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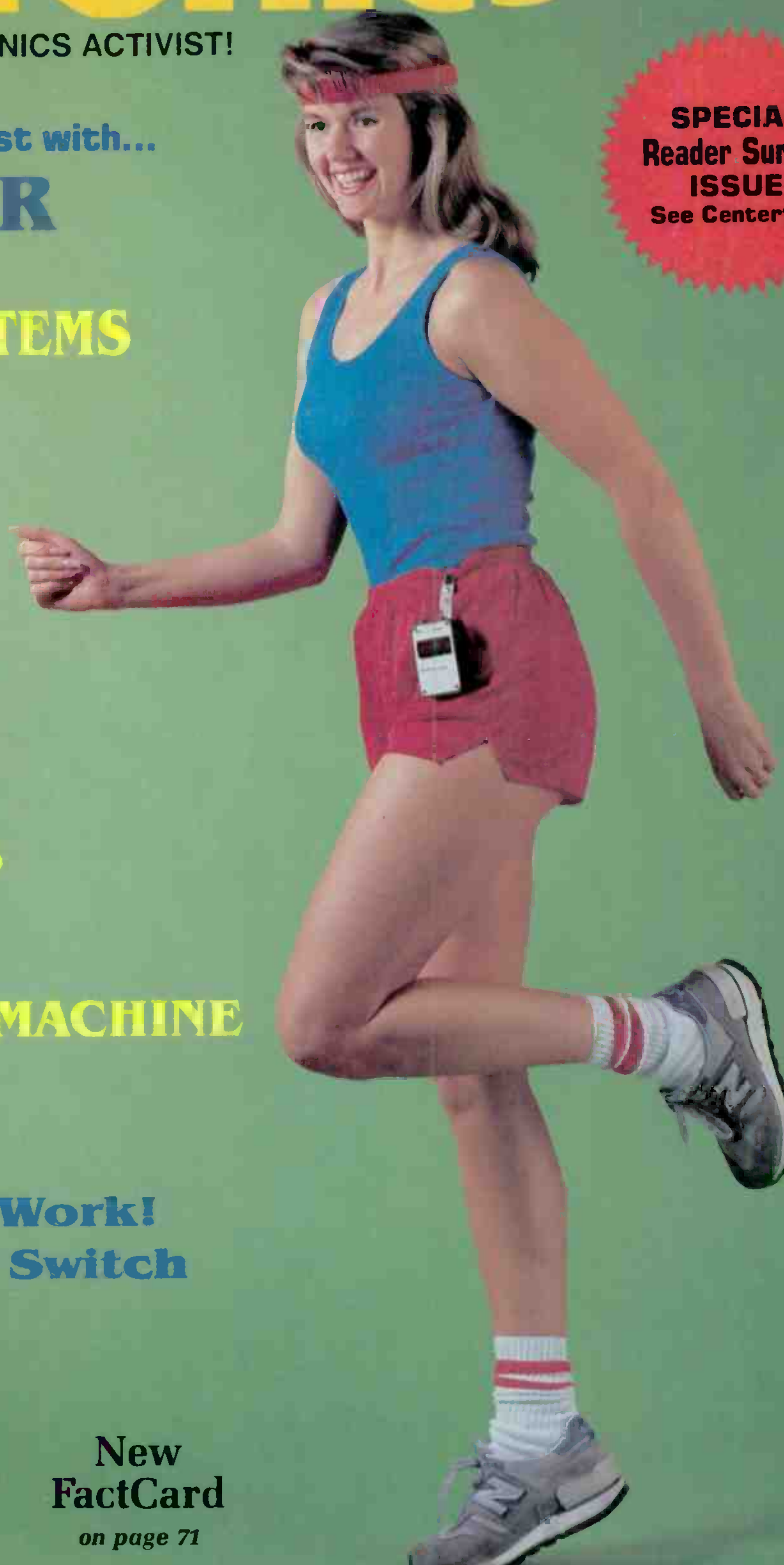

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New FactCard

on page 71

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CIRCLE 28 ON FREE INFORMATION CARD

Hands-on Electronics

Volume 3, No. 4 July/August 1986

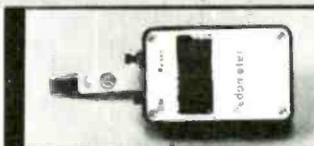
FEATURES

THEORY AND CIRCUITS

CONSTRUCTION PROJECTS

SPECIAL COLUMNS

DEPARTMENTS



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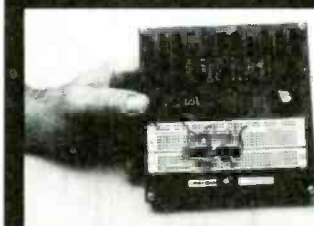
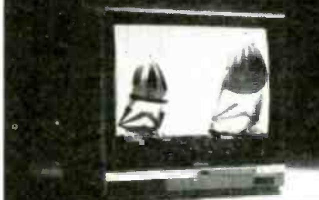


Counter builder—page 33



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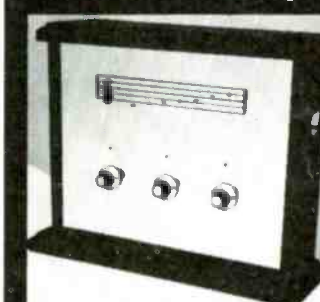

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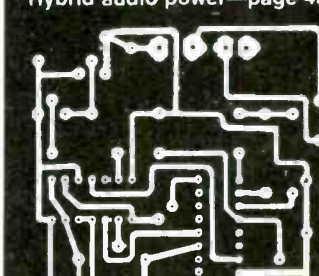

Hands-on Electronics

The Magazine for the Electronics Activist!

EDITORIAL PAGE

Volume 3, No. 4

JULY/AUGUST 1986

New kid on the block!

Hi there, readers! I'm the new member of the **Hands-on Electronics** editorial staff, and I'd like to thank you all...because it's your interest in electronics that's made it possible for me to return to my roots—*electronic projects*.

Although many people claim my very first *home-brew* was a land-detector for Noah, in actual fact my first project was the transmitter Jonah used to send an S.O.S from the belly of a whale. From whale-finding I moved on to VHF radio, auto-electronics, hi-fi, photography, and finally...you guessed it...computers. The problem was, however, that each step along the way I built less and less. The day I measured a full inch of dust on my workbench I knew it was time to get back to my roots—*electronic projects*—and fortunately, **Hands-on Electronics**, was looking for someone who actually enjoys the smell of burning soldering flux.

So here I am, part of the team that keeps you right on top of the action in electronics: whether it's a gizmo that will find wall studs when the carpenter goofed and put them on 20-inch rather than 16-inch centers, or a new kind of home-study that will teach you in less than an evening about other trades that relate to electronics.

And while we're on the topics of *new* and *other*, please complete and mail us the *tear out* survey located in the center of this issue so we'll know the kinds of subjects, projects, and even book reviews you'd like us to cover in future issues. Actually knowing what interests you is a lot better than us making educated guesses—you get more of what you want when we don't have to *guesstimate*.

Until we meet again a few pages down this issue, 73's

Herb Friedman

Herb Friedman, W2ZLF
Associate Editor

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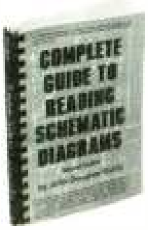

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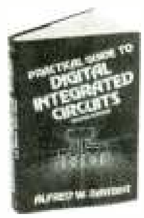

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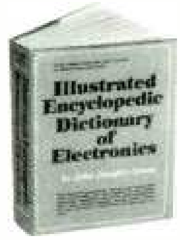

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By John Douglas-Young

Quickly and easily find concise definitions and detailed illustrations for thousands of electronic terms and concepts—everything from Charge-Coupled Devices and Interdigital Transducers to Bubble Memories and Magnetic Amplifiers. This handy workbench tool is arranged in easy-to-use dictionary form. You get mathematical tables, reference charts, conversion factors, preferred values, electrical equations and formulas to help you solve the toughest technical problems. $39.95

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By Robert C. Genn, Jr.

This one-of-a-kind service manual contains nearly 200 tests that cover the spectrum of electronic servicing problems, including audio equipment...linear and analog circuitry...radio frequency equipment...high frequency transistor circuits ...and more. This massive collection of service-related reference data contains everything you need to speed up your servicing and solve problems that stump experts. $29.95

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NEW PRODUCTS SHOWCASE

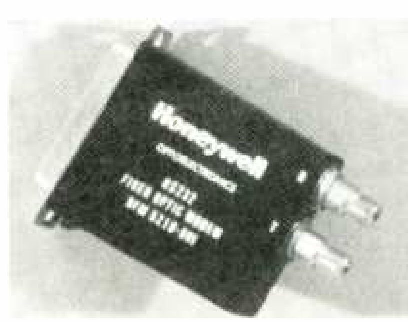
All Purpose Tool Kit

Jensen Tools all-purpose tool kit for the small plant and electro-mechanical service shop features a Codura nylon tool bag and 21 general maintenance tools. Included are screwdrivers, pliers, wrenches, files, hammer and punch, hacksaw, flashlight, socket set, tape measure, knife and more. A 140/100-watt soldering gun is available as an optional accessory. The tool bag has eight sewn-in pouches for small parts and tools, and two triple-partitioned snap-close exterior pockets. For more information write to Jensen Tools, Inc., 7815 S. 46th St., Phoenix, AZ 85044; or telephone 602/968-6231.

CIRCLE 5 ON FREE INFORMATION CARD

Fiber Optic Modem

Honeywell's HFM-5210 asyncronous RS-232-compatible fiber optic modem is a low-cost, compact, secure and emission-free device that can link personal computers to peripherals or mainframes, or connect dumb or smart terminals to mainframes. The HFM-5210 measures only 2.75-inches long by 2.25-inches wide and 0.7-inches thick, which is just slightly larger than the standard RS-232 connector. Other features include low power loss, immunity to interference, high operating speed and low cost.



CIRCLE 21 ON FREE INFORMATION CARD

The modem is immune to ground loop and electromagnetic and radio-frequency interference, and complies with FCC class A equipment requirements. It has full duplex asynchronous operation up to 19.2-kilobits per second. Operating power can be derivied from either the existing handshake lines or pin 9 on a 25-pin connector. The modem plugs directly into standard RS-232, 25-pin ports, and the fiber-optic interface can be either AMP-SFR or Amphenol-SMA.

The HFM-5210 costs $96.10 each for single units, $76.48 each in lots of 500. For additional information, contact Honeywell Optoelectronics Division, 830 East Arapaho Road, Richardson, Texas 75081, or call toll free 1-800-FOR-OPTO.

Pocket Megohm Meter

The Charleswater Micro-Megger provides a safe and simple way of testing the surface electrical resistance of static dissipative and conductive materials. The device is powered by rechargeable NiCad batteries and can perform over one thousand surface measurements on a single charge. Surface resistivity is indicated by a series of LED's.

CIRCLE 25 ON FREE INFORMATION CARD

Incorportating an exclusive bi-electrode system, the Charleswater Micro-Megger measures surface electrical resistance in accordance with ASTM D-257. The unit is palm-size, measuring 3-3/8- L × 2-1/2- W × 1-1/4-in. D. It sells for $249 (list). Literature is available on request from Charleswater Products, Inc., 93 Border St., West Newton, MA 02165.

PC-AT Compatible

Heath's HS-241-1 Advance PC Desktop Computer kit is compatible with the IBM PC-AT computer, but because it uses an Intel 80286 microprocessor and a 6 MHz

(Continued on page 6)

NEW PRODUCT SHOWCASE

(Continued from page 4)

clock speed the HS-241-1 runs 2.5 times faster than a standard IBM PC and up to 30% faster than the IBM PC-AT. Compatibility with the PC-AT allows use of virtually all 16-bit IBM software currently available. The unit supports MS-DOS and also supports Microsoft's Xenix operating system.

The computer comes standard with one serial port, one parallel port, and a 5.25-in. double-sided/double density floppy

CIRCLE 16 ON FREE INFORMATION CARD

disk with 1.2 megabytes of data storage. The controller card accommodates up to two floppy drives and three Winchester disk drives. Memory storage is standard at 512 kilobytes and is expandable to 15 megabytes.

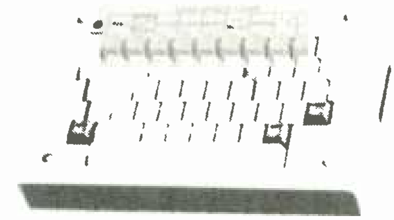
The IBM-compatible keyboard features an enlarged L-shaped *Return* key and a double-wide *Shift* key located at the standard typewriter positions. The computer's detached keyboard is connected by a three foot coiled cord which is expandable to six feet. An improved video design makes the HS-241-1 20 to 400 times faster in screen scrolling operations as compared to the IBM AT.

The HS-241-1's pricing starts at $2899.

For more information about the HS-241 Advanced PC and the full line of Heathkit computers, terminals, printers, peripherals and accessories, send for Heath Company's free catalog. Write Heath Company, Dept. 150-745, Benton Harbor, MI 490022. In Canada, write Heath Company, 1020 Islington Avenue, Dept. 3100, Toronto, Ontario, Canada M8Z 5Z3.

Video Effects Titler

The MFJ Video Effects Titler is a computer-based, stand-alone titler for the home video enthusiast and professional. Featuring a typewriter-style keyboard, it allows the superimposition of 30 pages of color titles over a camera image, or titles may be added over existing video footage during editing. Each of the 30 pages can display eight lines of 16 characters in upper and lower case: each character may be one of 15 colors. The memory is non-



CIRCLE 12 ON FREE INFORMATION CARD

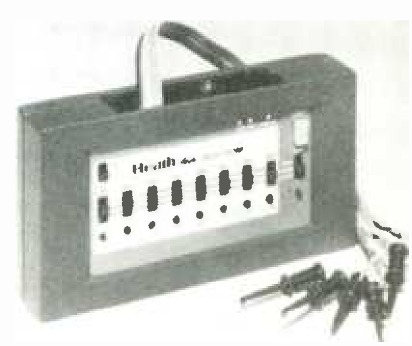
volatile, and up to 30 pages of titles will be retained even after the titler has been turned off or unplugged. The device can also provide power for the camera, give mono or stereo audio signals and allow a remote pause.

An exterior port located on the right side of the unit that is similar to a cartridge connector on a home computer or video game allows the use of accessories as they are developed and released by MFJ.

Intended accessories include character port cartridges for different style fonts (two fonts may be displayed per page), and program cartridges for special effects—scrolling, flashing, special logos, borders and page transistions such as 3-D word zooming and the rearranging of jumbled characters to form words and sentences; Interface connectors are available for the IBM PC, Commodore 64, Apple II+, Apple IIe and the TRS-80 color computer. The Video Effects titler sells for $599.95. For additional information contact MFJ Enterprises, Inc., 921 Louisville Road, Starkville, MS 39759.

A Byte Probe

The ID-4804 Byte Probe is designed to aid in troubleshooting logic circuits by displaying logic levels up to 10 MHz from any TTL or CMOS circuit that operates from a +5 volt DC supply. It can be used to check the logic states of address lines, data lines, and any other general logic level line. It also detects and alerts a user



CIRCLE 8 ON FREE INFORMATION CARD

to a coincidence occurrence of the same logic level on all eight input lines. Also, the probe can be used to trigger an oscilloscope or other test instrument.

The ID-4804 is expandable in 8-bit blocks simply by using more ID-4804

(Continued on page 8)

NEW PRODUCT SHOWCASE

(Continued from page 6)

probes in series. The probe can be powered by either a 9-volt transistor battery or an optional battery eliminator.

More information about the ID-4804 Byte Probe plus other quality test instruments can be found in Heathkit's free catalog. Write to Heath Company, Dept. 150-587, Benton Harbor, MI 49022. In Canada, write to Heath Company, 1020 Islington Ave., Dept. 3100, Toronto, Ontario, M8Z 5Z3.

Strip 'n Crimp Coaxial Tool Kit

Mouser's ME382-SNC859 Strip 'n Crimp Coaxial Tool Kit eliminates most of the problems of finding the correct dies and fittings the next time you want to install crimped connectors on coaxial cables. Packaged in a fitted carrying case, each kit includes a dual crimping tool having dual large diameter pivot rollers, a

CIRCLE 23 ON FREE INFORMATION CARD

controlled cycle mechanism, and a built-in release catch.

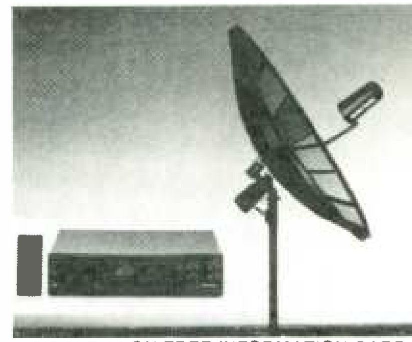
The stripper is the Simplex coaxial stripper, with a renewable three bladed cassette that presets the stripping length.

The Strip 'n Crimp Coaxial Tool Kit is priced at $185. Write for a catalog to Mouser Electronics, 11433 Woodside Ave., Santree, CA 92071; or phone 619/449-2222.

Do-It-Yourself Satellite TV

Designed specifcally as an install-it-yourself home satellite system, the Realistic-2500 Home Satellite System is supplied complete with everything except the simple hand tools and the sand cement to anchor the dish. Supplied hardware even includes color-coded, UL-approved direct-burial type wiring. The installation takes only a few hours, because the assembly is aided by a 30-minute video cassette tape manual that is supplied in addition to a 40-page written guide..

The two main components of the Realistic-2500 are an 8.5-foot mesh dish and a receiver with a hand-held remote control. The receiver automatically switches to the correct stereo format being used by each satellite. (Three different stereo systems are currently being used in broadcasting



CIRCLE 14 ON FREE INFORMATION CARD

television audio and FM radio.)

The horizon to horizon tracking satellite dish is weatherproof. The system "knows," through a built-in computer, the horizontal and vertical polarity of each C-band satellite currently in orbit and those planned in the near future.

The receiver's display screen shows the name of the satellite tuned in, its channel and audio frequencies. Provision is made for a remotely activated external descrambler unit.

The Realistic-2500 Home Satellite TV System is priced at $1995. It is available through Radio Shack Stores and participating dealers.

High Accuracy 4½-Digit DMM

The Mercer Model 9401 is a full function 4½-digit DMM. Its many features include both low and high energy fusing, audible/visual continuity indication, 0.058% basic DC accuracy and data hold. The Model 9401 measures up to 1000-VDC, 750-VAC, 10-A AC/DC and 20-Megohms resistance. Resolution is 10μV,

CIRCLE 10 ON FREE INFORMATION CARD

0.1μA, 0.01-ohms. All voltage and resistance ranges are protected against transients up to 6-kV and 50 μsec.

The meter is powered by a 9-volt battery, which is supplied along with color-coded test leads and an operator's manual. It is priced at $129. For more information write to Mercer Electronics, Division of Simpson Electric Company, 859 Dundee

(Continued on page 12)

New Product Showcase

(Continued from page 8)

Avenue, Elgin, IL 60120. (312) 697-2265.

LED Light Bars

The ME351-1711, 1811, 1911 & 2011 series light bars from Mouser Electronics feature solid state reliability that's compatible with most DTL and TTL circuits. Characteristics include a nominal forward voltage of 1.6 volts at 10 mA, reverse current of 100 µA at 5-volts, and an operating wavelength of 6550. The light bars come in 5 and 10 light arrays, both in the *open* and *enclosed* styles. They are available in red, green, yellow and orange in any combination needed.

Write for a catalog to Mouser Electronics, 11433 Woodside Ave., Santree, CA 92071; or phone 619/449-2222.

CIRCLE 19 ON FREE INFORMATION CARD

Triple Output Power Supply

For $149.95, the MFJ-4002 Triple Output Lab Power Supply offers two variable 1.5 to 20-VDC outputs at 0.5 A and one fixed 5-VDC output at 1 A. The supply is short-circuit protected, has excellent line regulation (typically 0.1%/V) and load regulation (typically 0.1%), and has very low ripple.

Separate transformers are used for

CIRCLE 6 ON FREE INFORMATION CARD

completely isolated outputs; this allows the outputs to be connected in series or parallel for higher voltage or current.

Two lighted 3-inch precision meters are provided for monitoring voltage and current simultaneously. Multi-way binding posts are used for all outputs, with a separate binding post used for chassis ground. The circuit is designed for heavy-duty commercial use in both analog and digital circuits, so it will find application for education, circuit design, product development, testing and repair, quality control, and production.

The MFJ-4002 is made in America and built with heavy guage aluminum. It uses 110-VAC with a 3-wire safety power cord and fast acting pop-out fuse.

To order, or for additional information, call toll-free 1-800-647-1800; or write to MFJ Enterprises, Inc., 921 Louisville Road, Starkville, MS 39759.

Improved Tracking

A moderate-price straight-arm turntable that provides improved tracking—even for warped records—is available from Bang & Olufsen of Denmark.

CIRCLE 17 ON FREE INFORMATION CARD

Known as the Beogram RX2, the turntable features a newly-developed tonearm that also minimizes resonance and record wear. In addition, the RX2 incorporates a new pendulum suspended chassis with

CIRCLE 30 ON FREE INFORMATION CARD

greater mass that increases protection from external vibrations. The new turntable, which uses the familiar elegant Bang & Olufsen slim-line styling, is available from quality audio outlets throughout North America. The suggested retail price is $199.

Computer Oscilloscope Interface

Got a computer but not a storage 'scope? Then use Heath's new IC-4802 Computer Oscilloscope, which turns an IBM-PC or a PC-compatible computer into a dual-trace, 50-MHz, digital storage oscilloscope with a fast 7-nanosecond rise time. Available as a kit or wired, the IC-4802 Computer Oscilloscope adds testing capabilities to any IBM PC-compatible computer, enhancing the computer's function above word-processing and spreadsheet use at the engineering workstation.

CIRCLE 22 ON FREE INFORMATION CARD

Supplied software enables full programmability of the oscilloscope from the keyboard of the computer. The computer displays the dual traces, one for each channel, on an 8- × 10-division graticule. There are three display modes: Y1, Y2 and Dual. All displays are chopped except for the highest time-base range that uses an alternate display. Waveform displays can be stored on a floppy disk for later use as a reference or for waveform manipulation, such as signal averaging.

the Computer Oscilloscope is just one of over 400 products in the new Heathkit Catalog. To receive the catalog free, write Heath Company, Department 150-755, Benton Harbor, MI 49022. In Canada write to Heath company, 1020 Islington Avenue, Dept. 3100, Toronto, Ontario, Canada M8Z 5Z3.

Heathkit Catalog

A wide variety of electronic products in kit form and assembled versions are showcased in the new Heathkit Catalog from Heath Company of Benton Harbor, Michigan. A new 2-Meter handheld-mobile system is being offered featuring ease of operation and greater flexibility. Also, a low-cost user-installed satellite system is being offered featuring the General Satellite Dish and the Norsat Satellite Receiver.

The HW-6502 2-Meter hand-held transceiver is complete with built-in CTCSS encoder, S/B meter, squelch con-

(Continued on page 99)

CIRCLE 27 ON FREE INFORMATION CARD

LETTER BOX

Speaker Filters

In your otherwise noteworthy article on speaker baffles, boffles, and other speaker enclosures (May/June, page 32), reference is made to the dynamic speakers of the late 1920's. Maybe they really existed, but I never saw one. The only kind of speakers I came across were electro-dynamic, which, considering that several hundred volts of DC passed through the speaker, is a far cry from what's described in the article. Exactly what kind of speaker was the author writing about? D.X.E—Mexican Water, UT

The author was using the word "dynamic" as a generic term for speakers having a paper cone and a voice coil. In the early days of radio, most speakers were, in fact, "electro-dynamic," meaning that the magnetic field for the voice coil was created by passing the B+ (high voltage) from the power supply's rectifier through a coil of wire that was wrapped around the rear of the speaker: It was the current through the coil that created the magnetic field.

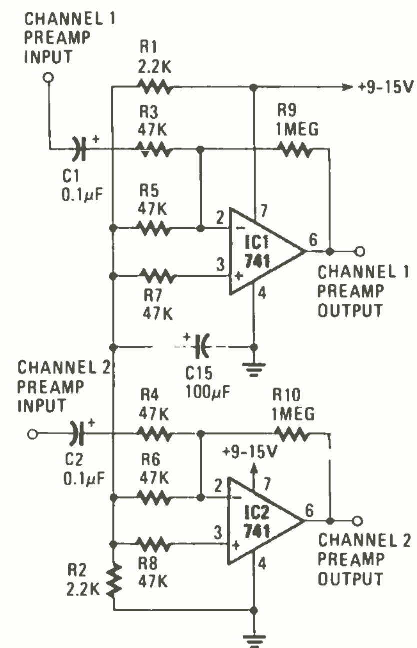
The reason for the electromagnet was twofold: A) The coil functioned as the radio/amplifier's filter choke, thereby eliminating the need for a somewhat expensive and large dedicated filter choke; B) Alnico-5 magnets were not yet developed, so the magnet needed to create the magnetic field necessary for a large speaker would be almost as large as the entire speaker. With the development of Alnico-5, a small magnet no larger than a thumb provided the magnetic field needed by a large voice coil. Almost simultaneously with the application of Alnico-5 to speakers, small B+ filter chokes were developed, as well as high-voltage filter circuits that didn't require chokes, so the electromagnet was no longer needed for either the speaker or the power supply.

The magnet-powered speakers were called "dynamic" speakers, to distinguish them from the electro-dynamic models. Later on the magnet-powered speakers were called PM (permanent-magnet) speakers.

Stereo Preamp

I need a stereo preamp to go between my turntable and my amplifier. I know I could buy one commercially, but I'd rather roll my own. Any ideas? J.T., Waco, TX

The dandy little circuit shown here should do a job-and-a-half for you. You can mount the whole thing on a piece of PC board or perfboard. You should get better than 20-dB gain in each channel. We selected 741 op-amps, because they are easy to get and inexpensive. You may want to opt for a better op-amp type that will give a better noise figure and bandpass. In this circuit the roll-off is acute at 20,000 Hertz, but what recording or FM broadcast goes above 15,000 Hertz?



Getting Past The Barrier

From time to time I see the word *breakover* in an article on how to build something, and it usually refers to the reason why the builder can't make substitutions. Exactly what does breakover mean? Y.F.—Bitter Wells, AZ

"Breakover" is often used as a synonym for the technically-correct term "barrier voltage," meaning the voltage difference at which electrons move (flow) between two different semiconductor materials. In hobbyist projects, it generally refers to the barrier voltage of small signal diodes. For example, germanium diodes have a barrier voltage of approximately 0.3 volts, meaning that the anode to cathode voltage must be 0.3 volts or greater for the diode to conduct; and once conducting, the diode will produce a voltage drop of 0.3 volts. Silicon, on the other hand, has a barrier voltage of 0.5–0.7 volts, which means

the voltage drop across the silicon diode, when conducting, will also be 0.5–0.7 volts. (Controlled "doping" of the semiconductor material can somewhat vary the natural barrier voltage.)

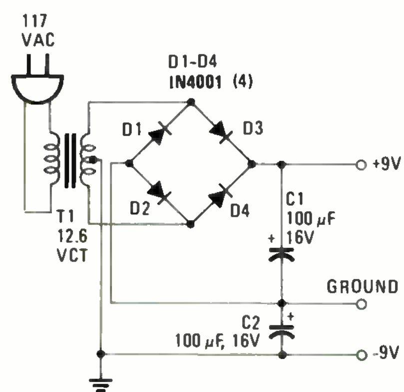
Because of silicon's higher barrier—or "breakover"—voltage, a circuit that calls for a germanium diode might not work if a silicon diode were substituted.

Power Supply

OK, I need a power supply that will give me both nine-volts positive and nine-volts negative. What do I do? Wire up two separate supplies? S.P.—San Francisco, CA

C'mon! You know we've got the answer for you. Check out this schematic diagram. I'm sure it's what you've been looking for.

To keep the record straight, we'd like everyone to know our policy regarding



circuit requests. We do not provide design services. When requests start to pile up, we look to answer the requests as best we can. Sometimes we place the answer in this letter column. Other times we develop a story through a free-lance writer, thus providing the circuit to the readers who requested it. The delay is unfortunate, but we try to speed it up as best we can.

Pacemaker Update

I'd like to add to your pacemaker letter that appeared in the March/April 1986 issue. I have a pacemaker installed under my skin, good for 12 years, with a battery that can be replaced in ten minutes.

I'd like to caution pacemaker users not to work on a car's engine while it is running. You may become very dizzy, because RF energy from the spark-ignition circuitry is too high and may interfere with the pacemaker's operation.

Microwave ovens are no problem to me. However, I found it best not to go through metal detector at airports; have the guards frisk you instead. R.J.M.—Lapine, OR

Thanks for keeping us informed.

Your Circuits Don't Work

Enclosed is the telephone tester I built from your plans. It doesn't work. I think you should check to make sure that circuits work before you publish them. That project cost me a lot of money. T.S.—Wellfleet, MA

At first we thought you were a putting us on; then we realized you might be serious. We don't know what you consider "a lot of money," but the project has only two parts, plus some wire and insulation, which should have cost you less than $2—assuming that you didn't have some of the materials lying around the shop. Of the two components you used, neither are correct. Instead of an LED you used some kind of neon bulb, and the resistor's value isn't even in the same country, let alone the same ballpark as the value we specified. We believe you simply picked up two parts that happened to be on your workbench. If your letter is really serious, we suggest you take up a different hobby. ■

By Herb Friedman

ON COMPUTERS FRIEDMAN

You Must Have Parity

GENERALLY SPEAKING, GETTING A PERsonal computer on-line using a modem should be a piece of cake: plug the modem into the computer, run the communications software, and *presto*, the system is instantly up and running. Unfortunately, it often happens that modem communications becomes a head-splitting nightmare. For example, the user who has absolutely no trouble communicating with his or her own remote lap computer might get only a screen full of garbage when accessing a local community bulletin board (BBS).

Then again, it might be the other way around: The computer/modem might have no problem reading a BBS, but gets totally wiped out when communicating with another computer. And then there's the problem where the user just can't seem to raise anyone via a modem. No matter what's tried, the screen shows garbage at one or both ends of the communications circuit.

Assuming that there's no difficulty with the hardware, problems in modem communications can generally be traced to the software; in particular, the so-called "parity bit."

Everything The Same

In order for computers to communicate via modems, the individual bit elements that make up the electrical structure of each character must be the same on both ends of the circuit. In plain english that means that both computers must use the same baud rate, start bit, same number of characters and stop bits, and if needed, a parity bit—all of which must occur within a specified period of time.

Because virtually all character elements except parity are predetermined, the real key to trouble-free modem communications is the parity bit. Assuming all else is proper and the parity bit is incorrect, the screen will display garbage rather than recognizable characters and text.

Blame The Machine

The problem comes about because our modem ASCII terminal originated as a mechanical device—what we call a *teletypewriter* or TTY. In order to maintain system compatibility, the TTY's mechanical standards were used when electronic terminals were introduced.

Figure 1 shows the data stream for a single character used in the earliest ASCII mechanical terminals. Note that it takes 11 bits (not 8) to represent a character. The first bit (S) is the *start* bit, which starts and synchronizes the mechanical system of the TTY for each character. Next, there are 7 bits that can represent the ASCII codes 00 through 127 (the standard ASCII character set), then a parity bit (P), and finally, two stop bits (SP). The two stops bit gave the mechanical device time to print the character and settle down before the start of the next character.

In later years, the mechanical TTY needed only one stop bit settling time, and so the second stop bit was eliminated for baud rates of 300 and higher. The parity bit got into the electrical structure of each character because TTY communication paths—particularly the wireless circuits—weren't all that good, and the parity bit provided a rough check on the accuracy of the data exchange.

How Parity Works

The parity for the TTY equipment within the same communications circuit could be set to be *odd* or *even*. A transmitting TTY would literally count the number of "high" bits used for the character bits, and if the system parity were even and the count odd, the TTY would set the parity bit high so that the total number of high bits was even. If the character's high bits were even to start with, the TTY made the parity bit low so that the total number of high bits remained even. It was the same for odd parity; the TTY made the parity bit high or low as required to keep the total number of characters and parity bits odd.

(Continued on page 93)

S	1	2	3	4	5	6	7	P	SP	SP

Fig. 1—The conventional ASCII terminal uses 11-bits per character at 110 baud; 10 bits at 300 baud and higher transmission rates. At a 300 baud rate (or more) the second stop bit is eliminated.

