REM clear TE for error-free reads
360 MO=PEEK($6009).AND.$3f
370 PRINT "month =", (MO/16)*10+MO\16
380 DM=PEEK($6008)
390 PRINT "day of month =",(DM/16)*10+DM\16
400 YR=PEEK($600a)
410 PRINT "year =",(YR/16)*10+YR\16
420 DW=PEEK($6006)
430 PRINT "day = ",DW
440 HR=PEEK($6004).AND.$1f
450 PRINT "hour =",(HR/16)*10+HR\16
460 MN=PEEK($6002)
470 PRINT "minutes =",(MN/16)*10+MN\16
480 SC=PEEK($6001)
490 PRINT "seconds =",(SC/16)*10+SC\16
500 IF TT=0 THEN 550
510 IF AP=1 THEN 540
520 PRINT "am"
530 GOTO 550
540 PRINT "pm"
550 POKE($600b,$c8):REM set TE when reads are done
560 REM ********read ADC every 10 minutes for 1 hour********
570 CT=0
580 AD=$600e: REM initial address for storing ADC data
590 POKE ($6003,$00):REM alarm when minutes match, minutes=0
600 POKE ($6005,$80)
610 POKE ($6007,$80)
620 A=PEEK($600b):REM read 1286 command register
630 POKE ($600b,A.AND.$fb):REM clear bit 2 to enable alarm
640 WHILE CT<$60:REM wait for interrupts
650 ONIRQ 1,900:REM when minutes match, read ADC
660 ENDWH
670 ONIRQ 0,680:REM disable interrupts
680 END
900 REM **********on interrupt, store ADC outputs**********
910 A=PEEK($6003):REM read register to clear interrupt
920 CT=CT+$10:REM add 10 minutes to alarm time
930 POKE($6003,CT):REM store new alarm time
940 FOR I=0 TO 7:REM read ADC channels 0-7
950 POKE (AD,ADC(I)):REM store adc outputs in RAM
960 PRINT I,AD,PEEK(AD):REM display readings
970 AD=AD+1:REM increment RAM location
980 NEXT I
990 RETI
```

bits in a byte while ignoring other "masked" bits. For example, assume that you want to store a month in Bits 0 through 4 of the 1286's Register 9, without affecting the settings of Bits 5, 6 and 7.

To do so using masking would involve the following steps:

(1) Read the current value of the byte. In our example, with a current month of December, the clock enabled and the square wave disabled, Register 9 will hold 0101 0010.

(2) Create a mask byte by setting all bits to be masked, or ignored, to 1 and clearing the other bits. To alter only the month's value, Bits 5, 6 and 7 are masked: 1110 0000.

(3) Perform a bitwise logical AND of the current value and the mask byte. That is, compare the eight pairs of same-valued bits in the above two bytes. If both bits are 1, the resulting bit is 1, otherwise the resulting bit is 0. In BAS11, the .AND. function performs the operation, giving this result: 0100 0000.

(4) Add the new month's value to the ANDed byte. To change the month to June (sixth month), add the above byte and: 0000 0110, which results in: 0100 0110.

(5) Save the final result in the original location. Bits 5, 6 and 7 are unchanged from the original, while Bits 0 through 4 have been changed from 12 (December) to 6 (June).

The Fig. 4 circuit is one of many possibilities for using the 1286. Other microprocessors and microcontrollers can be interfaced to the 1286 in a similar manner, and assembly language or other programming language can be used instead of BASIC.

The 1286 can be especially useful in battery-powered systems. Since it continues to keep time when the main power supply is off, its interrupt output can be used to power up circuitry at programmed times or intervals. For example, by adding circuitry to control a power supply, the 1286's interrupt could trigger a data logger or other instrument to power up at a programmed time. After taking data or performing other operations, the instrument could power itself down until the next interrupt from the 1286. The longer the time between readings, the greater the power savings.

A data book with more details on the 1286 is available from Dallas Semiconductor. You might also want to take a look at the other ICs available from Dallas, including the DS1386 timer with 8K or 32K of nonvolatile user RAM and the DS5000T 8051-compatible microcontroller with embedded nonvolatile RAM and real-time clock. You can order components and data books directly from Dallas (there's no minimum order) or check your usual suppliers.

Serial Timekeeper

Similar functions are offered by the 68HC68T1 real-time clock chip with serial interface. Motorola's version is the MC68HC68T1, while Harris' equivalent is the CDP68HC68T1. I'll call it the 68T1 for short. The serial interface means that the chip requires fewer interconnections and fits in a smaller package; you have a choice of a 16-pin DIP or SOIC (small-outline IC).

The 68T1 is especially suited for use with microcontrollers that have built-in synchronous serial interfaces, like the HC11's serial peripheral interface (SPI) or National Semiconductor's MICROWIRE serial interface. However, using the interface requires mastering the configuration and operating details. Getting the 68T1 to work properly isn't quite as simple as writing to a memory location.

If you're interested in using the 68T1 in your designs, ask for data sheet No. MC68HC68T1/D, available from Motorola, which has complete specifications, as well as applications information and circuit examples. Also, study relevant chapters of the data book for the microprocessor or controller you'll be using with the 68T1.

Figure 5 shows the pinout for the 68T1. This chip performs the same basic functions as the 1286. That is, it keeps track of time from seconds to years and generates watchdog and periodic alarms. A typical interface uses four lines for transferring data: a serial clock, data input, data output, and slave select line.

The 68T1's SPI transmits and receives data in a controlled, timed sequence, with the serial clock synchronizing data transfers between devices. In this way, the SPI differs from an asynchronous serial interface like RS-232, which relies on start and stop bits to signal the beginning and end of each of each transmitted word. The 68T1 can be clocked at up to 2.1 MHz.

Because the 68T1 contains no embedded timing reference or backup power, these must be added to the circuit. An external crystal may be any of four frequencies: 4.194 MHz, 2.097 MHz, 1.049 MHz or 32.768 kHz (these values are all powers of 2), or you can use a 50- or 60-Hz source. Lower frequencies will yield lower power consumption.

The more accurate your timing reference, the greater the accuracy of your clock. You can tune the frequency of a crystal slightly by adjusting one of the capacitors that connect from the crystal's legs to ground.

Temperature variations cause a crystal's frequency to drift. Crystal accuracy is rated in parts per million per degree Celsius (often abbreviated

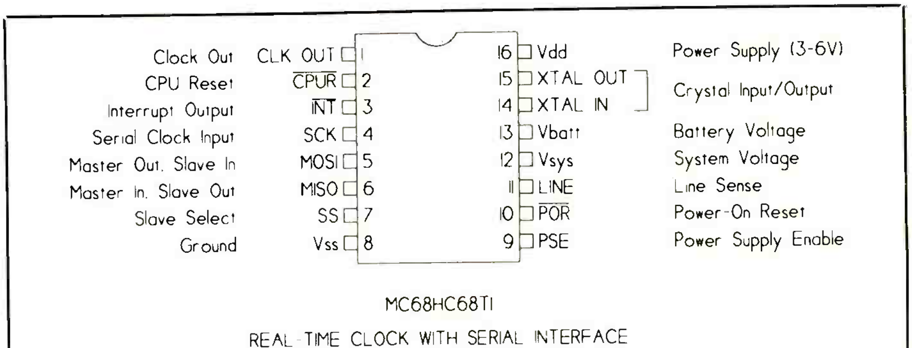


Fig. 5. Motorola's 68HC68T1 real-time clock chip has a synchronous serial interface that permits fast data transmission over two lines, plus a clock line.

"ppm"). A crystal rated at ± 10 ppm varies no more than 0.001%/°C, which translates to 0.86 seconds per day or 5 minutes per year. If your clock must be super-accurate, choose the best-quality crystal you can find, tune it for an accurate output and avoid temperature fluctuations.

The 68T1's V_{batt} input makes it easy to add battery backup, which will maintain the clock/calendar down to 2.2 volts. For ac-powered circuits, a line input can sense ac transitions and generate an interrupt if ac power fails.

A programmable square-wave output generates a signal at XTAL, XTAL/2, XTAL/4, XTAL/8, 1 or 2 Hz, or the line frequency.

The 68T1 stores clock, calendar, alarm and other information in internal registers, or memory locations, much like the 1286. To initialize the clock/calendar, you write time and date in BCD format to the 68T1's registers and then start the clock. Alarm times and frequencies are also stored in registers in the 68T1, and 32 user RAM bytes are available.

An example circuit using the 68T1, again using the 68HC11 microcontroller, is shown in Fig. 6. The HC11 acts as a "master," which outputs the clock (SCK) that controls transmissions with the "slave" 68T1. SCK is active only during data transfers.

Three pins on the HC11's Port D have alternate functions meant for use with a synchronous serial interface. Bit 4 outputs the serial clock (SCK), Bit 3 is the HC11's serial output (MOSI) and Bit 2 is the HC11's serial input (MISO). The 68T1's slave select (SS) input connects to an additional port pin on the HC11, which acts as a chip select for the 68T1. For timed interrupts, the 68T1's interrupt output drives the HC11's interrupt-request (IRQ) input.

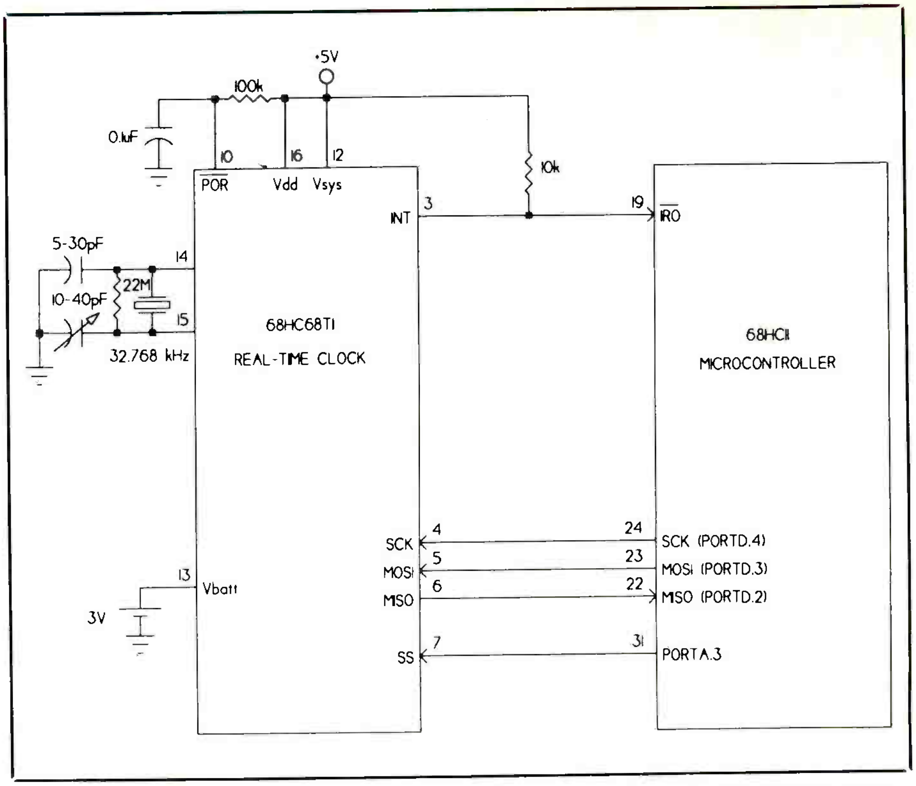


Fig. 6. The 68HC68T1 interfaces to the HC11 using alternate functions of the HC11's Port D pins. An external backup battery continues to keep time when the +5 volts source is removed. (This schematic shows only those HC11 pins relevant to the 68T1 interface.)

Before using the HC11's SPI, you must program the associated registers to configure and enable the interface. These include the SPI status and control registers and Port D's data-direction register. Details about the HC11's SPI are contained in Motorola's HC11 reference and technical data manuals.

When the interface has been configured, all transmitted and received data passes through the HC11's SPI data register. Instead of reading and writing to an external memory address, you read and write to the data register. The HC11 takes care of the details of sending and receiving the serial data.

Writing data to the 68T1 involves the following steps:

(1) Bring SS high to enable the 68T1.

(2) Write the desired 68T1 address to the SPI data register, with Bit 7 high to indicate a write operation. For example, to write to address 12h, write 92h to the SPI data register. Writing to the data register causes the HC11 to output eight SCK cycles and transmit the byte stored in the data register to the 68T1.

(3) Read the HC11's SPI status register until Bit 7 is set, indicating that transfer is complete. Bit 7 is cleared by reading the status register, followed by accessing the SPI data register. The status register *must* be read before each eight-bit SPI transfer (except the very first after power-up), since the SPI's data register can't be written to if the transfer-complete bit is set.

(4) Write the desired data to the SPI data register. The HC11 clocks the data from the HC11 to the 68T1.

(5) Read the SPI status register to clear Bit 7.

(6) Bring SS low to disable the 68T1.

Reading data from the 68T1 follows a similar process, as follows:

(1) Bring SS high.

(2) Write the address to be read to the SPI data register, with Bit 7 low to indicate a read operation.

(3) Read the SPI status register to clear Bit 7.

(4) Write a byte (any value) to the SPI data register. This causes the HC11 to output eight more SCK cycles, allowing the 68T1 to transmit the requested byte back to the HC11's SPI data register, where it can then be accessed.

(5) Read the SPI status register to clear Bit 7.

(6) Bring SS low to disable the 68T1.

For faster transfers, you can use a "burst" mode to write to or read from adjacent addresses without specifying an address each time.

The 68T1 is available from Newark Electronics and other Motorola

Sources

Dallas Semiconductor
4350 S. Beltwood Pkwy.
Dallas, TX 75244-3292
214-450-0400
Orders: 1-800-336-6933

Harris Semiconductor
P.O. Box 883
Melbourne, FL 32902-0883
407-724-3000

Motorola Semiconductor Products Inc.
P.O. Box 20912
Phoenix, AZ 85036
1-800-521-6274

Motorola Freeware BBS:
512-891-3733
300/1,200/2,400 baud; 8 bits; no parity; 1 stop bit

Newark Electronics
4801 N. Ravenswood Ave.
Chicago, IL 60640-4496
312-784-5100

distributors. It's just one of several synchronous serial ICs available. Others include an A/D converter, eight-bit port and RAM chip. If there's interest, I'll do more on serial interfacing in a future issue. Let me know about this, or if you have other comments, suggestions, or questions on topics relating to designing, building and programming microcontrollers or other small, dedicated computers, send them to Jan Axelson, *ComputerCraft*, 76 North Broadway, Hicksville, NY 11801. For a personal response, please include a self-addressed, stamped envelope.

Next time around, our discussion will be on how to use the Z8 single-chip microcomputer. ■

Jan Axelson

 By Duane M. Perkins

An RGBI-to-Analog Monitor Adapter

This project lets you use an analog RGB color monitor with IBM and compatible computers

If you own an analog color video monitor, such as Tandy's CM-8, you can use it with an IBM/compatible computer by adding this simple adapter. The many Tandy CoCo 3 users who have a CM-8 or similar monitor can use the adapter described to convert RGBI signals from any IBM/compatible computer to the signal levels required by it to duplicate the display that would appear on a CM-5 or similar RGBI monitor. Component cost for the project is about $25 if items all are purchased at your local Radio Shack store.

About the Circuit

An RGBI monitor requires six TTL-level input signals: red, green, blue, intensity, horizontal sync and vertical sync. Since TTL signals are digital, they have only two levels. A high is defined at being near + 5 volts, and a low is defined as being near 0 volt. The intensity of each pixel is determined by the intensity signal. Accordingly, only two levels of intensity are available in such monitors.

The color of a pixel is determined by a specific combination of the red, green and blue signals. Colors other than red, green and blue are obtained when more than one of these signals is high. If all three are high, the pixel is white. A special case occurs when all three color signals are low and the intensity signal is high, which results in the color gray (a low-intensity white) being displayed. As their name implies, sync signals synchronize the horizontal and vertical sweep with the other four signals.

An analog RGB monitor has only five input signals (the CM-8 also has provision for an audio input). Sync signals required by a CM-8 are identical to those required by an RGBI monitor and, thus, require no conversion. The red, green and blue signals may be at any level up to about 2 volts. The voltage level determines the intensity. Consequently, no intensity signal is needed.

Conversion of RGBI signals to drive an analog monitor is accomplished by generating red, green and blue signal levels that produce pixels that correspond to the color and intensity that would be displayed on an RGBI monitor. For each primary color, the output signal would be about 2 volts for high intensity and about 1.4 volts for low intensity. A gray pixel results when all three color signals are at about 1.0 volt, and a black pixel results when all three signals are below 0.8 volt.

A circuit that performs the required conversions is shown schematically in Fig. 1. The right half of the diagram is the RGB logic, the left half the gray logic. The RGB logic will function without the interconnections to the gray logic (gray will be black). If display of gray isn't important, it isn't necessary to build the gray-logic circuit.

The RGB logic consists of three identical circuits, one for each of the primary colors. Input signals enter at inputs R_{in}, G_{in}, B_{in} and I_{in}. The output signals are taken from outputs R_{out}, G_{out} and B_{out}.

The red logic circuit shown at the top in Fig. 1 works as follows. When both the R_{in} and I_{in} signals are high, *D1* and *D2* won't conduct. Current flows from + 5 volts through *R4*, *D3*, *R1* and *R5*, which serve as elements of a voltage-divider network. The voltage on the base of *Q1* is determined by the position the *R1* wiper. The voltage at the emitter of *Q1*, connected as an emitter-follower, will be 0.6 volt below the voltage at the base.

When R_{in} is high and I_{in} is low, *D2* conducts and allows current to flow through *R3* and *R2* in addition to the current flowing through the divider network. The additional current through *R4* causes additional voltage drop across *R4*, reducing the voltage

PARTS LIST

Semiconductors
D1 thru D15—1N914 silicon switching diode (276-1122)
D16,D17—1N4001 silicon rectifier diode (276-1101) IC1—7402 TTL quad two-input NOR gate
IC2—7805 fixed +5-volt regulator (276-1770)
Q1 thru Q4—2N2222 npn silicon transistor (276-2009)
Capacitors
C1,C2—0.01-µF capacitor (272-1065)
C3—2,200-µF, 35-volt electrolytic (272-1048)
Resistors (¼-watt, 10% tolerance)
R3,R4,R5,R9,R10,R11,R15,R16,R17—4,700 ohms
R6,R12,R18—10,000 ohms
R20—2,200 ohms
R1,R2,R7,R8,R13,R14,R19—4,700-ohm miniature pc-mount trimmer potentiometer (271-281)
Miscellaneous
J1—DB-9 male connector and hood (276-1537 and 276-1508)
J2—See text
T1—12.6-volt, 0.45-ampere center-tapped power transformer (273-1365)
Printed-circuit board; socket for *IC1*; suitable enclosure (see text); ac line cord with plug; wire nuts (2); hookup wire; rubber grommets; spacers; machine hardware; solder; etc.
Note: Numbers shown in parenthese are Radio Shack Catalog Numbers. These items may be available from other sources as well.

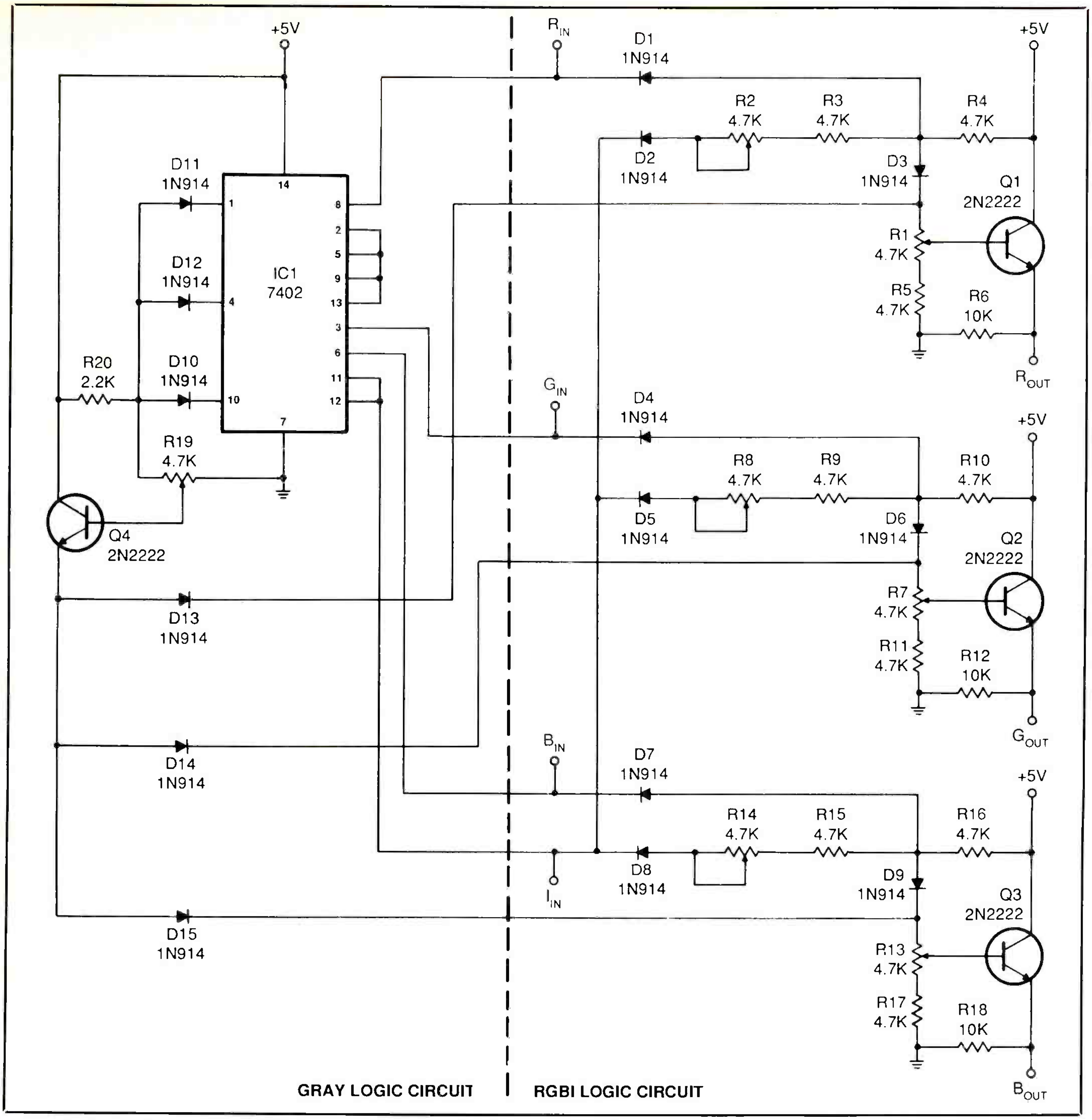


Fig. 1. Schematic diagram of RGBI-to-Analog Monitor Adapter sans its ac-operated power supply.

at the base and emitter of *Q1*.

When Rin is low, *D1* conducts, reducing the potential at its anode to about 0.8 volt. Assuming that the voltage at the emitter of *Q4* is low, *D13* won't conduct. The output from the emitter of *Q1* will be at ground level (zero).

When all three color inputs (Rin, Gin and Bin) are low and the intensity input (Iin) is high, the gray logic functions. The output of any NOR gate in *IC1* is high only if both inputs are low. With Iin high, the output at pin 13 of *IC1* will be low. Since Rin, Gin and Bin are low, the outputs at pins 10, 1 and 4 of *IC1* will all be high and *d10*, *D11* and *D12* won't conduct. Current will then flow through resistors *R19* and *R20*.

Transistor *Q4* is also connected as an emitter-follower. Its emitter will be 0.6 volt below the voltage at its base, which is connected to the wiper of *R19*. Current will flow through *D13*, *R1* and *R5* to generate a voltage at the emitter of *Q1*. The same result is obtained at Gout and Bout from current flow through *D14* and *D15*.

Note that if Iin is low, the output at pin 13 of *IC1* is high and the outputs at pins 10, 1 and 4 of *IC1* will be low. Also, if color input is high, the out-

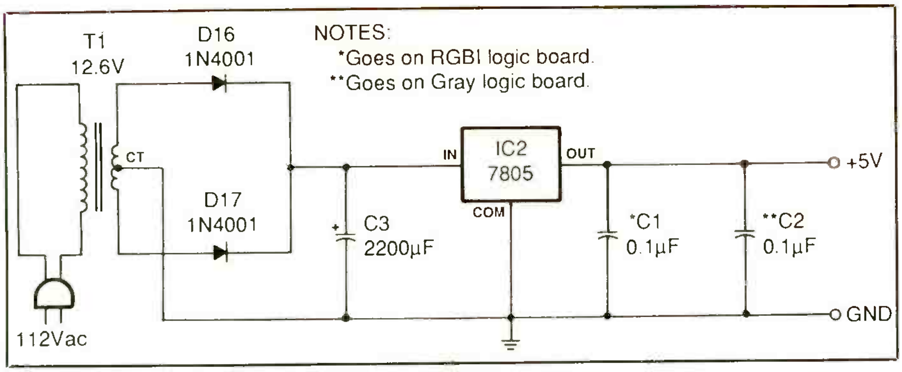


Fig. 2. Schematic diagram of a simple ac-operated dc power supply for project.

put of the gate to which it's connected will be low. In either case, at least one of diodes *D10*, *D11* or *D12* will conduct, pulling the voltage at the base of *Q4* below the level for conduction and disabling the gray logic.

The circuit for a suitable 5-volt power supply is shown schematically in Fig. 2. Power transformer *T1* should have a secondary rated at 12.6 volts (center-tapped) at 0.45 ampere. Diodes *D16* and *D17* rectify the secondary current, and capacitor *C3* filters out most of the ac ripple. Regulator *IC2* generates a fixed +5-volt output for delivery to the rest of the circuitry. Capacitors *C1* and *C2* help to immunized the circuitry against the effects of electrical spikes that may be coupled from the ac power line and should be mounted near the components in the RGB and gray-logic circuitry.

Construction

All components, except *IC1*, are available from Radio Shack stores. The Parts List gives the Radio Shack catalog numbers in parentheses after each available item. The 7402 TTL quad NOR gate specified for *IC1* can be obtained from many mail-order suppliers. A 4001 CMOS NOR gate (Radio Shack Cat. No. 276-2401) can be used for *IC1*, but its greater propagation delay will result in a vertical black bar several pixels wide at the left edge of a displayed gray block. Even with the very short propagation delay of a 7402, a thin black vertical bar will be seen, though it isn't particularly noticeable. (Note: the pinout of a 4001 differs slightly from that of a 7402. The connections to pins 1 and 3, and 11 and 13, must be reversed if you use this CMOS part.)

Printed-circuit boards are recommended for the RGB and gray-logic circuitry, although other construction methods can be used. In Fig. 3 are shown the actual-size etching-and-drilling guides for the pc boards so that you can fabricate them yourself. When the boards are ready to be populated, refer to the wiring guides shown in Fig. 4 for component installation.

Begin construction by wiring the RGB board, using guide (A) in Fig. 3. Start with installation of the resistors, capacitor and diodes, taking care to properly orient the latter before soldering their leads into place. Note that the resistors and diodes mount on-end to conserve board space. Next, install the three transistors, taking care to properly base them before soldering their leads into place. Finally, install and solder into place the six pc-mount trimmer controls and set them for about mid-rotation. Temporarily set aside this assembly.

Wire the gray-logic board next, referring to guide (B) in Fig. 3. Begin wiring it by installing and soldering into place the socket for *IC1*. Do *not* plug the IC into the socket until you've conducted preliminary voltage checks and are certain that your wiring is correct. Next, install the resistors, capacitor and diodes (watch polarity with the last), followed by the transistor (watch basing). Temporarily set aside this assembly as well.

Now wire the power-supply board, referring to guide (C) in Fig. 3. Make sure that *all* components on this board are properly polarized and based before soldering their leads into place.

You can house the project in any enclosure that will comfortably accommodate the three circuit-board assemblies and power transformer. For the prototype, the author used a 5″ × 2¾″ × 2″ aluminum chassis box. Though this size enclosure

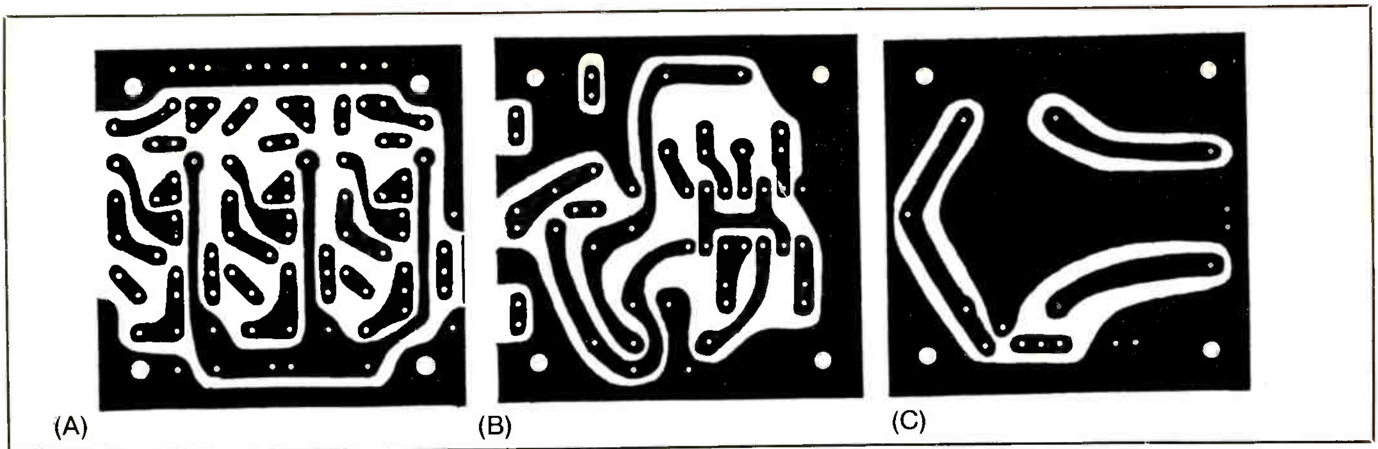


Fig. 3. Actual size etching-and-drilling guides for (A) RGBI, (B) gray-logic and (C) power-supply boards).

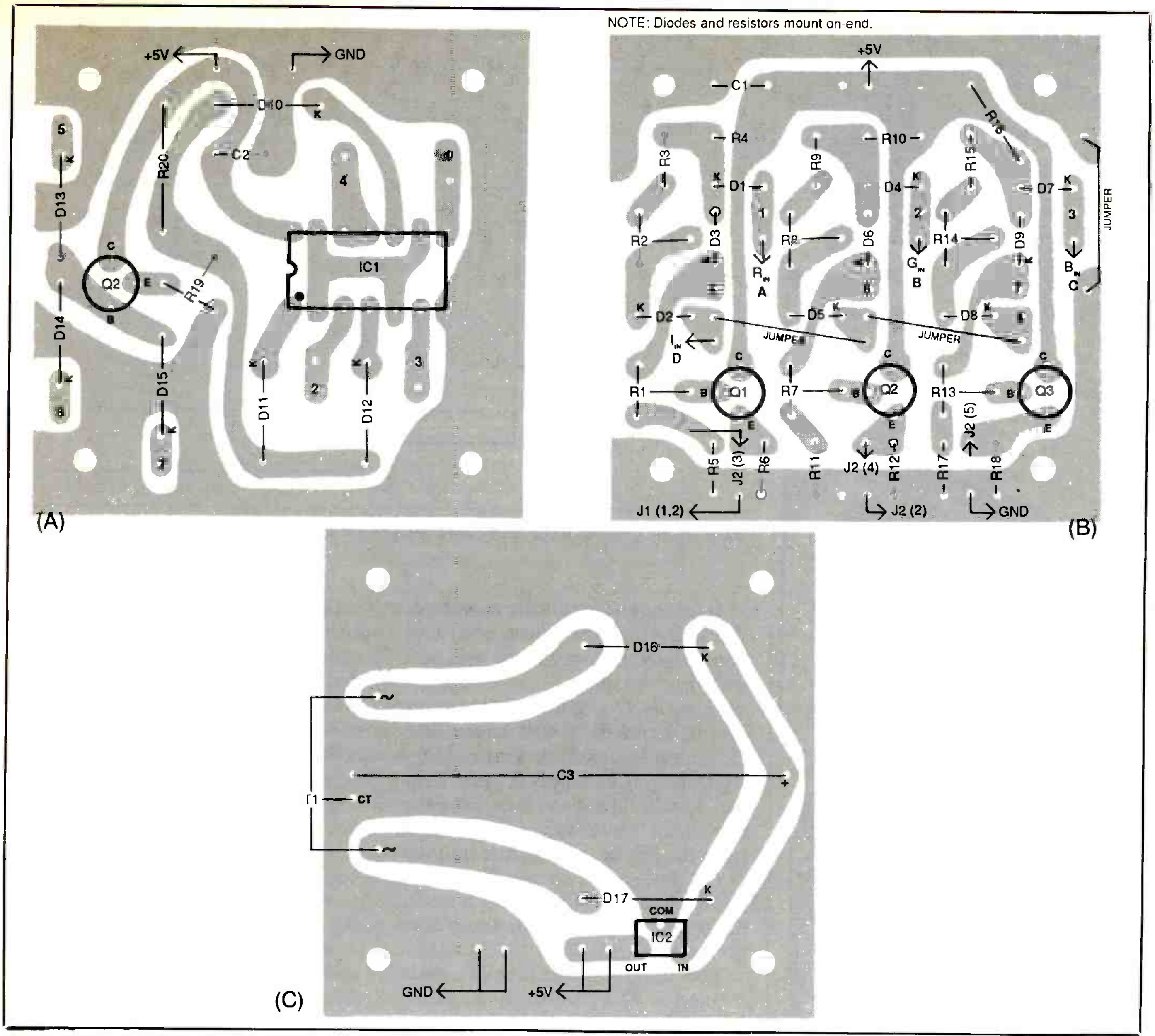


Fig. 4. Wiring guides for (A) RGBI, (B) gray-logic and (C) power-supply boards.

might appear to be too small, it's more than adequate if you stack the RGBI board on top of the power-supply board with spacers of adequate length between the two and mount the gray-logic board and transformer beside the stacked boards.

Referring back to Fig. 3, note that single-numbered holes are wiring references. When you wire together the circuit elements, match the numbers—1 to 1, 2 to 2, etc. Also match +5V and GND.

Strip ¼" of insulation from both ends of 15 4" lengths of hookup wire. If you use stranded wire, tightly twist together the fine conductors at both ends and sparingly tin with solder. Plug one end of 13 of these wires into all *numbered* holes in RGBI board (A) in Fig. 4 and solder into place. When you're done, the only holes still vacant on this board should be those labeled R_{in}, G_{in} and B_{in}, into which you should plug solder posts and solder them into place.

Plug the free ends of the +V and GND wires coming from the RGBI board into the same-numbered holes in power-supply board (C) in Fig. 4. Solder both connections. Set aside this assembly.

Now machine the enclosure. Start by drilling mounting holes for the circuit boards and power transformer. You need four holes for the RGBI/power-supply board stack and two holes for the gray-logic board. Next, cut a slot and mounting holes for *J2*. Finally, drill entry holes for the ac power cord and input cable. When you're done, deburr all sharp edges, and line the last two holes with rubber grommets.

Mount the power transformer in place. Then route the ac power cord through its grommet-lined hole and tie a strain-relieving knot in it about

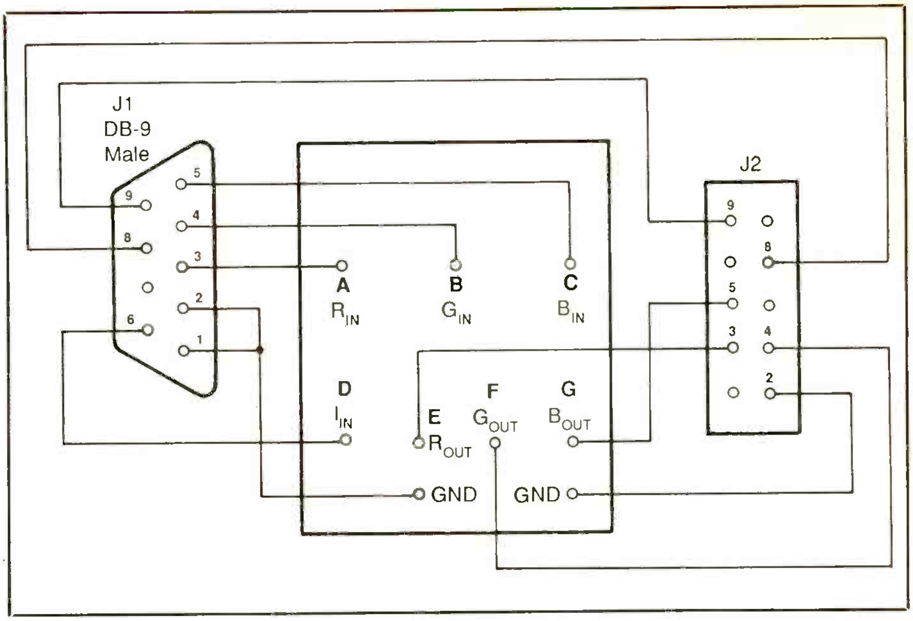


Fig. 5. Wiring details for input and output jacks.

3″ from the end inside the enclosure. Twist together the power-cord and transformer *primary* leads and follow with wire nuts.

Plug the free ends of the wires coming from the RGBI board into the same numbered holes in gray-logic (B) and power-supply (C) boards in Fig. 4 and solder into place. Plug the secondary center-tap wire coming from the power transformer into the T1 C.T. hole and two remaining secondary leads into the T1 SEC. holes in the power supply board, and solder the connections.

You can fabricate nine-pin male connector *J2* by soldering 22-gauge bare solid wire to the foil of a piece of pre-drilled printed-circuit board. Make sure the wires protrude from the component side of the board far enough to fully seat in the female connector on the monitor cable and solder them securely to strips of foil.

Mount *J1* in its slot. Then assemble and mount into place the RGBI/power-supply-board stack using 1″ spacers between the board assemblies and ½″ spacers between the power-supply board and enclosure, using appropriate 4-40 machine hardware. Use small L brackets and machine hardware to mount the gray-logic board beside the dual-board stack.

At this point, you should make voltage checks on the circuit before completing assembly. Note that *IC1* should *not* be in its socket at this time.

Clip the common lead of a dc voltmeter or multimeter set to the dc-volts function to a convenient point that's supposed to be at circuit ground. Plug the ac line cord into an ac outlet and verify that you have the following at the points indicated:

+5 volts at the OUT pin of *IC1*;

+3.5 volts present at junctions *R3/R4*, *R9/R10* and *R15/R16*;

+2.9 volts present at junctions *R1/D3*, *R7/D6* and *R13/D9*;

+1.5 volts present at junctions *R1/R5*, *R7/R11* and *R13/R17*;

+0.9 volt at the emitter of *Q1*, *Q2* and *Q3* with *R1*, *R7* and *R13*, respectively, set for minimum output;

+2.3 volts at the emitter of *Q1*, *Q2* and *Q3* with *R1*, *R7* and *R13*, respectively, set for maximum output.

+3.5 volts at the *R19/R20* junction.

The voltage at the emitter of *Q4* should vary between 0 and +2.9 volts as you adjust the setting of *R19* from stop to stop.

If you fail to obtain any one or all of the above readings, immediately power down the project and rectify the problem. When you're certain that your wiring is correct, power down again and allow the charge to bleed off *C1*. Then plug *IC1* into its socket. Make sure it's properly oriented and that none of its pins overhang the socket or fold under between the IC and socket.

Wire connector *J2* to the RGB

board as shown in Fig. 5, using the wires you already installed with you assembled the circuit board.

Still referring to Fig. 5, wire the input cable to DB-9 connector *J1*. You need seven conductors for this cable, preferably with the insulation on each conductor a different color. Length depends on your particular needs. You can use individual conductors that you loosely twist together or a multi-conductor cable with plastic outer jacket. If you use the latter, cut away and discard 1" of the outer plastic jacket from both ends of the cable.

Strip ⅛" of insulation from the conductors at the connector end and ¼" from the circuit end of the cable. Tightly twist together the exposed fine wires in each conductor at both ends of the cable and sparingly tin with solder. Work fast to avoid excessive charring of the insulation.

Solder the individual conductors to the DB-9 connector, again working quickly to avoid charring the insulation. Make certain that you jumper together pins 1 and 2 as shown.

Route the other end of the cable through its grommet-lined hole into the enclosure and secure it in place with a plastic cable tie. Crimp the conductors coming from pins 3 through 6 of the DB-9 connector to the solder posts in holes A through D, respectively, as shown. Then crimp the conductor coming from pins 1 and 2 to the solder post in the GND hole. Solder all four connections.

Finally, wire the two remaining conductors coming from *J1* to the indicated pins on *J2*.

Final Adjustment

You need a multi-color display to make final adjustment of the project. Create a text file as follows:

esc[0,31mblue	esc[1mBLUE
esc[0,32mgreen	esc[1mGREEN
esc[0,33mcyan	esc[1mCYAN
esc[0,34mred	esc[1mRED
esc[0,35mmagenta	esc[1mMAGENTA
esc[0,36myellow	esc[1mYELLOW
esc[0,37mwhite	esc[1mWHITE
esc[0,30mblack	esc[1mGREY

where ESC is escape character hex 1B (decimal 27).

With ANSI.SYS installed (listed in CONFIG.SYS on boot-up), type the above file. Lower-case letters will be of normal intensity; upper-case letters will be bold. Connect the adapter and analog monitor to the computer. Adjust *R1*, *R7* and *R13* for intensities that approximate bold characters on an RGBI monitor. When all are finely adjusted, bright white should be paper white with no tinting.

Adjust *R2*, *R8* and *R14* for intensities that approximate normal on an RGBI monitor. Final adjustment should result in a low-intensity white that is also untinted. Finally adjust *R19* so that gray is barely visible. At this point, some tweaking of the adjustments can be done by viewing a graphic display that includes patches of gray.

If any problems occur when performing any of these tests, check for faults such as solder bridges, poor solder joints and improper connection of interconnecting leads.

Construction of this adapter isn't particularly difficult. Anyone with basic assembly skills should be able to produce a working unit the first time out. ■

Compression and Decompression Methods

Hardware and software products that let you as much as double the capacity of your hard disk

Imagine that you've painted a picture with a super VGA card in 16-color, 1,024 × 768-pixel mode. If you want to save the picture, you might think of reading the color number of each pixel and writing that number as a one-byte data entry in a file. Your finished file will be 768 × 1,024K or 768K long. If you save a couple of dozen pictures, your hard disk will soon be full.

What you need is some way to compress the data in the file, and there are dozens of techniques that will help. One approach would be to realize that the possible color values range from 0 to 15; so each can be represented in only four bits or half a byte. You can easily pack two color values into each byte and make your file half as large: 384K.

But now imagine that your picture is simply a screen of blue. You can describe it in a few words as "786,432 blue pixels," but it still takes a 384K file to hold the picture. Obviously, at least in this case, your file storage technique is inefficient.

The problem of finding efficient storage methods for files of all kinds is both difficult and intriguing. Most files, and especially text, data and image files, contain a large amount of "redundancy." Although redundancy is a complex mathematical concept, you can generally think of redundant material as being predictable. If there's redundancy in a file, it's possible to predict, with better results than pure chance, what each byte will be.

English contains a large amount of redundancy in both its written and spoken forms, as do most other languages. For example, a text file is likely to contain more Es than any other letter and very few Zs. If you simply guess "E" for each letter in a text file, you'll be correct more often than if you used a 26-sided die to guess each letter.

If you look at pairs of letters, you can see other redundancies. A "Q" in a text file is almost certain to be followed by a "U" (unless you're reading a news report about Iraq). Also, a period will be followed by a space more than by any other character. There are many more redundancies as well.

Once you leave the realm of "most text files" or "most image files" and concentrate on a single file, the amount of redundancy becomes even clearer. For example, even if a text file includes word-processor formatting marks, it probably won't contain all 256 possible byte values. And most image files don't contain all possible color values, especially files created for eight-bit (256 colors) and higher color systems.

If you can remove the redundancy from a file, you'll end up with a smaller file that contains the same information. If you could remove all the redundancy from all files on your hard drive, you could effectively double its capacity, according to some estimates. And if you remove redundancy from files that are transmitted by modem, you can cut transmission times (and phone bills) significantly and double the effective bandwidth of your phone line.

These considerations have led several companies into the business of file compression. There are hardware devices and software programs that will compress image files, general files and even an entire hard disk.

The most popular software programs can also combine compressed files into special libraries, so that you can keep (and transfer) all related files together. And some can turn the compressed library into an executable (.EXE) file that create the original, decompressed files automatically when it's run.

Another advantage of combining compressed files into a library is that you reduce the amount of inevitable disk "slack space" or waste. DOS computers store data in clusters that can range in size from 2 to 32 sectors, or 1,024 bytes to 16,384 bytes. All files use a whole number of clusters, regardless of real length. A one-byte file on a 32-sector-per-cluster filing system will take up 16,384 bytes of disk space and, as a consequence, waste 16,383 of those bytes!

On average, you waste about half a cluster per file. On my system, clusters contain 2,048 bytes each and I have 9,298 files at the present time. I expect to waste 2,048/(2 × 9,298) bytes of space, or just over 9.5M. According to one utility, the files on my hard disk are actually wasting about 10% more than that.

But when files are combined in a library of compressed files, only the total library, not each individual file, wastes "slack" space. If you combine files into libraries, even if they aren't compressed at all, you can recover a lot of unused disk space.

Selecting a Product

Many compression products are available. One of the newest, and most interesting, is a combination of

hardware and software called Stacker. This product creates a huge compressed library on your hard disk of everything on the disk. It makes the compressed library of files appear to be a new hard disk to DOS and all your software.

Every time DOS or a program writes to the disk, Stacker intercepts the write and compresses the data before putting it on the disk. Whenever a program reads from the disk, Stacker intercepts the read and uncompresses the data before passing it on to DOS or the program. The hardware board contains a special processor that speeds up the compression and decompression process, but you can also purchase a software-only version of Stacker that works with software alone.

I've used a Stacker processor board in one computer for several months and found it compatible with everything from Microsoft *Windows* to file-recovery programs. It does slow down the computer noticeably during disk-intensive operations like copying files from one directory to another. Otherwise, it doesn't seem to interfere with the computer's operation at all.

Stacker has added about 70%, or 110M, to my 160M hard-disk's capacity. The amount of extra space that you'll get with Stacker (or any compression hardware or software) depends on the types of files you have. Executable files, files that have been encoded for security reasons and pre-compressed image files (like those in the .GIF format) generally have a low redundancy and can't be compressed much at all. On the other hand, text, database, spreadsheet and program source code files can often be compressed to 50% or less of their original size.

Traditional compression programs take a completely different approach than Stacker. They let you name, usually with wild cards, a list of files that you want to compress and put into a library. The compression program then compresses each file and puts it in the library.

If you look at the library with a file viewer, the original name of each file will appear, but everything else will look like random bytes. And it should—the less redundancy there is in a file, the more it should appear as random information.

The first really popular compression program was ARC from System Enhancement Associates (SEA). Originally distributed as shareware, ARC in its many forms is now only sold commercially. One form, called *ZARC*, runs as a *Windows* application. It combines many features of the *Windows* File Manager and can search for data and files within .ARC libraries of compressed files. The other major product from SEA is called *ARC+PLUS*. It runs under

Using PKZIP and PKUNZIP

PKZIP and *PKUNZIP* are probably the most popular compression and decompression programs available, but they aren't easy to use at first. The manual included with them is more technical than helpful, and the help screens they display are meant more for experienced users than neophytes.

Both programs are distributed in a single, self-extracting file. Once you run this program (called PKZ110.EXE on CompuServe), the programs, manual, registration form and other files appear on your disk. You might want to create a temporary subdirectory, move PKZ110.EXE into it and run it there to keep all related files together.

If run *PKUNZIP* to uncompress a file, you might first try this command:

```
PKUNZIP
```

PKUNZIP will notice that you've typed its name alone on the command line and displays the screen shown in Fig. A.

Before give up and look for something easy to do, like programming your VCR, you must realize that most of that screen describes options you may never need. The first line after the copyright information—labeled "Usage:"—tells you that you must put the command PKUNZIP and name of a zipfile on the command line. Everything else is in square brackets, which means that it's all optional.

If you have a file named ABC.ZIP to uncompress, you type the command:

```
PKUNZIP ABC
```

This assumes that PKUNZIP.EXE is in the current directory or is available on your search path and that ABC.ZIP is in the current directory.

PKUNZIP would be powerful enough if it stopped there, but it has several other capabilities you can select by adding switches and other information on the command line. Each optional switch begins with a hyphen, and it's the list of options that makes the help screen look so intimidating.

If you want to see the names of files in the .ZIP library, the last option, "-v" or view, is the one to choose. Try typing in the following:

```
PKUNZIP -v ABC
```

or, if you want to see the list sorted by name, use the command:

```
PKUNZIP -vn ABC
```

The other options are just as easy to use. If you want to extract just the .DOC files, use the command:

```
PKUNZIP ABC *.DOC
```

When you want to create your own .ZIP library files, you'll face the same kind of confusing screen when you run *PKZIP*. This is illustrated in Fig. B.

Most often, you'll want to compress files and add them to a .ZIP file (or create a new zip file for them). If you want to compress all files in the current directory and put them into a zipped file called ABC.ZIP, use the command:

```
PKZIP -a ABC *.*
```

You can use other options to do things like add comments about each file to the .ZIP file, view the contents of a .ZIP file in a number of different ways and have *PKZIP* collect files for compression from both the current directory and all its subdirectories. I use the "-a" option to add files and the "-v" option almost exclusively, but I've also found the "-f" option to be very handy at times.

If you collect some files into a .ZIP file and then update the originals, you'll probably want to update the files inside the .ZIP file. The easiest way is to let *PKZIP* do it for you by using the "-f" option. *PKZIP* will compare every file in the .ZIPped library with its original, uncompressed counterpart (if it's available). If the uncompressed version has been updated since it was added to the library, *PKZIP* will compress the up-

```
Usage: PKUNZIP [options] zipfile [d:outpath\] [file...]
Options summary - consult the PKWARE documentation for additional information
   -c[m] = extract to screen [with more]       -t = test zipfile integrity
   -d = create directories stored in ZIP       -l = display software license
   -n = extract only newer files               -o = overwrite existing files
   -q = enable ANSI in comments                -s<pwd> = unScramble with password
   -f = extract only newer & existing files    -$ extract volume label if in ZIP
   -p[a,b,c][1,2,3] = extract to printer [Asc mode,Bin mode,Com port] [port #]
   -<j|J><H,S,R> = | j=mask | J=don't mask | Hidden/System/Readonly attributes
   -e[c,d,e,n,p,s] = extract files in CRC/Date/Ext/Name/Percentage/Size order
   -v[b,c,d,e,n,p,s,r] = view ZIP(s) [Brief listing/sort by CRC/Date/Ext
     /Name/Percentage/Size/sort Reverse (descending) order]
zipfile = ZIP file name, wildcards *,? ok.  Default extension is .ZIP
file    = Name(s) of files to extract. Wildcards *,? ok. Default is ALL files.

If you find PKUNZIP fast, easy, and convenient to use, a registration of $25
would be appreciated.  If you send $47 or more you will receive, when
available, the next version of the PKZIP, PKUNZIP, and PKSFX programs.
Please state the version of the software that you currently have.  Send
check or money order to:    PKWARE, Inc.
                            7545 N. Port Washington Rd.
                            Glendale, WI 53217
```

Fig. A. Opening screen displayed after invoking PKUNZIP.

dated version and put it in the library in place of the older version. Automatically thereafter, every file in your .ZIPped file will be up-to-date.

Most of the other switches are useful for advanced situations. All are described in the *PKZIP* manual and addendum, both of which will be on your disk after you've run the self-extracting distribution file. But don't let the many options intimidate you; you'll need only a few of them to find that a compression program may be one of the most important utilities on your hard disk.

