FIRST ISSUE: AN EXCITING NEW ELECTRONICS MAGAZINE!

ICD 08559

MODERN ELECTRONICS

OCTOBER 1984
$1.95

THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

* Easy Steps to Add Electronic Ignition Systems to Cars & Boats * Heath's New "Hero Jr." * Controlling a VCR with a Flashlight * Getting Started in the World of Hobbyist Electronics * How Far Did Apple IIc Computers Fall from the Tree? * Lower Fuel Bills with Simple Furnace Add-On * Coil Tester Detects Shorted Turns * Epson's New Pocket Color TV * Latest News in the Electronics Field

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Plus: ● Testing Luxman's Compact-Disc Player/JVC's New Stereo HiFi VCR/Star Micronics's "Powertype" Computer Printer/Heath's Component Tester ● Electronic Experimenting with Forrest Mims ● Technical Book Reviews ● International Shortwave Listings

The DX1000 makes tuning in London as easy as dialing a phone.

Direct access keyboard tuning brings a new level of simplicity to shortwave radio. With the Uniden® Bearcat® DX 1000, dialing in the BBC in London is as easy as dialing a telephone. And you can switch from the BBC to Peruvian Huayno music from Radio Andina instantly. Without bandswitching.

Featuring the innovative microprocessor digital technology made famous by Uniden® Bearcat® scanner radios, the DX 1000 covers 10 kHz to 30 MHz continuously, with PLL synthesized accuracy. But as easy as it is to tune, it has all the features even the most sophisticated "DXer" could want. 10 memory channels let you store favorite stations for instant recall —or for faster "band-scanning" during key openings. The digital display measures frequencies to 1 kHz, or at the touch of a button, doubles as a two time zone, 24-hour digital quartz clock. A built-in timer wakes you to your favorite shortwave station. Or, it can be programmed to activate peripheral equipment like a tape recorder to record up to five different broadcasts—any frequency, any mode—while you are asleep or at work.

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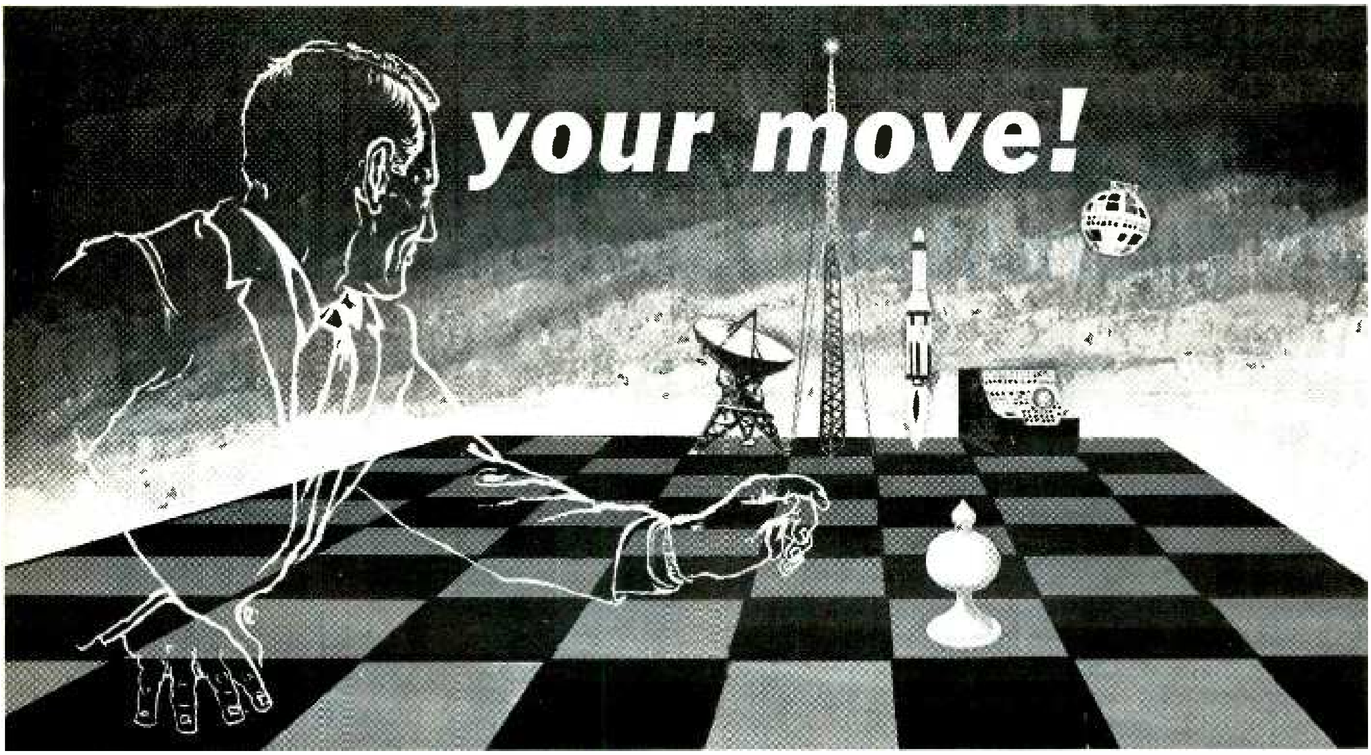

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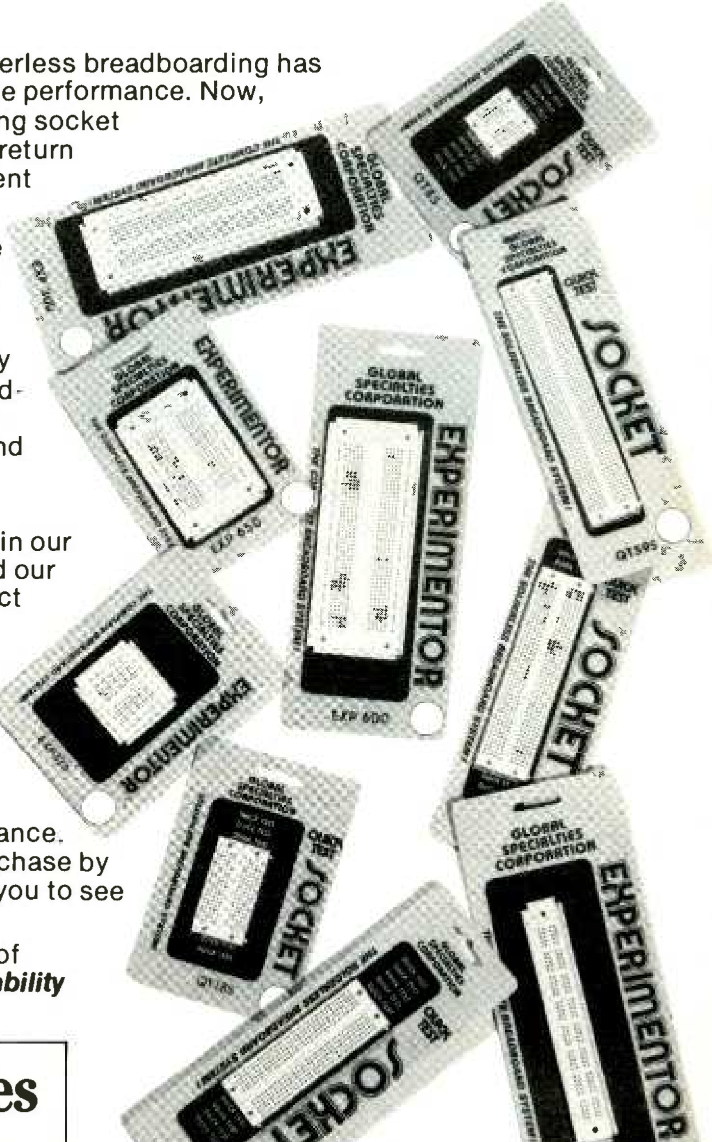

For more than a decade, Global Specialties' solderless breadboarding has set the standard for quality, durability and dependable performance. Now, we offer a lifetime guarantee. If a Global breadboarding socket fails to perform according to your needs, you merely return it to Global Specialties. We will send you a replacement free of charge. *No questions asked.*

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Seven sockets and three bus strips are included in our QT Series. Our new UBS-100 and UBS-500 models and our Experimentor line include socket and bus strip contact arrangements in single modular breadboards.

The industry's largest selection, unmatched quality and economy have earned Global solderless breadboarding sockets the reputation for being number one with professionals, hobbyists and students. Now, the unconditional lifetime guarantee is your assurance that when you buy from Global you receive maximum durability and trouble-free performance. Unlike some manufacturers who require that you purchase by mail, our nationwide network of distributors permits you to see and inspect our products before you buy.

See your electronics distributor or for the name of your local distributor, call our toll-free ***Product Availability Phone.*** 1-800-243-6077.

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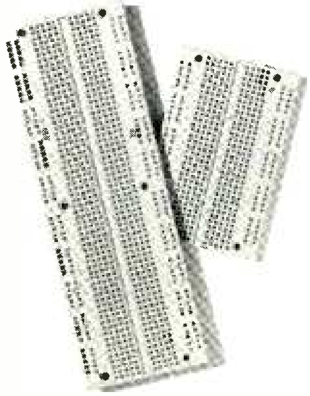

Two new solderless breadboarding sockets have been added to the Global line. The new UBS-100 is now the largest socket in the line, with 840 tie-points and the smaller UBS-500 has 430 tie-points. Each includes two rows of bus strips on each side for power and ground connections and the UBS sockets are made of the highest grade plastic material to insure maximum resistance to warping and breaking.

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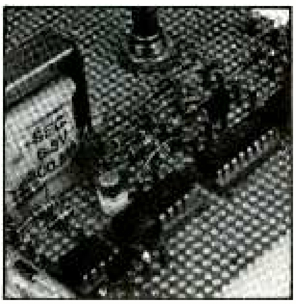

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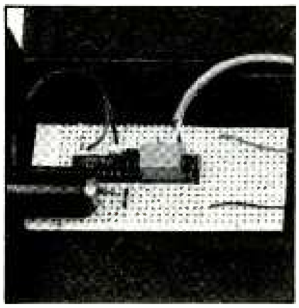

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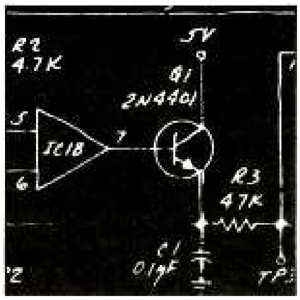

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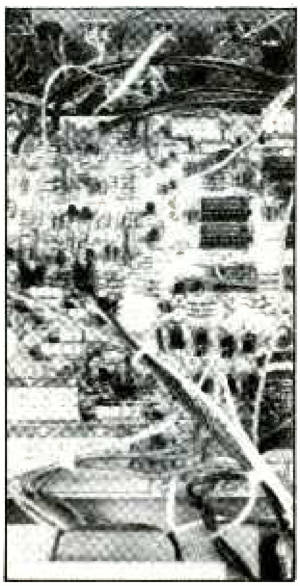

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DEPARTMENTS

LETTERS

A New Electronics Magazine

• Just learned you are starting a new electronics magazine, a real need since *Popular Electronics* became just another computer magazine. Really do miss a good nuts and bolts electronics publication. Please direct this to your circulation department so that I can subscribe. I'm a ham radio operator, but have two and one-half computers (one is in the building stage), and do a lot of electronic construction. I hope you will balance coverage between computers and electronics. There are a "zillion" computer magazine out now, and I subscribe to close to a dozen.
David D. Holtz
Eastman Kodak Company
Rochester, NY

• I just read about your new *Modern Electronics* and I'm excited about it. After subscribing to *Popular Electronics* for the past 25 years, I was very dismayed over the switch to a 100% computer magazine.
F. Hoffart
Santa Clara, CA

• Delighted to hear about launching of *Modern Electronics.* There's a great need for a replacement for the *Popular Electronics* of old. Many of us feel left out in the cold.
Harold Wright
Ontario, Canada

The following letters are representative of reader responses that came across my desk when Popular Electronics *changed its editorial thrust.*

• What are you doing? I found your magazine very enjoyable in the past, but you dropped all the projects. Now you're just another product magazine.
Anoy Prigge
Bromalea, Ontario, Canada

• I mainly subscribed for overall coverage of the electronics field. The articles I liked best, such as those by Forrest Mims, were dropped. Cancel my subscription.
Ricky Huegel
Allentown, PA

• Thanks for many years of enjoyable reading. I'm not renewing my subscription because of your new magazine format. I enjoyed the construction articles you used to have. I haven't built many, but seeing other peoples' designs is always informative.
Robert Blick
Fort Bragg, CA

EDITORIAL

A Warm Welcome

Welcome to Volume 1, Number 1, the very first issue of our new monthly magazine, *Modern Electronics.* As you digest its contents, you'll observe that it is a veritable one-stop source of "hard" information for electronics and computer enthusiasts: stereo, video, computers, hobbyist electronics, communications, servicing, technology, and electronic experimenting. All in one neat package.

Directed to enthusiasts like yourselves, who savor learning more about the latest developments in electronics and computer hardware, *Modern Electronics* shows you what's new in the world of electronics/computers, how this equipment works, how to use them, and construction plans for useful electronic devices.

Many of you probably know of me from my decade-long stewardship of *Popular Electronics* magazine, which changed its name and editorial philosophy last year to distance itself from active electronics enthusiasts who move fluidly across electronics and computer product areas. In a sense, then, *Modern Electronics* is the successor to the original concept of *Popular Electronics,* providing a virtual continuum in catering to the needs of technically oriented people who thirst for ongoing knowledge about all the innovative happenings in the electronics/computer field, stressing what's happening inside the enclosure and presenting this information in an inviting manner.

We've gathered a galaxy of fine writers to cover the myriad fields that make up "electronics." Forrest Mims III, for example, the leading star in electronic experimenting today, will regularly illustrate how to work with a variety of devices and circuits, every one of which he has personally built and checked out. His "Electronics Notebook" column will explore this area with you every month. Stan Prentiss will cover the video waterfront, starting next month. From videocassette recorders to satellite TV systems, his biting comments will give you new perspectives in every area of "sight" equipment. Len Feldman, a distinguished audio authority and author, will do the same for audio, while Dr. Charles Rubenstein will dissect computers, as will other computer specialists. And a host of leading electronics authors will add their creative efforts to the battery of exciting articles we will continually present.

Who reads *Modern Electronics*? Past experience indicates that the typical reader will be male with a median age in the mid-thirties. More than two-thirds can be expected to be professional, managerial, business owner, or technical people, most of them allied in one manner or another to the electronics field. Largely college trained, our readers will likely be intelligent, inquisitive, elitist, and have a special affinity for technical matters and high-tech products of every sort. About 15% of our readers will probably be college or high-school teachers of engineering, science, computers, or math and students in these areas.

As a participating type of reader, many of you would like to write for us we know. To do so, you should send a brief summary of your proposed article and your background together with a stamped/self-addressed envelope. Construction project proposals also should be accompanied by a schematic or block diagram and the approximate builder's cost. Payment is made upon acceptance.

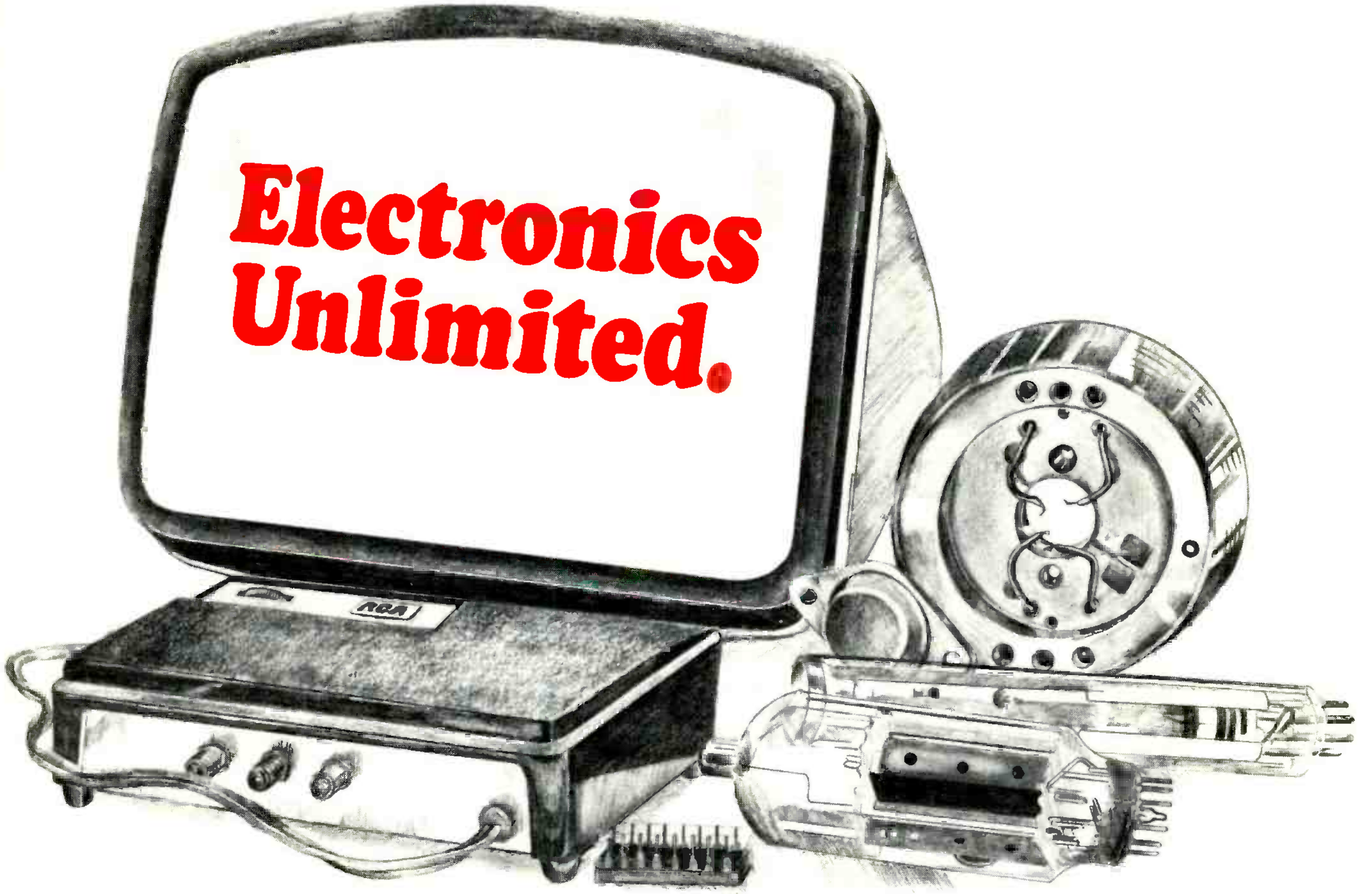
We'll be starting a "Reader Assistance" department to help you locate hard-to-find parts, equipment, and schematics, and to list used equipment you'd like to sell. This will be published once on a first in, first listed basis at no charge.

Naturally, your letters will be received with great pleasure. Interestingly, our first issue has a "Letters" department, below. They came from people who learned that we were starting *Modern Electronics* and from readers who objected to the elimination of electronics in the magazine I formerly edited.

As part of the publishing group that produces *CQ Amateur Radio* and *Popular Communications* magazines, *Modern Electronics* has the underpinning support that's usually necessary to produce a high-circulation magazine today. So we're here to stay.

Looking forward to your comments and suggestions as we grow.

Art Salsberg



RCA is one source for the best of everything in servicing parts and components — to give you a better payoff with less effort.

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CIRCLE 45 ON FREE INFORMATION CARD

HELPING SOFTWARE DEVELOPERS. Apple Computer introduces a new "school" for computer software (and hardware) developers. It's called "MacCollege," a three-day session for developers who want to put finishing touches on their Macintosh-computer products. Classes held at Apple's Macintosh Software Mill in Cupertino, CA are open 24-hours a day. Features direct contact with Mac software engineers, and covers subjects such as user interface, program design, and real-time debugging. Call (408) 973-4897 to register. Sessions end mid-November.

ELECTRONIC DROPOUTS. Giving up is never easy. Among the recent dropouts in the electronics/computer business is RCA's benching of its videodisk player, launched in March 1981. The company sold "only" about 500,000 units in three years, racking up a $580-million loss. That's about $1,100 per player, which started life at a suggested retail of $499 and dropped down to $199. . . . The Postal Service signed off, too, running away from its computer -mail business, E-COM. First-year mail projection of 20 million was in reality only 7 million. What could one expect when a minimum of 200 pieces with different addresses were required, and communication links to other cities could not be established? . . . .The Direct Broadcasting System (DBS) satellite-to-home TV transmissions took some knocks when CBS decided to drop out of the embryonic business. Included in its early plans was a high-definition video channel. Western Union killed its DBS plans on the heels of CBS's announcement, while RCA cut back its investment. Will we ever see those anticipated 2½-ft. antenna dishes marring the skyline? . . . .Pac-Man notwithstanding, Warner Communications "sold" its Atari unit to former Commodore Computer chief exec Jack Tramiel, who recently separated from Commodore. Interestingly, it was Tramiel who led computer price-cutting at Commodore that induced Atari to follow suit, that appears to have been Atari's downfall, that. . .oh, well.

COMPUTER HEALTH INSURANCE. More and more insurance companies are excepting computers from fire/theft policies, just as they generally do now with stereo and VCR's. For protection, you'll need a separate policy. Industry has a similiar problem--computer-controlled equipment such as robots are not covered by most machinery insurance policies. So Kemper Insurance has stepped in with a machinery repair and lost-time protection policy for such "iron-collar" workers.

COMPUTER SEXISM. With the drive to pronounce women equal to men, it's interesting to observe that a software company's startup premise is that there are no uncomplicated programs written especially for women. Neon Software, Middletown, CN intends to fill this gap, though, with its "Women's Ware" line for the IBM PC and PCjr, starting with a bevy of programs from BUDGET to CALENDAR to CHECKBOOK.

NEW AM-RADIO BAND CHURNING. The National Association of Broadcasters is pressing the FCC for utilization of the unused 1605 to 1705-kHz band for AM broadcast use.

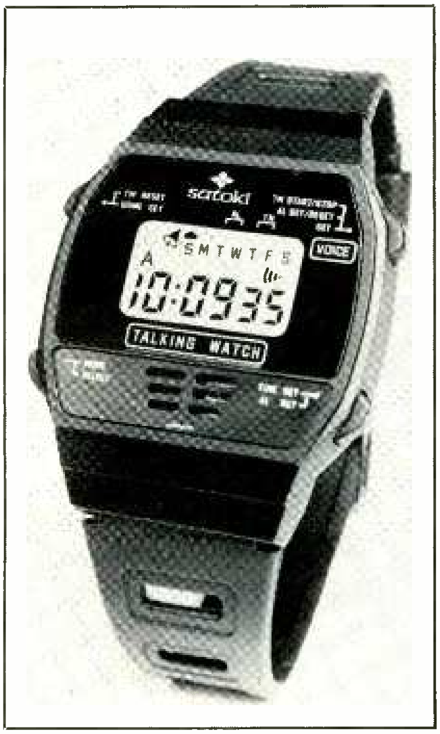
A NATIONWIDE PAGING SERVICE. To speed up introducing a nationwide wireless paging system, the FCC plans to use a lottery to select three network organizers from among the companies respond- to its invitation to construct such a system. Satellite or phone facilities will be used to link local paging companies around the country. With this system in place, which applicants had to pledge would be constructed within two years, a Californian businessperson travelling in New York could be "beeped" there any time and place.

BETTING ON CD PLAYERS. Audio companies and dealers feel that the sales success of CD players will grow markedly. Prices are still too high, even though dramatic reductions have been made to as low as $300. Furthermore, the catalog of CD records is still rather skimpy, and Compact Discs don't come cheap (about twice the price of vinyl LP records). Nonetheless, more audio companies have a CD player in their line than ever. They're moving into automobiles, too, with Sony showing two models and Mitsubishi and Fujitsu Ten promising them. Sharp Electronics demonstrated an impressive junior-size "jukebox" that selects from among 100 Compact Discs. About 100,000 CD players have been reportedly sold so far, which is some distance away from being a mass-market product.

SMARTER WRISTWATCHES. Both Casio and Seiko introduced real smart wristwatches at a recent electronics tradeshow. Casio's is a data-bank watch that stores 50 information elements with up to six letters and 12 numbers each. Seiko's is an honest-to-goodness wristwatch terminal. The terminal part can hold up to 80 pages of data with 24 characters each page. Notes such as phone numbers can be entered into the terminal and displayed on command.

CARTOONS FOR COCO. A new program for Radio Shack's TRS-80 Color Computer, "The Animator" from Triad Pictures Corp., Sequim, WA, is said to turn COCO into a Hollywood cartoon studio. The three-cassette $35 package comes with a library of character positions, sample sequences, sound effects, and a course in the art of animation. Positions can be cycled and recycled to give the illusion of motion. The frame rate is reportedly about equal to an average "Bugs Bunny"-type cartoon, and yields a smooth professional look.

SHOOT LIKE A PRO. Sony is offering a new 44-minute Beta-format videocassette titled, "Home Video: Shoot like a Pro." The cassette, which includes an instruction booklet, illustrates how to make good sound recordings, sequencing of shots to tell a story, and how to incorporate camera movement into video shoots. $29.25. Sony trumpets that Betamax BCR owners now have more than 6,000 prerecorded software titles available for their use, with more than 450 Beta HiFi titles. VHS prerecordings have a lot of catching up to do in this area, though some 70% of VCR machines sold have been VHS types.



A Talking Wristwatch

If you're accustomed to "reading" the time from your wristwatch, maybe it's time you had a change of pace and bought a watch that *tells* you the time. That's just what the Satoki Talking Watch from Z.I. Talking Technologies is designed to do. Just touch a button and the watch announces the time in a synthesized voice. If you prefer to be alerted to the time automatically, the watch can be programmed with interval voice alerts, with a final "please hurry up" signal. But if you can't break the reading habit or need more information than just the time, the watch has a conventional LCD panel that displays time in hours, minutes and seconds; day and date; and elapsed-time in its stopwatch function.

The watch is programmed in the standard 12-hour format, with AM and PM voice and visual indication. A built-in alarm function sounds a monotone chime and features a snooze function (with buzzer) with 5-and/or 10-minute intervals. The watch is available in black, beige, and khaki colors. $59.95. Address: Z.I. Talking Technologies, 8619 Reseda Blvd., Northridge, CA 91324.

CD Player for Cars

Now you can have all the advantages of the home CD (Compact Disc) player in your car with Sony's Model CDX-5 CD player. Designed to fit into the dashboard slot in DIN-size cars, this ruggedized player's mechanism is made to provide reliable operation even in the extreme environments inside the typical car. It is claimed to deliver the full measure of performance, including a 90-dB dynamic range, 0.007% THD, and flat frequency response across the entire audio spectrum.

Automatic disc loading and feather-touch controls make the player easy to use. Featured are an Automatic Music Sensor (AMS) button for skipping directly from selection to selection in either direction; Music Scan that runs through the entire disc in either direction at 10 times normal speed and produced normal-pitched sound at reduced volume; and separate repeat modes for any individual track and the entire disc. A fluorescent display keeps track of either track number or elapsed time.

Sony also offers the Model CDX-R7, which teams a CD player with an AM/FM-stereo tuner, all in the same size package as the CDX-5.

CIRCLE NO. 102 ON FREE INFORMATION CARD

PC*jr* Expansion Card

Microsoft has a hardware option for PC*jr* owners who wish to make their computers more compatible with the existing base of software. Called the PC*jr* Booster with Mouse, it adds 128K of RAM to the memory in the computer as well as mouse control to programs. With the card installed, the PC*jr* can run larger, more sophisticated programs, including Microsoft's World, Lotus 1-2-3, and Microsoft FORTRAN and Pascal. As a bonus, the card is said to double the speed of programs that require 128K or less of memory. A battery-backed clock/calendar is also included.

Software supplied with the PC*jr* Booster with Mouse includes a mouse driver and Mouse Menu, Piano, Life, Doodle, RAMDrive, Clock/Calendar, Example Configuration Files, and JBASIC. The last is a software enhancement for the Microsoft BASIC cartridge sold for the PC*jr*. With the mouse, users have the option of developing and customizing menus to fit individual needs, rather than having to adapt to the predefined sequences of each application program. $295 without RAM; $495 with 128K of RAM.

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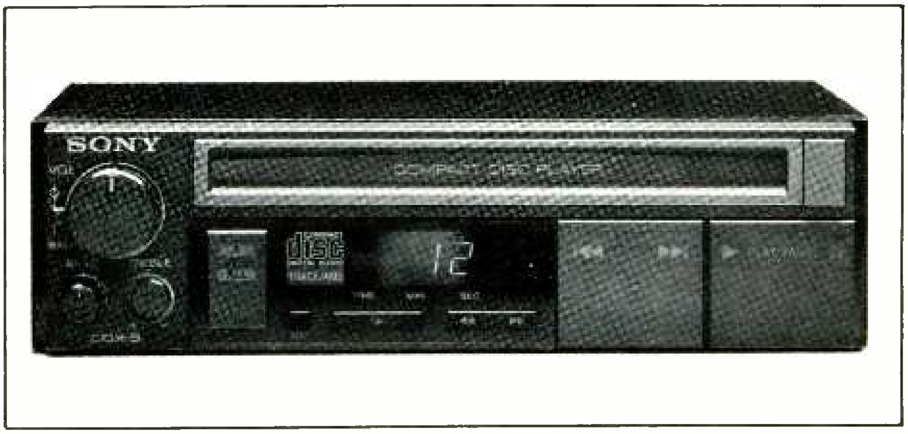

Telephone Line Analyzer

Calling the telephone company for repair service can prove to be costly if the problem you are having is with your home instrument and not the incoming line. A good way to avoid this expense is with B&K Precision's inexpensive, compact, portable Model 1042 telephone line analyzer. This easy-to-use accessory tests basic line parameters that can affect telephone operation. It verifies line polarity, ring, and line voltage levels and checks the condition of the line from the central office to your home. In addition, it can be used to verify basic telephone instrument functions and the condition of the telephone line cord. This is a handy item to have around if you repair consumer electronics equipment or install telephone systems, too. $19.95.

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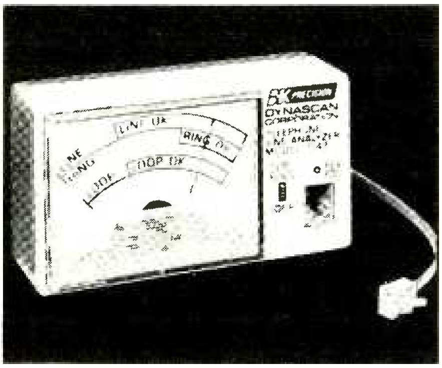

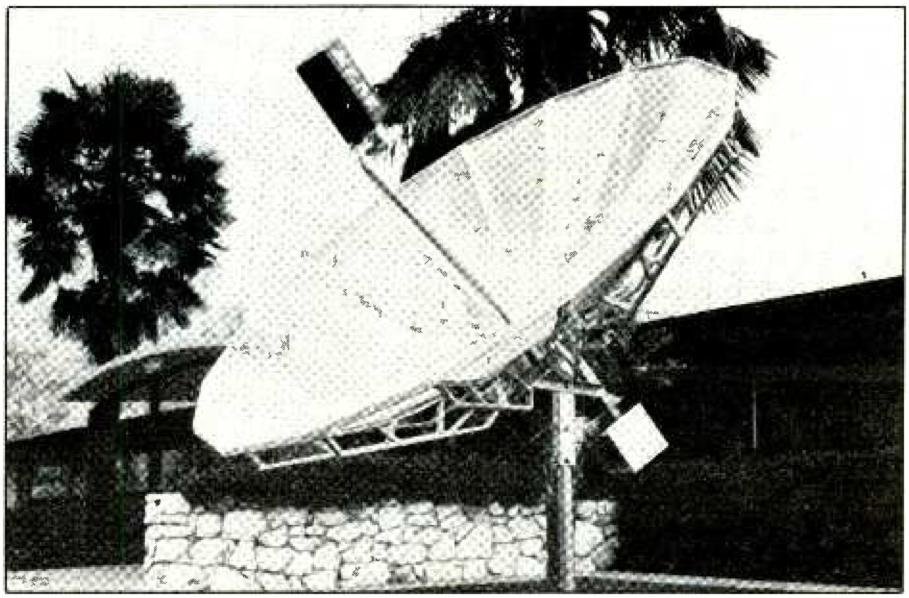

Satellite-TV Products

A pair of products designed to make satellite-TV reception more attractive to a larger segment of US viewers is now being offered by KLM Electronics. One is the high-performance, synthesized-tuned SSD single-conversion receiver equipped with a unique downconverter that is claimed to prevent signal drift over a $-40°$ to $+140°$F temperature range. It features an illuminated signal-strength meter, tunable 5.5-to-7.5-MHz audio control, polarity skew control, polarity select switch, format select switch, and detented channel selector. Connectors on the rear panel provide for: 70-MHz input; LNA dc power input; r-f output for an optional modulator; audio and video outputs; and an interface for a Polarotor I. Dimensions are 12.6"W × 8.1"D × 2.1"H.

The other product is KLM's Mini-X 8-ft. modular satellite TV dish antenna that gives people with limited room an opportunity to join the satellite-TV revolution. The 85-lb. (excluding motorized mount) antenna is available with an optional automatic-tracking polar mount) can be assembled and mounted by two people in about 1½ hrs. It is designed to withstand 100-mph winds and features gold-zinc plating to resist corrosion. Efficiency is rated at 55%, the same as KLM's 11-ft. dish.

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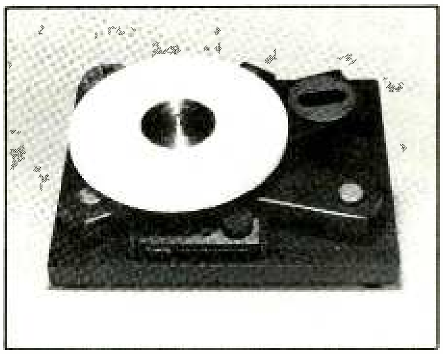
The "Ultimate" Turntable

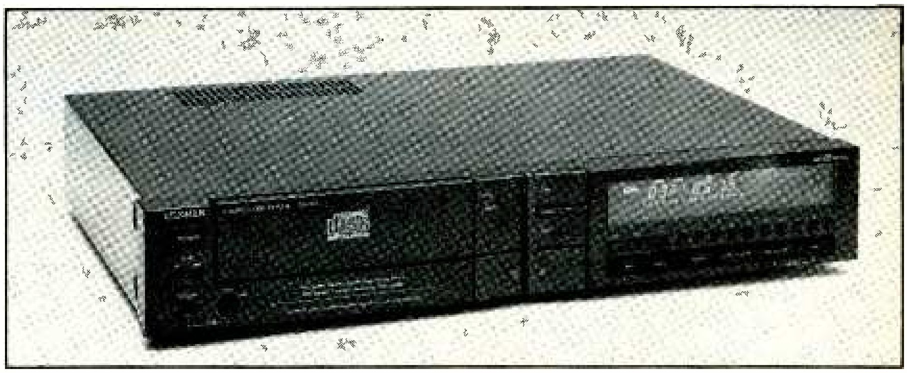


Looking for the "ultimate" in record turntables for your home audio system? Kyocera may have just what you want in its new Model PL-910 belt-driven turntable. This massive 52.75-lb. turntable features a brushless dc servo motor that drives a combination ceramic/cast-aluminum platter that weighs more than 11 lbs. and is designed for rock-solid stability. Only $2000 takes it all (tonearm is extra, of course.)

It also has a three-point dual suspension system and adjustable shock-absorbing feet, plus a unique ceramic-compound resin base that is claimed to have essentially zero resonance to virtually eliminate microphonics and acoustical feedback problems. Built in are a strobo-scope

Continued on page 96

Luxman's New DX-103: A CD Player Deluxe



If you're thinking about upgrading your stereo component system with a new record player or buying a good-quality whole new system, you will likely give Compact Disc machines more than fleeting consideration. These remarkable components use a laser beam to "read" digital audio information that's encoded in the form of microscopic pits beneath the surface of 4¾" records. Each of these discs can hold more than an hour of noise-free, wide-dynamic-range music. Moreover, given reasonable care, these discs will sound as good after a thousand plays as they do the first time since there's no phonograph stylus to cause wear; in fact, there's no physical contact while getting information from the compact disc.

Selling prices range from under $400 to over $1500, so they're not inexpensive. Furthermore, Compact Discs are more expensive than ordinary LP records, which cannot be played on CD players. Nonetheless, a growing number of serious music lovers are buying these space-age audio record players.

By latest count there are more than 30 models of Compact Disc players on the market, all using the same basic concept. There are significant differences in operating ease, convenience features, the ability of a player to track discs properly in the face of slight flaws or defects, and even in some circuitry design aspects. The CD player examined here is a just-under-$1,000 model from Luxman (a division of Alpine Electronics, the well-known maker of car stereo equipment). It has some distinctive features that set it apart from many other CD players.

The DX-103, Luxman's entry to the the digital audio world, has one of the fastest access times ever measured.

It locates a desired "track" or selection on a disc in a matter of two to three seconds and up to 16 music selections can be stored in its program memory for playback in any selected order. A repeat function further allows repeated playback of an entire disc or any music selections stored in the CD machine's memory.

Light-touch pushbuttons handle all control functions. An optional wireless remote control (Model RC-3) is also available to control major functions such as playback, stop, pause, fast forward or backward, and skip forward or backward for next or previous music selections.

In case you can't remember what's on the disc you've chosen to play, there's even a "scan" feature that enables the laser pickup to scan and play the first 10 seconds of each selection on the disc. This function operates at the touch of a button and works in both the normal mode (when playing through an entire disc) or in "memory" mode (when playing only selected tracks stored in the player's memory).

A Touch Of Class

Control layout of the DX-103 is also a cut above the ordinary. Play, pause, fast forward and fast reverse are all controlled by large touch buttons near the disc loading tray. Illuminated indicators on the play and pause buttons let you know where you stand.

Power on/off, a timer switch, a stereo headphone jack and a phone level control are located to the left of and below the disc drawer. Repeat, scan, disc and data indicator signals light up in conjunction with the operation of corresponding touch buttons or functions. The disc indicator, for example, flickers when power is first turned on or when the disc tray is slidden in or out. It stays on when a disc is properly in place. The data light flickers when the "table of contents" of the disc is being read. When that function has been completed, the indicator stays on.

The display area to the right of the tray shows the track number and index number of a disc, as well as the time in minutes and seconds. A total time display nearby reveals total time played on the disc or, at the touch of a toggling touch button, time remaining on the disc.

A memory play indicator at the extreme right of the panel lights up when a selection recalled from memory is being played. Just below the display area are "Up" and "Down" skip buttons which are used to advance the laser pickup in either direction, one track at a time. Ten small numbered keys are also located in this area of the panel and are used to select tracks for playback, either during normal play or in the memory play modes. Using these numbered keys, it is possible to select not only a track (selection) but an index number within a given selection if the disc being played has such subdivisions encoded within it.

The lower row of touch buttons on the front panel includes a memory call button; a memory clear button; a memory write button (for storing desired selections to be played); the "Repeat" button; the "Scan" button, whose function was described earlier, and the "Time" button that causes the display to toggle between "time played" and "time remaining" on the disc being played.

The rear panel of the Luxman DX-103 is equipped with two sets of output jacks—one at fixed level and the other variable in level, the latter controlled by means of the front-panel headphone control.

Lab Performance

There is very little point in quoting lab measurements when it comes to Compact Disc players. Just about every one of them exhibits signal-to-noise and dynamic range capabilities in excess of 90 dB. Distortion levels are so low they can be ignored. They have no measurable wow-and-flutter and stereo separation is usually so high (approaching 90 dB) that all talk of crosstalk between channels becomes meaningless, too.

Of extreme importance, though, in measuring a CD Player on the test bench is its error correction and servo tracking ability—i.e., its ability to stay "on track" even if the laser misses parts of the digital audio code because of opaque scratches on the surface of the disc or any other reason.

For these tests, we use a special test disc that is deliberately flawed in measurable, controlled amounts. The Luxman DX-103 played completely through our special "defects" disc without ever mistracking or muting. That means if you have a disc with as long an opaque scratch as 900 microns (slightly less than 1 millimeter), the player will probably ignore it completely. Similarly, dust particles as great as 800 microns in diameter, lodged on the surface of any disc, would also be ignored.

The player was also very acceptably resistant to any external shock or vibration, remaining "on track" even when tapped lightly on the top and side surface of the machine while discs were being played.

Sound Tests

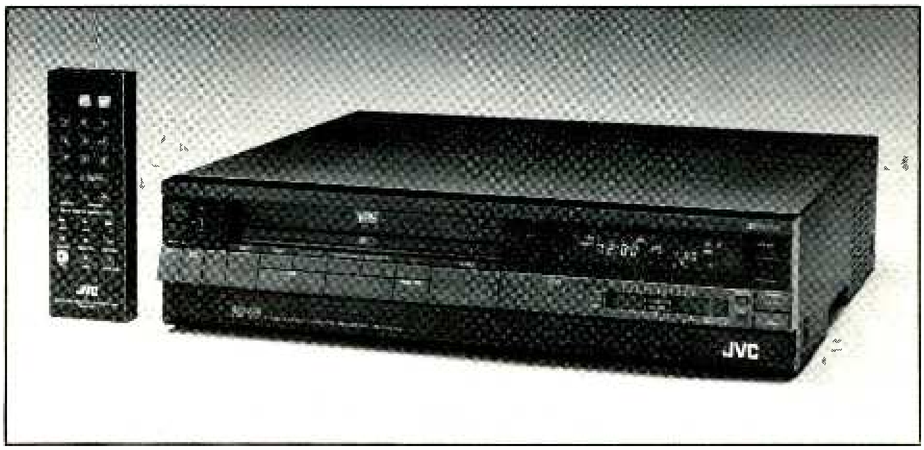
The Luxman DX-103 is one of those select machines that has a great number of features but remains relatively easy to use. As for the sound quality it delivers, that is beyond reproach. Luxman has taken the trouble to incorporate its highly regarded "duo-beta" feedback circuitry into the final, analog stage of the player (which is, after all, an analog signal rather than digital, or we couldn't feed it to our amplifiers).

Some experts have suggested that the chief differences between sounds produced by different CD players may well be caused by differences in that final stage of the player—where digital signals have been converted back to analog signals and then must be amplified by analog audio circuitry much as they would be in any audio equipment. If that is the case, then the Luxman's analog circuitry ironically goes a long way towards making this one of the best sounding CD digital players we have yet tested.—*Len Feldman.*

CIRCLE 82 ON FREE INFORMATION CARD

Hearing is Believing: JVC's New VHS Hi-Fi Video Cassette Recorder

Video products have not generally been noted for their high-quality audio. Indeed, television sets are often equipped with tiny, unbaffled loudspeakers no better than those found in small radios. Furthermore, connecting the audio signals from a TV receiver to inputs on a stereo component system only underscores how little attention TV makers give to audio.



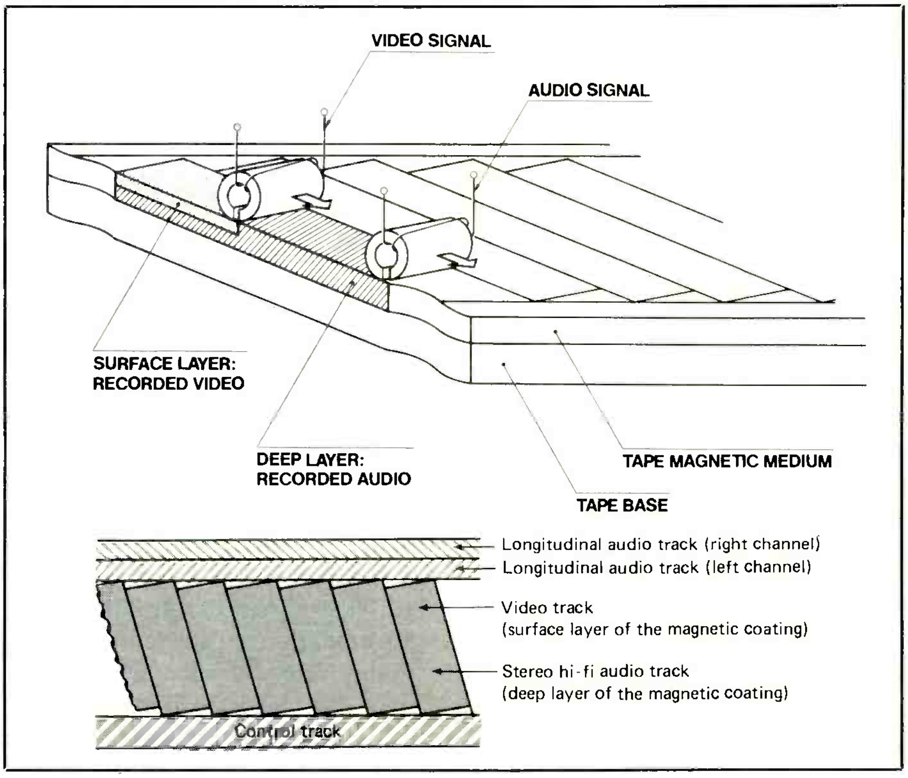
Good audio quality is not a hallmark of video cassette recorders either. In addition to emulating a TV set's restricted audio frequency response, the audio track on video tape typically delivers a high level of tape hiss that's immediately apparent if the VCR's audio outputs are connected to a good stereo component system's high-level inputs.