BOOKSHELF

By Barmard de Backus

Digital Logic Failed

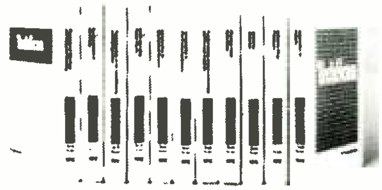
No, this is no expose on some exotic flip-flop. It's an admission of an error! I reveiwed an excellent text, *Handbook of Digital Logic with Practical Applications* by Sam Cowan in a previous issue and placed a photo of another bookcover in the review. (I said I was a *good reviewer*, not *coordinator*!) So, if you were

CIRCLE 18 ON FREE INFORMATION CARD

confused, please forgive me. I am including the correct photo of the bookcover with this comment and with two hopes: The first is that I use the correct photo in this issue; and the second is that I urge my readers, who are inclined to experiment with digital circuits, to circle the number below the photo on the free literature post-card in this issue. If you want direct action, write to Prentice-Hall, Inc., Dept. F. Roes, Englewood Cliffs, NJ 07632 for the catalog that includes the above title.

Getting To Know About Almost Everything
By TPC Training Systems

Because electronics is presently so significantly integrated with other technologies, it's no longer possible to get by with a working knowledge of only electronics. Today, the electronics technician—and even hobbyists—must be able to understand the blueprints and drawings used for other technologies: You're not going to get very far if you confuse, say, the parallel-line symbol representing a



CIRCLE 7 ON FREE INFORMATION CARD

relay contact in an electrical drawing with the parallel-line symbol used to represent a capacitor in an electronics schematic diagram.

One way to get a handle on other technologies is through a TechScan, a *volume* (monograph) specifically designed to cover the basics and applications of particular technological fields. Essentially, a TechScan is a desktop guide for people who need to know the basics of a particular technology, but who don't have the time to attend classes or seminars, or who simply have no need for *in-depth* knowledge.

The TechScan volumes are at *entry level*, meaning that they are written in a particularly clear and concise style that explains and defines the *buzzwords* indigenous to each technology. Also, the volumes are extensively illustrated with drawings, pictorials, and schematic diagrams that use the symbols and organization native to each particular field. In that way the reader not only learns how to understand the blueprints and drawings of other technologies, but also how to express his or her own ideas in a way that that others can understand.

TechScans are priced at $19.95. There are presently 11 volumes available, covering a broad variety of subjects, such as: Elements of Drawing and Blueprint Reading, Fundamentals of Air Conditioning, Refrigeration, Electrical devices, Mechanical Devices, Power Plants, Instrumentation and Process Controls, Industrial Materials, Automation in Industry, and even Introduction to Electronic Equipment.

For additional information on the subjects available, quantity pricing, or just general information, write or phone the publisher, TPC Training Systems, 1301 Grove Ave., Barrington, IL 60010; Tel. 312/381-1840.

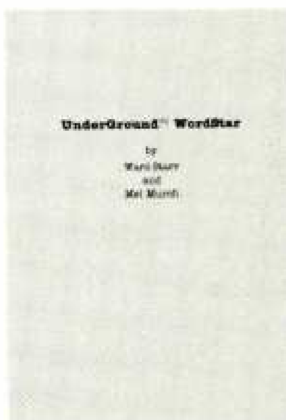
Underground WordStar
By Ward Star and Mel Murch

WordStar was the first full-featured, general-purpose word-processor to hit the microcomputer market. It has gone through several incarnations, and, despite the difficulty people have in learning how to use it, a devoted following has eagerly learned how to squeeze every last drop of performance from *WordStar*.

Many tips on how to increase *WordStar's* performance have been printed in various publications. The Hard/Soft press has collected many of those tips, and others from out-of-print MicroPro documents, as well as numerous discoveries and hints of their own, in an 80-page + diskette package called *UnderGround Wordstar*. The information contained there is specifically applicable to the IBM-PC version of *WordStar*, but CP/M users may learn a thing or two from it also.

Specifically, the package discusses basic uses of all the standard *WordStar* commands, and it provides information on how to use the dreaded *dot* commands. The diskette includes sample *MailMerge* templates that you can adapt for uses such as variable file printing, multiple-file printing, etc.

If you're willing to learn to use DEBUG, the MS-DOS system debugger (and *UnderGround WordStar* shows you how), you can customize



CIRCLE 13 ON FREE INFORMATION CARD

WordStar to your heart's content. (The diskette also includes a BASIC program that allows you patch WS.COM.) For example, *UnderGround WordStar* includes complete information on how to eliminate *WordStar's* annoying delays; change the meaning of the function keys; add, change, or delete function keys; change the number of lines and columns per screen, foreground and background colors, editing defaults such as line spacing, justification, etc.

If you've kept up with the patches

published in the popular press, and if you have a copy of the out-of-print *WordStar Customization Notes*, you may not need a copy of *UnderGround WordStar*. Otherwise, there's a good chance you'll find at least one gem that makes the package well worth its meager cost of only $19.95 plus $2.00 for shipping and handling from Hard/Soft Press, Box 1277-E, Riverdale, NY 10471.

All About Crystal Sets
By Charles Green

Although we live in an age when an integrated circuit no larger than the head of a pin can represent thousands of transistors, and an entire radio might consist of a single integrated circuit, there is still something thrilling and exciting about old-fashioned *crystal radios*—the kind

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grandpa used to build from scraps of cardboard, old cereal boxes and Grandma's breadboard (a real breadboard).

Written especially for the electronics hobbyist/experimenter, *All About Crystal Sets* explains what the various components that make up a crystal radio do and how they work, and provides schematics and constructions details for seven simple and advanced receiver projects for which the reader makes his own coils, tuning devices, even the tuning capacitor. Some projects use such advanced hardware as a IN34 germanium diode (and that's about as sophisticated as they get), others do it the oldfashioned way with a spiderweb coil form cut from ⅛-inch fiberboard, sheet plastic, or a couple of shirt cardboards pasted together.

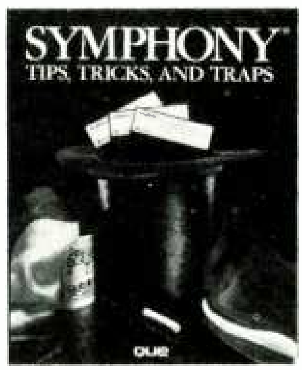
They are all fun projects, certain to amaze and astound visitors to a Science Fair. ("My Heavens! Did people really listen to music on that contraption?) While you probably won't hear any rare DX using these crystal sets, they'll give you many evenings of entertainment just building them.

The book is available at $7.75 (postpaid U.S.A) from All About Books, Dept. B, Box 4155, Freemont, CA 95439. 58 pages. Paperback comb binding.

Symphony Tips, Tricks, and Traps
By Duane L. Feldman

Symphony, the popular integrated program from Lotus Development Corporation, has so many features and little-known capabilities that much of its power isn't realized by occasional, and even frequent, users. *Symphony Tips, Tricks, and Traps* untangles the hassles and simplifies using the program by demonstrating hundreds of shortcuts, helping with problems, and by suggesting many ways to use the program's little-known capabilities—shortcuts that can save hours of work.

Each Tip, Trick, and Trap is a concise, self-contained unit. The Tips are suggestions for achieving maximum productivity. The Tricks are



CIRCLE 11 ON FREE INFORMATION CARD

innovative ways of using *Symphony's* features to achieve results usually not thought possible. The Traps are problems that might be encountered when using the program.

The book explains how to use *Symphony's* Command Language to simplify data entry and create custom menus; how to build macros; how to control interaction with the worksheet; how to move quickly between windows. There are even instructions on creating a desktop organizer, printing documents in multi-column formats.

If you need all the power you can get from *Symphony*, this book will tell you how to get it.

Que Corporation, 7999 Knue Road, Suite 202, Indianapolis, IN 46250. Softcover, 327 pages, $19.95

If you're interested in a book on a particular subject, write to the publisher and ask for a general catalog on that subject. Say **Hands-on Electronics** *sent you.*

JENSEN ON DX'ING

By Don Jensen

Pulling in the Filipino Hot Spots

The media called it a *people's revolution* that ousted the 20-year regime of Philippine president Ferdinand Marcos in late February. But it could, as easily, be termed a *radio revolution*.

For without radio, the 54-million Filipinos in the archipelago of some 7,000 islands would have been out of touch with the political situation in Manila. Radio—far more so than television, according to observers—kept the people informed and brought them into the streets to demonstrate, really making the popular revolt possible.

The key broadcaster during those tense days, *The New York Times* reported, was an old friend to shortwave listeners, *Radio Veritas*.

In the Philippines, *Radio Veritas*—meaning "truth"—has a reputation for living up to its name. In time of trouble, it is the station Filipinos turned to with confidence. Station director, the Rev. James B. Reuter, an Elizabeth, New Jersey native, made no bones about its anti-Marcos position.

With its four powerful transmitters—a medium-wave outlet on 849 kHz and three shortwave stations—*Radio Veritas* broadcast non-stop, 24-hours-a-day, during the crisis, until finally, Marcos supporters blasted them off the air.

As *Times* reporter, Francis X. Clines, described it, gunmen invaded the Roman Catholic Church's radio station and riddled its four transmitters with bullets. Station officials said the attackers had caused $1.8-million damage. A local medium-wave operation was patched together, allowing *Radio Veritas* to continue airing its support for Marcos' opponent, Mrs. Corazon Aquino, who became the new Philippine leader. Although it was first reported that it could be from six months to a year before overseas listeners would hear the voice of *Radio Veritas* again, the station has returned to the air with a single shortwave transmitter.

Radio Veritas, which means "truth," broadcasts in at least 14 languages. Its transmitters were machine-gunned off the air during the recent political strife, Only its medium-wave braodcasting has been restored—others to follow soon.

Up until a few months ago, SWL's could find *Radio Veritas* programs in a number of different Asian languages and English on shortwave frequencies including 9,670 and 11,955 kHz.

An earlier problem for *Radio Veritas* may, in the end, be a blessing in disguise, allowing it to return to shortwave in full voice earlier than expected.

Last year, the Catholic Church in West Germany donated a new higher-powered shortwave transmitter to *Radio Veritas*. Marcos, however, decreed that the station would have to pay a $900,000 import duty. But the Federation of Asian Bishops' Conferences, which controls the station, lacked the funds for the entry tax. That equipment, which had been impounded by Philippine Customs before the Marcos overthrow, has been released and should soon be available to improve shortwave reception throughout Asia.

For overseas listeners, there are several other ways to hear the Philippines now.

One of the easiest is by tuning in the *Voice of America* shortwave programs which are relayed by transmitters at Poro and Tinang in the Philippines.

The Poro site has a jumbo, one-million-watt medium-wave transmitter, which can reach listeners in much of Asia on 1143 kHz, plus a pair of 100-kilowatt, three 50-kilowatt and two 35-kilowatt shortwave stations. The facilities at the Tinang site are more modern; a dozen 250-kilowatt and three 50-kilowatt shortwave transmitters.

Not surprisingly, the VOA stations in the Philippines use many languages and many shortwave fequencies—9,575 kHz at 1600 UTC; 9,770 kHz at 2200 UTC; 11,715 kHz at 1300 UTC; 11,775 and 15290 kHz at 2200 to 0100 UTC; 15,215 kHz at 0100 to 0400 UTC, or 15,445 kHz at 1900 to 2300 UTC, are some to try. The English programs of the American Forces Radio TV Service, beamed to military forces in Asia, are also carried by the Philippine relay transmitters at times.

The VOA programs are, of course, the same as are aired by stateside SW stations. The fact that the transmitters are in the Philippines is not readily apparent, except for announcements at beginning and end of transmissions.

Nearly as extensive is the radio network operated by a Protestant religious organization *Far East Broadcasting Co.* It has medium-wave outlets throughout the islands, plus a number of 50- and 100-kilowatt shortwave transmitters not far from Manila.

FEBC Radio International, its shortwave service, likewise used many frequencies from the 49- to the 19-meter band to reach its farflung audiences, programming in most of the major languages of south and southeast Asia, and in English.

Some times and frequencies worth trying include: 9,670 kHz from 1400 to 1600 UTC; 11,850 kHz from 1300 to 1400 UTC, and 15,310 kHz from 2300 to 0500 UTC.

Then there are the government's own shortwave stations of the *Maharlika Broadcasting System* (MBS).

It was Marcos himself, some years back, who chose the Maharlika name for the state-run radio. With nationalistic fervor, he pointed out that the name Philippines—in honor of the discovering conquistadores' soverign, King Philip of Spain—had too many colonial overtones. He prefered Maharlika, an indiginous name for the island chain.

MBS' foreign broadcasting service, called *Radyo Pilipinas, the Voice of the Philippines*, operates on 9,580 kHz with a 50-kilowatt transmitter. It is scheduled in English between approximately 0700 and 1900 UTC.

Tougher to hear for two reasons are the MBS domestic shortwave stations, whose programs are directed to the nation's outlying islands. They are DUB4, running just 2.5 kilowats of power on 3,286 kHz, and the wandering DUH2, nominally 10-kilowatts strong on 6,170 kHz. It has been heard, however, as high as 6,285 kHz.

If you tune in any of these Philippine-based SWB'ers, and want to send them reports of your receptions, here are their addresses:

Radio Veritas, Philippine Radio Educational and Information Center, P.O. Box 939, Manila,

Voice of America, Washington DC 20547.

Far East Broadcasting Co., Box 1, Valenzuela, Metro-Manila.

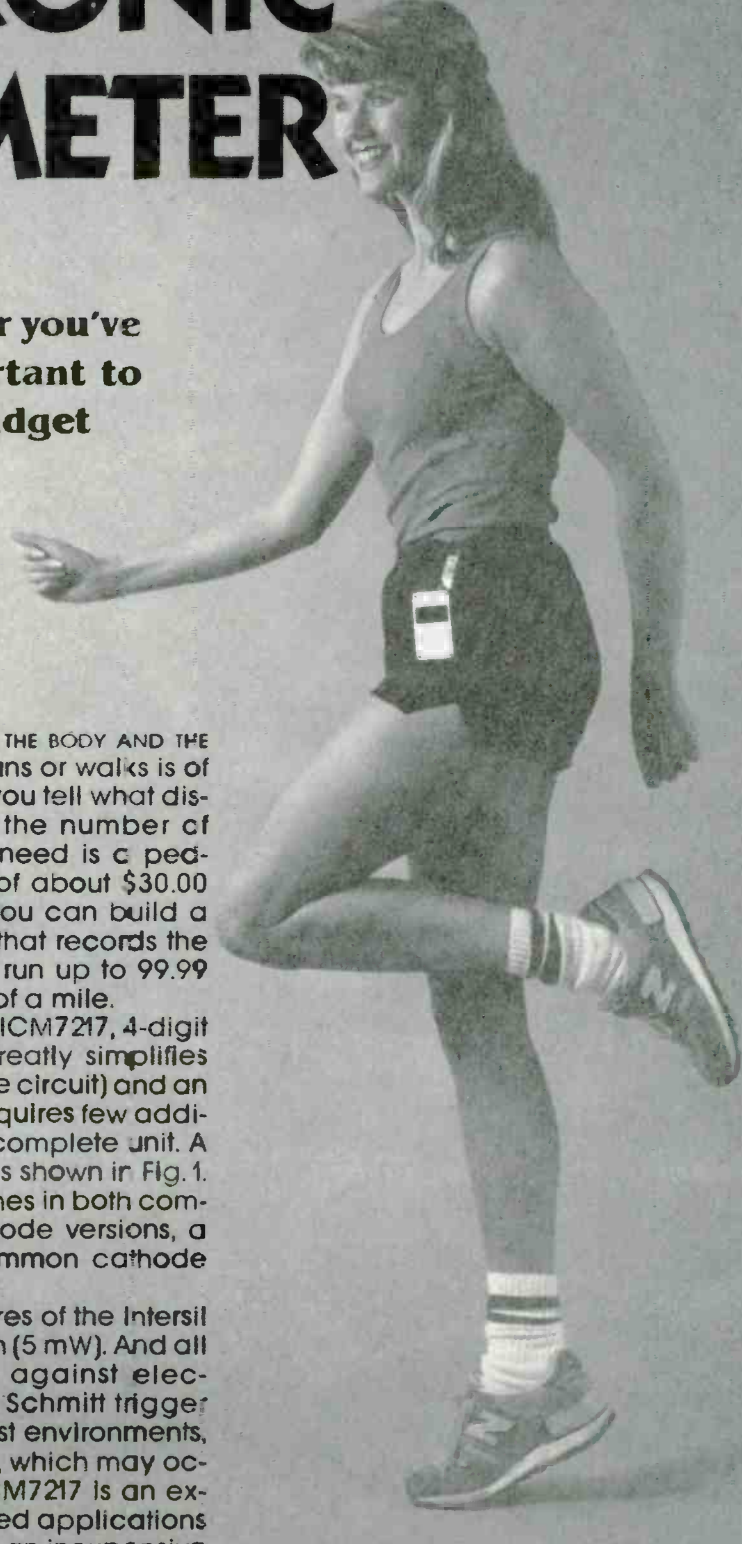
Radyo Pilipinas, 15th Floor, Philcomcen Bldg., Ortigas Avenue, Pasig, Metro-Manila.

Maharlika Broadcasting System, Home Services, Media Center, Bohol Avenue, Cubao, Quezon city 3005.

(Continued on page 106)

Hands-on Electronics
JULY/AUGUST 1986

ELECTRONIC PEDOMETER



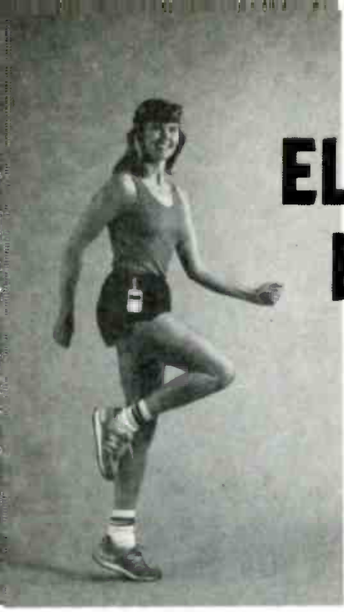
If knowing just how far you've walked or run is important to you, then this little gadget is just what you need.

By James Worzala

A GOOD RUN IS GOOD FOR BOTH THE BODY AND THE mind. So knowing how far one runs or walks is of great importance. But how can you tell what distance you've traveled: count the number of blocks?—not hardly. What you need is a pedometer. Well, for an investment of about $30.00 and a few hours of your time, you can build a small but accurate pedometer that records the distance that you've walked or run up to 99.99 miles with accuracy to a 1/100th of a mile.

The circuit—based on Intersil's ICM7217, 4-digit counter/display driver (which greatly simplifies and increases the reliability of the circuit) and an ordinary 555 oscillator/timer—requires few additional components to build the complete unit. A block diagram of the two chips is shown in Fig. 1. (Note: Although the ICM7217 comes in both common anode and common cathode versions, a block diagram for only the common cathode units is provided.)

Some of the outstanding features of the Intersil chip is its low power consumption (5 mW). And all terminals are fully protected against electrostatic discharge. An internal Schmitt trigger permits operation even in noisiest environments, and prevents multiple triggering, which may occur with changing inputs. The ICM7217 is an excellent choice for battery powered applications and can be used as the basis for an inexpensive



ELECTRONIC PEDOMETER

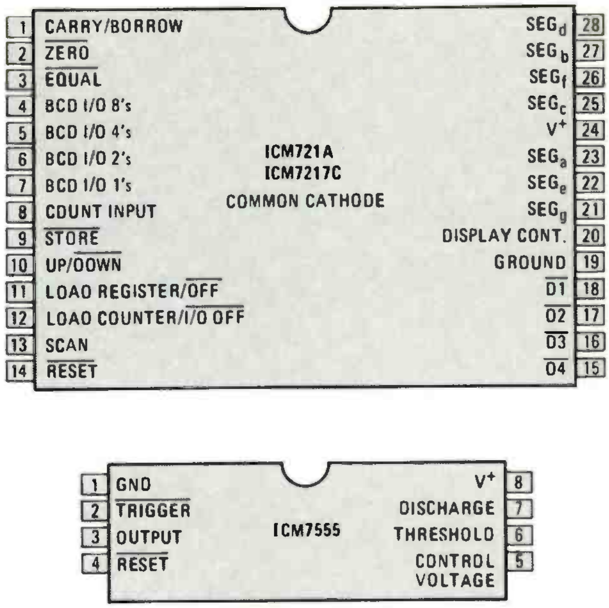


Fig. 1—The pinouts for the two integrated circuits used in the Electronic Pedometer make breadboarding or hand-wiring the circuit using point-to-point wiring or wirewrapping techniques a snap to accomplish without error.

digital counter/display system.

Equally essential to the operation of the Electronic Pedometer is a mercury switch, which acts as a pendulum. Normal walking or running causes the body to sway (rock) back and forth. That rocking motion, in turn, produces a swing in the pendulum. Each swing is then translated into a finite distance or stride. The total distance covered can then be found by counting the number of strides. But enough of this general gibberish; let's get down to the ins and outs of the circuit.

A Closer Look

Refer to the schematic diagram of the Electronic Pedometer shown in Fig. 2. The circuit is triggered into operation by mercury switch S2. One leg of the switch is connected to the supply voltage, and the other is connected to the trigger input of the 555 oscillator/timer, U1. The mercury switch contains a small pool of liquid mercury that opens and closes the contacts as it moves back and forth. Thus, with each swing of the pendulum (mercury switch), the pool of mercury shorts and opens the switch's two inner contacts, producing a pulse for each swing.

The pulse string (strides) is then fed into U1, the stride-adjustment circuit, built around a low-power CMOS TLC555, U1 (configured as a one shot multivibrator), which exhibits greatly reduced supply-current spikes during output transitions. That reduces the need for large decoupling capacitors as would be needed by the 555. The stride-adjustment or pulse-divider circuit allows compensation and calibration of stride variables. For example, a seven-foot basketball player's stride would be much longer than that of a five-foot jockey.

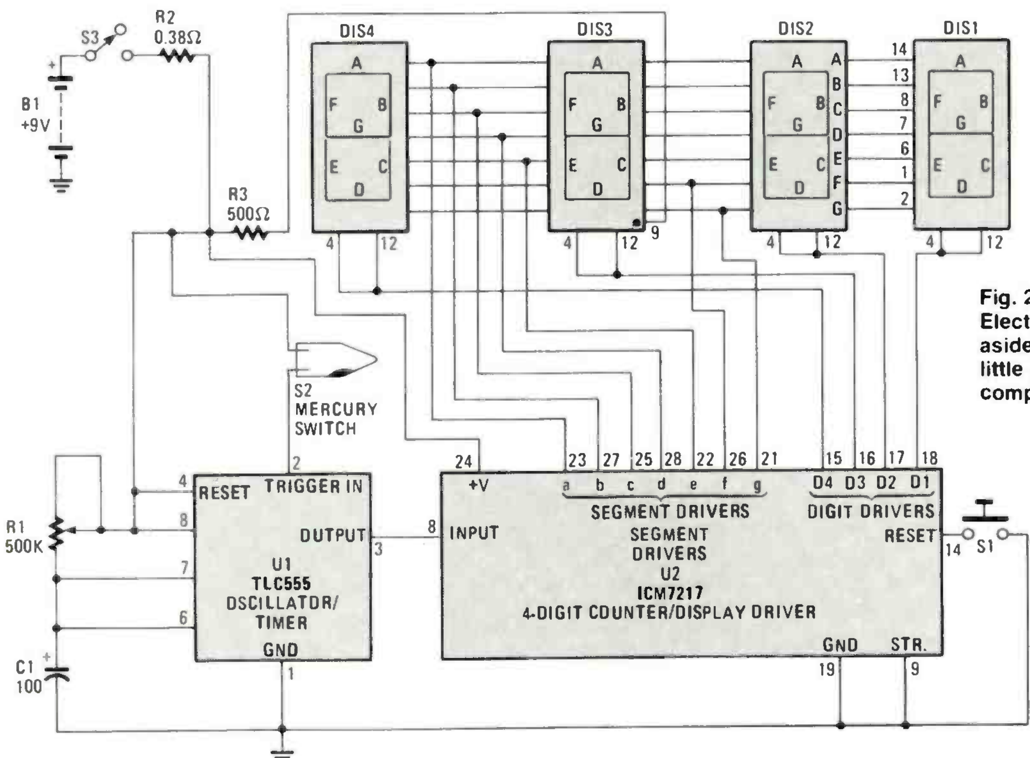


Fig. 2—The schematic diagram of the Electronic Pedometer reveals that aside from the two integrated circuits, little else is required to complete the project.

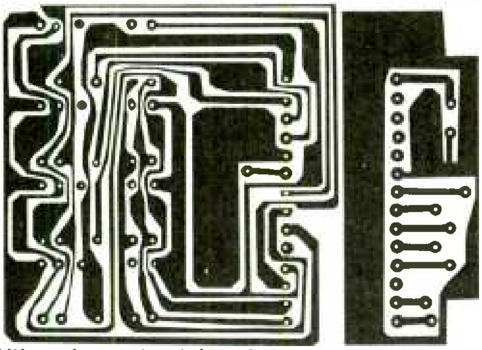


Fig. 3—Although the circuit is quite small, the author chose to use two printed-circuit boards—the template for the counter/display driver board is shown full-scale.

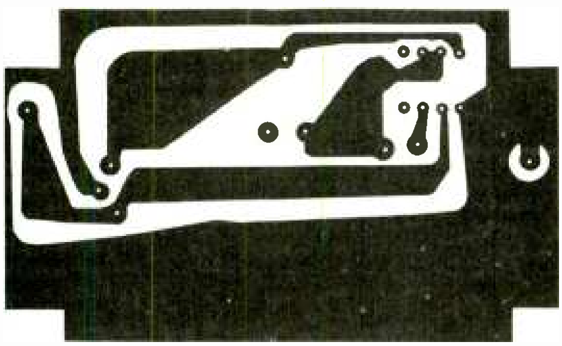


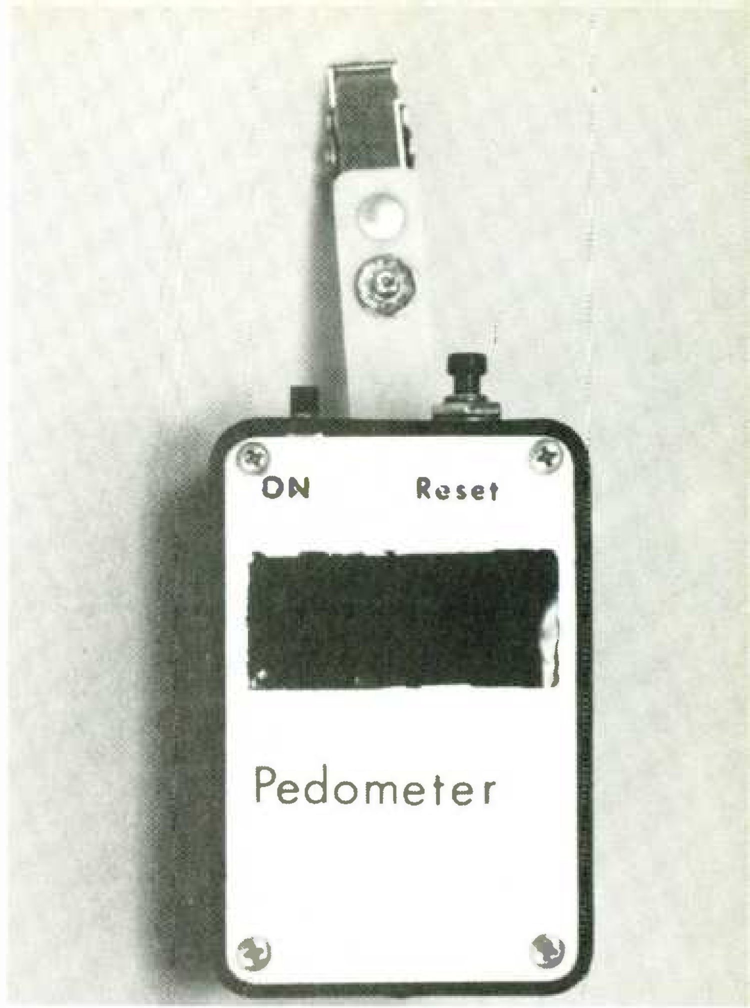
Fig. 4—This full-scale template of the stride adjustment circuit for the Electronic Pedometer can be copied (along with Fig. 3) from the page and used to produce your boards.

Input stride pulses that arrive during the timing cycle are ignored. Careful adjustment of R1 during calibration results in an accurate output pulse at pin 3. After calibration, each pulse equals a distance of about 52.8 feet (or one one-hundredth of a mile); the lowest unit of measurement on the counter. The pulses are then fed into U2. Circuitry within U2 counts the incoming pulses and routes the signal to U2's internal decoder/driver circuits, which provide sufficient current to drive the display. S1, RESET, is used to pull pin 14 to ground, which zeros the four-digit display.

Construction

The author's prototype of the the Electronic Pedometer (see photos) was built on two printed-circuit boards, about 2½ × 1¾-inches and 1⅞ × 2⅞ inches. Full-scale templates are shown in Fig. 3 and Fig. 4. After etching, you can populate the boards guided by the parts-placement diagrams in Fig. 5 and Fig. 6. But, if you prefer, you can put the project together using wirewrap techniques by following the schematic and pin-out diagrams (Figs. 1 and 2, respectively). When drilling the holes in the printed-circuit board, use a #57 drill bit.

A word of caution before drilling: Center punch and then drill. Because of the small size and tight spacing of the boards, it's easy to accidentally jump a pad and sever a signal carrying trace. It would be a good idea also to wear a dust mask while drilling to keep all the nasty fiberglass dust-particles from getting into your lungs! Component values are



The Electronic Pedometer's two tiny printed-circuit boards can easily be made to fit into an enclosure that's small enough to go anywhere you go while attached to your clothing.

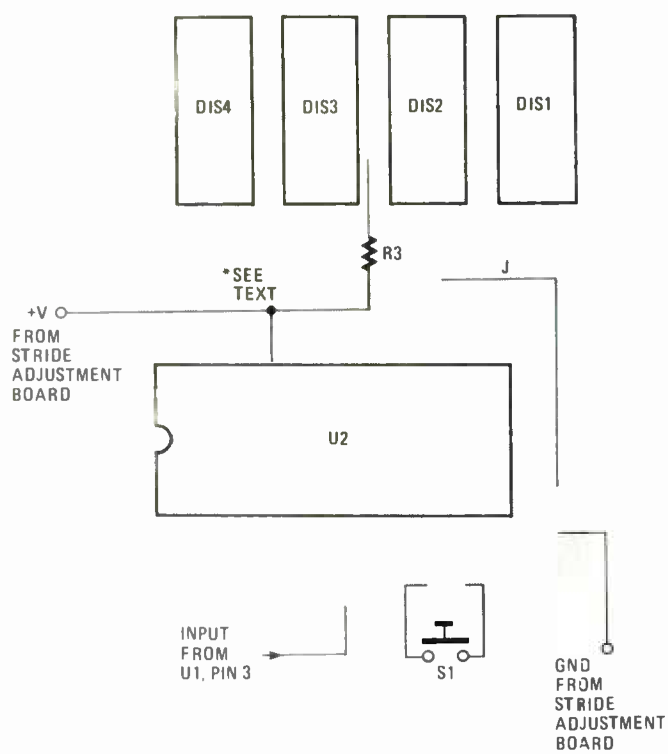
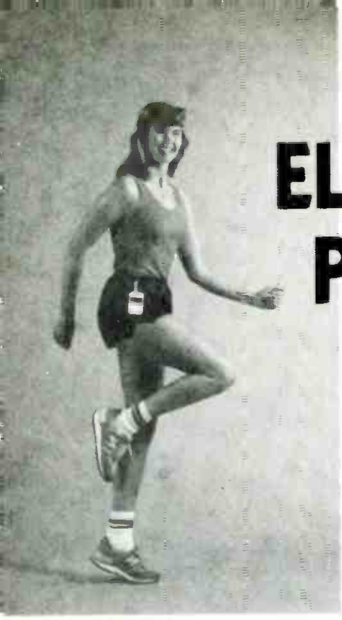
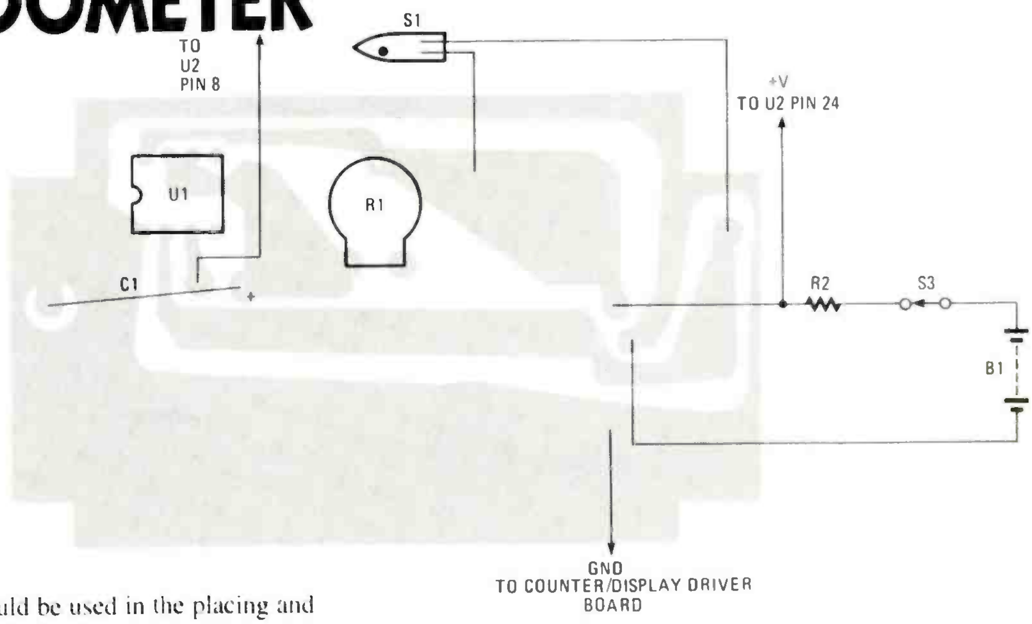


Fig. 5—The parts-placement diagram for the Electronic Pedometer's counter/display driver board shows a jumper connection that, if not included, prevents the entire project from operating. The jumper provides a ground return path and is connected to pin 19 of U2. Also, follow instructions when installing R3 on the counter/display driver board.