```
Usage: PKZIP [-b[path]] [options] zipfile [@list] [files...]
Options summary - consult the PKWARE documentation for additional information
   -x<filespec|@list> = eXclude filespec(s)                -z = add zipfile comment
   -d = delete files              -f = freshen files       -i = add changed files
   -l = display license info      -u = update files        -m[u,f] = move files
   -a = add files                 -b = create temp zipfile on alternate drive
   -c = add/edit file comments    -C = add comments to new files only
   -k = keep same ZIP date        -o = set ZIP date to latest file
   -q = enable ANSI comments      -s<pwd> = Scramble files with password
   -r = recurse subdirs           -$[drive] = save volume label
   -t[mmddyy] = Compress files on or after specified date (default=today)
   -e[x,i,s] = use maXimal compression/Implode only/Shrink only
   -<p|P> = store pathnames | p=recursed into | P=specified & recursed into
   -<w|W><H,S> = | w=include | W=don't include | Hidden/System files
   -<j|J><H,S,R> = | j=mask | J=don't mask | Hidden/System/Readonly attributes
   -v[b,c,d,e,n,p,s,r,t] = view ZIP [Brief listing/show Comments/sort by -
     Date/Ext/Name/Percentage/Size/sort Reverse/Technical (long) listing]
zipfile = ZIP file name.  Default extension is .ZIP
file    = Names of files to compress. Wildcards *,? ok. Default is ALL files.
@list   = listfile containing names of files to add or view etc.
Press any key to continue
If you find PKZIP fast, easy, and convenient to use, a registration of $25
would be appreciated.  If you send $47 or more you will receive, when
available, the next version of the PKZIP, PKUNZIP, and PKSFX programs.
Please state the version of the software that you currently have.  Send
check or money order to:    PKWARE, Inc.
                            7545 N. Port Washington Rd.
                            Glendale, WI 53217
```

Fig. B. Opening screen displayed after invoking PKZIP.

DOS, but other versions are available for mainframe and minicomputers as well. *ARC+PLUS* uses the same compressed-file format on all supported computers, which makes it popular for companies that have to transport data between machines.

The most popular shareware compression programs are from PKWare. The flagship program is *PKZIP*, which creates a library of compressed files with a .ZIP extension. A large majority of files available for downloading from bulletin boards and information services, as well as many shareware disks, are compressed with *PKZIP* to conserve space.

To uncompress a .ZIP file, you will need *PKUNZIP*, which creates uncompressed files from the compressed files inside a .ZIP library. *PKZIP* and *PKUNZIP* are available from virtually every information service and BBS in the country, along with a companion program that produces self-extracting files.

Two other programs from PKWare also deserve mention. *PKLite* compresses executable (.COM and .EXE) programs but leaves them in executable form. When you run one of the compressed programs, it decompresses itself in memory and then runs as usual. Except for a very short pause while the program decompresses itself, you'll hardly ever know that you're running a specially compressed file. *PKLite* works well on all programs except those that save configuration information into their own .EXE image on disk.

Another PKWare shareware program is *PKMenu*, which serves the same purpose as *PKUNZIP*. The advantage of *PKMenu* is that it has a point-and-shoot menu that's easier for novices to use and understand.

The newest popular compression product is a freeware program from Japan called *LHA*. Like the PKWare products, *LHA* is available from almost every information service and BBS, as well as from shareware dealers. *LHA* creates libraries of compressed files much *PKZIP* and *ARC+PLUS* do. It gained popularity because it was one of the first programs that could create a self-extracting library file. The self-extracting feature was popular with people who wanted to distribute compressed files to others and didn't want to worry about whether the recipients had the correct program (or the correct version of a program) to uncompress the files. Many software vendors utilize *LHA* to reduce the number of diskettes they have to include in each package.

With the exception of the *Windows*-based *ZARC*, all compression programs are about equally easy to use, or equally difficult to use, depending on your point of view. The power of the programs is in their compression abilities, not in their user interface, which tends to be nearly nonexistent. These programs are command-driven, which means that you start them and give them a command all on the DOS command line, not from menus or fancy file lists. For example, if you want *PKZIP* to compress all .DOC files in the current directory and put them together into a library, you'd type something like this:

```
PKZIP -a DOCFILES *.DOC
```

Even though this may seem archaic and awkward in an age of *Windows* and "mousey" DOS shells, it means that you can accomplish quite a lot very quickly. The Using *PKZIP* and *PKUNZIP* box accompanying this article explains the many options available with *PKZIP* and *PKUNZIP*. One quick glance should convince you that these are very powerful programs.

Uncompressed files are great when you're actively working on a project. Unless you have Stacker or one of its competitors installed to automatically compress everything that goes on your disk, you probably don't want to decompress and recompress your database every time you want to look something up or change someone's address. But you don't have to let redundancy and slack space from archives and rarely-used files eat up your disk space and modem time, either. If you haven't started compressing and organizing libraries of files, get yourself a compression program and discover how much free disk space you really have. ■

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Double Heath/Zenith Memory Without an Extra Plug-In Board

A new PAL and some 256K chips give Z-150s and 160s a full 640K memory without an extra expansion board or circuit modification

Some eight years ago, Zenith Data systems and its Heath Company arm moved into the computer fray with both legs. That is, they finally embraced IBM's *de-facto* standards instead of producing an MS-DOS system that was uniquely their own. As a result, standard MS-DOS applications software could be used with it without being specially tweaked. It also meant that users could now buy discounted software from any mail-order house instead of being locked into purchasing from the computer's parent.

Z-150 and 160 models were among their new truly IBM-compatible offerings, which at that time were 8088 or 8086 microprocessor-based computers that operated at 4.77 MHz. A color graphics adapter (CGA) provided color or monochrome display with the appropriate video monitor. The 150-base models were desktop units, while the 160-base models were transportable ones, with a dual floppy-disk section on the top that popped up like a camper's sleeping quarters, and a built-in monochrome (amber color) monitor.

Heath/Zenith Z-160 flip-top transportable IBM-compatible computer is one of two candidates for upgrading as described in this article.

There are still plenty of both models in full use today. Though they're getting kind of clunky in terms of computing power, they're especially worthwhile upgrading due to many special features incorporated into them by H/Z engineers.

Some of you bought the dual 360K floppy-disk machine with options, such as a second memory-expansion card or a hard-disk drive. Most purchasers at the time didn't elect either. In this discussion, I'll talk about expanding RAM (read/write memory) if you didn't buy the expansion board or know how to maintain full memory on the first memory card while you throw away the second one and free up an expansion slot (which is always at a premium).

The H/Z models being discussed have eight expansion slots, by the way, compared to the IBM PC's five slots plus motherboard, for a two-slot advantage (H/Z uses one slot for the CPU circuitry, which accounts for the seemingly incorrect arithmetic). With 640K on only one board, however, that'll make it a three-slot advantage.

Although these models are, indeed, in the IBM-compatible category, they aren't clones by any means. Heath/Zenith put a lot of distinctive design engineering into the models that set them apart from IBM, much as Compaq did. For example, traditional clones maintained IBM's horizontally positioned main board that contained such basic system components as the microprocessor and expansion board connectors. This large board is attached to the chassis, with expansion boards mounted atop it at a 90° angle, plugged into the connectors. H/Z used a more-professional backplane system so that the system card inserts vertically into one of the backplane's 62-pin edge connectors just as any other card is mounted. The edge connectors are identical and are connected in parallel both electrically and physically.

"It's IBM-compatible, but not a clone by any means."

The result of this decision was to make any component changes on the CPU board a snap to do, at least mechanically. Making changes with an IBM or clone, one is forced to remove any number of expansion boards before getting to the system board. Moreover, to remove the IBM system board requires removing all expansion cards and unplugging power-supply connectors, among others, that are plugged into the system board. You also must remove one of the floppy drives that overhang the motherboard. Then you have to remove some screws and disengage plastic standoffs from mounting slots.

Among other appreciated H/Z engineering innovations are built-in diagnostic subroutines run from the keyboard that delve a lot deeper than diagnostic disks supplied at extra cost by other companies, if indeed they were available (H/Z supplied a diagnostic disk, to boot). Furthermore, the backplane board and CPU (central processing unit or microprocessor) card has a bevy of diagnostic LEDs that enable you to determine a host of faults without having to resort to test instruments. (The backplane has five LEDs and the CPU card has six LEDs.)

In other words, if you own one of these H/Z models, they're admirably suited to upgrading with more memory, hard-disk drives, speed-up boards and whatnot. It can be rewarding because they're not at all throwaways. Happily, there are many hardware changes that can be made bit-by-bit, as money becomes available. For only modest investments, the original models can be enhanced to match performance of many presently sold personal computers, while retaining H/Z's many outstanding attributes. Among the rewarding upgrades is our subject, memory expansion without using another expansion slot.

H/Z-150/160 User Memory

As I observed earlier, Heath/Zenith adopted IBM standards—but it didn't parrot them in areas where compatibility wasn't in question. User-memory configurations are a case in point. Where IBM/clones used a system board that had up to 256K of RAM (or 64K if it was an earlier model, the PC1) as well as the CPU, clock generator and other supporting chips, Heath's memory card has a maximum memory capacity of 320K (and a separate CPU card).

Great, you say? Not really, since third-party board makers produced memory boards where the biggest market was—384K-capacity boards (256K + 384K = 640K). Furthermore, RAM memory has to be contiguous; you can't leave gaps. Switches must be manually set on the CPU and memory cards to match the amount of memory installed on the system and expansion boards. (Today's 386 computer systems do this automatically.) Also, the system board has to be filled to its maximum RAM before expanding memory on another board. Remember, with DOS, user memory has to be contiguous; you can't leave blank blocks.

The switching system for IBM and clone memory expansion typically *starts* at 256K (or 64K or 512K, etc., but not at 320K, the H/Z requirement.) So you're locked into Heath/Zenith or one of a small handful of H/Z independent specialists for a memory-expansion board. This means more bucks for the product, naturally, since at best there aren't many such boards produced in comparison to IBM-standard types. And suppliers are harder to locate.

You can easily increase your existing 320K memory card to a full 640K (or 704K), however, by simply buying 18 256K integrated-circuit (IC) chips from a reliable dealer at the best price you can get, which today runs around $2 or so each plus postage for mail order. Retail stores typically charge more (New York's H/Z retail store charges in the area of $5 or $6 each).

You also need a new PAL (programmable array logic) chip for about $20 plus postage (H/Z charges $40 for its Software Wizardy ROM!). After substituting the new chips for ones already in the computer, you make a few memory-configuration switch adjustments and you're set. A simple step-by-step procedure shortly follows.

Should this move to a full 640K not satiate you, you can even get a super PAL that will enable you to squeeze 1.2 megabytes of memory onto the same single memory card that was holding 320K, giving you a large RAM disk. It's only ten bucks more than the standard new PAL device costs, to the delight of any memory-hungry devil. (It's supplied by Micronics Technology, 54 Dalraida Rd., Montgomery, AL 36109; tel.: 205-244-1597). Of course, you have to buy the memory chips needed to populate the board further.

The reason you need the new PAL is that you can't simply insert 256K-bit chips in place of existing 64K-bit chips on your memory board and be through with it. The existing traffic cop—the PAL device—controls what's on the address and data buses, picking and choosing from the memory banks. The original device (PAL 16L8) has been, alas, conditioned to control memory blocks and access of 64K ICs only. With 256K chips installed, it'll pick the wrong memory banks to work with. So changing this device is a given.

Doing It

Set yourself up properly before embarking on replacing integrated circuits such as the RAM and PAL you'll be working with. They're not especially prone to being destroyed by static electricity as are some other devices, but they can be if you build up a fair static charge and discharge them to the device.

There are all manner of counsel

"The basic 320K memory card can be expanded to 640K . . . or even 704K to take advantage of a 64K window in DOS reserved memory . . . or 1.2M to gain a RAM disk."

concerning the foregoing, including attaching yourself to the umbilical cord of a static-preventive wristband, using a slightly damp towel as a working mat and so on. Frankly, I don't use any of these, though I take some other precautions. I've never lost a device yet to static electricity, but I don't live in a very dry location either, and I employ a humidifier during winter months. Anyway, do keep in mind that static electricity is your enemy.

Before I start, I spritz some static spray around me and up my sleeves. Then I touch bare metal, such as the casing on the power supply. After that, I go full steam ahead, handling the devices and keeping in mind that I shouldn't rub my hands on my pants or through what's left of the hair on my head. Every once in a while, I touch the metal power-supply case again . . . just in case. It's best, too, to push the pins of ICs you'll be working with into a small section of conductive plastic foam or aluminum foil. To be especially safe, connect a jumper wire with clips to the foam and to the computer chassis.

For tools, I use a simple IC extractor that looks like a large tweezer, two screwdrivers (one with a small, thin blade and the other a medium-size blade), a medium-size Phillips screwdriver, small long-nose pliers and a multimeter (which I hope not to need). I try to get as much technical information as possible before I start the job, too. You won't be doing any soldering; so soldering tools aren't needed.

In the case of this upgrade, I had the original Heath/Zenith service data manual and a Sams *Computerfacts* data package at my side. I expect that all this data will serve me well as time goes on. The model I worked on was the Zenith ZFA-161, which was the transportable one with the handle that served to help lug it (not too far away) and as a tilt bail for the machine so that its built-in screen will be at the right angle for comfortable viewing.

Step-By-Step

Let's now run through the step-by-step procedure for performing the actual memory upgrade:

Step 1. Power up the machine to make sure everything is working well in the first place. Then park the hard disk-drive's head if you have a hard disk. Turn off power by pressing the POWER rocker switch (at the rear), and pull out the plug(s) attached to the ac line. Make absolutely certain that the computer isn't connected to the power line!

Step 2. Remove signal cables attached to the CPU card (keyboard connector) and memory card (parallel port printer cable).

Step 3. Now remove screws that attach the top cover to the main section. The transportable has four Phillips-head screws, the desktop model seven. Slide the cover toward the rear to clear the front panel lip and then up and off, and place it aside.

Unless you have the transportable model, you can ignore the remainder of step 3 and all of 4. Slide back the narrow-depth plastic liner that fills the gap between the transportable's floppy drives and the machine's front. Then pop up the dual-drive section by pushing forward the plastic slides on both ends of the front-top. Now push back on the two plastic leg supports that hold the drive(s) section up at an angle and tilt the whole unit toward the back of the computer.

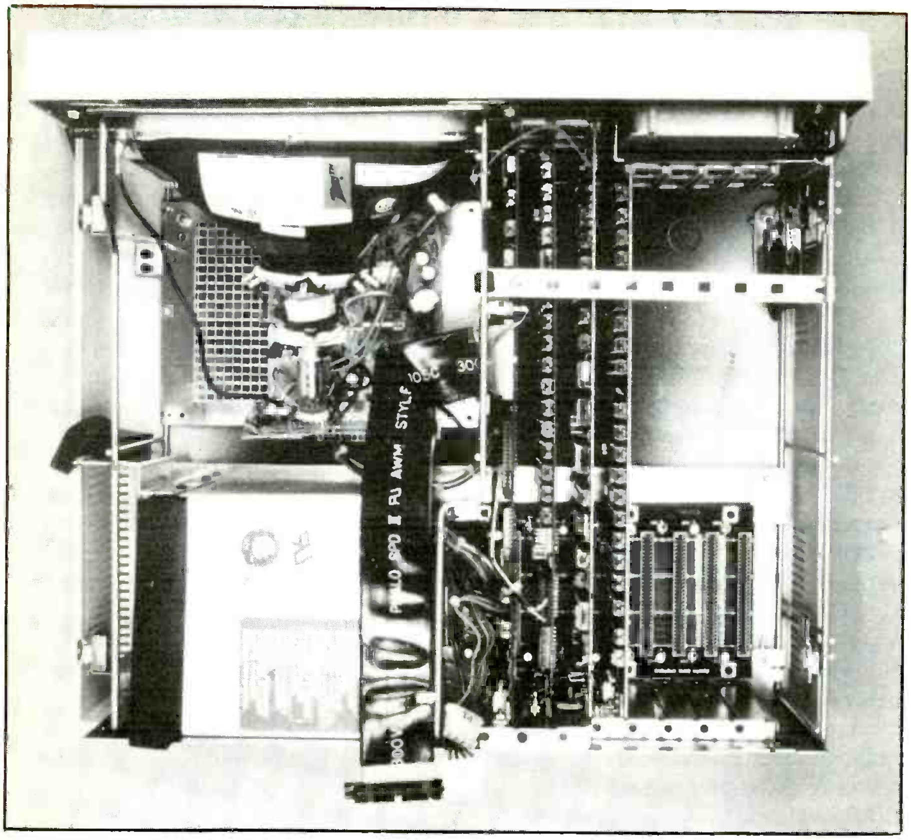
Step 4. You observe that two curved plastic pieces at the back of the drive section are fitted into two slots near the left and right rear-ends/top of the main unit's remaining case surround. Carefully hold the drive section upright. You'll see some large slots on the main chassis, at the rear, where some cables and connectors protrude and are attached to similar connectors and cable from the drive section. Propping up the drive section with your elbow (or a friend's helping hand), disengage the connectors.

There are two white plastic connectors. Each one, male and female end, are marked as P1 and P2 ("P" is for power) so that you'll put the right ones back together again. (If they're not marked, be sure to mark them so you won't have to depend on your memory.) Now there's a length of flat cable coming from the main chassis with a connector that plugs into a similar one from the drives. There's one more lead from the drive section (ground) that slides off a lug on the main chassis. Remove this, bend back the drive section slightly so that the plastic hinges are free, and lift up the drive section, placing it down in a safe spot.

Looking down at the exposed computer, you'll see a long bar of metal, about 3/40 wide, that runs across the top of the expansion cards to prevent them from working loose. One curved end is force-fitted to a metal rod, while the other end has a securing screw tightened against another rod. The bottom of the retainer bar is covered with foam rubber to absorb vibration when the computer is being transported. Remove the screw and pry the other end up and off.

Step 5. Locate the CPU card and unscrew its slot cover. Gently pull off the LED cable connected to it. Then carefully remove the card. To do this, you slightly push the plastic card supporter's retainer at the opposite side of the slot cover so that the card will slide past it. Then pull the card straight up and out, jiggling it a bit as you go to unseat it from the expansion slots.

Now you'll find CPU Switch 2, a small switch with eight on/off slide settings. For a 640K complement of memory chips, push the first switch to ON or to the right, the second to the left, the third and fourth to the



Removing floppy-disk drives and cover is first step in performing memory upgrade of Z-160 computer. This gives easy access to the computer's interior.

right, and the fifth to the left. That's RLRRL. Leave the remaining switches the way they are. Now reinstall the CPU board, securing its slot cover with the screw you had removed. One more step and you're finished with this board: plug in the LED connector that you originally removed. You can't make a mistake here, since the connector has a cutout groove and, therefore, can be inserted in only one direction.

Step 6. Remove the memory board now in the same way you did the CPU board. Check Jumper *J401* on the board (it's labeled to identify it). It has a plastic-covered jumper that shorts two of three connections, which two depending on whether it's positioned to short the first one or the second one. For your purpose here, the jumper should be on the second position. If it's not (the position is silk-screen marked as 1 or 2), simply pull up the shorting piece and move it to short the right-end (third protruding wire post) connector with the middle one by pressing it down atop the two.

Step 7. With this done, you're ready to remove some existing devices and replace them with the new ones you bought. Start by locating the PAL chip, which is the IC in the U455 socket. Before commencing, have your IC at the ready and touch some metal on the computer in the event you've stored up some static electricity. Using an IC extractor or a thin-blade screwdriver, gently pry up the integrated circuit with a gentle rocking motion while pulling upward if you use an extractor. You'll be moving one end up a bit first, then the other end, and so on, until the whole device can be lifted up and out. Try to do the same if you're using a thin-blade screwdriver.

Do observe that the IC has a dimple or notch or a painted-on circle at one end. The new device will have the same or similar sort of identification that directs you to position the device in that direction. If the notch is at the top end of the socket, then the new device must be installed the same way. Otherwise, you'll likely destroy the device when you power up.

Remove the PAL device and set it aside, preferably on a surface like conductive foam. Now take the new PAL IC, whose pins are probably set in a static-preventive material, and start inserting it into the PAL socket. Make sure that the IC's notch is pointed the right way.

Everyone's got his own technique to insert an IC. I first position the device over the socket pins and gently push down a bit, checking both sides to make sure that the pins are positioned to go into the socket holes. Sometimes the device's two rows of pins are a bit too wide. If this is the case, you can hold the device and gently press one row of pins inward just a bit. Then check pin alignment in the socket again. When all seems in order, softly press down on the body of the device, continuing the pressure until it's firmly seated. Examine both sides, holding the board up, to be certain that all pins are in their respective socket holes.

Some people recommend that the IC pins at one end be started into the socket first; others say that one row should be positioned first. But I do it in one fell swoop using my thumb in the middle of the device's body.

Step 8. With the foregoing under your belt as a practice run, you're ready to remove and install a bunch of memory chips. To expand your system from 320K to 640K you should have gotten 18 256K-bit 100-nanosecond RAM chips. These are generally identified as 41256-100. They might also be identified as 256 × 1, 100 ns. However they're called by suppliers, you should know that prices on such dynamic RAMs are volatile.

With the memory board lying flat in front of you, you'll be removing three banks of nine 64K-bit chips. They're probably stamped as 4264-15 atop their dark bodies. One bank (Bank 4) will be left empty if you bought the PAL that handles 640K; the fifth will remain installed if you purchased a PAL that handles 704K (DOS will directly address only 640K; so the extra 64K will be for a RAM disk).

There are five banks total since bank numbering starts with 0 (zero). Each bank is identified with white silk-screened printing, so you can't mistake them. Start by removing all nine 64K devices in Bank 0, which is a bank of chips off to the left on the

(Continued on page 88)

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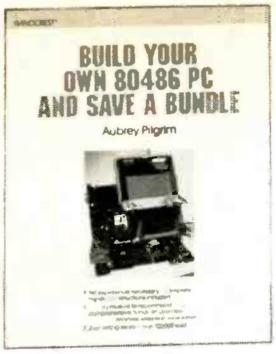

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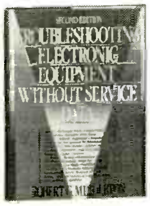

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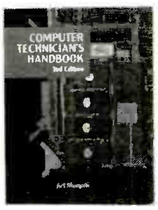

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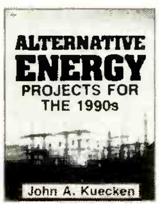

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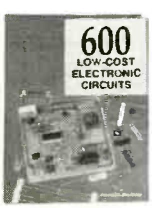

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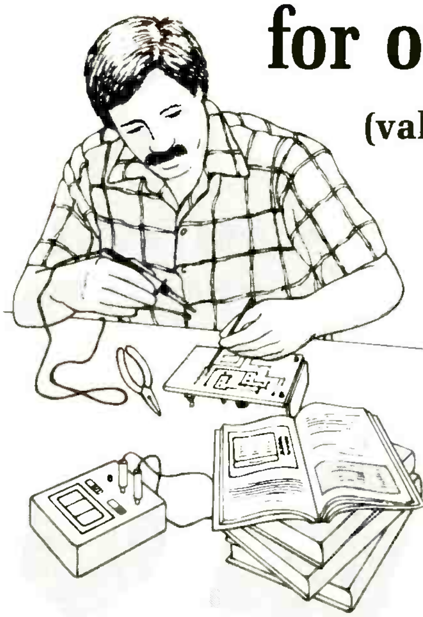

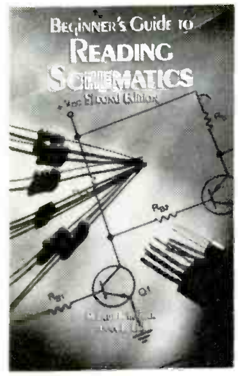

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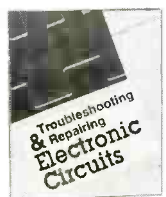

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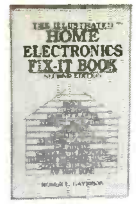

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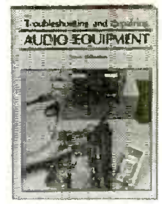
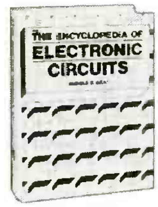
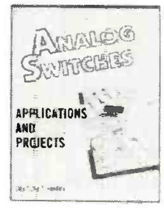


2867P $18.95



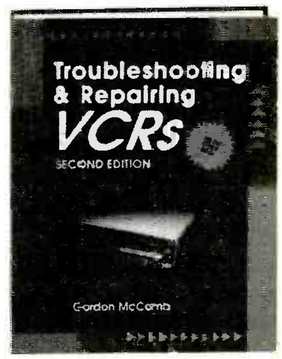
1938 $60.00
Counts as 3

2925P $9.95

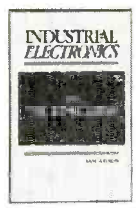


3445 $21.95

2995 $25.95

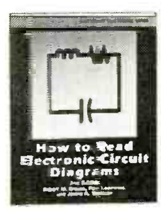


3777 $32.95
Counts as 2



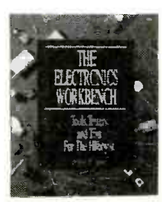
3321P $16.95

3241P $16.95



2880P $14.95

3345 $39.95
Counts as 2



3672 $28.95
Counts as 2

3475 $27.95
Counts as 2

MC68705 Single-Chip Microcontrollers

A close look at three members of this popular and versatile family of Motorola devices

Motorola's 6805 family of single-chip microcontrollers is one of the most widely used processor families on the market today. Because the 6805 is optimized for specialized controller applications, rather than for general-purpose data processing, it has become a part of everyday things like VCRs, printers, modems, toys and appliances.

There are currently 34 devices in the 6805 family. New ones are being added and old ones are replaced every year. Every device in the family has the same eight-bit CPU core. Therefore, if you can program one device, you can program any device in the family. All 6805 devices have some RAM, ROM, I/O and timer, though different devices have synchronous or asynchronous serial ports, analog-to-digital converters, EEPROM or EPROM.

In this article, we'll look at three members of the 6805 family: the 68705P3, 68705R3 and 68705U3. These devices are ideal for small control projects and can immediately be put to use with very little effort. They're currently available in single quantity for less than $17.

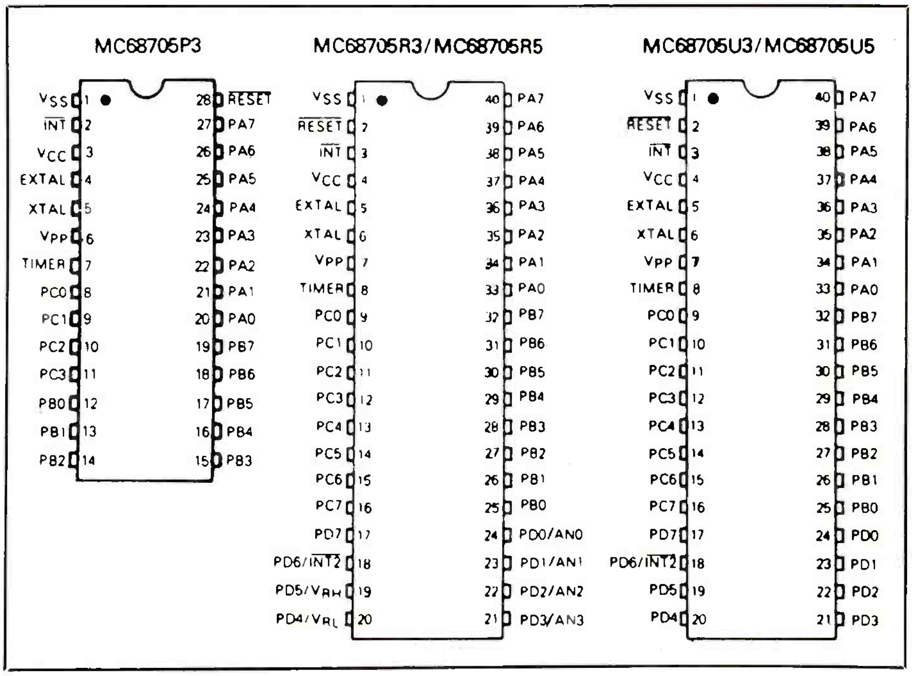


Fig. 1. Pinouts for (A) P3, (B) R3/R5 and (C) U3/U5 versions of Motorola's MC-68705 single-chip microcontrollers. (Courtesy Motorola Inc.)

The Details

Shown in Fig. 1 are the pinouts for the three Motorola microcontrollers that are the focus of this article. Table 1 compares their features. All three chips have built-in erasable EPROM, which permits them to be erased and re-programmed almost at will as the need arises.

Figure 2 is a block diagram of the 68705P3. This is the smallest of the three chips. To understand how this chip performs in an actual application, you should know a few things about it from the start. Therefore, let's discuss each section of this chip in turn.

• *Clock Oscillator*. The inputs labeled XTAL and EXTAL control the on-chip clock oscillator. A crystal normally connects to these inputs. However, a resistor or external signal can also be used if the correct option is set in the Mask Option Register (MOR). If this option is exercised, oscillator frequency must be between 0.4 and 4.2 MHz. A divide-by-4 circuit reduces the oscillator frequency to establish the chip's internal clock frequency.

• *Reset*. On power-up, the RESET input should be held low until the clock oscillator has had time to stabilize. Since the RESET input has an internal pull-up resistor, this can be done by connecting a 1-μF capacitor between RESET and ground.

• *Memory*. At first glance, memory in the 68705s may seem rather limited. Actually, there's plenty of memory for the type of job these chips are designed to do. Because 6805s are usually used in embedded control applications, they don't require large amounts of variable-data storage. Math-intensive algorithms are usually reduced to a set of precalculated solutions stored in EPROM.

Because the program counter is only 12 bits wide, maximum address space is $FFF. Figure 3 is the memory map for the 68705P3, the address space of which goes to $7FF (the R3 and U3 versions go to $FFF). All the available memory and I/O is easily accommodated in this memory space.

Table 1. Chip Features

	68705P3	68705R3	68705U3
Number of Pins	28	40	40
On-chip RAM (bytes)	112	112	112
On-chip ROM (bytes)	120	120	120
On-chip EPROM (bytes)	1,804	3,776	3,776
Bidirectional I/O Lines	20	24	24
Input-Only I/O Lines	0	8	8
A/D Converter	No	Yes	No
Timer	Yes	Yes	Yes
External Interrupts	1	2	2

Also, since there's no external address bus, there's no possibility of expanding memory.

Memory from $000 to $00F is assigned to the internal register area, as detailed in Table 2. This area consists of the registers used to control and monitor the on-chip peripherals.

RAM extends from $010 to $07F. The stack pointer is always initialized to $07F and can access the top 31 bytes of RAM.

• *I/O Ports*. Each bidirectional port is controlled by two registers. The Data Direction Register determines which lines are input and which are output. A 0 in a bit location makes that line an input, while a 1 makes it an output. All data direction registers are cleared when RESET goes low. The Data Register is used to both read input and write output data.

Port lines are designated by the letter "P," followed by the port letter and the bit number. Thus, PB2 refers to Port B, bit 2. Ports A and C pins have standard TTL drive capability; Port B pins can sink up to 10 milliamperes and source 1 milliampere.

Port D in the 68705R3 and U3 versions is input-only. This means that it has no Data Direction Register.

• *A/D Converter*. The analog-to-digital (A/D) converter in the 68705R3 is an eight-bit successive-approximation type. The lower 6 pins of port D are used as inputs to the A/D converter. Four analog inputs, PD0 through PD3, go to an internal multiplexer. Then 30 clock cycles after setting the desired multiplexer channel in the A/D Control Register, the result can be read from the A/D Register. Inputs PD4 and PD5 are used to set the high and low voltage for the ratiometric conversion. Normally, PD4 would be at ground potential (0 volt) and PD5 would be at +5 volts. Thus, an analog input of 5 volts would convert to $FF, 2.5 volts to $80, and so on.

• *Programmable Timer*. The timer is an eight-bit counter with a seven-bit prescaler. Desired output from the prescaler is selected with the Timer Control Register. The clock source that drives the prescaler can be the internal clock, an external signal applied to the TIMER input or the internal clock gated by a signal applied to the TIMER input. The eight-bit counter value is always accessible in the Timer Data Register. Whenever the counter reaches a value of $FF, an overflow flag is set, which can be used to generate a timer interrupt.

• *Interrupts*. The timer interrupt mentioned above allows the 68705 to

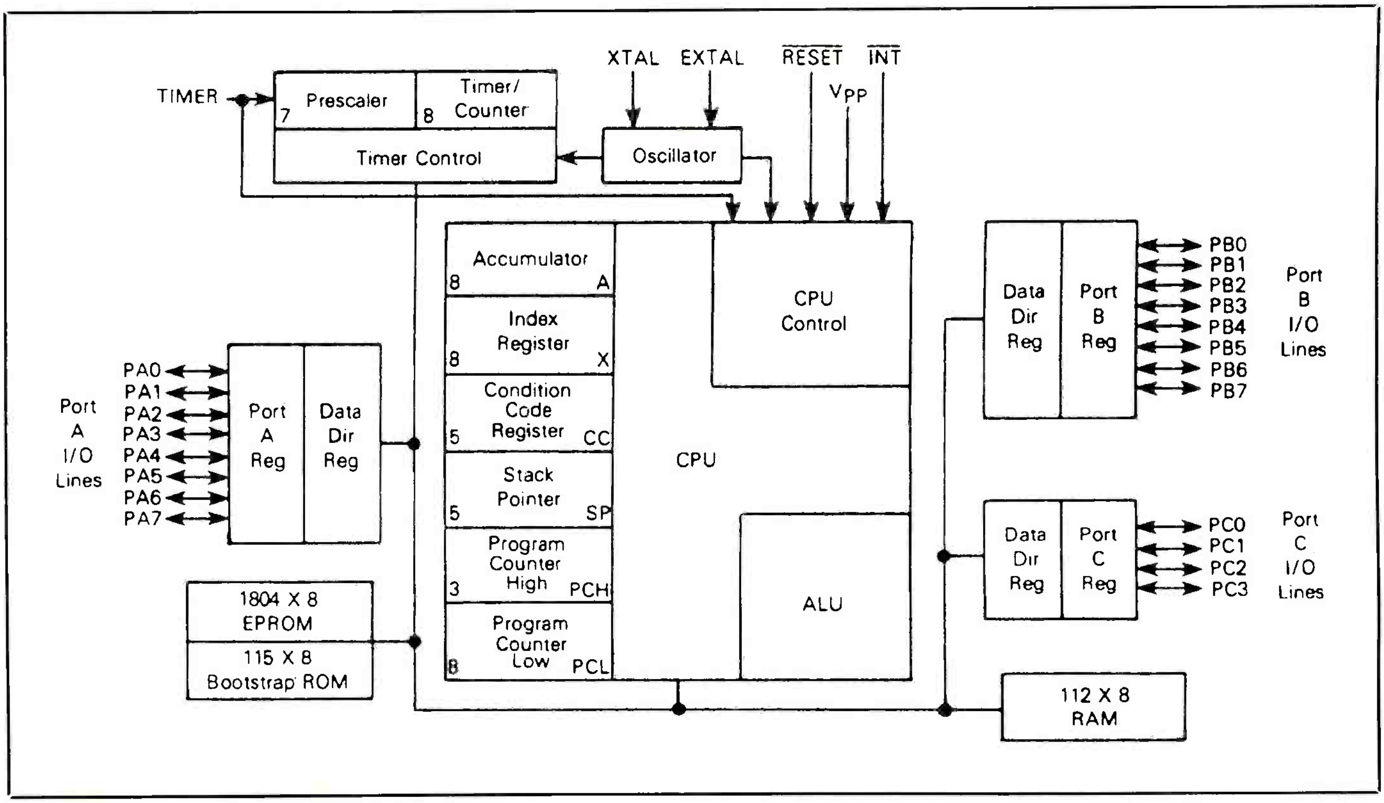


Fig. 2. Internal details of MC68705P3 chip.

(Courtesy Motorola Inc.)

execute a particular function after a fixed delay or at a specific time. The external interrupt (INT) permits quick response to events outside of the chip. Eleven clock cycles after INT goes low, the code pointed to by the external interrupt vector will start to execute. If INT isn't used, it should be pulled high through a resistor to +5 volts

• *Software*. Because memory space and speed of execution are usually

A 68705 Assembly-Language Example

To be able to effectively use the 6805 family of single-chip microcontrollers, you must know how to program them in assembly language. This isn't very difficult to do, as the following will demonstrate.

Listing 1 is a simple example of 6805 assembly language. Comments, like those in the first two lines of the program, begin with an asterisk. The next 11 lines are examples of the EQU or equate directive, which assigns a name to a numerical value so you can use the name in place of the value. For example, consider these two lines of code:

```
PADDR  EQU  4
CLR    PADDR
```

The first line assigns the name PADDR, for Port A Data Direction Register, to the value four. The second line clears the data at the address PADDR, in this case address $04. You can do the same thing with CLR $04, but using the name PADDR gives clearer meaning to the intent of the code. Equate directives are valuable programming tools because they help you create an environment that uses familiar names. However, they generate no executable code.

The next directive is ORG, or originate, which tells the assembler where code should be placed in memory. In this case, the code would be assembled to start at $0100, which is near the bottom of user EPROM. Hexadecimal values must begin with the $ character; otherwise, the assembler will interpret them as decimal.

Executable code is divided into two parts: an initialization section that begins at the label RESET, and a main program that begins at the label LOOP.

The initialization section starts by disabling all maskable interrupts. It then sets the stack pointer to address $007F, the top of the 68705's internal RAM. The next line clears the Port A Data Direction Register at address 00. The accumulator is loaded with the value FF. This instruction uses immediate addressing (#). Hence, the accumulator is loaded with the literal value FF, not the data stored at address FF. Finally, the accumulator is stored at Port B Data Direction Register, which sets all Port B bits to outputs.

The main program loads the accumulator with the data from Port A, complements it and stores the complement in the Port B Data Register. Since port B is all outputs, any value written to its data register immediately appears on the Port B pins of the 68705. Finally, the program jumps back to LOOP, which is the top of an infinite loop.

The interrupt vectors are the last part of the listing. There are four vectors, each a 16-bit address. The processor requires the vectors to be at the very top of the internal EPROM. The second ORG directive starts the vectors at the correct place. An FDB or Form Double Byte directive places a 16-bit value at the next two bytes in memory. For this example, all vectors are set to the label RESET (address $0100).

When power is applied to the 68705 a reset interrupt is generated and the vector at $07FE is fetched. In this case, address $0100 is fetched and the program begins to execute there. The initialization code runs, followed by the main loop. The processor continuously reads the data on Port A and puts out its complement on Port B.

When the source code is assembled using the freeware cross-assembler from Motorola, two files are created. These are illustrated in Listing 2, known as the listing file, and Listing 3, which is the S19 output file. The listing file contains the address and data assembled for each line of input followed by the original source code. The S19 file is an ASCII representation of the binary file that will be programmed into the EPROM section of the 68705P3.

Listing 1. Assembly-Language Source Code

```
* 68705P3 ASSEMBLY LANGUAGE EXAMPLE
*
PADAT   EQU   $0      *PORT A DATA REGISTER
PBDAT   EQU   $1
PCDAT   EQU   $2
PADDR   EQU   $4      *PORT A DATA DIRECTION REGISTER
PBDDR   EQU   $5
PCDDR   EQU   $6
CNTR    EQU   $8      *COUNTER DATA
TCSR    EQU   $9      *TIMER CONTROL AND STATUS REGISTER
PCR     EQU   $0B     *PROGRAM CONTROL REGISTER
STACK   EQU   $07F    *TOP OF STACK
MOR     EQU   $784    *MASK OPTION REGISTER
*
        ORG   $0100   *START OF EXAMPLE PROGRAM
RESET   SEI           *DISABLE MASKABLE INTERRUPTS
        RSP           *RESET STACK POINTER
        CLR   PADDR   *MAKE PORT A LINES ALL INPUT
        LDA   $FF
        STA   PBDDR   *MAKE PORT B LINES ALL OUTPUT
LOOP    LDA   PADAT   *READ THE DATA ON PORT A
        COMA          *COMPLEMENT IT
        STA   PBDAT   *PUT IT OUT ON PORT B
        JMP   LOOP    *GO BACK AND DO IT AGAIN
*
* INTERRUPT VECTORS
        ORG   $7F8
        FDB   RESET   *TIMER INTERRUPT
        FDB   RESET   *EXTERNAL INTERRUPT
        FDB   RESET   *SOFTWARE INTERRUPT
        FDB   RESET   *RESET
*
```

important in control applications, microcontroller programs are commonly written in assembly language. The box shown elsewhere in this article gives a basic example of 6805 assembly language for using a 68705P3 as an octal inverter. (Actually, a 6805 can be used to replace a lot of discrete logic components if propagation delay isn't critical.)

A programming model for the 6805/68705 is shown in Fig. 4. Accumulator A is a general-purpose eight-bit register used for arithmetic calculations and data manipulations. Index Register X is used for indexed addressing and as an auxiliary accumulator.

Addressing Modes

Six addressing modes are supported. They are as follows:

**Immediate Addressing.* In immediate addressing, the instruction contains the value to be acted upon and not a pointer to the value. For example,

```
LDA   3
```

loads the accumulator with the value 3, not the data stored at address $03.

**Direct Addressing.* Instructions using direct addressing contain a one byte address for the data to be acted upon. Therefore, only data stored between $00 and $FF can be accessed with direct addressing. The instruction

```
LDA   3
```

loads the accumulator with the data at address $03.

**Extended Addressing.* Similar to direct addressing, extended addressing permits a two-byte address. Therefore, data from the entire address space can be accessed. The instruction

```
LDA   $03FF
```

loads the accumulator with the data at absolute address $03FF.

**Indexed Addressing.* Instructions using indexed addressing add the value of the index register (0 to 255) to the address specified in the instruction. The result of this addition is the address of the data. Consider the following two lines of assembly code:

```
LDX   #$40
LDA   LIST,X
```

The first line loads Index Register X with the absolute hex value 40. The second line loads the accumulator with the data at address LIST + $40. The label LIST can be a 16-bit value or an 8-bit value or may not even be used. If LIST isn't used, X contains the address of the data to be acted upon.

**Inherent Addressing.* These are single-byte instructions. The op-code

Listing 2. Assembler Listing

```
                            *#68705P3 ASSEMBLY LANGUAGE EXAMPLE
0000                 PADAT      EQU    $0       *PORT A DATA
                                                 REGISTER
0001                 PBDAT      EQU    $1
0002                 PCDAT      EQU    $2
0004                 PADDR      EQU    $4       *PORT A DATA
                                                 DIRECTION
                                                 REGISTER
0005                 PBDDR      EQU    $5
0006                 PCDDR      EQU    $6
0008                 CNTR       EQU    $8       *COUNTER DATA
0009                 TCSR       EQU    $9       *TIMER CONTROL
                                                 AND STATUS
                                                 REGISTER
000b                 PCR        EQU    $0B      *PROGRAM
                                                 CONTROL
                                                 REGISTER
007f                 STACK      EQU    $07F     *TOP OF STACK
0784                 MOR        EQU    $784     *MASK OPTION
                                                 REGISTER
                     *
0100                            ORG    $0100    *START OF
                                                 EXAMPLE
                                                 PROGRAM
0100  9b             RESET      SEI             *DISABLE
                                                 MASKABLE
                                                 INTERRUPTS
0101  9c                        RSP             *RESET STACK
                                                 POINTER
0102  3f  04                    CLR    PADDR    *MAKE PORT A
                                                 LINES ALL INPUT
0104  a6  ff                    LDA    #$FF
0106  b7  05                    STA    PBDDR    *MAKE PORT B
                                                 LINES ALL OUTPUT
0108  b6  00         LOOP       LDA    PADAT    *READ THE DATA
                                                 ON PORT A
010a  43             COMA                       *COMPLEMENT IT
010b  b7  01                    STA    PBDAT    *PUT IT OUT ON
                                                 PORT B
010d  cc  01  08                JMP    LOOP     *GO BACK AND
                                                 DO IT AGAIN
                     *
                     *                          *INTERRUPT
                                                 VECTORS
07f8                            ORG    $7F8
07f8  01  00                    FDB    RESET    *TIMER INTERRUPT
07fa  01  00                    FDB    RESET    *EXTERNAL
                                                 INTERRUPT
07fc  01  00                    FDB    RESET    *SOFTWARE
                                                 INTERRUPT
07fe  01  00                    FDB    RESET    *RESET
                     *
```

Listing 3. Assembler S19 Output File

```
S11301009B9C3F04A6FFB705B60043B701CC01088A
S10B07F80100010001000100F1
S9030000FC
```

specifies everything needed. For example, the instruction CLRA means clear accumulator. Nothing more is required, since the location to be accessed is inherent in the instruction.

**Relative Addressing*. Only branch instructions use relative addressing. A branch instruction contains a one-byte signed offset (−128 to 127) that's added to the program counter if the branch condition is true. If the condition is false, execution continues with the next instruction.

Because microcontrollers must use their memory efficiently, compact data storage is necessary. To permit this, the 6805 family has excellent bit-manipulation instructions. Bits can be cleared (or set) with a single instruction instead of having to load a mask, AND (or OR) the accumulator with a memory location and store

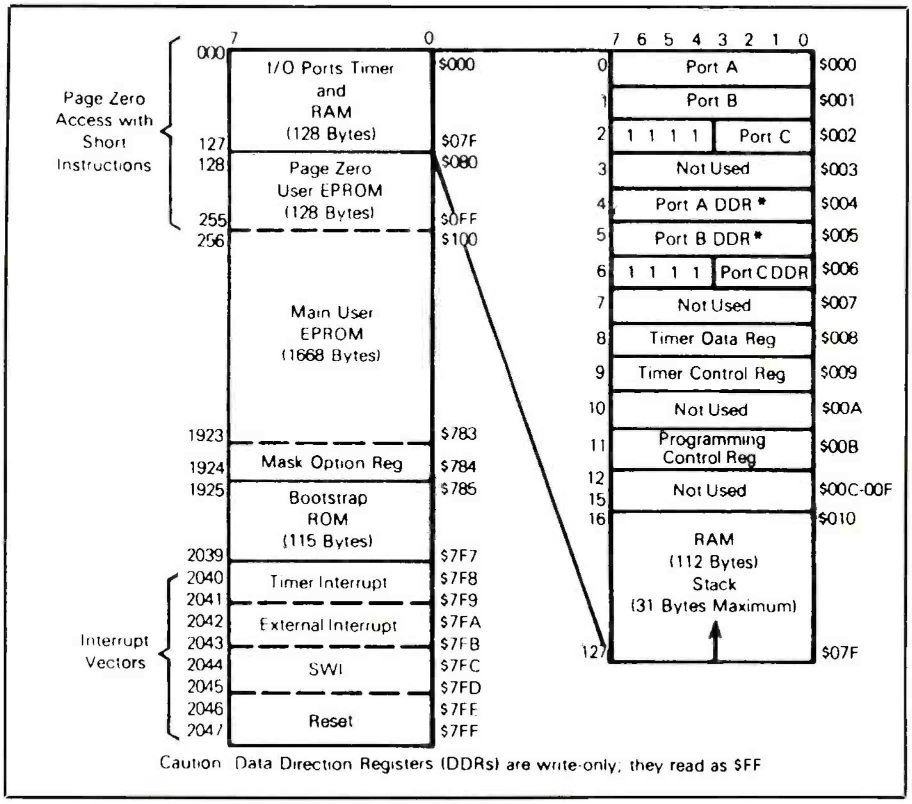


Fig. 3. Memory map for MC68705P3 chip. (Courtesy Motorola Inc.)

Table 2. Internal Register Area

Register	Address	P3	R3	U3
Port A Data Register	$00	Y	Y	Y
Port B Data Register	$01	Y	Y	Y
Port C Data Register	$02	Y	Y	Y
Port D Data Register	$03	N	Y	Y
Port A Data Direction Register	$04	Y	Y	Y
Port B Data Direction Register	$05	Y	Y	Y
Port C Data Direction Register	$06	Y	Y	Y
Not Used	$07	N	N	N
Timer Data Register	$08	Y	Y	Y
Timer Control Register	$09	Y	Y	Y
Miscellaneous Register	$0A	N	Y	Y
Program Control Register	$0B	Y	Y	Y
Not Used	$0C	N	N	N
Not Used	$0D	N	N	N
A/D Control Register	$0E	N	y	N
A/D Register	$0F	N	Y	N

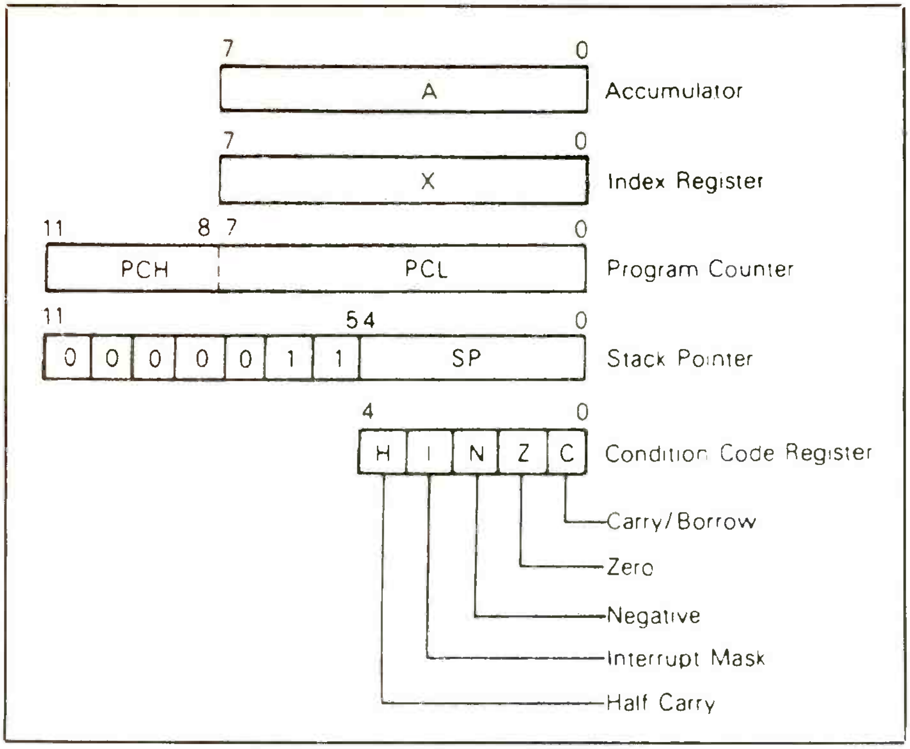


Fig. 4. Programming model for MC68705 series.
(Courtesy Motorola Inc.)

back the modified byte. For example,

```
BSET    0,$060
```

sets the least-significant bit (bit 0) of the byte at address $060. In addition, the program can test and branch on an individual bit with just one instruction! For example,