The first company to respond to audio shortcomings of VCRs was Sony, which introduced video machines that incorporate the innovative Beta HiFi audio system. Its extended frequency response captures the entire audible range. Furthermore, its signal-to-noise ratio—or more importantly, dynamic range (the difference between the softest and loudest sounds that could be recorded and played back)—was improved from the unacceptably noisy 40 dB of a standard VCR's audio output to an impressive 80 dB. Moreover, wow-and-flutter (the wavering of pitch that can be so disturbing when viewing a music video, especially at lower tape speed) was reduced from high levels of more than 0.3% to an inaudible 0.005%.

By retaining the conventional longitudinal audio track, owners of older Beta-format machines could listen to video tapes made on or for the new Beta HiFi VCRs. (They would play in "low-fi" in this case, of course.) With these advantages, Sony was in effect challenging the dominant VCR-format machines in this country—the VHS system that accounts for more than 70% of VCR sales today.

The Beta HiFi system had barely reached the market, however, when JVC, originator of the VHS format, announced development of—you guessed it—VHS HiFi!

The first VHS HiFi units recently became available, and we were able to acquire JVC's Model HR-D725U and put it through its paces. The VCR's *video* performance is just about the same as that of any other good VHS machine. Therefore, we concentrated on its audio performance since this is what would likely distinguish the unit from other video cassette recorder models.



Three-dimensional detail and simplified two-dimensional views of how JVC's VHS Hi-Fi videocassette recorder records sound and video tracks on tape.

How It Works

VHS HiFi utilizes two extra recording heads located on the rotating video-head drum to apply frequency-modulated audio signals to the tape. This contrasts with Beta HiFi's method of applying two pairs of FM high-frequency carriers (one for the left channel and one for the right channel) through the rapidly spinning video recording heads. In both systems, it's the *relative* video tape head to tape speed that makes the systems capable of producing an extended frequency response.

Whereas the Beta HiFi system's audio information becomes part of the wideband, complex video signal itself, video signals with VHS HiFi are recorded separately, though on the same portion of tape that the audio is recorded on.

Video and audio signals don't mix, however. The video signals' higher frequency content can only magnetize the tape close to the surface, while the audio recording's stereo information is impressed relatively deep into the tape's magnetic coating. As a result, the deeper audio recording is not erased by any video recording atop it. JVC calls the process "depth multiplexing." Fig. 1 illustrates the basic principle of VHS HiFi.

Audio Control

Integrating VHS HiFi along with conventional stereo on this VCR has necessarily meant the addition of several front-panel and sub-panel controls that ordinarily would not be needed. Two slider controls to the right of the panel are used to adjust recording levels for the HiFi tracks. (Automatic Level Control, or ALC, is used on the conventional tracks, so there has never been a need before to manually adjust audio record level controls.) Calibrated record-level meters (in the form of two rows of light-emitting diodes or LEDS) are located near these slider controls.

Behind a drop-down door near the bottom of the front panel is a sub-panel containing a pair of microphone inputs, a stereo phone jack, a Dolby noise reduction on-off switch (used for the conventional audio tracks only, since VHS HiFi is noise-free), an audio dubbing selector switch, and an audio output monitor switch and control.

Audio dubbing is possible only on the conventional tracks. If you were to try to over-record on the VHS HiFi tracks, you would erase the picture as well. But this allows for an interesting feature. The output monitor control will let your hear only the VHS HiFi sound if it is rotated fully in one direction, or conventional sound alone if it is rotated fully in the other direction. If set to a mid-position, you will hear a mixture of both.

This was done in order to allow you to listen to a dubbed narration (recorded after the video recording was made), while at the same time allowing you to enjoy the high quality of VHS HiFi sound emanating from the mixed audio outputs.

Test Results

Frequency response in the HiFi mode extended all the way out to 20 kHz, with no more than a ±2.0 dB deviation over the entire audio spectrum. Results were the same at either of the two available tape speeds. (Compare this with the conventional audio response which, at slowest tape speed, covered a range of from 90 Hz to 3.5 kHz!)

Harmonic distortion at "0 dB" record level was only 0.07% in the HiFi mode, increasing to about 2% at a ±10 dB recording level. Signal-to-noise measured precisely 80 dB as claimed, whereas using the conventional audio tracks it measured no more than 39 dB without Dolby; 46 dB with it turned on. Wow-and-flutter measured 0.006% in the VHS HiFi mode, as against 0.25% using conventional audio.

These lab tests certainly tell the story. But to appreciate fully the significance of VHS HiFi, you have to listen to the playback of a recording using this new technology, and then compare it with the type of sound you will get from the conventional audio tracks of this or any other VCR. The difference is astounding. Suddenly, the sound delivered by the VCR is as high in quality as that of any of your favorite hi-fi sources (good audio tape recordings, your finest LP records, live stereo FM broadcasts, etc.). You will find it, in fact, only marginally inferior to the sound produced from those fantastic laser-read Compact Discs.

With Beta HiFi and now VHS-HiFi available on VCRs, there's no longer any reason to settle for poor sound quality with your video entertainment. Happily, the cost of these remarkable new systems will add no more than $100 or so to the price of a conventional VCR.—*Len Feldman.*

CIRCLE 96 ON FREE INFORMATION CARD

Heath's New IT-2232 Component Tracer

Heath's newest test instrument kit, its Model IT-2232 Component Tracer, is a novel device for checking the operating quality of electronic parts in or out of the circuit. Actually, it's a curve tracer with some interesting twists.

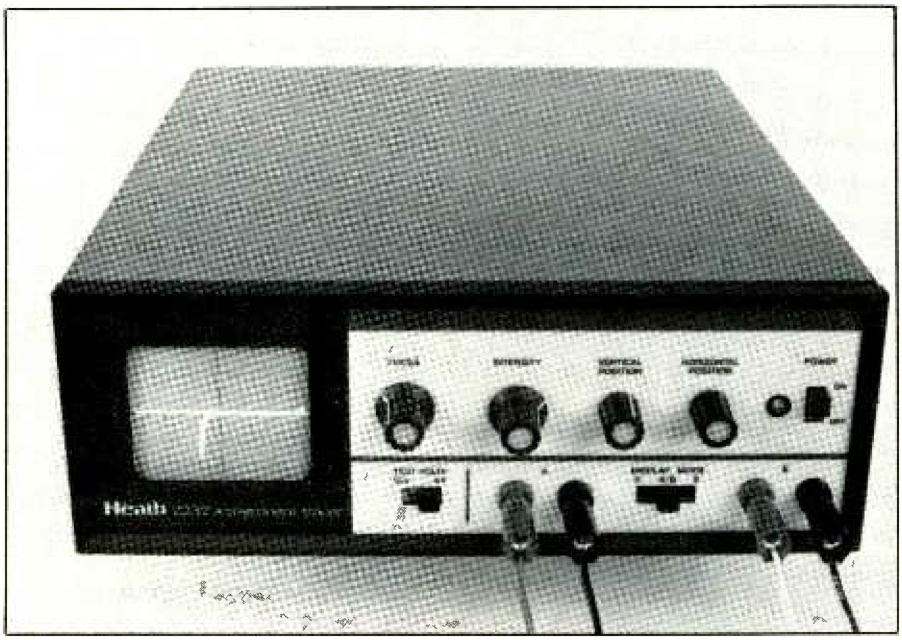
The $249.95 kit features a built-in green, 3" CRT monitor and dual-channel capability that enables the user to make direct A/B comparisons between known good and bad circuits although each channel can be used individually, if desired. To avoid confusion, one channel is displayed with a solid-line trace and the other with a dotted-line trace.

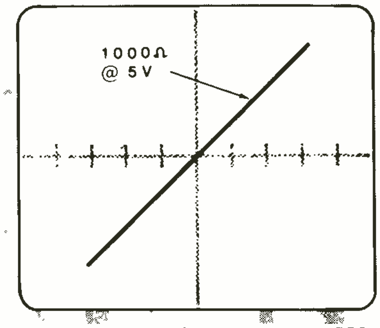
The object of tests performed with the component tracer is to display on its CRT monitor the unique E/I (voltage/current) characteristics of the device or circuit under test rather than depending on numeric measurements. In essence, the general condition of a component or circuit is checked. The CRT thus displays a trace (or traces in the A/B mode) whose characteristics are interpreted directly in much the same manner as you would interpret the traces of an oscilloscope.

Two testing ranges are provided: a 5-volt range for use with the vast majority of analog and digital circuits; and a 50-volt range for testing high-voltage circuits. Built-in current limiting protects circuits under test. Power is not applied to equipment being tested in any case.

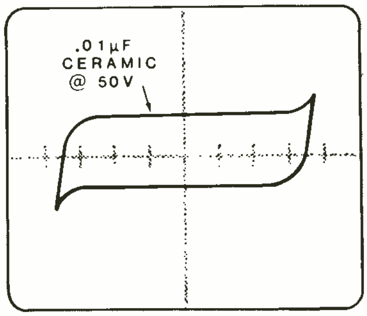
General Description. This is a line-powered instrument and, as such, is designed for bench use. However,

PRODUCT EVALUATIONS . . .

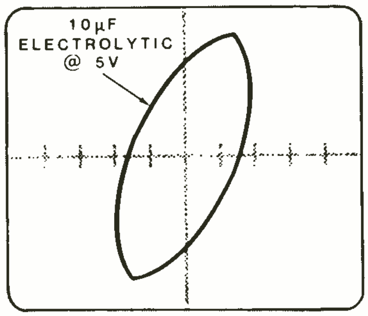




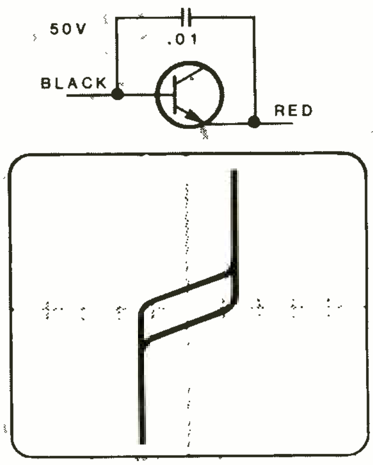
1000-ohm resistor trace at 5V



0.01-υF capacitor trace at 50V



10-υF electrolytic capacitor trace



Base-emitter characteristic trace

since it has a low, flat silhouette dimensions are 12.5″ deep by 10″ wide by 4″ high and weighs 8.4 lbs., it can easily be tucked under or on top of other bench instruments. Through internal wiring, the component tracer can be adjusted for either 117- or 220-volt operation. Power consumption is just 22 watts.

The component tracer is designed to be very easy to operate and use. To this end, its front panel contains controls only for focus, intensity, vertical position, and horizontal position, plus switches for power on/off, test volts (5V and 50V), and mode (A, A/B, B). All other controls for setting it up and adjusting it are buried inside the instrument, where they are set once and forgotten.

The component tracer operates in almost the same manner as an ordinary curve tracer. When it applies a 2.6 test-voltage to a component or circuit during a test, the voltage across and the current through the device or circuit are displayed horizontally and vertically, respectively, on the CRT. If the current flow is positive, it is displayed in an upward direction. A positive voltage is similarly indicated to the right of the CRT screen. The greater the current and/or voltage, the wider the deflection upward and to the right.

Typical examples of the CRT displays for different values and types of components and circuits are shown in the accompanying drawings. To obtain these results, the Model IT-2232 component tracer employs a sophisticated collection of circuits built around ICs. These include oscillator, power supply, blanking, ramp, test and switching circuits. The power supply develops -1200 and +205 and +160 volts d.c. for the CRT and high-voltage circuits, as well as +10 and +5 volts d.c. for the remainder of the circuits.

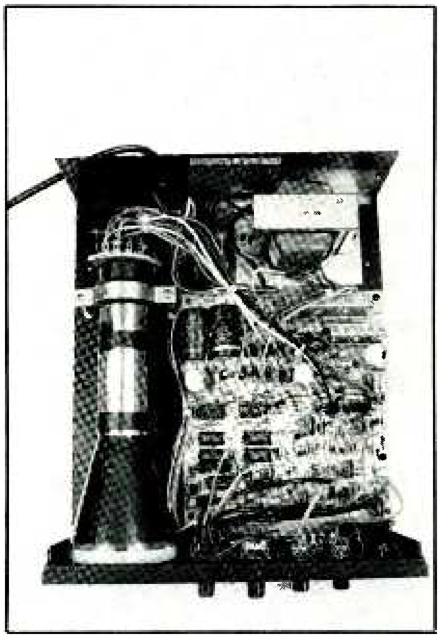
Kit Details. The IT-2232 component tracer is one of the kits marketed by Heath during the past few months that typifies the company's new approach to component identification and presentation of assembly details.

Until very recently, Heath packaged resistors, miniature capacitors with axial leads, and diodes in separate envelopes, usually by type but without regard to value or coding. These components—especially resistors—were tedious to identify. Heath's solution to the problem is to arrange all resistors, miniature capacitors and diodes in taped-together strips (very similar to those used by automatic-insertion equipment for assembling printed-circuit cards in factories).

The person who assembles the kit tapes the component strips over the outlines printed on accompanying Taped Component Charts, and has a no-error means for identifying each component as it is called for. The values of the components are printed along the left side of the drawings along with any special coding used to identify them. As you need a component, all you do is look it up on the charts and snip it from the tape.

In some kits, the components are arranged in ascending order of value and/or according to tolerance and type. In other kits, particularly the IT-2232, Heath has gone one step further by arranging the components in the order in which they are used in the assembly process. The result of this new approach is that kit assembly time is considerably reduced, since you don't have to waste time locating each component.

Heath also has take a welcome new tack in the way in which it presents assembly instructions. Up till now, if you built a Heath kit in which one or more printed-circuit board assemblies had to be wired, a multiplicity of drawings were incorporated into this Assembly Manual proper, with boxed step-by-step details for component installation arranged along one or both sides of the drawings. For large, densely populated boards, these drawings had to be presented in partial detail, which meant you'd often "lose your place" whenever you had to interrupt work.



Uncluttered appearance characterizes interior of instrument. Most parts mount on a single pc board.

Now Heath provides an Illustration Booklet with full-scale-or-larger drawings of the board or boards. Using both the Assembly Manual and the Illustration Booklet, the builder is guided step by step, through the completion of component installation. If you have built kits from Heath before, obviously you will have to make a couple of adjustments in assembling the newer kits. You'll have to work with two manuals simultaneously, instead of just one. And there are no pointer lines as there used to be, from each step in the manual to corresponding locations on each circuit board.

For some, this will take a little getting used to. For me, though, assembling the IT-2232 kit happily presented no major difficulties. With assembly proceeding along logical lines, the single printed-circuit card is wired first and various wires and cables are soldered to it. All chassis wiring follows—to the various controls, switches, jacks, and the power LED mounted on the front panel—and to a pair of five-lug terminal strips, ground lugs, and the fuse block's solder tabs.

Unlike most other Heath kits I assembled during the past few years, this one comes with no precut cables or wires ready to plug into sockets. All wires and cables had to be cut to size, prepared and soldered into place. Fortunately, this was not a particularly difficult task since there are very few connections. Most interconnections are made from cables cut from an eight-conductor, color-coded, flat-ribbon cable.

The most difficult part of assembling this kit was in connecting and soldering wires to the range and mode switches located very close to the bottom of the chasis. There is very little manipulating room in that area, and I had to be very careful to make sure that each connection was mechanically secure and properly soldered into place.

When the kit is fully assembled, initial tests and adjustments are performed with a single test instrument that almost every electronics enthusiast has—a multimeter. No other instruments are necessary, although if you have an oscilloscope handy, you can use it to observe the shapes and levels of the various waveforms throughout the circuits.

In terms of difficulty, I would rate the IT-2232 kit's level as "moderate," not because it is such a tough kit to assemble but simply because it took me a full 12 hours to complete. That's from the time I opened the carton until the time I completed the initial tests and adjustments and secured the last screw.

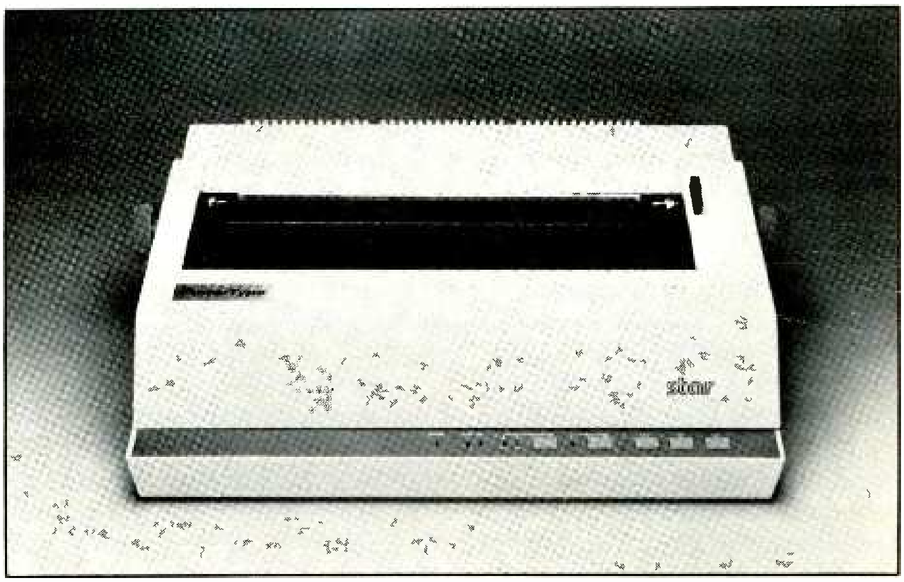
For someone less experienced in kit building, though, a more realistic figure might be in the range of 14 to 15 hours. Had Heath not arranged the smaller components in taped strips in the order in which they're used, that figure could easily have been swelled another hour.

Conclusion. With the Model IT-2232 Component Tracer, Heath has brought to the professional electronics technician, as well as the serious experimenter, an additional troubleshooting tool that could speed up servicing. With patient use, a service technician can whip through a circuit more quickly than with the conventional multimeter, oscilloscope, or logic probe to isolate a defective component without removing it from the circuit. Getting used to the waveshapes will take some time, though, before it becomes second nature. Also, with the wide use of integrated circuits today, not being able to check out these devices leaves the instrument only partially useful.

In essence, the Component Tracer is a fine new test instrument that can be a most useful companion to the standard complement of instruments commonly used. As such, its $250 price tag limits its likely purchase to those who make a living servicing electronic equipment, where minutes saved are money made.—*Alexander W. Burawa.*

CIRCLE 99 ON FREE INFORMATION CARD

From Star Micronics, a Daisywheel with a Difference



I confess that I have ignored letter-quality printers for personal use. My justification has been: operation is tiresomely slow, they are very noisy, cannot print a wide variety of type fonts under software control or special graphics wizardry, do not fit comfortably on my desk, and prices for solid-looking ones are high compared to dot-matrix machines. All this would be moot, of course, if I were a lawyer or corporate business letter writer, where favorable impressions extend to super-looking letters.

Nonetheless, the plethora of new, modestly priced formed-character computer printers introduced to the marketplace this year captured my serious interest. Smith Corona appears to have started the path to relatively low-cost letter-quality printers, with a host of other manufacturers following its lead, from Brother to Transtar to Juki. Among the latest of this breed to reach the marketplace is Star Micronics' "PowerType" daisywheel printer, a $499 "list-price" machine whose low cost places it in direct competition with dot-matrix printers at the lower price-class rung. I have been using a sample model for a time now and here are my impressions.

The PowerType is comparatively low priced, but it's a full-featured printer in every way. It weighs about 26 lbs., and measures roughly 20" wide by 6" high by 14" deep. Its friction-feed carriage is more than 13 inches wide, and thus it can handle a standard 8½ × 11 sheet of paper even sideways, printing up to 165 characters on a line when using condensed printing.

The printer uses a standard 96-petal Qume-compatible daisywheel type element, which is available in more than 100 different print styles and languages. Furthermore, you are not limited to the normal petal-striking sequence. The PowerType allows you to download your own sequence for use with non-ASCII, foreign or special printwheels.

All this sounds pretty complicated, but when turned on, the printer defaults to the most common settings, so you may never have to set any of these switches.

You can, of course, use only one printer font at a time—the one currently installed—but the PowerType allows you to specify (by switch setting or software command) any of four spacings. These include 10, 12 or 15 cpi, or proportional spacing.

Continued on page 98

Heathkit instruments. Some buy them for pride...some, to save money.

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2. IO-4205 Dual-Trace 5 MHz Scope. 10mV/cm sensitivity.
3. IT-2232 Component Tracer. Checks circuits without power.
4. IP-2718 Power Supply. Fixed or adjustable supply. 5 to 20 VDC.
5. IG-1271 Function Generator. Sine, square, triangle waveforms. 0.1 Hz to 1 MHz.
6. IG-1277 Pulse Generator. 100 ns to 1 sec width pulses.
7. IT-5230 CRT Tester. Tests, cleans, restores CRT's.
8. IM-2264 DMM. True RMS readings. Analog metering, too.
9. IM-2420 Frequency Counter. 5Hz to 512 MHz. Ovenized oscillator. Includes period and frequency modes.
10. IM-2215 Hand-held DMM. Five DC ranges. Accuracy: ±0.25% of reading +1 count.
11. IT-2250 Capacitance Meter. 199.9 pF to 199.9 mF. Auto ranging.
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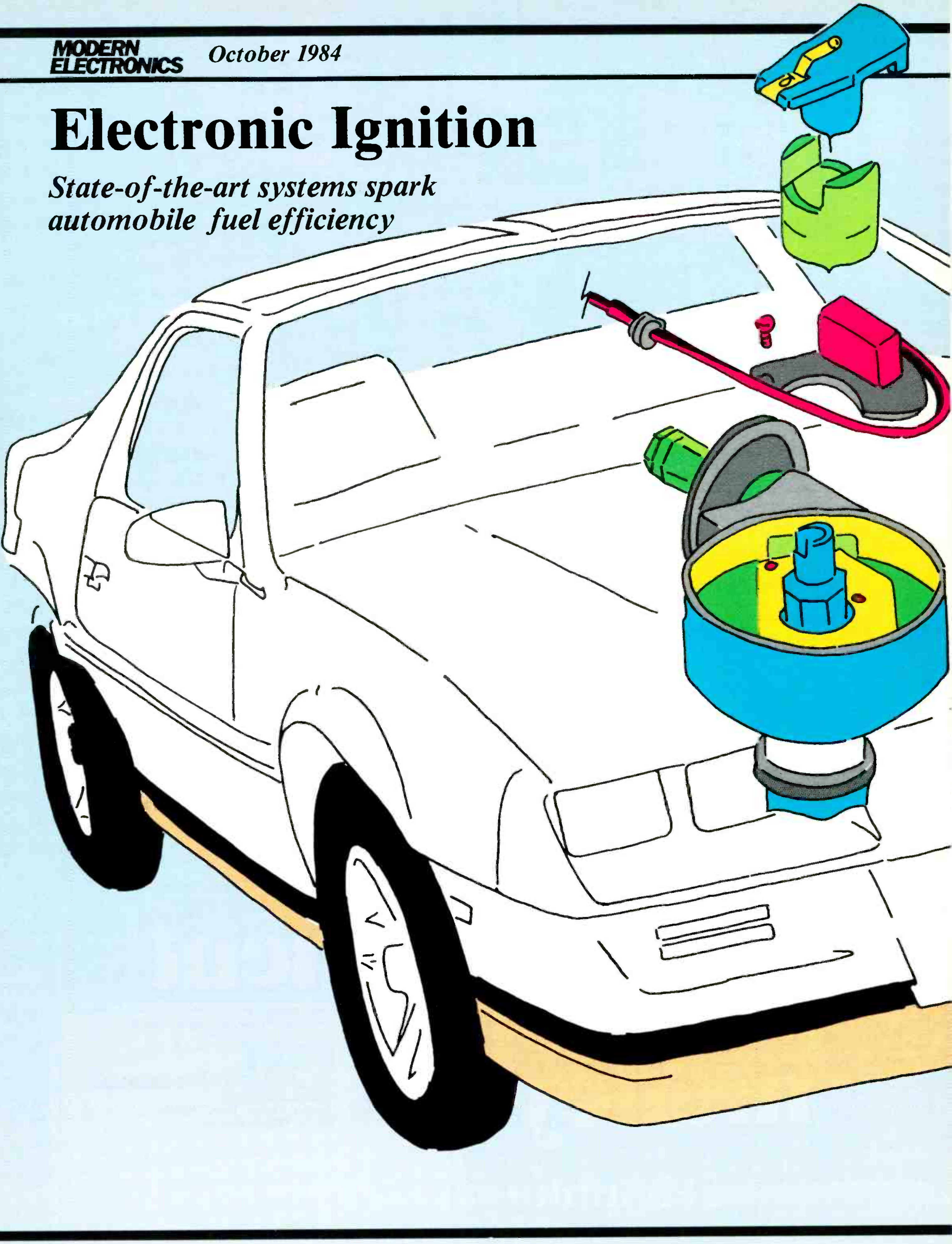


By Ron Cogan

Mention automotive electronics and many of us think only of the more exotic applications in the modern automobile: automatic interior climate control, synthesized vocalized warning systems, dazzling dashboard digital displays, and so on. But an unseen electronic controller, the electronic ignition system, really started the movement toward electronics in an automobile and other vehicles.

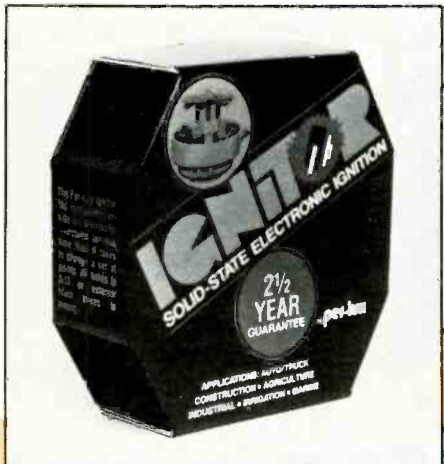
What started some years ago as a retrofit system to replace mechanical breaker points used in an automobile's distributor, has become standard equipment for the past few years. With the electronic ignition system, there are no longer any points to wear out, requiring adjustments or replacement. Electronics handles the job efficiently and reliably, and without being obtrusive.

With people holding on to their older cars longer and longer owing to the high cost of a new car, there is still an active market for add-on electronic ignition systems. Here is an overview of how they developed and how to install them in cars that still use the old mechanical ignition systems.

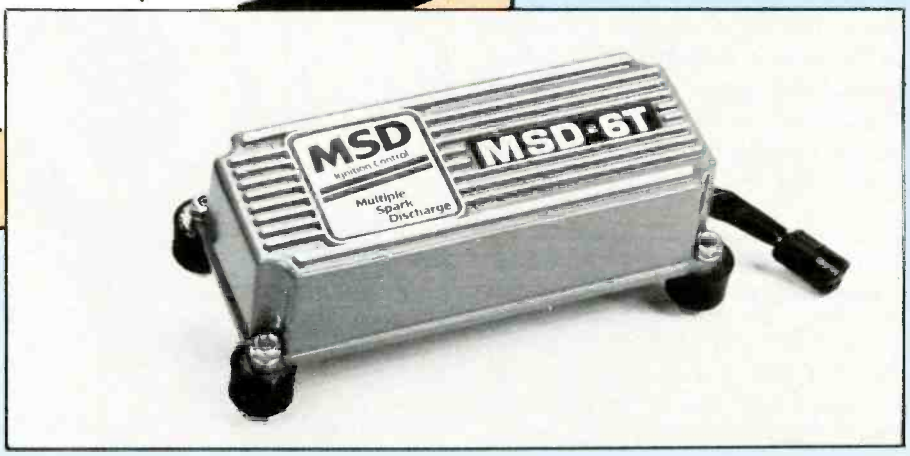
Efficient Control

Electronic ignition systems, and the breaker points that preceeded them, deliver an appropriately-timed spark of the proper duration to each cylin-

In addition to its electronic ignition systems, Accel has other products designed to enhance operation of a car's ignition system. One is the Super Coil, which increases ignition spark energy by developing an ultra-high 50,000 volts.



Per-Lux's Ignitor electronic ignition system replaces the breaker points on most engines and updates earlier factory-installed electronic ignition systems. The entire electronics package installs inside the distributor housing and has only two wires to connect.



Offering a completely different approach to ignition efficiency, Autotronics' MSD system supplies multiple-spark discharge to the plugs to assure complete firing of the fuel/air mixture. The initial spark is backed up with a barrage of later sparks to make sure the job gets done under all conditions.

der's spark plug. In turn, this fires the air/fuel mixture in the combustion chambers to produce the horsepower that ulitmately drives the car's wheels. The sequence of events is an impressive orchestration of fuel/air intake, firing, and exhuast of the wastes resutling from ignition. The ignition system must work with split-second timing to make the engine work with peak efficiency and thus provide maximum economy.

The electronic ignition system is unquestionably technologically superior to the mechanical points system. To begin with, the electronic ignition does not wear out, nor does its performance degrade with time. Breaker points never work better than when they are first installed, since they are mechanical devices that immediately begin a slow wearing process as soon as the engine is brought to life. Since there are no moving parts subject to fatigue in it, the electronic ignition does its job with full efficiency as soon as it is installed and will continue to do so just as efficiently years later.

Another advantage of the electronic ignition system is that it saves time and money during tune-ups. Since there are no mechanical parts to wear, there are none to replace during routine maintenance. A tune-up simply consists of changing spark plugs and occasionally replacing the rotor, distributor cap, and plug wires as they wear after many thousands of miles. Your engine's timing does not change once it has been initially set during installation of the electronic ignition system.

Enter the Electronics Age

In an effort to eke maximum performance from their powerplants, the hot rodders of the 1960s began experimenting with electronic ignition and, unknowingly, brought the automobile into the electronics age. By 1972, Chrysler recognized the benefits of electronic ignition and began installing systems of its own manu-

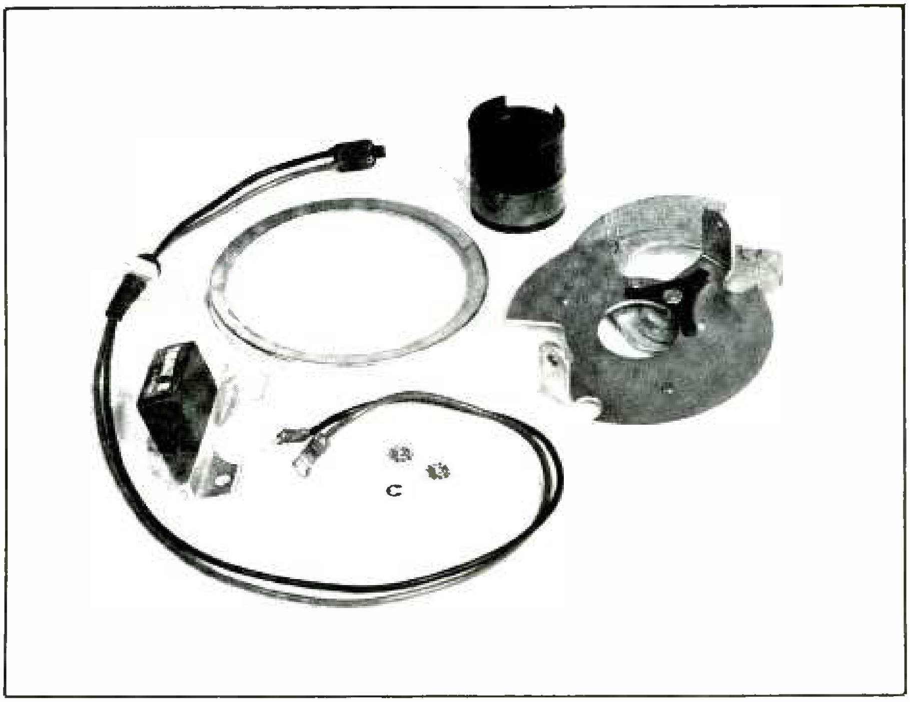


Fig. 1. One of the simplest retrofit electronic-ignition systems on the market, the Per-Lux Ignitor kit contains (clockwise from top) a magnet assembly, adaptor plates, a wiring harness and installation hardware, the Ignitor module, and a spacer for the distributor cap. The spacer plates may or may not be required, depending on the distributor in the vehicle.

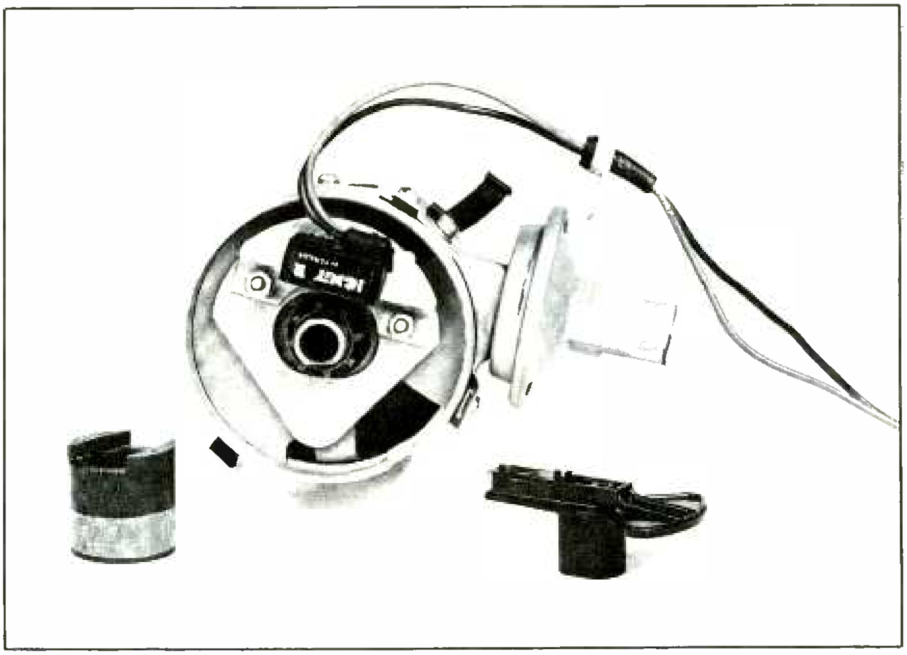


Fig. 2. Installation of the Ignitor kit begins with removal of the cap, rotor, points, and condenser from the distributor. The adaptor plates and solid-state ignition module are then installed in place of the stock parts as shown. Complete illustrated step-by-step instructions are provided in the kit to guide the do-it-yourselfer through the installation procedure.

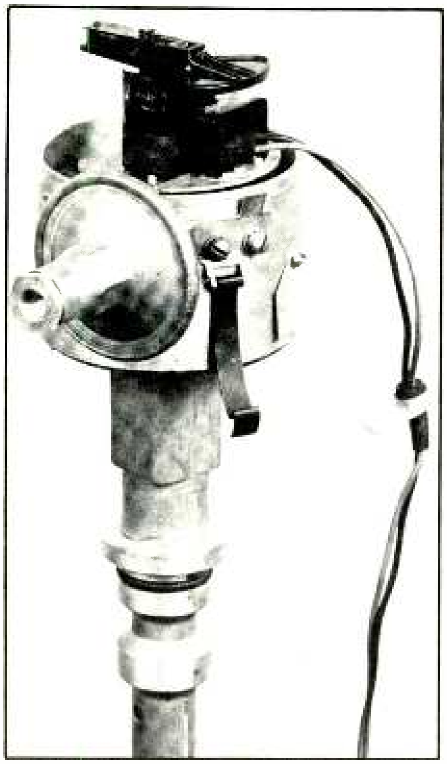


Fig. 3. Once the Ignitor module is installed inside the distributor housing, the magnet assembly is mounted, followed by the rotor and distributor cap. Note how the wiring harness simply plugs into the Ignitor module. The free ends of the harness are then routed to and connected directly across the vehicle's ignition coil.

facture in its vehicles. General Motors and Ford followed suit within the following three years. Since then, we have seen dozens of other companies develop and market electronic ignition systems of every type imaginable for every possible need.

The most obvious benefit afforded by these aftermarket systems is the ability to retrofit older automobiles with electronic ignition and do away with the troublesome breaker points. In most cases retrofitting is a straightforward procedure that can be handled by any competent do-it-yourselfer. To make the job go as smoothly as possible, many of these aftermarket companies supply fully detailed instructions and step-by-step installation photographs with their electronic-ignition kits.

The parts contained in a typical retrofit electronic-ignition kit are shown in Fig. 1. The example shown is the Ignitor system from Per-Lux, one of the simplest retrofit kits on the market. Contained in this kit are a magnet assembly, adaptor plates, wiring harness, the Ignitor module, a spacer for the distributor cap, and installation hardware.

Installation of this kit is very simple. You begin by removing the cap, rotor, points, and condenser from the distributor. Following this, you install the Ignitor adaptor plates and solid-state module, as shown in Fig. 2.

Completion of installation involves mounting the magnet assembly, followed by the rotor and distributor cap, as illustrated in Fig. 3. Note how the wiring harness simply plugs into the Ignitor module.

The whole disassembly and installation procedure for the Ignitor is shown diagramatically in Fig. 4. The drawings indicate the relative positions of the stock ignition parts and the new Ignitor components that replace them. Note that the entire retrofit electronic ignition system fits *inside* the distributor. No electronic boxes are required elsewhere in the engine compartment. The drawings in Fig. 5 show the before and after details with regard to connections to the ignition coil assembly. Whereas only one wire goes to the coil from the conventional system, two go to it in the Ignitor system.

Along with retrofitting earlier model automobiles with the new breakerless ignition, the aftermarket ignition companies also set their sights on the efficiency-minded motorists who would be interested in updating their late-model "Detroit" systems with new gear. To this end, these companies actively market a variety of solid-state ignition kits designed to replace existing original equipment electronics with the latest technology.

The electronic ignition systems designed to replace both the earlier breaker points or the later Detroit breakerless setups follow one of two popular designs. One works by virtue of a magnetic pickup and an electronic chip called the "Hall Cell;" the other uses an advanced optical distributor pick-up.

In the case of the first system, the timing signal is initiated when the magnetic pickup triggers the system's Hall device. This basic type of system is used by all three of the Detroit automakers. The optical system triggers the spark as its light-emitting diode (LED) hits the phototransistor with an infrared beam. Both types of systems efficiently accomplish the same job using distinctly different approaches.

Other Applications

While the primary emphasis of electronic ignition companies has been on replacement of breaker points with some sort of breakerless system, this by no means comprises the industry's entire effort. Other types of electronic enhancements, ranging from mild to exotic, have been developed to make engines run more efficiently than ever before.

The capacitor-discharge (CD) system is designed to supply a hotter spark to the plugs for more efficient and complete firing of the air/fuel charge, especially at higher rpms when problems within adequate firing voltage are sometimes experienced. The problem develops because the primary coil windings have to develop some 350 volts to deliver to the secondary windings between firings. It usually builds up this charge in about 35-thousandths of a second. Though this is more than adequate when an 8-cylinder engine is running at low to mid rpm's, there is not sufficient time to develop the full voltage required at high revs. The primary windings do not feed a full charge to the secondary windings, resulting in a weak charge supplied to the spark plugs and incomplete fuel/air burn.

The end result of this is unsufficient firing of the plugs and, therefore, incomplete combustion of the air/fuel mixture. To solve this, CD is

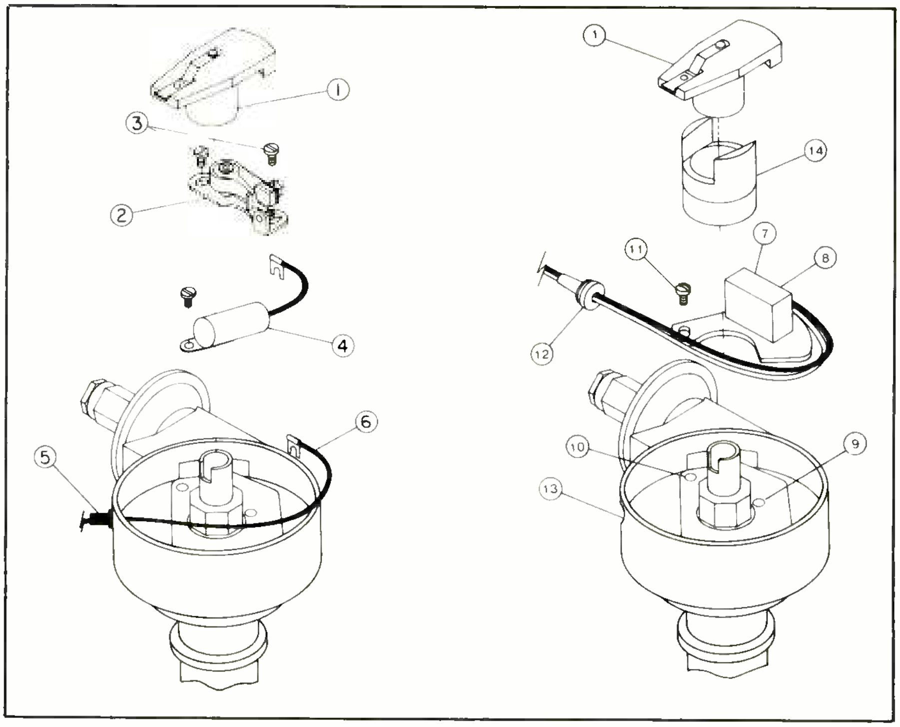


Fig. 4. The above drawings illustrate the relative positions of the stock ignition parts as supplied in a conventional points ignition system (left) and the new Ignitor components that replace them (right). The appeal of this retrofit system is that the entire electronic package fits inside the distributor.

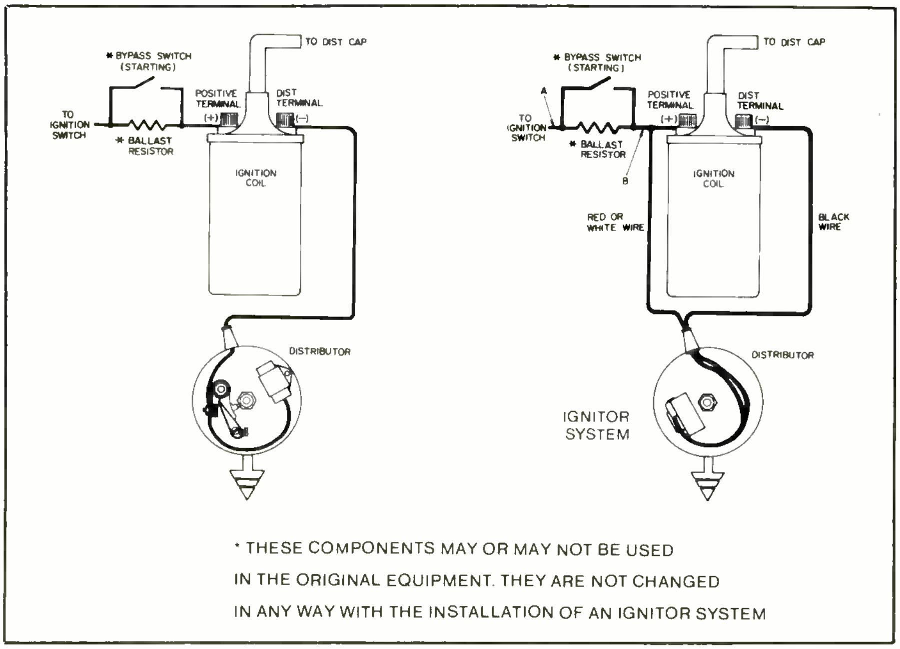


Fig. 5. Instead of a single wire running from the distributor to the ground terminal of the ignition coil in the breaker-point system (left), the new wiring harness that comes with the Ignitor electronic-ignition system (right) has one wire that connects in this manner and a second wire that connects to the positive terminal of the coil as well. The Ignitor system installed, ignition operates as before, except that it is much more reliable and accurate.

introduced to the ignition system between the car's battery and the coil. In milliseconds (thousandth of a second), this device builds up a full 350 volts and stores this power in a capacitor. This charge is then "dumped" to the coil's primary windings in a simple, short-duration high energy pulse between each firing so the secondary windings will be able to generate maximum voltage to efficiently fire the plugs at any rpm neatly solving the problem.