ELECTRONIC PEDOMETER

Fig. 6—Although the parts-placement diagram for the stride adjustment board (shown here) may differ slightly in appearance from that shown in the photos, they are electrically (and physically) identical: The only difference is that the circuit was cut down to fit into the smallest enclosure possible.



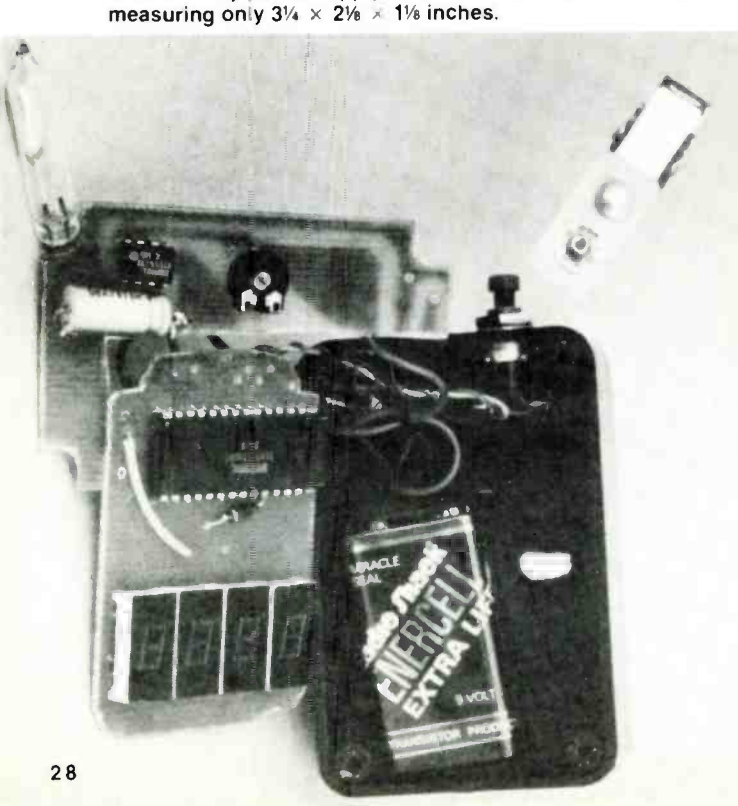
not critical; however, care should be used in the placing and soldering of the parts.

Note particularly, resistor R3 in Fig. 5: Although it appears as an on-board component, one end is really tack-soldered to pin 24 of U2 on the component side of the board and the other end connected to a wire running to pin 9 of DIS3 (as shown in the schematic diagram of Fig. 2). Jumper connections are also needed between pin 4 and 12 of each display module.

Also, the +V tap on the stride adjustment board (Fig 6), which feeds power to the counter/display driver board, can be made at any point in the line after R2 or at an appropriate point on the board itself and tack-soldered to pin 24 of U2 on the copper side of the counter/display driver board. In addition, a jumper should be connected between pin 8 to pin 4 of

(Continued on page 95)

The Electronic Pedometer's two circuit boards, along with the 9-volt battery power supply, can be housed in an enclosure measuring only $3\frac{1}{4} \times 2\frac{1}{8} \times 1\frac{1}{8}$ inches.



PARTS LIST FOR THE ELECTRONIC PEDOMETER

SEMICONDUCTORS

DIS1–DIS4—Radio Shack #2766-075 (or equivalent), seven-segment, common-cathode display
U1—555 timer (Radio Shack 276-1718 or equivalent), integrated circuit
U2—Intersil ICM7217 4-digit CMOS counter/display driver, integrated circuit

RESISTORS

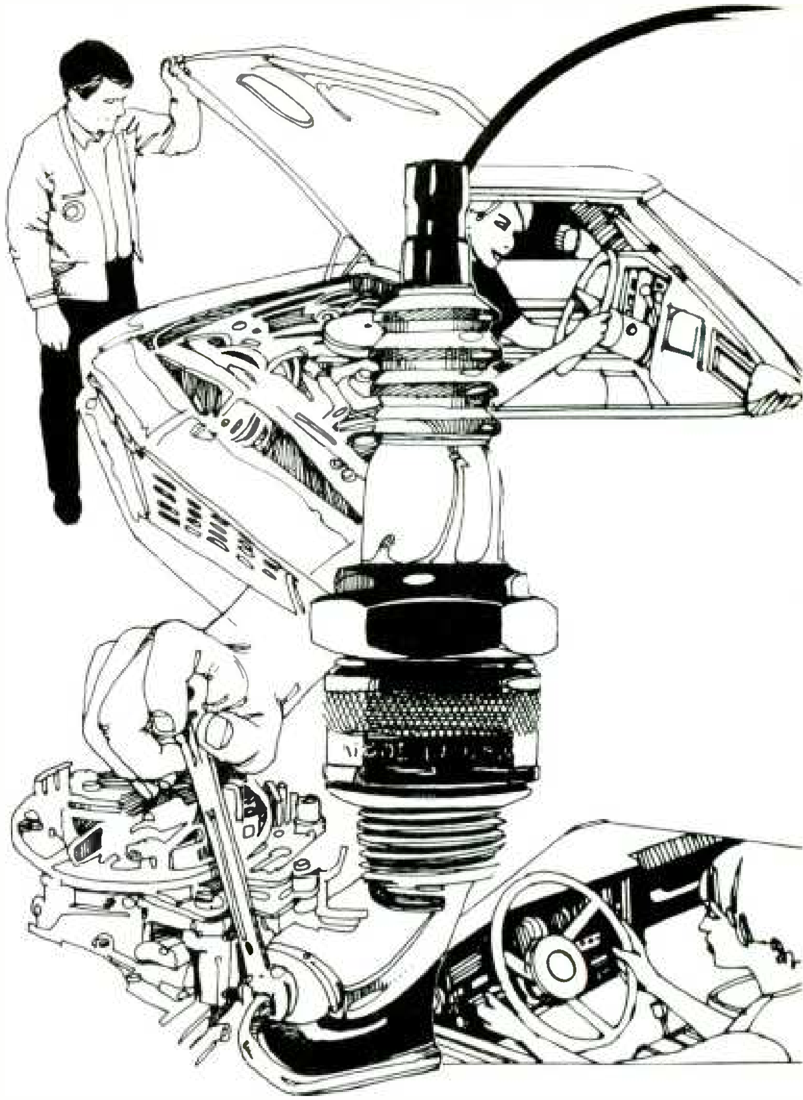
R1—500,000-ohm, $\frac{1}{2}$-watt potentiometer (Radio Shack 271-339 or equivalent)
R2—0.38-ohm, $\frac{1}{2}$-watt, fixed resistor
R3—470-500-ohm, $\frac{1}{4}$-watt, fixed resistor

ADDITIONAL PARTS AND MATERIAL

B1—9-volt transistor-type battery
C1—100-μF, 20-WVDC, electrolytic capacitor
S1—Push-button switch (normally open)
S2—Mercury-bulb switch (Radio Shack 275-027 or equivalent)
S3—SPST, slide or miniature-toggle switch (Radio Shack 275-406 or equivalent)
Experimenters cabinet (Radio Shack 270-230), 9-volt battery connector, wire, hardware, cement, red plastic (to cover LED display) solder, etc.

Note: Intersil's ICM7217 can be obtained from Circuit Specialists Co., PO Box 3047, Scottsdale, AZ 85257; 800/528-1417.

AUTO IGNITION SYSTEMS—



FROM POINTS TO COMPUTERS

By Herb Friedman

Did you ever join a clique of men standing around the opened hood of a stalled car and you couldn't offer a credible suggestion as to why the engine wouldn't run? This article will take you through ignition theory—from the battery posts to the spark-plug electrodes —in clear, concise steps!

MANY OF THE EARLY SLAPSTICK-COMEDY MOVIES DEpended heavily on the automobile. Humor could be found in almost everything about the horseless carriage; from the arm-busting whips of the crank needed to start the car to the shakes, rattles, and rolls once the engine got started. Many of the humorous problems of those early autos—from simply starting the car to keeping it running—depended on the ignition system; and it wasn't until the invention of the *Kettering ignition system* (better known as a *breaker-point* ignition) that the automobile with its gasoline engine became a truly-reliable machine.

The Kettering, or breaker-point, ignition lasted from the 1920's until *computerized* ignitions were introduced in the early 1970's. The first *ignition computer* was actually nothing more than a solid-state switch (transistor) that substituted for the breaker points. But we're getting ahead of ourselves. Today, three generic ignition systems can be found in cars zipping along the interstates.

The old breaker-point ignition is still to be found in the older *buckets of bolts* not yet consigned to the junkyard. Some more modern vehicles use solid-state (transistor-switch) ignitions, and the very latest *wheels* from both Detroit and offshore actually use a computer (or to be more precise, a microprocessor) to control the ignition. We'll take a look at all three, so that you will have some idea of what trouble to look for when your car's engine starts to shake, rattle, and stop rolling.

Give Me A Zap!

The purpose of the ignition system is to produce a spark of sufficient power to ignite the air/fuel mixture in the engine's cylinders. For optimum power, and to prevent the engine from literally destroying itself, the spark must be timed to fire when a piston in a cylinder is at, or slightly before, top-dead center (TDC), ready to be driven downwards on an exhaust stroke by the burning air-fuel mixture. To those of you who've not yet tangled with automotive-electric systems, creating a spark might appear to be a simple enough task. But, contrary to appearances, lots of hardware is needed to produce an efficient spark that occurs at precisely the right time.

The circuit that both generates and times the firing of the spark is called the *ignition system*; although engineering types also call it the *Secondary Electrical System*—the *Primary Electrical System* being the battery and its current-charging system.

The Ignitor

The spark itself occurs in a device called a *spark plug*, which is often called an *ignitor* when someone wants to justify a substantially higher-than-usual replacement price. The spark plug is a simple device with two contacts, and threads into the top of an engine cylinder. One contact is its metal shell, which is grounded through the engine. The other contact is a center conductor insulated by a ceramic sleeve, precisely spaced from the grounded terminal and connected to an externally-switched high-voltage source of from 20,000 to 40,000 volts. When high voltage is applied to the spark plug's center conductor, it leaps across the gap between the center conductor and ground in the volume enclosed above the cylinder where the spark ignites the air-fuel mixture.

Figure 1 shows a simplified breaker-point ignition system for a 4-cylinder engine. To keep things simple, we'll speak of *current flow*, which is a flow of current from the positive to negative terminals of the battery, rather than *electron flow*, which is negative to positive. (The reason for that is that, back in the early days, scientists made a guess on a 50-50 chance and lost! They said that current flowed from positive to negative. When that theory was proven to be incorrect, it was easier to substitute something called *electron flow* than to re-write the textbooks. And since automobile manuals still use "current flow," we'll follow suit.)

The device that actually controls the ignition system is the distributor, which is driven directly by the engine so that it remains in synchronization with the engine. The distributor provides two independent electrical functions. Its first duty is to open and close the breaker points, causing the generation of some 20,000 to 40,000 volts. Its second job is the electrical distribution of the high voltage to the spark plugs through a device called a *distributor cap*—which is nothing more than an insulator that secures the contacts to which the spark plugs connect, and a *rotor*, which is the switch's wiper connection. (As indicated by the dotted line in Fig. 1A, the points and rotor are directly driven and synchronized.)

The rotor's mechanical drive by the engine is so arranged that the rotor is opposite the corresponding distributor terminal when a piston is near the end of the compression stroke, or TDC. (The compression stroke occurs when a selected amount of air-fuel mixture is compressed by the upward stroke of the piston in the cylinder.) A special kind of high-voltage wire connects the distributor terminals to the spark plugs, which are located in the engine's four cylinders.

Generating the High Voltage

Current flows from the lead-acid battery, (Fig. 1) through the ignition switch, through a current-limiting resistor called a *ballast*, into the primary winding (P) of *ignition coil* L1. The other end of L1's primary winding is switched to ground through the breaker points. Normally, when no cylinder is TDC, the breaker points are closed and current flows through the ignition-coil's primary winding. At the instant the rotor is opposite a distributor terminal, a cam within the distributor forces the points to open.

Now, the magnetic field surrounding the primary winding (P in Fig. 1) of the ignition coil caused by the flow of current in that coil collapses almost instantly, inducing a high voltage in the secondary winding (S). (Maximum voltage is always generated when a magnetic or current field is interrupted.) The high voltage flows to the rotor, jumps the small air gap between the larger round-end of the rotor and the distributor terminal, flows through the terminal's connecting wire to the spark plug, and then arcs across the gap in the spark plug, firing the cylinder's air-fuel mixture. Yes, a small arc does occur when the voltage leaps the rotor-terminal air gap, which is what causes the rotor and distributor-cap terminals to wear—actually pitting and appearing burned.

Because the coil's primary winding (P in Fig. 1) is also within the collapsing magnetic field, as you would expect, a high voltage is similarly induced in the primary winding

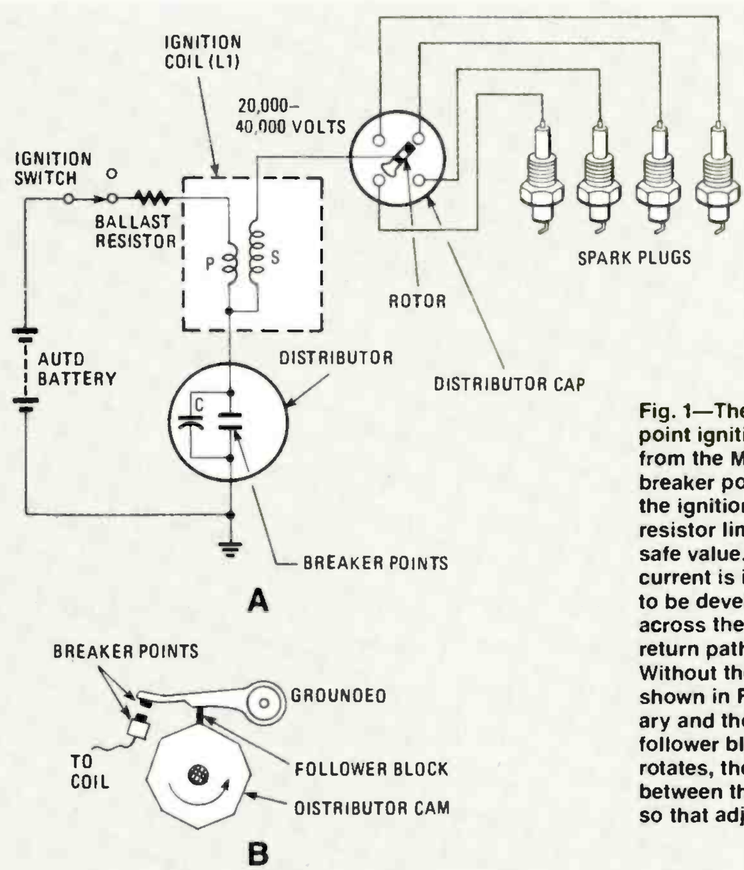


Fig. 1—The simplified diagram, shown in A, of a breaker-point ignition is actually all there was in many vehicles from the Model A Ford to the early 1960's. Normally, the breaker points are closed, permitting current to build in the ignition coil's primary winding, with the ballast resistor limiting current through the primary winding to a safe value. When the distributor opens the points, primary's current is interrupted, causing approximately 20,000 volts to be developed in the secondary winding. The capacitor across the points protects them against arcing and is the return path to ground for the secondary's voltage surge. Without the capacitor there is no high-voltage output. As is shown in Fig. 1B that one set of contact breaker points is stationary and the other is spring loaded, having an insulated follower block that rides on the distributor's cam. As the cam rotates, the points alternately open and close. The friction between the follower block and cam causes wear on the block so that adjustment is required from time to time.

itself, which could possibly arc across the breaker points, thereby *burning* the points. There's also a small arc generated when the points interrupt the primary current flow. To reduce the arcing and its associated damage to the points, a small capacitor is connected directly across the points. (By quenching the arc, the capacitor also helps to reduce electrical interference in the car radio.)

Normally the breaker-point system is simple and works well at low to moderate engine speeds. Other than mechanical wear and tear, and electrical burning on the points themselves, the only problems with breaker points arise at the higher speeds of the modern car. The faster the engine turns, the faster the points open and close, and the smaller the magnetic field created in the coil's primary before the points open. Also, at the higher engine speeds the points tend to *float* (intermittently opening when they're supposed to be closed).

Reduced point contact lowers the magnetic field in the coil, the relatively heavy current switched by the points when directly controlling the ignition coil and the *kick back* (self-induced arcing), the points now controlled only the minuscule current needed to cause the transistor to conduct and saturate (pass large currents).

While that effectively eliminated the burning of the breaker points, the problem of mechanical wear was still left to contend with. Also, as many car owners learned to their horror on a dark and stormy night, engine vapors leaking into the distributor caused an oily *insulating* film to build on the breaker points; suddenly, the ignition would poop out because the points can no longer feed base current to the transistor. As it was to be discovered, the same electric current that caused the point contacts to burn out also burned off the oily insulating film.

The problems of both breaker-point mechanical wear and vapor insulation was eliminated in the early 1970's by replacing the breaker points with a magnetic "pickup coil" in

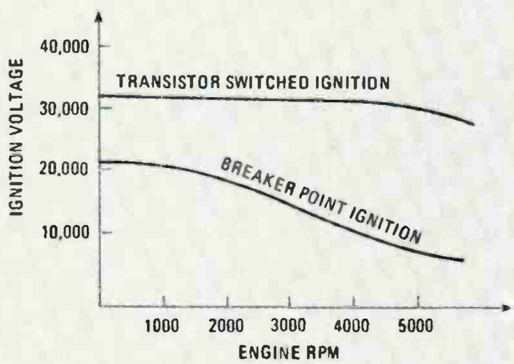


Fig. 2—In a breaker-point ignition system, the ignition coil's output voltage falls off as the engine speed increases. Because transistor-switched ignition allows a heavier current to flow through the coil (there are no points to *burn* with a larger current or float at higher revolutions), the voltage fall-off is sharply reduced.

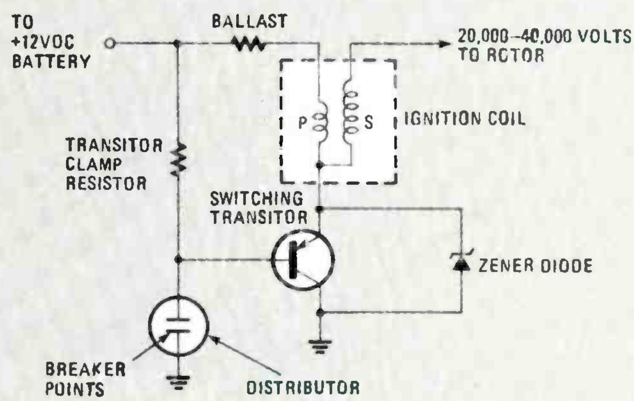


Fig. 3—Earliest solid-state switching used breaker points to control the transistor. When the points were closed the transistor base and collector were connected, causing the transistor to conduct and "charge" the coil. When the points opened the coil's primary current was interrupted, producing a high voltage output from the secondary. The base (clamp) resistor insures that the transistor's emitter-collector opens, and prevents the the 12-volt battery source from being shorted to ground when the points are closed. The Zener diode prevents the coil's self-induced (kick-back) voltage from exceeding the transistor's breakdown rating.

so that the voltage fed to the spark plug is similarly reduced. The fall-off in ignition voltage caused by speed (engine *rpm*) is shown in Fig. 2. In plain terms, one of the causes of decreased engine efficiency as speed increases is the reduced ignition voltage. What was needed for modern cars was an ignition system that would be maintenance-free and relatively unaffected by engine speed. The first successful commercial device was a solid-state controller for the ignition coil.

Computer Switching

The earliest attempt at reducing the failure of breaker points (as shown in Fig. 3) replaced the points as the switching device for the ignition coil's primary winding (P). The switching of the ignition coil to ground was now handled by a solid-state (transistor) switch. The points, however, remained as the triggering device for the solid-state switch. Instead of which a current was generated by a magnetic assembly mounted on the distributor cam. Now it was a wear-free electric current that triggered the transistor. Although automakers took slightly different approaches to eliminating breaker points, all eventually came down to generating the transistor's triggering current by varying the magnetic field through a coil or semiconductor.

Figure 4 shows the distributor's pick-up-coil systems used on Chrysler and Ford engines. Chrysler used a magnetic triggering device called a *reluctor* (as shown in Fig. 4A), which substituted for the cam that drove the points. As the reluctor turns, it varies the magnetic lines of force flowing through a small pick-up coil. At the instant the tips of the reluctor are in alignment with the pick-up coil and magnet, maximum current is induced in the pick-up coil (actually when the tips move out of alignment causing the collapse of the magnetic field). The current induced in the pick-up coil is

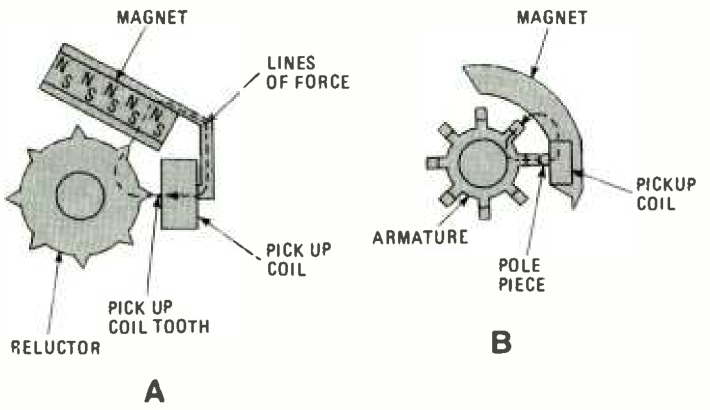


Fig. 4—Instead of breaker points, Chrysler cars use a reluctor device (shown in A) to vary the magnetic field through a pick-up coil. The varying field induces a current in the pick-up that's used to trigger the ignition coil's solid-state switch. Ford cars use a similar device (shown in B) to vary the magnetic field through the pick-up coil.

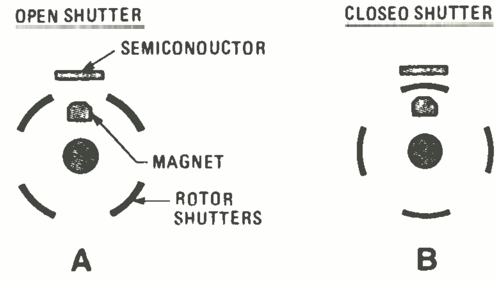


Fig. 5—In a Hall-effect distributor, the magnet and semiconductor sensor are fixed. The magnetic field is varied by rotating shutters that alternately open and close the magnetic path to the semiconductor.

used to trigger the solid-state switch that interrupts the primary current in the ignition coil. The Ford system in Fig. 4B does essentially the same thing by substituting a magnetic device they call an *armature* for the points.

Another substitute for breaker points is the *Hall-effect pickup* shown in Fig. 5. In the late 1800's, Edward Hall discovered that when a magnetic field passes through semiconductor material in which current is flowing, a small voltage—called the *Hall voltage*—is generated across the semiconductor at right angles to the excitation current. As Fig. 5 shows, in a Hall-effect distributor, the magnet and semiconductor material are fixed. The distributor drives a shutter device (a metallic, slotted vane) that alternately blocks and passes the magnetic field to the semiconductor, thus changing the Hall voltage each time that the shutter moves between the magnet and semiconductor. It is that voltage change that's used to trigger the solid-state switch controlling the ignition coil.

Figure 5 shows how a pick-up coil can develop a timed signal that can control a semiconductor switch. As you can see, there are no contacts to wear, burn, or insulate; the solid-state switch is triggered by the voltage (current) induced in the pickup coil.

Computerized Ignition

Now there's nothing wrong with the pickup/transistor-switch ignition. If not for anti-pollution rules, its design might have sufficed well into the next century. Unfortunately, not everything can be improved; there is a limit to what can be done with anything, particularly gasoline engines. The modifications to automobile engines needed to reduce pollution sharply degraded the performance of the automobile. As a result many people considered cars to be unsafe, because they could not accelerate rapidly to reach highway speeds, nor get out of the way of a developing ac l l out of the way of a developing accident.

It was the need to put safe engine performance back into family cars coincident with minimal pollution that created the need for a truly computerized ignition. To keep things simple, early engines used a series of compromises in air-fuel mixture and ignition timing. In fact, the engine has many different operating parameters that depend on external and internal temperatures, coolant temperature, exhaust, and just about everything you can think of.

When we didn't know any better and simply polluted the atmosphere, engines were adjusted to average all the problems and somehow start on the coldest day, becoming most efficient at high-

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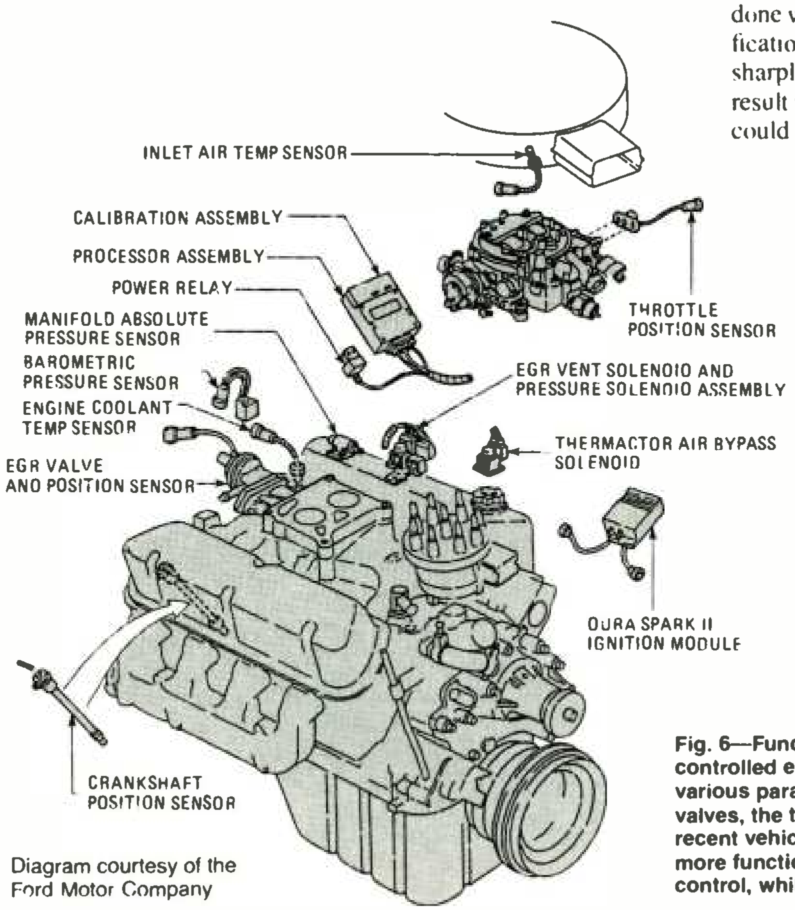
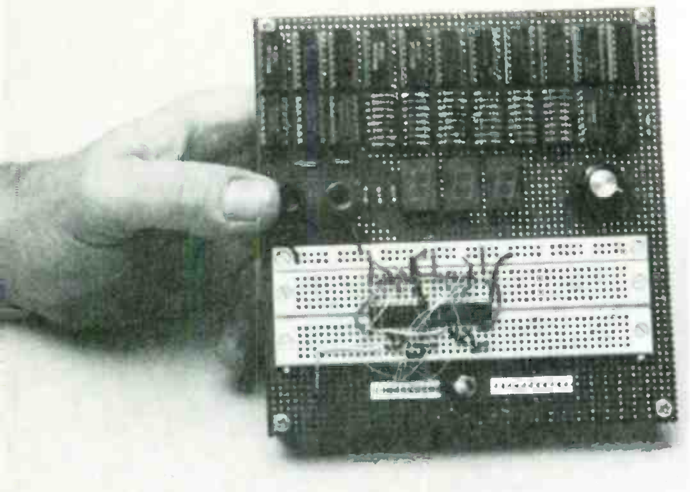


Diagram courtesy of the Ford Motor Company

Fig. 6—Functional diagram of an early Ford computer-controlled engine. The computer not only measures various parameters, it also directly controls various valves, the throttle, and the engine ignition timing. In recent vehicles, the computer measures and controls even more functions in order to further increase pollution control, while maintaining engine performance.



COUNTER DEVELOPMENT CENTER

By Mike McGlinchy

This dandy professional-quality instrument takes the hassle out of building and testing binary and BCD counter circuits.

COUNTERS ARE AMONG THE MOST COMMON OF DIGITAL circuits. They can be used for an almost unlimited variety of applications, among them, measuring frequency and counting pulses, people, things and events. Counters come in many different configurations and designs, such as, divide-by, down only, up-only, up-down, presettable, modulo, unit cascadable, BCD (binary-coded-decimal), binary, and decade. Although counters are a very important part of digital circuits, because of differing notations used to describe the circuits, various operating techniques, and generally poor application literature, counters can often be confusing to understand, develop and use. However, use our Counter Development Center to develop, breadboard and test your BCD and binary (base 2) counter circuits, and the mystery and mystique of counters vanishes in the glow of numeric LED indicators that tell you most of what you need to know about a particular counter circuit. In fact, the Counter Development Center is an excellent device for learning how counters function.

On A Breadboard

Basically, the Counter Development Center consists of a solderless breadboard for assembling counter circuits and a testing device that indicates the count sequence of the counter(s). To keep things as simple as possible, the power source used for the experimental counter circuit also powers the testing device.

Conceivably, counter circuits could be tested by setting up a row of discrete LED diodes individually connected to the Q outputs of the counter and then decoding the LED's BCD or binary count in your head. In fact, this is a good way to easily learn how to count in binary. However, if you're testing a counter with a large count length, or, say, a down counter, you can quickly lose track of the count in the winks and blinks of the LED's. Besides, in this day and age, you want something easier so you don't spend all your time building a test jig or mentally decoding a bunch of blinking LED's. What you want is something that provides a direct decimal readout, which is precisely what you'll get from the Counter Development Center. The block diagram for the Counter Development Center is given in Fig. 1, and the complete schematic diagram is given in Fig. 2.