```
BRSET    0,$060,RF1
```

tests the least-significant bit at address $060 and, if it's set, the program branches to label RF1. Of course, there's also a BRCLR instruction.

Conclusion

This article is much too short to completely describe all aspects of these versatile chips. If you want to learn more about the 68705, and particularly if you plan on using it in a project, contact Motorola for complete data. A good way to do this is to call the Motorola Freeware Bulletin Board System at 512-891-3733. The protocol is 300 or 1,200 baud, eight bits, no parity, one stop bit. This BBS is a treasure trove of valuable information. There are free cross-assemblers, application notes, lists of local sales offices and distributors, user group libraries and much more.

In an upcoming article, we'll discuss programming the 68705's internal EPROM with a build-it-yourself programmer that's compatible with any personal computer that has a parallel printer port or an RS-232 serial communications port. ■

Programmer Availability

A Programmer Kit and various other items that will allow you to put into action the details discussed in this article is available from:

Lucid Technologies
7439 Highway 70 South
Unit 297
Nashville, TN 37221

The 68705 Programmer Kit contains a bare ready-to-wire printed-circuit board, programmed 2764 EPROM, MC145411 bit-rate generator and a 360K documentation disk. Price for the entire package is $45.

A CD-ROM Sampler

Capsule summaries of 34 titles that cover a wide range of topics and interests

In August, we showed how to install a CD-ROM drive in a PC. This article is a firmware follow-up that focuses on CD-ROM disks.

A CD-ROM disk can contain the entire contents of a 20-volume encyclopedia, including pictures and any other graphics it contains, and then some. Instead of yards of bookshelf space needed for individual printed volumes, you need only a fraction of an inch for the one disk. Disks are very durable, too. All these attributes are driving CD-ROMs to greater popularity.

Assembling a CD-ROM library is a combination of personal taste, the type of information needed and how deep your pockets are. If you're interested in "getting your feet wet" with CD-ROM, a good starting place is a sampler disc of shareware or public-domain software, which will give you the biggest bang for your buck. If you're looking for standardized reference material, you'll find encyclopedias, atlases and fact books galore on CD-ROM. If programming is your penchant, there are thousands of programs, libraries, utilities and routines available as well.

Literature buffs will find works from Shakespeare to Sherlock Holmes represented on CD-ROM and just about everything in between. Military, geographic, trivia, game and other databases are all here and more, too.

With more than 1,500 CD-ROM titles now commercially available, it's indeed a buyer's market. Here are a batch of CD-ROM titles I've personally used and reviewed. All represent excellent value.

Aircraft Encyclopedia, The, $129
Quanta Press Inc.
Full-text database contains descriptions and images of worldwide aircraft. Descriptions of each plane; includes country of origin, model number, aircraft name, manufacturer, service use, crew size, mission, wingspan, length, air speed, range and ceiling. Each country description is complemented by at least one image. A line drawing and silhouette is provided for each plane. There are also many b&w and color images are included. Requires 1M.

Amazing Moby, The, $395
ALDE Publishing
Useful full-text tool for such computer applications as spelling, hyphenation and pronunciation. Consists of four databases written in ASCII: Moby Words, Moby Hyphenator, Moby Part-of-Speech and Moby Pronunciator. Moby databases are not machine- or compiler-dependent. Requires 512K.

Between Heaven and Hell II, $99
Bureau Development, Inc.
Collection of 12,109 shareware files that include "adult" images as well as those suited for family viewing, in addition to the full text of The Bible. The Still River Shell is also provided to facilitate transferring files to your floppy or hard disks and two image-display programs are also included. Requires 256K.

CD-Guide Optical Edition, $259 subscription (Quarterly)/$99 single purchase
WGE Publishing
Multimedia package contains a database of almost every Compact Disc released to date, plus more than 10,000 quality ratings, 4,000 reviews (full text), articles, graphics and music samples. Requires 640K.

CD-ROM Directory Disc—1991, The, $149
UniDisc Inc.
Electronic version of TFPL's CD-ROM Directory, now in its fifth edition, provides comprehensive details on all CD-ROM and multimedia titles available; companies involved in all aspects of the industry; relevant conferences, exhibitions, books and journals. International in coverage, this disc is a complete reference work of the CD-ROM industry. Requires 640K.

CD-ROM Sampler, $24.95 + S&H
Discovery Systems
An innovative multimedia CD-ROM developed to demonstrate the wide range of applications addressable by CD-ROM technology in the MS-DOS environment featuring software submitted by more than 50 software publishers. A hands-on PC demonstration with integrated natural image and graphics based tutorial on CD-ROM complete with audio narration and music. Requires 640K.

CIA World Factbook, The, $129
Quanta Press Inc.
Government's own world almanac is an excellent reference that profiles 248 countries, territories and islands around the world. This is a full text, search and retrieval database for anyone who does research on world affairs. All text can be exported to ASCII text files or sent directly to a printer. A subdirectory on the disc contains 248 maps for each country, territory and island listed in the database, each scanned at 300 dpi. Requires 640K.

Compton's MultiMedia Encyclopedia, $895
Britannica Software Inc.
Integrated research tool gives students of all ages greater access to knowledge than ever before. Users can look up articles in several exciting ways, depending on their styles of learning, including Picture Explorer, World Atlas, Topic

Tree, US History Timeline, Science Feature Articles, Idea Search, Title Finder, and Researcher's Assistant. Contains 26 volumes of the printed version. It features 9-million words, 32,000 articles, 15,000 images, maps and graphs, 60 minutes of sound, music and speech, 45 animated sequences, 800 full-color maps and 5,000 charts and diagrams, in addition to the complete *Merriam Webster Intermediate Dictionary*. Requires 640K.

Guinness Disc of Records 1990, The, $149
Mirrorsoft Ltd. (UK)
UniDisc Inc. (US)
Multimedia CD-ROM based on the best-selling *Guinness Book of Records* provides fu[illegible] [illegible]xt searching, color graphics of record-breaking feats, animations. a musical score and sound effects; a must for anyone involved in education or providing a general information service. Compendium of facts is intelligently supported with music and sound effects, 300 full-color photos, comprehensive text screens for all subjects and on-line help. Requires 640K.

Mammals—A Multimedia Encyclopedia, $149.95; $99 educational institutions
National Geographic Society
Multimedia encyclopedia for home, library and classroom use contains 700 full-screen color photos; more than 200 different animals; 150 range maps; facts boxes; vital statistics screens; essays equivalent to more than 600 pages of text; captions for every photo; 45 full-motion movie clips; 155 animal vocalizations. Includes an animal classification game, pop-up glossary and printing capability for captions, essays and screens. Requires 640K.

Microsoft Bookshelf, $295
Microsoft Multimedia Div.
Tool for writers contains *The American Heritage Dictionary, Bartlett's Familiar Quotations, The World Almanac and Book of Facts, The Chicago Manual of Style, Business Information Sources, US Zip Code Directory, Roget's Electronic Thesaurus, Forms and Letters, Houghton Mifflin Usage Alert* and *Spell Checker & Verifier*. Allows you to copy and paste information into most major word-processing programs. Requires IBM PC, XT, AT or compatible; MS-DOS 3.1 or later; any CD-ROM drive; 640K.

Microsoft Programmer's Library, $395
Microsoft Multimedia Div.
Collection of MS-DOS and OS/2 programming references that include complete product manuals, related textbooks, and sample code for Microsoft's O/S2, *Windows*, MS-DOS, C, Macro Assembler, BASIC, Pascal and Microsoft Fortran, in addition to other printed matter on Microsoft products, including more than 3,000 sample programs. Requires 512K.

Movie Directory Database & Software Potpourri, $69
Bureau Development, Inc.
Entire King James Bible and a hodgepodge of programs, utilities, applications and demo programs, plus a 1,000-film movie database indexed by title, release date, cinematography, studio, genre, producer, director, cast, roles played and plot descriptions. Requires 256K.

North American Facsimile (FAX) Book, The, $495
Quanta Press Inc.
Provides fax numbers and addresses to 150,000 corporations in the United States, Canada and Mexico; database can be used for blast faxing, marketing, research and mailing-list generation. Requires 512K.

PC Blue, $99
ALDE Publishing
Taken from the files of the New York Amateur Computer Club members only, this collection of public-domain freeware and shareware consists of 440 volumes. Categories include communications, bulletin boards, DOS utilities and more. Requires 512K.

PDSI-003 Shareware, $159
CARRS CD-ROM Publishers
This 500-plus-megabyte CD-ROM contains 12,671 up-to-date IBM-compatible programs and files, including business, education, CAD, communications, text editors, hilite graphics and games. An easy-to-use retrieval program allows you to view and unzip any of the programs contained in the 35 directories. Requires 640K.

Programmer's ROM, $129
Quanta Press Inc.
Provides hundreds of megabytes of DOS-based public-domain source code, programming libraries and applications. If you're a programmer or instructor who uses ADA, Assembler, BASIC, QuickBASIC, C (Turbo, Lattice, Microsoft, Aztec, Desmet), dBASE, Lotus, Pascal, Turbo Pascal, or other PC high-level languages, the *Programmer's ROM* can save you thousands of programming hours. If you need to add a communications package to a program, just take it off the disc; if you need an algorithm, download it off the disc. Most files are compressed in the PKware ZIP format. Each file is catalogued with a one-line description, including file name, byte size, date and description. Requires 640K.

Phethean's Public Domain Library #1, $49.95
Peter J. Phethean, Ltd.
Public-domain software collection comprising more than 4,000 programs, files, utilities and images and using almost 300M of space on this CD-ROM. Subdirectories include BBS files, file utilities, games, graphics, Lotus, Microsoft, keyboard utilities, printer utilities and much more in addition to the CHKCD.EXE and TEST-CD.EXE programs. Requires 512K.

Publique Arte, $199
Quanta Press Inc.
Time-saving disc contains thousands of images in the .PCX (PC Paintbrush) format. All images were scanned at 600 dots-per-inch for crisp reproduction quality. A viewing program is also included for previewing the images before publishing. For public-domain enthusiasts, each image also exists in the compressed .ZIP (PKWare) format. This allows quick downloading of images via modem. You can add this disc to your electronic bulletin board. Requires 1M.

Shareware Gold, $129
Quanta Press Inc.
Contains the top shareware from such sources as ButtonWare, Magee Enterprises, Medlin Accounting, Quicksoft, Mustang, Formalsoft, PKware, Vern Buerg and a host of others. Each program is verified virus-free by the shareware authors themselves. The disc itself is mastered in gold, with estimated life expectancy in excess of 20 years. Requires 512K.

Shareware Grab Bag Vol. 3, $99
ALDE Publishing
Contains public-domain, freeware and shareware programs including utilities, programming and source code and roughly 6,500 zipped files to move to hard disk, unzip and use. Requires 512K.

Sherlock Holmes on Disc, $99
BCMC Research Inc.
Contains the full text of all Sherlock Holmes stories, full text of the Medical Case Books of Sir Arthur Conan Doyle and original illustrations by Paget (appeared in *Strand Magazine*) and 75 prints of each story by Dr. George Wells. Also medical poetry by Dr. George S. Bascom. Full word text search, brows-

ing and traditional table of contents. Requires 640K.

Spectrum Clip-Art, $299
ALDE Publishing
Outstanding collection of 7,000 usable clip-art images from the Dover Clip-Art and Quick-Art collections formatted in PCX and PostScript formats for use in all major desktop publishing and paint programs. Categories include accents and attention-getters, alphabets, borders, banners, corners, designs, illustrations, spot and old-fashioned illustrations and much more. Requires 512K.

Sporting News Baseball Guide and Register, The, $129
Quanta Press Inc.
Contains the last 5 years of *Sporting News Baseball Guide and Register*. Requires 640K.

Super Blue, $149
ALDE Publishing
This is the second edition of *PC-Blue*. While the first edition had 440 volumes, *Super Blue* has 612 volumes and all existing programs have been updated, if available. The files are from the New York Amateur Computer Club members only. Requires 512K.

TIME Magazine Compact Almanac—1990, $195
Compact Publishing Inc.
Brings together more than 6,000 articles covering *Time* magazine's 67-year history, including great moments and major events, trends and the trivia reported on by *Time* since 1923. The full text of *Time* for 1989 is also provided. The Compact Almanac presents facts and figures on the United States, with more than 500 charts, tables and other entries. Requires 640K.

US Atlas, The, $109.95
Software Toolworks
Features point-and-click operation for complete information on all 50 states. Information on each state's population, average temperature, precipitation, latitude and longitude, local times and area codes is provided along with a wealth of pertinent facts. Requires 512K.

US History on CD-ROM, $395
Bureau Development, Inc.
Contains full text of 107 books relating to US history, from the arrival of Native Americans to the present. Detailed coverage from a variety of historical perspectives is provided on US political, social, military and economic history. Includes more than 1,000 VGA photos, maps and tables of historical events. Requires 640K.

USA State Factbook, The, $129
Quanta Press Inc.
Electronic almanac of the US and its territories, published annually on CD-ROM, describes all the facts, figures and historical data any researcher would need. This full-text, search-and-retrieval database is easy to use. It delves deeply into the geography, people, government/politics, economics, communications, traditions and other state- and territory-specific information. Also included are 600-dpi outline maps for all 50 states and US territories in .TIF and .PCX formats. Requires 640K.

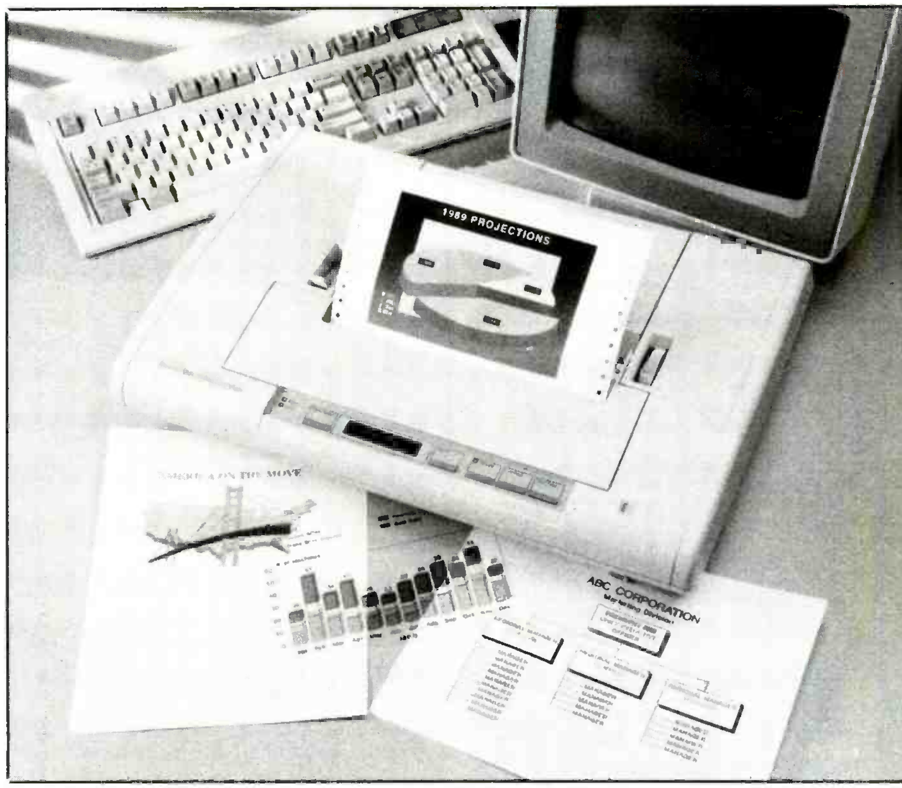
USA Wars—Vietnam, $129
Quanta Press Inc.
Covers US involvement in the Vietnam conflict. It includes special and general operation orders, order of battle, major unit histories, b&w and color battle images, order of military rank, medals and awards and the entire Vietnam Memorial database (the WALL). A portion of the proceeds from this database is donated to the Minnesota Vietnam Veterans Memorial Fund. Requires 640K.

Wheeler Quick Art, $249
Quanta Press Inc.
Contains more than 2,200 TIFF-format clip-art images scanned at 300 dpi for clear reproduction on a desktop publishing system; collection of clip art is contemporary and realistic, not a run-of-the-mill collection of woodcuts. No royalties or subscription fees required for use of these images. Includes contemporary and realistic style cartoons, decorative borders and illustrations. Requires 1M.

World Almanac and Book of Facts—1990, $59.95 (add $5.50 S&H)
Discovery Systems
This version is the 120-page volume first published in 1868. Keyword searches and browsing permits accessing more than 1-million up-to-date facts in such categories as the year in review, science and technology, astronomy and calendar, area and zip codes, nations, economics, environment, health, noted personalities and consumer information. Requires 512K.

World Atlas, The, $109.95
BSoftware Toolworks
Atlas, almanac and world fact-book are contained and interwoven on this CD-ROM under license from ElectroMap. Data is presented in seven specific areas: geography, people, government, travel, economy, defense and communications, in concert with excellent cartographic screens. Requires 512K. ■

Diconix Color 4: Color Ink-Jet Printing From Eastman Kodak



In many instances, color printing is preferable to black and white. For complex schematics, it makes it easier to follow circuitry. For charts, graphs and the like, there's nothing like multiple colors for effective presentations. Consequently, sales of color printers are rapidly rising.

Color printers for personal computers fall into three main categories: impact, ink-jet and thermal-transfer. Impact printers, which use a color ribbon to produce an image, are low cost and offer relatively low quality. Ink-jet printers are medium cost and offer good quality. Thermal-transfer printers are very high in cost and offer very good quality. Due to the cost-versus-quality issue, color ink-jet printers are often the preferred type of color printer. At this time, the Hewlett-Packard PaintJet dominates the color ink-jet printer category. The Eastman Kodak Company doubtlessly hopes to change this, however, with its new Kodak Diconix Color 4 printer.

The Diconix Color 4 printer works with IBM and compatible and Macintosh computers, and prints on plain paper or transparencies. For software compatibility, the Color 4 comes with a software driver and also emulates the HP PaintJet printer. Suggested list price of the Color 4 for IBM and compatible computers is $1,495, which includes a parallel interface, system card, manual and driver for Microsoft *Windows*; price for Macintosh computers is $1,595.

Features

The Diconix Color 4 is a nicely designed color ink-jet printer. Its front control panel has the usual buttons (On Line, Line Feed, Form Feed) found on virtually all printers plus two other buttons—Menu Select and Scroll—and a one-line by 16-character LCD. There are LED indicators for power, error and on-line. The printer has two paper handling devices, a lever for selecting cut-sheet or continuous-form paper, and a thumbwheel for manually advancing the paper. When the printer is operating, the platen and tractor-feed mechanism are concealed from view and access.

To see the paper bail and platen, you lift a plastic cover. With the cover lifted and rested against the top of the printer, you observe five graphic panels that explain—in pictures, not words—how to load the ink-jet printheads. Four separate printheads hold different color inks: yellow, cyan, magenta and black.

The tractor feed mechanism is hidden under two plastic panels. To see it, you lift a main panel at the top of the printer, and then unhinge a smaller panel. Even after doing this, all you see is about one-fourth of the tractor wheel. The power switch for the unit is at the front right lower corner of the unit.

The printer measures 20″W × 13.7″D × 4″H and weighs a relatively light 13 lbs. On the rear panel are the interface (parallel for our review unit), two slots for system cards, a bank of DIP switches, a power cord receptacle and a cut-sheet paper tray. The tray, which holds 60 sheets of paper, is flush with the back of the printer. When you pull on the paper tray, it extends about 4″ beyond the rear of the printer. On the tray are graphic panels that explain how to load paper into the tray.

The Diconix Color 4 Printer prints bidirectionally at resolutions up to 192 × 192 dpi (dots per inch). The printer also offers draft, near-letter-quality (NLQ) and letter-quality modes. Rated print speeds are 150 cps for draft and 75 cps for letter quality. A full page of color graphics is rated at 4 minutes.

The printer's inks are specially formulated to adhere well to plain paper, without smearing the way water-based inks can. Each cartridge is rated to deliver up to 500 pages of standard printed text. Printhead cartridges cost $13.95 for black ink and $19.95 for each color.

The display panel indicates printer status, allows users to select features, informs you when paper is out and provides other error messages. You make selections by taking the printer off-line and pressing the menu select button. There are five main menu options: Output Media, Fonts, Resolution, Text Color and Text Mode. Each menu has a set of selections that are accessed with a scroll button. Through a DIP-switch setting, these menu options can display in any one of

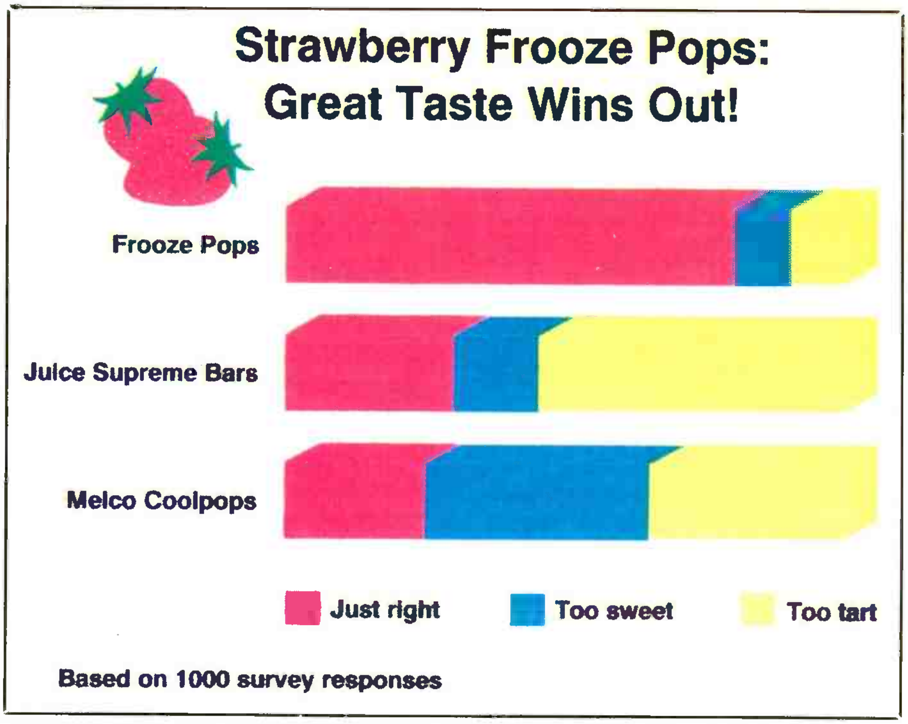


Fig. 1. Example of an actual four-color printout from the Kodak Diconix Color 4 Printer.

four languages: English, German, French and Spanish.

The system card supplied with the printer is one for HP PaintJet emulation. Although there are two slots, Kodak isn't offering other system cards at this time.

Other features of the printer include three resident fonts and 64K RAM with an 8K buffer. The fonts are Prestige 10, Prestige 12 and Gothic 18. The printer accepts 8½" wide paper.

The manual supplied with the printer is well-written and richly illustrated. If you enjoy programming printers, there's a chapter devoted to this subject.

Printer Setup

The Diconix Color 4 printer comes packaged with four printhead cartridges (in boxes), power cord, system card, manual and 3½" floppy disk. To assist you in getting the printer up and running, Kodak includes a *Quick Setup* pamphlet. The first step is to take each printhead cartridge out of its packaging and "prime" it by poking it with the edge of a straightened paper clip. You then open the front lid of the printer and place each cartridge into its correct holder on the printer.

Each holder has a colored dot that corresponds to the color of the ink in the cartridge. Slipping a cartridge into its holder is easy to do. You release a plastic clamp, insert the cartridge and reset the clamp. When all four cartridges are inserted, you close the front lid of the printer. The printer also needs a system card. This card (about the size of a credit card) is inserted into one of the slots at the back of the printer.

The printer has two banks of eight-position DIP switches. The first bank isn't used; the second bank lets you select such options as symbol set, page length, lines per inch, pitch, carriage return definition, graphics resolution and language for the panel display.

Before you can print with the Diconix 4 Color printer, you must perform a software installation. If you're using *Windows* on an IBM or compatible computer, you copy the drivers on the Kodak disk to the *Windows* directory. Then you install the printer through *Windows'* Control Panel. If you're installing the printer on a non-*Windows* product, you must select either the Diconix Color 4 printer or the HP PaintJet printer in your software's installation program. When this is done you're ready to print.

Using the Color 4

The first task assigned to the Diconix Color 4 printer was to perform a self test. This generates a pattern that shows if all colors are printing, if any portion of the print is missing and if printheads are aligned. The test showed all colors printing and no print missing, but printhead alignment of black and magenta were very slightly off. Although we made several attempts to correct this, we couldn't get the printhead alignment to look quite as perfect as it does in the sample shown in the manual. However, this wasn't at all noticeable in final graphics and charts that were printed.

We connected the Diconix Color 4 printer to an ALR Power Flex PC. The printer was tested with a selection of graphics packages, including Lotus *Freelance Plus* 3.01 and *Paintbrush*, the paint program supplied with Microsoft *Windows* 3.0. We also tested it with a word processor, *WordPerfect* 5.1. With the *Windows* package, we installed the Diconix Color 4 printer driver that Kodak supplied; with *Freelance* and *WordPerfect*, we used the HP PaintJet driver.

The printer worked perfectly with all the software we tried. That is, the printer and software worked together to print the desired graph or document. But like other moderately priced printers, hard-copy output didn't always accurately match colors on a color (VGA) monitor. Figure 1, a sample graph printed from Lotus *Freelance Plus* 3.01 using the HP PaintJet driver, illustrates this. None of the colors matched the colors on the display. The reds and yellows were lighter, and the greens and blues were much darker than colors that appeared on-screen. Colors produced with *Paintbrush* had the same discrepancies. The Kodak manual states: "In the draft mode, the printer can use a wide range of color. In Quality print mode or in the transparency mode, the color palette is limited to 7 colors . . . " We found that switching modes didn't alter color output, however.

Print speed for graphs under Lotus *Freelance Plus* 3.01 was more 50% higher than the rated speed (150 cps for 12 characters per inch in draft mode and 75 cps in Quality mode). The Fig. 1 graph took 6 minutes to print. The printer is very quiet and is rated at 45 dB. All you can hear are the printhead mechanism changing direction and the paper advancing.

We printed on both form-feed and cut-sheet paper. When you print with cut-sheet paper, you open a plastic cover that catches the paper as it's ejected from the printer. When you don't use this feature, you don't even realize it's there. A very nice comment on the printer's design.

Conclusions

The Kodak Diconix Color 4 printer is relatively easy to set up and use. Printheads slide right into place without any hassle. The printer uses plain paper and works fine, whether operating it with its own driver or using HP PaintJet emulation. A cut-sheet feeder and bin that are essentially hidden when not in use is also a product of thoughtful design.

The Kodak Diconix Color 4 is certainly an affordable ink-jet printer with a nice selection of features. It can be used for text as well as graphics printing.

Colors saturated the areas very well and were reasonably deep, although not truly representative of actual screen colors, as cited. Edges of the printed matter weren't as sharply defined as one would wish, especially with plain paper that has a high rag content and, therefore, a greater absorbency factor. Consequently, a bond paper with less than 25% rag content should be used. Accordingly, you won't mistake it for laser-printer output.

Using plain paper and non-smearing ink are definite advantages that the new Diconix Color 4 offers, as is its ability to automatically feed single sheets of paper. In contrast, H-P's PaintJet requires you to feed cut sheets by hand.

In sum, Kodak's color printer is a welcome addition to the field in the ink-jet category. Although it doesn't knock H-P's PaintJet out of the box, it does offer some advantages along with some shortcomings. The latter also includes narrower dealer distribution and a higher street price by some $200. But if less costly paper, automatic multiple cut-sheet feed, non-smearing ink, built-in paper bin and some other favorable attributes are to your liking, then it should be seriously considered when making an ink-jet color printer purchase.

The printer's inability to truly match colors presented on the video screen display is disappointing but not surprising as it's a problem generally associated with color printers in general. Instead of bright red, we got coral; instead of sky blue, we got deep turqoise. ■

In Brief

Diconix Color 4 Printer
Eastman Kodak Co.
Printer Products Div.
Rochester, NY 14653
1-800-344-0006

CIRCLE NO. 52 ON FREE INFORMATION CARD

Beating Copy Protection: A hardware/software system that lets you "unlock" programs on copy-protected disks

When the personal computer market was first getting started and software companies began selling their products, much research and development went into the subject of copy protection. The issue of how to protect software and still cater to the consumer is still of industry concern.

A software product usually comes with some kind of licensing agreement that states the limitations of usage. Some companies allow the purchaser to make one back-up copy for himself. Others don't want any duplication of any part of the product for any reason. These views are understandable. It takes a great deal of planning, work and money to develop and market a product. If someone copies and distributes that work, damages are done in the form of lost sales.

In general, there are two kinds of copy protection: on-disk and off-disk. On-disk copy protection involves writing of particular data somewhere on the floppy disk. The data may be written in unusual patterns or places. Schemes for doing this range from varying disk parameters to making physical deformities on the disk itself. In contrast, off-disk copy protection requires that information from elsewhere be entered before the program will fully execute. That information may come from a user's manual, a specialized hardware lock or other external device. Either approach comprises added expense in order to implement the protection. It also means frustration to users who have to deal with it during installation and use.

Consumers have chafed under the use of copy protection. Their viewpoints are understandable, too. Apart from outright piracy, some users feel that they should be able to do pretty much what they want with something they've purchased. Some software companies have yielded to user complaints and dropped copy protection altogether. Other companies continue to use some form of protection as a matter of course. Naturally, a dichotomy now exists between those who believe that information should be freely exchanged and those who don't.

A bevy of companies produce software and hardware that enable users to break copy protection on a disk. Among them is Central Point Software, a leader in developing products to defeat copy protection. We'll look at the installation and use of the Copy II PC Deluxe Option Board. It's not a new product but it remains a most effective tool for beating copy protection.

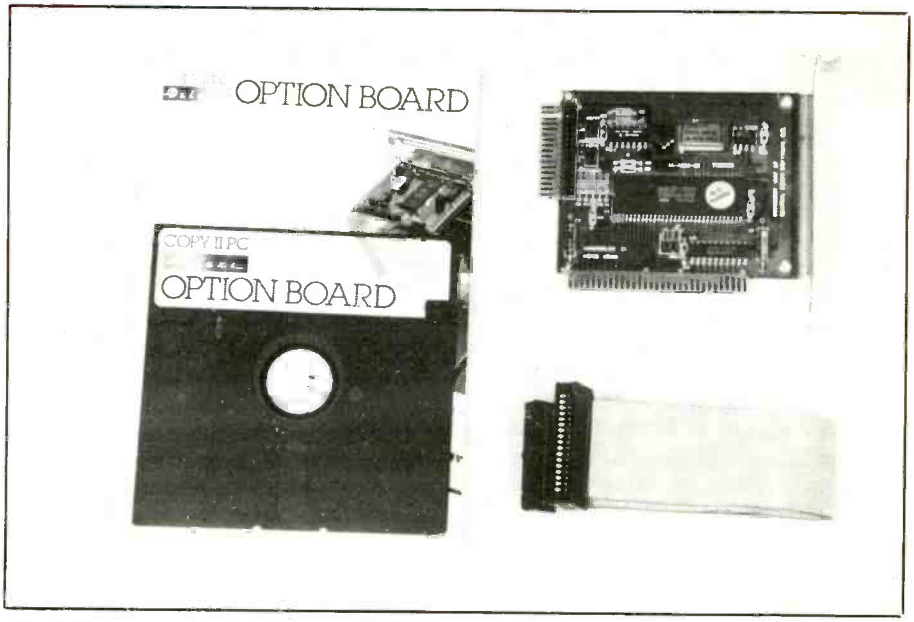


Fig. 1. Four elements make up the PC Deluxe Option Board package. Clockwise from top-left, they are the user's manual, the Option Board itself, a cable that installs between the Option Board and a diskette containing required software.

Setting Up

The Option Board's approach to copy protection is simple. It copies everything it sees, bit for bit. It copies magnetic transitions from one diskette to another without looking for anything in particular. When it copies a disk, it copies everything, copy protection and all. That makes it easy for users who don't have the knowledge, time or inclination to go poking around the code structure.

A word about static discharge before getting started. The human body readily accumulates an electrical charge, especially on dry, cold days. Such charges carry enough potential to damage electronic components. It's good practice, therefore, to use a wrist strap to ground yourself. If you don't have a wrist strap, physically touching the grounded case of the power-supply before touching anything else inside your computer may be enough to dissipate a static charge.

There are four parts to the Deluxe Option Board kit, as shown in Fig. 1. They are a cable, instruction manual, software and the Option Board itself. The Option Board works in most PC-, XT- and AT-style computers after being correctly configured.

On the Option Board, locate dual-pin headers *J4* and *J5*. Jumper positions are labeled according to use. Set the jumpers to the tops of their respective headers for PC- or XT-style computers. Use the bottom position for any other computer. Another header, *J7*, is used to set the DMA line. Leave it set for DMA 1. Now locate header *J6*, which is used to set the port address for the Option Board. Default address is 268 through 26F. Change this setting only if you have other devices that use this address range.

Tip: Users of the Intel Above Board may experience address conflict. The Above Board comes factory set for address 268. If the Above Board port address hasn't been changed during installation, there will be a conflict once the Option Board is installed. Setting the Option Board to an address other than default (268 through 26F) range will pre-empt the conflict.

Installation

Turn off your computer and remove the cover from the system unit. The Option Board connects between the floppy drive(s) and the floppy controller. The card in the slot closest to the computer's power supply is normally the drive controller. On AT-style machines (with '286, '386 and '486 microprocessors), this card serves as controller for both hard and floppy drives. PC- and XT-style computers have separate controllers for hard drive and floppy drive.

Near the top middle of the controller are four rows of dual-pin headers that are used for connecting to floppy and hard drives. Starting from the right-most header they're labeled *J1*, *J2*, *J3* and *J4*. Header *J1* is of interest because that's where the floppy drives are connected. If in doubt, run your finger along the ribbon cable connected to the equivalent of *J1* in your computer. Tracing the cable in this manner verifies that it's connected to the floppy drives.

• *Step 1:* Gently unplug the floppy-drive cable from *J1*. Place your finger snugly on the base of the ribbon cable connector and slowly pull on it, using a gentle rocking motion. Be careful not to remove one side of the connector before the other side comes off. If you do this, some of the header pins are likely to bend. If you do bend some header pins, use small pliers to straighten them. After unplugging the cable from *J1* of the controller card, connect it to dual-pin header *J2* on the Option Board. Do *not* connect the cable the wrong way. Pin 1 on *J2* is labeled, while pin 1 on the floppy-drive cable is the side that has the colored stripe. Match up pin 1 to pin 1.

• *Step 2:* The Option Board comes with its own cable. Note that the connectors on the ends of the cable aren't the same. One end has a connector for header pins. The other is an edge connector. Plug the edge connector end of the cable onto the gold edge fingers of the Option Board. Again, check cable alignment. The edge connector on the Option Board is slotted so that pin 1 is easy to identify. The cable, though, may not be keyed.

• *Step 3:* Only one additional cable connection must be made. Take the free end of the Option Board Cable and connect it to *J1* of the floppy/hard drive controller. Observe the location of pin 1, which is near the top end of header *J1*. Don't plug it in the wrong way!

Cabling is now complete. The last step is finding a suitable expansion slot for your Option Board. Electrically speaking, you've placed the Option Board between the floppy controller and floppy drives. When the Option Board is used, it actually takes control of the floppy drives.

• *Step 4:* The Option Board should be installed in an expansion slot that's physically close to the floppy controller and the floppy drives so that the cables can easily bridge the distance. It may be necessary to move or swap existing cards to make room. Install the Option Board in the desired slot. In some systems, there's the problem of properly dressing the cables. If you have to unplug any cables from the Option Board or any other devices in your computer, remember where they went and how they were connected. It's a good idea to unplug only one cable at a time and dress it before going to another. Again, be sure to match pin 1 to pin 1 on all your cables. After seating the Option Board in an expansion slot, leave the system unit cover off until after you check out the hardware and software and are satisfied that the system is working properly. Make sure all your cables are correct and secure.