Another approach designed for optimum firing efficiency is supplied by the multiple spark discharge (MSD) unit. This type of system works on the reinforcement theory. That is, if the first pulse does not do the job, the others will! The unit supplies a powerful spark at the proper time for each plug, and then backs this up with a succession of bursts to guarantee that air/fuel is ignited. The rationale is that ignition will occur even if the air/fuel mix is far from ideal, and that multiple sparks not only can't hurt, but will actually smooth the combustion process.

Another system worth mentioning is the "computer ignition" in which computer technology is used to enhance automobile ignition system operation. The unit utilizes electrical feedback to "read" the resistance of each spark-plug gap prior to firing and use this information to automatically adjust the voltage and duration of the spark supplied to each cylinder to attain optimum combustion.

Technical Details

Ignition occurs in an internal-combustion engine when a light-energy electrical spark jumps the gap in a spark plug. This spark explosively ignites the pressurized fuel/air mixture in the engine's cylinder. When the mixture ignites, it rapidly expands, forcing the piston to move downward and, in turn, rotating the crankshaft a set number of degrees (90° for a 4-cylinder, 60° for a 6-cylinder, and 45° for an 8-cylinder engine). After the first cylinder fires, spark energy is applied to the second, then the third, and so forth until all cylinders have fired and the crankshaft had made one complete rotation. To keep the engine going, this sequence is repeated over and over.

From the foregoing, it should be obvious that the timing sequence is of critical importance. Precision control is essential for maximum power to be developed, best fuel economy, and mimimum generation of air pollutants.

With a conventional electromechanical ignition system (Fig. 6), timing is controlled by elements that are prone to fatigue and wear. This deterioration begins the moment the mechanical elements are installed and steadily increases as time goes by.

As the parts fatigue and wear, the spark can lead or lag the optimum moment in time when it should occur. (This optimum time is called "top dead center," commonly abbreviated TDC.) If a spark does not occur when the piston is at its minimum distance from the spark plug, (top of the cylinder chamber), the fuel/air mixture burn will be incomplete. In terms of performance, this will result in reduced torque (reduced horsepower). Furthermore, unburned fuel will exit the exhaust, resulting in higher operating cost and increased air pollution. If this condition is allowed to continue, deterioration will accelerate, until the engine runs rough and begins "lugging" (turning over slower and slower even with increased pressure on the accelerator pedal).

To keep an internal-combustion engine that uses electromechanical ignition in reasonable operating order, it is necessary to have it relatively frequently tuned and almost as frequently have the points replaced.

The move to electronic ignition (Fig. 7) brings some obvious and not so obvious benefits. Though this system does not do away with the need for periodic tuneups, it does have the advantage of providing near-optimal performance for a longer period of time with little or no maintenance.

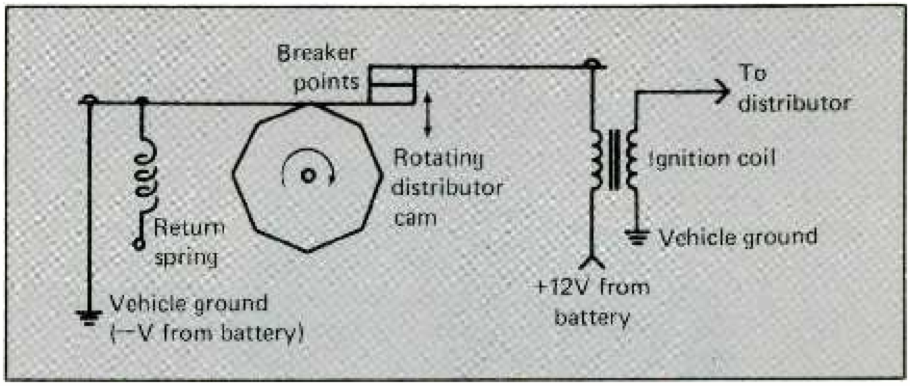


Fig. 6. In the electromechanical ignition system, timing is controlled by a points/cam arrangement that is subject to wear and fatigue. The cam rotates so that its peaks close the breaker points in synchronism with the firing requirements of the cylinders in the engine. Constant opening and closing of and sparking across the contacts of the points leads to deterioration.

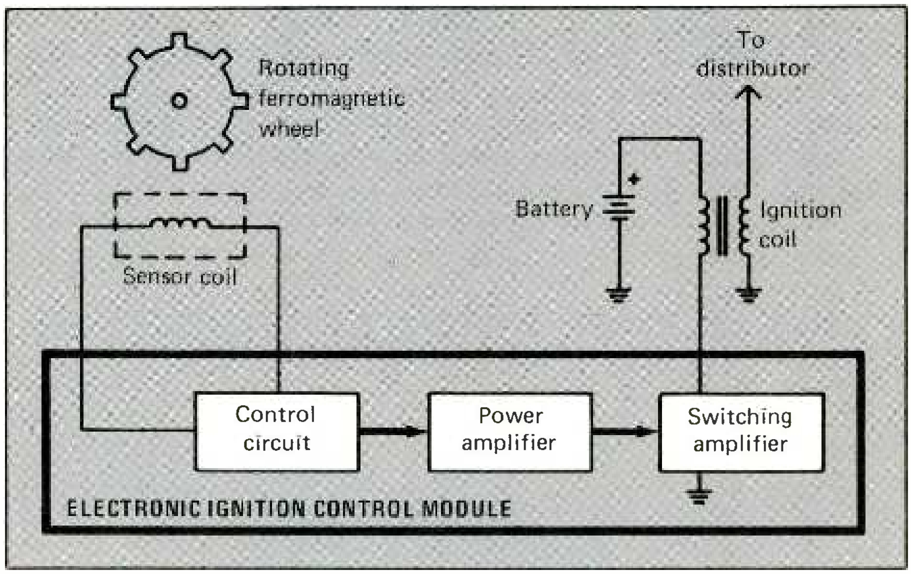


Fig. 7. The all-electronic ignition system presents a sharp contrast to the electromechanical system. The cam assembly is replaced by a ferromagnetic-wheel/sensor-coil assembly, while the points are replaced by a compact electronic control module. Instead of opening and closing mechanical contacts, the electronic-ignition system turns on and off a switching transistor. There are no moving parts to wear out in this all-electronic system.

You will still have to replace spark plugs and cables, though not as frequently as with the traditional system.

An electronic ignition system does not completely change how things are done in the internal-combustion powerplant. In fact, it changes very little. The basic ignition element—the ignition coil—remains the same. However, in place of the rotating breaker cam, the electronic-ignition system uses a rotating ferromagnetic wheel, which has the same number of "cogs" on it as there are cylinders in the engine. This cogged wheel serves as an angular-position generator that tells the system when to fire any given cylinder's fuel/air mixture.

Replacing the actual breaker points in the electronic-ignition system is an

Mallory's HyFire electronic ignition control is a high-energy, inductive storage system that increases the performance of both electronic and breaker-type ignition systems. It increases primary energy at the coil and features a built-in dwell control for greater engine efficiency at all rpms. The device mounts anywhere inside the engine compartment.

Jacobs Electrical brings the automobile into the computer age with its Compu Sensor ignition system. This unique device actually senses the resistance of each spark plug's gap prior to firing and then delivers a spark of proper energy and duration for each cylinder. The unit also features a three-position switch that enables the driver to turn it on for normal operation, off for ignition diagnosis and tuneups, and to disrupt the ignition system and serve as an anti-theft device.

electronic control unit that is fed pulses induces by the ferromagnetic wheel as it rotates past a sensor coil. Contained inside the control unit is a control circuit that conditions the pulses, passes them on to a power amplifier, which in turn toggles a switching amplifier that makes and breaks the primary side of the ignition coil through which battery current is flowing. From this point onward, the "electronic" ignition has no further effect, and the system reverts to operating in the same manner as it did traditionally with electromechanical elements.

Summing Up

As you can see, there is more to the subject of electronic ignitions than one might think. However, if you're the owner of a late-model automobile you might not have to "think" about it at all. If you wish to retrofit an earlier car, your concern should be only momentary. That's the beauty of electronic ignition, really. Once installed and operating properly in your car, it is a virtually maintenance-free system that you can simply forget about. You can then spend all your time with all those other gadgets and electronic whiz-band effects that do demand your attention. **ME**

Electronic Ignition Manufacturers

Accel Performance Ignition
Rte. 139, Box 142
Branford, CT 06405

Allison Automotive
1613 Flower Avenue
Duarte, CA 91010

Autotronics Controls/MSD
6908 Commerce Street
El Paso, TX 79915

Jacobs Electrical/Compusensor
3327 Verdugo Road
Los Angeles, CA 90065

Mallory Ignition
550 Mallory Way
Carson City, NV 89701

Midway Industries/Stinger
15116 Adams Street
Midway City, CA 92655

Per-Lux, Inc./Ignitor
1242 East Edna Place
Covina, CA 91722

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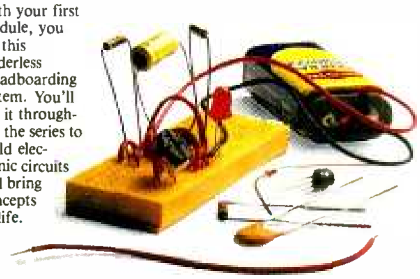

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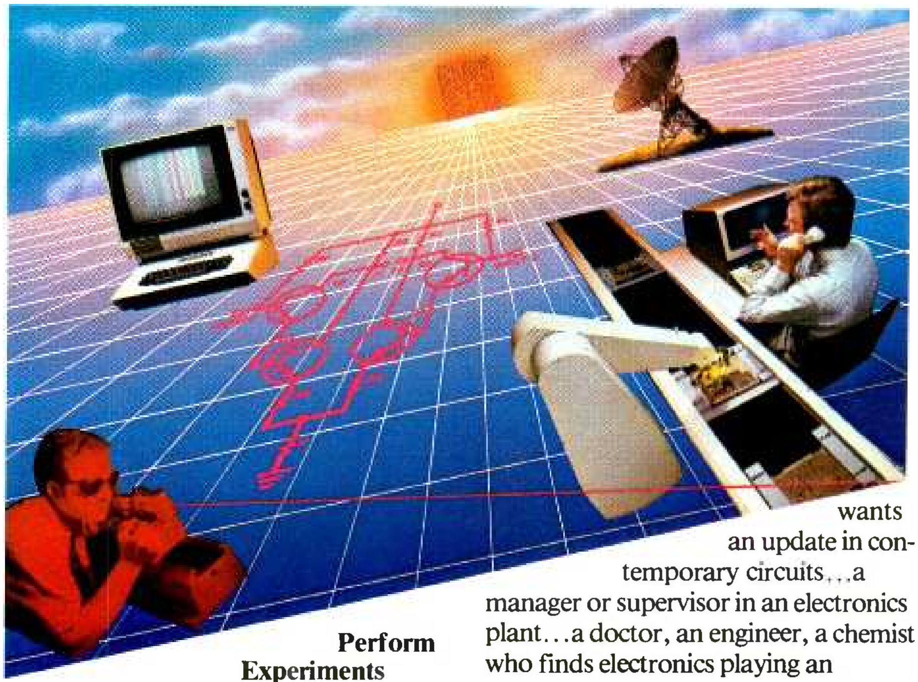

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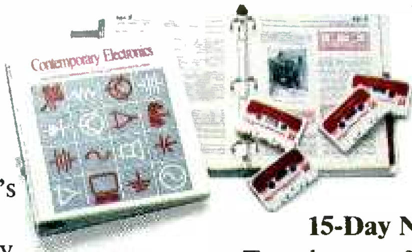

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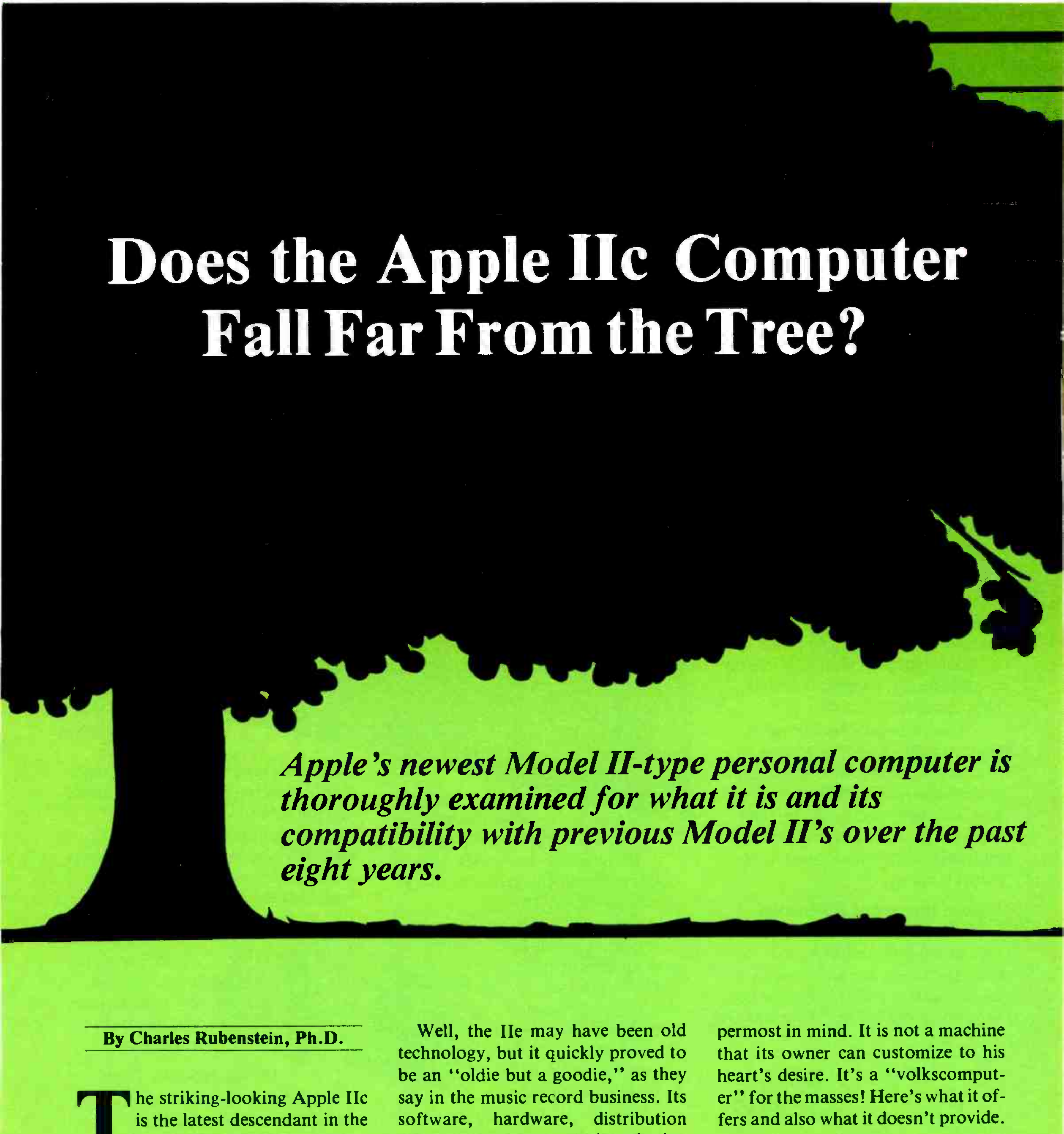


Does the Apple IIc Computer Fall Far From the Tree?

Apple's newest Model II-type personal computer is thoroughly examined for what it is and its compatibility with previous Model II's over the past eight years.

By Charles Rubenstein, Ph.D.

The striking-looking Apple IIc is the latest descendant in the Apple II series of computers. Its introduction must be a slap in the face to industry pundits who overwhelmingly pronounced Apple Computer's downfall when it unleashed its Apple IIe a year or so ago. After all, it was merely an upgrade of the Apple II+, they proclaimed. Coleco's "Adam" and IBM's upcoming "Peanut" will destroy it, they said.

Well, the IIe may have been old technology, but it quickly proved to be an "oldie but a goodie," as they say in the music record business. Its software, hardware, distribution depth combined to make it a winning product in the marketplace, IBM, Coleco, Commodore, and others notwithstanding.

So here we are with another "II" model. Only now, no one's laughing and pointing. The Apple IIc is a II with another philosophy—it's an appliance computer. It is not a machine with technically inclined people uppermost in mind. It is not a machine that its owner can customize to his heart's desire. It's a "volkscomputer" for the masses! Here's what it offers and also what it doesn't provide.

An "Apple Jr.": Apple IIc

At long last for this model line, the floppy disk storage system has been recognized as a near-necessity, not outboard baggage. The new model has a built-in half-height 5¼" disk drive, a 143K single-side type. Moreover, there's 128K of user memory residing inside, a built-in serial printer port, a modem port, a game port, and an external disk-drive port for adding a second drive. Furthermore, it incorporates NTSC and RGB video ports. So the IIc borrowed from Apple's model III, too.

The retail price tag for this Apple II fairly compatible model is $1295. A video monitor is optional.

The Apple IIc is therfore a neatly packaged, self-contained, disk-operating-system microcomputer. Unlike its II + and IIe big brothers, it has an external power supply, so the main system weighs in at only 7½ lbs. (this includes the 4½ lb. Apple II external drive that is included in its raw form in the IIc). The big, bulky, 3½ lb. power pack lightens the load by being a separate external device. Acting like an already expanded Apple IIe, there is 128K of soldered-in read-write memory (16 OKI 3764 64K × 1 RAMs), a low-power CMOS version of the 6502 (NCR's 65C02A), the upper-case/lower-case/special-character set of the IIe, and a similar complement of ROMs (the IOU, MMU, KR3600-PRO keyboard encoder, a Char Gen, MON, MAP, and IWM-integrated chips).

There are actually three fewer ICs on the IIc motherboard (41) compared to the IIe model, even though there's a second bank of 64K RAM. This is accomplished by a greater use of VLSI circuitry for the included 80-column, serial I/O and disk-controller circuits.

In contrast to other models in the "II" line, only the microprocessor, and the monitor, character generator, IOU, and MMU ROMs are in sockets. This model is indeed a computing appliance, one that is not intended to have its insides seen by an owner upon pain of a voided warranty. (We took it apart anyway.) Thus, absent from the board and the IIc are the "APPLEBus" and its convenient expansion slots, replaced if you will, by extensive r-f shielding.

An Apple IIc at left, with its built-in disk drive and optional video monitor, is contrasted with an Apple IIe model with an external drive.

The Keyboard to Your Future

The U.S.-made keyboard on the IIc is a standard QWERTY-type that's the same overall size as on the model IIe. It features 63 keys. The reset key is repositioned to the upper left of it and is recessed where it is less likely to be accidentally pushed, which would eradicate program data stored in memory. There are two other "keys" in this same area: one for toggling between 80- and 40-column displays and the other for toggling between QWERTY and Dvorak keyboards, the latter being able to increase typing speed (if you can learn the new

"Absent are convenient expansion slots."

fingering method). There is even a chapter in the manual to explain this non-traditional keyboard standard. The absence of any way to easily change your keytops into Dvorak style leaves this option as more of a frill than an aid.

The keyboard itself is a Photocircuits Atlanta device that uses sculpted keys with positive tactile and auditory keyback. (In English, you can hear and feel youself typing on the keys). In contrast, the keyboard on the IIe (by the same manufacturer) is much deeper and has its phenolic cir-

In the Beginning . . .

Since 1976, when the first Apple I computers fell from the tree, Apple has become a giant in the field of personal computers. The orginal Apple single-board microcomputer with a 6502 processor that required case and keyboard, did not have provisions for color video and was cassette-based. The Apple II that quickly followed it (and then the Apple II+) fixed the company's banner for the balance of the '70s and the early '80s with a complete machine that included a keyboard, cassette and gameport interface, color, video, graphics, an "open bus" for add-on devices, and upper case display text.

The Apple II+ model that succeeded the Model II had up to 48 kilobytes of resident memory, a built-in power supply, slots for up to four mini-disk drives, a printer card, and 80-column card, extra memory, and even a Z80 processor for running CP/M programs. It consisted of about 125 integrated circuits to perform these tasks, measured about 4.5" H × 15.25" W × 18" L, weighed about 11 lbs., and used an external floppy disk drive.

Included with the unit were a set of manuals that were useful to hobbiests, hackers, and any small company wishing to create hardware or software for the Apple machine. Incredible as it may now seem, manuals taught Applesoft BASIC, and even had schematics and pinouts for the open "APPLEBus" structure of the machine.

The Apple IIe

Near the end of 1983 Apple introduced its Apple IIe model. Cleverly using the same external package as the II+ negated any need for new tooling, new 3rd party fan, and other add-ons.

"All" Apple Computer did was improve the machine's electronic innards. It kept the open-bus structure, and used very-large-scale integrated circuits (VLSI) to reduce the number of circuits to 31 (including eight 426K 64k × 1 RAM chips, and keyboard, video, and other ROMs) in the basic unit. If an 80-column card and a disk-controller card were used, the count went to only 44 ICs.

The IIe was also created to allow for a few long-needed improvements. First was the location of a standard DB-9 socket for "normal" use of paddles and joysticks without opening the cover to connect them to the game port. Apple retained the in/out plugs for a cassette system. Also included are cutouts for 12 additional DB-type connectors, 4 each of 9-pin, 19-pin, and 25-pin versions, maintaining expansion versatility.

Unlike the II+, which had upper-case text only and a maximum of 48K of user memory, the IIe lets you jam upper case, lower case, and even special characters into 64K of memory on top of its built-in 64K. Thus, the latest model gives one up to 128K memory space. As in its predecessors, the IIe uses a 6502(B) microprocessor, and *all* ICs in sockets for future upgrades and easy repair, and has 7 "APPLEBus" 50-pin expansion slots for peripheral cards (CP/M, printer, etc.).

Possessing something called double Hi-Res (560 × 192 pixel) graphics, the IIe can show 16 colors in the Hi-Res mode. Furthermore, Apple claims that the IIe can run about 90% of the earlier models' pre-packaged programs (exclusive of 80-column-board programs). The IIe weighs about the same as the II+, too, but its manuals are a lot lighter, having been rewritten to remove technical information. More pictures, lots less "beef."

Continuing to be a rather "international" system, there are components and modules from the Phillipines (VLSI circuitry), Taiwan (speaker and power supply), Singapore (disk controller and 80-column cards, Maylaysia (circuit board), and even the good old U.S.A. (Photocircuits Atlanta Keyboard). The IIe, disk drive and controller card, 80-column card, and video monitor "list" for around $2000 (but are usually heavily discounted).

Introduced somewhat earlier was the Apple III business computer. It had a built-in disk drive, 128K memory, a serial printer or modem port, and a game port. These was also a NTSC and a RGB color signal connector, an audio port, and a monochrome output port. I mention this only as a hint of what the newest Apple computer has. The price tag for this "not-really-Apple II-compatible" unit was $3495.

Not many months ago Apple debuted its Apple IIc model, a unit that's clearly the mass-market version of other models in the Apple II series of personal computers.

cuit board fortified by having the keys pressfit in a metal retainer. In the lighter IIc, the phenolic is reinforced by a ½" plastic strut across its bottom. This is important because phenolic can easily bow out about ¼" without much force applied. The other Apple boards are all made from the more rigid greenish epoxy-fibreglass material.

The IIc has a plastic handle on the back, which is easily folded under to create a very comfortable (15 degree) typing angle, and also provides convection cooling for the bottom of the circuit board.

A Built-in Disk Drive

The half-height disk drive for the IIc is made in Japan by ALPS Electric Co., LTD., and can store 143K on a single-sided 5¼" disk. The drive is opened by pressing in the spring-loaded "door," which pops up and ejects any disk already inserted. Disks are inserted "face up," slid in until they can go no further, and then the "door" is pressed down.

As noted previously, if you knew what the pinouts were, one could merely plug a second drive into the DB-19 connector to have convenient backup and data-transfer capability. It might have been nicer to use the same 20-pin inline connector for *both* the interal and external connections so that Apple Disk II drives could be plugged in without adapter or modifications.

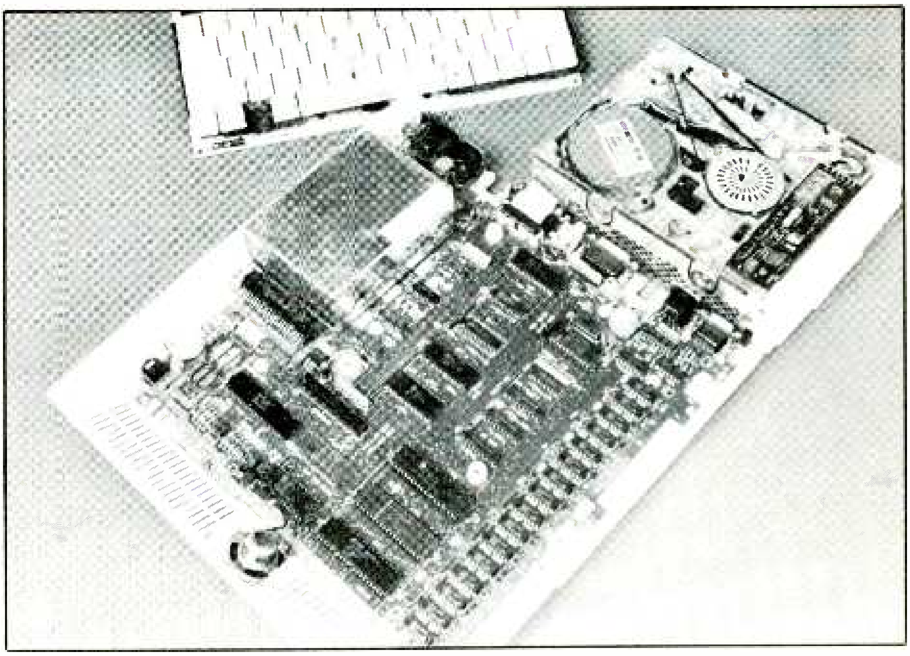
The combination of an improved VLSI controller and the Alps drive make for a much smoother and quieter-running disk-drive system than the Apple IIe with Disk II in spite of its half-size. In fact, the IIC's system is even more accurate than Disk II's, which although helpful to the user, is a drawback for some of the copy-protected software, that relies on the Disk II's higher error rate.

A Color-Coordinated Monitor

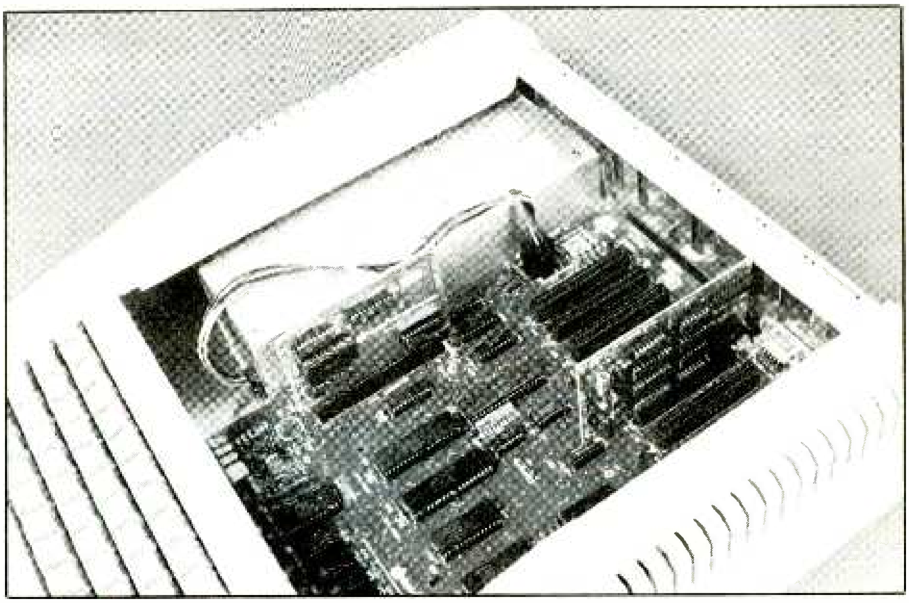
Although not part of the standard package, the "Monitor IIc" (about $250) fits neatly around the computer, as you can see in an accompanying photo. It has an approximately 8"×10" face with a 9" diagonal (5.5"×7.5") screen, and is mounted on a stand that allows the viewing angle to be adjusted from about 15 degrees above horizontal to about 20 degrees below horizontal.

The monitor and IIc combination stand less than 14" high and occupy roughly one square foot of desk space. It is styled modernistically, and color coordinated to the IIc line with its cream color and green monochrome screen.

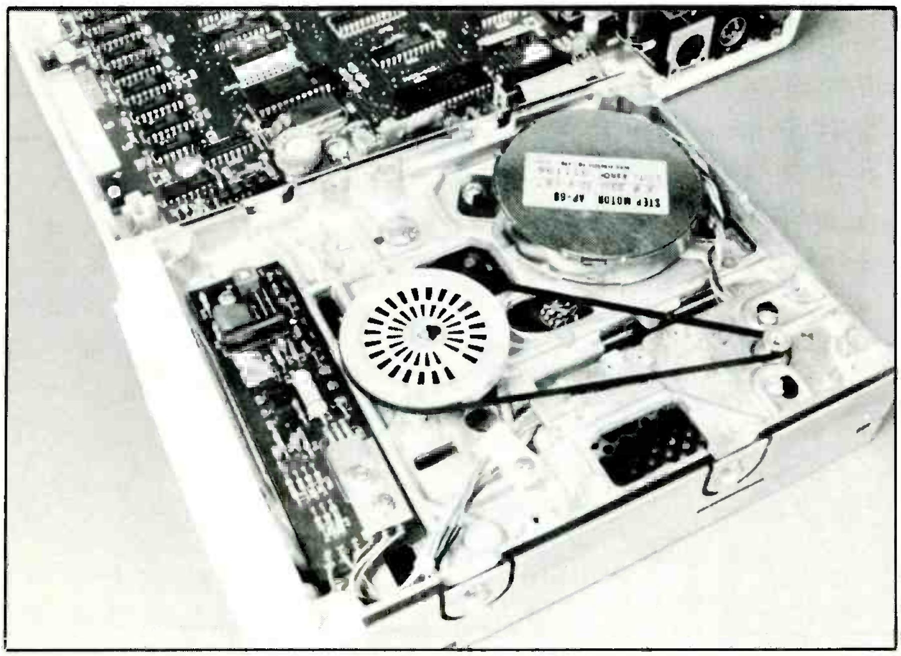
The monitor's 40-column 5×7 dot-created-text is easy to read and



Taking apart a Model IIc is not an easy task (and voids a warranty). Here you see the integrated disk drive that is normally positioned over the main pc board.



Apple's Model IIe is designed for easy access to its innards. Simply flip off the top cover and everything is exposed, including the expansion slots for adding boards vertically.



A closeup of the IIc's half-height disk drive reveals its Japan origin.

includes lower-case decenders. Unfortunately, the 80-column display has been reduced in all directions for better proportion, making the letters rather small and nearly illegible at normal working distances. Later this fall Apple is scheduled to release a full-screen liquid crystal display (LCD) which will yield up to an 80-column, 24-line display.

The IIc (minus power supply) fits into a large attache case, leaving little room for anything else; or it may be carried using its built-in handle.

The IIc Power Supply

The power pack was not integrated with the unit to reduce heat dissipation problems, as well as basic weight and bulk. But alas, a floppy disk left inside the drive for any length of time comes out a bit warm to the touch anyway.

As there is no on/off switch on the power pack, be careful to attach it to the IIc *before* you plug into a wall socket. If you don't, sparks may fly when you attempt to attach it to the 7-pin DIN plug on the IIc, even when the IIc's on/off switch is off. The power supply pumps 18 watts into the unit at 15 volts, and that power gets out via the memory ICs, the drive motor, and other components.

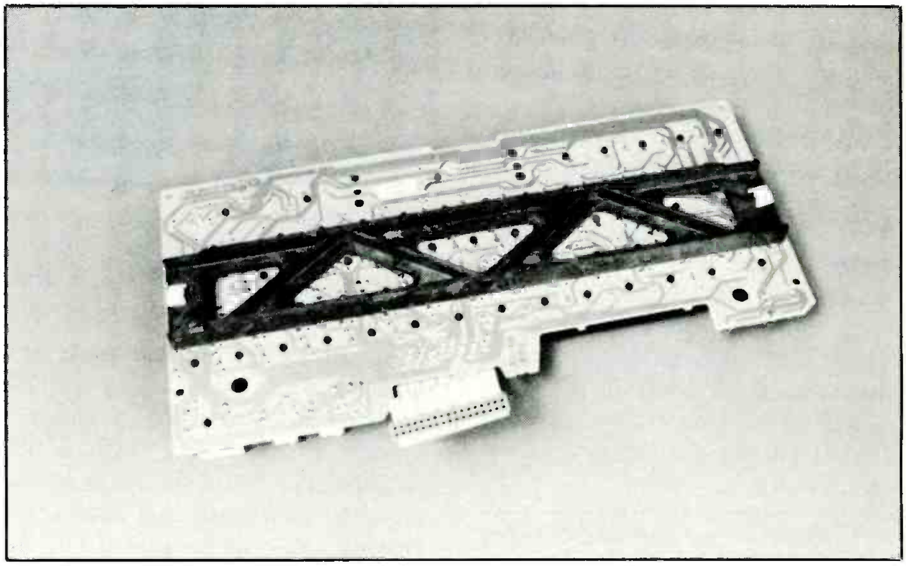
Inputs, Outputs

The IIc supplies a variety of connections to the outside world. These are all identified by icons on the rear panel (to allow for multilingual sales, I assume) and include a socket for an external speaker; and RCA phono plug for standard composite video color or monochrome monitor output; a 15-pin DB-15 for Color (RGB) video output (40 character TV output is obtained using the provided r-f modulator via this connector); a 9-pin DB-9 for paddle/mouse use; 5-pin DIN plugs for serial printer/plotter and 300-Baud modem RS232 ports; and 19-pin DB-19 for an external disk drive, which uses a built-in controller.

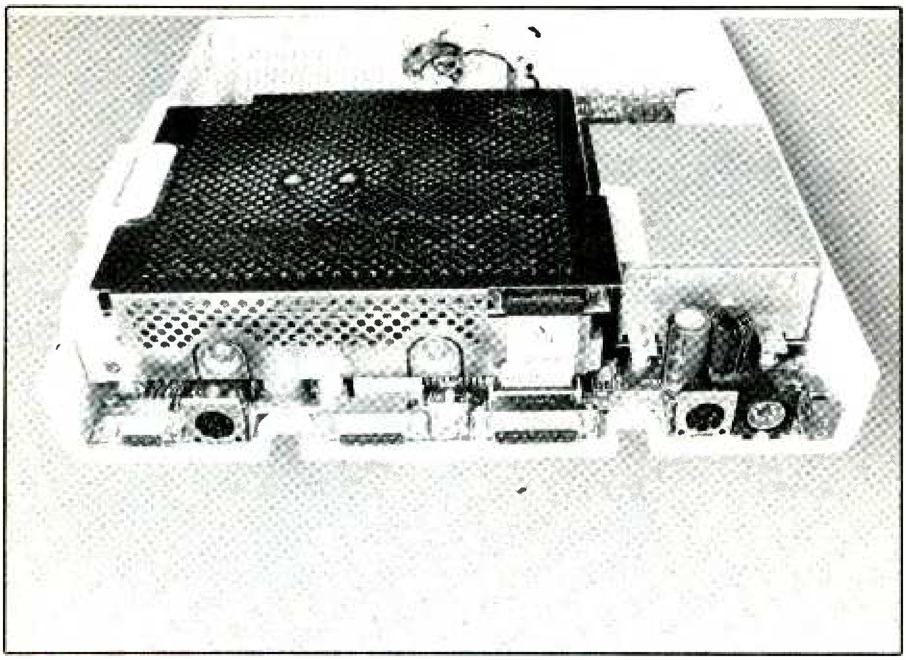
The extended video output will also be used for a soon-to-be-released LCD display. Available now is a serial printer for the IIc called the "Scribe." At $299, the Scribe is color-coordinated with the IIc, and has color printing capability. It prints 100 sheets per ribbon change, and is supplied with a stand.

Software on the IIc

The new marketing-for-the-masses philosophy by Apple Computer really hits home when you work with the softwave bundled with the IIc. Firstly, if you forget to put the disk in



The phenolic board in the IIc's keyboard is reinforced with a plastic strut across its bottom.



The Model IIc's rear-mounted input/output ports are exposed.

when you turn on, you are no longer greeted by a cryptic error message. Here we see a more reassuring "Check Disk Drive." If you want to use the ROM Applesoft BASIC, press control and reset. Otherwise, turn off the unit, insert a disk, and you're on your way.

The bundled software consists of a half-dozen disks with word-and-picture-story material from Apple.

The programs are actually a series of Computer-Assisted Instruction courses that gently introduce the user to the computer ("An Introduction"; and "The Inside Story") and its uses ("The Apple at Play"; "The Apple at Work-Writing, Figuring and Filing"; "Exploring Apple LOGO"; "Getting Down to BASIC"; and "The System Utilities").

The Introduction disk "logs on" with a keyboard graphic on the screen, followed by an Apple logo that appears along with a "typed" audio-enhanced message. You are then guided through the basics of operating a computer keyboard, the return and delete keys, etc. Follow the instructions correctly and you may never realize that this is indeed computer-controlled learning, so please make a few mistakes so that you can be ever so gently coaxed and guided through until you give the correct response.

The New Family Computer

Clearly, the Apple IIc is no Apple IIe in many respects. For one, it comes with a virtually sealed case. It really doesn't matter, though, because it doesn't have any printed-circuit-board slots to expand it internally. Nonetheless, it packs in a lot of circuitry that you'd pay extra for with an Apple IIe.

As an example, you don't need the Applebus, assuming you're not networking a bevy of computers, to add another 64K of memory since it's already included with the IIc. You needn't require slots to add an 80-column board or a disk-drive controller either, since they are all part and parcel of the IIc!

Should you wish to add voice recognition or some fancy peripheral card for, say, A/D and D/A conversion, an IEEE interface, a hard disk controller, etc., well . . . you can't. You see, the Apple IIc is not designed to be a mix and match machine. It's a family computer and, essentially, what you see is what you get.

The newest Apple Computer model is not a replication of the previous Model II's in sleek packaging. This is both good and bad. Its light weight makes it more easily transportable than other II's. But the bulky external transformer defeats this attribute to some extent. And if you plan to use a video display other than a standard TV set, which I recommend you do, then it is not much more easily transportable than previous II's are.

There are a host of tradeoffs that aren't necessarily on the plus side of the IIc, too. For example, the keys on the other Apple II keyboards are more comfortable to use. Though the Apple IIc's graphics are great, the character dots on text bother me somewhat for word processing applications. Moving to 80 characters from 40 corrects this, but the display area and the characters are smaller, which makes it a bit disconcerting to say the least.

I'd like it better if I could install a little fan inside because I don't like my floppies toastie warm. And I wish Apple had used standard connectors instead of one of this and two of that. Also, the single-side disk's data storage capacity will be a limiting factor for some people. I'd certainly look for a double-sided floppy-disk drive down the road.

Most importantly, however, is the fact that the Apple IIc is not as compatible with other Apple II's as one might think. Even Apple Computer admits to only 90% compatibility. I'd guess that it's less since the Apple IIe has been said to miss out on about 10% of earlier Apple II software. Furthermore, such numbers are always deceiving since they do not reflect compatibility percentage figures on the best-selling software on the market. For example, the popular

Continued on page 101

A New Era of Go-Anywhere Color TV Has Arrived!

New developments in LCD technology bring to market a lightweight color TV receiver you can slip into your pocket

By Alexander W. Burawa

Long awaited, the era of color viewing in a TV receiver small enough to be comfortably carried around in a pocket is finally here! And the surprise is that it is not being manufactured and sold by one of the traditional video giants, but by a company that has made a worldwide name for itself in personal computer products. The company is Epson America, and the product is the Epson "Elf," a tidy little receiver that offers a 2″ diagonal color picture in a package that measures only 6.3″W × 3.15″H × 1.22″D and weighs a mere 1.1 lb. Suggested retail price for this nifty little wonder is about $500, and availability is projected for early October, not long after you read this.

Groundbreaking Technology

In designing the Elf pocketable color TV receiver, new design ground in liquid-crystal technology had to be broken. Since traditional LCD panels, like those used in wristwatches and calculators (see "What Went Before" box), were not really suited to the action sequences normally encountered in TV programs. The SUWA Seiko-sha Company in Japan, to which Epson belongs, set about designing a fast-responding liquid crystal. What emerged from the design labs is a marvel in miniaturization, as shown in an accompanying drawing.

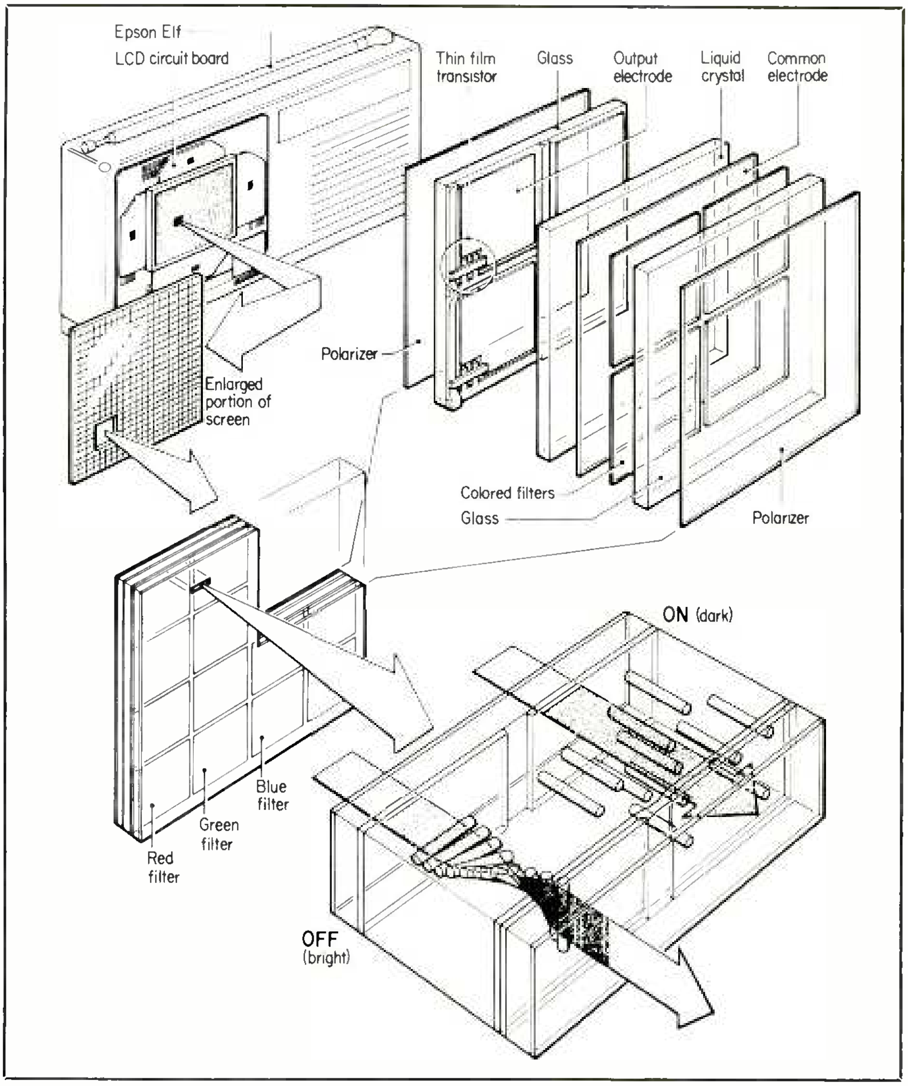
The LCD panel that makes up the display area of the Epson Elf is composed of a matrix of thousands of picture elements, known in TV and computer jargon as "pixels," that are selectively turned "on" and "off" by signals demodulated from the TV broadcast program. There are 52,800 of these pixels, arranged 240 horizontally by 220 vertically. Theoretically, the display is capable of resolving 220 lines, which is not as much as is theoretically possible with a standard CRT system but is plenty for the tiny picture displayed on the LCD's 2-inch diagonal screen.