Numeric Displays

The Counter Development Center displays the count in decimal notation on three 7-segment, numeric-display de-

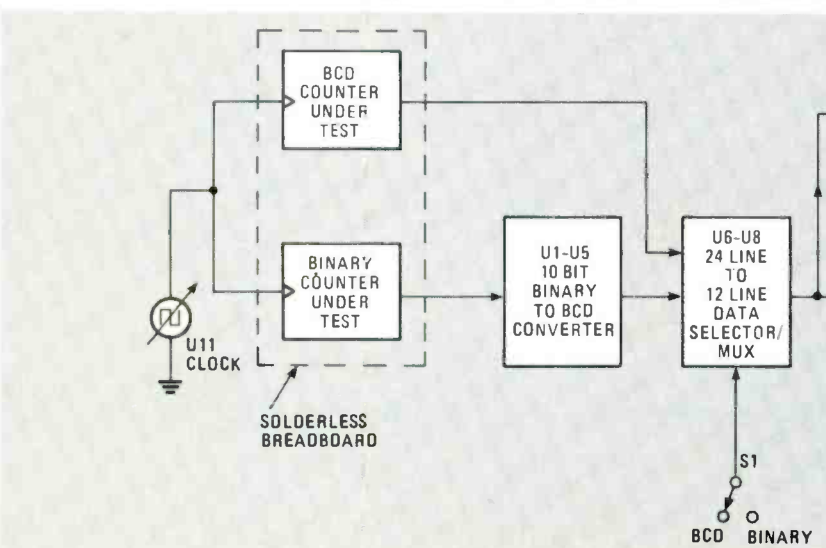


Fig. 1—As shown in this block diagram, there are two independent entry paths: one for BCD counters, the other for binary counters. Although there are only three LED display devices, they provide a four digit display for BCD values representing up to 2 to the tenth power (1024).

PARTS LIST FOR COUNTER DEVELOPMENT CENTER

SEMICONDUCTORS

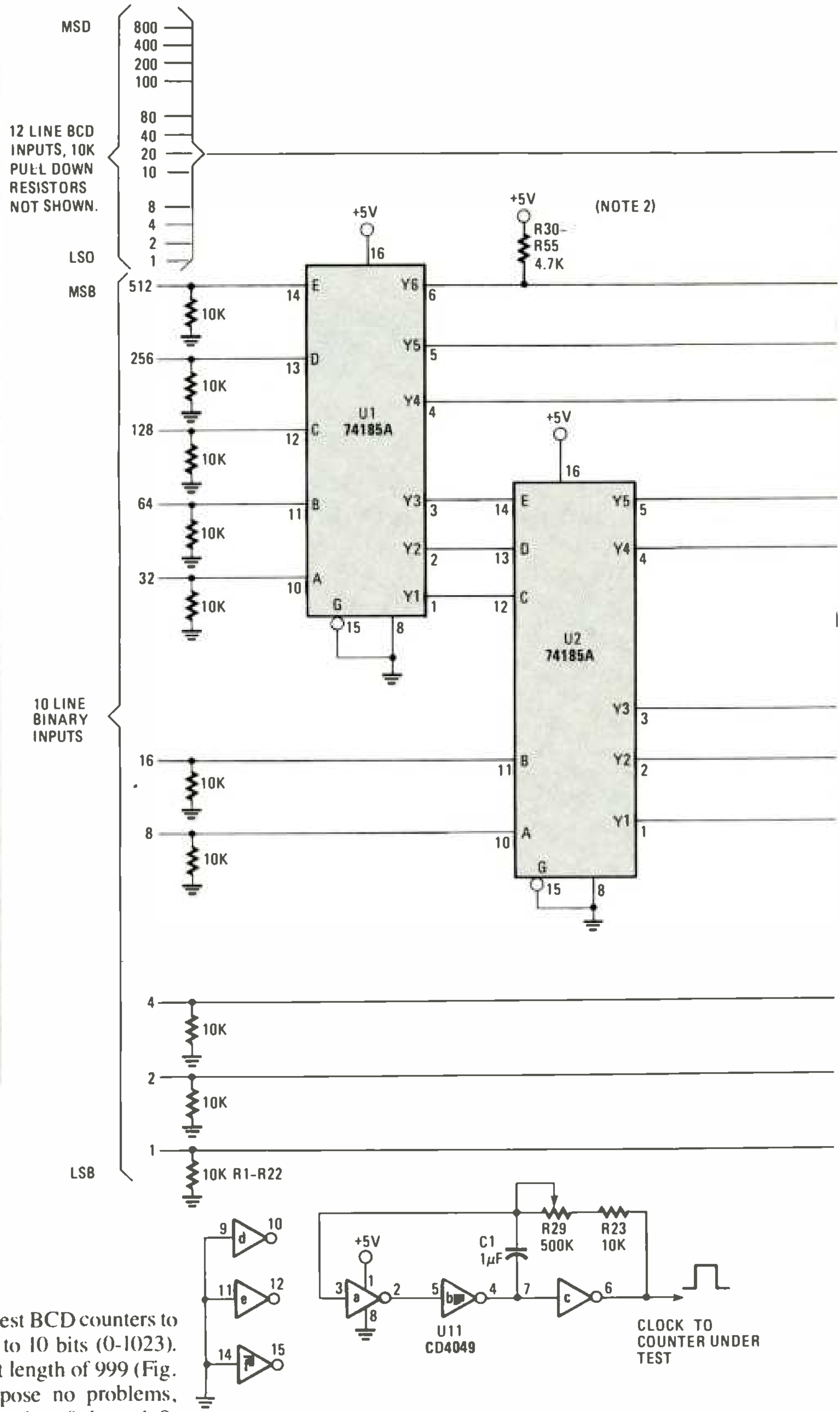
U1–U5—74185 binary-to-BCD converter integrated circuit
U6–U8—74LS157 quad 2-line to 1-line data selector/multiplexer integrated circuit
U9–U10—74LS32 quad 2-input positive OR gate
U11—CD4049 hex inverting buffer integrating circuit
U12–U14—74LS47 BCD-7 segment LED decoder/driver integrated circuit
U15—74LS00 quad 2-input positive NAND gate
DIS1–DIS3—7-segment LED display, common-anode (Hewlett-Packard 5082-7650, or equivalent)

RESISTORS

(All resistors ¼-watt,5% fixed units, unless otherwise noted.)
R1–R23—10,000-ohm
R24, R25—1000-ohm
R26–R28—270-ohm
R29—500,000-ohm, linear-taper potentiometer
R30–R55—4700-ohm

ADDITIONAL PARTS AND MATERIALS

C1—1-µF, 16-WVDC, non-polarized tubular or disc capacitor
S1—SPDT miniature toggle switch
BP1, BP2—multi-way binding posts
Perfboard, standoffs, solderless breadboard, wire, solder, wirewrap wire, 18 16-pin and 3 14-pin wirewrap DIP sockets, headers, knob, etc.



vices; a more convenient way than light-emitting diodes to display a counter's output. Occasionally, it is necessary to build a counter that, for instance, counts from 7 to 13, or 349, or 894. (Try counting 349 LED blinks.)

Four Digit Readout

The Counter Development Center can test BCD counters to 3 digits (0-999) and binary counters up to 10 bits (0-1023). Since 3-digit BCD has a maximum count length of 999 (Fig. 1), the three numeric display devices pose no problems, because each device can display decimal values 0 through 9. However, 10-bit binary equals 2 to the tenth power (2^{10}), which is the same as 1024 unique states (equivalent decimal value 0-1023). This would seem to require four numeric displays, the fourth being used to display counts above 999 (eg: 1021).

Fortunately, the integrated circuit(s) used to drive the display—the 74LS47 BCD 7-segment decoder/driver—provide unique display patterns for BCD input counts above 9 to

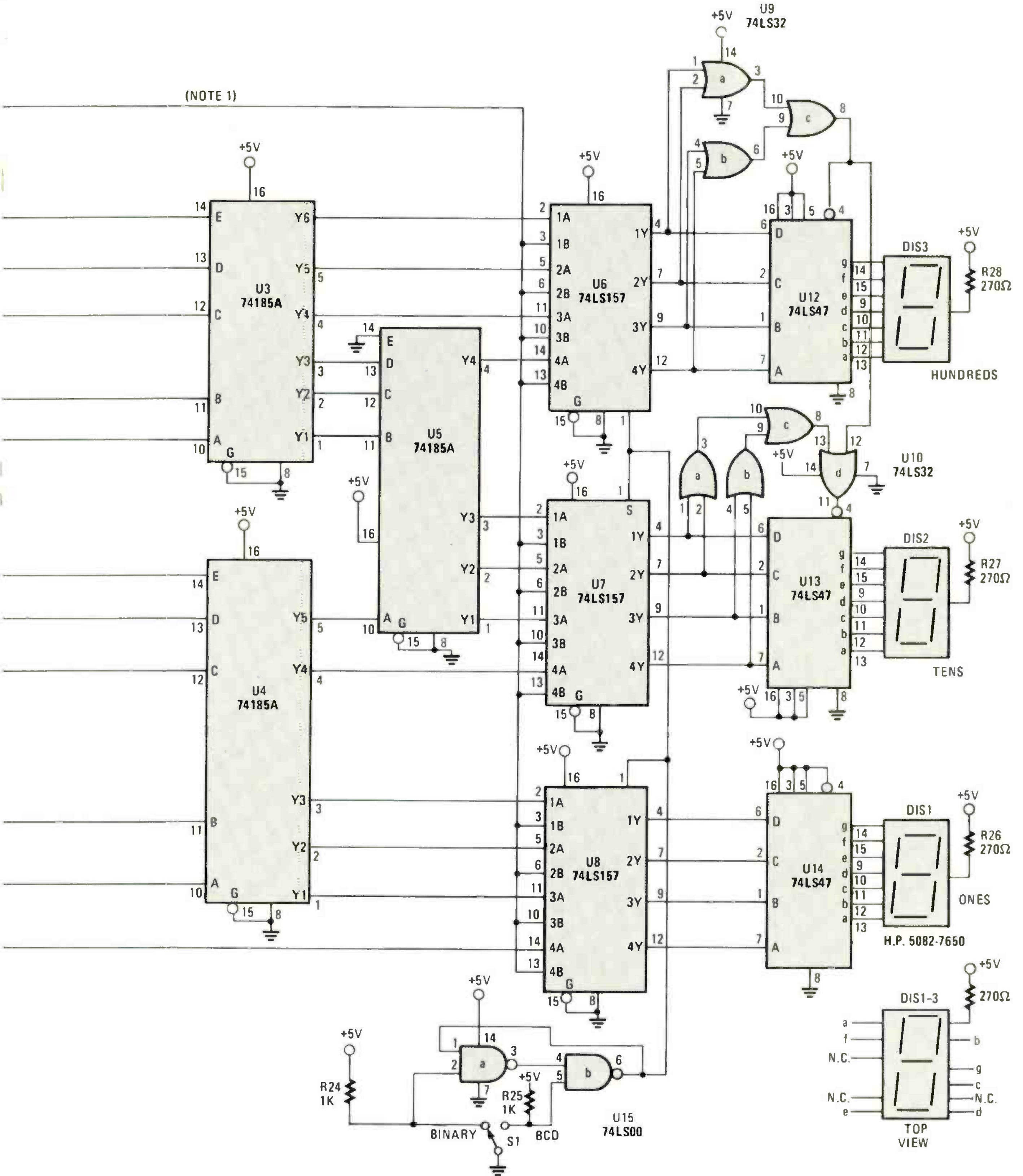
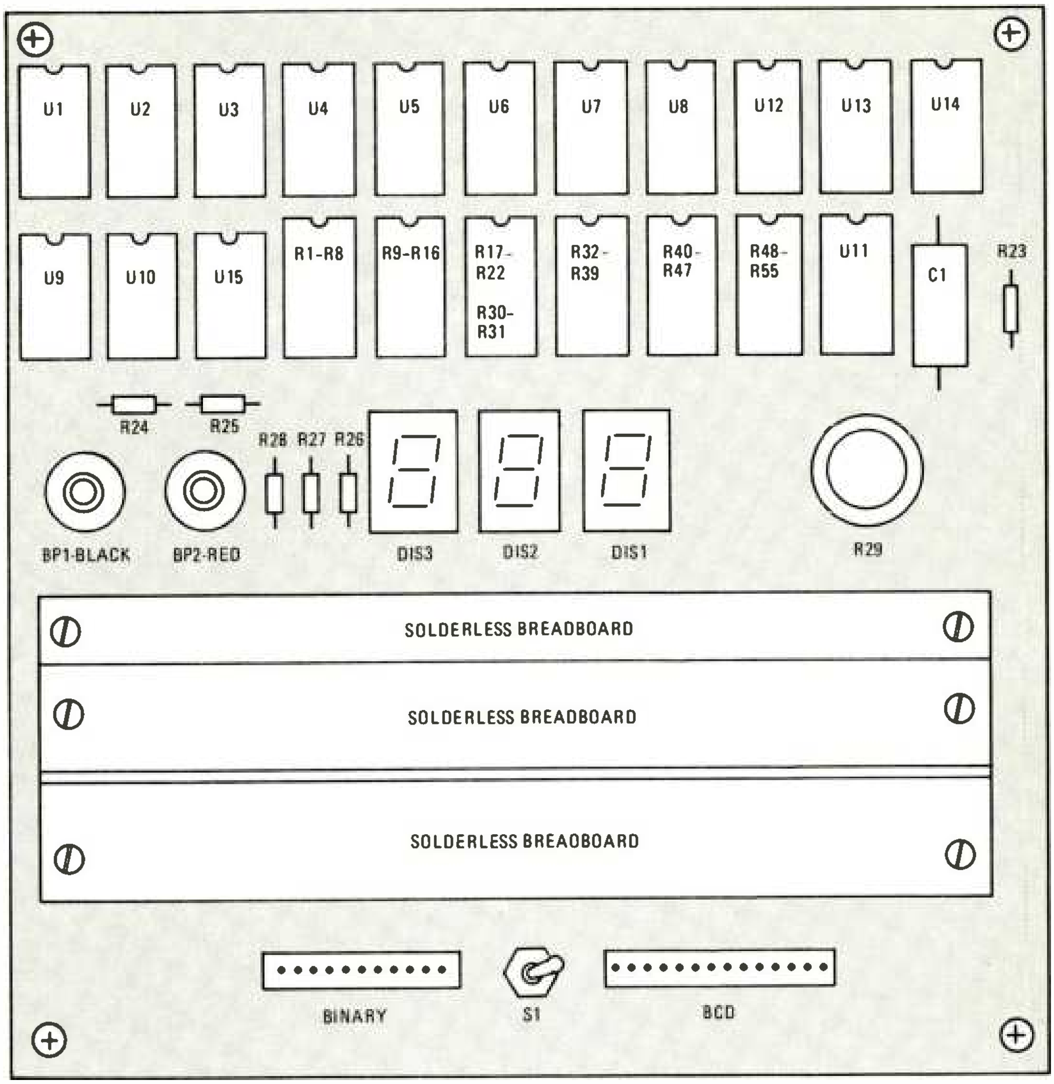


Fig. 2—Both the binary and BCD inputs should originate at some kind of terminal block so they aren't damaged or disturbed when making connections to the counter being tested. Note 1 refers to the wire that actually represents all 12 connections for the BCD inputs. Make certain you install a 10,000-ohm pull-down resistor from each input to ground. Note 2 refers to the resistors labeled R30–R55, which represents the 26 resistors required on those 74185 outputs (Y1–Y6) that are used.



The author wired his Counter Development Center using the wirewrap technique. The design of a printed-circuit board would have required at least a double-foil layout that would have made the overall board larger than necessary. The solderless board used by the author are three sections providing the necessary terminations. You may want to use some other layout that will be suitable for your needs and available parts.

authenticate the input conditions. In operation, when a counter under test is between 1000 and 1023, the 74LS47, which determines the most significant digit display, will cause the most significant display device to create a pattern that closely resembles a lowercase letter "C" having squared corners, which is understood to represent a decimal value of 10. For example, a count of 1019 would be indicated as "c19." Since you know that "c" represents 10, the entire count represents 1019. The use of a single symbol to represent 10 saves using a fourth numeric display in order to cover the complete binary range through 2 to the 10th power.

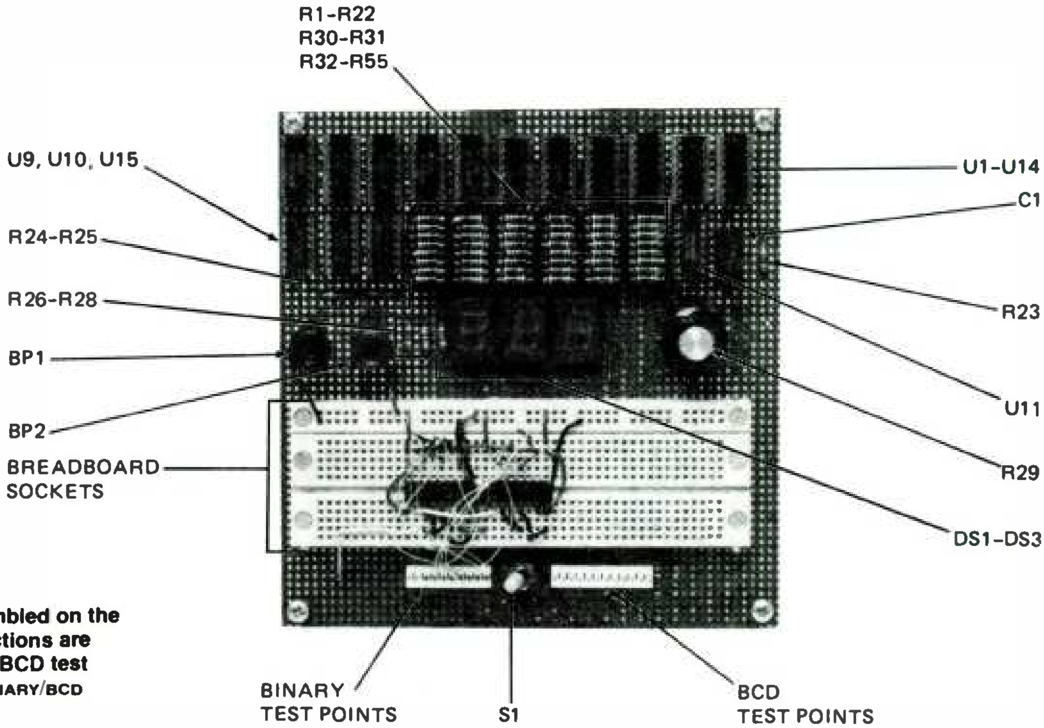
Circuit Description

Integrated circuit U11 (Figs. 1 and 2), a CMOS CD4049 hex inverting buffer, along with passive components C1, R29, and R23 comprise a 3-gate ring oscillator circuit, which is used to clock the counter under test. The oscillator generates a squarewave whose frequency is inversely proportional to the R-C time constant. This frequency can be varied with R29, a 500K linear taper potentiometer; it is low enough to allow the LED displays to cycle slow enough for the human eye to observe the count sequence. The outputs of the counter are connected to the appropriate input lines of the tester. Twenty-two 10,000-ohm pull-down resistors (R1–R22), are used to insure that all inputs are at a low logic level until the Q outputs of the counter under test pulls them high.

Integrated circuits U1 through U5 are 74185 binary-to-BCD converters cascaded to handle 10 bits of binary information. In effect, these five chips can be looked at, as shown in the block diagram of Fig. 1, as a 10-bit binary-to-BCD converter. The 74185's have open-collector outputs so 4,700-ohm pull-up resistors are required on all 26 outputs that are connected to other integrated circuits. Their BCD outputs are accepted by U6–U8—74LS157 quad 2-input multiplexers. When the BINARY mode is selected by SPDT toggle switch S1, the BCD outputs of the 74185's are routed to U12 through U14—74LS47 BCD-to-seven-segment display drivers. OR gates U9 and U10 provide leading zero blanking. When BCD counters are being checked, their outputs are fed to the 74LS47's via the 74LS157's when the BCD mode is selected by S1. U15, a 74LS00 quad 2 input NAND gate, is simply used to debounce S1.

Construction

The Counter Development Center is essentially a test instrument, therefore, cosmetic appeal is not of paramount importance. The device may be assembled on a piece of perforated-construction board. Be sure and get the *perfboard* with holes spaced .1-inch apart. If you get perforated board with a different hole spacing the IC sockets won't fit into the holes. Parts layout is not critical, because low frequencies are used. *(Continued on page 39)*



Although the counter is assembled on the breadboard socket, its connections are brought out to the binary and BCD test points on either side of the BINARY/BCD selector switch on the center.

The perfboard measures 6 inches square. The component layout is shown in Fig. 3. Power and ground for both for the circuit and the counter under test are obtained by connecting to two multi-way binding posts: Red for +5 volts and black for ground.

A total of 21 IC wire wrap sockets are required; 18 of them have 16 pins, three are of the 14-pin variety. The twenty-two 10,000-ohm pull-down resistors (R1–R22), and the twenty-six 4700-ohm pull-up resistors (R30–R55) are soldered (with a very fine-tipped, low-wattage soldering iron) to component carriers, otherwise known as *DIP headers*. After the resistors are installed, the headers are plugged into their corresponding IC sockets.

Four 1-inch, nylon standoffs under each corner of the perfboard are used as legs to support the perfboard. Any standoff of suitable height and composition may be used.

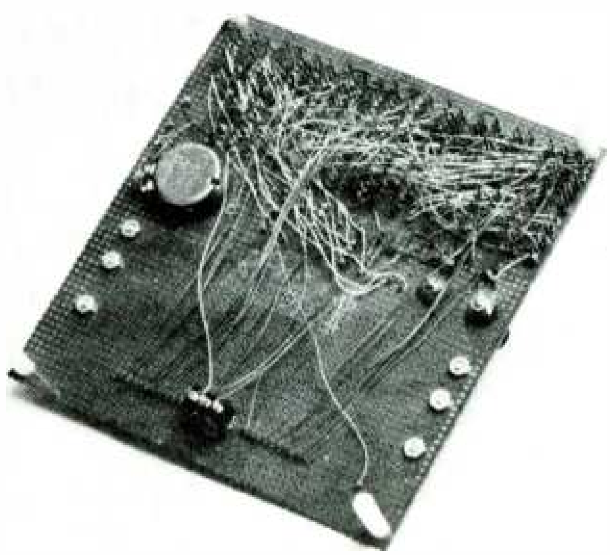
Breadboarding Circuits

A solderless breadboard, sometimes called a *protoboard* is used to wire the various connections of the counter under test. This allows a great amount of flexibility since different types of counters are obviously going to have disimilar functions and pinouts. All you have to do is assemble your counter design on the solderless breadboard, then connect #30 AWG Kynar wirewrap wire from the counter's Q outputs to either the binary or BCD input header. This will depend, of course, on the type of counter you are testing. Solid hookup wire (#26 AWG) is ideal for use with the protoboard. Do not use heavier wire, because it can cause damage to the solderless breadboard's internal connection strips. Refer to the parts layout diagram in Fig. 3.

There are six inverters in a CD4049 IC package. U11 is a three-gate ring oscillator, so three inputs are unused: Ground these unused 4049 inputs to prevent logic malfunction and/or excessive power dissipation—the three pins are U11-9, 11 and 14, as shown in Fig. 2.

The seven-segment LED's are Hewlett-Packard's common-anode devices. The 74LS47 has open-collector outputs which will drive LED's directly. In addition, the 74LS47 has active low outputs; that is why you must use common-anode LED displays. A current limiting resistor is required for each LED display. Three 270-ohm resistors were chosen as a nominal value for R26 through R28. The pins on the displays are very fragile and care must be taken when soldering to them.

That's about it. Build the Counter Development Center and future projects using counter circuits can be developed with ease and understanding. ■



Although the wiring looks formidable, it is conventional wirewrap, which is done one terminal at a time. While it might prove to be tedious, it is really not difficult, and it's less trouble than *umpteen* solder connections.

CAR STEREO IN YOUR HOME

A car's stereo radio is an inexpensive way to get an extra stereo system for your home

By Jack Cunkelman

☐WE HAD ALWAYS WANTED A RADIO/CASSETTE PLAYER FOR our den; something to use when we wanted to listen to some quiet music or one of our favorite tapes while enjoying a good book. But because we wanted the player for "background music," it didn't make sense to invest in yet another hi-fi receiver, cassette deck, amplifier, speakers, etc. But then I thought of those newspaper advertisements that always catch my attention:

"AM/FM STEREO CASSETTE AUTO RADIOS FOR UNDER $20"

How could they offer all that at such a low price? Maybe that's what I needed for our den: just an inexpensive car cassette radio, so I decided to check out an advertisement for an $18.95 auto stereo cassette radio.

When I got to the demo room, I zeroed in on the unit on sale, turned it on and listened—not bad. The radio right above it was also on sale, but for $24.95, so I checked that one out too. Just to sort of calibrate things, I listened to a $150 radio, then back down to the $18.95 unit. To make a long story short, I ended up walking out of the store with the $24.95 model because I liked its features.

Now all I needed was a 117-VAC to 12-VDC power supply and a cabinet to turn my auto radio into a hi-fi for my den. (Naturally, a $25 dollar car radio isn't going to be any kind of a match for a true hi-fi system, but the sound can be pretty good; certainly enjoyable and pleasant. All it takes is a little care in selecting the right equipment.)

Choosing Your Radio

The old adage that "You get what you pay for" still holds true for many things, so I suggest that you purchase the best radio you can squeeze into the budget. Most stores have extensive demo facilities for car radios, so always listen before you purchase. Pick a good set of speakers and listen to all the radios on the same set of speakers. Turn up the volume and listen at high levels for distortion. Most important, bring your favorite tape along for checking out the tape player.

The power output ratings on many car radios often seem too good to be true. This is because they are rated for peak output power rather than *rms* power. (The *rms* power rating is more indicative of the radio's performance when reproducing sound rather than test tones.) The radio I purchased was rated at 20-watts per channel output, but it put out only 4-watts *rms* when on the test bench.

Sizing Up The Power Supply

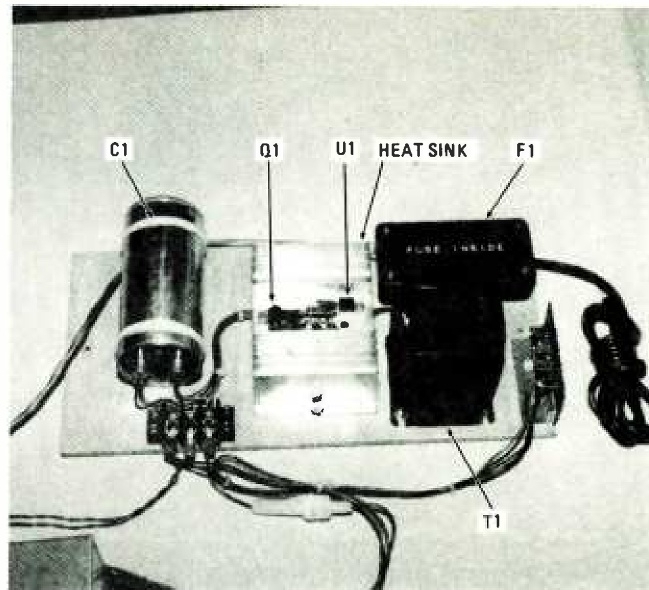
Once you have purchased the radio you want to use, check the size of the fuse in the hot lead, because it will determine the capacity of the power supply you need to build. My radio has a 3-ampere fuse (which I suspect is typical). The radio's steady-state (continuous) demand will be about half that of the fuse's rating. The power supply in my case had to supply 1.5-amperes.

The power supply schematic is shown in Fig. 1. It uses a full wave bridge rectifier and a 12-volt stepdown transformer. The current rating of the transformer should be:

$$1.8 \times I_{DC}$$

where I_{DC} is the DC output current. In our example, for an output current of 1.5 amperes we need a transformer with a secondary rated for at least a 2.7 amperes. This is not a critical value, but transformers with lower current ratings will cause the output voltage to sag under heavy loads and possibly overheat.

Making C1 an unusually large value will give the power supply a needed "reserve" for musical peaks and loud passages. While 1000-µF will provide the needed filtering and usually prove adequate, a 10,000-µF capacitor will squeeze the last bit of peak power from the amplifier when it's pushed to its limits.



Just about anything that will keep the parts secure can be used for a layout, even this "breadboard." The plastic box labeled "Fuse Inside" covers the powerline connections, protecting you from accidental shocks.

Capacitor C1's voltage rating isn't critical, but it should be at least equal to the peak voltage, which is $1.414 \times V_o$ (the secondary's output voltage). For example, if the transformer's output is 12.6 volts, the minimum C1 voltage rating is 1.414×12.6 or 18-WVDC. Note that 18-WVDC is between the "standard" capacitor voltage rating values of 16- and 20-WVDC. Always go higher, not lower, so that voltage surges don't cause the power supply to exceed C1's voltage rating.

The Regulator

Voltage regulation is provided by a three-terminal regulator and a PNP power transistor. Three terminal regulator U1 supplies about 0.8 amperes. As the current demand for the radio increases, the drop across R1 increases and turns on Q1,

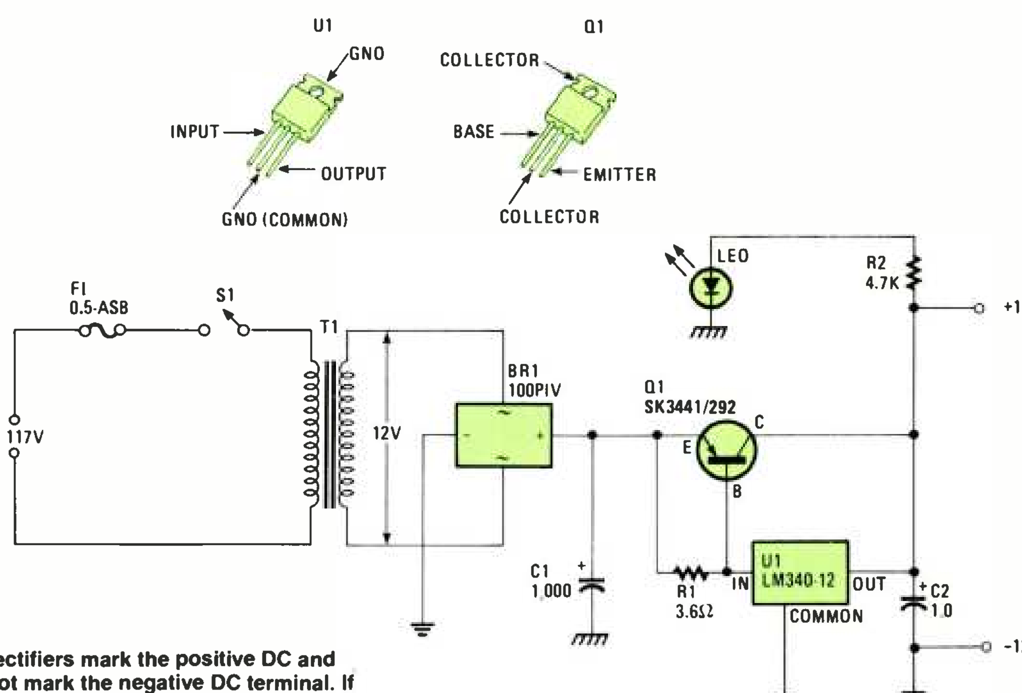
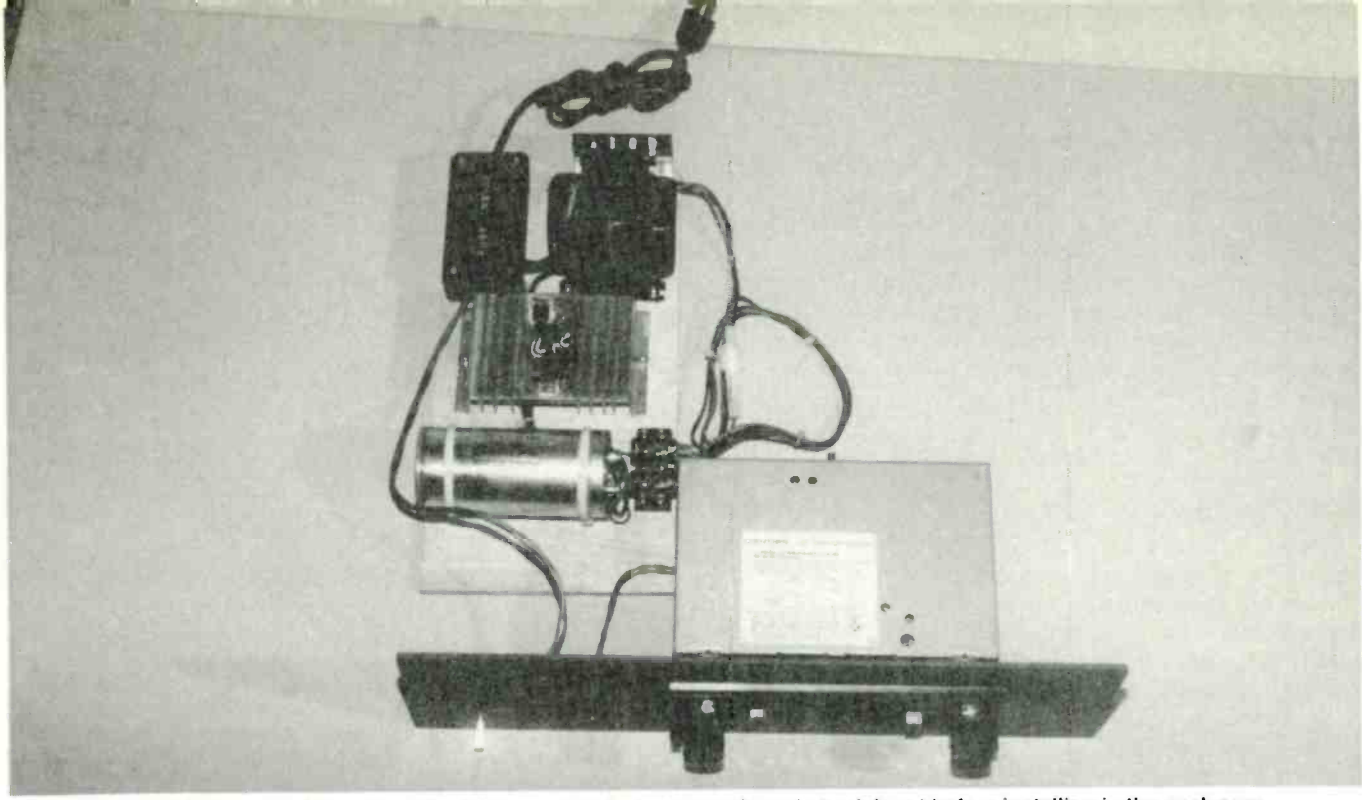


Fig. 1—Although all bridge rectifiers mark the positive DC and the AC terminals, some do not mark the negative DC terminal. If the unit you use doesn't have a marked negative terminal it is obviously the only one of the four terminals that is not marked.