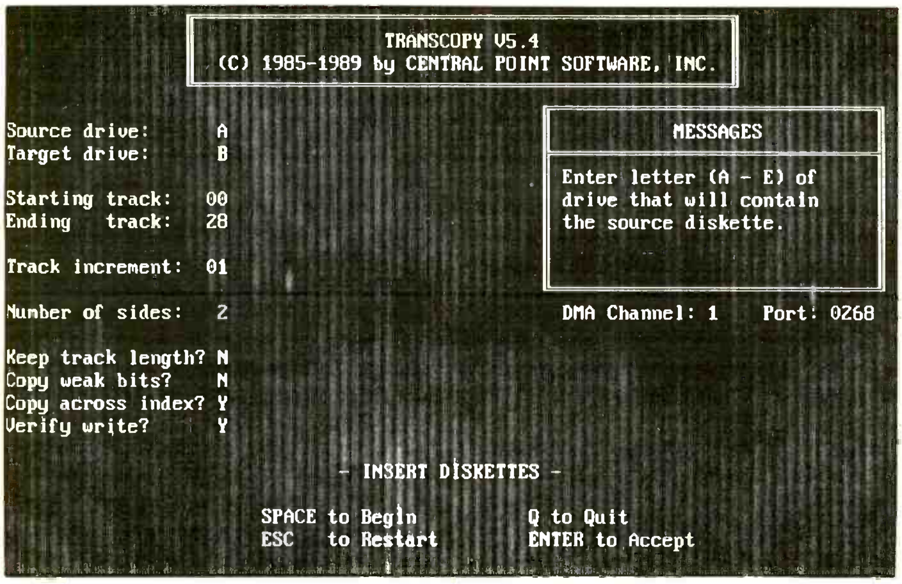


Fig. 2. The main menu of the Trans Copy software supplied with the PC Deluxe Option Board.

Software Installation

Now install the software. Begin by turning on your computer and letting it boot.

The Option Board software can run from floppy disk, but letting it run from a hard drive is better. If you have a hard drive, install the software there, after first making a directory for the it and copying all files from the distribution disk into the directory. From the DOS prompt, start the software by entering TC from the keyboard. *TC* (*Trans Copy*) is the menu-driven program that automates usage of the Option Board. Figure 2 shows the *TC* main menu and default values. Put a floppy disk in drive A: and try to make a copy.

Tip: If your computer hangs up while trying to read the disk, turn it off and proceed to change the DMA setting of the Option Board. Try to copy the disk again. If you still have trouble, use other address settings for the Option Board. If that doesn't solve the problem, remove all other add-on devices that may conflict with the Option Board. If that doesn't do it, you have to call Central Point Software for assistance.

The default values for *TC* usually don't need to be changed. Occasionally, though, a disk with a tough copy-protection scheme comes along. When that happens, change the settings for track length, weak bits and index. Keep making copies while setting these three values in various combinations. One combination is bound to work.

Tip: It helps to have a clean disk before copying tough protection schemes. You can exclusively reserve brand new disks for this job. Or you can use a disk wiping utility such as WIPEDISK, which can be found in *Norton Utilities* 4.5. If you still can't make a reliable copy, call Central Point Software for assistance.

TC Capabilities

Trans Copy and the Option Board can read and write several formats of disks. A partial list includes 360K and 1.2M in 5¼-inch, 720K and 1.44M in 3½-inch, Macintosh, Apple and Amiga. With Macintosh formats, *Trans Copy* can copy and translate some kinds of data from IBM to Mac and Mac to IBM. It can use expanded memory or hard-disk space as data storage. That is a nice feature for users who have only one floppy drive because it cuts down on disk swapping and speeds the copy process.

Tip: When copying 1.44M 3½-inch disks or 1.2M 5¼-inch disks, you must use a track length of 4F to get all 80 tracks. A supporting program called *TCM* is included with the package. It's used to read an image of a floppy disk and then save the image to hard drive as a binary file. The binary file can be read and restored to floppy at any time and as many times as you like.

A final capability of the Option Board has nothing to do with copy protection. The Board can be used in conjunction with Central Point's *PC Tools* disk utilities. The back-up function of *PC Tools* can use the Option board to get extra data compression during back-up.

Summary

The legal and moral questions of copy protection and back-up may never be finalized. Both sides of the matter have valid points and serious concerns. If you purchase the Option Board or any other copy system, remember to exercise good judgment. ■

Product Mentioned

Copy II PC Deluxe Option Board
$159
Central Point Software
15220 NW Greenbrier Pkwy.
Suite 200
Beaverton, OR 97006
503-690-8090

CIRCLE NO. 53 ON FREE INFORMATION CARD

Forrest M. Mims II

How to Select a Data Recorder

Over the years, I've used various kinds of analog, digital and computerized recorders for many different applications. Even though today's technology means your computer can be used as a sophisticated data recorder, there's still a place for the old-fashioned analog recorder. In this column, I'll describe some of the many applications for recorders and enumerate the advantages and disadvantages of some of the most common recording methods. I'll also explain how you can modify a miniature recorder that's sometimes available on the surplus market to operate from a single 9-volt battery.

Recorder Applications

There are countless applications for recorders that store information for later playback and review. Television and motion pictures have made famous analog recorders used by "lie detectors" to record physiological reactions when a person is being interviewed. After an earthquake or volcanic eruption, TV news programs invariably broadcast images of the erratic trace of a pen on a seismometer's recording drum. Programs about health and medicine often include images of recorders showing a patient's pulse rate or various other signals his body produced.

Recorders have many uses outside the scientific laboratory. Amateur weather observers use various recorders to store information about temperature, humidity and barometric pressure. Serious computer users use recorders to keep track of fluctuations in the voltage of the power line that powers their equipment. Gardeners use recorders to monitor temperature changes inside greenhouses or/and in outdoor soil. Amateur astronomers use recorders to monitor changes in the brightness of a planet or variable star. The list goes on and on.

Recorder Types

Recorders can be divided into two broad families: analog and digital. The two major categories of analog units include mechanical recorders and strip-type chart recorders.

Many kinds of digital recorders are available. Some emulate their analog counterparts and produce traces and text on moving strips of paper. Others are data loggers that sample and store data, which then can be graphed using various kinds of spreadsheet software.

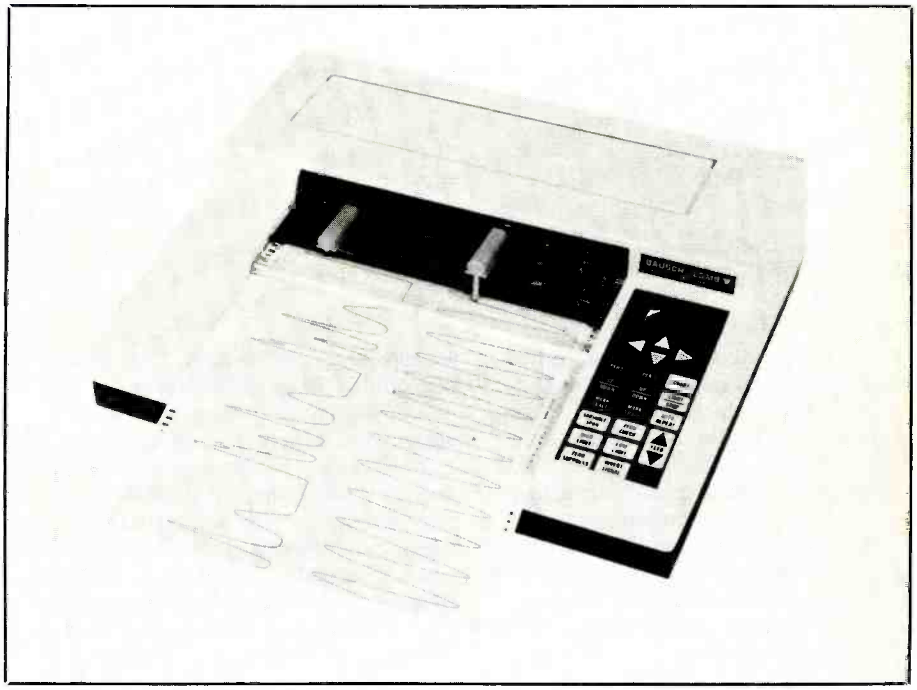


Fig. 1. A conventional two-channel analog chart recorder with a digital control panel. (Photo courtesy Bausch & Lomb.)

Let's now take a look at some examples of various kinds of analog and digital recorders.

•*Analog Recorders.* The simplest analog recorders are mechanical instruments in which a drum or disk bearing a recording surface rotates under a movable pen or stylus. These days, the recording surface is usually paper, sometimes heat- or pressure-sensitive. Wax-coated paper, smoked glass and other recording surfaces are sometimes used as well.

The pen or stylus in these mechanical recorders is moved by a mechanical linkage that's sensitive to what's being measured. The sensitive element of a recording barometer, for example, is an evacuated bellows (called an aneroid) that expands and contracts in response to changes in barometric pressure. The stylus is mechanically linked to the bellows in so that it moves across the recording surface when changes in pressure occur. Since the end of the stylus moves much more than the bellows, the linkage functions as a mechanical amplifier.

Mechanical recorders are powered by a spring- or motor-driven mechanism. Some include a crystal-controlled clock that applies pulses to the drive motor at precise intervals.

Though they might seem primitive, mechanical recorders offer many advantages. They're easy to use and require little or no external power. They're reasonably compact and are highly reliable.

The major disadvantage of mechanical recorders is their lack of flexibility. A recording barometer does only one thing: record pressure changes. Another drawback is that mechanical recorders lack the adjustability of other kinds of recorders. If it's possible to change the speed of some of these instruments, a gear change is the usual method.

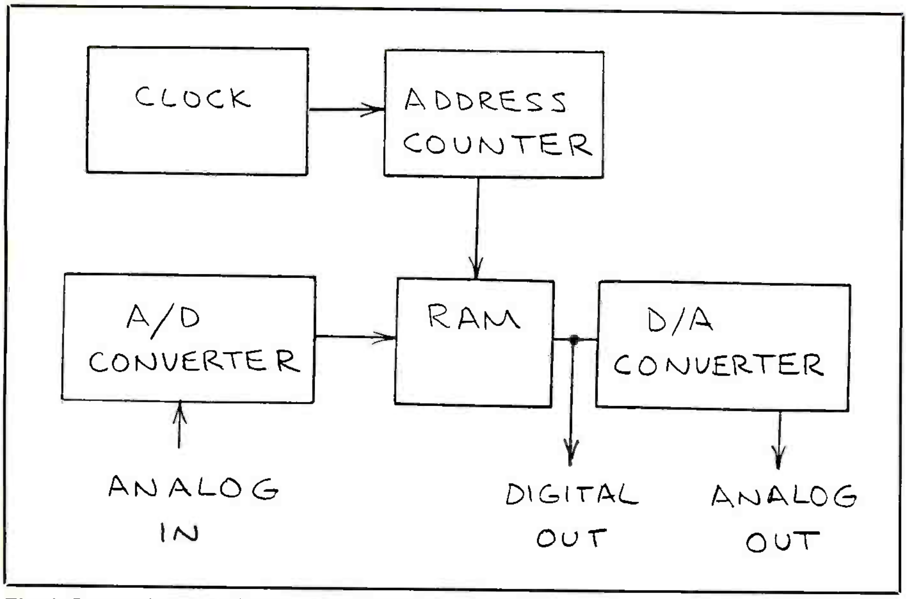


Fig. 2. Block diagram of a basic data logger system.

I recently recently bought a mechanical recorder to use in an important experiment I plan to conduct involving changes in barometric pressure. I could have built or purchased a digital barometer that downloads data into a digital data logger or computer. But the circumstances of the measurements requires absolute reliability with the simplest possible instruments. Therefore, I selected an old-fashioned but highly reliable mechanical recording barograph.

Incidentally, the mechanical system I purchased does incorporate one modern feature. The old-fashioned spring drive motor has been replaced by a battery-powered motor that's controlled by a quartz-driven clock.

•*Strip-Chart Recorders.* The familiar chart recorder, like the two-channel unit shown in Fig. 1, incorporates a motor-driven mechanism that pulls a continuous sheet of roll paper past one or more recording pens. The pens swing back and forth across the paper, inscribing traces by means of ink, heat or pressure.

A chart recorder provides an instant graph of the data it has recorded. No computer or software is needed. Moreover, it keeps a continuous record of data. Digital recorders sample data at specific intervals. Therefore, an event that occurs between samples can be missed. The continuous trace of a chart recorder misses only those signals that occur faster than the mechanical response of the recorder's pen can keep up with.

Another advantage of a chart recorder is that it forces you to evaluate the trace, rather than have a computer do it for you. Let's say you want to record the intensity of the sun's radiation at some wavelength of visible light. You insert a photodiode in a collimator tube and mount the assembly on a telescope that automatically tracks the sun. Each time a cumulus cloud passes between the sun and the photodiode, the signal level will increase substantially just before and after the cloud's passage. This false signal, which is caused by reflection of sunlight from the cloud, will be very obvious when viewed on a recording. A computer programmed to record signal peaks, however, would record these false signals as real ones.

Chart recorders are very versatile. A built-in amplifier permits maximum pen excursion to be easily adjusted. Various controls permit the position of the pen to be set to any desired baseline point. The speed the chart moves past the pen can be adjusted over a wide range.

An important drawback of the chart recorder is the response time of its pen. Since a finite amount of time is required for the pen to move across the paper, there's a built-in delay that affects the recording of signals that exceed the pen's response time.

Another drawback of the chart recorder is all the paper it spews forth. A drawer in the desk where these words are being typed is stuffed with dozens of rolled-up chart recordings from many different experiments. Some of this data is quite interesting—but every time I look at it, it's necessary to spend a fair amount of time rolling the charts back up. If the data on these charts was digitized and loaded in a spreadsheet, I could quickly recall it without the hassle of having to unroll long charts. When these thoughts occur, I remember that the chart recorder saved the data quickly, efficiently and continuously. For some experiments at least, the hassle of unrolling and reviewing paper charts is easily justified by the simplicity and reliability of a chart recorder.

•*Digital Chart Recorders.* A new generation of hybrid chart recorders combines digital and analog technology. Like traditional chart recorders, these units employ a moving chart. Instead of a moving pen, however, hybrid recorders write data on paper using a randomly-addressable printing device like a thermal printhead. This eliminates the lag time of recorders with a moving pen. It also means the recorder can store incoming data and print numbers, symbols, notes and even a grid. When you find out how much chart paper with a pre-printed grid costs, the grid-printing capability is particularly attractive.

•*Data Loggers.* The simplest data logger consists of a random-access memory (RAM) array, counter and clock. As the clock increments the counter, data is stored in successive addresses in RAM. If the data is analog, an analog-to-digital (A/D) converter is required to digitize the incoming signal.

Figure 2 is a block diagram that details the basic elements of a data logger. You can assemble your own data logger, but many commercial versions are available, some at reasonable prices. Many commercial data loggers can be connected to a computer and are supplied with appropriate software.

•*Computerized Recorders.* Any computer contains most of the basic ingredients for a data logger. All that need be added is A/D conversion capability.

Many different data-acquisition cards for computers are available. Some are supplied with graphing software that converts a computer into a chart recorder. Others store a string of data measurements in a file for later processing by a graphing or spreadsheet program.

Among the lowest-priced data-acquisition boards for computers are those made by Alpha Products (242 West Ave., Darien, CT 06820). They're designed to be connected to any computer via what the company calls an A-Bus, which is a ribbon cable connected to an interface card that plugs into the computer bus. Different computers get different interface cards, but a single A/D card works with the A-Bus and all the interface cards.

Over the past few years, I've purchased various analog-to-digital and digital-to-analog (D/A) conversion boards from Alpha Products and used them in data-acquisition and control systems for my experiments. For example, Fig. 3 shows the AD-142, an eight-bit A/D converter

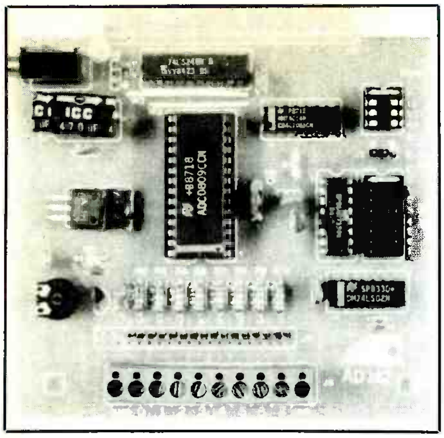


Fig. 3. This eight-bit A/D conversion board from Alpha Products is designed to be connected to an interface board installed in a computer.

board that sells for $142 in single quantity.

Alpha Products isn't the only source for reasonably priced, do-it-yourself data logging. I mention Alpha because I've purchased and had good results with some of their boards. Other companies also offer reasonably priced data logging accessories for computers, and you can find their ads in various electronics and computer publications.

Modifying a Surplus Recorder

For three decades, the Rustrak has been a chart recorder favored by experimenters. This is among the least-expensive of all analog recorders. It's compact and built to take abuse. Rustraks are made by Gulton/Rustrak (Gulton Industrial Park, East Greenwich, RI 02818).

The secret to the low cost of the Rustrak is its clever writing mechanism. Instead of the complicated servomotor system used in most analog recorders, the Rustrak employs an ordinary moving-coil meter. A metal bar periodically slams the needle against a moving strip of pressure-sensitive paper.

Both dc- and ac-powered Rustraks are available. You can buy them new for as little as $300. Exact price depends on the meter movement you select and whether or not you want a dc drive motor and a digital display on the front of the recorder. Alternatively, you can do as I've done and buy them surplus. I paid $50 each for two battery-powered Rustraks at a surplus electronics store. The one shown in Fig. 4 has a 0-to-1-milliampere meter movement. The other has a ±50-microampere movement. Recently, a friend of mine bought a Rustrak for only $5 at a ham radio swap meet!

Rustraks have a single chart speed. According to Rustrak literature, the speed of a given Rustrak is determined by the drive motor and its gearing ratio. Since my knowledge of gearing is limited to the gear ratios provided by a 15-speed bicycle, I've found a method to vary the speed of a Rustrak without changing its gears or drive motor. In the process, I've also learned that 12-and 24-volt Rustraks will operate for extended periods of time when powered by a 9-volt battery and the variable drive circuit shown schematically in Fig. 5.

The Fig. 5 circuit is a basic 555 timer. Potentiometer *R1* and capacitor *C1* control the repetition rate of pulses applied to the Rustrak's motor. Potentiometer *R2* controls the duration of these pulses. If the pulses are too narrow, the motor may not respond. If they're too wide, the motor may advance more than you intend it to each time it receives a pulse of current.

With the component values shown in Fig. 5, a 12-volt Rustrak recorder can be operated over a wide range of speeds. Once *R2* is adjusted to provide a pulse wide enough to advance the motor, all you have to do to alter the speed is adjust the setting of *R1*.

I assembled the first version of the Fig. 5 circuit on a small perforated board that was attached to one of the screws that secures the electrical socket on the back of the Rustrak. This arrangement worked for several months until the board broke away from the screw. Recently, I built a new driver circuit and installed it in an aluminum box that measures only 3¼″ × 2⅛″ × 1⅛″ (LMB No. 772).

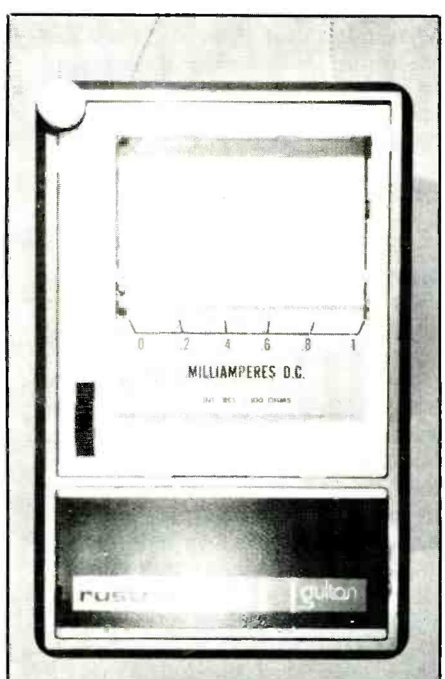


Fig. 4. This surplus Rustrak chart recorder was purchased by the author for $50.

It's easy to attach the box containing the driver circuit directly to the back of the Rustrak. First, remove the two screws that hold the electrical socket in place. Use tape or labels to identify the conductors that lead to the motor and meter movement. Then desolder the leads from the socket.

Before installing the circuit board in the metal box, place the box over the large hole in the Rustrak where the socket was installed. Be sure the box covers the socket opening when it's screwed into place. Then measure the locations of the two socket mounting holes and drill two holes to match their locations in the back of the box. Also, drill a larger hole between the two mounting holes and install a grommet in it. This hole will be for the wires between the controller circuit and the Rustrak.

Referring to Fig. 5, solder lengths of color-coded insulated stranded hookup wires to the input phone jack and output of the 555 circuit (pin 3 and the positive supply or pins 4 or 8). Thread the wires through the grommet, slip lengths of small-diameter heat-shrinkable tubing over each wire and solder the wires to the correct Rustrak leads. *Caution:* Make certain that you connect these wires properly to avoid damaging the meter movement. After soldering the wires into place, slide the tubing over each connection and use a soldering iron to heat-shrink into place.

Next, attach the circuit board to the back of the box using 6-32 machine hardware. Use spacers to keep the soldered connections on the back of the board from touching the metal box.

Finally, gently push the leads into the socket hole and attach the box to the Rustrak, using screws with threads that match those of the holes used to secure the socket. (The Rustraks I have require 6-32 screws.)

Figure 6 shows the external controller box, with cover removed, attached to the back of a Rustrak. While the label for this recorder specifies an operating potential of 115 volts, the recorder had been retrofitted with a 12-volt dc motor before I bought it. Notice the phone plug inserted into the jack on the side of the box. The wires go to a photodiode whose signal will be recorded by the Rustrak. Current through the meter movement can be adjusted by inserting a small screwdriver through a hole drilled in the side of the housing to adjust 10-turn trimmer potentiometer *R3*.

In my version of the driver circuit, *R1*

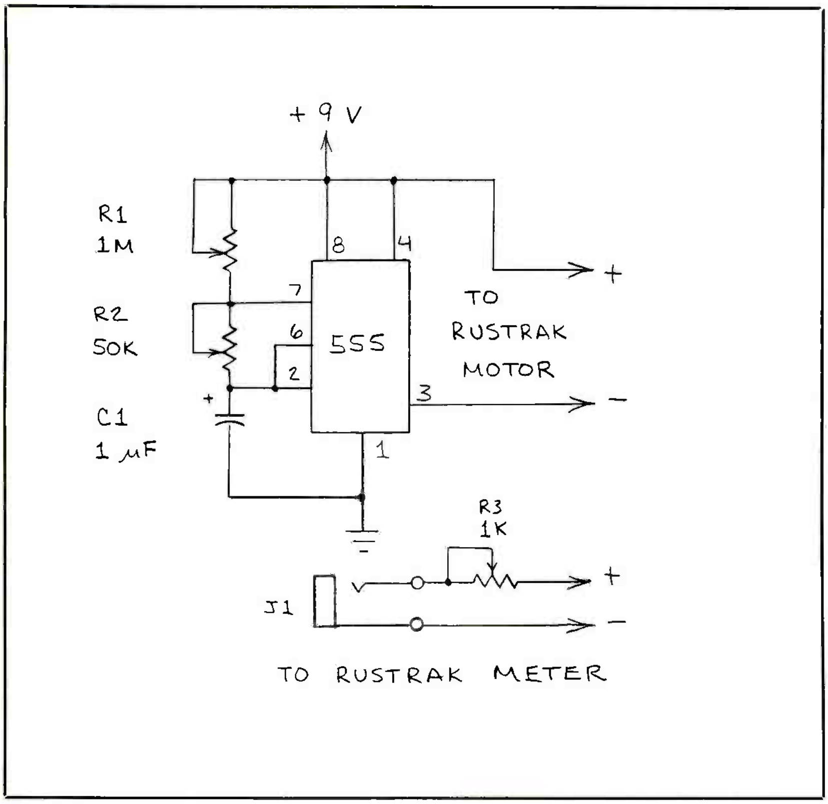


Fig. 5. Schematic diagram for a variable-speed drive mechanism for inexpensive Rustrak chart recorders.

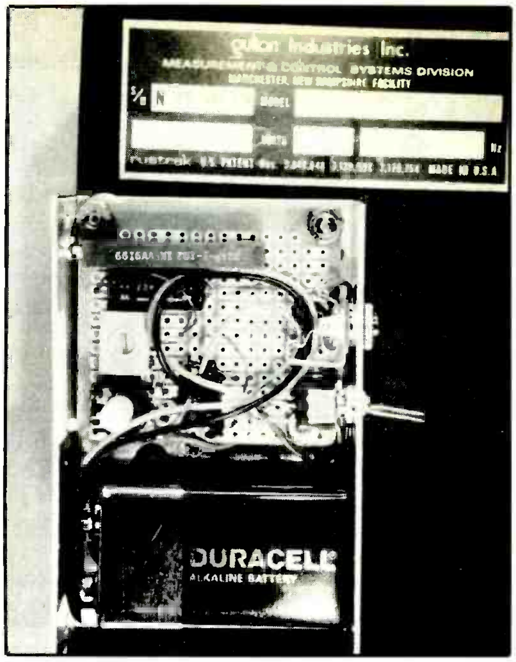


Fig. 6. The Fig. 5 circuit installed in a small metal housing mounted on the back of a Rustrak recorder.

and *R2* are single-turn trimmer potentiometers. If you prefer, you can use conventional potentiometers for *R2* and, especially, *R1* so that they can be quickly adjusted by turning a knob.

Calibrating the speed of the Rustrak can be as simple or as complicated as you want. One way is to tune a shortwave radio to WWV (5, 10 or 15 MHz) and listen to the 1-second signals. Then adjust *R1* so that the hammer strikes the paper after a desired number of second signals. To take care of calibration drift, always mark the time you start and end a recording session so that you can determine the time scale simply by measuring the length of the chart.

Incidentally, when you build a circuit like this, it's good practice to attach a circuit diagram inside the enclosure. Include some basic operating tips in case you set the circuit aside for a few years and return to it later.

Where to Find More Information

My file on chart recorders, data loggers and data-acquisition boards is thicker than the vertical dimension of this page. It includes products made by dozens of vendors and sold for prices ranging from a few tens to many thousands of dollars.

Since there simply isn't space here to list all these vendors and their products, here are a few tips on finding out what's available. For starters, the giant Cole-Parmer catalog is crammed with many different kinds of chart recorders and data-acquisition systems. If you can't find a copy of this catalog at a school or university science lab, write the company (Cole-Parmer Instrument Company, 7425 North Oak Park Ave., Chicago, IL 60648).

Another excellent source of chart recorders and data-acquisition systems is Omega Engineering, Inc. (P.O. Box 4047, Stamford, CT 06907-0047). In particular, see the company's thick Data Acquisition Systems Handbook and Encyclopedia™.

Another good way to find out about what's available is to review advertisements in recent back issues of electronics trade magazines at a technical library. When you contact manufacturers, be sure to ask about latest products and prices. New products may have become available and prices may have changed.

If you're interested in surplus chart recorders, check the yellow pages of your phone book. If there's a large government or industrial research laboratory in your town, there may be a local surplus dealer who just might have what you need at a substantial discount.

Surplus recorders are sometimes available through mail-order dealers. I recently bought a brand-new Rustrak four-channel event recorder for $82.50 from Herbach & Rademan (401 East Erie Ave., Philadelphia, PA 19134-1187). This unit requires 115 volts ac for the drive motor. The four pens indicate an event by moving when an external switch connected to the recorder is closed. Each of the four pens requires 18 to 24 volts at 70 mA.

Herbach & Rademan recently listed a new Rustrak 0-to-1-milliampere recorder for $125. Catalog price for this unit is $272. This unit has a 115-volt ac motor—but I'm sure it can be driven by a suitable pulser circuit powered by a 9-volt battery. A step-up transformer might be necessary.

Another occasional source for surplus recorders is *Nuts & Volts Magazine* (P.O. Box 1111, Placentia, CA 92670), but you have to act fast. The last time I spotted an ad for a nice surplus recorder, it was sold by the time I called the seller.

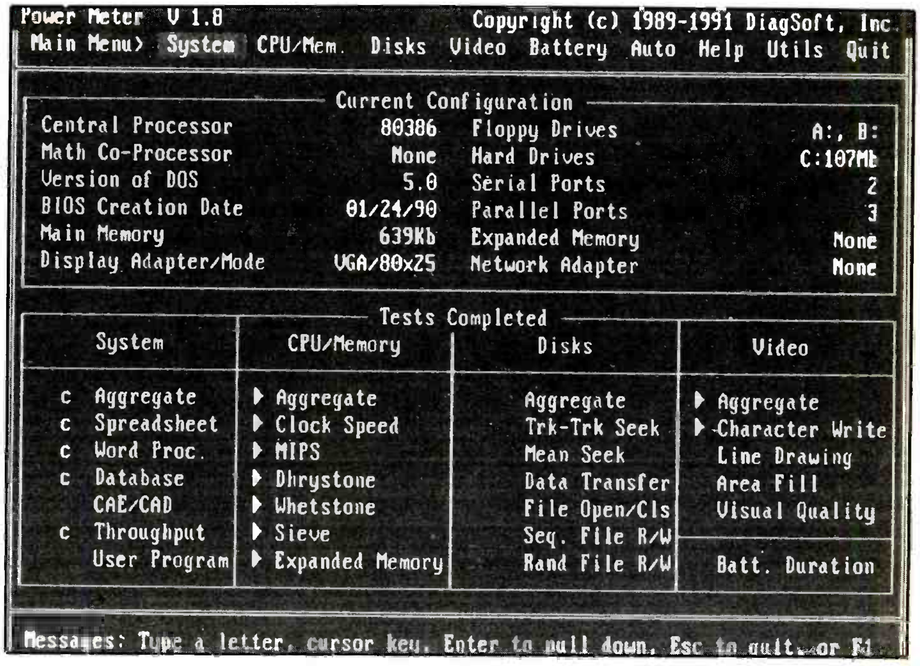
Over the past few years, several individuals with stocks of used chart recorders for sale have sent me letters. Since it's been some time since these letters arrived, I won't list them here. However, if they still have economical chart recorders for sale, perhaps they'll send an updated list, and I'll give their addresses in a future column. ■

Ted Needleman

Benchmarks or Baloney?

When I decided to do an evaluation of the Micro Express 386/40 computer I'll be reporting on next month, I was faced with a small dilemma. In computer reviews I've performed for this column in the past, I've avoided benchmarks like the plague, sticking to more subjective impressions of performance. This has been a very conscious decision on my part because of my own feelings about the worthiness and applicability of benchmarks in general. Yet, at the same time, because the ME 386/40 is one of those PCs that use an AMD (Advanced Micro Devices) CPU, rather than the ubiquitous Intel CPUs, and runs at 40 MHz, about 20% faster than Intel's fastest 386 33-MHz unit, I felt that some quantification of performance was not only justified but necessary.

The problem is the same one that faces any reviewer: How to you quantify performance? Most magazines answer this quandary with a series of tests called "benchmarks." Instead of solving the problem, though, benchmarking has opened a whole new can of worms. To see why, let's take a look at the concept of benchmarking and how it has been applied by the industry as a whole to evaluating computer performance. Having done so, the Micro Express 386/40 review that will appear next month may be of more use to you.



PowerMeter's Main Menu tells the user the current system configuration of the computer being tested and lists the various tests that can be performed. The user can pick and choose among a wide variety of tests that can be performed.

Benchmarking

Benchmarking is hardly a new process. The term is thought to derive from the craftsmen of the Renaissance age. At least one version of the story goes like this. In an attempt to introduce some sort of uniformity to the products he made, a clever craftsman scribed lines onto his workbench. One set of lines could delineate the length of a chair leg, for example, and every chair leg the craftsman produced was measured against that set of lines. As a production tool, this technique beat having to saw a little off each leg to even things out (my usual *modus operandi*). As a fable, this tale aptly illustrates what the term benchmarking has come to mean: creation of a measurement that allows similar products to be compared.

My problem has never been with the concept of benchmarking, I've only taken exception to the way many benchmarks are constructed and applied. Take a look at many computer magazines, and you'll see reviews that compare systems based on disk access times, LandMark speed and esoteric measurements like Dhrystones, Whetstones, MIPS and MFLOPS. When the IBM PC was fist challenged by clones, Peter Norton's SI (system information) utility, included with the terrific *Norton Utilities* package, was a common comparison.

The problem with all of these measurements is not that they aren't valid. They usually are, within the constraints they're meant to be used. It's in their applicability as a means of comparison for most users. To explain and expand upon this last statement, let's take a closer look at the process of benchmarking.

At it's simplest, a benchmark is simply a measurement, or set of measurements, that lets you compare a group of like products to see how one of the group stacks up against the others. For a benchmark to be usable, it must to be both appropriate to the products being compared and relevant to the user's comparison process.

If I'm benchmarking automobiles to see which models will fit in my garage, it doesn't really matter whether I'm using inches, feet, yards, meters or blabs (one blab being the length of the tree branch I found in my backyard.) As long as I can express the dimensions of both car and garage in the unit of measure selected, I can compare several different car models to see which ones will fit in the garage. In this illustration, a blab is a legitimate measure to use as a benchmark only as long as I can take my 1-blab stick to various car dealers to measure their offerings. Where the blab falls short as a benchmark is in its general applicability. Since I have the only 1-blab measure around, I certainly can't call car dealerships in the area and ask how long and wide their models are in terms of blabs.

I could also choose the small birch tree in my backyard as a basis of measurement. My Honda is about a fifth as long as the tree is high. Unfortunately, my garage is also about a fifth as deep as the tree is high. Will the Honda fit in the garage? If I'm using the tree as my basis of measurement there's no way to know because there's no way I can perform the measurement with any degree of accuracy.

The same holds true if I choose miles as my basis. I'm sure that with a bit of computation, I can express the length of both the Honda and garage in fractions of a mile, and that will tell me whether the Honda will fit in the garage (assuming I carry the computation out to enough decimal places), but it won't easily tell me how much room I have left over when the Honda is in the garage.

Using a tape measure is a much better benchmark in this case. If my garage is 20 feet deep and my Honda is 14 feet long, I know immediately that not only will the car fit in the garage, but that I'll have 6 feet of room front and back. If I'm thinking of getting a new car, I can benchmark an 18-foot-long Lincoln Town car against both the garage and the Honda and quickly determine that my kids' bicycles will have to go somewhere else if I buy the Lincoln. In this scenario, the benchmark is both appropriate (being expressed in units that have some usable relationship to the qualities I'm looking at) and relevant (providing information that allows me to make a valid comparison.)

Most benchmarks in use today are neither appropriate nor relevant. In fact, the benchmark I finally settled on, Diagsoft's *PowerMeter* 1.8, while appropriate for the purpose of this review, may or may not be relevant for your particular decision. Before I get into the reasons for this, let's take a short look at some of the popular and commonly used benchmarks and the means of measuring computer performance to see where they fit in terms of applicability and appropriateness.

Common Benchmarks

Two of the more commonly quoted benchmarks are Dhrystones and Whetstones. These two tests were developed more than three decades ago to compare mainframe computers.

The Dhrystone is a measure of processing power and refers to how fast a computer can execute a series of pre-defined instructions. This instruction mix consists of a variety of machine-level commands but are primarily NOP-type instructions (NOP, short for no operation, is a command that does absolutely nothing; NOPs are great for building timing delays into programs). The actual standard for constructing a Dhrystone test, which I haven't looked at for many years, defines the instruction mix and the method to calculate the number of Dhrystones.

Two important things to remember about about the Dhrystone test are that it provides a measure of how fast the computer can execute a program and it's a good bet that running two different Dhrystone programs on the same computer will give you different results (though they should be within about 15% of each other.) The reason for this variation is that different compilers and languages produce code that may be more or less efficient than others.

A Whetstone test has a similar concept, except that it measures a computer's ability to execute a mix of primarily mathematical instructions. As with Dhrystone tests, different versions of the Whetstone test will yield varying results.

MIPS and MFLOPS are similar types of tests, both to each other and to the two tests just described. They both also measure a computer's ability to execute instructions. MIPS stands for millions of instructions per second, while MFLOPS are millions of floating point operations per second.

All four of these benchmarks yield a basis of comparing different (and sometimes very dissimilar) computers. The problem, as we'll see, is that the basis of comparison they provide isn't always relevant. Other common tests, such as the Norton SI and LandMark tests compare the unit under test to the original 4.77-MHz IBM PC. These benchmarks suffer from many of the same deficiencies as the first four we looked at.

The greatest problem with most available benchmarks is that they don't take into consideration three important things. One is that performance of a PC depends not only upon how fast it is computationally, but how the system as a whole ties together. A PC is more than just a CPU. It has RAM memory, ROM memory, disk memory and a variety of I/O devices (video, serial, parallel and keyboard.) The speed of all of these component subsystems and how effectively and efficiently they're used plays a large part in the PC's overall performance.

The other two factors are just as important, if not more so. Different applications use systems resources differently. Even two differing spreadsheet programs won't make the exact same use of a PC's resources. Knowing how fast a system's clock speed, or average track to track seek won't by itself tell you if your spreadsheet will run better on System A or System B. The problem with almost every benchmark is in its relevance—applying the information provided to determining whether one system under test will better meet your needs than another.

Though there are a number of approaches you can take to address this problem, there really is no perfect solution. One technique is to construct your own set of benchmarks from the applications and files you use most frequently. If you automate loading, running and other keystrokes with a keyboard macro program, writing the system clock time to a file before starting and after finishing, you solve the problem of relevance. This approach gives you benchmark results that tell you precisely how the systems differ in running your particular application sets.

Even if you make up your own set of benchmarks in this manner, there's still the problem of running this benchmark on a variety of systems. You must also be very careful in selecting the files and operations performed during your benchmark. Unless your particular application benchmark is representative of all the ways you use the application, results obtained may be very deceptive. For example, suppose you decide to create an application benchmark using Microsoft's *Excel* spreadsheet. You could use *Excel*'s back-solver capability to really give the machines under test a workout. If your normal day-to-day use of a spreadsheet is very calculation-intensive, the results you obtain from this particular benchmark might be very useful in making a purchasing decision or in evaluating planned system upgrades. On the other hand, if you normally use a spreadsheet for fairly simple tasks, the results from a computation-intensive benchmark may not be germane.

You've probably also come to the same conclusion I did. How do you use a widely available benchmark that's somewhat generally applicable to many users and attempt to find some way to relate the results to an individual user's needs and requirements? In my opinion, this can be accomplished using several of the benchmark tests available in DiagSoft's *Power Meter* 1.8 package to describe how the tests weigh the individual system resources they measure and then tell you about a program you can use that determines how your particular applications make use of your PC's resources.

This approach is workable on several levels. The particular tests that I'll report on are several of *Power Meter*'s application simulations. *Power Meter* itself is designed to make many of the same measurements that other magazines use in reporting on system performance. These include various disk measurements, such as seek time and data-transfer rate; processor measurements, such as Dhrystones and Whetstones; and RAM tests, such as read/write rates.

Power Meter goes a step further. After running all these tests, it weights the results obtained to simulate the system load a "typical" database, spreadsheet or word-processing application places on the PC under test. Even though I've just spent considerable verbiage explaining how there's no such thing as a "typical" application, expressing the results in this manner does make them a bit more relevant in assaying the general performance of a number of systems.

To make the results a bit more relevant to your specific information needs requires two more things. One is knowing what the load components and percentages each *Power Meter* simulation places on the system under test being able to relate the results of loads your applications place on your own system. Fortunately, both are fairly easy to obtain. *Power Meter*'s documentation lists the weight each simulation places on the various system performance components (Fig. 1).