The twisted nematic liquid crystal material used in the display panel does not in itself have color characteristics. Instead, the display assembly employs color filters to develop the actual colors you see when viewing the Elf. Just as there are only red, green, and blue primary colors in the color CRT picture tube, there are only red, green, and blue filters used in the Elf's LCD panel assembly. Technically speaking, though the Elf has a total of 52,800 pixels, this figure must be divided by three to take into account the RGB arrangement whose colors are combined to produce any but the three primary colors. The net result is a display consisting of 17,600 color points for displaying full-color pictures, which is more than sufficient for the tiny display area.

Images are displayed on the screen area of the LCD panel by light passing through from behind the panel. Hence, the LCD panel is of the transmissive variety (as opposed to the reflective variety used in most digital timepieces, calculators, and test instruments). Light for displaying viewable pictures on the screen of the Epson Elf can come from either of two sources. For indoor viewing, where light is usually subdued or lights are turned out altogether, the Elf has a built-in user-replaceable fluorescent lamp that backlights the display area. Outdoor viewing uses natural sunlight as the light source. When viewing outdoors, the internal fluorescent lamp is disabled and the receiver's rear panel is swung open to permit entry of light. The stronger the light, the more brillant the colors and the better the picture.

The lattice structure of the nematic liquid crystal used in the Epson Elf's LCD panel is designed so that it twists into a helix-like spiral when an electrical charge is applied between the two electrodes that back and face the material. When the material is at rest—that is, no electrical potential is applied across it—the liquid crystal material is twisted into a helix-like spiral that orients the light passing through to permit maximum brightness when the LCD panel is viewed from the front. Applying an increasing potential to the electrodes causes the material to untwist and allow less and less light to pass, until at maximum potential the amount of light getting through is, for all practical purposes, nil and that particular pixel's color does not enter into forming of the picture on the screen.

Until last year, nematic liquid crystals were relatively slow to respond to electrical signals applied to them. This limited their efficiency as a medium for displaying action video pictures, and only passable-quality monochrome TV receivers were available using this technology. With Seiko's new fast-responding LCD panel, much of the difficulty has been countered. The LCD panel used in the Elf responds twice as fast to



Details of the seven layers that make up the elf's LCD panel arrangement are shown upper right. Remainder of drawing shows progressively larger magnifications of the matrix arrangement of pixels in the matrix.

electrical signals than was heretofore possible with liquid-crystal displays.

LCD Panel Construction

To understand how the picture display system works in the Epson Elf, it is necessary for you to know how the LCD panel itself is constructed. As shown in the detail drawing, the basic LCD panel consists of seven layers that are laminated together to form a compact "sandwich."

The rearmost layer is a polarizer that orients the incoming light to provide the conditions required by the twisted nematic crystal material. This polarizer has a glass substrate directly in front of it upon which special thin-film transistors (TFTs) are deposited. There are as many

TV Display Evolution

Before the development of practical liquid-crystal displays, electronic TV receivers were always built around the cathode-ray tube, or CRT. The CRT, however, places severe restrictions on how small (or large) the tube—not the picture—can be made. To provide a sufficiently bright viewable picture with good contrast and minimal distortion, the CRT system must contain, in addition to the picture tube itself, an electromagnetic deflection system and a high-voltage power supply. The purpose of the deflection system is to maneuver the electron beam as it draws pictures on the screen's phosphor coating.

The length of the CRT is governed mainly by two factors: the size of the electron gun assembly and the distance that must be maintained between the electron gun and the phosphor coating on the inside surface of the CRT. It is possible to make a very short electron gun, thus shortening the length of the CRT's neck. However, this would not solve the overall tube length problem, since it would be much more difficult and maybe even impossible for an effective deflection-coil system to be used.

Because an electron beam is used to draw the pictures you view, high voltages are necessary to control the process at various stages until the beam finally arrives at and excites the phosphor coating on the picture tube's screen. The high-voltage circuit's main function is to provide the potential needed for accelerating the electrons in the beam to a velocity sufficient to excite the phosphor into fluorescence.

Battery powering a portable TV receiver requires a built-in converter circuit to boost the low battery voltage to the high voltage required by the picture tube. Because losses occur during conversion (and power is continuously required by the CRT's heater to produce the electrons for the beam), a bulky and heavy high-energy battery is required if a reasonable viewing time is desired from a fresh set of cells.

The combination of CRT, deflection system, high-voltage power supply, and bulky battery has defeated most attempts by manufacturers to design and make a pocketable portable CRT-based TV receiver. Currently, the only exceptions to this have been Sony's "Watchman" and Panasonic's "Color Solo", both of which are ultra-compact CRT-based pocketable portables. The Sony Walkman has a monochrome (black-and-white) 2″ diagonal "flat" CRT; the Panasonic compact has a 1½″ diagonal color CRT.

Enter LCDS

When the liquid-crystal display (LCD) became a practical reality in the timepieces and calculators of the late 1970s, TV manufacturers finally saw the possibility of producing ultra-compact TV receivers. These early LCDs were not suitable for displaying TV pictures depicting action sequences, since they were slow to respond to electrical signals and lacked

TFTs and electrodes as there are pixels in the display area, one to drive each pixel. Much of the LCD panel's fast response speed is attributable to these microscopic-size TFTs.

The next layer in the sandwich is the actual matrix arrangement of 52,800 LCD pixels. The fourth layer is the common electrode for all LCD pixels. Fronting the common electrode layer is an arragement of tiny color filters, each of which is carefully positioned over the appropriate LCD pixels. These filters are arranged in "triads," groupings of red/green/blue that closely resemble the red/green/blue phosphor dots or stripes on the rear of the color CRT's screen.

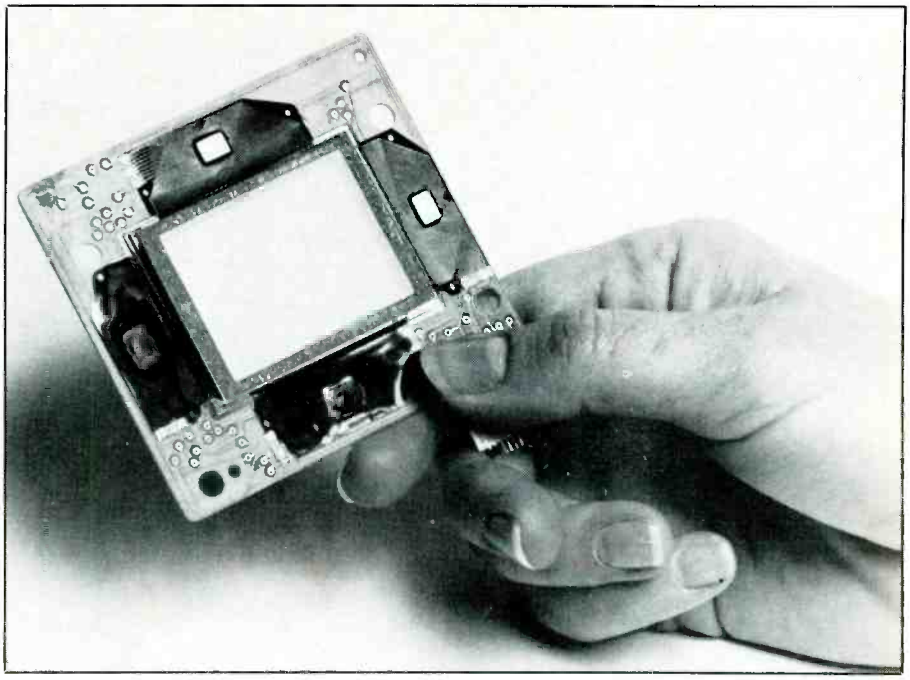
The sixth layer in the sandwich is an optically clear slice of glass that both holds the filters in place and serves as protection for the LCD panel assembly. Further light conditioning is provided by a final polarizing layer. Rotated 90° to the plane of the rear polarizer, the front polarizer permits maximum light coming through the LCD panel to reach the viewer's eyes.

Even with the TFTs and electrodes (both microscopically small or microscopically thin) in the light path, the panel exhibits a relatively high light-transmission index. The amount of light prevented from getting through accounts for a small portion of the total entering the rear of the LCD panel. Hence, the light efficiency is rather good with this LCD panel arrangement.

Producing Color

The manner in which color pictures are obtained with the LCD technology used in the Epson Elf resembles the operation of the traditional color CRT. One parallel is the triad arrangement of the primary color filters that closely emulate the primary color phosphor arrangement in the CRT. Colors other than the three primaries are obtained by mixing judicious amounts of any two or all three of the primary colors.

Any color or combination of colors can be produced with the light-plus-filter scheme used in the Epson Elf. Just as in the CRT system, where the primary colors are mixed in specific percentages (intensities, controlled by the luminance signal), the light passing through the LCD panel's pixels, also at different intensities, is mixed and presented to your eyes. In



Heart of the Epson Elf is this circuit board, which contains the color LCD panel and thin-film transistors. The transistors drive very sensitive liquid crystal pixels at twice the speed heretofore possible with LCDs.

the ability to present fine detail with high contrast.

With the development of faster-responding, high-contrast LCD panels, true pocket portable TV receivers built around them made it possible for Casio, Citizen, and Sony to come to market during the past year or so with consumer products. Offering only monochrome pictures, these receivers provided barely satisfactory performance in terms of resolution of fine detail and contrast. Response of the LCD in them is medium-fast, which means that slight smearing of the picture can occur in fast-action picture sequences.

The LCD panel, by nature, is much more compact than even the most miniaturized cathode-ray tube. In fact, it cuts the volume of space required for the display system to only a small fraction of that required for the CRT alone. Since in LCDs there is no need for an electron beam, there is also no need of a high-voltage power supply, an electromagnetic deflection system, or heavy, bulky batteries. Power for the LCD panel is derived directly from the same source as that used for the r-f and audio circuits in the receiver—namely, the battery. And power consumption is in the microwatt (millionths of a watt) range, which means that only a small fraction of the power consumed by the receiver is actually needed for the display system.

Lacking in all pocketable TV receivers up to this point in time has been the ability to present color pictures. With the development of a color LCD panel, however, on-the-go viewers now have even this highly desirable feature.

turn, your eyes and optic nerve integrate the incoming color-mix information, as intended, to present to your brain not just the three primary colors of the filters but any color imaginable from white to black, and every color of the rainbow between these two extremes.

Other Features

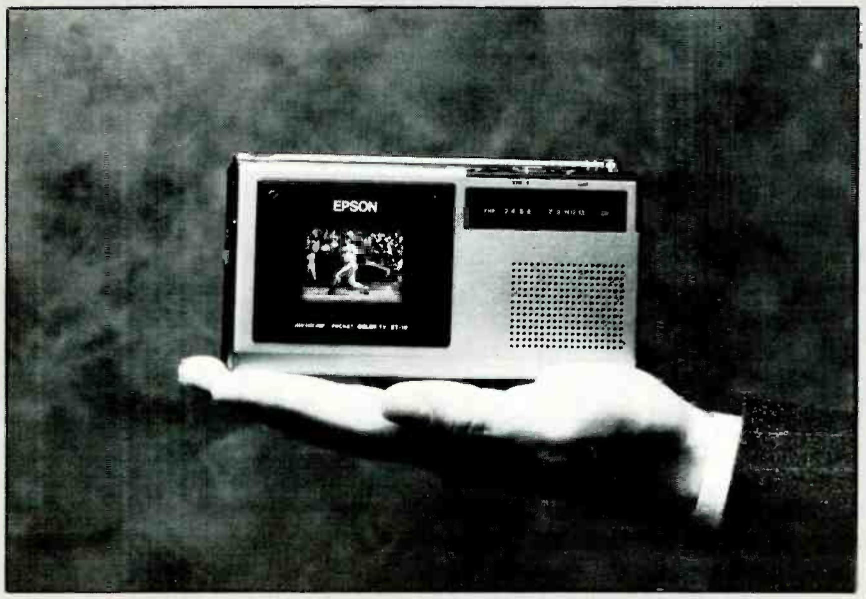
From the foregoing, it should be obvious that the major breakthrough in the micro-miniaturization of color TV receiving is in the new LCD technology employed by Epson in its Elf. The remainder of the circuitry in the Elf is more or less standard for an ultra-compact TV receiver. It consists of the various r-f, i-f, chroma, and audio circuits, all microminiaturized to take up a minimum of space and add only negligible weight to the product.

The Elf can be powered by any of four different sources. For carry-along portability, you have a choice of either AAA-size flaslight or rechargeable nickel-cadmium (Ni-Cd) cells. In either case a total of five cells are required to provide power. Operating time from fresh alkaline cells is rated at 2.5 hours with the flourescent backlight on and about 5 hours with it off. An optional rechargeable battery pack is scheduled to be available at about the time the Elf is due to go on the market. So is an optional cigarette-lighter adapter that permits the Elf to be powered by a car battery. For operation at home, or wherever ac line power is available, an ac adapter will be available as standard equipment with the purchase of the Epson Elf.

Other standard fare due to be packaged with or installed in or on the Elf include a minature earphone for totally private listening, a hand strap and carrying case, a 27″ telescoping whip antenna, and an earphone jack. A small loudspeaker is built into the Elf's case for those people who do not wish to listen with an earphone.

Continued on page 103

Hands-On Report



Epson's "Elf" is a neat color TV receiver that resembles in size and weight a good-quality, pocketable transistor radio. Thus, this is quite a technical accomplishment.

The "Elf" uses a continuously variable manual TV tuner to select a desired TV station, a switch for VHF or UHF band selection, and another switch for turning on a small fluorescent lamp that's used for backlighting the LCD for best indoor viewing. It employs a monopole rod antenna.

The color picture's quality was remarkably good, being both sharp and with good color saturation. Tuning in channels with the manual control was easy, too, though some jiggling is required, naturally, to lock in the best picture. Sound was satisfactory, too.

In the sample model we used, in a location about 40 miles from the TV transmission point, we could only receive a few (three) channels well from among seven in the area. Moreover, changing position of the pocket TV required adjusting the antenna in order to get satisfactory reception. It's clear, therefore, that the Elf must be used in a stationary position to avoid the frustrations of changing the antenna's position whenever the set is moved. Fine for the beach or picnic grounds, but not so fine for hand-held use.

Its video and audio input jacks enable the Elf to be used conveniently as a VCR TV monitor when one employs a video camera outdoors. Moreover, it would make a fine entertainment package for people in an automobile (not the driver, or course).

Color and tint controls were easy to use, though their ranges were much more limited than we would like them to be. The brightness control worked fine.

Aside from the novelty of the smallest color TV portable in the world at this time, and what its design portends for the future, Elf can only be viewed as a luxury at this time. With greater input sensitivity, a substantially lower price, and automatic adjustment circuitry, it would receive more serious purchase consideration.

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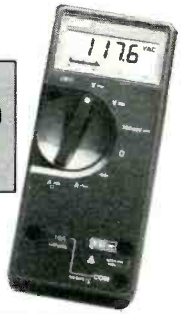

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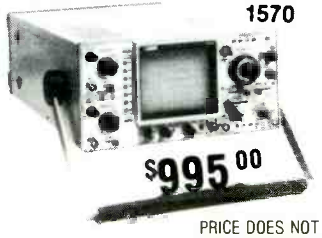

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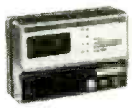

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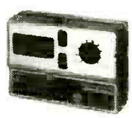

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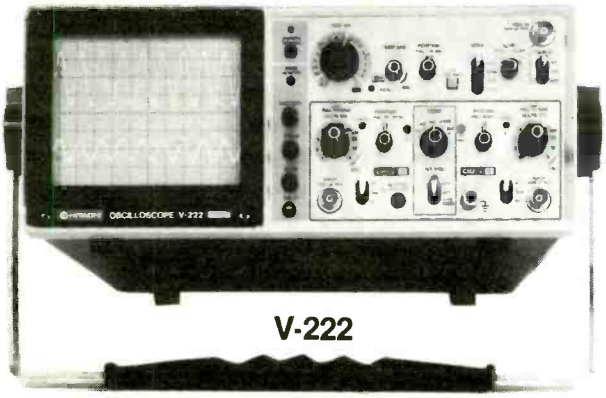

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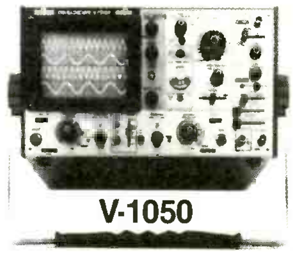

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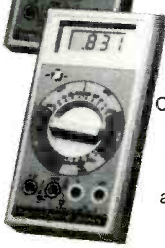

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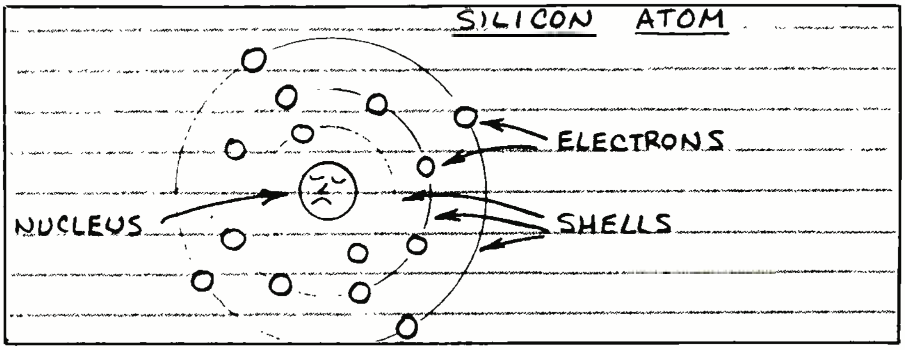
How To Get Started In Electronics

Part I: Inside Semiconductors

By Forrest M. Mims III

The material for this article is extracted from the author's book Getting Started in Electronics, *published by Radio Shack.*



Electronics experimenting is rewarding, and challenging. There are few other pursuits that are more satisfying, especially when you finish building a project, turn it on, and find you've created from a meaningless pile of components something really useful. Thus, you've become a creator with an end-product to show for your efforts.

Electronics experimenters often have different objectives. You might wish to simply convert an idea for a circuit into a finished project just for the fun of seeing it take shape and operate as you designed it to do. Or you might have a need for a device that isn't available commercially, or you might want to make something that is available commercially but you feel you can build at lower cost.

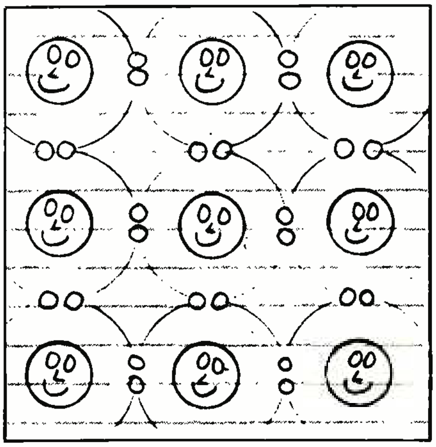
Whatever your reasons for wanting to build projects or experiment with your own circuit ideas, you'll need some idea of how to use the various elements available to create practical circuits. To be able to do this, you must understand how these devices work and how they interact.

As the title of this series implies, the objective of this series is to introduce you to these elements starting with semiconductors.

Silicon Recipes

There are many different semiconducting materials, but silicon, the main ingredient of sand, is the most popular ingredient.

A silicon atom has only four electrons in its outermost shell, but it would like to have eight. Therefore, a silicon atom will link up with four of its neighbors to *share* electrons as follows:



A cluster of silicon atoms sharing outer electrons forms a regular arrangement called a crystal. To keep things simple, in the above drawing of a silicon crystal, only the outer electrons are shown.

Pure silicon isn't very useful. That's why silicon makers spice up their silicon recipes with a dash of phosphorous, boron, or other goodies. This is called "doping" the silicon. Then silicon has very useful electrical properties indeed!

P and N Spiced Loaf. Boron, phosphorous, and certain other atoms can join with silicon atoms to form crystals. Here's the catch: A boron atom has only *three* electrons in its outer shell, while a phosphorus atoms has *five* electrons. Silicon with extra phosphorus electrons is called *n*-type silicon (*n* = negative). Silicon with electron-deficient boron atoms is called *p*-type (*p* = positive) silicon.

P-type Silicon. A boron atom in a cluster of silicon atoms leaves a vacant electron opening called a "hole." It's possible for an electron from a nearby atom to "fall" into the hole. Therefore, the hole has *moved* to a new location. Remember, holes can move through silicon (just as bubbles move through water).

N-Type Silicon. A phosphorus atom in a cluster of silicon atoms donates an extra electron that can move through the crystal with comparative ease. In other words, *n*-type silicon can carry an electrical current. But so can *p*-type silicon! Holes are what "carry" the current.

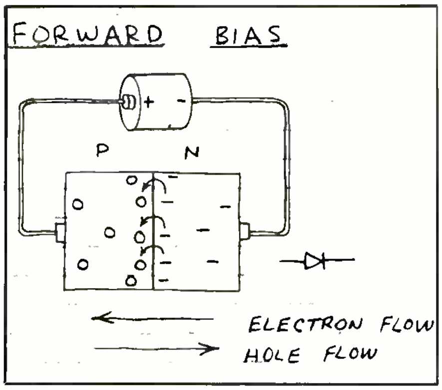
The Diode

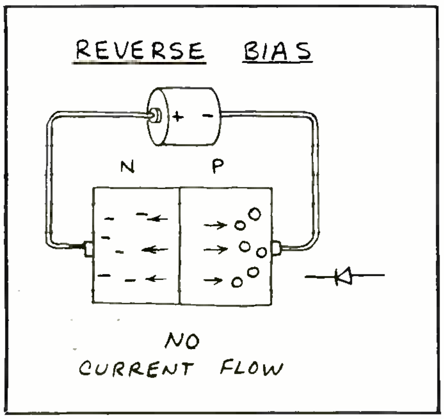
Both *n*- and *p*-type silicon conduct electricity. The resistance of both types is determined by the proportion of holes or surplus electrons. Therefore, both types can function as resistors. And they will conduct electricity in any direction.

By forming some *p*-type silicon in a chip of *n*-type silicon, electrons will flow through the silicon in only one direction. This is the principle of the *diode*. The *p-n* interface is called the *pn junction*.

How the Diode Works

Here's a simplified explanation of how a diode conducts electricity in one direction (forward) while blocking the flow of current in the opposite direction (reverse).

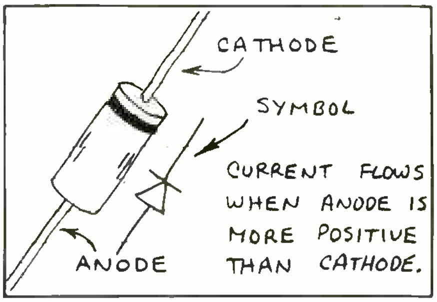




In A, the charge from the battery *repels* holes and electrons toward the junction. If the voltage exceeds 0.6 volt (silicon), electrons will cross the junction and combine with holes, allowing a current to flow.

In B, the charge from the battery *attracts* holes and electrons away from the junction. Under this condition, no current can flow.

Diodes are commonly enclosed in small glass cylinders. A dark band around one end of the cylinder identifies the *cathode* terminal. The opposite terminal is the anode. The above drawing illustrates both the physical packaging of the diode and its schematic symbol.



You already know from the foregoing discussion that a diode is like an electronic one-way valve. It's important to understand some additional aspects of diode operation. Here are some key ones:

1. A diode will *not* conduct until the forward voltage reaches a certain threshold point. For silicon diodes, this is about 0.6 volt.

2. If the forward current becomes excessive, the semiconductor chip may crack or melt! And the contacts may separate. If the chip melts, the diode may suddenly conduct in both directions. The resulting heat may vaporize the chip!

3. Too much reverse voltage will cause a diode to conduct in the wrong direction. Since this voltage is fairly high, the sudden current surge may zap the diode.

Diode Types & Uses

Many different kinds of diodes are available. Here are some of the major types in common usage:

Small Signal. These diodes transform low-current ac to dc, detect (demodulate) radio signals, multiply voltage, perform logic operation, absorb voltage spikes, etc.

Power Rectifier. Functionally identical to small-signal diodes, power rectifiers can handle much more current. They are installed in large metal packages that soak up excess heat and transfer it to a metal heat sink. They are used mainly in power supplies.

Zener Diode. This specialty rectifier is designed to have a specific *reverse breakdown* (conduction) *voltage*. This means zener diodes can function like a voltage-sensitive switch. Zener diodes having breakdown voltages (V_z of from 2 to 200 volts are available.

Light-Emitting Diode. All diodes emit some electromagnetic radiation when forward baised. Diodes made from certain semiconductors (like gallium arsenide phosphide) emit *considerably* more radiation than silicon diodes. They're called light-emitting diodes (LEDs).

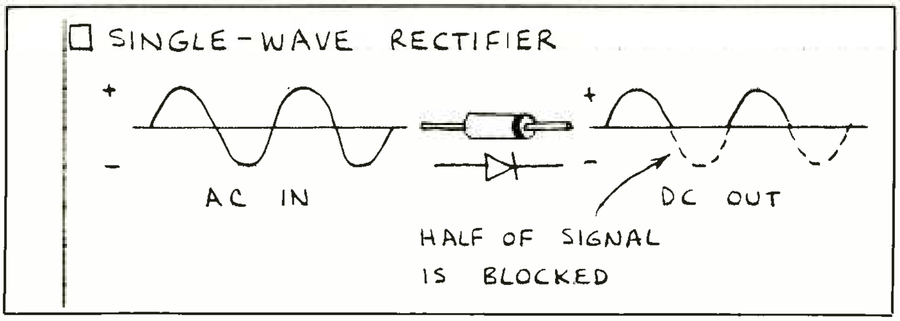
Photodiode. All diodes also *respond* to some degree when illuminated by light. Diodes designed specifically to detect light are called photodiodes. They include a glass or plastic window through which the light enters. Often they have a large, exposed junction region. Silicon makes good photodiodes.

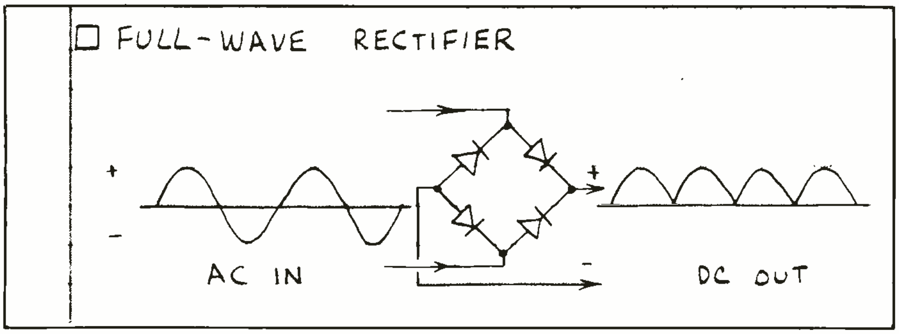
Various types of diodes are used in many applications. For now, here are two of the most important roles for small-signal diodes and rectifiers:

The first is a single-wave rectifier circuit in which an undulating (ac) signal or voltage is rectified into a single-polarity (dc) signal or voltage.

The second is the full-wave rectifier circuit in which a four-diode "network" (or bridge rectifier) rectifies *both* halves of an ac signal.

Note the difference in output from the two circuits. In the half-wave circuit only one alternation of the input generates an output, while *both* alter-

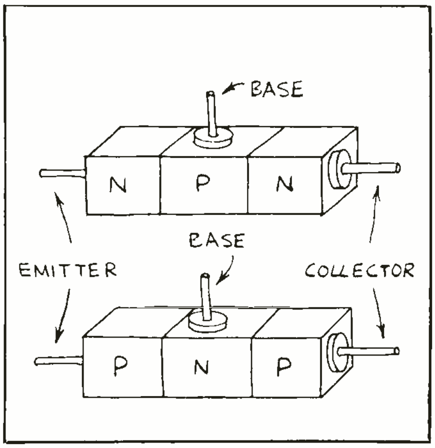




nations produce outputs in the full-wave circuit. This difference offers significant advantages, in the case of the full-wave circuit, when the output must be filtered to obtain a smooth (minimal-variation) dc voltage with minimum ripple.

The Transistor

Transistors are semiconductor devices with three leads. A very small current or voltage at one lead can control a much larger current flow-

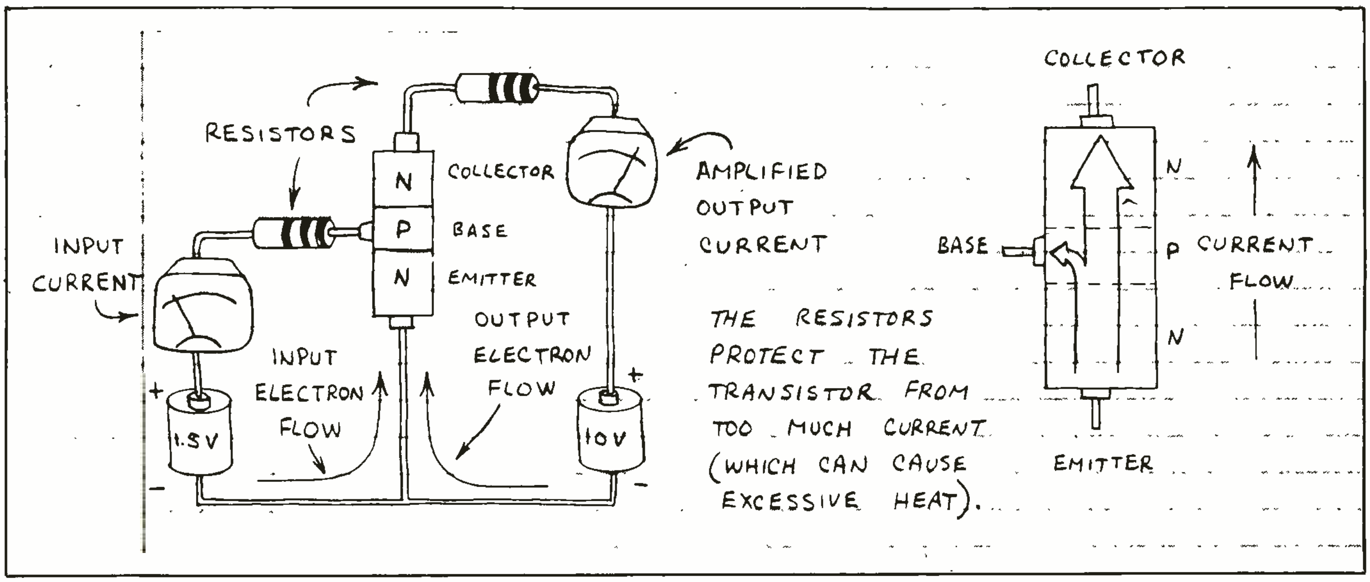


ing through the other two leads. This means transistors can be used as amplifiers and switches. There are two main families of transistors: bipolar and field-effect. We will concentrate here only on bipolar transistors.

Add a second junction to a *pn*-junction diode and you get a three-layer silicon "sandwich." The sandwich can be either *npn* or *pnp*. Either way, the middle layer acts like a faucet or gate that controls the amount of current moving through the three layers.

The three layers of a bipolar transistor are the emitter, base, and collector. The base is very thin and has fewer doping atoms than the emitter and collector. Therefore, a very small emitter-base current will cause a much larger emitter-collector current to flow.

Diodes and transistors share several key features: The base-emitter junction (or diode) will not conduct until the forward voltage exceeds 0.6 volt. Too much current will cause a transistor to become hot and operate improperly. If a transistor is hot (not just warm) when touched, disconnect the power to it! Finally, too much current or voltage may damage or permanently destroy the semiconductor chip that forms the transistor. Even if the chip itself isn't harmed, its tiny connection wires may melt or



separate from the chip. *Never* connect a transistor backwards!

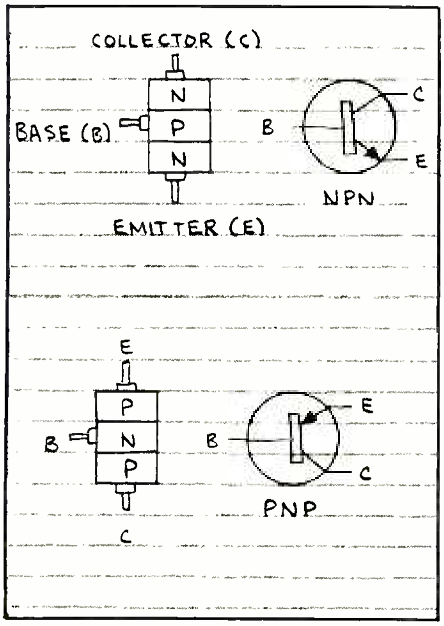
Many different types of transistors are available. Typical examples are as follows:

Small-Signal and Switching. Small-signal transistors are used to amplify low-level signals. Switching transistors are designed to be operated fully on or off. Some transistors can both amplify *and* switch equally well.

Power. These transistors are used in high-power amplifiers and power supplies. Large size and exposed metal surfaces keep them cool.

High-Frequency. These transistors operate at radio, television, and microwave frequencies. The base region is *very* thin, and the actual chip is very small.

The schematic symbols for the *npn* and *pnp* transistors is as follows:



Note that the arrow in the emitter leads always points in the direction of hole flow. If the arrow points away from the base, the emitter is made of *n*-type material, which identifies it as an *npn* transistor. Conversely, if the arrow points toward the base, the base is *n*-type material, which means the emitter and collector are both *p*-type material and, thus, the transistor is a *pnp* device.

Using Bipolar Transistors

When the base of an *npn* transistor is grounded (0 volt), no current flows from the emitter to the collector and the transistor is "off." If the base is forward-biased by at least 0.6 volt, a current will flow from the emitter to the collector and the transistor is "on." When operated in only these two modes, the transistor functions as a switch. If the base is forward-biased, the emitter-collector current will follow variations in a much smaller base current. The transistor then functions as an amplifier.

This discussion applies to a transistor in which the emitter is the ground connection for both the input and the output, and is called the *common-emitter* circuit. Some simlified common-emitter circuits are show below.

•Transistor Switch (A)

Only two inputs are possible with this circuit: ground (0 volt) and positive battery voltage (+V). Therefore, the transistor is off or on. A typical base resistance is 5000 to 10,000 ohms. If the resistor is replaced by a wire, the lamp can be switched on and off from a considerable distance.

•Transistor dc Amplifier (B)

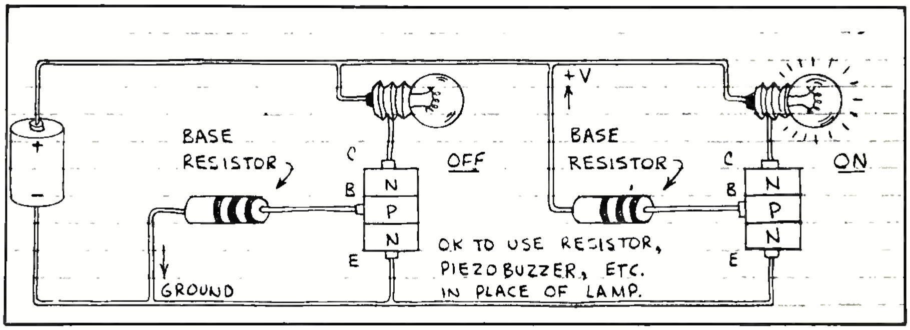
The variable resistor forward-biases the transistor *and* controls the input (base-emitter) current. The meter indicates the output (collector-emitter) current. The series resistor protects the meter from excessive current that can damage it.

In a working circuit, the variable resistor may be in series with a second component whose resistance varies with temperature, light, moistur etc. When the input signal chang rapidly, an ac amplifier such as t) one shown below is used.

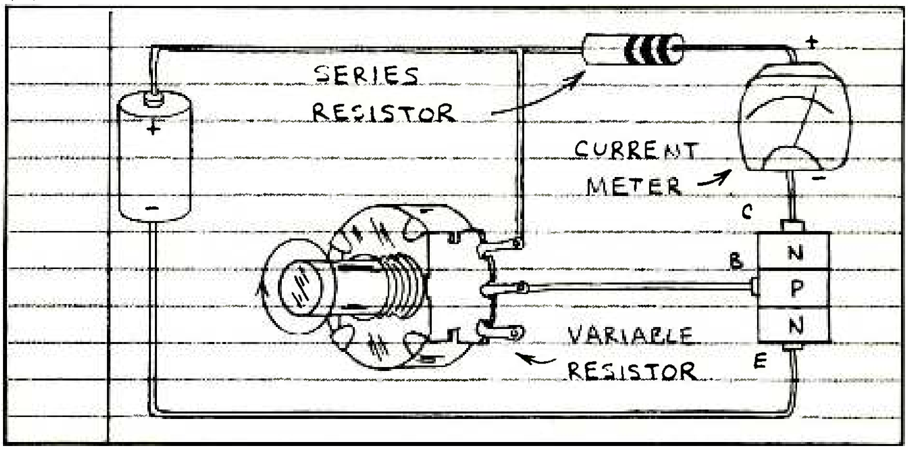
Transistor AC Amplifier (C)

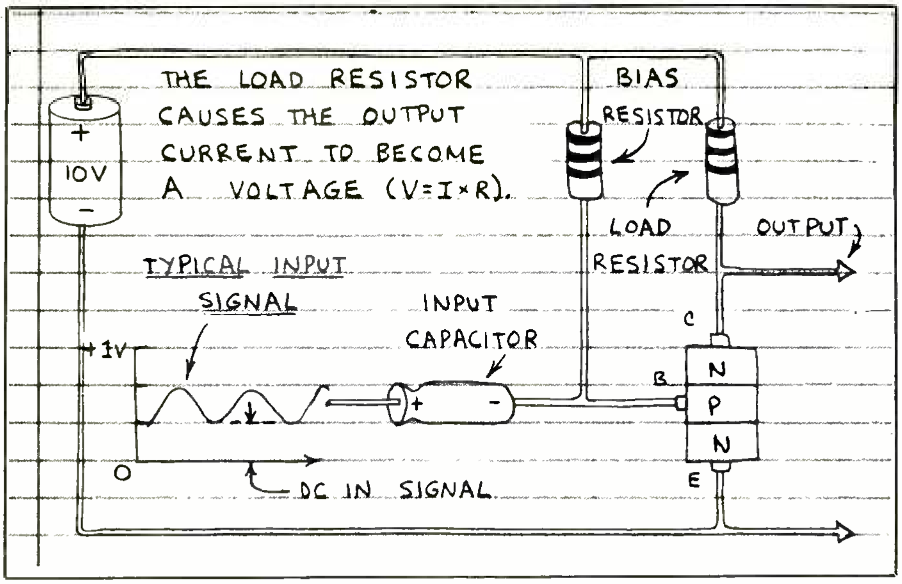
This is the simplest of several basic ac amplifiers. The input capacitor blocks any dc in the input signal. The bias resistor is selected to give an output voltage of about half the battery voltage. The amplified signal "rides" on this steady output voltage and varies above and below it. Without

(A)



(B)





(C)

the bias resistor, only the positive half of the input signal *above* 0.6 volt will be amplified. This will cause severe distortion.

About the Direction of Current Flow

An electrical current is the movement of electrons through a conductor or semiconductor. Since electrons move from a negatively charged to a positively charged region, why does the arrowhead in a diode symbol point in the opposite direction? There are two reasons:

1. Beginning with Benjamin Franklin, it was traditionally assumed electricity flows from a positively charged to a negatively charged region. The discovery of the electron changed that. But most electrical circuit diagrams today still follow the old tradition in which the positive power supply connection is placed *above* the negative connection, as if gravity somehow influences the flow of current in an electrical circuit.

2. In a semiconductor, holes flow in the direction opposite that of electron flow. It's therefore common to refer to *positive* current flow in semiconductors.

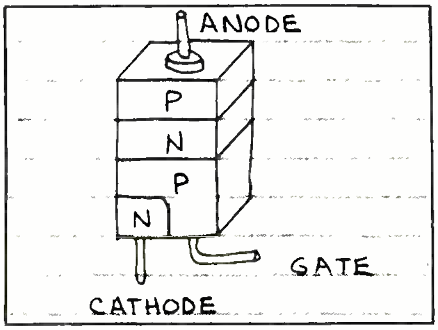
For accuracy here, "current flow" refers to *electron* flow. But we're stuck with symbols that indicate the direction of *hole* flow.

The Thyristor

Like transistors, thyristors are semiconductor devices with three leads. Also similarly, a small current at one lead will allow a much larger current to flow through the other two leads. Unlike transistors, however, thyristors do not amplify fluctuating signals. The controlled current is either fully on or fully off. Hence, thyristors are often referred to as "solid-state switches."

Silicon-Controlled Rectifiers

Commonly called SCRs, these devices make up one of two basic categories of thyristors. They are similar to bipolar transistors with a fourth layer and, therefore, three junctions, as in the following drawing.



The physical construction and schematic symbol for the SCR are shown in (D). Frequently, single-letter designations are used to identify the leads: A for anode, K (or C) for cathode, and G for gate.

If the anode (A) of an SCR is made more positive than the cathode (K), the two outermost junctions are forward biased. The middle *pn* junction, however, is reverse biased, and current cannot flow. A small gate current forward biases the middle *pn* junction and allows a much larger current to flow through the device. The SCR stays on even if the gate current is removed! (until power is disconnected.)

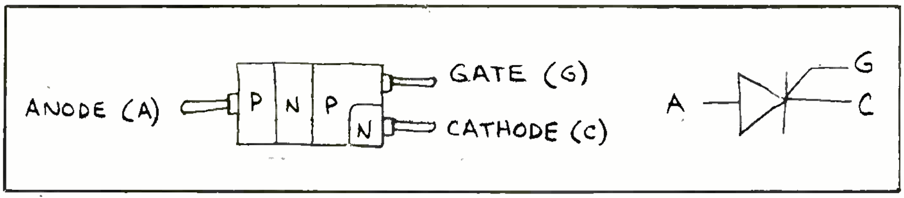
Circuit E shows how an SCR is used to switch on an incandescent lamp. (Other devices can also be controlled.) A single touch of the indicated switch applies current to the G terminal and causes the SCR to "fire." This, in turn, turns on the lamp. Since the SCR is a *dc* device, the current will continue to flow until the switch to the left of the lamp is momentarily pressed.

SCRs are available in a wide range of current and voltage ratings. Low-current SCRs switch up to 1 ampere at up to 100 volts; medium-current SCRs switch up to 10 amperes at up to several hundred volts; and high-current SCRs have the ability to switch up to 2500 amperes at up to several thousand volts!

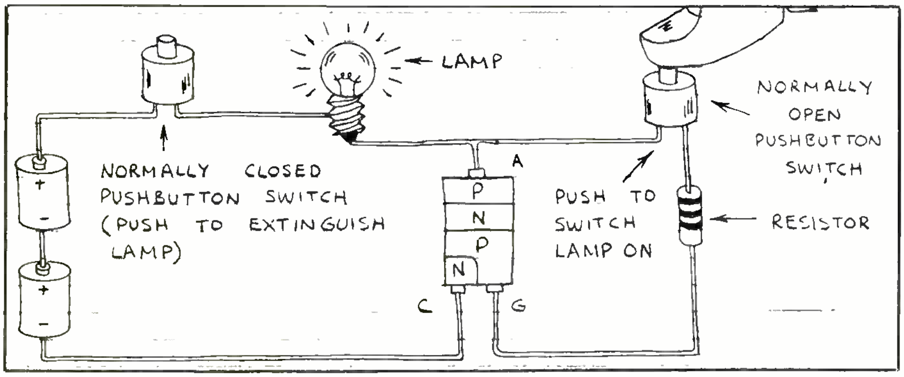
Triacs

The triac is equivalent to two SCRs connected in reverse parallel. This means it can switch both direct *and* alternating current (*dc* and *ac*). Notice that the triac has *five* layers and an extra *n*-type region and that all three leads contact two layers.