Assemble the complete unit, radio, front panel and power supply and check it out before installing in the enclosure.

which supplies the rest of the current. This type of power supply is not short-circuit proof, but since it is used in a dedicated environment this should not be a concern. The in-line fuse supplied with the radio will protect the power supply if something should short out in the radio.

Both voltage regulator U1 and transistor Q1 should be mounted on some sort of heatsink because the internal heating of the components will slightly exceed their normal heat-dissipation rating. (The size of the heatsink isn't critical; about four square inches or more will be sufficient.) Keep in mind, however, that the transistor has to be insulated from the heatsink with a mica insulator. Figure 1 shows the pin-outs for the regulator and the transistor.

Assembly

Any kind of assembly technique can be used for the power supply. I chose to assemble mine on a piece of fiberboard, enclosing the 117-volt powerline connections inside a plastic case for safety. The dropping resistor (R2) for the light-emitting diode pilot lamp (LED1) is mounted on a three-terminal barrier strip that is also used as a junction point for power going to the radio. The actual power supply components are mounted on both sides of a heatsink. Almost any physical layout will work for the power supply components; use whatever arrangement fits your needs and style.

PARTS LIST FOR CAR STEREO IN YOUR HOME

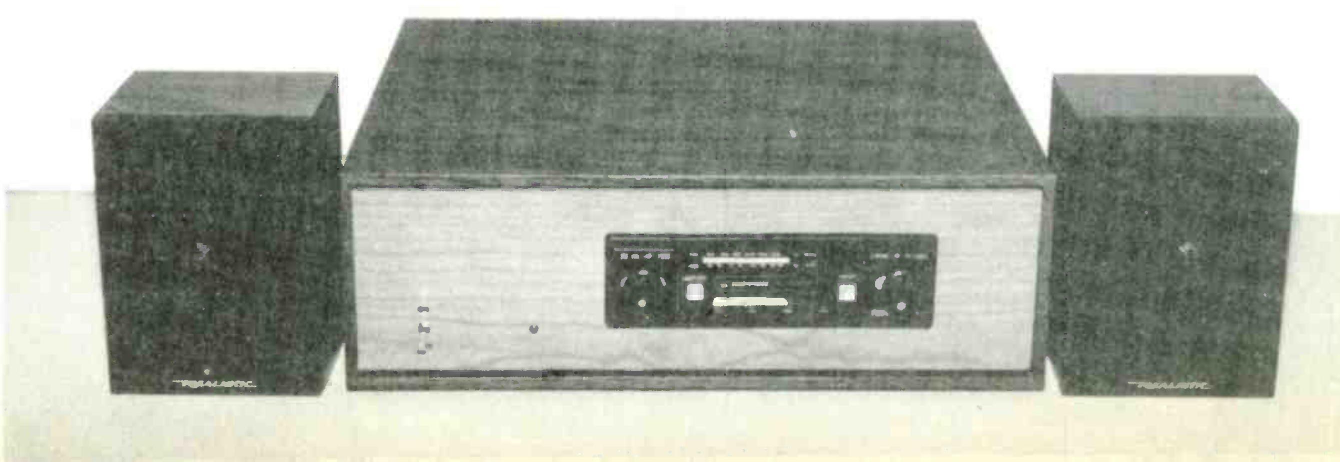
SEMICONDUCTORS

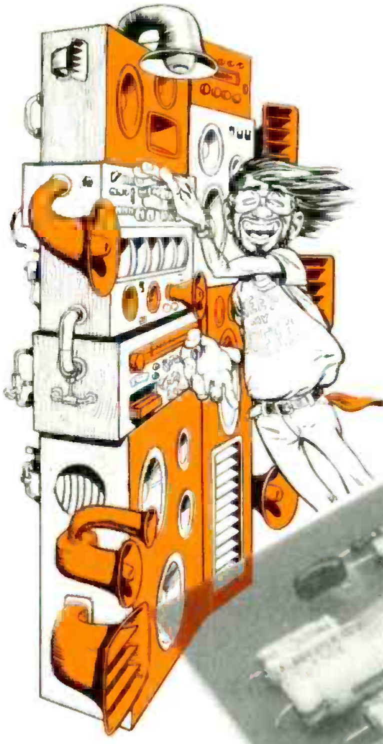
U1—LM340-12 12-volt regulator
Q1—SK344/292 PNP power transistor
BR1—Full-wave bridge rectifier, 100-PIV, 4-A
LED1—Light-emitting diode

ADDITIONAL PARTS AND MATERIALS

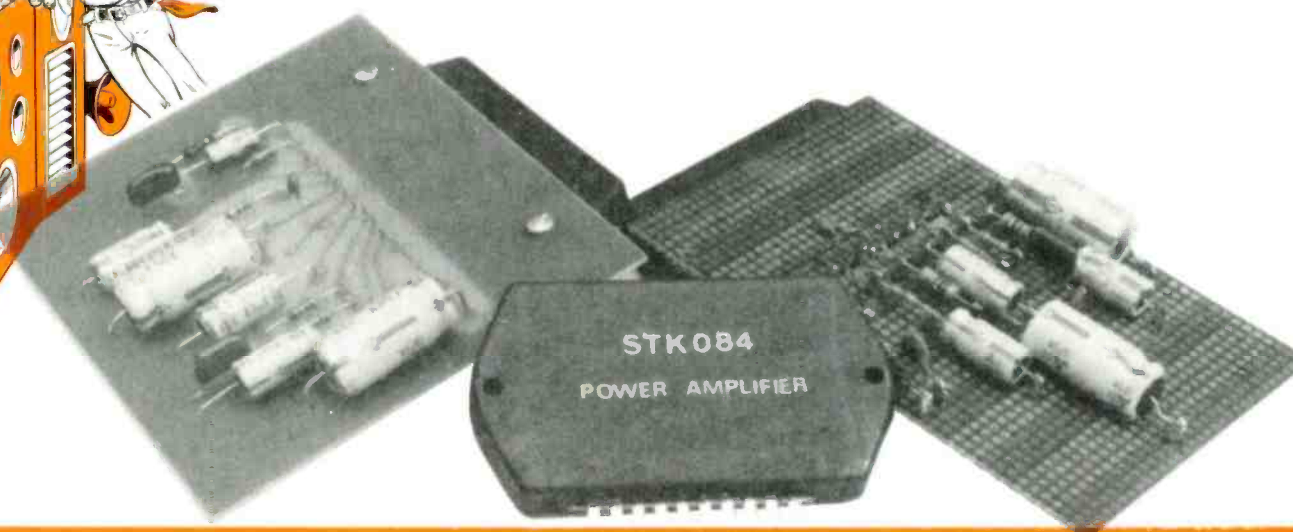
R1—3.6-ohm, 1-watt, 5% resistor
R2—4700-ohm, ½-watt, 10% resistor
C1—1000–10,000-µF, electrolytic capacitor (see text)
F1—Fuse, ½-A, slow-blow type
S1—SPST toggle switch
T1—Power step-down transformer, 12.6-volt secondary (see text)
Fuseholder, line cord, 3-terminal barrier strip, heatsink material, plastic box, hardware wire, solder, etc.

All that remains to be done is to mount everything in a suitable enclosure. I used a cabinet purchased at a flea market. Using the bezel supplied with the radio as a template, mark and cut the front panel and install the radio on the panel. Then connect the power supply so the whole assembly can be installed in the enclosure as a single unit. If possible, before installing the unit in its enclosure, check it out with the loudspeakers you intend to use. If everything runs for a while and nothing overheats, it's okay to install the radio. ■





HYBRID POWER AMPLIFIER



When it comes to audio power, this circuit proves that substance counts over size: Just one module and a few loose parts yield up to 50-watts of output power!

By Jack Cunkelman

IF YOU'RE AN AUDIO ENTHUSIAST OR ELECTRONICS HOBbyist, you're probably always on the lookout for an audio amplifier that can be incorporated into your custom-built projects. For example, I recently had need of an audio power-amplifier for a TV audio tuner I was building. With a similar need, a friend asked my help in building a disco PA system. Since, in the past, I'd experimented (with much success) with hybrid-amplifier modules, that seemed the way to go.

The search for just the right module ended with my discovery of the STK084, a thick-film hybrid amplifier module from Sanyo Semiconductors. Although there are many similar amplifier modules available, that unit proved to be the most useful and versatile. Optimum specifications for the STK084 amplifier module are given in Table 1. By using a minimum of external parts and operating from a bi-polar (±) 35-volt power supply, the device is capable of 50 watts of output power with only 0.05% distortion. Thus, our two problems were solved (as well as providing a circuit that could handle any future needs) by the *Hybrid 50* amplifier.

TABLE 1—SPECIFICATIONS FOR THE STK084 POWER AMPLIFIER

Power supply voltage:	±35 VDC
Power out:	50-watts *rms* into 8Ωs
Frequency response:	−1.0 dB 10-100 kHz
Harmonic Distortion:	less than 0.06%
IM Distortion:	less than 0.02%
Input Sensitivity:	1.0-volts *rms* for full-rated output
Signal-to-Noise (S/N):	95 dB below full-rated output

The Circuit

The schematic diagram in Fig. 1 shows all the external components that are needed to turn the STK084 module into a functional audio power amplifier. The input (from whatever source) to the Hybrid-50 is AC coupled to the amplifier through C2, which blocks DC signals that might also be present at the input. The R1/C1 combination forms a lowpass filter, which eliminates unwanted high-frequency signals by bypassing them to ground when they appear at the circuit input (which has an impedance of about 52K). The gain of the amplifier is set at about 26 dB by resistors R3 and R4.

The R5/C5/C7 combination on the positive supply and its counterpart (R6/C6/C8) on the negative supply provides power-supply decoupling. R7 and C9 together prevent oscillation at the output of the amplifier. From that point, the amplifier's output signal is direct coupled to the speaker through a 3-ampere fuse, F1.

The DC output of the amplifier at pin 7 is 0 volts, so no DC current flows through the speaker. Should there be a catastrophic failure of the output stage, fuse F1, which should be a fast-acting type, prevents DC from flowing through the speaker.

Power Supply

The power supply for the amplifier (shown in Fig. 2) is a

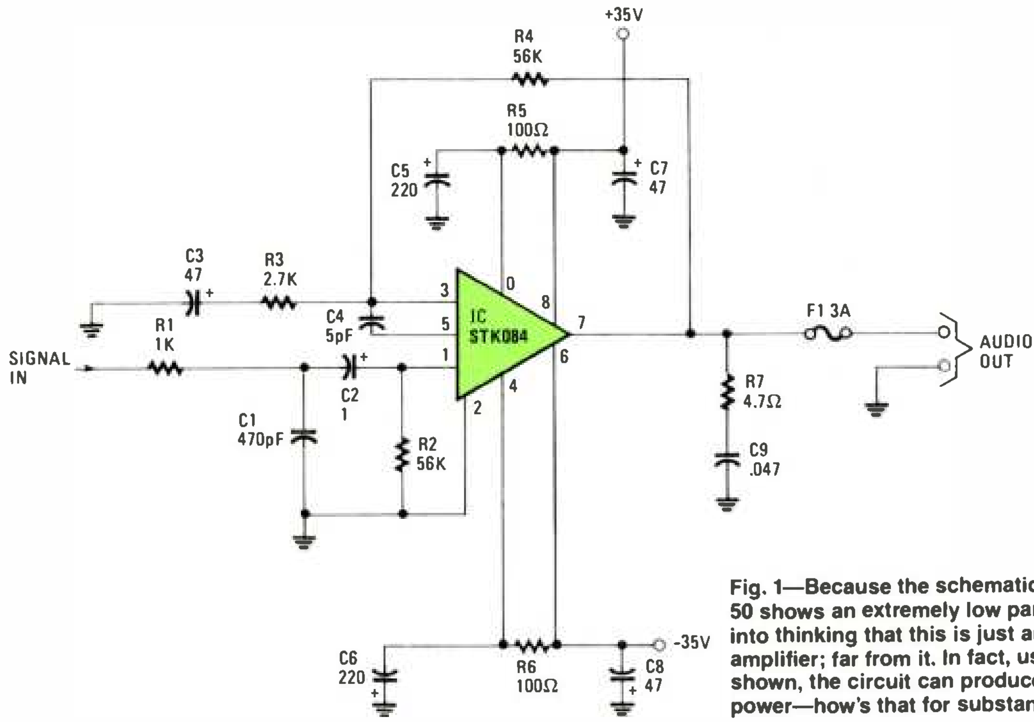


Fig. 1—Because the schematic diagram of the Hybrid 50 shows an extremely low parts count, don't be lulled into thinking that this is just another low-power audio amplifier; far from it. In fact, using the component values shown, the circuit can produce up to 50-watts of output power—how's that for substance over size?

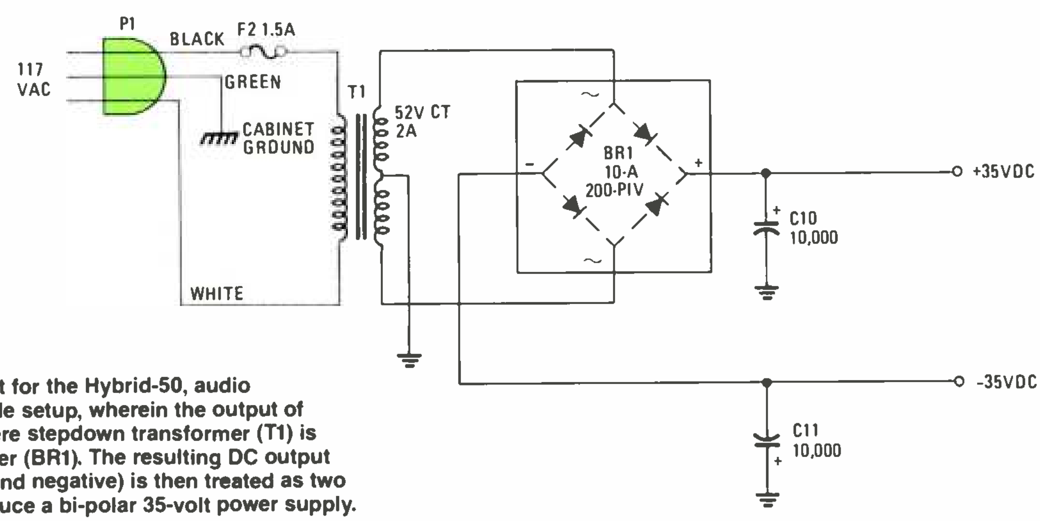


Fig. 2—The power-supply circuit for the Hybrid-50, audio power-amplifier is a rather simple setup, wherein the output of a 52-volt, center-tapped, 2-ampere stepdown transformer (T1) is fed to a 10-ampere bridge rectifier (BR1). The resulting DC output of the bridge rectifier (positive and negative) is then treated as two distinct voltage sources to produce a bi-polar 35-volt power supply.

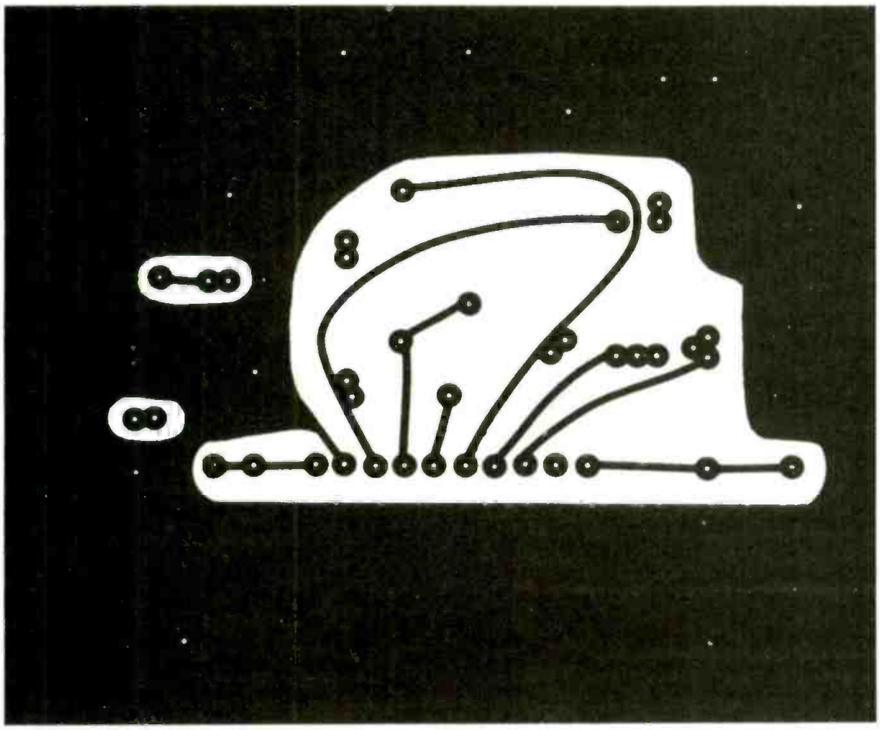
conventional full-wave bridge rectifier connected to the secondary of a center-tapped stepdown transformer, T1. Voltage regulation is mainly determined by the resistance of the transformer winding and the size of the filter capacitors. The higher the current rating of the transformer's secondary, the less power-supply voltage variation there will be. The minimum suggested rating of the transformer is around 2 amperes, but supply voltages are not particularly critical.

Table 2 lists various supply voltages (and the transformer ratings which provide the voltages) along with the output power that can be expected using those voltages. Also given are the suggested voltage ratings for the filtering capacitors at each voltage level. For instance, for a 50-watt output, the module should be powered from a bi-polar 35-volt supply (which would require a 52-volt center-tapped, stepdown transformer) filtered by 10,000-μF/45-volt capacitors (as per Fig. 2). The filter capacitor should have a capacitance value that is as large as possible. Although 10,000-μF capacitors are shown, any value between 4000- and 15,000-μF works just fine.

Since the power supply is so loosely designed, junkbox parts can play a major role in this section of the Hybrid Power Amplifier. If you plan to run two amplifiers from the same supply, increase the current rating of the power transformer you choose.

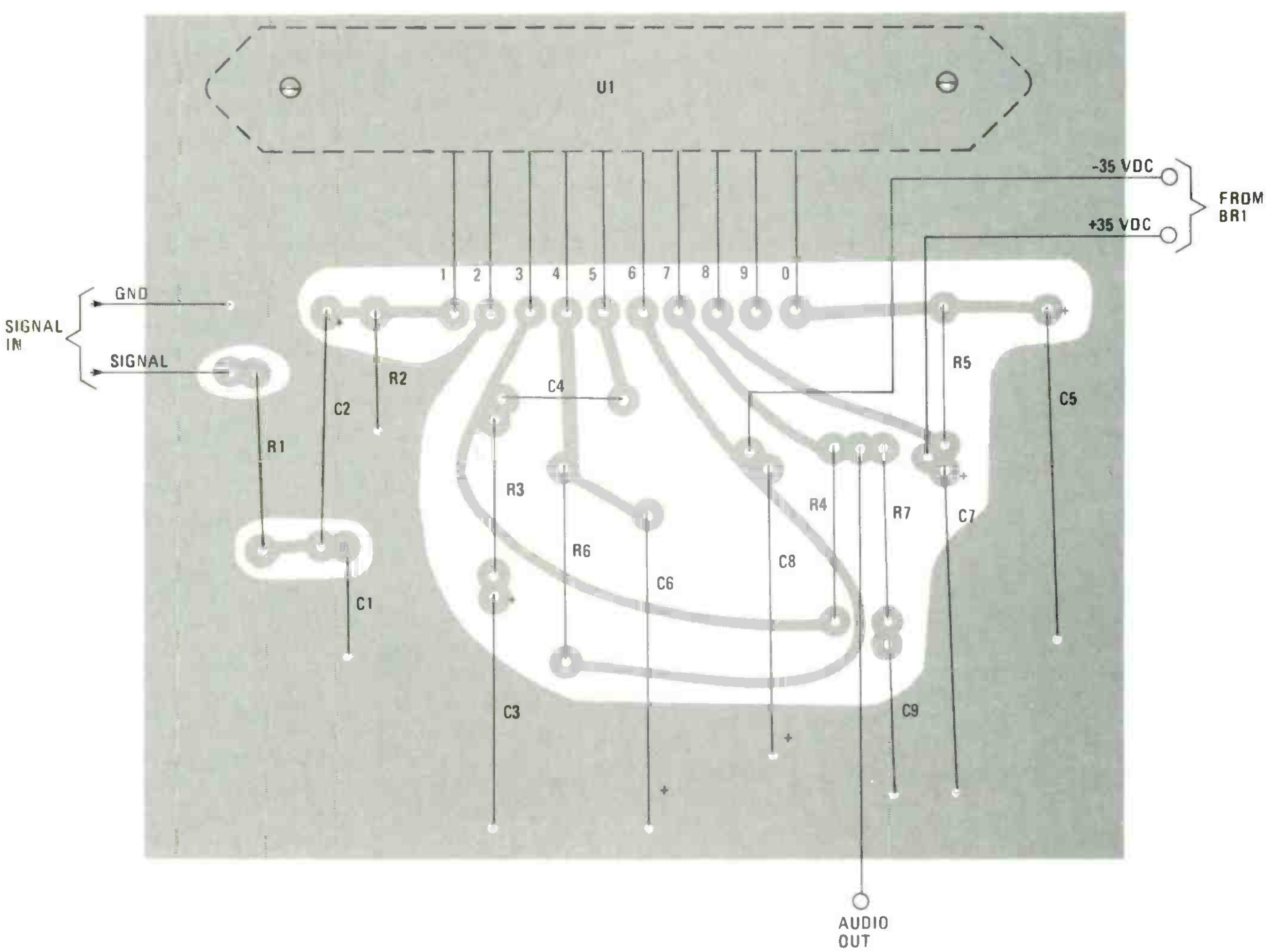
TABLE 2—V_{SUPPLY} Vs. P_{OUT}

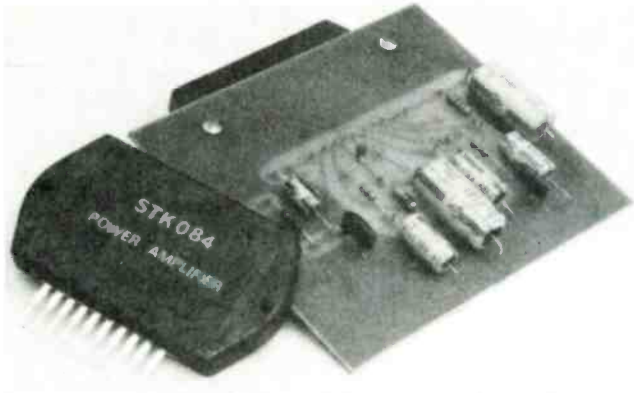
Power Supply Volts DC	Maximum Power-out (Watts)	Transformer RMS Volts	Capacitor WVDC (Minimum)
±35	50	52	45
±33	40	48	41
±30	34	45	39
±27	28	40	34
±24	20	36	31



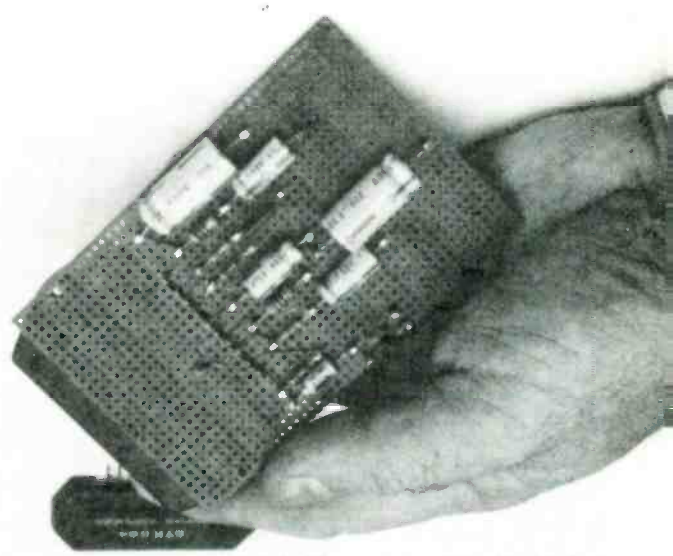
◀Fig. 3—The full-scale template of the Hybrid 50 serves to further illustrate the small size of the Sanyo STK084 circuit.

Fig. 4—Although shown as though mounted from the component side of the printed-circuit board, the module is actually inserted through the pads from the copper side, and secured with hardware. ▼





Looking at the Hybrid 50's printed-circuit board, it appears as though only the passive components are located there; however, on closer inspection, we see the amplifier module peering out from the underside (foil side) of the board. The module is inserted through the mounting holes from the foil side of the board, and secured in place with only two screws inserted from the component side.



The perfboard-mounted Hybrid 50 power amplifier is identical in layout to that of the printed-circuit version, except here the components are secured to a different mounting medium.

Construction

Although point-to-point wiring on perfboard can be used, a printed-circuit board is recommended. Figure 3 shows a full-blown template of the Hybrid 50's printed-circuit board, which may be lifted or copied from the page and used to etch your own circuit board. Once done, the next step is to obtain the parts. The amplifier module (alone), as well as a complete kit of parts, is available from the supplier given in the Parts List. The component layout diagram for the Hybrid 50's printed-circuit board is shown in Fig. 4: It can also be used to lay the circuit out on perfboard (see photos).

Be careful when mounting the hybrid module to the printed-circuit board. The STK084 module is housed in a 10-pin, single in-line package (SIP), with a dimple in the case indicating pin 1. Unlike other IC's, where pin numbers run from one to whatever, here the tenth pin (going from left to right) is designated "0" (zero). The module is inserted through the pads on the board from the copper side (not the component side) and secured with screws.

In order to prevent damage to the amplifier, the module must be mounted to a heatsink of some kind. Thus, by mounting the module as indicated in Fig. 4, with its back pressed flat against the board, the foil traces serve as a "limited" heatsink (capable of dispersing small amounts of heat). To ensure that the tab on the module contacts the heatsink, the pins are bent so that the package lies flat against the copper side of the board.

However, if you expect to draw heavy audio power from the module, a regular heatsink assembly should be used. If the demands on the amplifier are expected to be more moderate, you might consider using the chassis that the circuit is built into as a heatsink. Be sure to use silicone heatsink compound to ensure proper heat transfer between the module and the heatsink. If the STK084 module case runs hot during normal operation, more heatsinking is needed.

The power supply should be wired with heavy (18-gauge) wire to avoid unnecessary voltage drops. The center tap on the transformer and the ground leads to the capacitors should be brought out to one point on the chassis and grounded. Speaker returns should be connected there as well, also using heavy gauge wire. Resistors and small capacitors can be pulled from defunct instruments, plucked from your junkbox, or purchased at most local parts stores. Once you've gathered all the parts, the amplifier can be built in one evening. It provides lots of good, clean audio power for a minimum outlay of money. So put your favorite music into it, then, put your feet up and enjoy. ■

PARTS LIST FOR THE HYBRID-50 AMPLIFIER

SEMICONDUCTORS
BR1—Bridge rectifier, 10-A, 200-PIV
U1—STK084 Sanyo hybrid power amplifier module

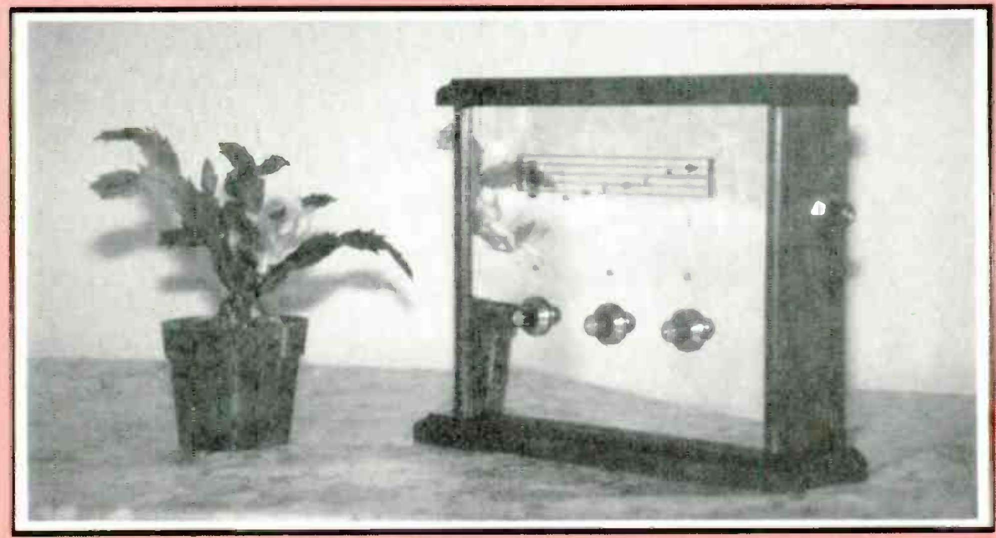
RESISTORS
(All resistors ¼-watt, 5% fixed units)
R1—1000-ohm
R2, R4—56,000-ohm
R3—2700-ohm
R5, R6—100-ohm
R7—4.7-ohm

CAPACITORS
C1—470-pF
C2—1.0-µF, 25-WVDC, electrolytic
C3, C7, C8—47-µF, 50-WVDC, electrolytic
C4—5-pF
C5, C6—220-µF, 50-WVDC, electrolytic
C9—0.047-µF
C10, C11—4000 to 15000-µF, electrolytic

ADDITIONAL PARTS AND MATERIALS
F1—Fuse, 3-A, AGX-type
F2—Fuse, 1.5-A, slow-blow type
P1—3-wire, molded power plug and line cord
T1—Transformer, AC-line, stepdown power; 52-volt CT, 2-A secondary
Perfboard and/or printed-circuit materials, fuse clips, fuse holder, chassis, heatsink, power supply, solder, mounting hardware, hookup wire, etc.