```
EXHIBIT
POWER METER TESTS--SYSTEM RESOURCE LOADS

DATABASE APPLICATION SIMULATION:

Total System Memory              20%
Character Write Test             10%
MIPS Test                        20%
Aggregate Disk Drive Test        35%
Sort Test                        15%

SPREADSHEET APPLICATION SIMULATION:

Total System Memory              10%
Total Expanded Memory             5%
Character Write Test             30%
Aggregate Disk Drive Test         5%
Cell Address Calculation         20%
Formula Calculation              30%

WORD PROCESSING APPLICATION SIMULATION:

Total System Memory              10%
Character Write Test             45%
String Searching                 10%
Dhrystone Test                   30%
Aggregate Disk Test               5%
```

Fig. 1. *Power Meter* documentation lists the weight each simulation places on the various system performance components, as shown in these printouts.

The second part of the equation, the loads your application places on a system, is also easy for you to determine. It requires use of *Personal Measure* from Spirit of Performance. (I reviewed this program a while back in this column.) *Personal Measure* lets you determine what system resources are used by an actual application.

Personal Measure is a TSR (terminate and stay resident) program that remains in memory, where it "watches" your application as it's running, keeping track of how much time the application is making use of the disk, I/O and processor. It can then produce a graph and set of reports that detail this usage in actual time the application spent using these resources and the percentage of time the application used each resource.

If you run *Personal Measure* on your own applications, you can make a direct comparison with the weighting *Power Meter* makes on its application simulations to see how appropriate the results are—and, more importantly, where they're completely inappropriate.

Next time, we'll start putting some of this theory to use by looking at how Micro Express's new 386/40 compares with several other systems. I'll also tell you about a product from Sonera Technologies that not only lets you compare different video monitors, but can also be used to fine tune the video system you're currently using. ■

Products Mentioned

Power Meter 1.8, $99.95
DiagSoft, Inc.
5615 Scotts Valley Dr.
Suite 140
Scotts Valley, CA 95066
408-438-8247

Personal Measure, $125
Spirit of Performance, Inc.
73 Westcott Rd.
Harvard, MA 01451
508-456-3889

Joseph Desposito

Fast EPROMs and transceivers, stand-alone and DRAM controllers and a compact modem for connecting MAP machines

This month, we lead off with a new 35-ns EPROM. This speedy device should encourage designers to dispense with memory schemes that move data from slow EPROMs to fast static RAMs.

35-ns EPROM

International CMOS Technology (2125 Lundy Ave., San Jose, CA 95131) announced its 27CX256 high-speed CMOS EPROM, offering access times as low as 35 ns. The 27CX256 is the second member of ICT's high-speed, high-density family of EPROMs, the first being the 45-ns, 1M-bit 27CX010 EPROM.

With speed grades of 35, 45 and 55ns, the 27CX256 is a good choice for operation within high-performance microprocessor and DSP systems. With the 27CX256, you can achieve maximum processor performance by eliminating wait states. A high-speed EPROM can replace traditional slow EPROM to fast static RAM memory schemes (that is, cache memory). This results in reduced power consumption and board space and, ultimately, increased system reliability and decreased system cost.

The 27CX256C-35, 45 and 55 devices (the last two numbers give speed in nanoseconds) are organized as 32K bytes of eight bits each. Available in a 28-pin ceramic windowed DIP package, the 27CX256 uses less than 1 mA in stand-by mode and a maximum of 50 mA while in active mode.

Programming of the 27CX256 is supported by popular third-party vendor EPROM programmers. Pricing of the 27CX256-35, 45, and 55 is $21.60, $16.50 and $13.20, respectively, in 1,000-piece quantity.

Dual Transceivers Run at 116K Bits/s

Maxim Integrated Products (120 San Gabriel Dr., Sunnyvale, CA 94086) announced its MAX222/232A/233A/242/243, five new RS-232 drivers/receivers that provide fast data rates from any +5-volt-powered RS-232 device while maintaining full compatibility with EIA-232D and CCITT V.28 standards. The devices are guaranteed to operate at data rates up to 116K bits/s and typically as high as 200K bits/s. These limits are achieved while driving real loads (2,500 pF and 3,000 ohms).

In addition to their high speed, all the new devices (except the MAX233A) enable the designer to build smaller, more cost-effective systems because they operate with space-saving 0.1-μF charge-pump capacitors. For systems that have even tighter space requirements, the MAX233A has internal capacitors that eliminate the need for any external components.

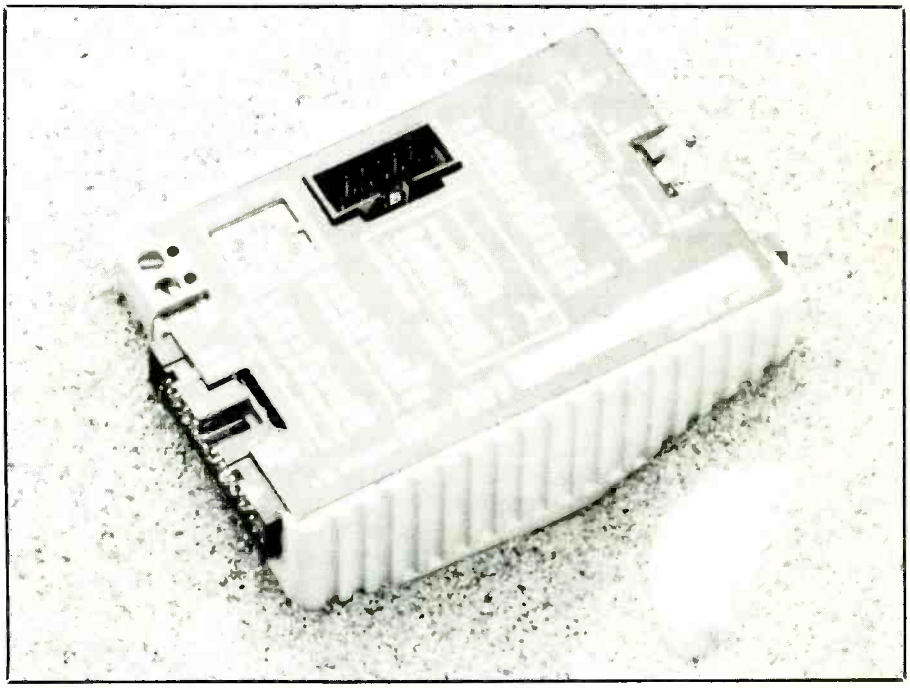
The MAX222/242 can save up to 67 mW of power when not receiving or transmitting data by reducing loaded supply current from 13.5mA during normal operation to 10-μA in shut-down mode. The MAX222 dual transceiver (two drivers and two receivers on each chip) features a shut-down mode that disables the device and turns off all driver and receiver outputs. The MAX242 is identical, except for an additional feature. It has a pin that has three-state controls for the driver and receiver outputs, allowing bused (party-line) configurations. The 242's receivers remain on in shut-down mode to receive incoming data.

The MAX243 allows alternate use of two- and four-wire interfaces without changing cables or adding jumpers. Because one of the two receiver-input thresholds is negative (−0.8 volt) instead of positive (+1.4 volts), CTS/RTS flow-control lines can float without interrupting communications.

MAX232A/243 chips are offered in 16-pin DIP and SO packages, MAX223/242 chip in an 18-pin DIP and SO package and the commercial, extended industrial and military temperature ranges. Prices for most of the devices start at $2.65 each, commercial grade in a plastic DIP package. The MAX233ACCP is priced at $4.21 in 1,000 and up quantity.

Programmable Controller

SEMIX's (4160 Technology Dr., Fremont, CA 94538) new stand-alone programmable controller, the RC-207, has 20 inputs and 16 outputs. This compact control module can be programmed through any computer with an RS-232-C

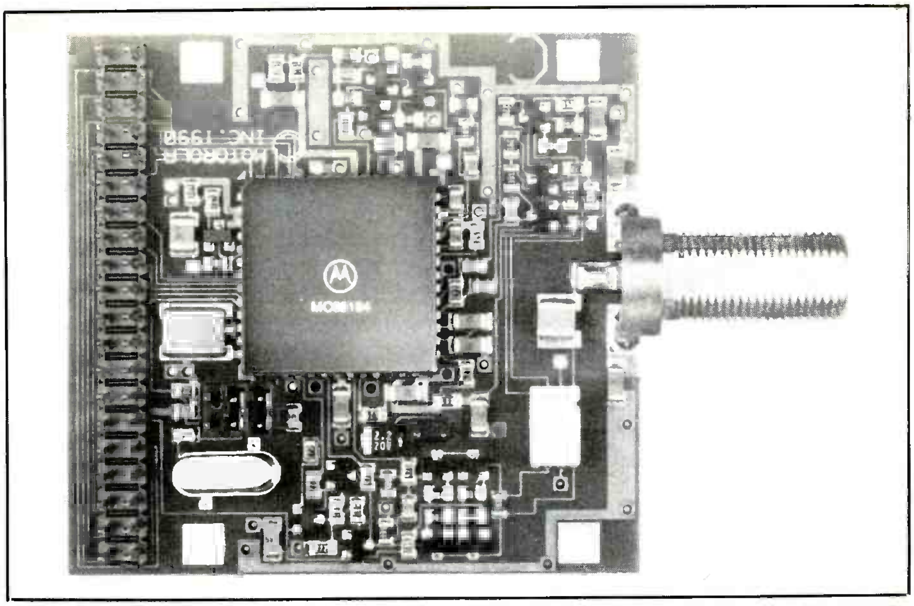


Semix's RC-207 stand-alone programmable controller has 20 inputs and 16 outputs and can be programmed using any computer that has an RS-232C communications port using a low-level command language.

communication port using a low-level, command language or SEMIX's RC-TALK high-level (BASIC-like) user interface software. After programming, the program can be saved into the unit's memory (8K EEPROM).The host computer and RS-232C interface can then be disconnected for stand-alone operation.

This modular controller's compact size (2.2″L × 4.1″W × 1.1″H) allows it to be placed in tight places, where space is at a premium. The casing is noise- and EMI-shielded and resistant to heat, dust and vibration.

The RC-207 has built-in logic for controlling two-step motor drivers. Its high-speed counter (100 kHz), 1,130 points of memory and 20 inputs/16 outputs allow it to do multi-axis step-motor control and be used with micro-step drivers.



Motorola's carrierband modem for LANS offers a low-cost, compact alternative for Token Bus users. It can be used to interconnect machines in factory environments using Manufacturing Automated Protocol (MAP).

Direct DRAM Interface For 40-MHz CPUs

Two programmable DRAM controllers optimized to interface 40-MHz microprocessors directly with large DRAM arrays of up to 72 devices are now available from Samsung Semiconductor (3725 North First Street, San Jose, CA 95134). The two controllers are the KS84C31-40CL, which supports 256K and 1M bit DRAMs and KS84C32-40CL, which supports these devices, as well as 4M- and 16M-bit DRAMs.

These controllers are the next generation of the system accelerator DRAM controllers introduced by Samsung in mid-1988. Samsung supports the burst-mode features of the Motorola 68030/40, the Intel 80486 and a variety of DRAM architectures. Support for burst-memory access helps improve cache hit rates when used with caching systems.

These controllers are designed for new 486 PCs that need high-performance memory control, since traditional chip sets are either too slow or not available.

The flexibility of these controllers is obtained with a 26-bit programmable mode register that allows the user to select such functions as support of synchronous and asynchronous access methods; page, burst or interleaved accesses; latching of address bits; programmed insertion of wait states in the CPU cycle; RAS or staggered RAS refresh options virtually transparent to the CPU; column address setup and row address hold times; and the ability to fine-tune the control signals.

Other features include page, nibble and static-column accesses; byte operation with four independent CAS outputs; built-in delay line; TTL-compatible inputs; on-chip capacitive load drivers; and the ability to operate in synchronous or asynchronous mode.

The controllers also offer page-detection logic that permits them to access data randomly within a page for use with page-mode and static-column DRAMs.

Both versions of the controller can drive large memory arrays—up to 72 devices. Several hundred DRAMs can be driven when damping resistors are used to control ground bounce. Both devices have a maximum current drain of 125 mA while active and 25 mA in standby.

These controllers are well suited for low-power applications because they can automatically refresh DRAMs in a powered-down state without any CPU input.

The KS84C31-40CL controller, supporting 256K- and 1M-bit DRAMs, is manufactured in a 68-pin plastic leadless chip carrier (PLCC). The KS84C32-40CL, which supports DRAMs with capacities of up to 16M bits, is available in an 84-pin PLCC.

Both DRAM controllers are manufactured on Samsung's advanced 1.2-micron CMOS fabrication line in San Jose, CA. Prices are $22.30 for the KS84C31-40CL and $27.76 for the KS84C32-40CL when ordered in 1,000-piece quantity. Samsung also has 25- and 33-MHz versions of both controllers.

Carrierband Modem for LANs

Motorola (5005 E. McDowell Rd., Phoenix, AZ 85008) introduced a baseband (no carrier frequency) modem for use in interconnecting machines in factory environments using Manufacturing Automation Protocol (MAP). The MHW11005 gives MAP/IEEE 802.4 Token Bus users a low-cost alternative to designing, building and testing a modem. Requiring only 5 volts dc, the low power consumption makes the MHW11005 a good choice for use in local-area networks.

Based on the Motorola MC68194 Carrierband Modem (CBM) chip, the MHW11005 operates at a 5M-bps data rate and uses frequency shift keying (FSK). A Bergstik II connector option permits easy insertion to a motherboard. This complete printed-circuit board module is constructed using surface-mount technology for operation over temperatures ranging from 0°to +70°C.

The CBM chip provides all of the physical layer management, data encoding and modulation and data reception and decoding. Remaining components on the module support operation of the CBM, providing connectivity to the LAN cable and to the Token Bus controller.

Management functions include standard IEEE 802.4 requirements of local loopback (internal to the CBM), command reset and transmitter enable (serial data transfer commands are non-acknowledged). These are controlled through the Token Bus controller interface. An RC-based Jabber Inhibit Timer provides a self-inhibit function if the transmitter has been active 0.5 second. The result of the time-out is transmitter disabled and an error is reported to the controller. A power-on reset function insures proper modem initialization. The LAN cable interface provides a standard 75-ohm F connector.

The MHW11005 is used for equipment needing to be interconnected via coaxial cable for exchanging digital information. Pricing is $250 for 500-piece and up quantities.

Navigating Through CyberSpace

There's a level of computer communications beyond that of on-line service users. Computers are connected all over the world by a system called "the net." Corporations, government facilities and, most of all, universities are attached to it. By knowing how to interact with this net, we can send electronic messages to individuals in such diverse places as AT&T Bell Labs, Ben-Gurion University of the Negev, Autodesk, Inc., Kadena Air Base in Okinawa, Southern Methodist University, National Film Board of Canada, The Michigan UNIX Users Group, NASA Johnson Space Center, IBM, Tokyo Shosen University, Christian Medical & Dental Society, National Security Agency, Notre Dame University, ABC Broadcasting, National Energy Authority of Iceland, Lotus Development Corp. and most of the commercial databases and electronic mail services.

That's right—we can send messages to persons on CompuServe, MCI, GEnie and others without having to pay those services for the privilege of communicating with its members! We don't even have to be members of those services to send messages to its members or receive messages from them. Even beyond electronic mail, we can subscribe to newsgroups that let us read reams and reams of material daily or weekly on specific topics of interest. Once again, this type of information-gathering costs little more that a local telephone call.

How do we set up this type of communications? The initial steps are no different than any other form of communications. You require a modem and a general-purpose communications program for MS-DOS systems or for Macintoshes. The next step is to find a local "Usenet" or "Bitnet" connection. It's these connections that will serve as our gateways to the overall net. Most colleges and universities have the connections, as do many major corporations through their internal e-mail systems. If none of these accesses are available, then a user must find a local bulletin board or service that has a Usenet connection.

A popular national service, the Whole Earth 'Lectronic Link (WELL), provides a way into the network. The Well can be accessed by dialing the user's local CompuServe number and, at the "Host:" prompt where "CIS" is usually entered, keying WELL. The connection is made through the CompuServe network, although the user isn't actually going into the CompuServe service.

Persons in the San Francisco Bay area can access the Well by dialing 415-332-7398. The charge for Well use is $2 per hour plus line charges—either local or Compuserve network. In New York City, access to Usenet is provided by the Dorsai Diplomatic Mission (modem number: 212-431-1944; voice number: 212-431-01431), a public-service bulletin board (while basic membership in Dorsai is free, access to Usenet requires a higher-level membership at a cost of $25 per year).

Once access to Usenet is obtained, all that remains is to determine the address of those whom mail is to be sent to. The "To Address" is broken into two sections separated by an sign and is in the following format xxxxxxx@yyyyyy, where xxxxxxx represents the individual's identification on a particular system and yyyyyy represents the system to which the message is to be delivered.

Confused? It becomes much clearer with examples. Our identification on the Well is "mcmullen." If you were on the Well as a member of the system and wished to send e-mail to us, you'd simply use "mcmullen" as our address. However, if you were connected to any other computer on the net and wished to send us mail at our Well address, you'd address it to "mcmullen@well.com" for it to reach us ("well.com" is the address on the Internet system for the Well service and "mcmullen" is our unique address on that service). This addressing format is consistent across the entire net; so our address on other services is: CompuServe: 70210.172@compuserve.com MCI: 316-9687@mcimail.com; Marist College: JZJH@MARISTB.BITNET.

With this format, it's necessary to know both the address of the service to which the address is connected and the person's unique identification on that system. The individual's unique identification can, in most cases, only come from that person. The person, however, may or may not know the address of the system on the net. If he's never communicated outside the school, business or BBS before, it's possible that he won't know it. In that case, there's generally a "sysop" or communications manager who can give him the network address, which can then be passed on to the sender.

At times, the sender will have to be aware of some unique conventions, such as the fact that commas aren't used in addresses. Our Compuserve identification is 70210,172, but when addressed from outside Compuserve, it becomes 70210.172@compuserve.com, with a period replacing the comma. A very good

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Received: from CUNYVM.BITNET by VM.MARIST.EDU (Mailer R2.07)
with BSMTP id 6589; Tue, 04 Sep 90 19:32:26 EDT Received: from
CUNYVM by CUNYVM.BITNET (Mailer R2.03B) with BSMTP id 5415; Tue,
04 Sep 90 19:24:41 EDT Received: from apple.com by
CUNYVM.CUNY.EDU (IBM VM SMTP R1.2.2MX) with TCP; Tue, 04 Sep 90
19:24:39 EDT Received: by apple.com (5.61/25-eef) id
AA08679; Tue, 4 Sep 90 16:22:29 -0700 for Received: by
well.sf.ca.us (4.12/4.7) id AA23455; Tue, 4 Sep 90
16:15:55 pdt Date: Tue, 4 Sep 90 16:15:55 pdt From:
well!mcmullen@apple.com (John McMullen) Message-Id:
<9009042315.AA23455@well.sf.ca.us> To:
KL2Q%MARIST.BITNET@cunyvm.cuny.edu Subject: This is from the Well
```