Though the triac has a gate terminal similar to that in an SCR, it does not have separate anode and cathode terminals for the simple reason that each of the other terminals connects to both an anode *and* a cathode. Therefore, these terminals are identi-



(D)



(E)

fied as MT1 and MT2, where MT stands for "main terminal." (F)

When used to switch alternating current, the traic stays on only when the gate receives current. Remove the gate current, and the triac switches off when the ac passes through 0 volt.

The arrangement shown in (G) demonstrates how a triac can switch on a lamp powered by household line current. (Motors and other devices can also be controlled).

Like SCRs, triacs are categorized according to the current they can switch. But triacs don't have the very high power capability of high-current SCRs.

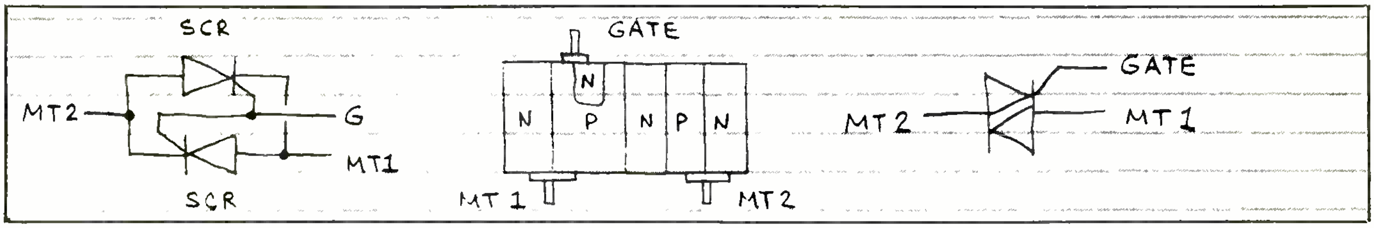
Semiconductor Light Sources

When bombarded by light, heat, electrons, and other forms of energy, most semiconductors will emit visible or infrared light. The best semiconductor light sources are the family of *pn* junction diodes.

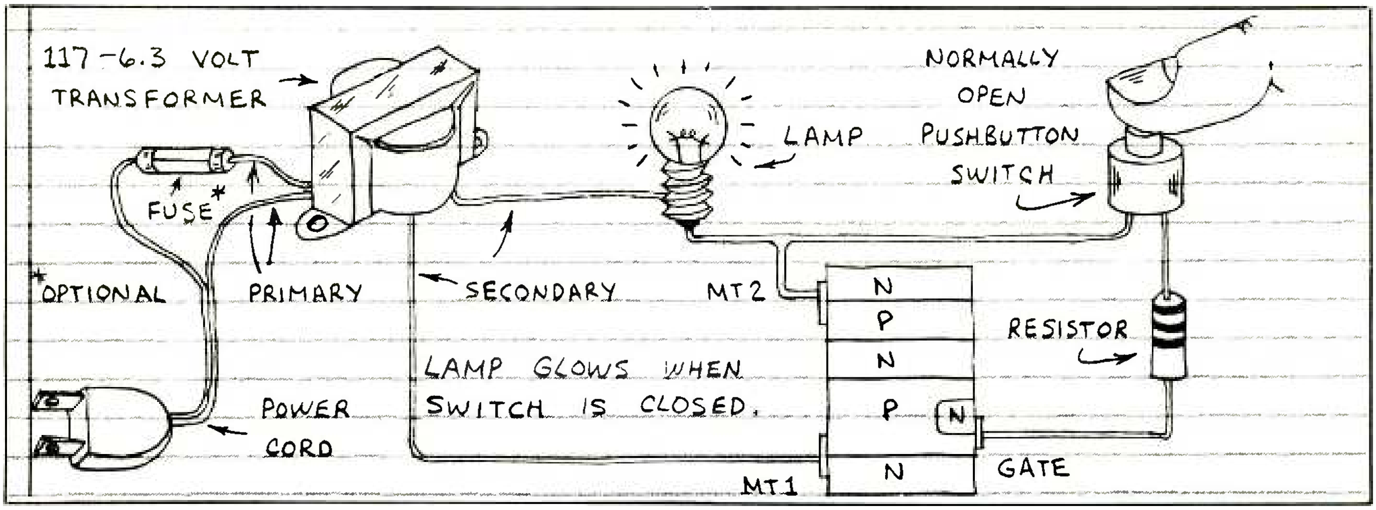
The light-emitting diode (LED) converts an electrical current directly into light. Therefore, the LED is more efficient than many other light sources. Inexpensive visible-light LEDs are used as panel indicators. Certain red LEDs are used to transmit information. Many kinds of LED readouts are capable of displaying digits and characters. They are more rugged than liquid-crystal displays (LCDs), but they use more current during operation.

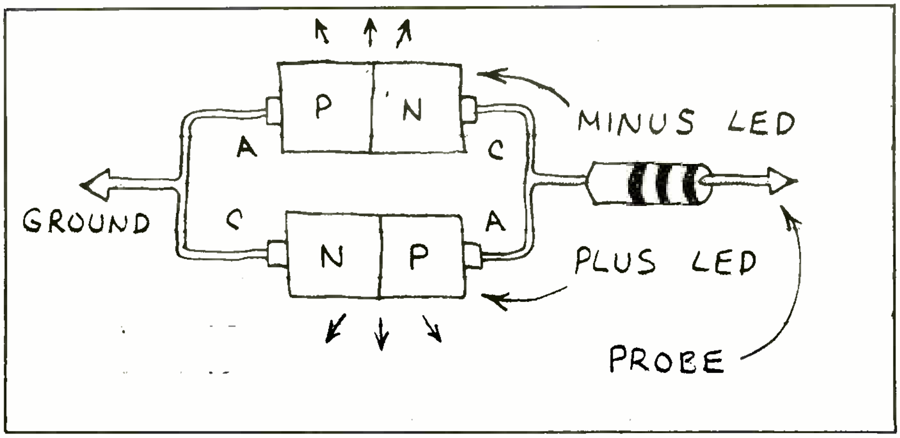
Infrared LEDs should be called "infrared-emitting diodes." They are used to transmit information. A special kind of infrared LED is the diode laser.

(F)



(G)





LEDs can be powered by continuous current or by brief pulses of current. When operated continuously, the current can be varied to change the light output.

Two different-colored LEDs can be connected in reverse parallel to serve as a polarity indicator.

The schematic symbol for the LED is the same as for the ordinary diode, except that it is accompanied by a pair or arrows pointing away from the symbol.

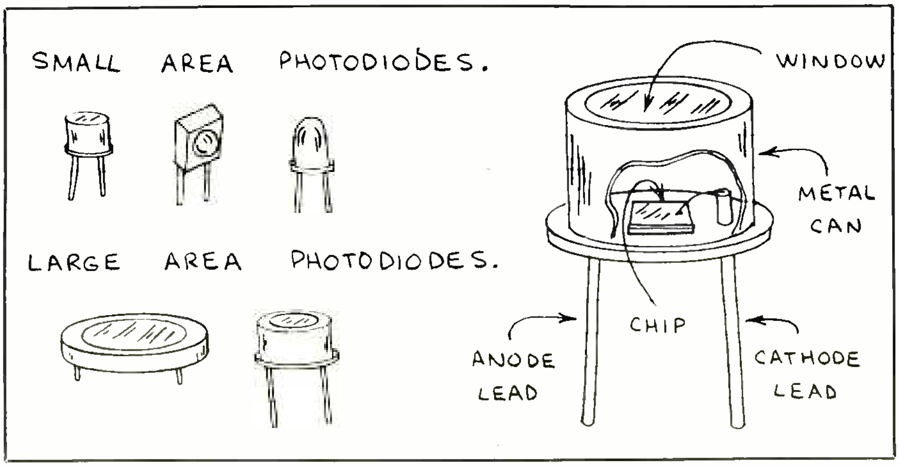
Semiconductor Light Detectors

Energy entering a semiconductor crystal can generate a current in the crystal. This is the basis of semiconductor light detectors. There are two major classes of semiconductor light detectors—those with and those without *pn* junctions. The latter are mentioned here only to make you aware of their existence. The remainder of this discussion will deal with the *pn*-junction detector.

Pn-junction light detectors form the largest family of photonic semiconductors. Most are made from silicon and can detect both visible light and near-infrared.

Photodiodes are specifically designed for light detection. They are used in cameras, intrusion alarms, lightwave communications, etc.

A photodiode will create a hole/electron pair at a *pn* junction. A current will flow if the two sides of the junction are connected. When operated in the photovoltaic mode, the photodiode becomes a current source when it is illuminated. In photoconductive operation, the photodiode is reverse-biased. A current flows when the *pn* junction is illuminated. When dark, a tiny current, called the "dark current," will flow.



There are many case styles used for photodiodes. Most have plastic housings, built-in lenses and filters, etc. The most important distinction is the size of the semiconductor chip.

Small-area photodiodes have very fast response times when used in the reverse-biased photoconductive mode. Large-area photodiodes, though slower responding, provide high sensitivity to photo energy.

The schematic symbol for the photodiode is the same as for the LED, except that the arrows point *toward* the symbol.

Photodiodes are commonly used to detect fast pulses of near-infrared, as in lightwave communications. The following circuit demonstrates how the photodiode might be used in a light-meter arrangement. Response of this circuit is very linear.

Phototransistors are specifically designed to take advantage of the light-sensitive property in all transistors. The most common phototransistor is an *npn* device with a large, exposed base region. Light entering the base replaces the base-emitter current of ordinary *npn* transistors. Therefore, a phototransistor directly amplifies variations in the light.

Two types of *npn* phototransistors are available. One is an *npn* device, while the other includes a second *npn* transistor to provide more amplification. The latter is called a "photodarlington" transistor and is very sensitive, though it's slower than the ordinary *npn* phototransistor.

The symbols commonly used for phototransistors are as follows:

Phototransistors are often used to detect fluctuating (ac) light signals. They are also used to detect steady (dc) light, as in this circuit in which a photodarlington is used to energize a relay. **ME**

Continued next month, where our focus will be on integrated circuits.

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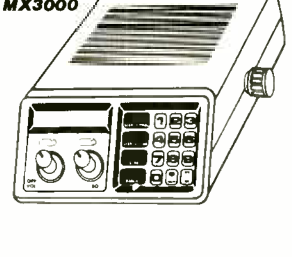

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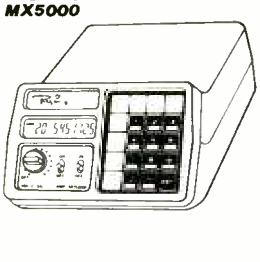

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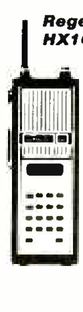

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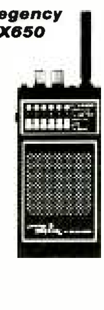

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CIRCLE 37 ON READER SERVICE CARD

The Versatile 555: How It Works, How To Use It

A comprehensive examination of one of the most popular integrated circuit timers along with guidelines on how you can use it in your own projects.

By Duane M. Perkins

Working with integrated circuit timers can provide you with some of the most interesting and enlightening experiences you're ever likely to encounter in electronics experimenting. They can be used for building clocks, triggering automatic devices, pulsing test gear—or in other experiments limited only by your imagination.

One of the most popular IC timers is the versatile 555, which is intended for use as a multivibrator in either a monostable or an astable mode. The following is an explanation of how the 555 works and how you can use it in your own projects.

The 555 contains two comparators, a flip-flop, an inverting amplifier, a voltage-divider network, an npn transistor and a pnp transistor, all connected internally as shown in Figure 1. Although you could build your own timer with discrete components, the ready-to-use 555 timer in its 8-pin DIP package is a great deal simpler to use and costs only a fraction of what you would have to pay for discrete components.

Power Supply

The supply potential that can be applied to a 555 timer IC can be as great as 15 volts or as small as 5 volts. This means that the 555 can be directly interfaced with TTL and most other families of digital ICs. Its output can source or sink 200 mA, a current sufficient to drive devices that consume modest amounts of power, including small relays, loudspeakers, low-power incandescent lamps, motors, or the primary of a suitable transformer.

Internal Functions

Each resistance element of the voltage divider is the same, about 5000 ohms (5k). If pin 5 is open, two-thirds of V_{CC} is applied to the inverting (−) input of the threshold comparator, and one-third is applied to the nonin-

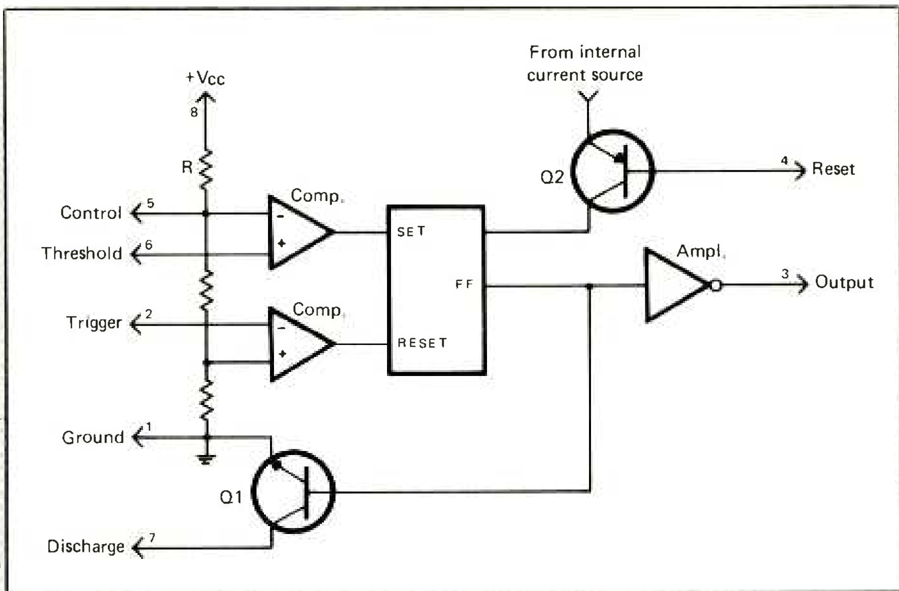

Fig. 1. Though not as complex as most computer chips, the 555 timer IC is nevertheless a tiny package with lots of circuitry. In addition to containing a pair of comparators, an RS flip-flop, and two transistors, it has an amplifier that can drive low-power speakers, relays, and more.

verting (+) input of the trigger comparator. These reference voltages can be varied by a current source or sink connected to pin 5, but the trigger reference voltage will be one-half the control voltage at pin 5 in any case. A low-value capacitor (0.001 to 0.1 μF, depending on the frequencies involved) should be connected between pin 5 and ground. This helps hold the control voltage steady and assures a more accurately timed output pulse.

The flip-flop is activated to change state by a high-level input from the output of one of the comparators. A low-level input has no effect. The RESET input overides the SET input, so if both are high, the flip-flop will reset. The output of the flip-flop is high when set and low when reset.

The amplifier inverts the output from the flip-flop and sinks or sources up to 200 mA. When the flip-flop is set, the output at pin 3 is low (near ground potential). When the flip-flop is reset, the output at pin 3 is high (near V_{CC}).

If pin 4 is held low, *Q2* conducts. This will set the flip-flop (overiding the RESET input if it is high), making *Q1* conduct and the output at pin 3 to go low. Pin 4 should be held high for normal timing operation by connecting it, either directly or through a resistor, to V_{CC}.

For as long as pin 4 is held high, the state of the flip-flop will be controlled by the inputs to the comparators. If pins 2 and 6 are both high (relative to their respective reference voltages), the flip-flop will be set. If pin 2 goes low, to less than half the control voltage, the flip-flop will reset regardless of the voltage at pin 6 and will remain reset when pin 2 goes high, provided that pin 6 is at a potential less than the control voltage. In this way, a high output pulse is triggered by a low pulse at pin 2. The width of the pulse is determined by the interval between the instant pin 2's potential goes low and the instant pin 6's potential exceeds the control voltage.

When the flip-flop is set (output at pin 3 low), *Q1* conducts and pin 7 sinks a large current. This is the means provided for discharging an external timing capacitor.

Any truth table for operation of the 555 will reveal to you that the trigger and threshold inputs have no effect on the output at pin 3 or the state of *Q1* when pin 4 is held low.

Although our explanations assume that positive logic is used internally for setting and resetting the flip-flop, the actual device may utilize negative logic. In this case, the inputs to the comparators would be reversed. From an external point of view, either type of logic is functionally equivalent to the other.

Monostable Operation

When the external circuit is configured for monostable operation, as in Fig. 2, the output remains low as long as pin 2 is held high. With the flip-flop set, *Q1* conducts and holds pin 7 near ground potential. The capacitor cannot charge and pin 6 also is held at a logic low.

A negative-going pulse at pin 2 of less than half the voltage at pin 5 causes the output of the trigger comparator to go high and reset the flip-flop. This cuts off *Q1* and makes the output at pin 3 high. Timing capacitor *C* begins to charge through *R1* and *R2* in series.

When the voltage at pin 6 exceeds the voltage at pin 5, the output of the threshold comparator goes high and sets the flip-flop, provided pin 2 has been returned to a potential greater than half the control voltage. The output at pin 3 then goes low and *Q1*

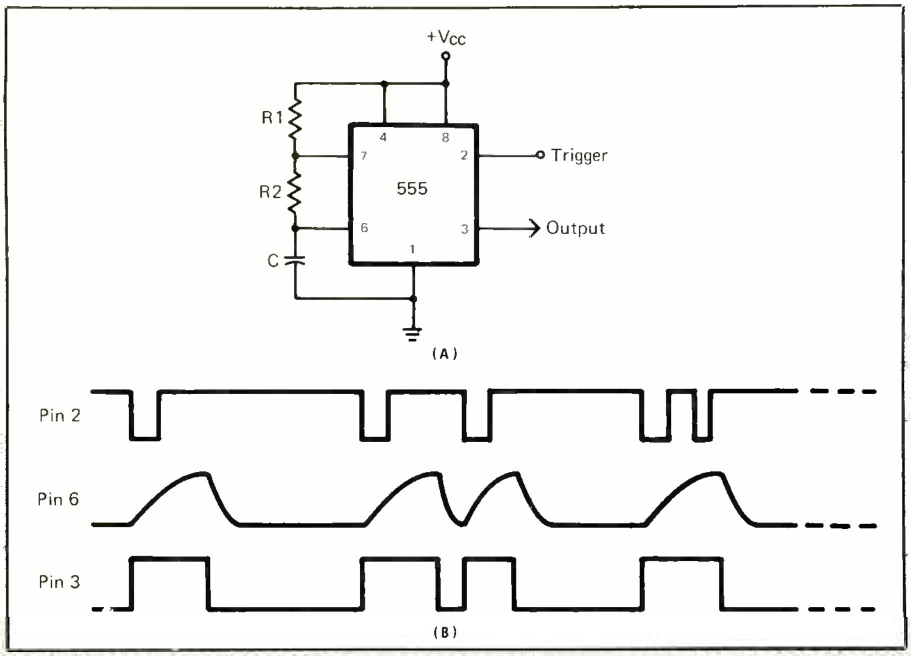

Fig. 2. With just two resistors and a capacitor added externally and connection to a source of dc power, the 555 is transformed into a monostable multivibrator (A); input, threshold, and output waveforms are as in (B).

FORMULAS

A. $t_c = C(R1 + R2)\left[\ln\left(1 - \frac{V_d}{V_{cc}}\right) - \ln\left(1 - \frac{V_c}{V_{cc}}\right)\right]$

B. $V_d = V_c e - \frac{t_d}{CR2}$

C. $t_c = C(R1 + R2)\left[-\ln\left(1 - \frac{2V_{cc}}{3V_{cc}}\right)\right] = 1.1\, C(R1 + R2)$

D. $t_c = \frac{C(V_c - V_d)}{I}$

E. $t_d = CR2(-\ln .5) = 0.693\, CR2$

F. $f_o = \frac{1}{C(R1 + R2)\left[\ln\left(1 - \frac{V_c}{2V_{cc}}\right) - \ln\left(1 - \frac{V_c}{V_{cc}}\right)\right] + .693CR2}$

G. $t_c = C(R1 + R2)\left[\ln\left(1 - \frac{1}{3}\right) - \ln\left(1 - \frac{2}{3}\right)\right] = 0.693\, C(R1 + R2)$

H. $f_o = \frac{1}{.693C(R1 + 2R2)} = \frac{1.44}{C(R1 + 2R2)}$

I. $f_o = \frac{1.44}{10 \times 10^{-6} \times (10^3 + 2 \times 3.3 \times 10^6)} = 0.0218\ \text{Hz}$

begins to conduct. The capacitor will discharge through R2.

When the voltage at pin 6 drops to less than voltage at pin 5, the output of the threshold comparator goes low. However, the flip-flop will remain set, since its state can be changed only by a high input. The capacitor will continue to discharge until another trigger pulse arrives.

The width of the output pulse is a function of the time required for the capacitor to charge to the voltage at pin 5. Variations in V_{cc} have little effect because both the reference and charge voltages are equally affected, provided that V_{cc} is the source for both. Charge time is calculated from formula A (see "Formula" box), where t_c is the charging interval; V_d is the voltage on the capacitor at the beginning of interval t_c; V_c is the control voltage at pin 5; and ln is the symbol in mathematics for the natural logarithm function.

The voltage on the capacitor at the instant the trigger pulse arrives can be calculated as in formula B. Here is the base of the natural logarithms,

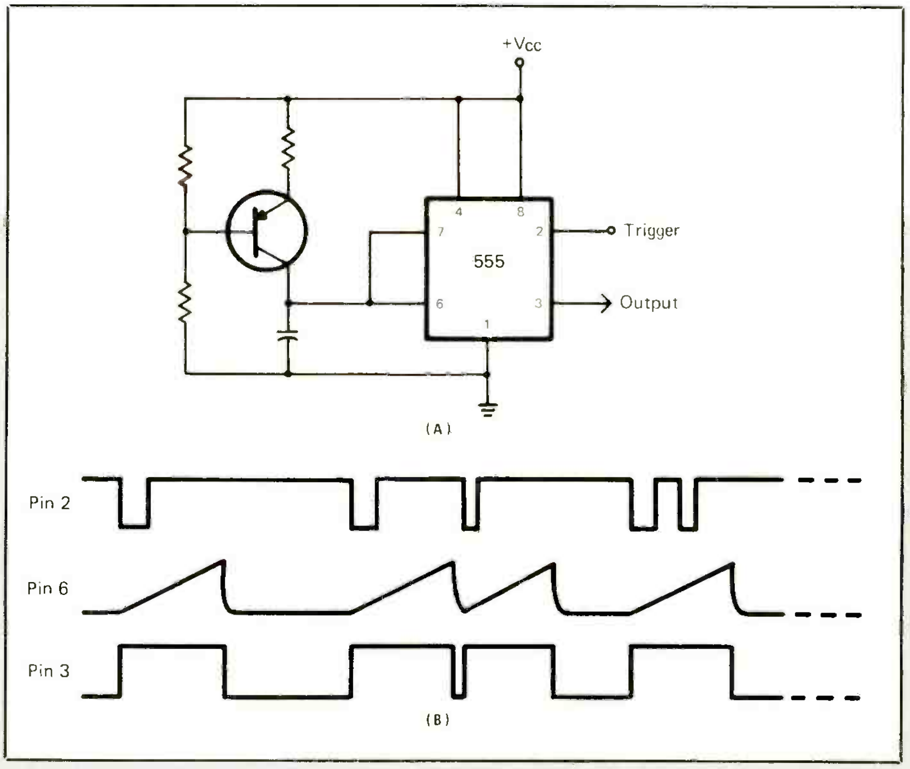

Fig. 3. By adding a constant-current source—the transistor shown in (A)—you can design and build a timer circuit that generates a sawtooth waveform, as in (B), that can be used to drive the horizontal amplifier of an oscilloscope, other applications.

and t_c is the interval between the arrival of the trigger pulse and the end of the preceding output pulse. If t_d is at least *5CR2*, V_d can be assumed to be zero, in which case the term $\ln [1-(V_d/V_{cc})]$ is zero. Assuming pin 5 is open and the control voltage is two-thirds V_{cc}, formula C gives the result calculated.

For example, if $C = 0.1\mu F$ and $R1 + R2 = 1k$ ohms, then $t_c = 1.1 \times .1 \times 10^{-6} \times 10^3 = 110$ microseconds.

In most applications, the discharge time should be made as short as possible to allow the trigger pulses to be as close together as possible without affecting the width of the output pulse. This is accomplished by eliminating *R2* and connecting the capacitor and pin 6 directly to pin 7. The discharge will then be as rapid as possible, and the interval will depend only on the value of the capacitor.

By selecting the lowest value of capacitance that will give the required pulse width in combination with *R1*, the discharge time will be minimized. Because the comparators have a very high input resistance, the value of *R1* can be as great as 3.3 megohms.

Any trigger pulse that occurs during an output pulse is simply ignored, because the flip-flop is already reset. However, if pin 2 is held low beyond the end of the normal charging interval, the capacitor will continue to charge and the output will remain in the high state for the duration of the trigger pulse.

If the trigger pulse is generated by a mechanical momentary-contact switch, the multiple pulses resulting from contact bounce will have no effect, provided the pulse width exceeds the period of contact bounce. A clean pulse of constant width will be generated each time the switch is momentarily closed.

If the charging rate is held constant, the voltage-versus-time curve will be linear and the charging interval will be linear with respect to the control voltage. This can be accomplished by supplying the charging current from a constant-current source such as the transistor circuit shown in Fig. 3.

Charging rate can be controlled by varying base-bias current in the transistor. When the circuit is triggered, the charge build-up results in a sawtooth waveform voltage at pin 6. Such a waveform can be used to drive the horizontal amplifier of an oscilloscope.

Since the sweep occurs only when the circuit is triggered, this current can be used as the basis for a triggered-sweep oscilloscope. The sweep time can be set by controlling the rate of charge.

With a constant rate of charge, the charging interval is given by formula D, where I is the charging current. For example, if $V_c = 10$ volts, V_d is zero, $C = 0.1\mu F$ and $I = 10mA$, then

$$t_c = \frac{0.1 \times 10^{-6} \times 10}{10 \times 10^{-3}}$$

$$= 100 \text{ microseconds.}$$

t_d is calculated as in formula E.

Pulse width can be changed by varying the voltage at pin 5. However, the variation will not be linear unless the charging rate is constant.

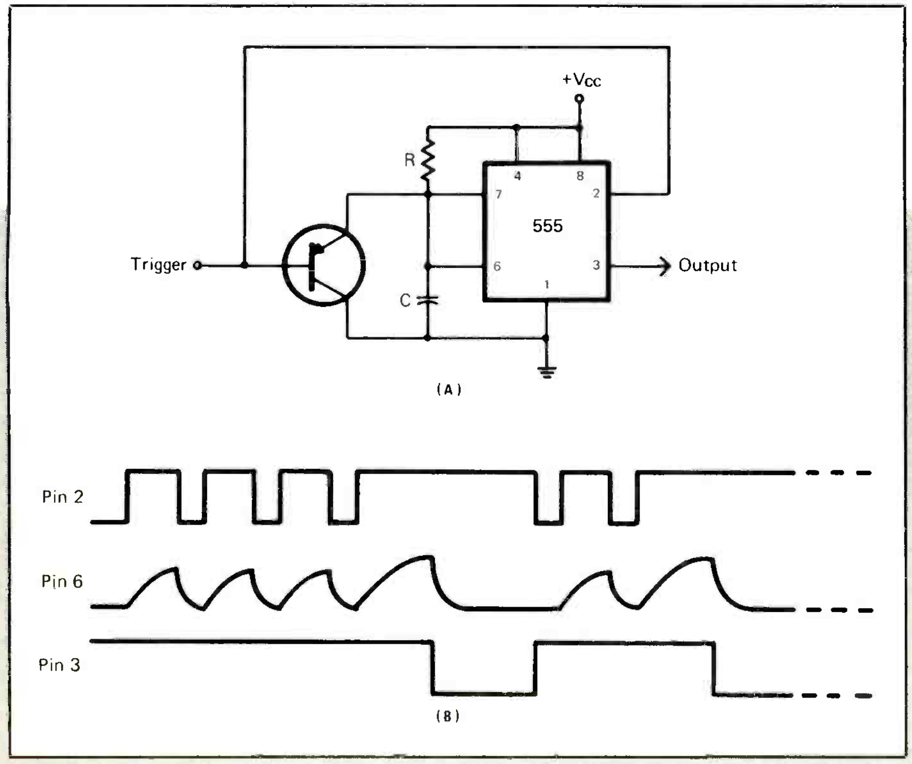

Fig. 4. A slight modification of the Fig. 3 circuit, as shown in (A), produces a timer circuit that can continually be retriggered whenever a pulse is applied to the trigger in-out at the base of the transistor.

With the constant-current charging source shown in Fig. 3, charging rate can be varied by coupling a signal to the base of the transistor. Pulse width will vary linearly with signal voltage variation. The charging interval must be shorter than the triggering interval, and the trigger pulse should be short to prevent holding the output high beyond the length of the charging interval.

Voice-frequency signals can also be transmitted on the pulses with good results, but only if the carrier frequency (input at pin 2) is many times the highest audio frequency component of the signal.

If the output of a monostable circuit is used to actuate a voltmeter (or a milliameter in series with a suitable resistance), the meter reading will be proportional to the trigger frequency. Since pulse width is fixed, the ratio of pulse width to triggering period will increase with frequency. The meter will respond to the average voltage level because of the inertia of the pointer's movement.

At low frequencies, a capacitor can be used to integrate the pulses and prevent vibration of the meter's pointer. To prevent the meter reading from being affected by supply voltage variations, regulate either the supply voltage or the output current. A circuit like this can be the basis for a frequency meter or tachometer.

If there is a provision in the external circuit that allows the timing capacitor to discharge whenever a trigger pulse arrives, the circuit can be continually retriggered during the charging interval. Such a circuit is shown in Fig. 4. The output remains high as long as the interval between trigger pulses is shorter than the charging interval set by the timing capacitor and resistors. The circuit functions as a missing-pulse detector, since the output goes low if a trigger pulse does not arrive before the charging interval has elapsed.

One possible use for the Fig. 4 circuit would be to start and stop a cassette recorder under voice control. An amplified signal from the microphone provides the trigger pulses, and the output could be used to operate a relay that opens or closes a circuit to the remote control jack of the cassette recorder.

Astable Operation

In its astable mode, the 555's circuit is free-running. To obtain free-running operation simply connect pin 2 to pin 6. When the charge on the capacitor drops to less than half the voltage at pin 5, the trigger comparator output goes high, resetting the flip-flop. The timing capacitor then begins to charge. When the charge voltage exceeds the potential at pin 5, the threshold comparator goes high and sets the flip-flop. The cycle repeats continuously.

The frequency of oscillation can be determined by calculating the sum of the charge and discharge times, and taking the reciprocal of the result. The charge on the capacitor will vary between the two limits set by the reference voltages on the comparators. The charging interval can be calculated using the formula given above for the monostable circuit, recognizing that V_d will be one-half of V_c.

The discharge interval is calculated from formula F, and the frequency of oscillation with formula G.

If pin 5 is open, the charging interval is determined using formula H, and the frequency will be calculated as in formula I.

The maximum possible frequency is limited by two considerations. Attempts to reduce the value of the timing capacitor below about 0.001 μF will be significantly affected by internal capacitance. The device can sometimes be made to oscillate on internal capacitance alone, but if the frequency is to be determined by the value of the timing capacitor, it should not be less than 0.001 μF.

Attempts to reduce the resistance of *R1* + *R2* will increase the current through *Q1* during the discharge interval. This current is the sum of V_{cc} divided by *R1* plus the instantaneous discharge current. While the value of *R2* can be safely reduced to zero, the value of *R1 must* be high enough to avoid swamping *Q1* or even destroying it with excessive current. A current of 15 mA is within the safe range. Frequencies well beyond 100 kHz are attainable.

The minimum possible frequency is limited only by the value of the timing capacitor, but care must be taken to assure that the current through *Q1* is not excessive. With a high-value capacitor and a low value for *R2*, the high discharge current could destroy *Q1*. However, the resistance of *R1* + *R2* should not exceed about 3.3 megohms and should be low compared to the actual leakage of the timing capacitor used.

If *R1* = 1k, *R2* = 3.3M, C = 10 μF and there is no leakage, then formula J applies and the period will be one cycle every 45.9 seconds.

The astable circuit can be triggered at any time during the discharge interval. This can be accomplished by connecting a resistor between pins 2 and 6 and coupling the trigger pulse to pin 2 through another resistor. The resistances must be chosen so that the potential at pin 2 will go below the trigger reference level while pin 6 is high. In this way, the circuit can be made to lock-in on a frequency that is somewhat greater than the free-running frequency.

If the trigger frequency is slightly greater than a multiple of the free-running frequency, the trigger pulses that occur during the charging interval will be ignored and the circuit will lock-in on a submultiple of the trigger frequency. The circuit then acts as a frequency divider. The monostable circuit will act in the same manner but will not be free running in the absense of trigger pulses.

The astable circuit is not capable of generating a symmetrical square wave. The charging interval must exceed the discharge interval because the capacitor charges through *R1* and

Continued on page 100

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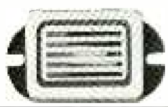

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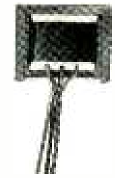

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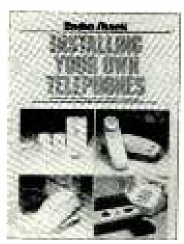

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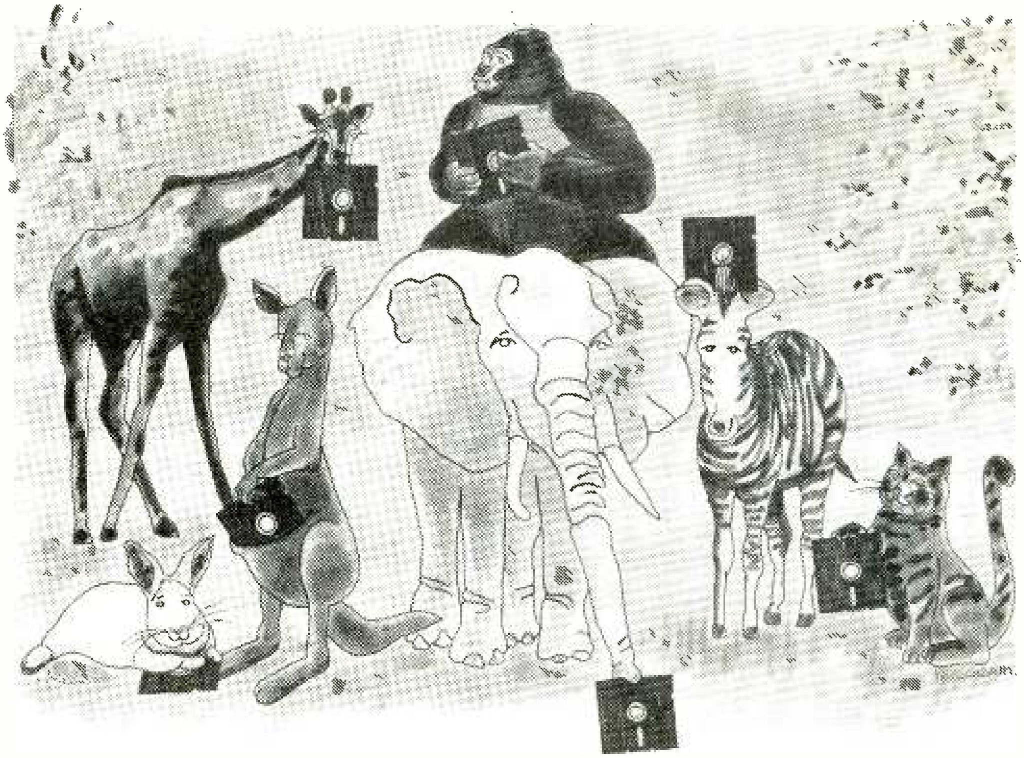

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Will The Real "Father Of Personal Computers" Please Stand Up . . . H. Edward Roberts

By Art Salsberg

The first time I met Ed Roberts I was struck by two of his attributes: he was a soft-spoken person and he was a big man in stature, towering over me. What wasn't immediately evident was the foresight and business courage he would display in the near future as the developer of of the first powerful, modestly priced small computer that paved the way for the entire personal computer industry.

While still on active duty with the U.S. Air Force in New Mexico, and armed with an electrical engineering degree from Oklahoma State, he started a little part-time business, MITS (Micro Instrumentation and Telemetry Systems), in his garage to make model-rocketry devices. He had three partners, one of whom was Forrest Mims III, who writes *Modern Electronics'* monthly "Electronics Notebook" column. Ed bought them out by the end of 1970 and transferred his full-time energy to other areas, such as developing and marketing electronic kits. His main competitor at that time was Southwest Technical Products Corp.

In a few short years, he was to launch the personal computer with his Altair model, the first BASIC language for personal computers, the first computer retail store, and the first national microcomputer convention. Here, the "Father of the personal computer" tells how he accomplished all this.

Modern Electronics: What gave you the idea to develop and market a small computer for "consumers?"
Ed Roberts: My interest in computers didn't start with the Altair computer, which was first publicized when you published a cover-story article on it in December 1974.

I look upon my first personal computer as the Model 816 desktop calculator I had presented in January 1973. It had a programmer-device option that could be attached to it. I did look at Intel's 8008 CPU in '73, but concluded that it wasn't powerful enough to do anything with it in terms of a real computer.

I got sidetracked with smaller calculators, but in 1974 I developed a video terminal with an acoustic coupler to support a time-sharing service I was selling. At this time I was examining Intel's new 8080 CPU.

Coinciding with this, the calculator business went bad. Dealers were unloading calculators below what they paid for them. With this part of my business declining, I concentrated on designing a computer using the 8080 microprocessor.

Q: This meant investing a large sum of money. Since you were evidently taking a beating in your calculator business, how did you manage this?
Roberts: Well, this was a labor of love for me, beyond making money. So I decided to risk all and met with my bankers, who agreed to extend me a line of credit to $65,000. I told them that I expected to sell 800 computers that year. I really guessed it would be around 200. The way it turned out, once I started shipping the computer, it never went below 1500 units per month.

Q: What kind of technical support did you receive?
Roberts: Very little. I was the only double-E in the company. Bill Yates, however, had an MS in Aeronautical Engineering from RPI, and helped immensely. Insofar as product concept was concerned, the only one I discussed this with in the formulating period was the late Larry Lekashman, the then president of Olson Electronics, since I respected his marketing acumen.

Q: Didn't Intel give you plenty of tech support?
Roberts: Regrettably, they weren't any help at all beyond their literature. In the Spring of 1975 I hired Paul Allen as Director of Software, and then part-time at first, a college student named Bill Gates. Bill was about 19 years old when I put him on the payroll, but he had lots of computer experience and was very bright.

They developed Altair BASIC while working for me, which became Microsoft BASIC when Bill and Paul went into business for themselves. In essence, MITS built Microsoft, whose BASIC is the most widely used programming language today.

Q: What was Dave Bunnell's (now publisher of *PC World* magazine) role in all this? When I met him in Albuquerque he was working on a MITS advertising program.
Roberts: Dave started as a tech writer with me, then took over advertising responsibilities. Dave is the one, by the way, who proposed the Altair Convention, the first national computer convention. We invited people from all over the country. Frankly, he was much more excited about this than I was. I didn't think it was feasible to draw many people beyond our immediate area. How many people would spend all that transportation and living-expense money to come to New Mexico for a computer meeting? But I wound up with egg on my face because droves showed up. Dave was right. It was a great success.

Q: Yes, it was. I was surprised at the large attendance myself. The dinner hall was packed. I don't think many people appreciated the Altair bus line at the time, which became known as the S-100 bus and then adopted as a standard (IEEE-696) by the Institute of Electrical and Electronic Engineers. How did you choose 100 connections, a nice round number?
Roberts: We designed the bus around October 1974. At the time it had 85 contacts. Searching around for an industrial-spec-quality connector, we decided to purchase new connectors introduced by AMP that had a glass-composite construction and 100 connectors. They cost me $7½ each, while lesser-quality ones were priced at $15. By the time production was rolling, 96 or 97 connections were committed.

Q: How come you didn't get a patent on the bus?
Roberts: Hindsight is always 20/20. It was called the Altair bus, of course, but other computer makers who used the same bus conveniently called it something else. The name S-100 was a disservice to us, but there wasn't much we could do about it.

Q: MITS was selling the complete Altair computer that included the 8080 CPU and a costly cabinet for about the same price as a single-quantity 8080 was selling for. Rumors went round that you were able to do this by buying 8080 "rejects." Would you comment on this?
Roberts: We never used 8080 CPU's that were deficient in specifications or even had so-called "cosmetic" defects. Out purchase orders plainly indicated that the devices were for full-spec parts. This is what we contracted for with the device maker, Intel, and this is what we received from them. Intel wasn't doing all that much business with the 8080 at that time, so our large order earned us a much lower price. Distributors and dealers, however, had fits. They complained to Intel, I was told, who tried to explain away the lower price by telling them that my microprocessors were defi-

cient in one way or another. It quickly occurred to them, however, that MITS was by far the biggest purchaser of 8080 CPUs, and that there were other users of the device as a result of this. Then they dropped the price for the CPUs to distributors. I paid $75 for the 8080 at that time, when it was retailing singly for around $350. By 1977 it dropped to less than $15 retail to illustrate what higher-volume can do to reduce prices.

Q: Did any commercial computer influence your design of the Altair?

Roberts: Yes, the front panel of Data General's Nova II did, with all its switches and LEDs.

Q: I remember having lunch with you at the "Montana Mining Company" restaurant in Alburquerque shortly after the Altair was introduced. Among the things we talked about was the future of computers. At that time you told me that about 40% of the Altair's sold were being used for business purposes. We also discussed competition. Looking back, do you think your views then held true?

Roberts: We were selling Altairs to purists. Lots of them were using them for business applications. Business is still the biggest market in terms of dollars, though purists account for only a small percentage now.

Apple at the time was just starting out with boards. It was a garage operation. In fact, I wondered if they were "for real" at that time and certainly did not look upon them as competition. That's why, I confess, that it irritates me when I read that Apple invented the personal computer. Tandy had announced that Radio Shack would market a computer. I considered *them* to be competition, of course. Processor Technology, with Bob Marsh and Lee Felsenstein [who later designed the Osborne I transportable computer], began to produce add-on boards for the Altair. I admired their products; they were fine-quality. Eventually the company produced its own computer, the SOL, which was the first all-in-one computer.

Q: What about IMSAI? They produced a computer that was an Altair look-a-like, adding large plastic piano-key knobs to the switches on the front panel. One of the owners told me that they had ordered Altairs to be used for their customers, but couldn't get delivery on time so decided to make their own computers.

Roberts: IMSAI copied the Altair design right down to errors that had occurred in early production models of the Altair computers.

Q: You later produced a smaller-size computer that used a 6800 CPU, which was developed by Motorola as a competitive microprocessor. It never matched the 8080-based Altair's success and I always wondered why you introduced it?

Roberts: It was designed to counter Southwest Technical's computer, which used the 6800 CPU. We were also getting some pressure from Sphere with its 6800-based computer. MITS sold several thousand of the Altair 680 models.

Q: You started the first computer retail store, followed by franchise stores. They disappeared amidst rumors that they failed because MITS allowed only MITS products to be sold in such stores.

Roberts: As a matter of record, the stores were very successful. They were a valuable asset to the company, enabling us to sell many machines. In 1977 more than 80% of the retail stores in the U.S. were MITS stores, excluding Radio Shack.

A MITS franchise computer store was allowed to sell anything they wished to. However, we would not provide a guaranteed territory if this was done. Thus, we would only give an exclusive territory to a store in, say, New York City, if there was no competitive products in that store. Otherwise, we insisted that other New York City franchises could be set up. Pertec, to whom I sold MITS, decided on their own to close the stores.

Q: When did you sell MITS and why did the new owner drop the "consumer" line of computers and allied equipment?

Roberts: We had a letter of intent in December 1976 from Pertec and the sale was closed May 1977. Pertec quickly decided that the consumer market was too small.