KIT AVAILABLE
The Sanyo STK084 power amplifier module—priced at $11.60, plus $2.75 (UPS) or $1.75 (postal) shipping and handling—is available from MCM Electronics, 858 E. Congress Park Drive, Centerville, Ohio 45459: 800/543-4330, Ohio 800/762-4315; or FUJI-SVEA, PO Box 3375, Torrance, CA 90510: 800/421-2841, in California, 213/533-1221

Build the...
Musical Madness Machine



Although there are many melodic electronic projects on the market, few provide the visual effects of this one.

By C.R. Fischer

☐MUSICAL CIRCUITS HAVE BEEN POPULAR WITH ELECTRONIC hobbyists for many years. While such circuits are easy to put together, the tones that they produce are much like those put out by a toy organ, or they make sounds that are just science-fiction special effects. It is much harder to build a circuit that actually generates a changing pattern that sounds like music to your ears.

Some popular gadgets use digital counting circuits to select individual tuning potentiometers for a variable-frequency oscillator. Unfortunately, each step must be tediously tuned by hand, and unless you're gifted with *perfect pitch*, it's nearly impossible to tune the circuit without an oscilloscope. Also, since such devices usually have 16 or fewer steps, they have limited repetitive capability. Similar circuits use sampled random voltage sources to generate tone sequences. While that, at least in theory, gives an infinite variety of patterns, it soon becomes obvious that the device does not compose music, but instead grabs at random pitches that do not conform to any musical scale. While such a circuit can be great fun and provide a good simulation of "computer noises," many listeners would be hard pressed to call the results musical.

However, the Musical Madness Machine is designed to avoid those pitfalls, while still being easy to assemble and use. The circuit produces a variety of musical patterns using only 4 controls. With light-emitting diodes (LED's) arranged on a musical staff, the circuit shows the notes as they are being played. That provides an eye-catching display that will provide both the builder and the end user many hours of entertainment. What's more, it's capable of driving an external audio amplifier or a small, self-contained speaker.

How It Works

The operation of the Musical Madness Machine is made easier to understand by breaking the circuit down into 4 distinct sections: the *tone generator*, the *pitch selection clocks*, the *analog switches*, and the *audio output stage*. The schematic diagram for the entire circuit is shown in Fig. 1.

To generate the proper musical pitches for the project without the use of precision resistors or lots of trimmer potentiometers, a special purpose chip, an MK50240 top-octave generator (U1), is used. Although the chip was designed for use in electronic organs and synthesizers, its relatively low cost and ease of use makes it suitable for this application. It requires a high-frequency clock to operate. That job is handled by U2, a 74C04 hex inverter, half of which is configured as an astable multivibrator. Although a 74C00-series inverter chip is shown, a CD4069B (which is identical for our purposes) may be substituted. Trimmer potentiometer R1 allows the frequency of the multivibrator to be adjusted for various instruments or different effects.

U3 and the remaining half of U2 form three additional clocks, which are used for pitch selection. All three run at subaudio frequencies and can be varied over a wide range by using the RATE controls associated with each clock circuit. Those oscillators can also drive LED's to give the user a visual reference for setting the knobs. The output (U2, pin 5 and U3 pins 5 and 9) of each of the rate clocks is routed to

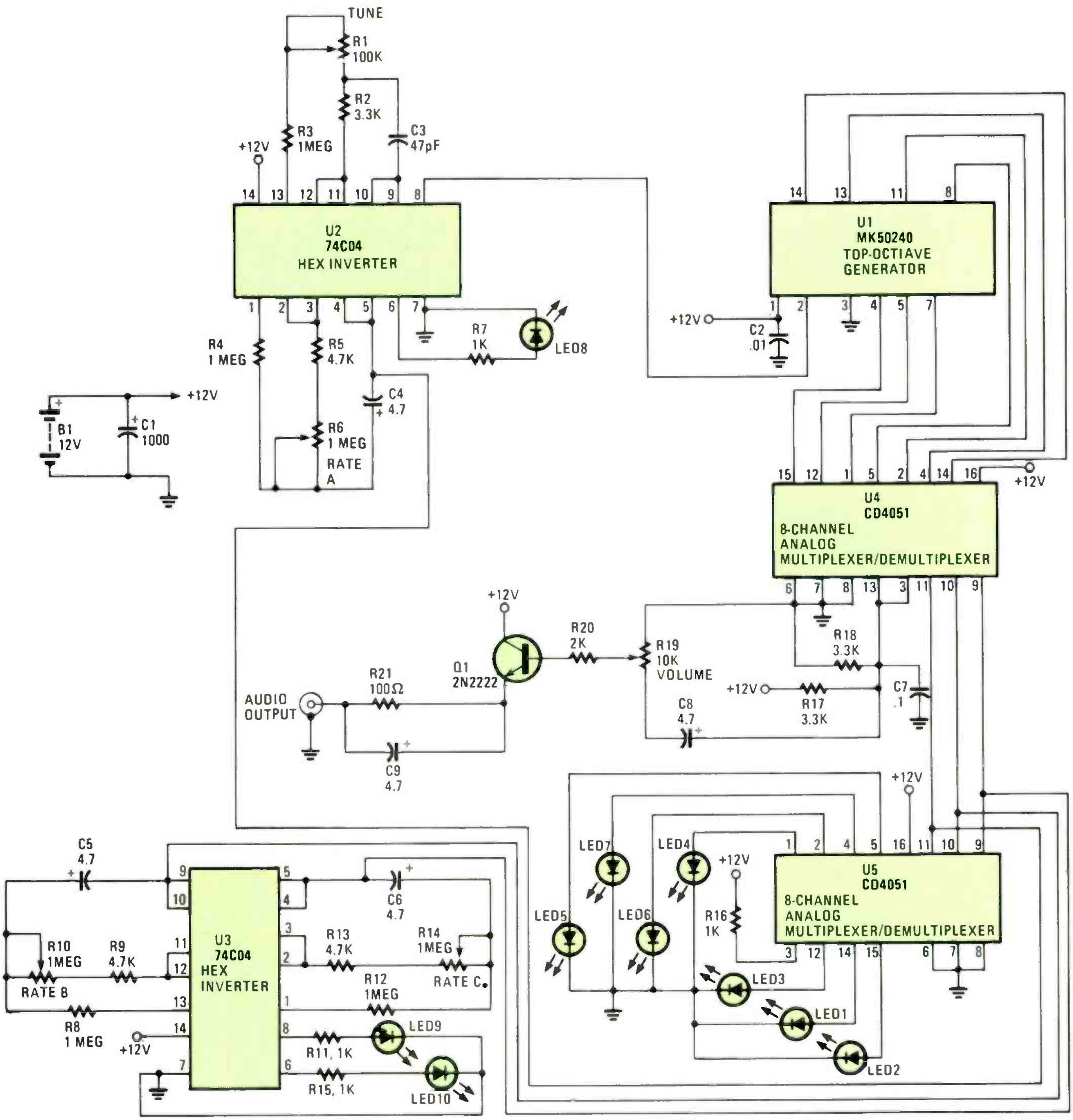


Fig. 1—Schematic diagram for the Musical Madness Machine. The circuit can be broken down into four distinct sections: The tone generator; the pitch selection clocks; the analog switches, and the audio output stage.

analog switches U4 and U5, which act as 8-position rotary switches. The logic levels sensed at pins 9, 10, and 11 determine which switch is to be closed. U4 selects between 7 tones and a reset (silence); U5 lights one of seven light-emitting diodes to indicate which note is played. The note selected depends on the rate of each clock and the difference in frequencies between clocks. (See Fig. 2.)

The audio output circuit is based around transistor Q1. It forms a simple amplifier that can drive a small speaker or larger sound system; the output level is controlled by R19, the VOLUME control. Because U1 generates a raw squarewave

A	0	0	0	0	1	1	1	1
B	0	0	1	1	0	0	1	1
C	0	1	0	1	0	1	0	1
Note Selected	—	D (L)	E	F	G	A	C	D (H)

Fig. 2—The notes generated by the Musical Madness Machine depend on the rate of each clock and the difference in output frequency between them.

PARTS LIST FOR THE MUSICAL MADNESS MACHINE

SEMICONDUCTORS

LED1–LED10—Jumbo red, light-emitting diode
Q1—2N2222 or 2N3904, general-purpose NPN transistor
U1—MK50240 top-octave generator (Mostek) integrated circuit
U2, U3—74C04 or CD4069B hex inverter integrated circuit
U4, U5—CD4051 8-channel, analog, multiplexer/demultiplexer integrated circuit

RESISTORS

(All resistors ¼-W, 10% fixed units unless otherwise noted.)
R1—100,000-ohm, trimmer potentiometer
R2, R17, R18—3300-ohm
R3, R4, R8, R12—1-Megohm
R5, R9, R13—4700-ohm
R6, R10, R14—1-Megohm, linear-taper potentiometer
R7, R11, R15, R16—1000-ohm
R19—10,000-ohm, audio-taper potentiometer
R20—2000-ohm
R21—100-ohm

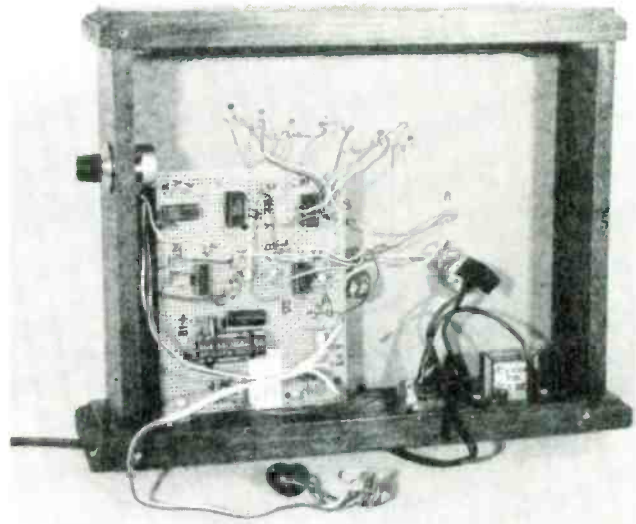
CAPACITORS

C1—100-µF, 16-WVDC, electrolytic or tantalum
C2—0.01-µF, ceramic disc
C3—47-pF, mica or ceramic disc
C4, C5, C6, C8, C9—4.7-µF, 16-WVDC, tantalum or low-leakage electrolytic
C7—0.1-muF, ceramic disc (optional, see text)

ADDITIONAL PARTS AND MATERIALS

Perfboard or printed-circuit material, IC sockets, 8-ohm speaker or audio connector (see text), etc.

NOTE: The MK50240 top-octave generator is available from PAIA Electronics, Inc. (1020 West Vilshire Blvd., Oklahoma City, OK 73116) for $5.95 and $1.00 for postage and handling.



There's plenty of room inside the cabinet so don't be afraid to spread out. The power transformer can be mounted directly in the base of the cabinet, along with a terminal strip to which both the line cord and power switch are connected.

output, the bright harmonic content can be grating to some. Optional capacitor C7 rolls off part of the treble content to mellow the sound somewhat. Depending on your taste, you might wish to change the value or even omit it all together. Greater capacitance would reduce the treble even more.

The Musical Madness Machine requires a regulated power supply of 12 to 15 volts and draws about 75 milliamperes. Although Fig. 1 shows a battery as the voltage source, a power-supply circuit might be more desirable. A suitable power supply is shown in Fig. 3. Because the circuit uses 4 separate clocks that are set at different rates, slightly more supply bypassing than usual is required. Note that C1 in Fig. 1 is of the same value shown in Fig. 3, but that the capacitance

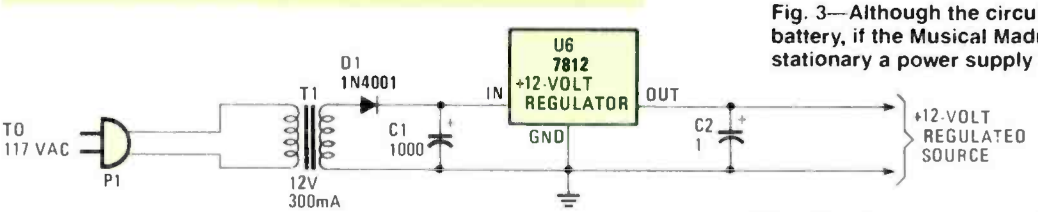


Fig. 3—Although the circuit may be powered from a 12-volt battery, if the Musical Madness Machine is to remain stationary a power supply such as this one may be used.

of C2 in Fig. 3 has increased. Capacitor C1 helps to filter out 60-Hz hum and reduce the effects of the pitch selection clocks on the power supply and the audio output. Capacitor C2 performs a similar function for the tone generator clock.

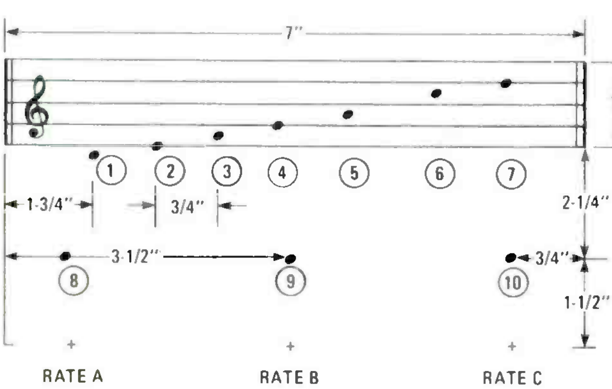


Fig. 4—The template-guide for the Musical Madness Machine's front panel provides the locations for the LED's and the oscillator RATE controls.

Construction

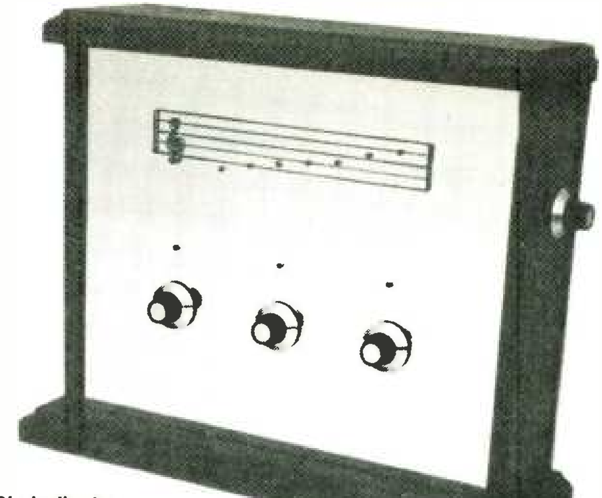
The Musical Madness Machine and its power supply can be built on a printed-circuit board or a piece of perfboard. A template-guide of the unit's front panel is shown in Fig. 4. When laying out a board, there are a couple of fine points to pay attention to for your Musical Madness Machine to be up and running with a minimum amount of trouble.

All power supply runs should be kept as short as possible to minimize the chance of noise popping up somewhere. Capacitors C1 and C2 are helpful in preventing that particular problem. A good location for C1 would be between U1 and the various clocks. Capacitor C2 should be installed as close to U1 as possible, preferably on the supply pin, as shown in the schematic diagram of Fig. 1. The use of sockets or Molex Soldercons and standard CMOS handling procedures are strongly advised for all of the integrated circuits. Remember that the chips are static sensitive. Finally, when arranging the off-board connections, you should keep the audio wiring (to and from R19 and the output connector) separate from the RATE controls and the LED wiring to keep pops and clicks from showing up in the audio path.

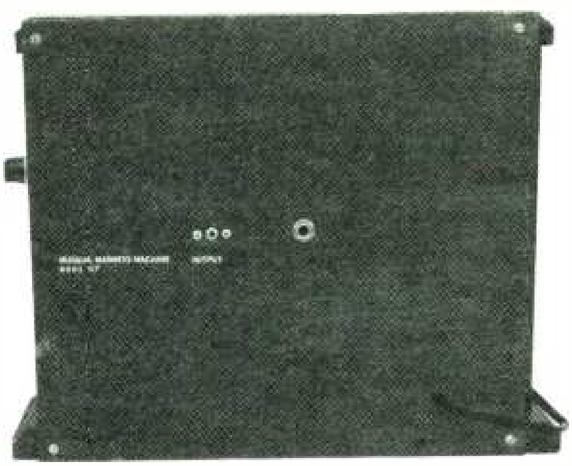
Packaging

The Musical Madness Machine can be installed into any type of ordinary cabinet; but, because of its unusual appearance and function, you might want to be a little more creative. The author's prototype was installed into a wooden case available in hobby outlets for building wall clocks. After staining and finishing the wooden portion, the glass panel that came with the kit was replaced with a sheet of mirrored plexiglass. The RATE controls and all of the light-emitting diodes were then mounted on the mirrored panel and the music staff was carefully drawn in with a permanent-type, fine-tipped marker. A template-guide of the front panel is shown in Fig. 4.

The VOLUME control was mounted on the right-hand side of the case and the output connectors were located on the back panel. (The prototype was equipped with a ¼-inch phono jack for connection to the speaker and an RCA jack for connection to an amplifier system).



LED's indicate the note playing. Standard phone and phono jacks permit easy connection to either a speaker or an amplifier.



Use

As mentioned earlier, all of the tones put out by the Musical Madness Machine are produced by U1, the top-octave generator. The chip actually generates all 13 pitches in the traditional equal-tempered octave, which leads to an interesting design problem. While we could use all 13 notes to make music, most of the results would be quite dissonant and unmusical unless we limited the possible patterns seriously. Instead of that, we simply limit the melodic choices to a very simple scale, as Fig. 5 shows.

The notes form an elementary minor scale, which is one of Mankind's oldest melodic systems. That assures that no matter how the clocks are set, we will almost always get a plausible melody. Due to the way the analog switches are set up, each clock has a different effect on the pattern. Rate clock A determines if the note selected is in the higher or lower end of the octave. If clock A is set to a fast rate, while the other two clocks are set much slower, the Musical Madness Machine trills rapidly between two notes at a musical interval of a perfect fifth or sixth. Clock B controls a smaller jump of either a third or a fourth. And clock C controls the smallest interval of all, that of a whole step (except for the half-step between the E and F). That means that if you want traditional melodies, you must set the tempo of the clocks to match generally accepted tastes—i.e. smaller jumps will happen much more often than larger intervals.

Furthermore, if the clocks are set so that there's no mathematical coherence between them the output tends to be irregular. If you take the time, say, to set the controls so that clock C is four times faster than B, which in turn is twice as fast as A, astonishingly natural melodies are produced. And because each clock is independent and not synchronized in any way, they'll eventually drift no matter how carefully they are set. That causes the Musical Madness Machine to go through variations on its theme, and slowly return as the clocks drift in and out of phase with each other.

The audio output works well with high-fidelity and musical instrument amplifiers, and the basic tone can be enhanced by many of the audio modifiers on the market. Echo and audio delay lines, for instance, work especially well. If you intend to use the Musical Madness Machine exclusively with external amplification devices, you might wish to omit C7 as discussed earlier. That allows the frequency response to be fully controlled by whatever external equalization you use.

The Musical Madness Machine has other uses aside from being a classic *do-nothing* box. By itself or with slight modifications it could serve as a musical alarm or horn, or as an *idea box* for songwriters and composers. Due to the large variety of patterns, it's safe to say that most of the possibilities are still undiscovered. ■

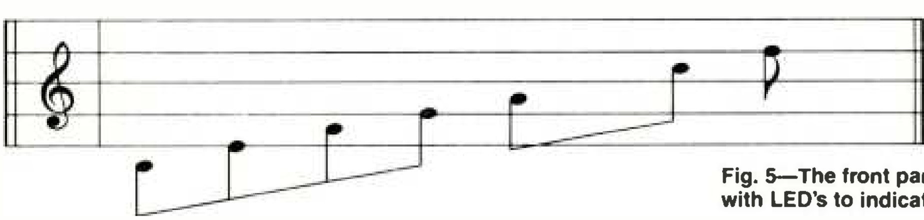


Fig. 5—The front panel, based on a simple musical scale, with LED's to indicate notes, provides an eye-catching display.

STUD FINDER

By Robert F. Scott

This ferrous locator can be of great value when it comes to finding the elusive wall beam in your house.

☐MOST OF US REALIZE HOW DIFFICULT IT IS TO PINPOINT THE exact location of a wall stud or ceiling joist that's needed as a solid support for a heavy picture, mirror, or a ceiling fixture. Usually, our efforts consist of probing for the beam with a small drill or icepick. Rarely do we strike the much *sought-after-beam* on the first, second, or even the fifth try—by the time it's finally located, the wall or ceiling surface usually looks like a sponge.

A Look At the Circuit

The *Stud Finder* (see Fig. 1), as described in a brief application sheet from the Cherry Semiconductor Corp. can be built as a pocket-size, hand-held device in a plastic or other non-metallic case. The circuit is based on the CS209 monolithic integrated circuit, which is designed to detect the presence or proximity of magnetic metals. It has an internal oscillator that, along with its external LC resonant circuit, provides oscillations whose amplitude is dependent upon the Q of the LC network. Bringing the circuit in close proximity to magnetic material reduces the Q of the tuned circuit, thus the oscillations tend to decrease in amplitude.

The decrease in amplitude is detected and used to turn on the light-emitting diode (LED1) indicating the presence of a magnetic material (i.e., nail or screw). That is, when the search coil (L1) is passed over the surface of the ceiling or wall LED1 lights, pinpointing the locations of nails and screws. To set up the Stud Finder, place the search coil well away from any magnetic metal, adjust the SENSITIVITY control (R1) so that LED1 just comes on. Then, carefully back off the control until LED1 just goes out. Touch-up the adjustments, repeating if necessary, until you reach a point where the LED goes on and off as a small steel screwdriver or a nail is moved close to and then away from the search coil.

PARTS LIST FOR THE STUD FINDER

B1—9-volt transistor-radio battery
C1—0.0015-µF, 16-WVDC, silver-mica or dipped-mica, 5% capacitor
C2—0.0022-µF, 16-WVDC ceramic-disc capacitor
C3—0.01-µF, 16-WVDC, ceramic-disc or dipped-mica capacitor
L1—100-µH RF choke (Radio Shack 273-102 or equivalent)
LED1—Jumbo red light-emitting diode
R1—220-ohm, ¼-watt or ½-watt, 5% (or better) fixed resistor
R2—720-ohm, ¼-watt or ½-watt, 5% (or better) fixed resistor
R3—6,000-ohm, multi-turn (preferably a 10-turn type) trimmer potentiometer
S1—Single-pole, single-throw (SPST) toggle switch
U1—CS209 electromagnetic proximity detector integrated circuit (Cherry Semiconductor Corp., 2000 South County Trail, Greenwich, RI, 02818.)
Printed-circuit materials, Global Specialties #300-PC experimenter board or Radio Shack 276-170; battery snap-on connector, enclosure, solder, hook-up wire, hardware, etc.

Construction

The Stud Finder can be built using any convenient wiring method, and the parts layout is not critical. The physical design (illustrated in both the photo and Fig. 2) is laid out on half of a Global Specialties Type 300 PC printed-circuit board. You can cut the board with a fine-tooth saw-blade in a

(Continued on page 94)

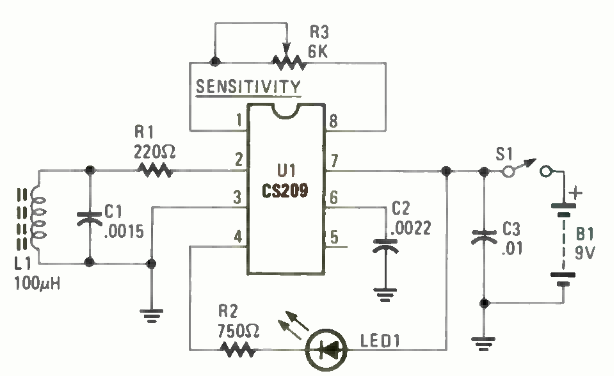


Fig. 1—As can be seen from the schematic diagram of the Stud Finder, the circuit is little more than a single integrated circuit (U1) and a couple of support components. Although the Stud Finder is shown powered from a 9-volt battery supply, it might just as easily be powered from the AC line using a home-brew power supply.

WE WANT TO KNOW ABOUT YOU

To keep bringing you the best in features and projects, we've got to know about the kinds of things that interest you.

SOMETHING FOR EVERYONE—THAT'S OUR MOTTO.

Each issue we come up with a broad selection of exciting features and projects so that every reader finds several things of interest; from new products, to book reviews, to feature articles that tell you *how-it-works*, to *build-it-yourself* projects.

And how do we know the kind of articles our readers want? From the reader mail we receive. Most readers who have occasion to write to us include a postscript on the kind of articles they'd like to see, and we feel that we have done a good job in keeping up with their interests.

But the electronics field is growing too fast and furious for us to depend only on your cards and letters to keep us informed about the kind of articles you would like to see. In order to keep you up-to-date on the latest products, technologies, and construction projects, we have to *anticipate* the kind of articles you want, and we can't anticipate your wants and desires unless we know more about you.

So we're asking you to help us plan the upcoming issues of **Hand-On Electronics** by using the tear-out **Hands-on Electronics Reader Survey** to tell us about yourself.

It's Secret.

First off, don't be afraid to tell us what you'd really like us to know. We don't ask for your name, address, or anything else that would identify you. We only want to know the city and state in which you live so we can determine regional interests. For example, while we receive many requests from readers in the Sun Belt for a treasure-finder project that will find coins lost in the sand, readers in the Snow Belt often request features on energy-saving devices so they can lower their heating and electric bills during the bitter days of winter.

Another purpose of the survey is to determine how much a project should cost. Should we compromise the features and performance of a project in order to keep construction costs at rock bottom, or should we go all out for the most features at maximum performance regardless of cost? We really can't decide if we have no idea of what you believe a reasonable cost should be; and so our survey asks for some information that will help us determine reasonable and acceptable costs for projects and equipment.

We've also got to plan ahead to the immediate future if we're to keep you up to date on emerging technologies. No one magazine is large enough to cover all the fast-breaking developments in electronics, so we want to be certain we specifically cover those subjects in your interest area. For example: We know you're not interested in 300-pound klystrons used in betatrons, but that you would be interested in an inexpensive chip that'll protect your car from forced entry. Your answers to our survey will help us do that by telling us what you're into now, and what you expect be into in the immediate future. We will know what you want if you tell us *the way things really are*, not how you would like them to be. For example, if you currently participate in electronics experimentation and think that some day you might be into video photography don't check off video photography—you're not doing it yet. On the other hand, when we do ask what you think you might get involved in some time during the next three years, tell us about it *if you're not doing it now*—we want to plan ahead so we can meet your needs as they arise a few months or a year or two down the road.

Write It In.

Where we couldn't fit in all possible choices, we've left room for your own entry (labeled "Other"). Please try to answer all the questions, because the more we know about you the better we can cover your individual interests. Mail the questionnaire to:

Hands-On Electronics
500-B Bi-County Boulevard
Farmingdale, New York 11735

HANDS-ON ELECTRONICS READER STUDY

ABOUT YOUR READERSHIP

1. How long have you been a reader of HANDS-ON ELECTRONICS?

   _______ Years and/or _______ Months (5-7)

2. Are you a subscriber? 8-1 ☐ Yes -2 ☐ No

3. On the average, about how much time do you spend reading an issue of HANDS-ON ELECTRONICS?

   _______ Hours and/or _______ Minutes (9-11)

4. What do you usually do with your copies of HANDS-ON ELECTRONICS when you are finished reading them? (CHECK ALL THAT APPLY.)

   12-1 ☐ Save the entire issue
   -2 ☐ Clip items of interest for future reference
   -3 ☐ Pass the issue on to someone else
   -4 ☐ Discard issue

5. How many people, other than yourself, usually read your copy of HANDS-ON ELECTRONICS?

   _______ Other Readers (13-14)

6. Where do you usually read your copies of HANDS-ON ELECTRONICS?

   15-1 ☐ At home -2 ☐ At work -3 ☐ Both at home and at work

7. In the past 12 months have you used the reader service card bound into the magazine (the card on which you circle numbers to get information from manufacturers) to request additional information about products or services appearing in the magazine?

   16-1 ☐ Yes 2 ☐ No

ABOUT YOUR INTEREST IN ELECTRONICS

8. Listed below are several different electronics activities. Please check off EACH ONE in which you currently participate.

   17-1 ☐ Audio, Stereo
   -2 ☐ Building Electronic Projects
   -3 ☐ CB Radio
   -4 ☐ Electronic Experimentation
   -5 ☐ Ham Radio
   -6 ☐ Hobby Computers
   7 ☐ Kit Building
   -8 ☐ Satellite TV
   -9 ☐ Scanners
   -0 ☐ Short-Wave Listening
   -x ☐ Tape Recording (Hi-Fi)
   y ☐ Video Photography
   18-1 ☐ Video Recording
   -2 ☐ Other_______________________
   (please specify)

9. For about how many years have you been participating in electronics activities?

   _______ Years (19-20)

10. What electronics activities do you think you will be involved with in the future? Please indicate. . .

    (a) How likely it is that you will be involved in EACH of the areas listed below during the NEXT 12 MONTHS?

    (b) Which activities you think you might get involved in sometime during the NEXT THREE YEARS.

	(a) During Next 12 Months			(b)
	Very Likely	Somewhat Likely	Not Likely	Might Be Involved In Next 3 Years
Audio, Stereo	☐ 21-1	☐ 23-1	☐ 25-1	☐ 27-1
Building Electronic Projects	☐ -2	☐ -2	☐ -2	☐ -2
CB Radio	☐ -3	☐ -3	☐ -3	☐ -3
Ham Radio	☐ -4	☐ -4	☐ -4	☐ -4

	(a) During Next 12 Months			(b)
	Very Likely	Somewhat Likely	Not Likely	Might Be Involved In Next 3 Years
Hobby Computers	☐ -5	☐ -5	☐ -5	☐ -5
Kit Building	☐ -6	☐ -6	☐ -6	☐ -6
Satellite TV	☐ -7	☐ -7	☐ -7	☐ -7
Scanners	☐ -8	☐ -8	☐ -8	☐ -8
Short-Wave Listening	☐ -9	☐ -9	☐ -9	☐ -9
Tape Recording (Hi-Fi)	☐ -0	☐ -0	☐ -0	☐ -0
Video Photography	☐ -x	☐ -x	☐ -x	☐ -x
Video Recording	☐ -y	☐ -y	☐ -y	☐ -y
Other ______ (please specify)	☐ 22-1	☐ 24-1	☐ 26-1	☐ 28-1

11. Listed below are a number of items of electronic equipment and components. Please review the list and indicate.

a. which items you now own;
b. which items you purchased within the past 12 months (regardless of whether or not you still own the item);
c. the amount spent for each item within the past 12 months;
d. and, finally, which items you are likely to purchase in the next 12 months (regardless of whether or not you currently own the item).

	a. Now Own Item	b. Have Purchased In Past 12 Months	c. Cost of Items Purchased In Past 12 Months		d. Likely To Purchase In Next 12 Months
Test Equipment					
Analog multimeter	☐ 29-1	☐ 35-1	$______ 41-44-		☐ 49-1
Digital multimeter	☐ -2	☐ -2	$______ 45-48-		☐ -2
Oscilloscope, single trace	☐ -3	☐ -3	$______ 49-52-		☐ -3
Oscilloscope, dual trace	☐ -4	☐ -4	$______ 53-56-		☐ -4
Digital logic probe	☐ -5	☐ -5	$______ 57-60-		☐ -5
Frequency counters	☐ -6	☐ -6	$______ 61-64-		☐ -6
Transistor testers	☐ -7	☐ -7	$______ 65-68-		☐ -7
RF signal generator	☐ -8	☐ -8	$______ 69-72-		☐ -8
Function generator	☐ -9	☐ -9	$______ 73-76-	80-1	☐ -9
Color bar/dot generator	☐ -0	☐ -0	$______ 5-8-		☐ -0
Power supplies	☐ -x	☐ -x	$______ 9-12-		☐ -x
Other ______ (please specify)	☐ -y	☐ -y	$______ 13-16-		☐ -y
None of these	☐ 30-x	☐ 36-x			☐ 50-x
Communications Equipment					
CB Mobile transceiver	☐ 31-1	☐ 37-1	$______ 17-20-		☐ 51-1
CB base station	☐ -2	☐ -2	$______ 21-24-		☐ -2
SWL receiver	☐ -3	☐ -3	$______ 25-28-		☐ -3
Ham equipment	☐ -4	☐ -4	$______ 29-32-		☐ -4
Scanner	☐ -5	☐ -5	$______ 33-36-		☐ -5
Antenna	☐ -6	☐ -6	$______ 37-40-		☐ -6
Other ______ (please specify)	☐ -7	☐ -7	$______ 41-44-		☐ -7
None of these	☐ -x	☐ -x			☐ -x

Satellite TV Equipment	a. Now Own Item	b. Have Purchased In Past 12 Months	c. Cost of Items Purchased In Past 12 Months	d. Likely To Purchase In Next 12 Months
Receiver	☐ 32-1	☐ 38-1	$______ 45-48-	☐ 52-1
LNA	☐ -2	☐ -2	$______ 49-52-	☐ -2
LNB	☐ -3	☐ -3	$______ 53-56-	☐ -3
Dish (Antenna)	☐ -4	☐ -4	$______ 57-60-	☐ -4
Positioner	☐ -5	☐ -5	$______ 61-64-	☐ -5
Remote Control	☐ -6	☐ -6	$______ 65-68-	☐ -6
Other ______ (please specify)	☐ -7	☐ -7	$______ 69-72- 80-2	☐ -7
None of these	☐ -x	☐ -x		☐ -x

Microcomputer Equipment	a.	b.	c.	d.
All-in-one, Monitor-Keyboard-Computer, Single Board	☐ 33-1	☐ 39-1	$______ 5-8-	☐ 53-1
Memory	☐ -2	☐ -2	$______ 9-12-	☐ -2
Peripherals	☐ -3	☐ -3	$______ 13-16-	☐ -3
Software	☐ -4	☐ -4	$______ 17-20-	☐ -4
Other ______ (please specify)	☐ -x	☐ -x	$______ 21-24-	☐ -5
None of these	☐ -x	☐ -x		☐ -x

Miscellaneous	a.	b.	c.	d.
Hand tools	☐ 34-1	☐ 40-1	$______ 25-28-	☐ 54-1
Power tools	☐ -2	☐ -2	$______ 29-32-	☐ -2
Wire wrap tools	☐ -3	☐ -3	$______ 33-36-	☐ -3
Soldering/desoldering equipment	☐ -4	☐ -4	$______ 37-40-	☐ -4
Security alarm	☐ -5	☐ -5	$______ 41-44-	☐ -5
Other ______ (please specify)	☐ -6	☐ -6	$______ 45-48-	☐ -6
None of these	☐ -x	☐ -x		☐ -x

ABOUT MAGAZINES

12. Please indicate which, if any, of the magazines listed below you read regularly—that is, at least three out of every four issues. Then, please tell us how you usually obtain your copies of those magazines you do read regularly.