Fig. 1. Routing header of a message received when a test message was sent from authors' account on the Well to their account at Marist College in Poughkeepsie, NY.

help in finding the addresses of net connections is *The User's Directory of Computer Networks* edited by Tracy L. LaQuey (Digital Press; 1990). In addition to listing net addresses, this worthwhile book gives very good explanations of various components of the net and has maps that show the actual telephone connections of various components.

When speaking of e-mail flowing through the net, it should be understood that this is often a circuitous route. The message moves from system to system in the vast maze of connected computers to find the best possible route. A prime example of such a travel is a test message we sent from our account on the Well to our account at Marist College in Poughkeepsie, NY. When the message was received the routing header looked like that shown in Fig. 1.

This indicates that the message went from the Well to Apple Computer to the City University of New York's EDUNet system to the City University's BITNet drop to Marist to our own mailbox—all in about 3 hours and 15 minutes. This is certainly not the speed of two persons on GEnie or Compuserve speaking to each other. However, it's considerably cheaper and certainly impressive when compared with the speed of the US Mail Service or even Federal Express or United Parcel Service.

This article has, for reasons of space, only gone into the electronic-mail features of the net. There are many more features, including "newsgroup" reading, of net connectivity that will be of benefit to the user. An outstanding resource in learning the power and features of the net is *The Matrix: Computer Networks and Conferencing Systems Worldwide* by John S. Quarterman (Digital Press, 1990). Although rather expensive at $49.95, the work is well worth it. In its 655 pages, *The Matrix* provides a comprehensive explanation of the worldwide network. Detailed technical explanation of each component of the net or "Matrix" is given, and each section is supported by an impressive bibliography. Anyone with even a passing interest in such communications should consider adding this work to his bookshelf.

Science-fiction writers refer to the space in which these communications are carried out and conferences are held as "cyberspace." There are engrossing novels, such as Bruce Sterling's *Islands In The Net*, that speak of an entire world completely linked. While enjoying these works, we must remember that much of the environment presented as "in the future" exists right now. Cyberspace is out there, and it's our challenge to benefit from it. ■

home crowd fool you. This lady has class. Even so, I nailed her. Sent her up the river. I thought it was for good, too. I should've listened to my detective's sixth sense, though—you know that little voice in the back of your head. It warned me that Carmen had some more tricks up her red sleeve. But I didn't listen and I could kick myself for it.

1986: Where in the USA Is Carmen Sandiego?

It should've taken longer than a year for Carmen to break jail. I don't know how she did it. Neither does Broderbund. Even Sterling and Switzer were stumped. Quick as right cross, I found myself signing on the dotted line with Acme again.

Don't ever ignore your detective's sixth sense. Carmen was at large again and had rounded up new gang members. They were the same kind of big-city scum that she traveled with before, all of them dumb as oxen. But they can give you the slip if you're not careful. Carmen must have taught them a thing or two. The classy lady confined her pilfering to the good old USA this time around, but that didn't put any reins on her theft rate. By this time, though, I was wise to her ways.

It didn't take long for me to get back into the swing of things. Searching for clues and pumping witnesses for info was getting easy. Like before, Acme included a fancy dossier on Carmen's gang. They may have been new faces, but their stories were the same. I had the gang wrapped up without too much trouble. But putting the arm on Carmen took a while longer. She'd gotten tougher. Even with Broderbund's reference book, she gave me the slip a few times.

Carmen was going for higher stakes, but Acme hadn't exactly been sitting on its collective thumbs. These boys had anted up, too. Game interface was a little smoother than before. Graphics were a little better. Broderbund was onto something with this line of games. I'll give even odds that nobody in San Rafael knew that the series would take off like a Saturn rocket.

1988: Where in Europe Is Carmen Sandiego?

You guessed it, pal. It took almost two years this time around, but Carmen sprung herself. I thought that I, Acme and Broderbund had things bottled up. But I guess I was wrong.

Acme and I had become good business associates by now. So I skipped signing the usual contract.

This time, Carmen vowed to ransack Europe. Hometown USA just wasn't big enough for her. Now she had to go over and bother Queens, Princes and other noble folk who deserved better. Looking over the dossiers gave me a bird's eye view of Carmen's newest mug line-up: June Bug—a florist who uses a flower shop to cover her dirty deeds; Clare D'Loon—a concert pianist who should be arrested for murdering the classics; and Chips Motherboard—a techno-nerd who tapped his grandmother's hearing aid when he was six years old. What a crop of losers.

This time, the trail took me to Edinburg, Scotland, where gang members were smuggling loot stashed in bagpipes, to the fast life and high stakes at Monaco, to Warsaw and Istanbul and even to Vatican City. I learned so much about Europe that I booked myself for a vacation after solving the case. Carmen's new gang had a couple tricks for me. But like I said before, different face, same story. Carmen was trickier than she had been back in the States. But I made good use of the Rand McNally *Concise Atlas of Europe* that Broderbund had shoved into the game package. It was better than a piece.

After Carmen was behind bars and wearing striped pajamas, I stopped in Athens to pat myself on the back and take a gander at the ruins at Cape Sounion. This time around, Ms. Sandiego was definitely out of commission.

1989: Where in Time Is Carmen Sandiego?

This was where I almost quit my chosen profession. How tough a prison does it take to hold one criminal? The only reason I took this assignment from Acme was because some kind of new time vehicle came with it. I know it sounds like I got rocks in my head, but they gave me a car called the Chronoskimmer 325i. It was more than a fancy set of wheels. It was a time machine. You know, like the kind you read about in those crazy science-fiction pulps. Anyway, the time car was to be used to tail Carmen and her newest gang back in time.

Seems that Carmen broke into some super-secret laboratory and got a five-fingered discount on the prototype. Now she and her overgrown kindergarten class can run foot-loose through 1,500 years of world history. Whew! I thought I had it tough in Europe!

Napoleon's hat was stolen. So was Don Quixote's lance and even Paul Revere's horse. If that ain't low and dirty, what is? So I worked for Acme as a Time Cadet and got all the proper papers and authority to go skipping through history. It was clever, alright, but all that time gizmo stuff set me back a couple of steps at first. Then I got the handle on driving the Chronoskimmer.

On this tour, VGA graphics and mouse interface helped a lot. This was a big uptown jump for Carmen—from the pokey to time traveling, I mean. Even so, Broderbund and Acme hadn't been sitting around looking dumb while Carmen was on ice. They came out with a bunch of game improvements, including a special classified Detective Manual and copies of the *New American Desk Encyclopedia*. That reference guide helped me bag goons like Russ T. Hinge, a handyman and safecracker so crooked that he once picked his own pocket. I also fingered Kari Meback, a cat burglaress who couldn't even sell the litters of kittens she heisted. The rest of the gang fell like a Joe Dimaggio grand slam. But again, Carmen threw me for a loop.

I finally lowered the boom on her, though, and learned world history like nobody's business. My high-school history teacher would pop her spectacles if she could see me now. Carmen was cooling her heels in the joint, and I was on a roll. This time-traveling stuff gave the detective business a new brand new look.

1991: Where in America's Past Is Carmen Sandiego?

So what else is new? Carmen didn't waste a minute breaking jail and rounding up another gang. Some of the deadbeats are the likes of Lucinda Boltz, ace auto mechanic; Stanley Cupp, retired hockey player; and Laverne Onions, a short-order cook. Don't be put off by their hyped-up names. They're as much a bunch of chowderheads as Carmen's other gangs. Again, different faces but the same old story.

Acme is giving me an improved Chronoskimmer for this one, the 450SL. It's the slickest set of wheels this side of time. They're sure needed, too. Carmen scampers back and forth through 400 years of American history like a wild pup looking for a bone. It takes all my savvy to keep her in sight. Acme says that what Carmen does back in time could change everything under our very noses. What a deal. The Liberty Bell has been stolen, Francis Scott Key's lyrics to the National Anthem are missing and the Statue of Liberty has mysteriously vanished from its harbor. What's next—mom's apple pie?

This kind of business really hits home. That's why I'm not charging Acme a dime. This one's on me, and I'm leaning on them pretty hard. Besides the Chronoskimmer, the reference guide is worth its weight in gold for tracking thugs through time. It's called *What Happened When—A Chronology of Life & Events in America* by Gorton Carruth. Without it, you're lost. You feel like somebody down at the precinct pulled your badge.

I've already iced most of Carmen's gang and it's been back to school for this old dog. I didn't think so much stuff could happen in only 400 years. Maybe that's why they call it America. Anyway, this is the flashiest Carmen yet. Hot VGA graphics, digitized photos and sound-card support make even a hard-boiled gamer like me glad to play.

The Future

Used to be I didn't give a hoot for the future. In my line of work, you live life one day at a time. And when you put the clamps on some crook, he stays put. Carmen has written a new chapter in my life. When dealing with her, you have to be ready for anything. Just to show you I know what I'm talking about, I got a hot tip the other day from an east-coast contact. Lisa Mogull of Michael Shepley Public Relations out of the Big Apple. The word is that Carmen has a TV deal based on the first Carmen World Affair.

The new series is supposed to mix elements of the computer game with live actors, studio participants, music, animation—you name it. It's going to air on PBS stations all around the country. They're even expecting celebrities to show up for cameos. And get this, it's all under the pretense of helping youngsters have a good time and teach them something about the world while doing it. If you ask me, there's gotta be some heavy bucks hitting the table. Anyway, if you're having trouble sorting all this out, you can get in touch with the right people and get the straight dope. Just don't tell 'em where you got their number. ■

Bird's Eye View

Where in America's Past is Carmen Sandiego?, $59.95
Broderbund Software
17 Paul Dr.
San Rafael, CA 94903-2101
800-521-6263

Requirements

RAM	640K
Graphics	VGA, MCGA, EGA, CGA, Tandy
Sound	Roland, Sound Blaster, Ad Lib, Tandy, PS/1
Controllers	Joystick, Mouse

Evaluation

Documentation	Excellent
Graphics	Good
Learning Curve	Short
Complexity	Easy
Play Length	Short
Playability	Excellent

In **Brief**: An easy-to-play fun game of chase and fact-finding that teaches useful information about American history and makes it fun for players young and old. VGA graphics and a hard drive are recommended for best performance.

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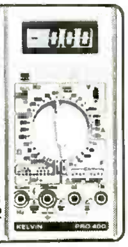

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We'd like to see your company listed here too. Contact Eric Teitelbaum or Margaret Milanse at 516-681-2922 to work out an advertising pro-

(from page 52)

memory board, while the remaining banks are lined up horizontally at the right, one after the other. Then remove all the chips in Banks 1 and 4 (assuming you'll wind up with a total memory size of 640K.) That's not Bank 1 through Bank 4, only 1 *and* 4.

Setting the removed RAM chips aside, start installing the 256K-bit chips in either Bank 0 or Bank 1. Completing one, do the other. When finished, you should have two banks of 256K chips, two banks of 64K chips and one bank of empty sockets. Lift up the board and peer down the socket aisles to be sure that all IC pins, eight on each side, are properly aligned in their respective sockets. When I did this, I saw that two IC pins were outside the sockets; so I had to remove the devices, push the out-of-line pins in a little and reinstall the chips.

Step 9. Next, you'll reinstall the memory card the same way you did the CPU card. Make sure the hold-down screw is put into the slot cover. Follow this by reinstalling the expansion card retaining bar that goes across the top of the cards. Now reverse the procedure you used when you removed the top case and then the disk-drive section.

Step 10. Now comes the final test. Did you pop a device? It's doubtful. Plug in your keyboard, video monitor (or not if you have the transportable) and printer cable to the computer. Plug in your ac power cord to your surge/r-f-suppresser power strip and turn on the computer.

When the blinking cursor turns into a screen prompt, type CHKDSK and press Enter. Total memory should now read 655360 on-screen. With this newly doubled memory, you can now run a host of fine application programs and TSR accessories that you never could before—without using up an expansion slot to do it.

The whole job should have cost you in the vicinity of $75 and less than 2 hours of your time. A Heath Computer and Electronics store in NY will charge you $50 to substitute only the PAL, not to mention what it would cost you to replace the RAM. So you've done okay for yourself. And you've got 27 free 64K-bit chips to do with as you wish (populate a printer buffer maybe?). ■

Educational Gaming: In Pursuit of Carmen Sandiego

It was hot in Big D. The kind of heat that drives two-bit fortune-seekers onto the sultry streets. I was playing connect-the-dots on my computer, making a picture of an electric fan, and thinking how nice it would be operate my computer by remote control from the swimming pool. That's when she showed up. She was quite a package. Federal Express package, I mean.

I took the package from the mail carrier and unwrapped it. It was her, alright. Her picture was on the game box, along with a reward for her capture. This angel's name was Sandiego. Carmen Sandiego. She was all prim and proper in her spike-heeled shoes, long red coat and matching hat.

One look brought it all back to me. This was no ordinary dame. She was a criminal mastermind, smart as a fox and with the killing looks to go with it. Carmen had apparently broken jail again, for the umpteenth time. Whenever she was on the loose, a phone call from Acme Detective Agency was never far behind. It had been a while since I'd contracted with that outfit. A brush-up on Carmen's *modus operandi* was in order.

I phoned the experts—Broderbund Software out of San Rafael. I had a couple of whiz-bang contacts named Francesca Sterling and Jessica B. Switzer. They were good at cutting through the red tape and getting their hands on the real bread and butter. I had to get the low-down on this new Sandiego Affair. Meantime, I guess I can clue you in.

1985: Where in the World Is Carmen Sandiego?

It all started back in '85 when Broderbund co-founder Gary Carlston wanted to make a program that would involve use of a reference book. Maybe he wanted people to have fun learning, or something. Anyway, he called on a crack team of employees—programmers, designers and marketing personnel. This ace group soon envisioned a detective-style game with the player chasing thieves around the globe.

The catch was that players had to make use of a reference book filled with facts that needed to be woven into clues and location descriptions. A reference book is safer than packing a piece. As you might think, a game like this had to have some substance to it, not to mention the ability to maintain player interest. To keep things entertaining, the designers came up with the idea of giving Carmen a set of wacky gang members for each adventure, as if criminals aren't wacky enough by nature. Maybe that was a good marketing idea, but chasing these guys down could wear a hole in your shoes—and socks.

The Broderbund brain trust came up with these fuzzballs: Lady Agatha Wayland, who has a predilection for sensible shoes; Dazzle Annie Nonker, who runs the toughest yogurt bar east of Suez; Fast Eddie B., who always carries his custom croquet mallets in the trunk of his convertible; and Nick Brunch, hard-boiled ex-private eye, ear, nose and throat.

I don't like Brunch. His type gives the private-eye business a bad reputation. Characters like him come off the bottom of the barrel. I know. Imagine traipsing across the globe after them. And when you do catch up to 'em, you can't nail 'em without a search warrant. You got to have evidence. What's the gumshoe business coming to? So Carlston and Broderbund unleashed Sandiego and her misguided low-lifes on the computer world.

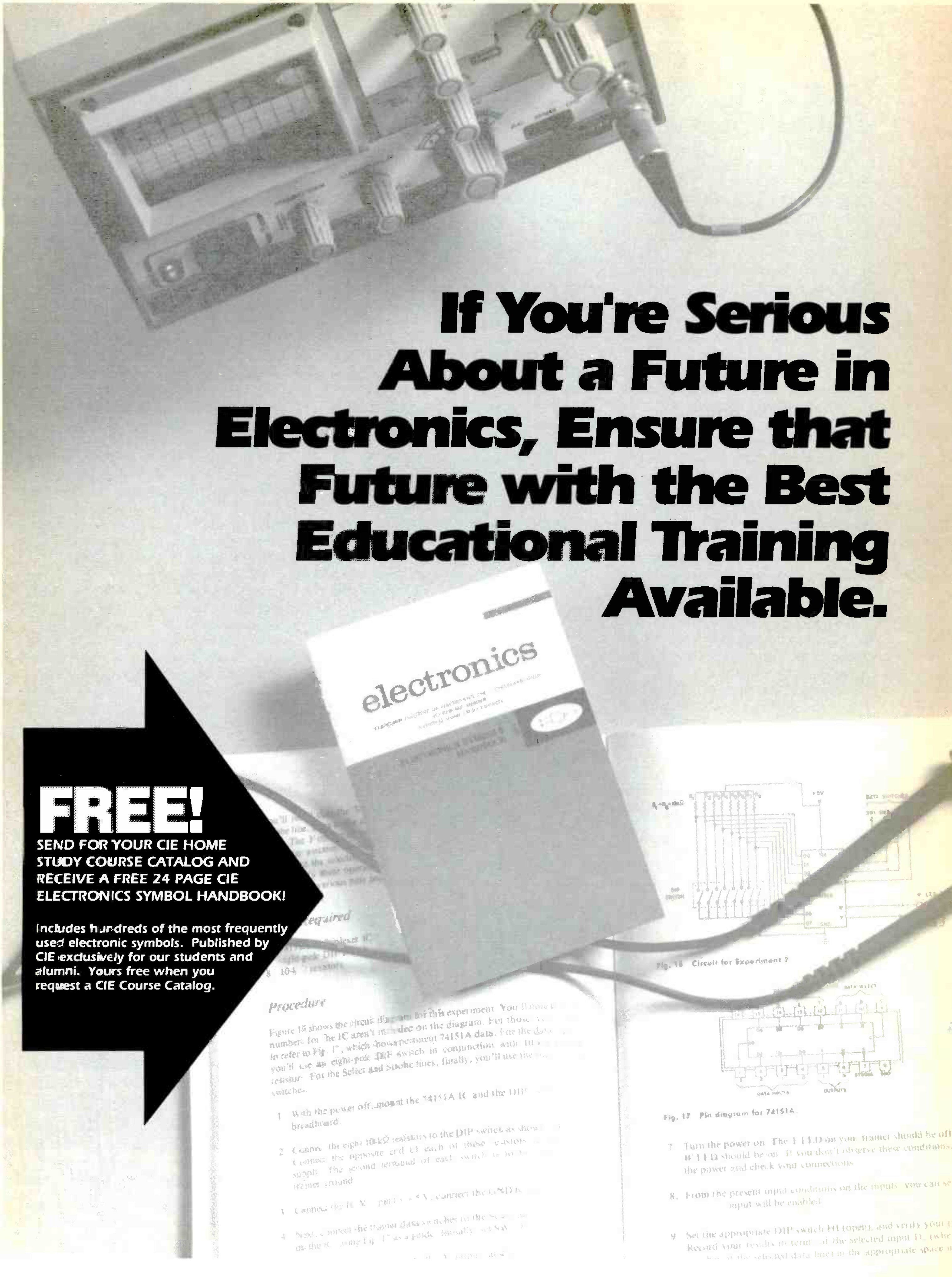
The first game was named *Where in the World is Carmen Sandiego?* It was sure named right. Carmen led me to all the continents, and I had to learn stuff like geography, currency used in different parts of the world, flag recognition, names of countries and sovereign states. You have to learn it all to stay hot on the trail of this criminal mastermind.

Along the way, Carmen was stealing everything in sight, like the Eiffel Tower and the Crown Jewels. It took a little time for me to settle in, if you know what I mean—even for an old pro like me. You start this fact-finding chase by signing on with Acme Detective Agency as a Gumshoe. Don't worry, Acme is a decent bunch to work for. You get promoted—if you do pretty good at catching Carmen's gang members. Acme gives useful clues and even dossiers on the suspects. Then you hit the streets.

Eventually, if Acme thinks you're ready, you can go for Carmen herself. But she's a slippery one. Don't let her

(Continued on page 84)

Here are two scenes from America's past, as depicted in the latest Carmen Sandiego saga from Broderbund: the San Francisco earthquake of 1906 at left and the first NASA Space Shuttle launch from Cape Kennedy, FL in 1981.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Procedure
Fig. 16 Circuit for Experiment 2
Fig. 17 Pin diagram for 74151A

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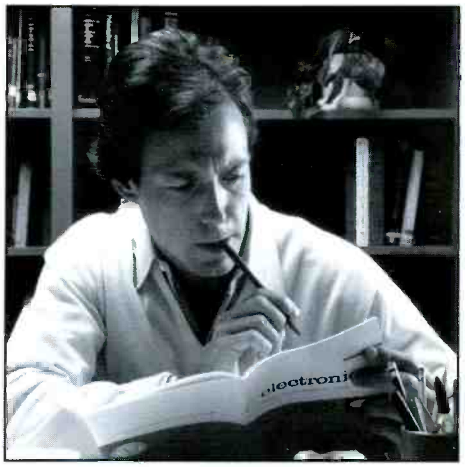

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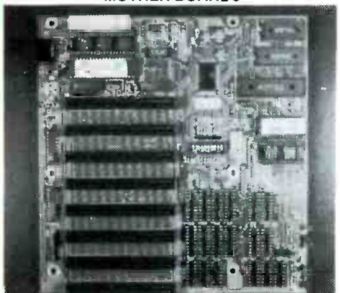
MOTHER BOARDS



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MB386-33C	386 33 MHz Motherboard	$459

MEMORY BOARDS

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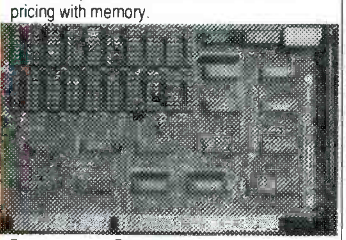

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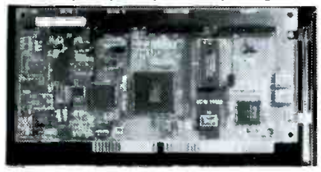

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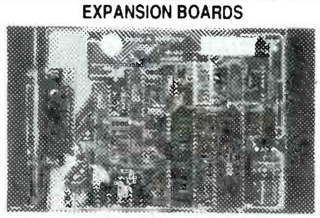
IFC-29	RLL Fixed Disk Controller Board PC/XT	$57
IFC-54	Add On Floppy Board XT/AT	$49
ST-01	8 Bit SCSI Controller	$29
ST-02	8 Bit SCSI/Floppy Controller Board	$47
IN-2000	16 Bit SCSI Hard/Floppy	$225

EXPANSION BOARDS



Part#	Description	Each
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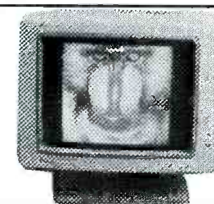

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