At that time I had a number of new products lined up. The Altair II was killed on the vine, for example. It was a Z80-based machine with 64K of memory that could be expanded to two megabytes, with parity test for memory. I also designed a lap computer, for which Pertec said, "There's no market."

Q: You left Pertec shortly after you sold MITS and disappeared insofar as computers are concerned. What have you been doing with yourself these past few years and are you sorry you left the industry?

Roberts: I disappeared to pursue a dream. I've been attending medical school all this time and by next year I'll be a doctor. At the same time I have a little medical electronics business. So I haven't given up electronics at all, nor computers. I work with computers at the medical school in Georgia, where we have many computers, including a CAD system.

Q: Looking at small computers today, what do you think of them?

Roberts: I personally like Hewlett-Packard's systems the best. Their H-P BASIC is terrific. The operating system is transparent and real easy to work with. Students writing software here like me virtually fight to work with the H-P computers rather than, say, the IBM PC.

To do any real work with small computers, I feel you really need a lot of memory, at least 256K, but preferably a lot more.

Q: A final question: If you had to do it all over, would you sell MITS?

Roberts: I've thought about that in the past and speculated on what I would have done with the company. But when you get right down to it, I still would have taken the money to pursue what I'm now doing. **ME**

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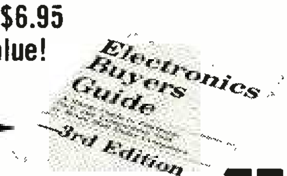

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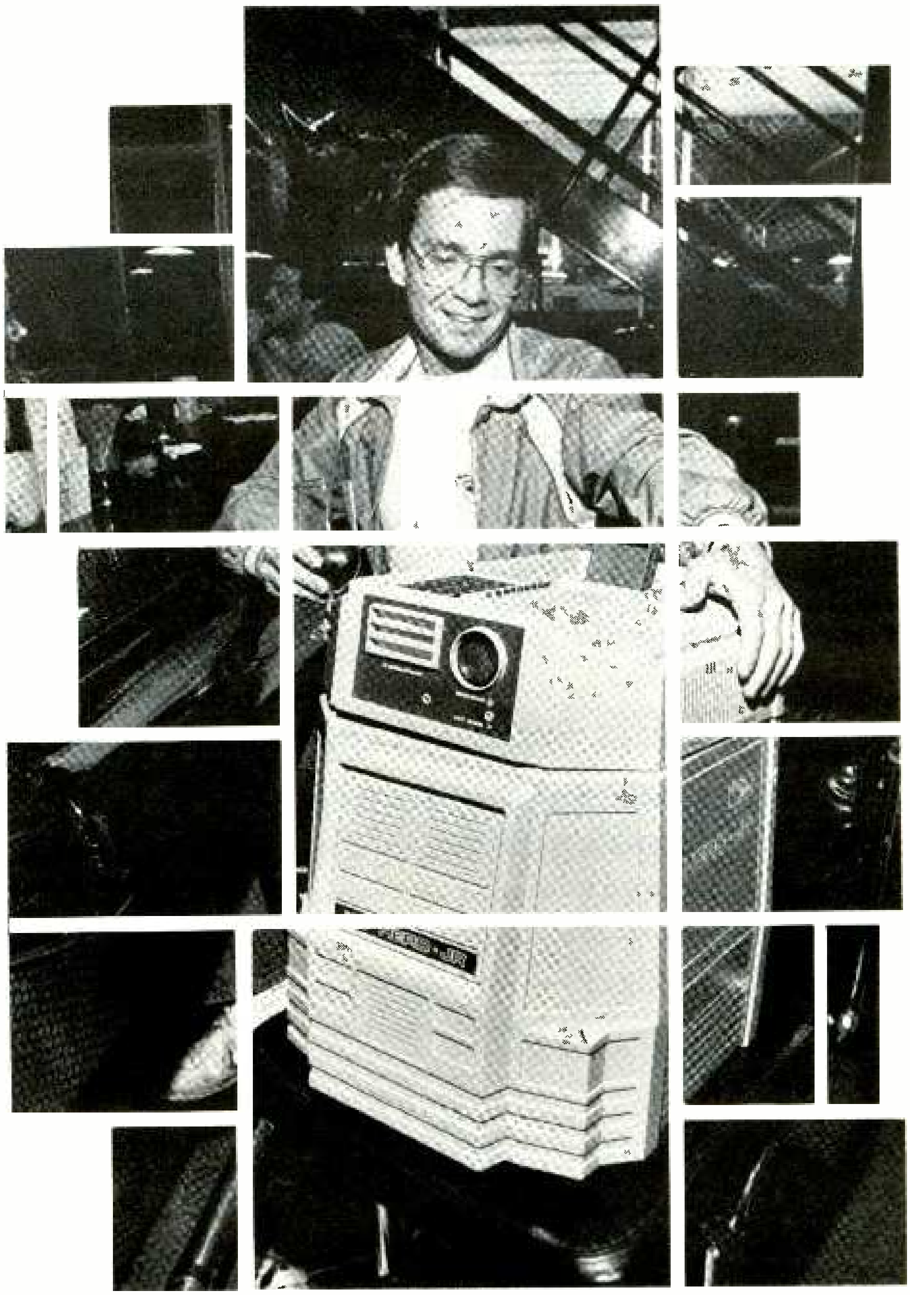
CIRCLE 26 ON FREE INFORMATION CARD

"I am HERO JR., Your Personal Robot"

Heath/Zenith's new personal robot has a dynamic personality that's sure to make you want to take him home

By Alexander W. Burawa



With all the fanfare about personal computers and video games, it's easy to forget that the computer-related personal robot is alive and thriving. But this situation is about to change. The Heath/Zenith people, who brought us the HERO 1 robot trainer a couple of years ago and who have been very active in the design and manufacture of personal-computer products since the late 1970s, have a new entry in the robot game. His name is HERO JR., and he's a very domesticated, even companionable, robot who likes people enough to seek them out.

HERO JR. is the first fully preprogrammed *personal* robot that doesn't require programming skills to use. Unlike other personal robots that have a minimum of preprogrammed software routines built into them and, thus, require considerable programming know-how on the part of the user (and this includes Heath's own HERO 1), HERO JR. has a whopping 32K built in. You just turn him on, punch in the desired function, and off he goes.

Among his built-in abilities, HERO JR. can speak English and "Roblish" (a robot version of English), play games, explore his environment, and act as an alarm clock and home security guard. Optional accessories allow HERO JR. to seek out humans and permit him to be manually controlled.

Plans for marketing HERO JR. are two-pronged. Assembled units will be sold through "high-tech" department stores that sell personal computers and related products and retail stores that sell computer games and software. A kit version will also be available through authorized Heath Electronic Centers and by mail order directly from the Heath factory in Benton Harbor, MI. The pricing schedule puts a $1000 tag on the wired version and about a $600 tag on the kit version.

The Externals

Standing just 19" tall and weighing 21.4 lbs. HERO JR. resembles Heath's HERO 1 robot, but not too closely. HERO JR. is not a clone of HERO 1. In fact, it has been newly designed from the ground up. And since HERO JR. is meant for the *home* market, its design doesn't include plans for retrofitting the optional articulated arm offered for the HERO 1 trainer robot, nor are there plans to offer a different version of the arm in the future.

Three wheels, including the steerable wheel at the rear, give the robot its mobility. With the drive system used, HERO JR. can carry loads of up to 10 pounds on the tray built into the top of his head. Behind this tray is a slot into which optional program cartridges can be plugged.

The head section of the robot is also equipped with a 17-key keypad that provides the means for modifying HERO JR's personality or initiating a special task. Eight data LEDs flash in time with what HERO JR. says and indicate sound levels when he's listening.

A window for an optional infrared motion detector, an ultrasonic sonar receiver, and a light sensor make up HERO JR.'s "face." Other transducers provide synthesized speech output and sound sensing.

On the rear of the head assembly are a jack for connecting the battery charger, a power switch, a sleep switch (set to sleep when the batteries are being recharged), and an RS-232 serial computer interface connector.

Sensors

For sound sensing, HERO JR. uses a pickup system with a 256-bit resolution, adjustable range, and a 200-to-5000-Hz bandwidth. The robot's light sensor also has a 256-bit resolution, adjustable range, and a 25-degree reception angle. The Polaroid ultrasonic sonar system can accurately measure distances from 4" to about 25 ft. It's the same system Polaroid uses in its auto-focus "One-Step" instant camera.

HERO JR's standard motion-detection sensor also uses his ultrasonic sonar. However, his optional six-field infrared sensor provides superior heat/motion detection and improves his ability to seek out human company.

The speech section includes a Votrax SC-01 IC synthesizer system that offers four pitch levels and 64 phonemes. This permits HERO JR. to articulate just about any vocalizing sound imaginable. The timekeeping system consists of a CMOS processor that contains a clock with a 100-year calendar and automatic correction twice a year for Daylight Savings and Standard time changes.

The RS-232 serial computer interface provides a convenient means for HERO JR. to accept an assembler and for loading data into and dumping data from memory. A HERO JR. BASIC cartridge permits programming through the RS-232 interface.

Software

HERO JR.'s software consists of a preprogrammed (built-in) personality that requires no user input. If you wish, however, you can shape the robot's personality by increasing or decreasing the priorioritie of each of the six personality traits. Or you can select any individual task or demonstration mode separately.

The software program consists of four special task commands. The "Setup" command is used for changing HERO JR.'s personality. "Guard" commands the robot to protect a specific area or to act as a security device while randomly exploring his environment. "Alarm" commands HERO JR. to wake his owner at a predesigned time. And "Plan" permits you to set HERO JR. for a future activity, such as reminding you of a birthday or an anniversary.

True multitasking is built into the software programming. That is, the software permits HERO JR. to do more than one thing at a time, such as move and speak simultaneously.

Electronic Specifications

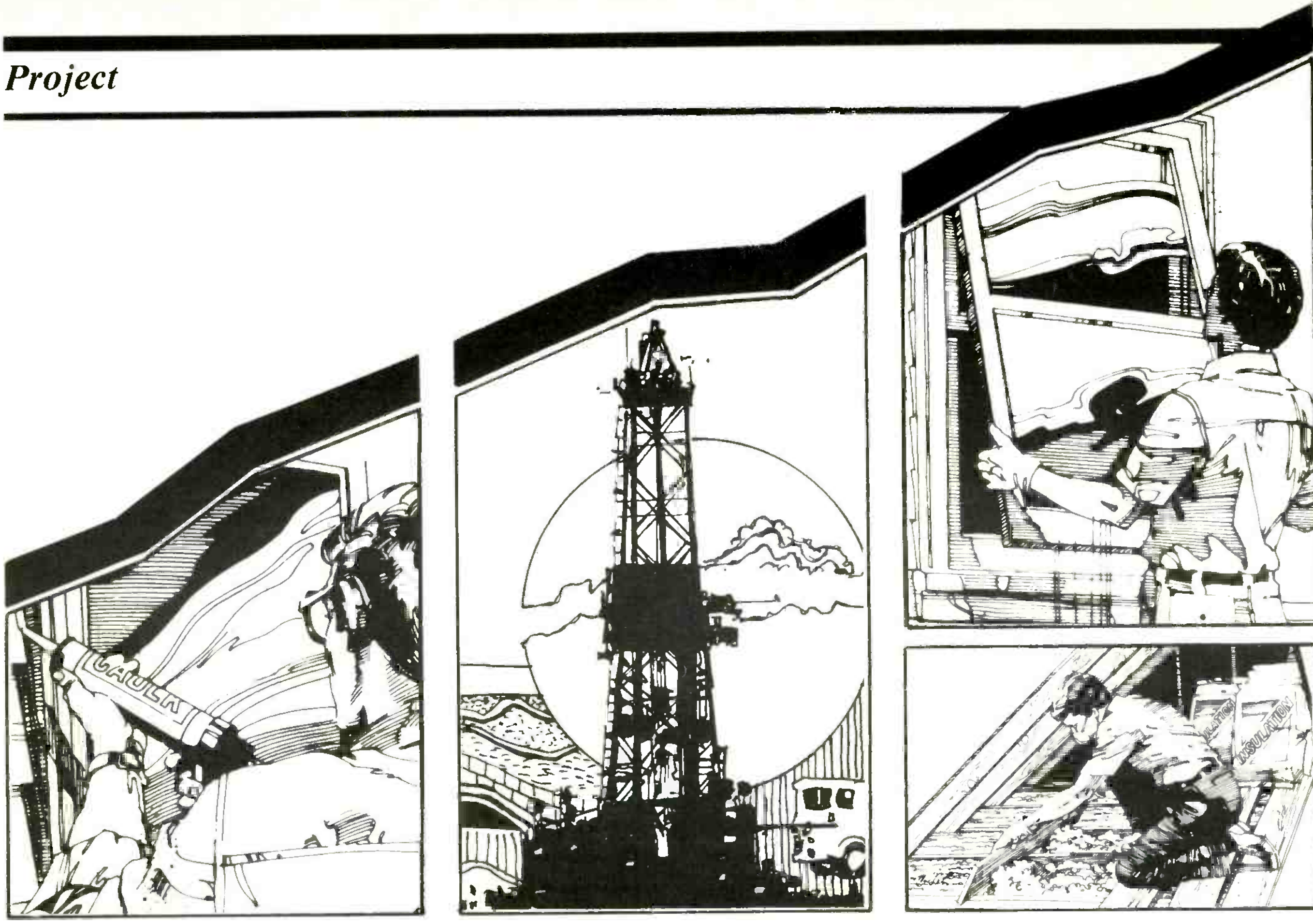
HERO JR. is built around a Motorola 6806 microprocessor. He has 32K of monitor ROM, 8K of RAM and on-board provisions for up to 16K of additional RAM or ROM for future expansion. Provision is also made for plugging in ROM cartridges.

Three printed-circuit cards accommodate all the electronics. One board is for the microprocessor and ROM/RAM system, the second is for the power supply and sensors, and the third is for the keyboard. Standard elements in the electronics package include two Motorola 6821 parallel interface adapters (PIAs) and the Motorola 146818 CMOS clock chip.

A stepper-type motor with 180-degree rotation is used for steering the rear wheel, while a 12-volt dc motor supplies the driving power that allows HERO JR. to move about. One idler wheel features an optical chopper feedback system that detects and keeps track of distance traveled. The alphanumeric keypad has clearly labeled function keys that provide access to HERO JR.'s Sing, Play, Gab, Alarm, Guard, Help, Demo, Plan, Set Up, and Enter functions.

The power supply in HERO JR. consists of two rechargeable jelled-electrolyte lead-acid batteries ("gel-cells"). Two optional batteries can

Continued on page 101



Heating Costs Too High? Try A Fuel Miser

It's easy to build, simple to install and suitable for use on either gas or oil heating systems

By Anthony J. Caristi

If you're like most of us, you've seen your home heating bills go up and up year after year, apparently with no end in sight. But there is something you can do right now to reduce your heating costs dramatically, and that's to enhance the efficiency of your present heating system.

How? By adding to it an electronic cycling device that I call a fuel miser, a remarkable little gadget that will automatically regulate your furnace with ruthless, digital precision, yet keep you just as warm and cozy as you've always been. It's also easy to build, simple to install and suitable for use on either gas or oil heating systems.

Sound too good to be true? Not at all. Let me explain.

A typical furnace, you see, operates only in an "off" or "full speed ahead" state. So when the thermostat calls for heat, your furnace instantly, automatically cranks itself up to 100 percent of capacity. It responds as if the weather outside is as cold as it's ever going to be, a figure generally set at about −10F, for much of the country.

Some of this "full speed ahead" operation is tempered by a feature called heat anticipation, which is built into your thermostat and causes the furnace to shut off shortly before the thermostat registers your desired temperature. That helps some; the fuel miser helps more.

The real problem here, it turns out, is your furnace's heat exchanger. No matter how much heat your furnace generates, no matter how long it generates it, your heat exchanger can transfer just so many BTUs of heat energy into your hot water, steam or warm air system in a given amount of time. After the heat exchanger has reached a certain temperature level, any further burner operation simply results in more heat loss up the chimney. Enter the fuel miser.

It enables you to select a "duty cycle" for your burner that can range from 10 percent to 100 percent of capacity, selectable in increments of 10 percent—nothing more. But once set, it will allow the thermostat circuit of your heating system to operate normally only for the duty cycle you have selected.

The rest of the time, your thermostat will be prevented from turning on your burner. However, residual heat from the heat exchanger will continue to flow into your heating system. The on-off cycle of the fuel miser is so fast, in fact, that the heat exchanger will always have sufficient heat, just as it would with a full-speed, lower-efficiency, non-controlled furnace.

Gas-operated furnaces respond especially well to relatively short bursts of demand. The fuel miser has thus been designed so that each 10 percent increment of heating time here is 45 seconds, with a complete cycle taking 450 seconds, or 7½ minutes.

Oil furnaces are more restrictive in their cycling requirements; each system must be permitted a short cooling period each time the burner turns off. For oil systems then, the timing cycle of the fuel miser is set at 3 minutes for each 10 percent increment of duty cycle. The total time for one complete cycle for an oil burner system is therefore 30 minutes.

The selection of either of these timing cycles is accomplished merely by connecting one jumper wire in the fuel miser's circuit board.

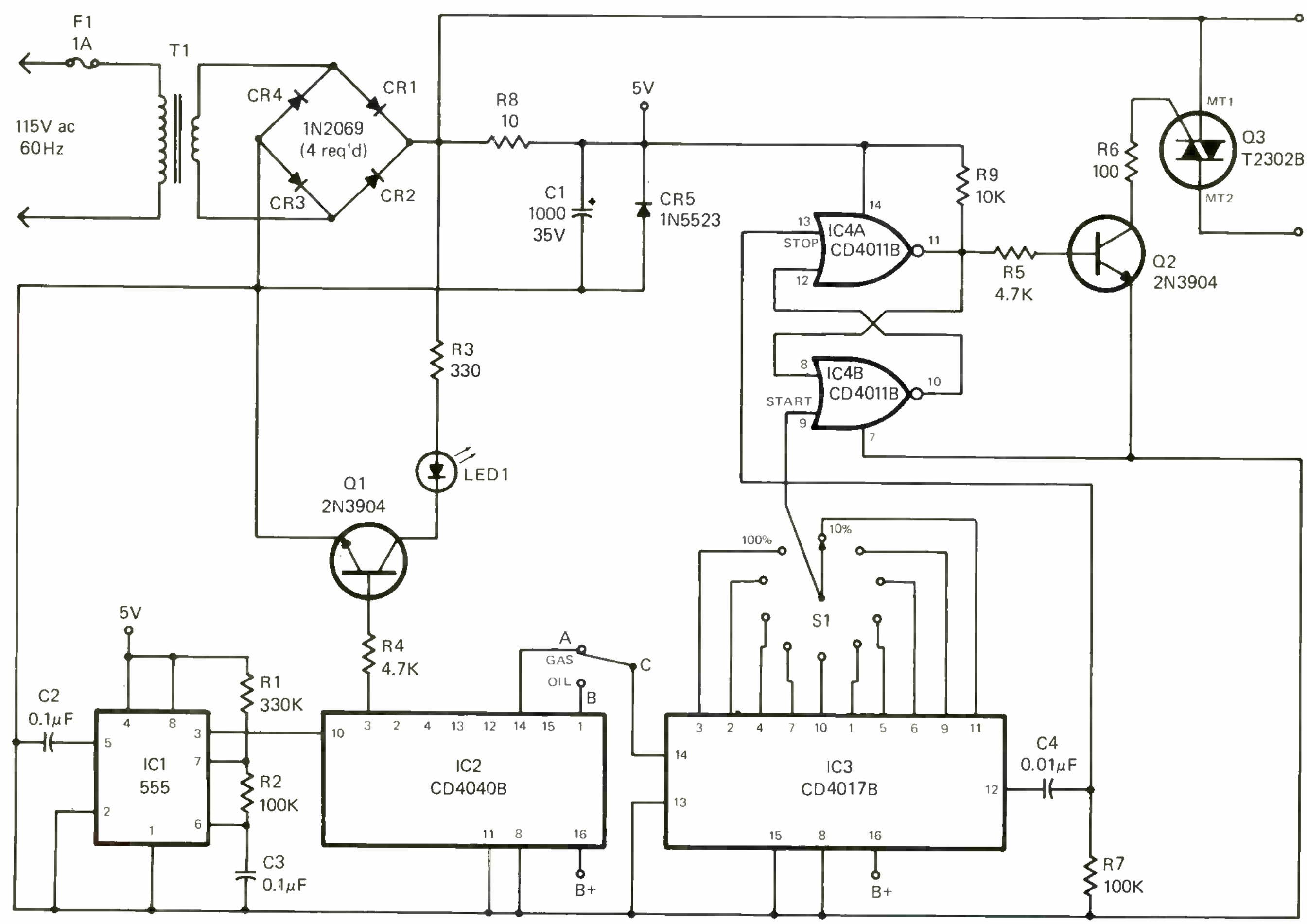
How It Works

As you can see from the schematic diagram and the timing chart shown in Figs. 1 and 2, the fuel miser is simply a clock dedicated to performing a specific task.

IC1, a 555 timer chip, operates as an astable multivibrator at a frequency of about 22.7 Hertz. This frequency is divided by IC2, a 12-stage binary divider, to provide a frequency of 0.022 Hertz for gas systems or 0.006 Hertz for oil systems. These frequencies represent periods of 45 seconds and 160 seconds (each period is the reciprocal of its frequency).

The selected output of IC2 feeds a

Fig. 1. Schematic diagram shows that Fuel Miser is simply a clock performing a specific task.



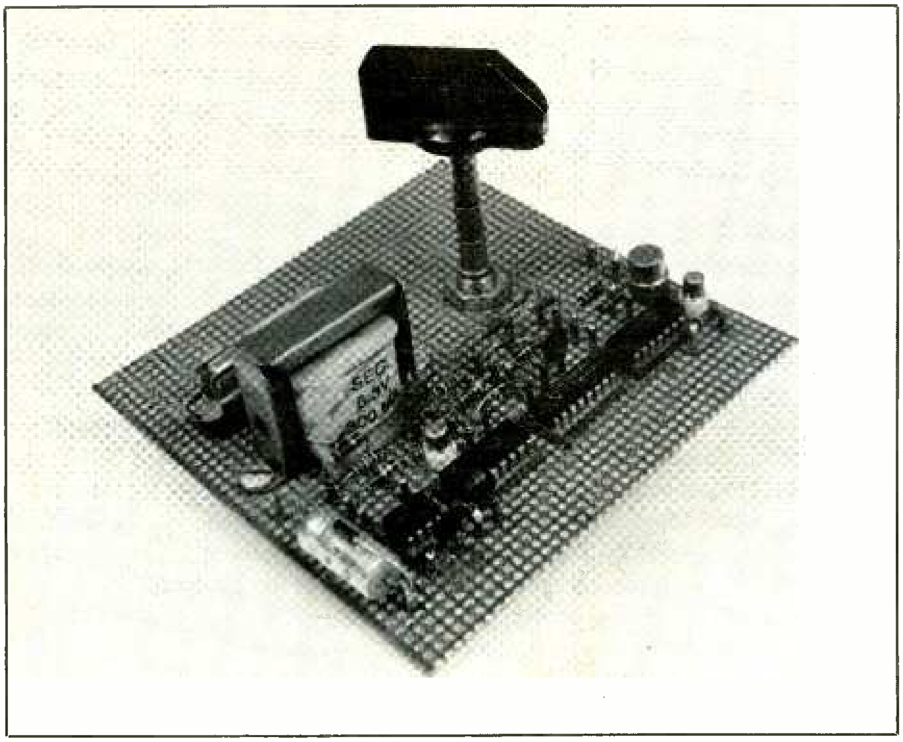


Photo of author's prototype shows project assembled on perforated board. Note the use of sockets for all ICs and transistors. All wiring is performed on under side of board. A homemade pc board can also be used.

decade Johnson counter, IC3, which counts from zero to nine over and over again. IC3 has 10 decoded outputs, one for each count, and a divide-by-10 output, pin 12, as illustrated in the timing diagram. One of the decoded outputs of IC3 is selected by the duty cycle switch and is used to trigger a latch circuit, IC4A and IC4B.

At this point the thermostat circuit of your furnace would be enabled. The divide-by-10 of IC3 is differentiated and used to reset the latch circuit. This disables the thermostat circuit.

If the output pulse of pin 4 of IC3, for example, is selected to start the sequence, the output pulse at pin 12 will stop the sequence eight decoded pulses later. Thus, the latch circuit output, pin 11 of IC4, will have a logic 1 level 80 percent of the time and a logic zero level 20 percent of the time.

This logic signal is fed to Q1, which acts as a switch to turn Triac Q2 on and off. Q2 is the controlling switch that permits your thermostat to operate or not operate in accordance with the duty cycle selected by S1. Q2 has a sufficient voltage rating and current-carrying capacity to handle both 24-volt and 115-volt thermostat circuits.

Construction

The fuel miser can be constructed on a printed or wiring circuit board measuring about 3½ by 5 inches. A printed circuit layout is illustrated full size in Fig. 3, as viewed from the copper side of the board. The parts layout, as seen from the component side of the board, is shown in Fig. 4.

The layout of this circuit is not at all critical. It would be good practice, though, to use sockets for the integrated circuits and Triac instead of soldering these components directly into the circuit, especially if the PC pattern is used. Such practice makes servicing the fule miser easy, if it's ever necessary.

It's also important to pay strict attention to the orientation of the integrated circuit chips. Pin 1 of these components is usually indicated on the top of the plastic package by a small dot or numeral 1. In Figs. 3 and 4, pin 1 of each chip is identified by a small dot.

When you have finished constructing the circuit, examine it very carefully to be sure that there are no solder splashes that might short out one copper path to another, or two adjacent IC pins. Check also the position of each diode to make sure it's placed in the circuit as shown in Fig. 4.

There is one jumper wire that must be placed in the circuit for the appropriate type of heating system that the fuel miser will control. For gas systems, connect the jumper wire between points A and B as shown in Fig.

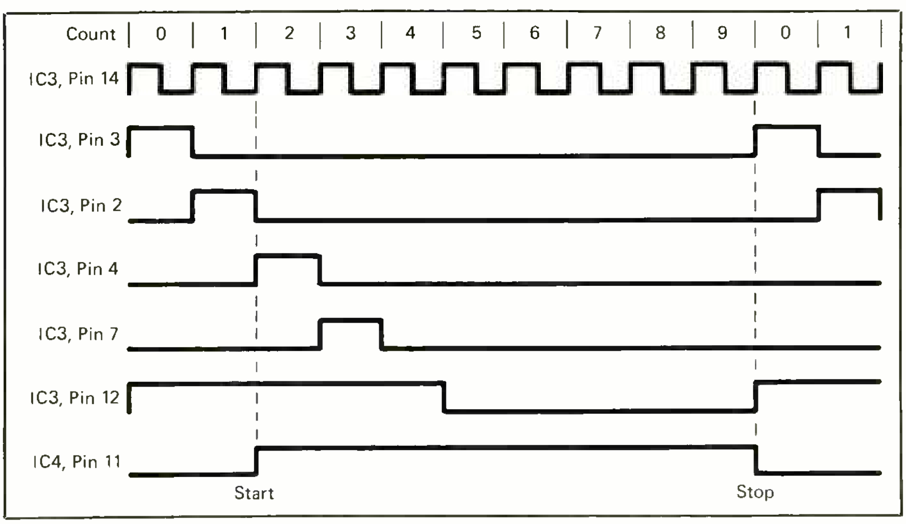


Fig. 2. Timing diagram for Fuel Miser.

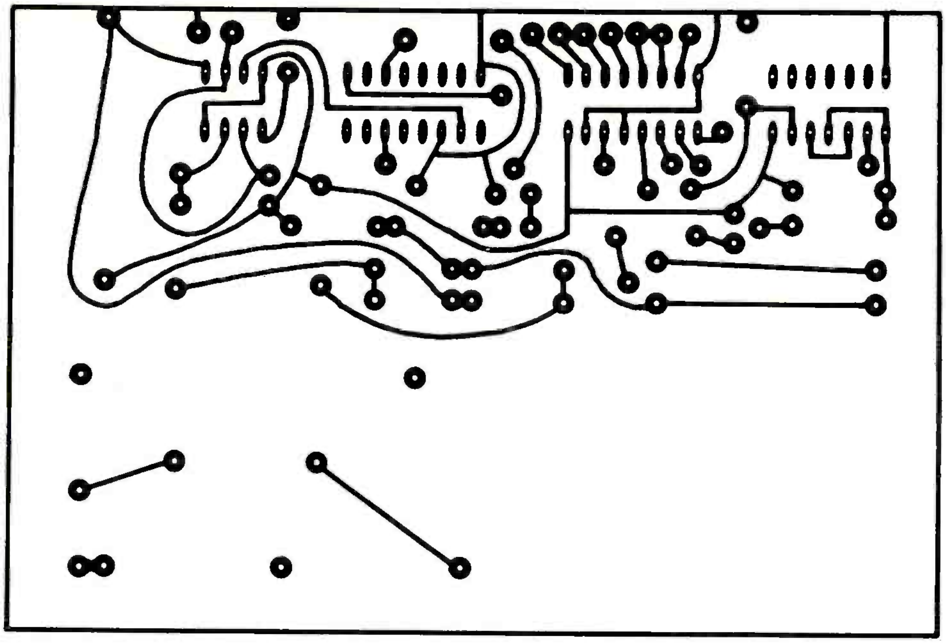


Fig. 3. Actual-size etching-and-drilling guide for Fuel Miser pc board.

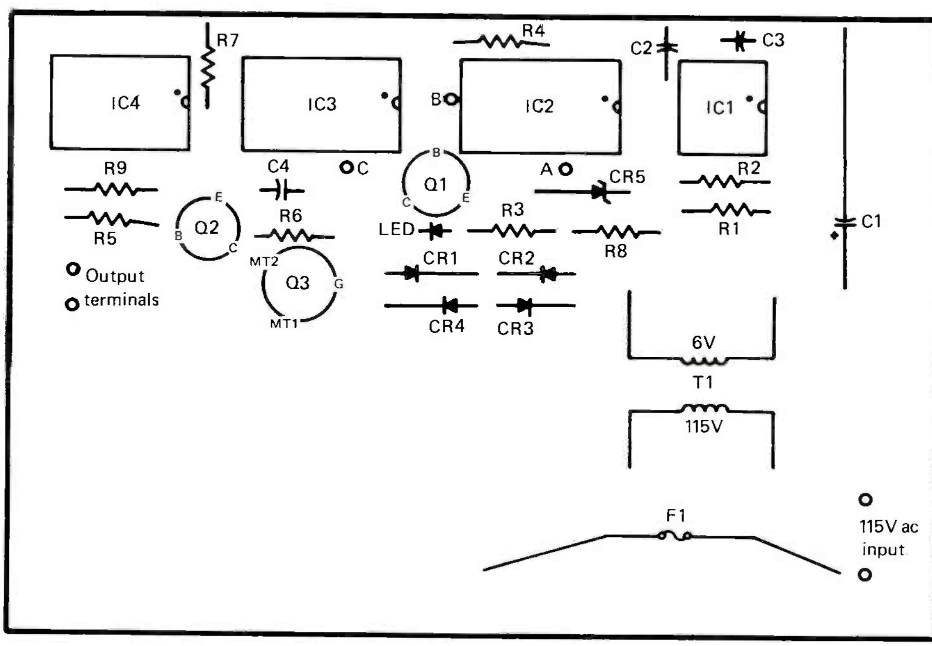


Fig. 4. Component installation guide for pc board shown above.

4. For oil burner systems, connect the jumper between points A and C. Be sure to use only one jumper wire in your circuit.

For ease of assembly into a cabinet, you may mount the duty cycle selector switch directly on the circuit board and wire it into the circuit. This will enable you to mount the board to the front of the cabinet with the switch shaft protruding through a hole drilled for that purpose. Use spacers to mount the circuit board.

Note that you may want to mount the LED on the panel of the cabinet so you can view it during operation to make sure it's working properly. After your assembly is complete, you will then want to label the switch positions, from 10 percent to 100 percent in increments of 10 percent each.

Before you connect the fuel miser into your furnace circuit, turn it on by applying 115 V of a.c. power to the transformer primary. The LED should flash about once a second. If it does, your fuel miser is probably wired correctly.

If you do not get the flashing signal from the LED, disconnect the electrical power and examine the circuit for bad solder connections or short circuits between adjacent pins on the IC chips. Also check the diodes, transistors and IC's to be sure that they are not placed backwards in the circuit. You will have to substitute new IC chips for those already in the circuit if one or more of these chips is defective.

Installation

Once completed, the fuel miser can be installed anywhere near your furnace or your thermostat. Turn off all electrical power to the furnace and the fuel miser before making the installation. For all heating systems that operate with a two-wire thermostat, all you need do to connect the fuel miser is to open one of the thermostat connections and connect the output terminals of the fuel miser in series with the thermostat. This is illustrated in Fig. 5.

In some oil burner systems, three-wire thermostats are used. These thermostats have two sets of contacts that close at slightly different temperatures and are designed so that the burner starts only when both contacts are closed.

In these systems, the thermostat is usually wired to a relay whose contacts operate the oil burner motor. This means that the fuel miser's output terminals must be connected in series with the relay coil. This is shown in Fig. 6, which illustrates a typical three-wire oil burner.

After you have made the necessary connections, whatever your system, apply power to both the fuel miser and your furnace. Set the fuel miser's switch to the 100 percent position,

Continued on page 103

A Universal Coil Tester

Under-$20 device reveals shorted turns that escape ohmmeter measurements

TJ Byers

Trying to determine the integrity of a low-resistance, high-impedance coil can be a frustrating experience. The kind I'm talking about are those used in TV receivers, such as CRT yokes, filters and flybacks.

The internal resistance of these devices is so low it is virtually impossible to measure the coil-winding with an ohmmeter. In fact, many such coils have a wire resistance of less than one ohm! Therefore, the difference a shorted turn or two makes in the overall resistance pattern is too minuscule to detect. Many times, it seems, your only recourse is to replace the suspected part with a new one—a costly and time-consuming chore.

Earphone is modified and glued to back of front panel. Circuit board and panel are joined with adhesive and clamped until adhesive sets.

There is, however, a simple, inexpensive alternative: The universal coil-tester presented here that is built around low-cost integrated circuits and should cost you less than $20 in parts.

It not only tests coils for opens and shorts, it can even reveal parallel resistance paths such as the kind you might encounter when dealing with carbon tracks or leakage.

As you might know, there's more than one way to test an inductor. For example, you could measure its resistance to an a.c. signal, the coil's inductive reactance. A simple test setup to do this can be seen in Fig. 1.

Notice that the coil has a resistor in series with it. When an a.c. voltage is applied across the combination, a voltage is generated across each device that's proportional to its effective resistance and the current passing through it. By knowing the frequency and the voltages, you can easily calculate the value of the inductor. In fact, this is how most laboratory instruments are used to test inductors.

A second method is to test the coil under actual operating conditions, such as placing it in an oscillating circuit. Such an oscillator is represented by the drawing in Fig. 2. Basically, an oscillator is an amplifier that has part of its output fed back into an input. This feedback produces oscillation. In order to sustain the oscillation, though, the signals must be shifted to 180 degrees of each other.

Phase inversion can be accomplished in many ways. In its most basic form, the signal is passed through a phase-shifting network. The network is frequency sensitive, so phase inversion occurs at only one frequency. This is the frequency at which the amplifier will oscillate. The network can contain capacitors, resistors, or inductors—or any combination thereof. The universal coil tester described in this article uses this test method.

By replacing the inductor in the feedback loop with the inductor being examined, we can determine its quality. A good inductor will oscillate; a bad one won't.

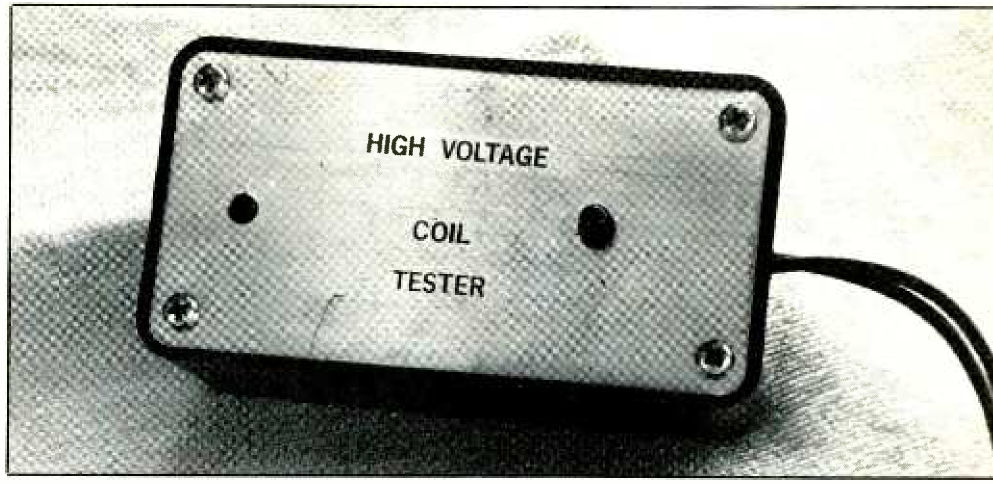


Photo shows author's prototype housed inside typical Bakelite project box with aluminum cover. Test leads exit box through hole in side of box.

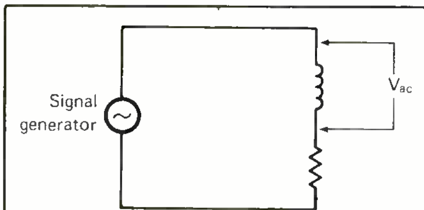


Fig. 1. Typical reactance test setup.

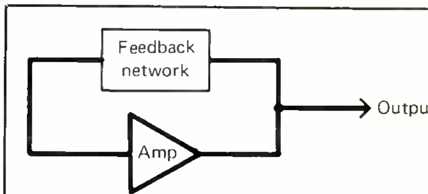


Fig. 2. Typical oscillator setup.

How It Works

The coil tester here is designed around a pair of LM3909 integratred circuits. The LM 3909 is a special integrated circuit that operates directly from a 1.5-volt battery. It was originally designed as a low-power LED flasher, but it can do much more. The LM3909 can also function as an amplifier, an alarm, a trigger or an oscillator element.

In the circuit shown in Fig. 3, the first LM3909 is configured as an oscilltor—but with one notable difference. Its feedback path is not complete. Part of the feedback loop consists of capacitor C1 and timing resistor R1. These two components set the basic oscillator frequency.

The mising link is the inductor. When a coil is connected from B+ to pin 2 of IC1, the feedback loop is completed and the chip oscillates. The tone of the oscillator's output is directly proportional to the quality of the coil. An analysis of the circuit's operation runs as follows:

When a good inductor is connected from B+ to pin 2, it supplies an out-of-phase feedback pulse to the chip that initiates the charging of C1. As C1 charges, the LM3909 monitors its voltage. When the voltage across C1 exceeds 1.3 V, the IC discharges the capacitor through the LED. This causes the LED to flash.

If you're wondering how an LED will light from a 1.5-V source, it's simple. During the discharge phase of C1, the 1.3-V charge stored in the capacitor is added to the 1.5-V battery to create a total charge of 2.8 volts. This is enough potential to light the LED.

A portion of the discharge current

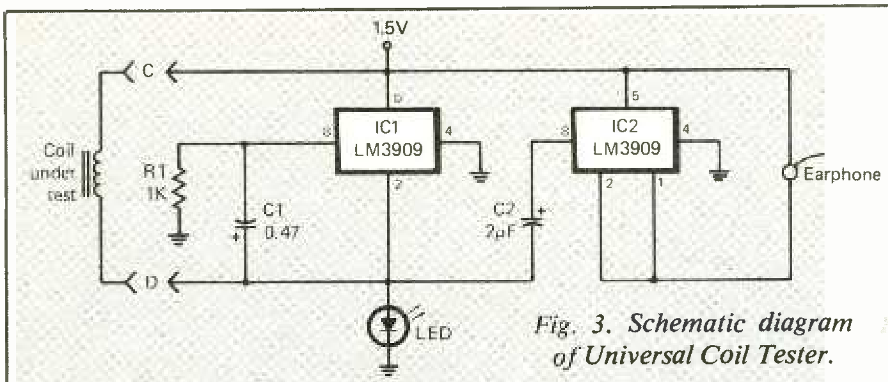


Fig. 3. Schematic diagram of Universal Coil Tester.

PARTS LIST

C1—0.47-µf, 35V tantalum
C2—2-µf, 16V electrolytic
IC1, IC2—LM3909 Radio Shack 276-1705 or equivalent
LED—Jumbo, red Radio Shack 276-041 or equivalent
R1—1k, ¼-watt resistor
Battery—C cell
Battery holder—Radio Shack 270-402 or equivalent
Earphone—Radio Shack 33-174 or equivalent
Project case—Radio Shack 270-231 or equivalent

Note: The following are available from Danocinths Inc., P.O. Box 261, Westland, MI 48185: Model RW-1 etched and drilled printed-circuit board, $5.50 plus $1.50 shipping and handling, Michigan residents add appropriate sales tax. Allow 4 to 6 weeks for delivery.

is also bypassed through the inductor, causing it to initiate another cycle. If the inductor is completely shorted (zero inductance), B+ is applied directly to pin 2 of IC1 with no inductive relief. Constant application of voltage on pin 2 (which is the negative feedback path for timing-capacitor C1) squelches oscillation.

The oscillator is also very sensitive to the inductance of a coil. A shift of just a few millihenries will produce a significant change in the frequency. Such a change can be brought about by shorted turns. Shunt resistance, created by a carbon path or leakage, also has a pronounced effect on the output.

In many cases, a shorted turn or leakage even prevents oscillation from occurring. It is often the case, too, that a defective coil will add a "strained" sound to the audio output.

The oscillator's output signal is fed into IC2 through coupling capacitor C2. IC2 is biased to operate as an amplifier. Its purpose is to isolate the oscillator from the audio output. The sound is heard through an earphone.

Construction

The complete tester is built right inside a 4″×2½″×2¼″ plastic utility box. The box is large enough to accommodate all parts, including the battery.

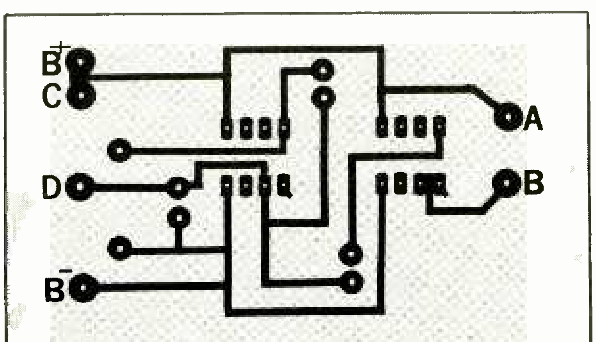
Begin by drilling two ¼-inch holes in the front aluminum panel, using the accompanying photo as your guide. One hole is for the LED, the other is for the earphone.

Before you can use the earphone, though, it must be modified. With an Xacto™ knife, carefully remove the protruding earplug. Take care not to damage the fragile speaker diaphragm inside. Some earphones have removable, clear plastic earplugs, which makes your job that much easier. Cut the leads to about 2″ and strip the ends.

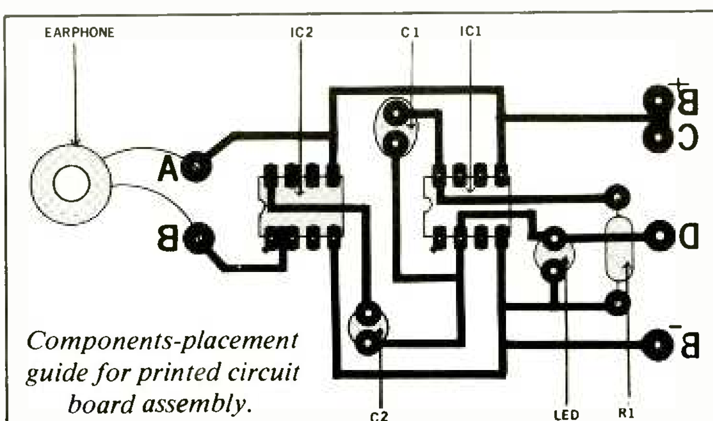
Now solder the components to the printed-circuit board, observing polarity and IC orientation. Note that capacitors C1 and C2 are positioned on their sides rather than standing upright. *Don't* install the LED at this time, though.