	Read Regularly (At least 3 out of 4 Issues)	HOW COPIES ARE OBTAINED: Subscribe	Buy On Newsstand	Someone Else's Copy	Other
Audio	☐ 55-1	☐ 57-1	☐ 59-1	☐ 61-1	☐ 63-1
Byte	☐ -2	☐ -2	☐ -2	☐ -2	☐ -2
CB	☐ -3	☐ -3	☐ -3	☐ -3	☐ -3
Ham Radio	☐ -4	☐ -4	☐ -4	☐ -4	☐ -4
High Fidelity	☐ -5	☐ -5	☐ -5	☐ -5	☐ -5
Mechanix Illustrated	☐ -6	☐ -6	☐ -6	☐ -6	☐ -6
Modern Electronics	☐ -7	☐ -2	☐ -7	☐ -7	☐ -7
Personal Computing	☐ -8	☐ -8	☐ -8	☐ -8	☐ -8

	Read Regularly (At least 3 out of 4 issues)	HOW COPIES ARE OBTAINED: Subscribe	Buy On Newsstand	Someone Else's Copy	Other
Popular Mechanics	☐ -9	☐ -9	☐ -9	☐ -9	☐ -9
Popular Science	☐ -0	☐ -0	☐ -0	☐ -0	☐ -0
QST	☐ -x	☐ -x	☐ -x	☐ -x	☐ -x
Radio-Electronics	☐ -y	☐ -y	☐ -y	☐ -y	☐ -y
S-9	☐ 56-1	☐ 58-1	☐ 60-1	☐ 62-1	☐ 64-1
Scientific American	☐ -2	☐ -2	☐ -2	☐ -2	☐ -2
Stereo Review	☐ -3	☐ -3	☐ -3	☐ -3	☐ -3
Other ____________ (please describe)	☐ -4	☐ -4	☐ -4	☐ -4	☐ -4
None of the above	☐ -x				

FOR CLASSIFICATION PURPOSES. May we remind you that all answers to this questionnaire are confidential and will be used only in combination with those of other respondents to develop a composite analysis.

A. What is your age? (PLEASE CHECK ONE.)

65-1 ☐ Under 18
-2 ☐ 18-24
-3 ☐ 25-29
-4 ☐ 30-34
-5 ☐ 35-39
-6 ☐ 40-44
-7 ☐ 45-54
-8 ☐ 55-64
-9 ☐ 65 or older

B. Are you male or female?

66-1 ☐ Male
-2 ☐ Female

C. What is the highest level of school that you attained? (PLEASE CHECK ONE.)

67-1 ☐ Grade school
-2 ☐ Attended high school
-3 ☐ Graduated high school
-4 ☐ Attended college
-5 ☐ Attending college
-6 ☐ Graduated college
-7 ☐ Post graduate study
-8 ☐ Masters Degree
-9 ☐ Doctorate

D. Are you employed (FULL OR PART-TIME) in the electronics field, or in an area where a knowledge of electronics is essential?

68-1 ☐ Yes (GO TO Q.E)
-2 ☐ No (PLEASE SKIP TO Q.G)

E. If you are employed in electronics or in an area where a knowledge of electronics is essential, check the one type of work that best describes your job.

69-1 ☐ Management
-2 ☐ Installation and maintenance
-3 ☐ Engineering
-4 ☐ Technician
-5 ☐ Education/Teaching
-6 ☐ Other (PLEASE WRITE IN)

____

F. Do you get involved in your company's purchase of electronic equipment and components?

70-1 ☐ Yes
-2 ☐ No

G. What is your job title or position? (OWNER, VICE PRESIDENT, MANAGER, ENGINEER, FOREMAN, CLERK, SALESMAN, STUDENT, ETC.)

____ (71-72)

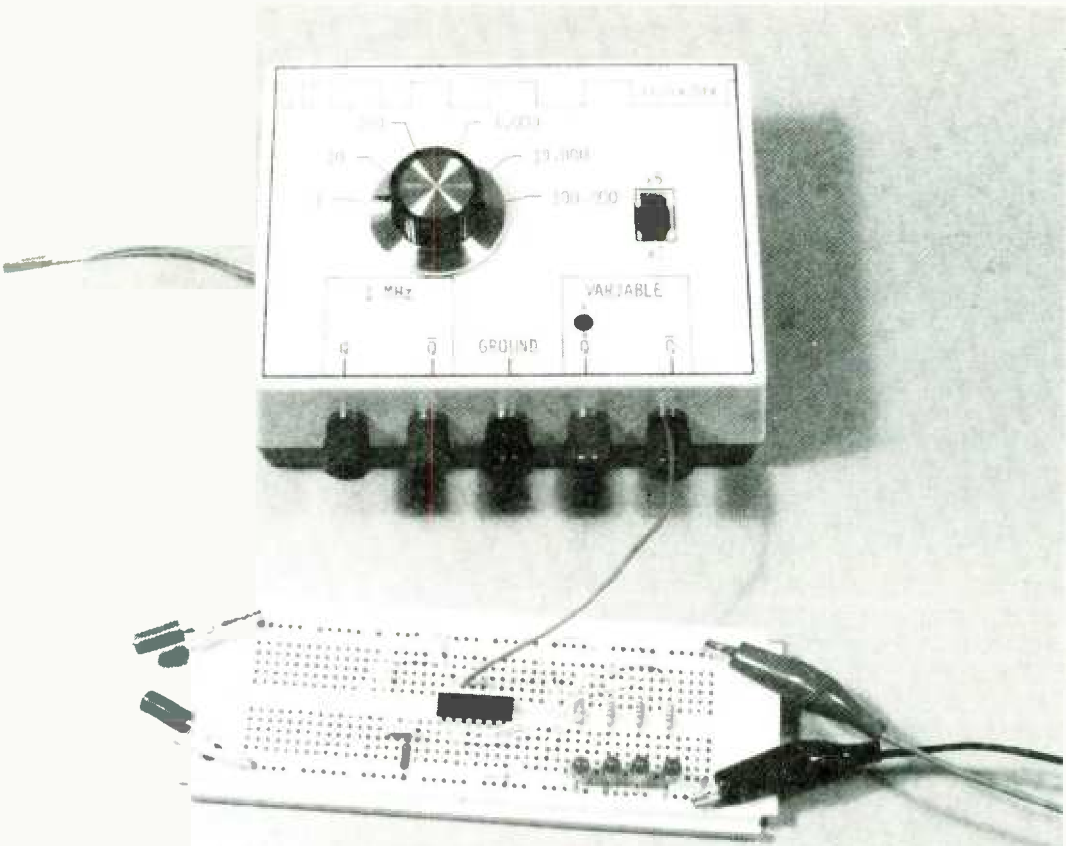
H. Please check the box that best describes your total annual household income. (Please include Income from yourself and all other household members from all sources such as wages, bonuses, profits, dividends, or interest, etc.)

73-1 ☐ Less than $10,000
-2 ☐ $10,000 - $14,999
-3 ☐ $15,000 - $19,999
-4 ☐ $20,000 - $24,999
-5 ☐ $25,000 - $34,999
-6 ☐ $35,000 - $49,999
-7 ☐ $50,000 - $74,999
-8 ☐ $75,000 - $99,999
-9 ☐ $100,000 - $149,999
-0 ☐ $150,000 - $174,999
-x ☐ $175,000 - $199,999
-y ☐ $200,000 or more

YOUR CITY: ____________________ YOUR STATE: ____________________ (74-75)

80-3

THANK YOU VERY MUCH FOR YOUR CONVENIENCE



The ClockBox

A low-cost precision clock generator you can build today!

By J. Daniel Gifford

□AN INDISPENSABLE ITEM TO HAVE ON YOUR TESTBENCH when you're working with digital circuits is a source of squarewave frequencies—in digital parlance, a *clock generator*. While it's possible to *cobble up* a clock source in one corner of each test or experimental circuit, assembling a clock every time you need one quickly becomes a tedious chore, and the need for a dedicated clock generator becomes apparent.

There are two basic approaches to building a clock generator. The first is to build a variable oscillator, either from inverters or from an integrated-circuit timer such as the 555, where the frequency is set by means of a potentiometer and a timing capacitor—switching between selected capacitor values provides several frequency ranges. The advantage to this kind of design is that *any* frequency in *any* of the ranges can be dialed up and set precisely—the output frequency is continuously variable within each range. On the other hand, a frequency meter is needed to make fine adjustments, and unless an expensive and complex circuit is used, drift will be a problem.

The second approach is to use a high-frequency, crystal-controlled oscillator to provide a reference frequency, and to use counters to divide the reference frequency down into useful ranges. This gives outstanding precision and stability, but at the loss of both adjustability and continuously-variable output frequencies. For general use, the variable type is satisfactory, but for even semi-precision needs a crystal-controlled type, such as *The ClockBox*, should be used.

The ClockBox is a crystal-controlled clock generator with twelve switch-selectable output frequencies and one dedicated output frequency. An additional band of six frequencies can be added, giving a total of 19 frequencies from 1 Hz to 1 MHz—more than enough for almost all testbench purposes. And despite the fact that the ClockBox can be built for about $15, it gets some fancy frills and features from only five integrated circuits.

The Circuit

The heart of the ClockBox, like most clock generators of this type, is a string of synchronous decade counters used to divide the main frequency down in multiples of 10. As shown in Fig. 1, six counters—and thus six decades of counters—are used, the six counters being provided by three 4518 dual synchronous BCD up counters. Most such generators use a 1-MHz oscillator frequency and divide it down to produce 100 kHz, 10 kHz, and so on down to 1 or 0.1 Hz. The problem with this is that few counters have 50% duty cycle outputs, which are desirable in general and required for some circuits. So, the ClockBox uses a 2 MHz oscillator frequency and adds an extra division stage—we'll see why shortly.

The oscillator is a standard CMOS design, using one inverter section of a 4069 as the active element (U1-e), with the 2-MHz crystal and tank circuit components in parallel. To avoid loading problems, a second inverter is used as an output buffer (U1-d). (Make certain you disable U1-a, U1-b and U1-c as shown in the schematic.)

Four Outputs

Binary coded decimal (BCD) counters like the 4518 have four outputs, which are designated as Q1, Q2, Q3, and Q4. Q1 divides the counter's input frequency by 2; Q2, divides the input by 4; and Q3 and Q4, both of which divide the input frequency by 10—Q3 with a 40% duty cycle, Q4 with a 20% duty cycle.

The 2-MHz output from the crystal oscillator is routed to the first counter's (U2-a) clock input. Its outputs are thus 1 MHz at the Q1 output, 500 kHz at Q2, and 200 kHz at Q3 and Q4. The Q3 output is used to clock the next stage, as it is on down the line to the last counter (U4-b), which has output frequencies of 10 Hz at its Q1, 5 Hz at its Q2, and 2 Hz at its Q3 and Q4.

The six Q4 outputs from the counters are connected to the six positions of one pole of S1 (S1a), a DP6T rotary switch, and the output of the switch is routed (via S2) to the clock input of a 4027 CMOS dual JK flip-flop U5-b. The frequency selected by S1 appears at the flip-flop's Q output: divided by two and with a perfect 50% duty cycle. With the final division of the flip-flop, the six output frequencies are now 1 Hz to 100k-Hz. As a bonus, the flip-flop's $\overline{Q}$ output gives a very useful *complementary* signal.

More Frequencies

The ClockBox also has a range switch (S2) that is used to select a ×5 multiplier. When set to the ×1 position the output is from switch S1a and the output frequencies are the ones listed above. When S2 is set to the ×5 position, output is taken from switch S1b, which connects to the counter's Q1 outputs. Hence, the output frequencies are multiplied by 5, covering the range of 5 Hz to 500 kHz. This gives the ClockBox 12 output frequencies from 1 Hz to 500 kHz at terminals BP1 and BP2, all with crystal precision and stability, all with 50% duty cycles, and all with a complementary output.

If more frequencies are desired, a third set of "×2.5" outputs can be added by using a three-pole, 6-throw (3P6T) switch for S1 and a one-pole, 3-position (SP3T) switch for S2. The six positions of the third pole are connected to the Q2 outputs of the six counters (U2-a through U4-b), which results in the frequency range 2.5 Hz to 250 kHz at the outputs. Light-emitting diode, LED1, indicates the phase of the Q output. Of course, individual states are only discernible at frequencies of 10 Hz and below, but the LED indicator is useful at all frequencies as a power-on signal. A Fresnel-lens LED is suggested because of its wide viewing angle and high visibility, even at low supply voltages.

In addition to the complementary, switch-selected, variable outputs, the ClockBox has a second set of complementary outputs driven by U5-a, the other JK-type flip-flop, which receives its signal directly from the main oscillator's output buffer. Those outputs from BP1 and BP2 deliver a two-phase 1 MHz signal, which is particularly valuable to the experimenter who works with breadboarded microprocessor circuits.

In addition to the four output terminals, note that the ClockBox also has a front-panel *ground* terminal, BP3 (see Fig. 1). Since the ClockBox is meant to be powered from the

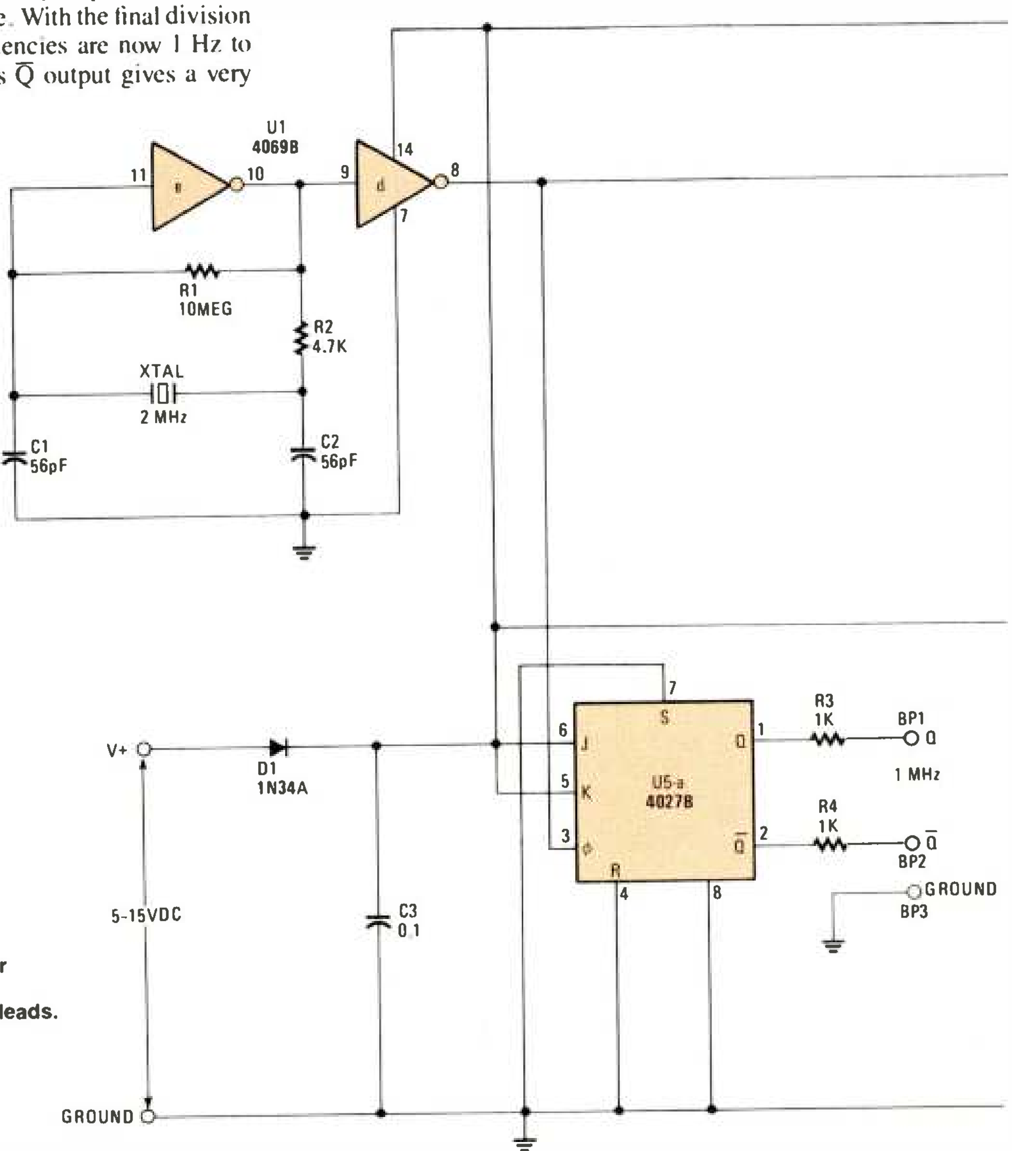


Fig. 1—The ClockBox is a high-precision clock generator with a range of thirteen—or nineteen—output frequencies. Like logic probes and pulsers, it draws its power directly from the circuit to which it connects through the test leads.

circuit it is clocking, it already has a common ground; however, when supplying frequencies of 100 kHz and up a separate ground connection to this terminal should be provided to ensure a clean signal.

As seen in the first photograph, alligator clips on the power supply leads are used to connect the ClockBox to the circuit it is providing with a clock signal. This is similar to the way a logic probe or pulser is used, and for the same reason—it simplifies the use of the device since the output level is inherently matched to the circuit. If desired, a light-duty variable power supply could be added to the ClockBox, also an external level control, but this complicates both the circuit and its use, and introduces the possibility of damage from a level mismatch.

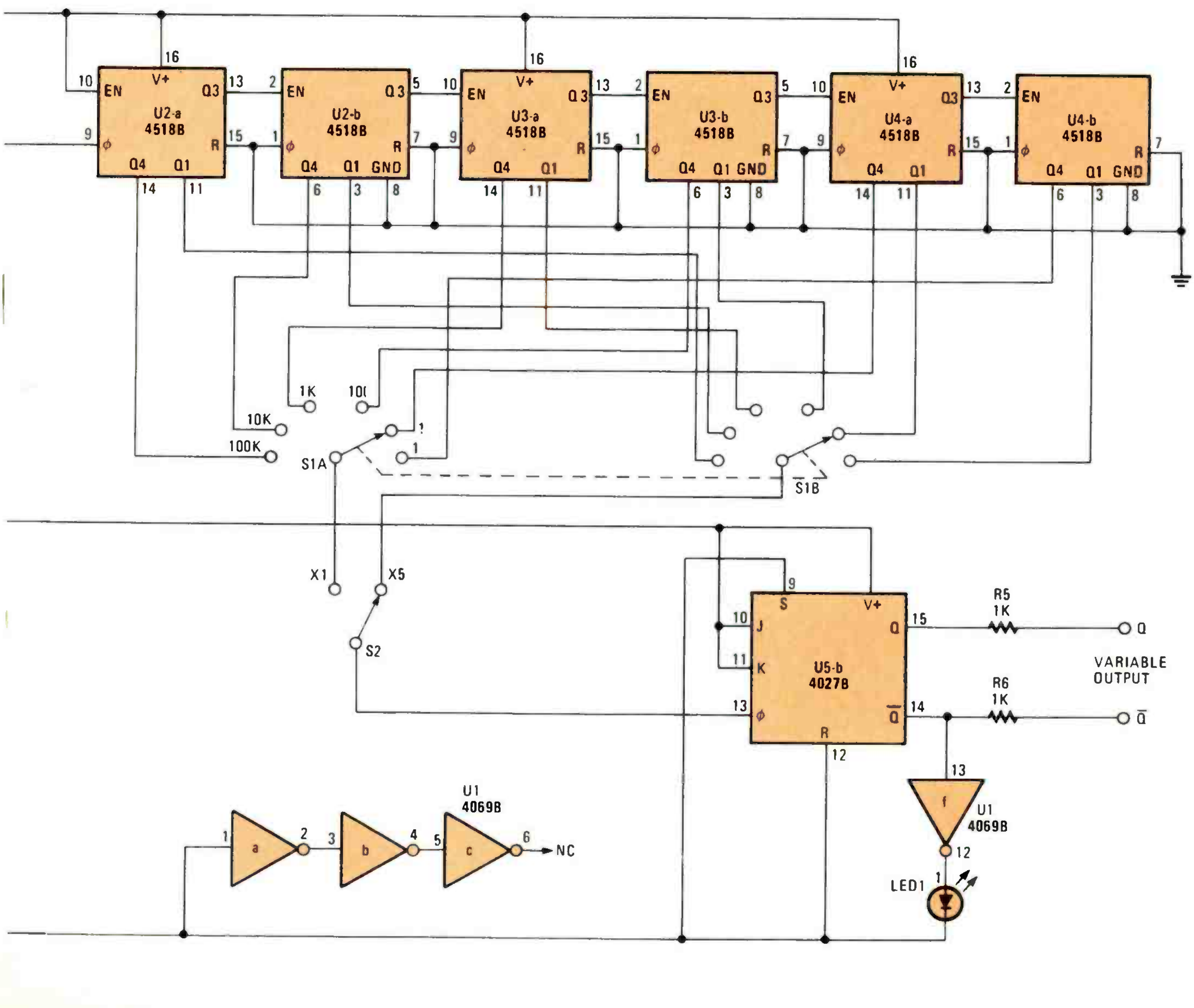
Since all of the IC's used in the ClockBox are CMOS, the device can be used with a wide range of supply voltages. The usual range quoted for CMOS is 5 to 15 volts. B-series CMOS integrated circuits can be used with voltages up to 18 volts), but the unit shown functioned down to 3.8 volts. It is preferred that B-series CMOS chips be used, but it is not mandatory. The ClockBox's outputs are TTL compatible with a 5-volt supply as long as only one TTL input is driven from each of the ClockBox's four outputs. In some instances a 2200-ohm pull-down resistor might be needed, particularly with standard 7400-series TTL.

Polarity Protection

Note that diode DI is inserted into the ClockBox's positive supply lead to prevent damage to the circuitry in the event the supply clips are accidentally reversed. Because germanium has a lower breakover voltage than silicon, a germanium IN34A diode is used for DI rather than an equivalent silicon device so that the diode's voltage drop will not interfere with output levels at the lower supply voltages. Capacitor C3—0.1-μF—is used to filter transients from the power supply, but note that no overvoltage protection is provided. If there is any chance of more than 18 volts being connected to the ClockBox some form of overvoltage limiting, such as a 10-watt, 18-volt Zener diode "crowbar," should be added to the circuit.

The ClockBox is economical in its use of current, drawing about 4-mA at 5 volts and a maximum of 35-mA at 15 volts.

Although crystal oscillators are inherently high in precision, it might be desirable to be able to tune the oscillator to run at exactly 2,000 MHz. This can be done by replacing CI with a 0-100-pF. variable capacitor. With a frequency meter



PARTS LIST FOR THE CLOCKBOX

SEMICONDUCTORS
DI—IN34A germanium diode
LED1—Light-emitting diode with Fresnel lens (lens optional)
UI—CD4069UB, CMOS hex inverter integrated circuit
U2–U4—CD4518B CMOS dual synchronous BCD up counter integrated circuit
U5—CD4027B, CMOS dual JK-type flip-flop integrated circuit

RESISTORS
(All resistors ¼-watt, 10% fixed units)
R1—10-Megohm
R2—4700-ohm
R3–R6—1000-ohm

CAPACITORS
C1, C2—56-pF, disc (see text)
C3—0.1-µF, Mylar

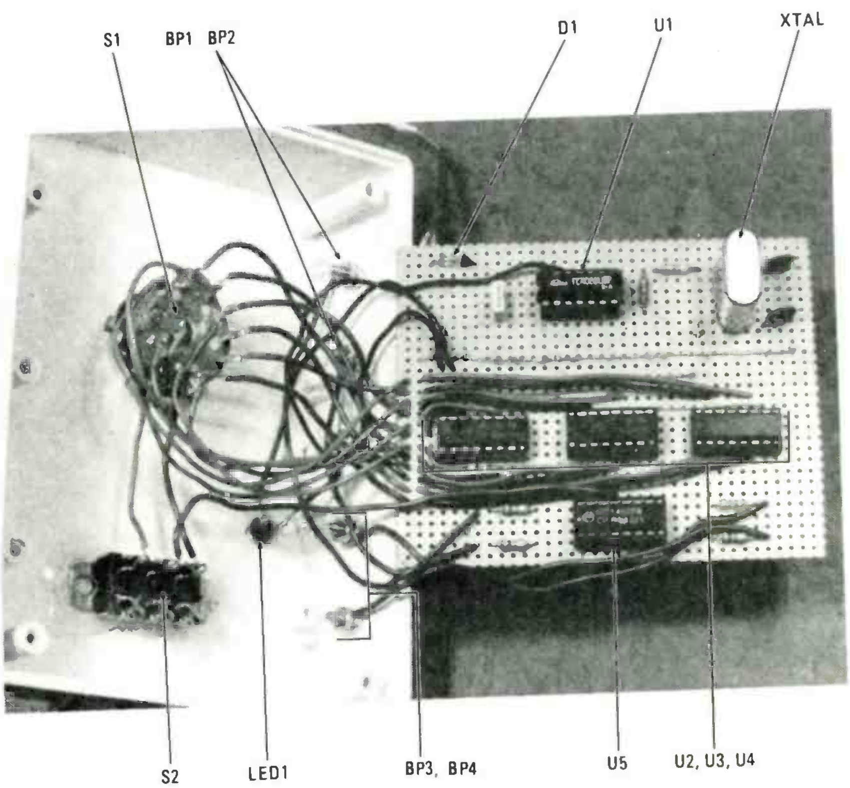
ADDITIONAL PARTS AND MATERIALS
BP1–BP5—Multi-way binding posts; one black, 4 red (optional)
SI—2-pole, 6-position rotary switch (see text)
S2—SPDT slide switch (see text)
XTAL—2.000-MHz crystal
Case, perfboard, one 14-pin IC socket, four 16-pin IC sockets, 2-conductor cable, alligator clips or test hooks, switch knob, hardware, wire, solder, etc.

attached to pin 8 of U1, adjust the capacitor until the meter reads as close to 2,000,000 Hz as its resolution allows. (The unit shown used an unpicked fixed capacitor for C1; a check with a meter showed an output of 2,000,168 Hz: an error of 0.0084%. Actually, frequency adjustment should only be necessary for very high-precision uses.)

Construction

The only tricky part about building the ClockBox is keeping the wiring between the circuit board and the switches neat—particularly if you opt for the extra band of frequencies. Other than that detail, construction is straightforward. The unit shown was built in a Unibox case, but other suitable enclosures include Radio Shack's 270-286 and 270-264. All three of these cases will allow for sufficient space without crowding.

For ease of construction, the ClockBox should be assembled on a section of perfboard using the layout shown in the photographs. Note particularly, the way the switch wiring is handled; the leads are brought from the switches to the edge of the perfboard where they connect with leads from the integrated circuits—this provides secure, intermittent-free connections.



To provide a secure installation to the switch leads, they are brought to holes along the edge of the perfboard where they connect to the wires coming from the integrated circuits.

Be certain to use sockets for all of the integrated circuits, because it's very easy to damage CMOS components with a soldering iron—either with heat or static electricity. The integrated circuits should be kept in antistatic foam until ready for insertion, and the use of a DIP inserter is recommended.

The power-supply leads can be any light-gauge, two-conductor cable about 18 inches long. Although mini-alligator clips are used on the prototype, they can be replaced with mini-test hooks: clips can be hooked to oddly-shaped points, but test hooks are more suitable for crowded printed-circuit boards. Whichever type is used should be color-coded red and black for an easy, error-free hookup.

The Panel Components

The switches, binding posts, and the LED are mounted in the top part of the case to line up with the panel label shown in the lead photo. Make your own label to use as a template when working on the project.

The template should be lightly tacked in place on the case, and the appropriate drilling and cutting done. When all the work is completed the template should be removed, the case cleaned, and a perfect label applied with rubber cement or artists's adhesive. The paper label should be protected with either a sheet of clear laminating film (from a photographic supply store) or several thin coats of clear acrylic spray.

The multi-way binding posts, BP1–BP5, and rotary switch, SI, are self-mounting, but other means must be used to mount slide switch S2 and light-emitting diode LED2. The switch can be epoxied into place, using care to keep the glue out of the switch's working parts, or more conventional screws and standoffs can be used. The LED can also be epoxied in position, but if a plastic case is used the LED, can be tacked in place with several light touches of a soldering iron. ■

FUNCTION GENERATOR

AS ANY ELECTRONICS HOBBYIST OR PROFESSIONAL knows, a function generator is almost indispensable when it comes to the design and repair of electronic gadgets. Design engineers use them to feed a specific frequency and voltage level to a circuit to see how it will react, so that the circuit can be modified to conform to design criteria. Similarly, the hobbyist might use such an instrument to troubleshoot and repair a project, by feeding the circuit a known frequency and tracing it through the labyrinth of foils, wires, and components.

So-called "lab-quality" function generators can cost hundreds of dollars and yet have a noise figure (total harmonic distortion or THD) up around 1%—not bad until you consider that you can build **Hands-on Electronics** .01% THD Function Generator that includes a tuneable filter, using trashed out, cannibalized, cheap parts at a fraction of the cost. Its .01% THD specification over the audio band is amplitude stabilized to within ± 1 dB in an easy to tune format that beats the socks off the commercial stuff, like Hewlett Packard's Wein Bridge 200 series (with its 1% THD), by a factor of 100.

It's THD is 400 times, or more, better than untrimmed monolithic function generator chips, which can have a maximum THD of 4% or worse. In terms of THD, it outperforms commercial lab-grade instruments (costing thousands of dollars) over the audio band. And if the basic circuit were to be trimmed and optimized (as must be done with circuits based on monolithic function generator chips to get sine outputs in the .1% to 1% range) we could push THD clear out of sight, into the .002% to .005% range at a given frequency.

Why the .01% THD Spec?