Using a silicon adhesive such as RTV, now cement the modified earphones to the aluminum front panel

Continued on page 100



Actual-size etching-and-drilling guide.



Components-placement guide for printed circuit board assembly.

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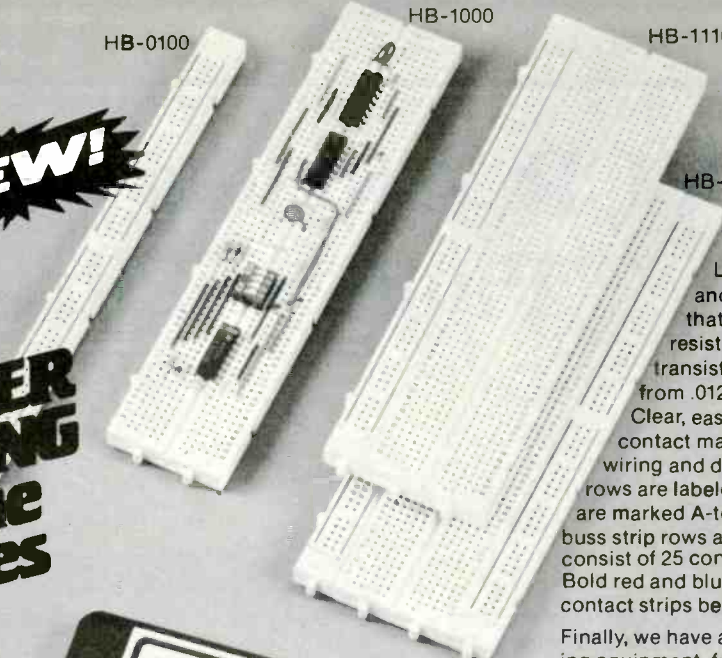

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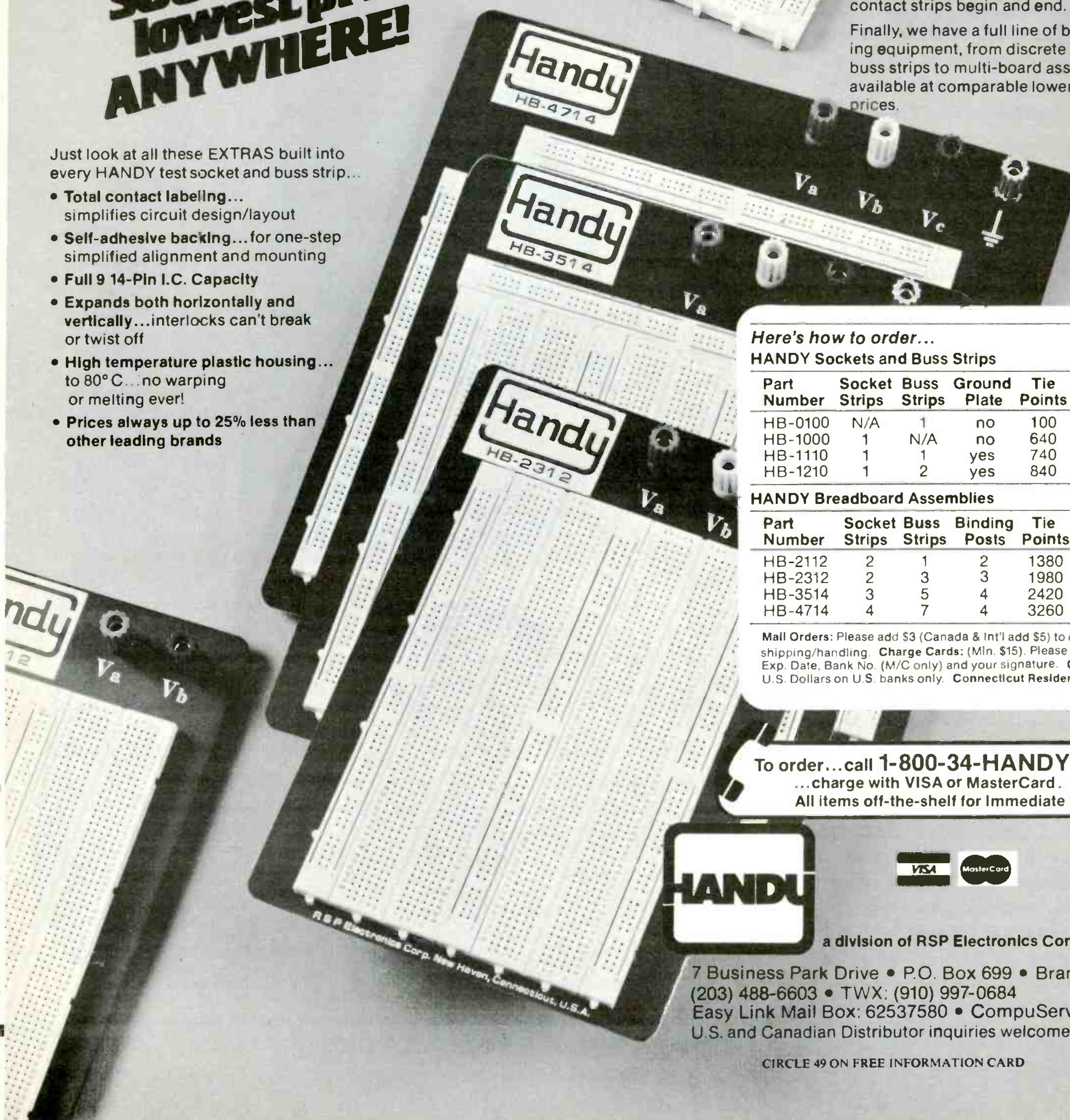

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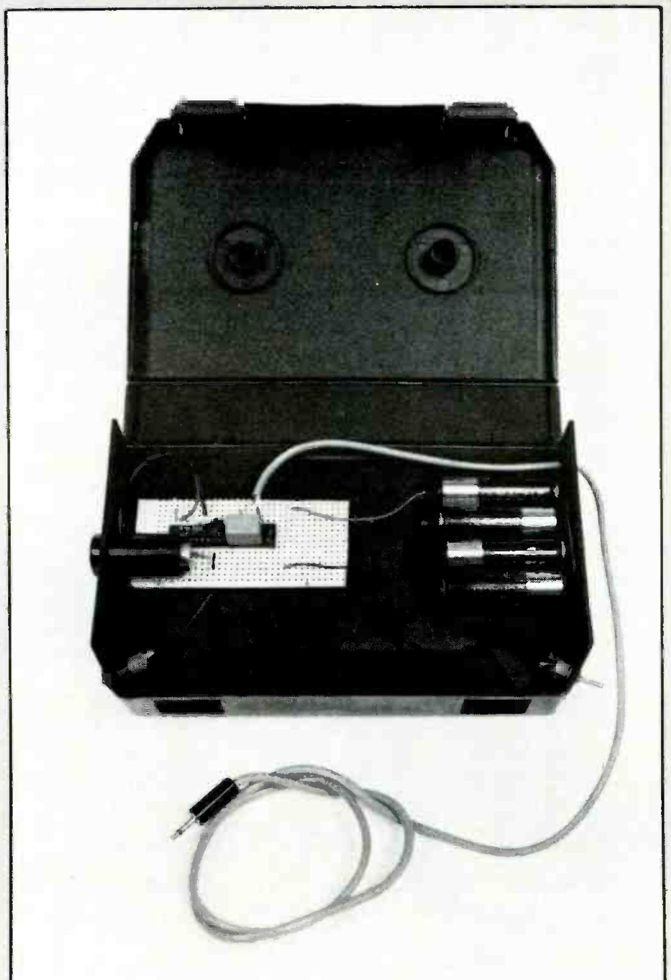


Photograph illustrates how project neatly nests inside a plastic videocassette case. Note particularly details of how the photocell mounts so that most room lighting is excluded.

By Rich Vettel

Probably the most frequently used control on a video cassette's remote controller is the PAUSE function. It's used to stop video recording of a TV program when the commercial goes on or when you're interrupted for one reason or another. If you have a wired-type remote control, and you're tired of tripping over its wire, the project presented here will delight you.

It replaces the wired control with a light-activated control unit. Using a flashlight, you can then activate and shut off the PAUSE function while anywhere in a typical room. Moreover, this project does not require opening up a VCR's chassis.

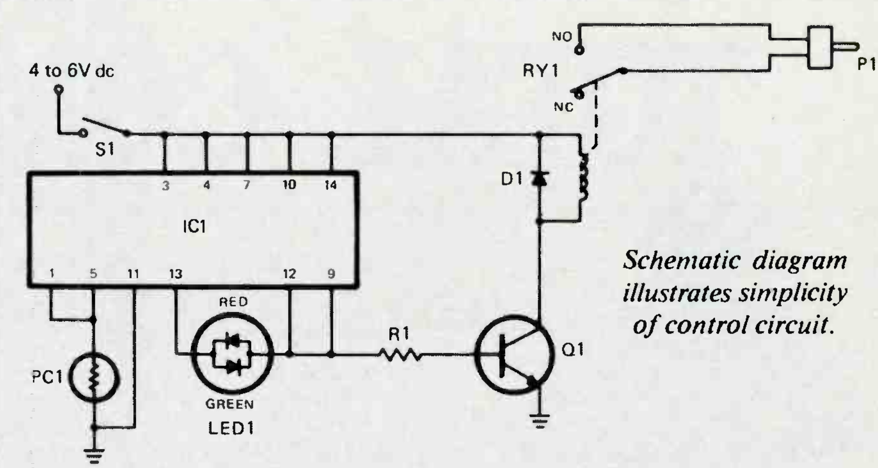
How it Works

When a light beam hits the photocell on the control unit, the resistance decreases to approximately 100 ohms, applying a negative pulse to the flip-flop input. The relatively slow reaction time of the photocell acts as a debounce circuit, eliminating false triggers. The flip-flop output then changes state and latches.

If the new state is HI, the transistor will be forward biased and therefore conducts, pulling in the relay. The relay contacts provide a closed circuit across the plug going to the VCR PAUSE jack, causing the VCR to go into the PAUSE mode. (This circuit will only work with VCRs having slide- or toggle-switch type remote pause controls. With the switch in one position, the connector plug is shorted and the VCR is paused. In the other position, there is an open circuit between plug tip and ground, and the VCR plays normally.) The next beam of light causes the flip flop to change state again, removing bias to the transistor. The relay drops out and, with continuity across the pause jack removed, the VCR exits the pause mode and resumes play.

The diode across the relay coil helps to protect the transistor from transient voltage spikes. These occur when the transistor is turned off and the relay's magnetic field suddenly decreases or collapses.

A tri-color LED is connected to the two outputs of the flop flop. When the Q output is HI, the Q output is LO and the LED glows red. When the flop flop changes state, the polarity of the LED is reversed and it glows green. This LED functions only as a status indicator and is not necessary for the rest of the circuit to operate.



Schematic diagram illustrates simplicity of control circuit.

PARTS LIST

R1—10,000 ohms (¼W, 5%)
IC1—7473 Dual Flip-Flop
Q1—2N2222 npn Transistor
RY1—5V relay, coil >50 ohms (Radio Shack #275-243 or equivalent)
LED1—Tri-color LED (Radio Shack #276-035 or equivalent)
PC1—Cadmium Sulfide Photocell, min. resistance <150 ohms (Radio Shack #276-116 or equivalent. Note: #276-116A will not work)
S1—SPST toggle switch
D1—1N914 Diode

Miscellaneous: Plastic VCR cassette case (Radio Shack #44-1192), 4 "AA" cells and holder, 2-conductor wire, plug to fit VCR pause jack, 20-pin IC socket, circuit board (Radio Shack #276-153), inline ¼" phone jack, velcro tape, double-sided foam tape, flashlight with batteries.

Assembly

I used one half of a Radio Shack prototyping board for the circuit. This layout required a minimum number of wire connections. The IC chip and transistor can be directly soldered to the circuit board or inserted into a single 20-pin IC socket.

The entire unit fits nicely into a plastic video cassette case. Besides looking like a natural extension of the VCR, the case allows easy access for battery changes. A 5/8" hole should be drilled in the case for the photocell to show through. To help keep the cell in darkness even in a well-lighted room, it should be recessed about an inch back inside the case. The barrel of an inline phone jack, fitted through the case opening and over the photocell, assures proper alignment and provides a finished appearance. The circuit board can be attached to the case with velcro tape, allowing for easy repositioning, while the battery holder can be fastened with double-stick foam tape. Any two-conductor wire may be used to connect plug P1.

Testing

Connect a continuity tester across plug *P1*'s tip and ground. Turn on the control unit power switch. The indicator LED should turn green, and there should be no continuity indicated across the plug.

As soon as a flashlight is momentarily shined on the photocell, the LED should turn red and there should be a closed circuit between the plug tip and ground. The distance from which the unit can be activated is determined by the brilliance of the flashlight. A light powered by 2 "D" cells can activate the unit from a distance of less than four feet, while a flashlight powered by 4 "C" cells is effective at up to 12 feet.

After passing the simple tests, just plug *P1* into the VCR's PAUSE jack, power up the control unit, and play the VCR as usual. Then momentarily activate the photocell with a beam of light to "pause" the VCR. To restart the PLAY function, just shine the flashlight at the photocell again. That's all there is to it. From wired to wireless for less than $10. **ME**

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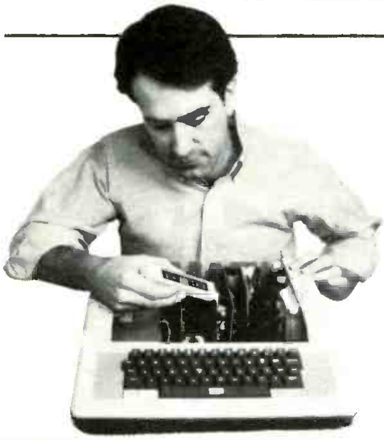

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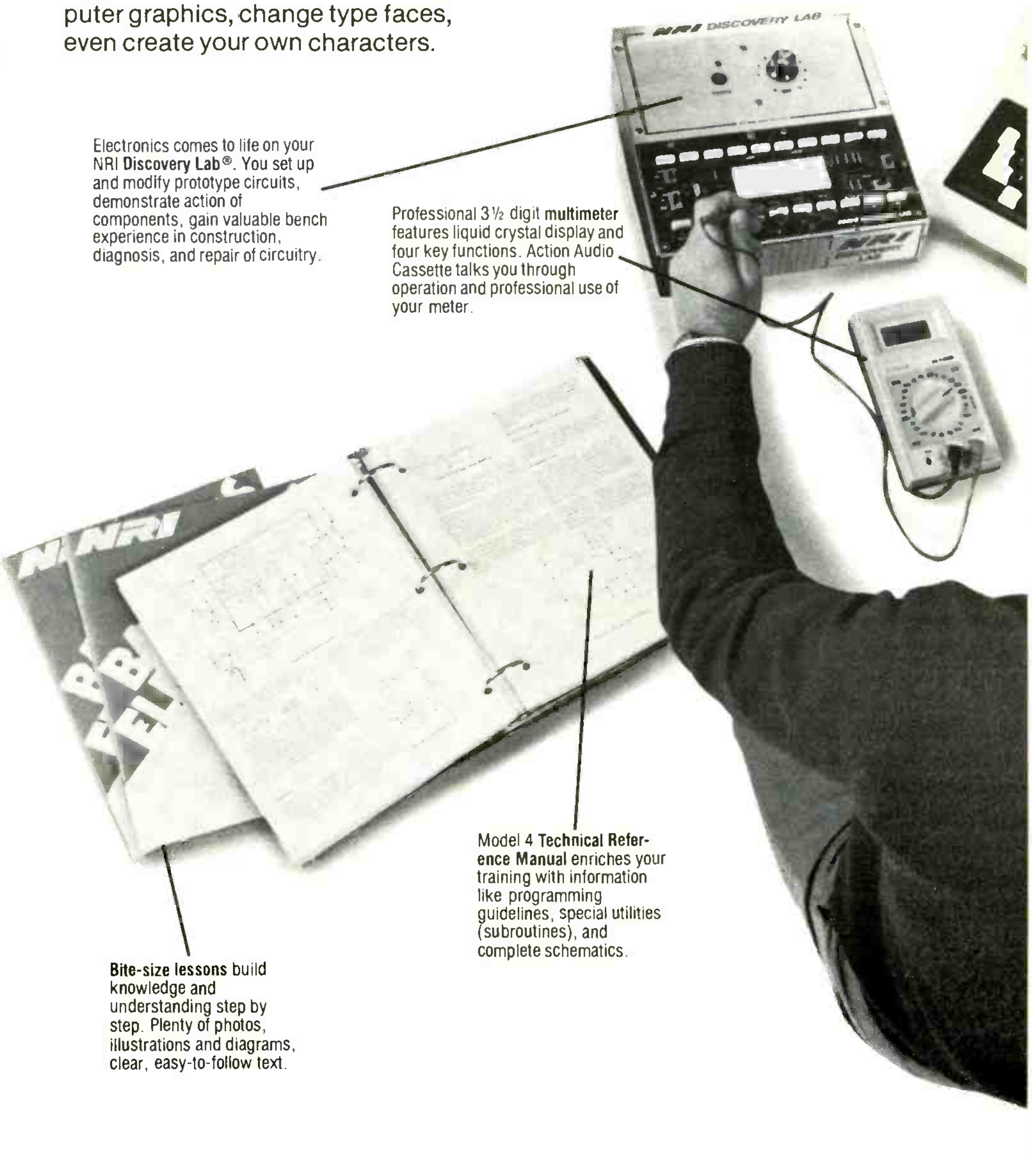

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ELECTRONICS NOTEBOOK

How Lightwaves Are Changing Communications

By Forrest M. Mims III

The wires and cables that connect electronic devices with one another and with their sources of power have always been considered a necessary nuisance. But are they always needed?

Simultaneous advances in low power CMOS circuitry and high-capacity batteries, both disposable and rechargeable, have eliminated power cords from many electronic devices. It's also possible now, with radio waves or beams of light, to replace the wires that traditionally connect between many devices.

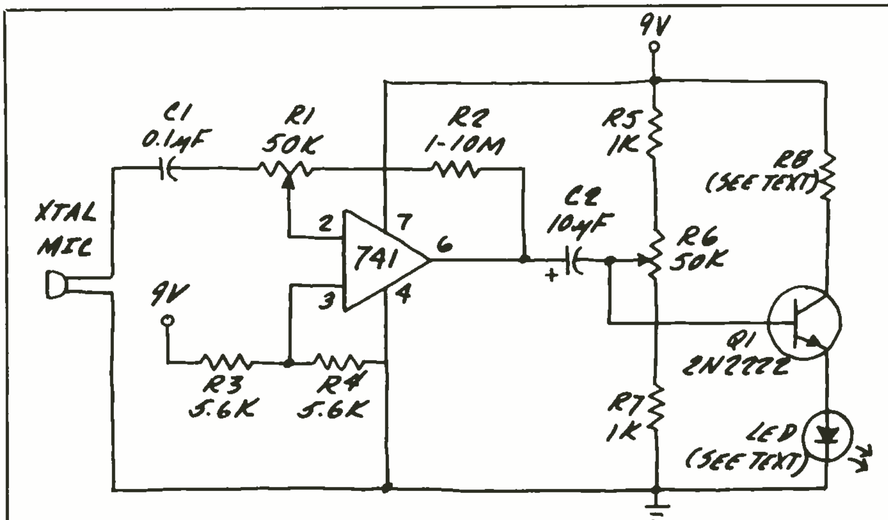


Fig. 1. Simple lightwave transmitter for speech.

Radio vs. Light

Radio links have been used for decades to open garage doors and to control model airplanes, boats and cars. They are easy to use and omnidirectional, but they require antennas and may be subject to government regulation. For these reasons, photonic systems that transmit information or control signals by means of near-infrared radiation and visible light often offer a viable alternative for short-range links.

Strictly speaking, the term light refers only to the range of wavelengths in the electromagnetic spectrum that is visible to the human eye. It's common practice, however, to classify systems that use visible light and those that employ near-infrared as lightwave links. I'll use that terminology in this column.

Often lightwave signals can be transmitted directly to a suitable receiver in what is usually called a free-space link. When total electronic security is important, or when distance or obstacles preclude a direct optical link, information-carrying beams of light can be injected into highly transparent fibers made of plastic, glass or silica material.

Whether radio or infrared is the best choice for a particular wireless application depends upon the circumstances. My personal preference is to use a lightwave link when possible. But I don't hesitate to use radio when transmitting data from model rockets or triggering a camera suspended from a kite or a balloon hundreds of feet in the air. In short, both radio and lightwave links possess relative advantages and disadvantages.

Lightwave Links

Communications over beams of light were first pioneered in the United States by Alexander Graham Bell and Sumner Tainter in 1880. Up until the 1950's, though, most lightwave communications research was conducted by the military and by individual experimenters. During World War II, Italy, Germany and Japan developed advanced lightwave voice communications gear.

Solid-state light emitters and detectors, as well as the laser, were developed in the United States during the 1960's. Japan and West Germany were among the first to apply these components in lightwave links for consumer products.

German companies were among the first, for example, to develop infrared remote control transmitters for television sets, toys and wireless stereo headsets. Japan's Canon further makes a midget infrared RS-232 free-space data-link that allows a handheld computer to communicate with a nearby printer.

Canon's infrared computer-printer link is merely the first of what may become many such wireless links between computers and their peripherals. Indeed, the keyboard of IBM's PCjr personal computer even now transmits keycodes to the system unit over beams of near-infrared generated by a pair of light-emitting diodes.

Telecommunications is by far the biggest application for fiber-coupled lightwave links. If you make a phone call to or from a major metropolitan area in the United States, Japan, Brazil, England, Italy or Canada, chances are your voice will travel at least part of the way as pulsations of near-infrared through silica fibers.

A Simple Lightwave

A free-space lightwave link capable of transmitting your voice several hundred feet can be assembled from surprisingly low-cost components. I've been building such communicators since 1965 when, as a student at Texas A&M University, I used flashlight bulbs and newly developed GaAs near-infrared-emitting diodes to send voice to receivers, using a silicon solar cell connected to an audio amplifier.

Since then I've designed and built dozens of lightwave communicators. Because of its simplicity and low cost, the transmitter circuit shown in Fig. 1 is one of my favorites.

In operation, the small voltage generated when voice pressure waves are intercepted by a crystal microphone is channeled through C1 into a 741 operational amplifier. The signal is then amplified with a gain determined by R1's setting.

The amplified signal is channeled through C2 to the base of driver transistor Q1. Resistors R5, R6 and R7 form an adjustable voltage divider that permits the bias on Q1's base to be adjusted for an optimum, distortion-free output from the LED.

The collector-emitter junction of Q1 acts like a variable current switch that controls the current flow through the LED. Maximum current flow is limited by R8.

Many different LEDs will work with this circuit. For best results, though, the LED should be an AlGaAs unit emitting at 880 nanometers. A GaAs:Si unit that emits at 950 nm will also work, but at less than half the power efficiency of an AlGaAs unit.

In any event, it's necessary to limit the quiescent forward current through the LED to a figure ranging from about 10 to 40 milliamperes. Brief high-level audio surges will substantially raise this level.

The easiest way to establish the LED quiescent current is to replace R8 temporarily with a 1000-ohm potentiometer. Then, while monitoring a milliammeter inserted between the LED's anode and Q1's emitter, adjust the pot until the current flow is from 30 to 50 percent of the maximum allowable for the LED you're using. Remove the meter and pot, measure the pot's resistance, and substitute a fixed resistor having a similar value.

The receiver shown in Fig. 2 detects the voice-modulated beam from the transmitter by means of a phototransistor, and this, together with load resistor R1, generates a voltage proportional to the amplitude of the signal. The signal voltage is amplified by a 741 op amp.

An LM386 audio power amplifier provides sufficient boost to drive a small speaker. R3 controls the signal level that reaches the LM386.

This transmitter and receiver pair will operate over a range of a few feet without external lenses. If you collimate the beam from the transmitter with a lens and place a second lens over the receiver's phototransistor, the range can be greatly increased.

Phototransistors saturate (i.e., turn fully on) in the presence of sunlight. Therefore, the receiver will work much better at night or if you block extraneous light with an infrared filter. Ironically, in total darkness a small amount of d.c. light falling upon the phototransistor will improve its sensitivity. This occurs because the light biases the transistor into conduction.

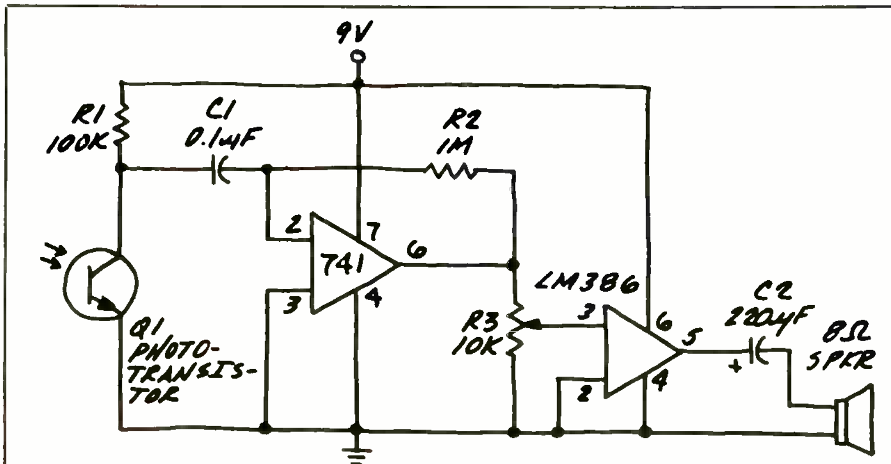


Fig. 2. Lightwave receiver with audio output.

A Low-Cost Communicator

The transmitter and receiver described above can be linked easily to one another by means of an optical fiber. In fact, I've done so many times over the years.

However, many experimenters who lack experience in building lightwave links have long hoped for an economical kit that would allow them to assemble, with minimum difficulty, a working fiber link.

One answer to their plight is the EDU-LINK Fiber Optic Kit. Available from the Advanced Fiberoptics Corp., 637 S. Hayden Road, Tempe, AZ 85281, for $19.95 plus $2 for shipping and handling, this kit consists of a transmitter, receiver and a one-meter length of sheathed plastic fiber. Both the transmitter and receiver circuits can be quickly assembled in under an hour.

The EDU-LINK transmitter is TTL compatible and will convert incoming logic signals into optical pulses. The transmitter also includes a self-contained oscillator that provides a 1-kHz signal for test and demonstration purposes.

ELECTRONICS NOTEBOOK ...

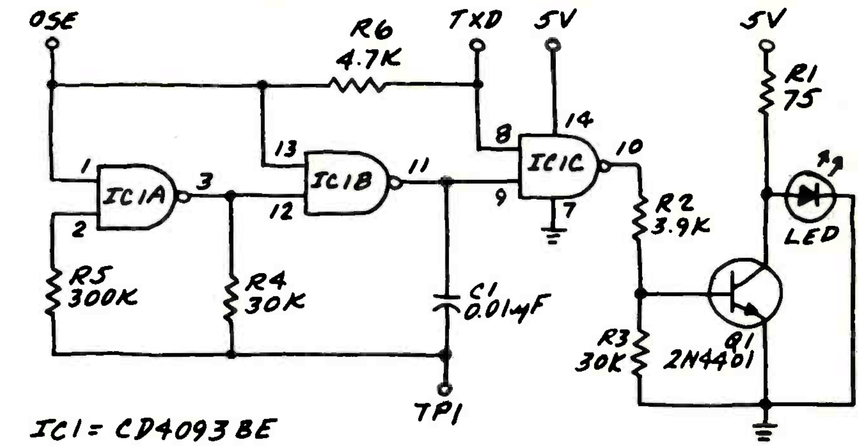


Fig. 3. TTL-compatible EDU-LINK transmitter schematic.

Fig. 3 is the transmitter's circuit diagram. IC1 (CD4093) is a quad of two-input NAND gates, each of which exhibits Schmitt-trigger operation on both inputs. Two of the gates (*a* and *b*) are connected as an astable oscillator that's enabled when the OSE (OScillator Enable) and TXD (Transmit Data) inputs are both high (logic level 1).

A third gate (c) steers the signal from the built-in oscillator or an external source to driver transistor Q1. R2 and R3 supply base bias to Q1, and R1 limits the current through the LED to about 40 mA.

The LED is a Siemens GaAsP visible red (665 nm) emitter. Since the receiver's silicon photodiode is much more sensitive to near infrared at about 800-950 nm, the wavelength range of the powerful near-infrared LEDs I specified for the free-space transmitter in Fig. 1, you may be wondering why the EDU-LINK transmitter uses a less powerful, red-emitting LED.

The principal reason is that plastic

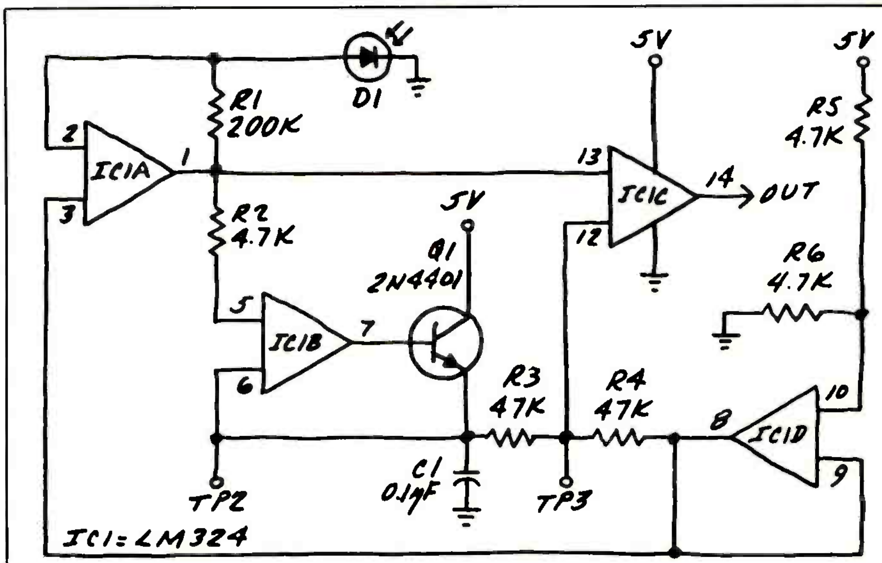


Fig. 4. EDU-LINK receiver accurately reconstructs incoming pulses.

fibers transmit near-infrared radiation very poorly. On the other hand, they transmit visible red wavelengths quite well.

The simple circuit in Fig. 2 will detect signals from the EDU-LINK's transmitter. The EDU-LINK receiver, however, employs a clever design optimized specifically for the amplification and accurate reconstruction of incoming pulses.

The circuit of the EDU-LINK receiver is shown in Fig. 4. IC1 is an LM324N quad op amp, and D1 is a high speed PIN photodiode. In operation, D1 is reverse biased and connected to one of the amplifiers (*a*) to form a voltage-to-current converter or, as it is commonly known, a transimpedance amplifier. The operation of the remainder of the circuit is more complex than it might at first appear.

Amplifier *d* is connected as a unity gain follower that provides, at pin 8, a buffered version of the voltage generated by the divider made from R5 and R6. Amplifier *b*, together with Q1 and C1, forms a peak detector that stores the amplitude of the incoming pulses. According to the EDU-LINK instructions, "This stored reference signal allows one to sample the incoming signal at its point of minimum distortion, thereby reducing pulse width distortion."

The output from the peak detector is halved, relative to the reference voltage, by the divider formed from R3 and R4. This signal, along with the amplified signal from the photodiode, is then applied to the output comparator (*c*).

The neatest features of the EDU-LINK kit are the plastic connectors into which the LED and photodiode are installed. Each of these connectors is attached to its respective circuit board by a pair of mounting screws.

Only a few minutes are required to terminate the plastic optical fiber supplied with the kit. After a quarter-inch of sheathing is removed from each end, the ends of the fiber are inserted into plastic ferrules. The exposed fiber emerging from the end of each ferrule is then cut with a hobby knife. The link between transmitter and receiver is completed when the plastic ferrules at each end of the fiber are snapped into the LED and photodiode connectors.

All that's necessary to test the link is a 5-volt power supply and an audio amplifier or oscilloscope. I powered the unit I assembled with a pair of 6-volt batteries. (I dropped the voltage from the transmitter battery to about 5.4 volts by connecting a 1N914 diode between the positive battery terminal and the circuit.)

You can hear the test tone by connecting the output from the receiver to a small audio amplifier. Or you can monitor the signal with an oscilloscope as described in the instructions supplied with the kit.

Going Further

If you would like to learn more about lightwave communications, you may want to read my book, *A Practical Introduction to Lightwave Communications* (Howard W. Sams, 1982). For a variety of both amplitude and pulse-modulated circuits, see *The Forrest Mims Circuit Scrapbook* (McGraw-Hill, 1983).

In the meantime, be sure to stay tuned. Along with many other topics to be covered in "Electronics Notebook," I'll include additional tips on free-space and optical fiber lightwave communication circuits in future columns. ME

50 Countries For Shortwave Listening

By Glenn Hauser

The world is on the air. Yet, most Americans are blissfully unaware that there's a gaping chasm between the frequency bands on their radios, where international shortwave broadcasting takes place. Much of it is especially beamed to North America, in English. Now it's easier than ever to get a shortwave radio with digital-frequency readout, even keyboard entry, so that once you have access to the broadcast times and frequencies as presented here later, it's a simple matter to expand your radio listening horizons beyond your local stations to the countries of your choice.

Keep in mind some important differences between international and local radio. Shortwave stations seldom have only one frequency they use all the time. Nor can you necessarily hear them at any hour of the day or night. With a few exceptions, English broadcasts typically last one hour or half an hour, perhaps aired twice each evening for eastern and western time zones. Frequencies change, too, from time to time, depending on the sunspot cycle, the season of the year, time of day, and interference. Stations seldom change all their frequencies at once, so be sure to try all frequencies we mention, and listen for announcements; changes are sometimes made with little or no advance notice. Furthermore, if you don't hear a certain station the first time you try, don't give up. Reception conditions can vary drastically from one day to the next, since shortwave signals come to us via the fluctuating ionosphere.

In general, European and African stations are heard better in eastern North America, while Asian and Pacific stations are received better in the west, but there is a great deal of overlap. More and more stations are establishing relay bases in Latin America to improve reception reliability throughout North America.

Radio Free Europe/Radio Liberty sends out this QSL to interested listeners.

Among the first things shortwave listeners must learn is the 24-hour UTC time system. Once you know how Coordinated Universal Time relates to your local clock, you won't have to bother with converting times or figuring out what time it is in the originating country. During DST, until the last Sunday in October, UTC is 4 hours ahead of EDT, 5 hours ahead of CDT, 6 hours ahead of MDT, 7 hours ahead of PDT, and so on. And the next day of the week starts the previous evening in North America. So to convert UTC to local time, subtract the appropriate number of hours. If the result is still 1300 or higher, you want to use the 12-hour clock, subtract another 12 hours and call it p.m. For example: in Denver, when would you listen for a broadcast at 2300 UTC? 23 minus 6 is 17; 17 minus 12 is 5 p.m. MDT. Once you're familiar with the system, you won't even have to think about converting—you'll know that 9 p.m. MDT is the same as 0300 UTC the next day.

Ready? Let's go through the alphabet with a sampling of what's to be heard on shortwave—in English unless otherwise specified. Broadcast frequencies are noted after the UTC time in kiloHertz. To convey to megaHertz, simply move three decimal places to the left (thus, 9750 is 9.750 megahertz (MHz).

Albania. Let's plunge right into the culture shock of Radio Tirana, the "Voice of Marxism-Leninism," at 0000-0025 on 9750 and 7065; 0130-0155 and 0230-0255 on 9750 and 7120; and 0330-0355 on 7300 and 6200. Frequencies vary up to ±5 kHz.

Algeria. Radio Algiers punctuates its newscasts with musical stingers. Listen at 2000-2030 on 17745, 15215, 9685, and do *not* believe this station's frequency announcements.

Argentina. RAE can be heard best when southern conditions are "up," and northern conditions are "down" —at 0200-0300 on 11710 and 15345.

Australia. Despite its great distance, ABC's station in Perth, intended to cover the Outback, puts a good signal into North America at 1000-1600 on 9610. Even more reliable is the overseas service, Radio Australia, from Melbourne. Main frequency is 9580 between 0800 and 1400. Many others are announced each half hour. After 0200 UTC try 15320 and 15395. Unlike the United Kingdom's BBC, Radio Australia has news on the hour *every* hour; there's lots of pop music and, especially on weekends, feature programs.

Austria. The Austrian Radio, ORF, has a polished and cultured program well worth hearing, at 0130-0155 and 0330-0355 on 5945 and 9770; 0430-0455 on 5945 and 11665; 1230-1255 on 15320. The 0330 and 1230 broadcasts start 25 minutes earlier on UTC Sundays. "Shortwave Panorama" appears on the Sunday 1230 and UTC Monday 0430 transmissions. If you listen before and after the times given, you'll hear ORF mostly in German with lots of fine music from folk to classical.

Belgium. BRT broadcasts at 0030-0115 on 9925 and 11620, repeated Mon.-Fri. at 1400-1445 on 17610.

Brazil. RNB, Brasalia coincidentally competes with Argentina, also in English, at 0200–0300 on 15290, but generally has a better signal. The emphasis here is on music.

Bulgaria. Radio Sofia can be heard at 2130–2200 on 11850, 11750 and 9700; 2230–2330 and 0000–0100 on 11870 and 9700; 0400–0500 on 11750.

Canada. Radio Canada International is easily audible here whether broadcasting to Europe, Africa, the Caribbean or the U.S.A., both with its own programs and relays from the domestic CBC Radio. "Sunday Morning" is an excellent review of the week's world and Canadian events, at 1310–1600 on 17820 and 11955. A widely respected and thorough evening newscast is "The World At Six" at 2200–2230 Mon.–Fri. on 15325, 11960, 9755 and 5960, and at 0100–0130 on 9755 and 5960. RCI's own programs include broadcasts at 0000–0030, 0200–0230 and 0300–0330 on at least 5960 and 9755. The middle program UTC Mondays carries "SWL Digest," which will help you update information here. Private low-powered shortwave stations CFCX in Montreal on 6005, and CRFX in Toronto on 6070 represent the only signals to be heard in the daytime on 49 meters in the northeastern U.S.

China. Radio Beijang is our major window on this country, and is quite responsive to listeners. Tune in at 1100–1155 on 15520; 1200–1255 on 15520 and 11650; 0000 through 0455 on two or three of: 17795, 15520, 15385.

Cuba. Radio Havana Cuba is too *close* to be heard well in Florida (its higher shortwave frequencies skip over) but it's regular in more distant parts of North America; program cycles are basically a sesquihour long, whatever the lengths of transmission may be: 2010–2140 on 17885; 2050–2140 on 17750, 17705; 0100–0450 on 11930, 15300; 0330–0600 on 11760; 0450–0600 on 15300; 0630–0800 on 11725. At other times of day, 17750, 17705, 11760 and several others are in Spanish with lots of good music.

Czechoslovakia. Radio Prague gives you two chances to hear the same program—0100–0155 & 0300–0355 on 11990, 9740, 9540, 7345, 5930.

Egypt: Radio Cairo is a very low-key station, making us suspect the wee hours over ther during the 0200–0330 broadcast are taking their toll; on 9475 and 9675.

Finland. Radio Finland battles BBC/Ascension on 15400, and Deutsche Welle on 17800, but sometimes they come out on top—at 1100–1125, 1200–1225, 1300–1325 and 1400–1425; except Sundays when "Sunday Best" repeats the best of the preceding week at 1230–1425.

France. R. France International still restricts English to Africa, but fortunately we can hear it without too much trouble. At 1605–1655 on 15315 and 17620; 0315–0330 and 0345–0400 on 15440 and 15180 (via French Guiana), 9790 (via Gabon), 9550, 9545, 7135 (direct); and at 0415–0430 & 0445–0500 on 15155, 11995, 11875, 11705, 9790, 9550, 7135.

Germany, East. Radio Berlin International is heard best with programs for Africa beamed to the Caribbean, at 2215–2300 on 9620 and 9600; 0200–0245 on 9620. Also try the Western North America service (even in the East) at 0230–0315 and 0530–0615 on 9560, 11975. All these shift an hour later from the last Sunday in September.

Germany, West. Radio Deutsche Welle, the Voice of Germany, is a bit heavy on politics, but at least not the leaden East German variety. Several relay bases assure reliable reception. At 0100–0150, Malta on 11785, 9590 and 6085; Antigua on 9545 and 6040; direct on 9565 and 6145. At 0500–0550 via Antigua/Montserrat on 11705 and 9545; direct on 9690, 6120, 5960 (subject to change). DW has a more extensive schedule of German-language broadcasts, repeating in 4-hour cycles throughout the daytime and nightime hours.

Greece. Voice of Greece broadcasts more than five hours a day to North America, mostly in Greek with lots of music, but with English news at 1235 and 1540 on 9815, 11645, 15635; 0130 and 0340 on 9420, 9865, 11645.

Guyana. You may well overlook GBC unless you're a night owl. It's on 5950 from around 0730 until local sunrise fades it out. Listen for the "Early Birdie Show."

Hungary. On any given night, the two Radio Budapest broadcasts have different content: 0100–0139 (except UTC Mondays), and 0200–0230 (daily) on 12000, 11910, 9835, 9520, 6025.

Indonesia. Voice of Indonesia is on 11790 at 1500–1600; best in the West.

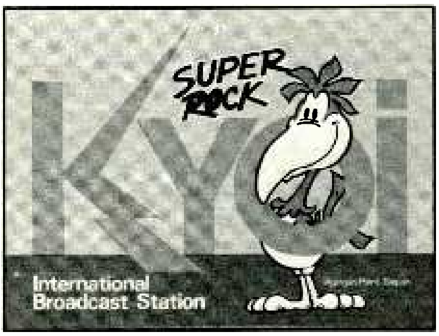
Iran. Voice of the Islamic Republic of Iran is at 1930–2030 on 9022 and 11930—reception is difficult.

Iraq. Radio Baghdad uses 9610 at 2030–2125; one hour later in the winter.

Israel. Israel Radio, when its journalists are not on strike, is heard very well at 0000–0030, 0100–0125 and 0200–0225 on 11655, 9815, 9440 (one hour earlier during summer time). Also at 0500–0515 on 11655 and others.

Italy. RAI has a token English service with dreary news and music fill at 0100–0120 on 11800 and 9575.

Japan. Radio Japan is planning a relay in Panama; until then it's spotty except along the West Coast, though the Gabon relay helps some. Hour broadcasts are at 0500 on 15300; 0700, 1300 and 1500 on 9505; 1500 on 21695 (Gabon); 0000 on 17825, 15300; 0145 on 21640, 21610, 17825,



A bumper sticker from Super Rock station KYOI in Japan.

15195. And for half an hour at 0900 and 1100 on 9505.

Korea, North. Radio Pyongyang is always deep in the mire of the personality cult of Kim-Il Sung, but it can be amusing for a while—1100-1250 on 9977 and 9745.

Korea, North. Radio Korean often sounds American, but has its own hard line to follow, in a country where people owning shortwave radios are suspected of being spies. Hour-long programs are at 0145 on 15575; 11810; 0330 on 15575, 18820, 9570; 1100 on 15575; 1400 on 15575, 9750, 9570; 1600 on 11810, 9870. Quarter hour news is at 1715 and 1745 on 15575; 2345 on 7550 and 15575; 0815 and 0845 on 9570; 1345 on 15575.

Libya: Radio Jamahiriyah is rather slipshod in its timing, approximately 1800-1930 on 15450 and 2130-2300 on 11815; about one hour later from Oct. 1. Listening to it might change your conception of Murmar Qaddhafi.

Mongolia. We include this difficult-to-hear station for the sake of exotica: Radio Ulan Bator, Mon.-Sat. at 1200-1235 in 12015.

Netherlands. Radio Netherlands is highly reliable, thanks to its Bonaire relay; new 500-kilowatt transmitters in Holland are coming on this year, and changes in program timing and content are expected. Listen at 1030-1125 in 9650; 2030-2120 on 17605, 15560, 11730, 9715 9540 (the last two via Madagascar); 0230-0325 on 9590, 6165; 0530-0625 on 9715, 6165. During the last two, 9895 has been testing direct from Holland.

New Zealand. Though low-powered at 7½ kW, Radio New Zealand is worth seeking out for its home service relays. Before 0330 try 17710, afterwards 11960 until 1215; before 0530 try 15485, afterwards 9620 until 1215.

Nicaragua. Voice of Nicaragua seems to be patterned after Radio Habana Cuba, but unlike it, hardly a broadcast goes by without several announcements deliniating the procedure of American to Nicaragua. At 0100-0200 and 0400-0500 on 6017.5; could change back to former frequencies of 6100 or 5950, or move again.

Nigeria. Voice of Nigeria has three separate English programs at 0500, on 7255, 15119 and 15185; at 0530 they merge for a common newscast.

Poland. Radio Polonia is at a disadvantage because of low power and geographical position in northeastern Europe (so more of its signal has to pass through the auroral zone); keep trying at 0200-0355 on 15120, 11815, 9525, 7270, 7145, 6095.

Portugal. By contrast, Radio Portugal can generally be heard further west, and holds up longer during propagational disturbances owing thanks to its favorable location in southwestern Europe—0300-0330 on 11925 and 6060; 0530-0600 on 9575 and 6075. It it's missing from one of these channels, mix up the numbers and try again—like 6750.

Romania. Radio Bucharest has two separate programs at 0200-0255 and 0400-0430, but both on 11940, 11830, 11810, 9570, 9510, 6155, 5990.

South Africa. Radio RSA is another station with a western sound, but a peculiar line to propagate. Listen at 2100-2157 on 11900 and 9585; 0200-0257 on 9615, 6020, 5980.

Spain. Spanish Foreign Radio is one the brighter voices in western Europe, but sometimes suffers from too-literal translation from Spanish. At 0000, 0100, and 0500 on 9630 and 11880.

Sweden. Radio Sweden has reception like Finland and Poland, but do give it a try, especially on Tuesdays for "Sweden Calling DXers"—at 1400-1430 on 15190; 2300-2330 on 11710 and 9695; 0230-0300 on 11705 and 9695.

Switzerland. Swiss Radio International concentrates on current events, weekdays; feature programs on weekends, with a generally reliable signal, now that it's out of band, even though lacking relays. At 1315-1345 on 17765; 1815-1845 on 12035; 2145-2215 on 9885, 12035, 15570; 0145-0215 on 12035, 9885, 9725, 6135; 0430-0500 on 12035 and 9725.

Taiwan. Voice of Free China still broadcasts direct, but reception is so much better via relays in Florida: 0100-0200 and 0150-0610 on 5985; one hour later after DST.

Turkey. Voice of Turkey is another station enjoyed for its music; preoccupation with the Aremenian question mars its talk portions. Listen at 2200-2250 & 0300-0350 on 11755.

United Arab Emirates. UAE Radio, Dubai, is putting this Gulf state on the map with unbiased news and features on Arab culture, at 0330-0400 or later on 17775, 15430, 11730.

United Kingdom. If you listened to no other shortwave station besides BBC World Service, your purchase of a shortwave radio would still be a bargain. BBC serves all tastes in music, has the world's most reliable and respected news (most hours on the hour), and eclipses all other stations, including VOA, in its entertaining and informative feature programming. Though on the air 24 hour, only certain times are received well in North

America. At 1100–1330 on 15215-direct, 11775-Antigua, 5965-Sackville, Canada; 1300–1330 also on 9510-Sackville; 1330–1600 on 21600-Ascension; 1600–1709 (1500–1745 on weekends) on 15260 and 11775 (both Sackville); 2000–2430 on 15070-direct; 2200–2430 on 9590-Sackville; 2300–0330 on 9915, 7325, 5975 (all direct), 6175-Antigua; 0330–0730 on 6175-Antigua; 0430– 0915 on 9510-Antigua. To keep track of BBC programs and their repeat cycles, you'll need a detailed schedule which appears in *Review of International Broadcasting.*

United Nations. UN Radio now has Monday–Friday broadcasts; during other times of the year when the General Assembly is not in session, it cuts back to once a week on Fridays. Facilities of VOA are used. 1930–2000 on 2170, and 15120; on SSB via 20060 and 18782.5. At 2100–2145 on 17730 and 15120.

U.S.A. With its reliance on overseas relays, Voice of America is not the cinch to hear in the daytime you might think. At 1100–1330 try the Philippines on 9760 and 11715. At 1600–2300 tune the African service via liberia on 15600. No problem at night, with U.S. transmitters serving Latin America at 0000–0400—17730, 15375, 15205, 11740, 9650, 9455, 6130, 5995. During the first half hour or so, 9455 and 6130 are separate with Caribbean programs.

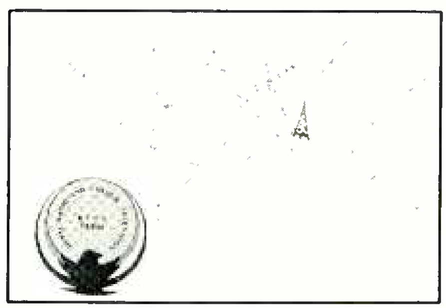
WRNO. New Orleans, has a peak signal toward Montreal, but reception is good in most parts of North America except the extreme southwest and southeast. On weekdays between 1700 and 0500, transmissions have been originating from the World's Fair site. WRNO has one transmitter, changing frequencies as follows—1700–2200 on 15420, 2200–0100 on 9705, 0100–0300 on 7355, 0300–0500 on 6185. Rock music is the format, except for lengthy blocks, especially on weekends, with religious programs in a variety of languages and two programs of special interest, "World of Radio," in which you are kept up to date on developments in international broadcasting, UTC Saturdays 0430 on 6185 repeated UTC Sundays 0130 on 7355 and 1300 on 9715; and "The World" from Radio Earth, an independent station buying time from WRNO, nightly at 0300–0400 on 6185. Radio Earth is a commercial entity hoping to set up its own transmitter; dedicated to giving shortwave listeners the programming and personalities they enjoy most, and in great variety; musical emphasis is Caribbean with Rudy Espinal in Santo Domingo.

Here is a very attractive QSL issued by Radio Korea.

AFRTS operates 22 hours a day in a never-ending cycle of mostly decommercialized network radio news and features. It's a good way to keep up with domestic U.S. radio in remote areas of our own country, and the only way to do so overseas. AFRTS also carries the two major news vehicles of National Public Radio, minus local interruptions so many other affiliates insert—"Morning Edition" at 1000–1200 Mon.–Fri.; and "All Things Considered" at 2100–2230. But sports always comes first at AFRTS, with a heavy schedule of play-by-play coverage pre-empting anything in its way; plans are announced in advance Mon.–Fri. at 1735 and Tue.–Sat. at 9535. All UTC times are none hour later after DST. Exact times of frequency vary from season, but this was the summer lineup: 0900–1100 on 9590; 0900–1200 on 6030; 1100–1700 on 15430, 15330, 11805, 9700; 1700–1800 on 15430, 15345, 15330, 9700; 1800–2200 on 17765, 15430, 15345, 15330; 2200–2300 on 21570, 17765, 15430, 15345, 15330; 2300–0100 on 21570, 17765, 15430, 15330, 11790; 0100–0200 on 21570, 17765, 15330, 11790, 6030; 0200–0430 on 21570, 17765, 11790, 6030; 0430–0700 on 17765, 15330, 11790, 6030.

U.S.S.R. Radio Moscow likes to use a dozen frequencies at once, or even more—and believe it or not, because of the polar path, sometimes only one or none make it through. But the Havana realy is extremely reliable propagationally, although audio quality can be quite poor. This is on 11840 between 1000 and 2200; 9600 at 0000–0500. Tune around the 11- and 9-MHz bands at 2200 to hear Radio Moscow's opening frequency announcements, which you can follow throughout the evening. If you look for them, you'll find programs about Soviet culture; without looking, you'll always be made aware of the party line. Between 2200 and 0700 there are only two hours of original programming that is repeated over and over.

Several regional Soviet station also broadcast in English, not necessarily from within their own borders.



RCTV Dubai's location is on its QSL.

Radio Kiev is on at 2330–2400 on 17860, 15405, 15180, 11720, 9800, 9688; at 0200–0230 on 17860, 15405, 15180, 11720, 9800; Radio Vilnius at 2200–2230 mostly on the same frequencies at Kiev's first broadcast; Radio Yerevan at 0253–0256 (the shortest daily English broadcast to North America) on 17860, 15405, 15180. In all cases, these three frequencies are from the Soviet Far East; the lower ones from Europe. Radio Tashkent broadcasts direct from Uzbekistan for an evening audience in India, but we're off the back in the morning—at 1200–1230 and 1400–1430 on 15460, 11785, 9715, 9650, 7340. All except Tashkent and the World Service shift one hour later Oct. 1, with frequency changes too.

Vatican. Overlapping RAI's English broacast, Vatican Radio is usually more interesting, at 0050–0110 on 11845, 9605, 6015.

Yugoslvia. Radio Yugoslavia can be heard at 2115–2130 on 9620; one hour later from October.

There are many other English broadcasts beyond these 50 countries, but reception is generally more difficult. We've also omitted here missionary stations, some with very strong signals, which are devoted to propagating Christianity rather than the culture of their host country. We already have plenty of gospel broadcasting on local radio. **ME**

QSL of Ecos del Torbes of Venezuela.

COUNTRIES USING U.S. VIDEO STANDARD

With the advent of small, lightweight TV receivers, international travellers might think they can carry one of them and simply plug it in to the foreign country's a.c. outlet to get local television reception. One can't be assured of this, of course, since many countries have different electricity standards. Furthermore, even video formats aren't standardized, so battery-powered models may not work either.

Though many countries do use the U.S.'s NTSC video standard (525-line system with 110 V/60 Hz electric power), many others employ the PAL standard (625-line system on 220 V/50 Hz) or SECAM (another 625-line system used in the U.S.S.R., among other countries). Obviously, a TV receiver designed to receive one video system's transmissions cannot operate with another broadcast standard.

Here is a listing of the countries that do indeed use the same video standard as in the U.S. Note that Europe is not the place to take along your U.S. TV portable.

Azores	El Salvador	Philippines
Bahamas	Greenland	Puerto Rico
Barbados	Guam	Samoa
Bermuda	Guatemala	St. Kitts
Canada	Honduras	Surinam
Chile	Japan	Taiwan
Columbia	So. Korea	Trinidad
Costa Rica	Mexico	Tobago
Cuba	Antilles	Venezuela
Curacao	Nicaragua	Vietnam
Dominican Rep.	Panama	Virgin Is.
Ecuador	Peru	

As previously cited, the three major color TV standards in the world are not compatible with each other. This was true at the onset of black-and-white TV, when two different systems were developed.

These same standards were carried over when color TV systems were adopted by respective countries. The two systems emerged as the U.S.'s NTSC (National Television Systems Committee) and the PAL (Phase Alternate By Line) designed by Germany's Telefunken. A third major color video system, designed in France, is SECAM (Sequential with Memory).

NEW PRODUCTS . . .

from page 9

and pitch control with a ±6% range. Wow and flutter are rated at a very low 0.02% wrms or less. Other features include a 33⅓- and 45-rpm speed selector, power switch, and removable tinted plastic dust cover. The PL-910, supplied without tonearm, will accommodate most add-on tonearms.

CIRCLE NO. 104 ON FREE INFORMATION CARD

Modular-System

With release of its MTX512, Memotech offers an under-$600 personal computer that you can structure to match your level of expertise and needs. It features Z80A (4-MHz) and TI 9928 8-bit coprocessors, 80K of user RAM (optionally expandable under program control to 512K), and an additional 16K or dedicated video RAM. Programmed into 24K of onboard ROM are MTX BASIC, MTX NODDY, an assembler/disassembler, and MTX Graphics Language.

The computer can display 40 columns of text as is or 80 columns with an optional plug-in card. It can also display high-resolution graphics in a 256 × 192-pixel screen arrangement in up to 16 colors. The system also supports up to 32 user-defined moveable graphics characters (sprites) for smooth animation. Standard interfaces include: Centronics-style parallel printer port; provision for an optional RS-232C serial port; separate TV and composite-video monitor ports; an uncommitted I/O port; 2400-baud cassette port; three-voice sound with hi-fi output port; white-noise output; and games cartridge slot. The built-in keyboard boasts full-travel keys and a separate numeric/cursor-control cluster. An optional DMX80 dot-matrix printer and MTX512S 500K floppy-disk system are available. The latter is a single 500 KB Qume drive with disk controller, power supply, and expandable (second-drive) disk cage.

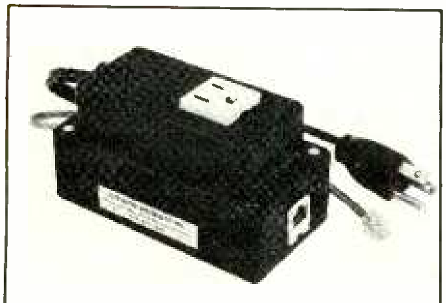
CIRCLE NO. 111 ON FREE INFORMATION CARD

Variable ac Power Source

There's no substitute for a good variable ac power source for many applications on the electronic workbench and other uses where precise control of power input is of critical importance for proper operation of electrical devices. One product that fills these needs is the Model WP-29A variable-output, isolated ac power source from VIZ Test Equipment. This product is designed to provide 0 to 150 volts ac at up to 2.25 amperes continuously from the 117-volt ac, 60-Hz line. Input and isolated output voltages can be monitored on a taut-band meter, whose accuracy is rated at ±2%. The unit measures 9½″ × 8⅝″ × 3⅜″ and weighs 15 lbs. $167.

CIRCLE NO. 106 ON FREE INFORMATION CARD

Modem Protector



If you are on edge from having data altered by electrical noise when transmitting and/or receiving through your modem, relief is just a purchase away. What you need is Electronic Specialists' "Kleen Line" Modem protector. The device is designed to suppress telephone and power-line spikes caused by lightning, spherics, and phone office switching gear. It uses modern semiconductor, metal-oxide varistor, and gas-discharge tube suppression techniques. Two models are available. The Model PDS-45P-36A/SUP has a modular 8-pin connector with phone-grade suppression on the red and green lines (pins 4 and 5) and data-grade suppression on the yellow and black lines (pins 3 and 6). A 6500-ampere suppressor protects the ac power line. The other Model, PDS-11, is similar, except that it is designed for single-line phones with 4-pin modular connectors. $130.95 for PDS-45P-36A/SUP; $65.95 for PDS-11.

CIRCLE NO. 103 ON FREE INFORMATION CARD

PRODUCT EVALUATIONS . . .

from page 16

To change printwheels, all you have to do is remove the ribbon cartridge, tilt back the hammerhead assembly, remove the old printwheel, and slip in a new one. This can be done in less than 10 seconds. You can further specify (by switch setting) either a normal ASCII PM (Printer Mode) or a WP (Word Processing) mode that is compatible with a wide assortment of commercial software.

Interfaces

The PowerType has been list-priced at under $500. Surprisingly, though (at these prices) it includes both a Centronics-compatible parallel interface and an RS-232C/20 mA current-loop interface.

Although Centronics parallel is certainly the most popular printer interface, it is significant that a major computer maker such as Apple has abandoned it and its computers now support only an RS-232C serial interface. This is also true of Radio Shack's Color Computer and its MC-10.

The major advantage of the serial interface is that it allows you to have long cables between the computer and the printer, whereas 20 ft. or so is the safe limit with a parallel interface. The PowerType uses a standard DB-25 female connector, so it can be used with regular RS-232C cables. On other printers, the addition of a serial interface might cost anywhere from $100 to $200; here, it's built in.

The PowerType's serial word length, parity and bit (or baud) rate are controlled by front-mounted switches. Baud rates from 150 to 19,200 are supported.

User Comments

The PowerType is reasonably fast at its price—for a letter-quality printer—with a printing speed of 18 characters per second. (Better, much costlier formed-letter impact printers can whiz along at 40 and 50 cps, of course.) Its "throughput" is further enhanced by bidirectional printing (unless intentionally disabled), which eliminates time-consuming carriage returns. This means it will print to the right until it reaches the end of a line, then drop down to the next line and continue printing "backwards"—in other words, from right to left as opposed to the normal left to right.

The PowerType "looks" at the length of each line before actually printing it out, adjusting its right margin automatically wherever necessary. This results in faster overall printing speed. I ran a test of the PowerType's throughput and found it to be roughly 16 or 17 characters per second, depending on line lengths.

The PowerType has a friction roller that allows you to use single-sheet, roll or perforated pin-feed paper (up to 13 inches wide, as noted earlier). No roll paper holder is supplied, which is one shortcoming of this printer, but it's easy enough to make your own out of wood, wire or sheet-metal materials.

A tractor (price not yet announced) will soon be available for the PowerType, allowing you the option of using pin-feed paper of various widths.

Switches and software commands allow you to specify vertical tabs, top and bottom margins, vertical paper movement (up or down in increments ranging from 1/48-inch to 2.65 inches), line feed, form feed, set top of form. Another switch sets the page length to 11 or 12 inches. You can also set a switch for carriage return plus line feed, or carriage return only, as you wish.

The PowerType also boasts a "self-test" feature that's activated by putting in a sheet of 11-inch wide paper and holding down the LF (line feed) button while turning on the power. This will give you a three-line print-out of the machine's entire 96 characters in regular, bold and shadow print styles at 10 characters per inch (cpi).

Using another switch or software command, you can print up to 110 characters on a line in pica pitch (10 cpi), 132 characters in elite pitch (12 cpi), or 165 characters in condensed pitch (15 cpi).

If you wish, you can specify proportional printing, where each character space is a width based on the specific character being printed. With proportional printing, *i* and *l* are given less horizontal space than standard letters like *b* and *c*, while extra-wide letters like *m* and *w* are given still more space. You can also set print pitch to any value from 1/120 to 126/120 inch to obtain "overlay" characters for graphics effects.

In addition to its text modes, the PowerType offers two graphics modes in which 1/60 or 1/120 inch horizontal movement can be specified with a space or backspace code, and vertical movement is in 1/48-inch increments. This enables you to print up to 1320 dots (120 × 11 on an 11-inch line, or 5760 dots (120 × 48) in a 1-inch square. Consequently, this letter-quality printer is capable of producing extremely high-resolution graphics printouts!

Of course, you can specify left and right margins, horizontal tabs, and backspacing. You can also specify bold printing, shadow printing (double-strike with a slight horizontal offset), underlining, subscripts and superscripts.

The PowerType Users Manual I received, though a preliminary version, was very good. It contained many detailed illustrations, plus all the necessary charts and instructions you need to set the switches and effectively use this printer. A Final User's Manual was to be sent to all owners who returned the manufacturer's 180-day warranty card.

I found the preliminary manual

sufficient to allow me to test all the modes of operation I've described. Frankly, about all that needed to be added to my preliminary manual were some specific programming examples and additional details on graphics and downloading a special printwheel sequence.

Now the bad news

I mentioned earlier some minor annoyances with this printer. The most annoying to me, primarily because I am a roll-paper user, is the lack of a tear-off bar above the platen. I use a straight-edge for this purpose, but the omission of a tear-off bar seems to me a glaring oversight. Sadly, many printers also ignore this need.

Slightly annoying, but understandable, is the noise level when the PowerType is printing. It makes a racket—although nothing like the loud tap-dancing noise of an ADAM printer. Also, there is noticeable vibration, especially if the printer is mounted on a flimsy table. Much of this can be alleviated by placing a thick foam pad, like those designed for typewriters, under the printer.

Surprisingly, there is no "out-of-paper" switch, so single-sheet operation must be watched closely. Also, when inserting paper, it is necessary to turn off the printer and manually move the print head to the center of the platen. Otherwise, the left paper edge catches in the ribbon guard. This is minor—unless turning off the printer zaps some special commands you have installed.

Another item you may have come to accept as a "standard" feature in printers, but is curiously lacking in the PowerType, is a print buffer. There are no provisions for installing a buffer inside the printer. So if you want the convenience offered by a buffer, you will have to use an external model.

These reservations aside, though, the PowerType has more features than I have even seen before in a low-cost letter-quality printer, though some features are absent, as cited earlier. As a letter-quality printer in the very modest price class, Star Micronics' new entry is a worthy challenger to the handful of other competitive brands on the market, and may even become the standard against which others are measured.—*Fred Blechman*

CIRCLE 97 ON FREE INFORMATION CARD

CIRCLE 37 ON FREE INFORMATION CARD

The Versatile 555

from page 58

R2 in series but discharges through *R2* alone. The output pulse must be wider than half the period of oscillation. If the output of an astable circuit is used to trigger a monostable circuit, the pulse width of the monostable circuit can be adjusted to any fraction of the period that is at least the width of the trigger pulse. The astable circuit will establish the frequency, and the monostable circuit will determine the pulse width.

In the circuit shown in Fig. 3, connecting pin 2 to pins 6 and 7 will result in an astable oscillator. The frequency can be varied by changing the charging rate. A signal coupled to the base of the transistor causes the frequency to vary linearly with the signal. As with pulse-width modulation, the carrier frequency should be many times greater than the highest-frequency component of the signal. If the output is used to trigger a monostable circuit with pulse-width modulation, as discussed earlier, two independent signals can be transmitted on the same carrier.

The average voltage over the period of one cycle of the carrier frequency will vary in proportion to the sum of the two signals. The FM component can be separated by a phase-locked loop (PLL). If this component is subtracted from the sum of the two signals, the difference will be the signal resulting from pulse-width modulation.

If pin 4 is momentarily held low, the circuit will reset (output low) and remain that way for the duration of the reset pulse. As soon as pin 4 goes high, the capacitor begins to charge and the output goes high. Since the capacitor may be fully discharged during the reset pulse, the first charging interval may be longer than normal, but oscillation resumes at the free-running frequency after that.

If the circuit generating the reset pulses is operating at a much lower frequency, the output from the higher-frequency oscillator will be in bursts that are synchronized with the reset pulses. Such a circuit could be the basis for a sonar device, such as a depth finder, that generates short bursts of sonic or supersonic waves and listens for the echo during the interval between bursts.

Limitations

While the range of potential applications for the 555 is very broad, it does have its limitations. Temperature changes cause less than 0.005 percent change in the timing interval or frequency per degree celsius. Slow changes in the supply voltage also have little or no effect.

However, the effect of voltage and temperature changes on the external circuit components must be considered. Rapid supply voltage variations that occur during the timing interval will affect the operation of the circuit. The supply voltage should be held constant by regulation and/or suitable decoupling where accuracy is an important requirement.

Even with these measures, alternatives should be considered if an accuracy of better than one percent or a frequency of greater than 100 kHz is required. **ME**

A Universal Coil Tester

from page 78

directly under one of the ¼ʺ holes. Make sure the diaphragm is pointing outwards, facing the outside world.

The LED can be installed in the circuit board as soon as the glue has set. First, push the dome of the LED through the front panel and glue it in place. Now adjust the length of the leads so that one end of the PC board rests against the earphone, all the while keeping the board parallel to the front panel. Solder the LED in place and then attach the PC board to the back of the earphone with a dab of glue.

While the assembly is drying, drill a hole in one end of the plastic case large enough to accommodate a pair of wires. These wires will serve as the test leads for the coil-tester. You may make a nifty pair of test leads by cutting a jumper clip lead in half and pushing the cut ends through the hole. Tie a knot in the wires and solder them to the PC board so that they can't be pulled back through the hole.

Using The Tester

Your instrument is now ready for use. All you need do is insert the battery into its holder. No provision has been made for an on/off switch; it really isn't necessary. The circuit draws very little power, so a fresh battery will provide many months of service.

Here are some helpful hints, though, that will make your coil-tester even more useful. Your coil-tester is extremely frequency sensitive, so you must make a good connection to the inductor. Just a couple of ohms of series resistance make a big difference in how audio sounds.

Shunt resistance also plays an important role in the quality of the sound. If the coil has a short—even if it's just a couple of turns—there is a noticeable change in the tone. It may sound very strained or not be audible at all. The LED will probably light under these conditions, however, indicating that you are making proper connection to the coil. In this manner, leakage resistance as large as 100 ohms is easily detected with this tester. Try that with your ohmmeter!

If you happen to have an identical coil on hand, you can even be more critical in your testing. Test the good coil first, then the suspect coil. Listen for a difference in the sound. The questionable coil should produce an identical sound it it's good. This same technique can be used to identify unmarked coils in your junk box.

Other uses include the testing of induction motors, auto ignition coils and power transformers. Although this is not the most sophisticated coil-tester around, it is extremely versatile, portable for field work, and costs very little when compared to commercial models. **ME**

"I am HERO JR."

from page 71

also be installed to double HERO JR.'s normal 4-to-6-hour operating time. A 12-volt wall charger provides full recharging of the batteries overnight (about 6 hrs.) while HERO JR. is in the sleep mode.

What he Does

According to Wayne Wilson, Product Manager of the General Consumer Products division of the Heath Company, HERO JR. is ". . . sentimental, sophisticated, and at times a real ham." For example, HERO JR. wakes up his owners with a personalized alarm and can sense whether ot not they awaken. To boot, he even permits a 10-minute snooze period to elapse before making a second attempt at waking you.

Another thing HERO JR. can be made to do is greet you with such phrases as: "I am HERO JR., your personal robot" and "I am your friend, companion, and security guard." If you really want to personalize the greetings, you can have HERO JR. identify you by name.

If you have to justify to your wife the money you plan to spend for a HERO JR., you can point out his very practical ability of being able to guard your home against intruders. Even with optional add-ons, he can issue a verbal warning and request a password. With an optional Heath GDA-2800-3 security transmitter, HERO JR. can even activate the Heath burglar alarm when an intruder is detected and fails to give the appropriate security code.

HERO JR. is a kid at heart. He enjoys playing games like "Cowboys and Robots," "Let's Count," and "Tickle Robot." (Other game cartridges are also available.) And when he's hamming it up, HERO JR. can sing "Daisy" and "America" from his preprogrammed software and other songs from optional cartridges.

The show topper is HERO JR.'s "Robot Variety Show," in which he demonstrates the numerous personable tasks he can perform.

Parting Remark

While HERO JR. is certainly no Positronic robot like those in Isaac Asimov's "robot-series" of science-fiction novels, he's much more than just a sophisticated toy. With all his abilities—both built in and optionally available—he gives a greater dimension to the meaning of the term "robot" than may of the much more expensive robots you might see in department stores or roaming around consumer electronics shows. True, HERO JR. has his lighter side, which certainly puts him in the "toy" category, but he also has a very practical serious side that makes him an attractive addition to your home as a premises protector.

The lack of an articulated arm prevents HERO JR. from pouring you a drink or fetching your newspaper and slippers. But the companionable way he follows you around and engages you in all sorts of activities makes up for this deficiency.

If HERO JR. sounds like the kind of friend and companion you'd like to have, look for him around the holiday gift-buying season in department and speciality retail stores or in Heath Electronic Centers. **ME**

Apple IIc Computer

from page 33

PFS File, VisiTerm, Bank Street Writer, Dow Jones Market Analyzer, Multiplan, Visicalc, and a host of others do not run or do not perform perfectly on the IIc. Some are available in separate versions for the IIc, but then they are not interchangeable with the IIe's or other II's. With the immense library of Apple II Software, however, this still leaves an Apple IIc owner with an enormous choice.

In addition, the absence of a parallel port on the IIc eliminates the use of some hardware attachments. Moreover, there aren't many printers or disk drives that can be operated with the IIe that work with the IIc.

Is this nitpicking? I think not. The Apple IIc is simply not a precise upgrading of a Model IIe with new clothes. For the general buyer who isn't much interested in having a choice of a zillion peripherals, it really doesn't matter much. For the first-time buyer, just be sure that the software being purchased is the Apple IIc version or indeed works with the IIc. Compensating for this in the future will be software that takes advantage of the fuller memory contained in the IIc, enabling it to run more sophisticated software (though it won't handle much of the memory-hungry software designed for full-time business applications).

The truth is that there isn't much competition in its price class for the IIc if you want color as well as black-and-white and lots of software (that's carefully chosen). The IIc is still an old friend that's been repackaged for family use with more standard facilities that a model II-series ever had. It's friendlier, too. In line with Apple's recent not-necessarily-for-tech-people philosophy, no one should even have any difficulty setting up the machine. Connecting cables are labeled with mistake-proof icons. Together with simplified operating instructions, it promises one a fast start in computing.

With upcoming options such as a battery power-supply, connection facilities to an automobile's cigar lighter, and an LCD screen, it promises easy transportability should one wish to buy the extras.

So the Apple IIc did not fall too far from the original tree. For a novice with no technical inclinations, it is indeed a fine family computer. For more adventuresome people, however, I'd recommend they take a closer look at the older Apple IIe. **ME**

BOOK REVIEWS

Understanding Digital Troubleshooting by Don L. Cannon. (Texas Instruments Learning Center, 272 pages, $6.95.)

Another in TI's marvelous series of "Understanding" books on electronics, this one leads off with the fundamentals of digital logic systems, segues into functions, and then, in the remainder of the text, illustrates how to approach troubleshooting techniques. The latter includes logic problems, memory problems, input/output problems, basic timing problems, and advanced techniques. Amply illustrated and clearly written, this makes a fine underpinning for anyone interested in digital repair work. Each chapter concludes with a quiz, with answers in the back of the book, providing readers with an easy self-study program.

Computer Programs for Amateur Radio by Wayne Overbeck and James A. Steffen. (Hayden Book Co.; 327 pp.; $16.95.)

More and more hams are using personal computers to reinforce their communications hobby. Since many aspects of radio amateur work are data-intensive, this is a natural marriage. There are 60 program listings, written in Microsoft BASIC, in this book. They're designed for use with TRS-80, Apple, Commodore, IBM-PC, and CP/M microcomputers. The majority of programs involve data base management, latitude-longitude, contest logging and dupe-checking, antenna design and evaluation, and earth-moon-earth work.

This is more than a program-listing book, though. Chapters 1 through 5 cover the evolution of microcomputers, hardware, and language, all in a brisk, friendly manner. What follows are applications programs with notes by experienced hams who are also into computers. As a result, the writers apparently empathize with hams who need a hand in merging the hobbies. The result is a welcome book that should make working a station more enjoyable than ever.

Build Your Own Laser, Phaser, Ion Ray Gun & Other Working Space-Age Projects by Robert E. Iannini. (Tab Books Inc., 390 pages, $14.50.)

This over-size book with its 14-word title promises a lot and, indeed, delivers a lot of electronic building plans. Though it doesn't really provide you with plans to emulate the space-age weapons in *Star Trek*, it does present some off-beat projects. The material is divided into four sections: lasers, ultrasonics, high voltage and scientific, and wireless transmitting. Each section commences with some theory to lay the groundwork for what's to come. Each project includes operational theory, fabrication, assembly steps, and troubleshooting. They're unusually complete, too, with nice big illustrations to guide the way, from pc foil patters to schematics to sketches. So if you want to build an infrared laser gun, a rodent and pest controller, a Tesla coil, a long-range FM voice transmitter, and a host of other projects in these categories, here's your opportunity.

Microprocessors In Industry by Michael F. Hordeski. (Van Nostrand Reinhold Company; hard cover; 523 pp.; $49.50.)

This is a fine book that covers the use of microprocessors in a valued manner. It illustrates in down-to-earth discussions how microprocessors are used in a variety of industrial applications. Covered are a wide variety of control systems, such as employing microprocessors with various sensors, for data acquisition, and with different motors. Additionally, interfacing methods and an overview of other commercial applications of microprocessors are presented.

Mixing hardware and software in as non-technical a manner as possible, and citing how it is employed in practical terms, offers a reader more of an education on using microprocessors than the standard texts on the subject that might bore one to tears can do. The book is nicely supported with drawings, too.

NEW LITERATURE

Free Catalog of tools, computer accessories, and test equipment. A full-color, 130-page catalog from Jensen Tools covers more than 2,000 items of interest to technicians, field engineers, and electronic hobbyists. Includes test instruments, soldering equipment, circuit board equipment, and a variety of precision tools. Write: Jensen Tools Inc., 7815 S. 46th St., Phoenix, AZ 85040.

Catalog Describes Eight New Instruments. VIZ Test Equipment offers a free 20-page catalog that presents more than 50 test instruments in the company's line, including new frequency-counter and isolated a.c. power sources. Technical specifications are listed. Write: VIZ Manufacturing Co., Test Equipment Division, 335 E. Price St., Philadelphia, PA 19144.

Latest Heath Catalog. Heath's colorful 104-page catalog of electronic and computer products in kit form features more than 400 products. New-product offerings includes personal computers, color television receivers, test instruments, computer software, and home security products. For free copy, write: Heath Company, Dept. 150-385, Benton Harbor, MI 49022.

Tools and Equipment. Davle Tech's new catalog 84-DTI-3 features 80 pages of tools and equipment for servicing, laboratory, and hobbyist use. The full-color catalog includes wire-wrapping tools, test and troubleshooting tools, and low-cost tools. Write: Davle Tech Inc., 2-05 Banta Place, Fair Lawn, NJ 07410.

Heating Costs Too High? *from page 75*

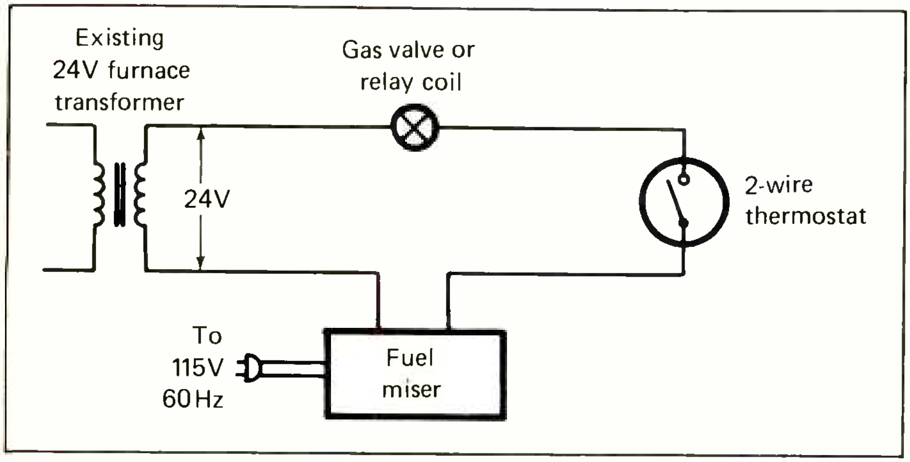


Fig. 5. Installation details for two-wire thermostat heating system.

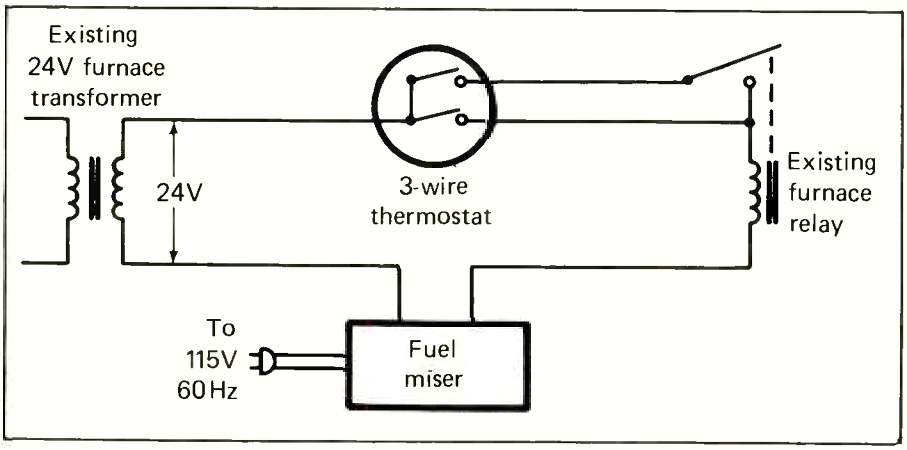


Fig. 6. Installation details for three-wire thermostat heating system.

PARTS LIST

C1—1000-μF 35-V electrolytic capacitor
C2,C3—0.1-μF ceramic capacitor
C4—0.01 μF ceramic capacitor
CR1 thru CR4 silicon diode, 1N2069 or similar.
CR5—5.1-V zene diode, 1N4733 or similar
F1—1-A fuse
IC1—555 timer
IC2—CD4040B 12-stage binary counter
IC3—CD4017B Johnson counter
IC4—CD4011B Quad 2-input, NOR gate
LED1—Light-emitting diode
Q1,Q2—2N3904 transistor or similar
Q3—T2302B triac (RCA or similar)
S1—Rotary switch, 10-position 1 pole
T1—6-V transformer
All resistors ¼-W, 10%
R1—330 ohms
R2,R7—100k
R3—330 ohms
R4,R5—4.7k
R6—100 ohms
R8—10 ohms
R9—10k

Note: The following parts are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: pc board, $4.75; triac T2302B, $3.75; CD 4040B, $3.75. Please include 50 cents for postage.

and check your furnace for normal operation when heat is called for.

Next, set the fuel miser's switch to the 10 percent position. Now set your thermostat to its highest setting and time the cycle of burner operation.

For gas systems the burner should operate about 45 seconds and be off for about 7 minutes. For oil systems, the burner should operate about 3 and be off for about 27 minutes.

When you've checked out your fuel miser, it's time, of course, to set it into operation. It is suggested that you start with a setting of 70 percent for a day or two. With some experimenting, you will quickly settle on a duty cycle that provides you with sufficient comfort while substantially reducing your heating bill.

You will probably find that during severe winter weather, your preferred setting will normally approach the higher end of your new heating scale. During milder weather, though, you'll probably find you can take full advantage of the lower settings—and lower costs. **ME**

Color TV *from page 38*

The Epson Elf receives all standard broadcast VHF and UHF TV channels. Tuning is via a VHF/UHF band switch and separate VHF and UHF dial controls. The remainder of the control complement consists of brightness, color, and tint controls.

Looking Ahead

The big question on many peoples' minds, now that flat-screen video displays measuring only a fraction of an inch deep are available in portable color TV receivers, is whether or not we can expect to see home TV receivers employing this new technology.

Optimistic predictions in this area do see a large picture-frame TV screen for the home in the future. However, these same optimists are quick to point out that the process for manufacturing them is very complex and expensive, and neither it nor the technique for producing it have been perfected for large, flat, color TV displays. **ME**

MODERN ELECTRONICS MART

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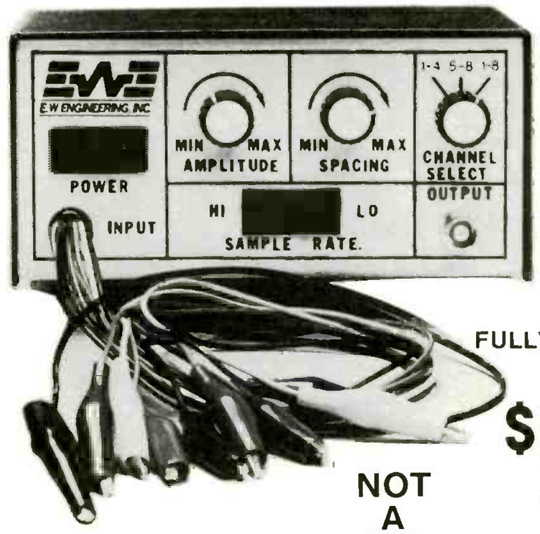

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Impedance: 10.9 K
Input Voltage: ± 5V peak (diode clamped to ± 5 Volt supplies)
Output: Staircase waveform summed with input signals, 0-800 mV full scale
Step Amplitude: Variable 0 to 150 mV/ step
Signal Voltage: Variable 0 to 150 mV/step @ 5V Input
Multiplex Rate: Switch selectable, 40 KHz or 4 KHz
Impedance: 50 Ohms
Power: 105-135 VAC @ 1 V a
Dimensions: 6.25" x 3.25" x 4.75" (WxHxD)
Operating Temperature: 0-40°C
Weight: 1 lb. 10.5 oz.
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Lighted on/off power switch
Wood grain finished metal case

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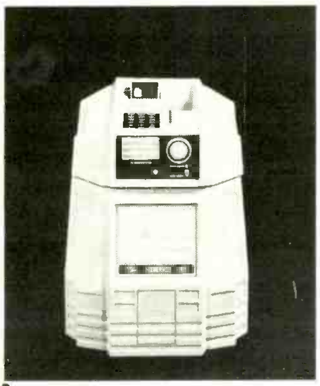

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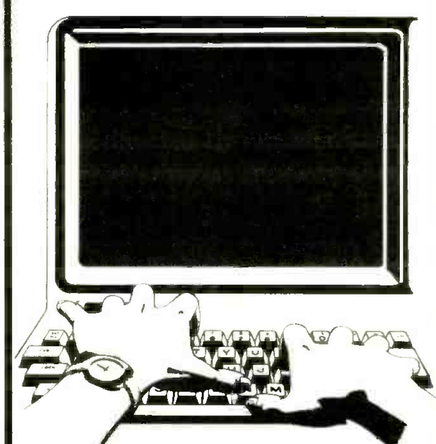

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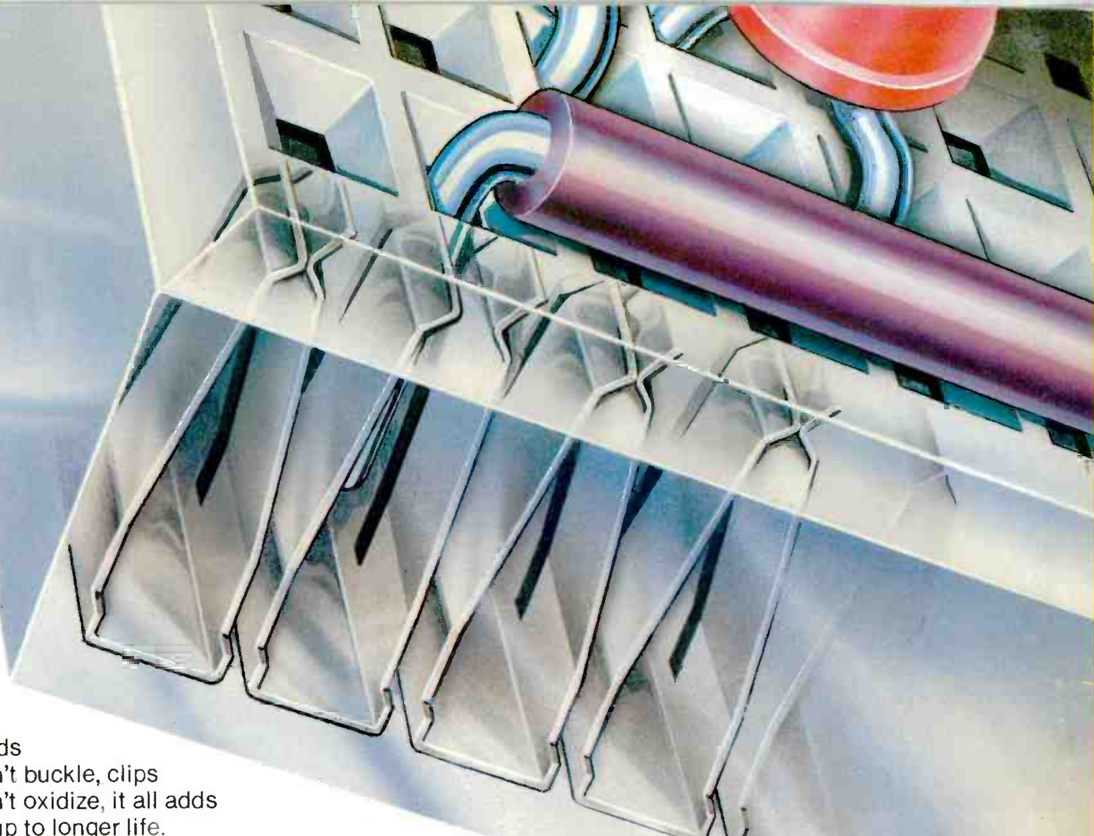

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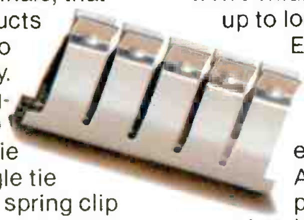

From our largest ACEBOARD with over 5000 tie points, to a single tie point block, our spring clip terminals give you nothing but good, solid contact on every connection. They accommodate a wide variety of leads and have the best electrical properties, because our spring clips are solid alloy, not plated nickel. We've even developed enough normal force to break through any oxides which could occur on solder plated leads. You've come to trust our test clips for the same reason.

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