Now, the question that's probably foremost in your mind is "Who needs this little ditty with it's ultra-low distortion figure?" Well that's a question that we'll let you answer for yourself—we just provide some of the particulars. First, consider that a few years ago an audio amplifier with a preamplifier rate for 1% THD might have been considered good. But, when's the last time you checked the spec sheet of even some cheap audio amplifiers? Things have changed dramatically. It's a whole new ball game, baby!

For starters, an *el cheepo* integrated dual-channel preamplifier can be had for under a buck with THD ratings typically in the 1% range. And higher-grade preamplifiers, such as National Semiconductor's LM381N, LM382N, LM387N, and LM1303N, for example (with typical THD's of 0.1% at 1 kHz), can be had for just over a dollar.

Now, suppose you want to measure THD in one of those *babies* while in a given circuit. What are you going to use for a sinewave input? The biggest unnoticed hangup about monolithic function-generator chips is the poor quality of sinewave output, especially when it comes to audio work. Look around your service bench. You'll find that even what has become an industry standard has a THD specified in the 1% range. The THD of the sinewave source should be 1/10 of the THD rating of the circuit under test (CUT).

Many a published project purporting to be lab-quality audio equipment has been based on monolithic integrated circuits. But what those articles have failed to mention is that those circuits are virtually worthless for distortion analysis and other tests when pushing their sinewave outputs directly into audio-preamplifiers. Some projects have taken an untrimmed function-generator IC (with a THD starting in the 4% range), amplified its output, ending up with THD's in the 5% to 10% range. Even trimming those beasts at one frequency and getting the distortion figure down to .1% doesn't mean that the specification will be constant over the entire audio range. And you'll never see a .01% THD spec from those or other inexpensive service grade function generators, either—at least not without some fancy post-output filtering.

But, what about Wein Bridge oscillators?

Wein Bridge Oscillators

Wein bridge oscillators are only as good as their AGC feedback loops and matched components. A wein-bridge network provides positive feedback to make the circuit oscillate and AGC negative feedback provides control. When the positive from the network equals the negative feedback from the AGC loop, you get unity gain and minimum distortion. However, even using fancy AGC FET-loops operating at a single frequency, optimizing everything in sight (including matched capacitors and resistors, etc.), you can only get a practical THD of around .01% at best.

But, that doesn't hold for continuous tuning, which requires premium matched dual tracking potentiometers and/or capacitors. The match is never that great even with expensive premium parts, so its unlikely that you'll ever see anything close to a .01% THD.

Going Further

Most cheap function generators have some inherent distortion (in the 1% range) in their triangle-to-sinewave conversion schemes. A typical cheap function-generator scheme might integrate a squarewave into a triangle and use piecewise approximation in a triangle-to-sinewave converter. That's good as far as it goes; only thing, it doesn't go far enough.

But, if we add a state variable or some other high Q tracking bandpass filter, then things change dramatically. In fact, pushing a triangle wave through a bandpass filter with a Q of around 50, gives output distortion levels in the under .05% range. A Q of 50 is just about the practical limit in an easily tuned active bandpass filter; generally, the higher the Q the slower the filter will settle out when tuned, which presents

By D.E. Patrick

Check out this junkbox function generator. It has a THD specification of .01 percent that out-performs commercial lab-quality instruments!

new sets of other problems (that we won't go into). But, using the above scenario, let's throw some trashed out parts together and see what we come up with.

How The Circuit Works

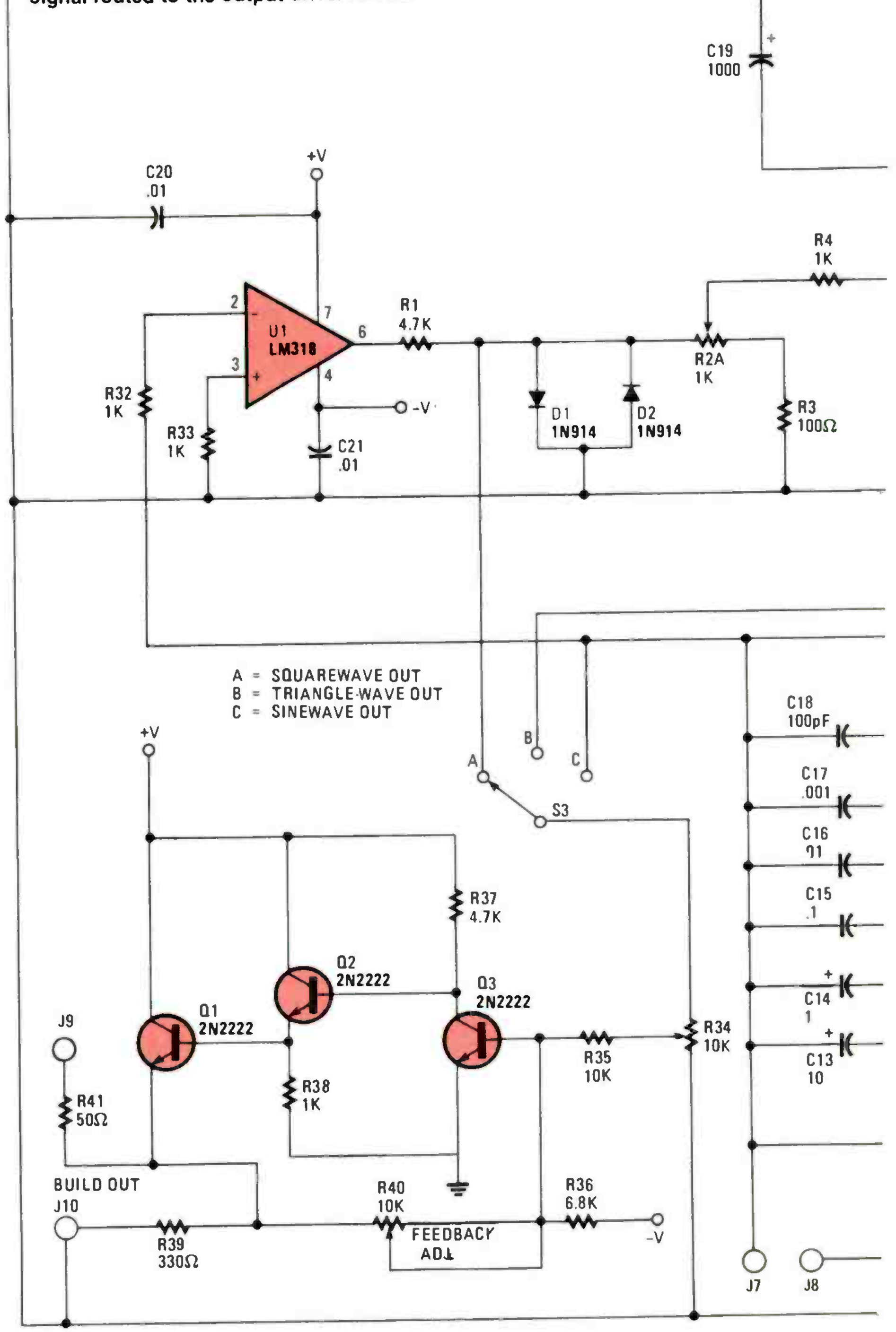
The circuit in Figure 1 may be built with individual op-amps like LM318's for operation over 100 kHz or the TL084's or TL074's quad op-amps for decent operation up to around 40 kHz. Virtually any junk box op-amp can handle the task, but the LM318 offers the highest slew rates and bandwidths available in cheap surplus stuff. They can cost from 25 to 50 cents, depending on where you shop. Quad op-amps, with slew rates in the 13V/μs region are generally pushed pretty hard when called on to provide a fast rise-time squarewave output. However, the LM318, with its 50 to 70V/μs slew rate is an excellent choice for operation at higher frequencies.

The circuit may be broken down into five sections; a squarewave generator (U1), a triangle-wave generator (U2), a triangle-to-sinewave converter (U3 and U4), an active filter (U5 thru U7), and an output driver circuit. The squarewave output of U1 is fed to the inverting input of U2, producing a triangular waveform at its output. That signal is then fed to S1-a and routed through a selected capacitor to the triangle-to-sinewave converter. With S2 in the position shown, the output of the triangle-to-sinewave converter is coupled to the active filter (U5–U7). When S2 is transferred, the filter may be used in a stand-alone format through its input at J6. The sinewave converter and other individual capabilities may optionally be used via J1 thru J10. The output of the filter at U7 is coupled back to U1, completing the loop necessary to make the circuit oscillate.

U1 acts as a comparator: When its input goes positive, its output swings negative: conversely, when its input goes negative, its output swings positive. U1's output is limited by D1 and D2 and is applied to the integrator, U2. The integral of a squarewave is a triangle, which is what we get at the output of U2. The output of U2 could be directly applied to the filter (U5 thru U7) for THD specs in the .05% range up to 10 kHz, and .08% in the 10 kHz to 20 kHz range. But, let's go a step further.

A triangle is rich in harmonics and may be thought of as a distorted sinewave as far as the filter is concerned, we can improve things via the triangle to sinewave converter. The sinewave converter reduces the possible distortion out from the triangle input to something less than 1% before being applied to the filter, which, in itself, is better than many function generator chips will do. Diodes D3 thru D9 provide a transfer function that decreases amplifier gain as the output increases, generating a piecewise linear approximation of the applied triangle input. The voltage at which the diodes conduct is determined by associated resistors. Thus, a reason-

Fig. 1—The Function Generator circuit is arranged so that by making use of the various switches in conjunction with the assorted input and output jacks, an alternate signal source may be fed to the circuit, or the desired signal routed to the output driver circuit.



ably good approximation is provided. That process can be extended for a closer approximation and lower distortion with the use of low-tolerance components. In any case, we continue around the filter loop to where we began completing the oscillator configuration.

The frequency-range bands are determined by switch S1 and associated capacitors in the function generator and filter sections. Continuous tuning is performed by R2, i.e., three variable resistors (ganged potentiometers) on a common shaft. R2a–R2c can track within 5% to 10% and still provide excellent results. The closer the tracking, the better. However, you can even get away with using two cheap dual-ganged, 41-position, detented potentiometers, although more expensive versions can probably be found at your local surplus dealer.

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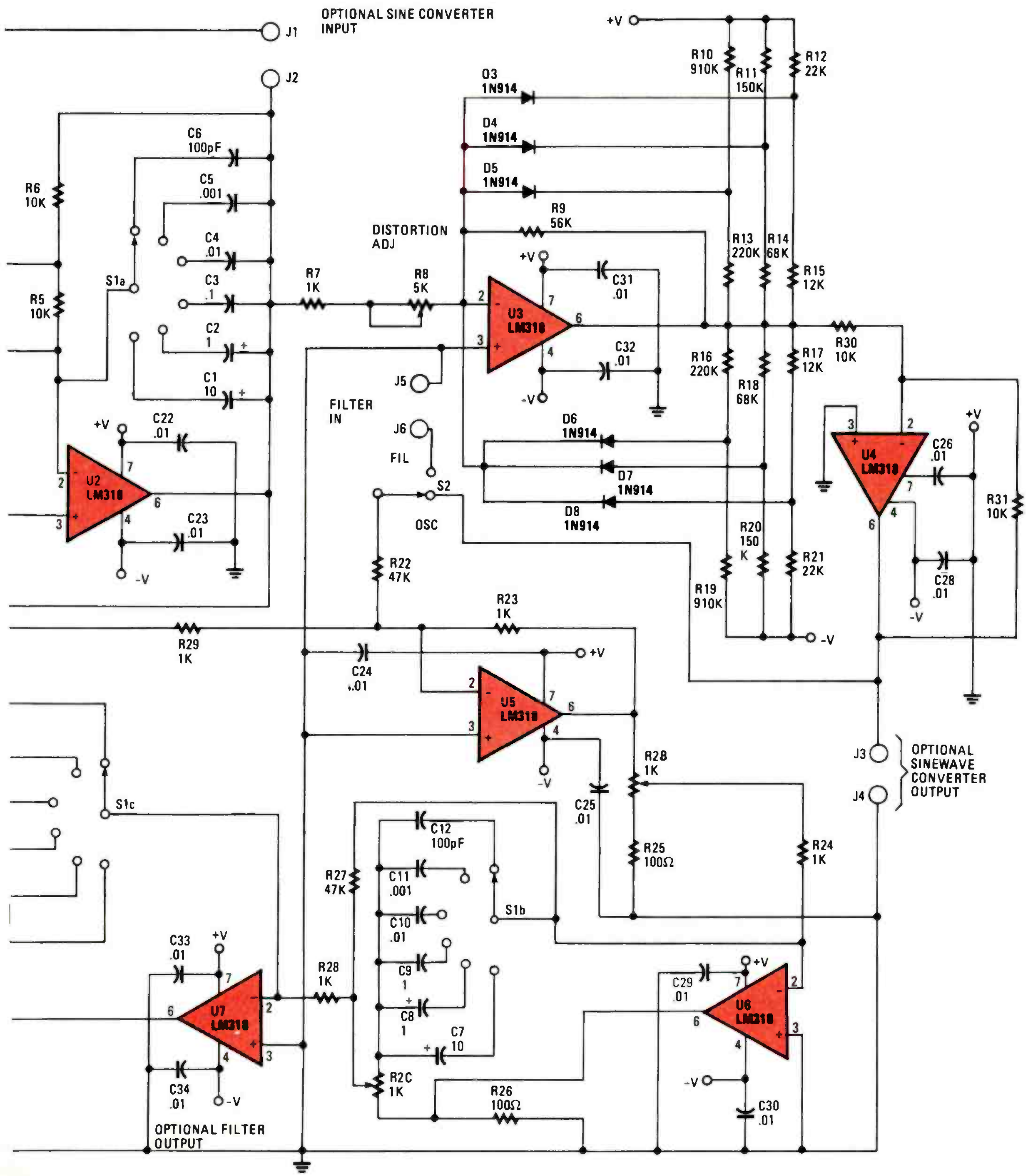

Dolby NR Works Well If It's Correctly Adjusted!

THE DOLBY-B NOISE REDUCTION SYSTEM IS ONE OF THE factors responsible for the compact audio cassette winning acceptance as a high-fidelity medium. But, say many readers, they often find it necessary to switch the Dolby off during replay in order to retain reasonable high-frequency response.

Possibly you have heard a comment like this before: "There is no doubt that the treble has more *presence* in my audio system than with the Dolby off, especially with poorer quality tapes." If that observation sounds familiar, it's possibly because you may have played back Dolbyized cassettes to advantage with the Dolby compensation switched off—particularly in a car sound system.

Many critics of the Dolby NR System state that they believe that the design of many cassette recorders actually hinders the correct operation of Dolby noise reduction.

In my own cassette deck (and, I think, many others) signals from the left and right tape heads pass through pre-amplifiers, thence through the Dolby processor to level meters, and on to a volume control, which governs the signal to a power amplifier and headphones.

I make all recordings with the VU meters peaking at 0 dB. Depending on the kind and brand of tape, the indicated level on playback (which does not depend on the setting of the playback volume control) can peak anywhere between +3 dB and -7 dB. Tapes giving lower output levels must have the Dolby turned off to obtain acceptable treble.

Given the known fact that different tapes have different input/output characteristics, it seems to me that it would be sensible to design cassette decks so that, in playback, the volume control would operate before the Dolby circuit. The level could then be adjusted to peak at 0 dB, so that the replay Dolby could track properly.

Agreed, additional level controls (perhaps presets) would be needed to set output levels to the amplifier or headphones, but this arrangement would at least ensure that the Dolby circuitry worked as intended. I do wonder whether it may, perhaps, have been dismissed too lightly by the domestic high-fidelity industry; a case of "She'll be alright, mate!"

There has been a tendency to brush it aside, however, on the grounds that their ears are being tickled by the touch of treble boost, which non-Dolby playback provides.

Undoubtedly, Dolby tracking has been examined and reported upon many times in engineering circles, as evidenced by the following passage from John Earl's book on *Cassette Tape Recorders* (Fountain Press, 1977):

"It will be appreciated that when a tape of different sensitivity from that on which the Dolby circuits were initially adjusted is used, it may be necessary to readjust the circuits for optimum signal integrity. Failure to do this could result in an overall frequency response which deteriorates from the ideal with reducing signal level."

That quote contains at least one vital clue to the mystery.

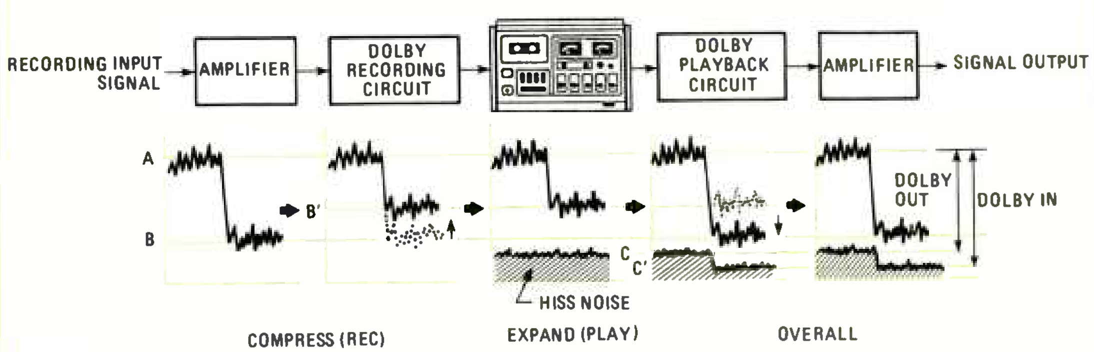

Fig. 1—Reproduced by courtesy of Technics, this diagram illustrates the effect on audio signals by the operation of the Dolby-B noise reduction system in a typical domestic cassette recorder.

Getting to Know Dolby

Figure 1, reproduced from a Technics booklet, illustrates the basic principle of the Dolby NR (noise reduction) system, as incorporated in most good quality compact cassette decks. Its function is to raise the wanted signals—particularly low-level signals—above the so-called *noise floor* of the tape system, thereby improving the overall signal/noise ratio.

Referring to the diagram, a typical audio signal, as fed to the first amplifier, contains high-level segments or passages

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A Dolby cassette recorder having a built-in Dolby calibration signal generator and a calibration control can deliver superb sound. Unfortunately, lower-cost recorders often lack the calibration features, and then the Dolby tends to do it own thing. Here's how to get the most from low-cost cassette recorders having factory-set Dolby calibration.

By Neville Williams*

(A) which pose no real problem, because they are loud enough to override (or *mask*) the tape noise, anyway. It is the low-level segments or passages (B) which are at risk.

From the first amplifier (again to Fig. 1), the audio signal passes to a Dolby recording circuit (noise-reduction processing stage) which, without modifying the higher-level segments, senses and progressively boosts the level of weaker segments by as much as 10 dB—from B to B'. In so doing, the Dolby recording circuit effectively compresses the dynamic range by that amount.

The processed (or *Dolbyized*) signal is then passed to the cassette record/replay section (symbolized as a cassette deck in Fig. 1), which characteristically introduces a noise component (or tape hiss) typically about 45 to 50 dB unweighted below the nominal maximum recording level. Hopefully, the noise will also be below the level of the weaker (now artificially boosted) segments of the audio signal.

During playback, the audio signal from the tape-head circuitry contained within the cassette player in Fig. 1 passes to a Dolby playback circuit, which has de-processing characteristics exactly opposite to those of the Dolby processor. (Often, it's the same one as used for recording, but now switched into the playback mode.)

As before, it senses the weaker audio segments but, this time, automatically drops them back to their original level (from B' to B) effectively restoring the dynamic range to what it was originally.

In so *de-emphasizing* the lower-level audio segments, the system also attenuates the tape noise so that, as implied by the diagram in Fig. 1, the audio signal ultimately fed to the power amplifier has a considerably reduced noise content and hence an improved signal/noise ratio.

An advantage claimed for the Dolby system is that it does not attempt to process high-level signals and therefore minimizes potentially audible *pumping*, or other undesirable processing effects. Whatever happens occurs at lower and less obvious levels.

Dolby NR systems in professional equipment normally process signals over the entire audio spectrum but, while very effective, they are also relatively complex and expensive.

The Dolby-B System

The Dolby system most commonly used in domestic cassette recorders processes signals—and noise—mainly in the region above 1 kHz, as illustrated in Fig. 2 (lower curve). Referred to as Dolby-B, it is now a relatively inexpensive inclusion to quality cassette decks, thanks to modern IC technology. It offers a potential improvement in signal/noise ratio of about 10 dB above 5 kHz—a figure that, historically, has proved commercially acceptable.

For the Dolby-B system to operate as intended, each and every Dolby-equipped deck should *track* and play back accurately all Dolby recorded cassettes, the accentuated low-amplitude, high-freuency components being suitably restored to their original level.

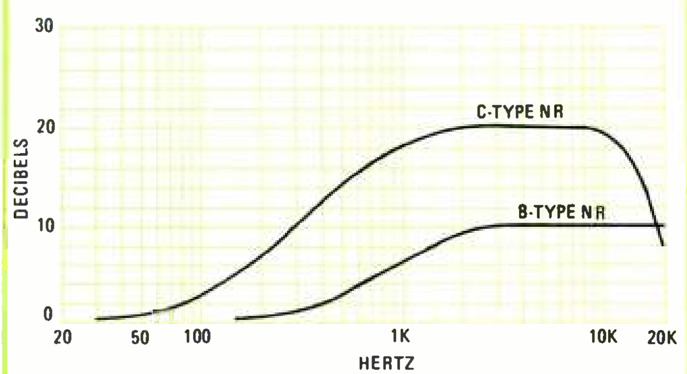

Fig. 2—Dolby-B noise-reduction system (lower curve) operates mainly over the frequency range above 1 kHz. Dolby-C is generally not available in low-cost electronic products and is not discussed in this article; however, the same considerations would apply in respect to tracking.

To this end, an official Dolby reference level was nominated (200 nWb/m, 333 Hz = 0 VU) and calibration tapes produced so that, in the factory, or on the service bench, replay head/preamplifier sensitivity could be preset accurately.

As well, Dolby-equipped cassette decks are normally provided with manual recording-level controls and calibrated level meters so that, hopefully, even *unskilled* home recordists can, with practice, get the signal level on their Dolbyized cassettes at least *in the ball park*.

Many of our readers could scarcely be grouped with the *unskilled*, but even the neophyte audiophile who is reading this page can adjust a gain or volume control knob so that the peaks just hit 0 dB on the level meter when he makes a recording. Not unreasonably, he expects it to read the same peak levels on playback but, depending on the tape in use, the peak level can finish up anywhere between + 3 dB and -7 dB!

Tracking Problem?

That's hardly reassuring. With the whole dynamic window displaced downwards by 7 dB, the treble playback de-emphasis would be affecting a larger slice of the lower-level high frequencies than it should, possibly resulting in a loss of treble and an urge to switch out the Dolby playback compensation to restore it.

So, as a quick check, and using a 1-kHz, left-and-right track on a CD test recording as a signal source, I fed it through to a relatively late model stereo casette deck. This done, I picked out seven different cassettes, ranging from an ancient bargain store ferric tape through chrome and ferrichrome to pure metal, and proceeded to record a test segment on each one, at 0 dB level.

On playback, two of the cassettes returned 0 dB, two more -1.0 dB, the other three reading -4.0 to -4.5 dB. On an aging Sony deck, the same pattern was evident except that the readings ranged from -1.0 dB to -6.5 dB. The latter readings were repeated when the Sony recordings were played back on the late model deck.

While the spread was small, the figures left open the likelihood that, given a wider selection of cassettes, and input signals less predictable than a 1 kHz sinewave, more serious tracking discrepancies would have become evident.

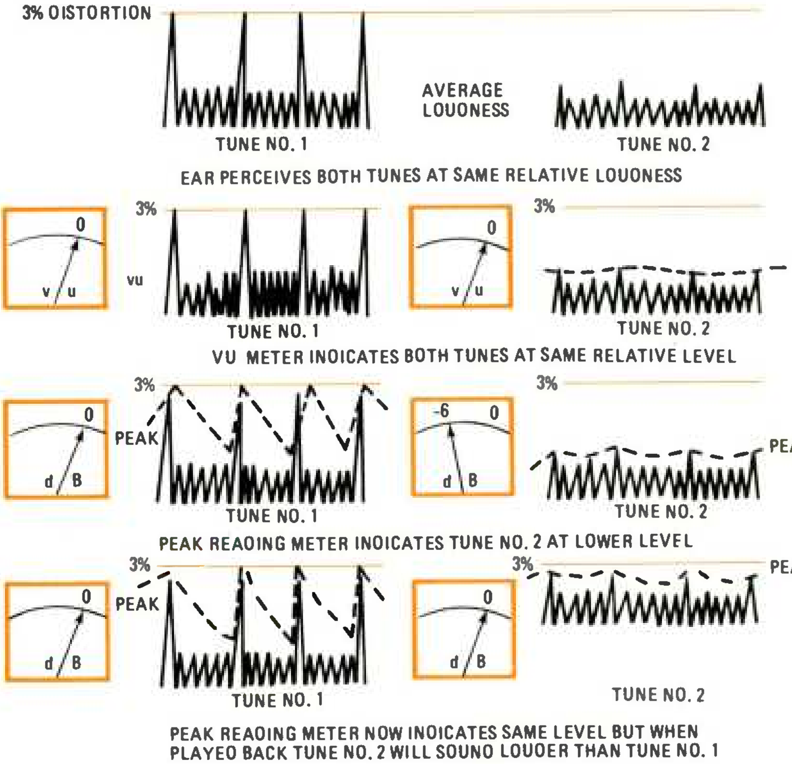

Fig. 3—Illustrating the connection between program waveform, level-meter readings, and subjective loudness, as discussed in the text, (From a White Paper by TEAC).

Those Level Meters

One may even question how meaningful output readings are with complex waveforms, and to what extent they reflect the frequency distribution of the meter drive signal and the influence of supersonic bias level.

A mid-frequency sinewave test is singularly unrevealing in that it involves only one frequency, with no conflict between rms, average, and peak values and only moderate sensitivity to bias level.

When attempting to measure the amplitude of an audio program signal, things are quite different, as illustrated in Fig. 3, reproduced from a TEAC *White Paper* (1975).

A program signal may contain very high amplitude peaks (or transients) without sounding subjectively louder than another program without such peaks. Moreover, a conventional VU meter may give little hint of the peaks which, in extreme cases, could extend into the tape overload region, resulting in signal crushing and distortion.

On the other hand, a predominantly peak-reading meter may induce the operator to raise the level of non-peak signals, causing them to sound subjectively much louder than other material.

While it is possible, particularly with LED and bargraph indicators, to convey information about both average and peak amplitude, cassette deck manufacturers have to consider cost and the need to present non-technical users with a non-confusing (even if compromised) readout.

They may also need to decide, rather arbitrarily, how best to compensate the frequency response of the metering circuit to take account of the anticipated frequency law of the signal being monitored.

In my own case, the analog meters on the aging Sony deck would appear to be reading about 1.5 dB higher in record mode with a 1-kHz sinewave than the bargraphs in the late model deck; in consequence, the flux level on an ex-Sony tape is down by that amount. But how the respective meters would react or be interpreted with program input would be anybody's guess.

On playback, to the extent that high-frequency energy contributes to the meter reading, it must be influenced by the high-frequency response of the tape, head and preamplifier.

But high-frequency response, in turn, is linked intimately with bias level, probably to a greater degree than is commonly allowed for.

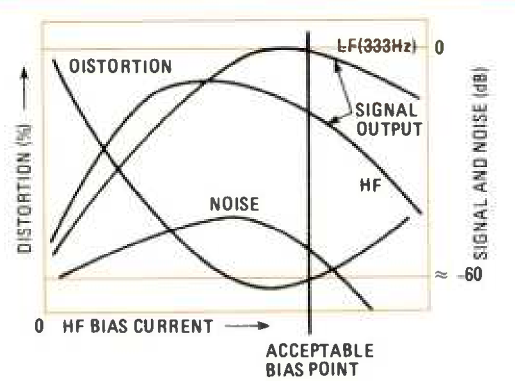

Fig. 4—Mid- and high-frequency signal level, noise, and distortion are plotted against bias current. An acceptable or "optimum" bias level is indicated.

Enter Distortion

Figure 4 shows mid- and high-frequency response, noise and distortion plotted against the level of supersonic bias. The coordinates will vary from tape to tape, but the shape of the curves remains substantially the same.

(Continued on page 96)

DIGITAL FUNDAMENTALS

We get into the heart of a microcomputer to discover what makes it tick

LESSON 8: Introduction to Microprocessors

By Louis E. Frenzel, Jr.

☐As you have seen in previous lessons, digital circuits are a collection of gates and flip-flops wired together to accept binary inputs from some source, process them, and generate one or more new outputs that will perform some useful function. There is nearly an infinite variety of ways that the various logic elements can be interconnected to process the inputs. The process itself may be nothing more than simple decoding or multiplexing performed by a combinational circuit. Or the circuit may be of the more complex sequential type that performs various timing and sequencing operations. In either case, as shown in Fig. 1, we can represent the circuit with a "black box."

The inputs can come from a variety of sources: From a keyboard, switches of one type or another, transducers that sense various physical values, or binary information from some other piece of equipment that may be under test, evaluation, or analysis. The outputs may operate displays such as LED's, LCD's or CRT's; or drive actuators such as relays, solenoids or motors. Or they may simply be binary words that will be transferred to another piece of equipment for storage or further manipulation.

So far, we have assumed that the digital circuits would be made up of individual integrated circuits: gates and flip-flops, functional MSI circuits, PLA's or other LSI or VLSI circuits. The circuit may be combinational, sequential, or a mix of the two. However, there is an option to using conventional logic circuits, and that option is called a microcomputer. In this lesson, we are going to discuss microcomputers and show how they can be used to replace large collections of more conventional digital IC's connected to form a custom circuit for some dedicated application. In subsequent lessons, we will cover microcomputer input/output techniques and programming.

What is a Microcomputer?

A microcomputer is a miniature digital computer made with an LSI integrated circuit, which contains most of the circuitry ordinarily associated with a digital computer. This special LSI circuit is known as a microprocessor. We will speak more about microprocessors in just a minute, but first, let's talk about digital computers in general.

A digital computer is an electronic device that processes data. Data, of course, refers to binary words or numbers that represent numbers to be used in calculations or information that must be stored or retrieved, such as ASCII text. Or the data may be simply random collections of binary signals that represent input information that must be processed in some way.

Processing refers to the way the data is manipulated. In its simplest form, processing may simply refer to the storage and retrieval of the data. Other kinds of processing might be mathematical operations, like addition or subtraction, or logical operations such as AND, OR, XOR, and inversion. Processing may also mean operations such as searching, sorting, editing, or pattern matching.

Digital circuits, as we have defined them in this series, meet this definition because they process data, and they may be designed to perform any of the above mentioned functions. Although a digital computer can perform the same functions, it does so in a somewhat different way. The key element in the definition of a digital computer is that the processing or manipulation takes place *automatically*. The digital computer is set up ahead of time by programming, which specifies the way in which the data is going to be processed. We can accomplish our processing objective by replacing the black box in Fig. 1 with a digital computer. The processing is automatic and preprogrammed.

Classifying Digital Computers

There are three basic types of digital computers: mainframes, minicomputers, and microcomputers. Mainframes, of course, are the large computers used in business and government for large data processing tasks: they are used for financial and accounting systems, storage, retrieval and manipulation of customer credit files, airline reservations, and

Fig.1—When we are interested primarily in input and ouput signals, we can use a "black box" to represent some kind of digital circuit, combinational or sequential, that processes the inputs to generate new outputs.

the like. Mainframes are super fast in their processing and store enormous amounts of data.

Minicomputers are smaller than mainframes but still very large and powerful. Because of their very high speed, they are generally associated with problem-solving in scientific and engineering applications. However, they are also used for business data processing and other functions.

Microcomputers are the smallest classification of digital computers. These are low in cost and small in size. The most visible type is the personal computer, which is used for a wide variety of data processing operations.

The type of microcomputer we are most interested in, at least for this series, is a special version usually referred to as a *dedicated controller*: a microcomputer that is designed to perform a specific function; usually preprogrammed to take care of a very definite processing function. This type of microcomputer is not general purpose in nature like a personal computer and cannot be used with a variety of software packages. Instead, this kind of microcomputer is built into a piece of equipment and difficult to distinguish from the hardware itself. It is simply the control circuitry for the equipment that happens to be implemented by the microcomputer. In other words, the microcomputer replaces more conventional digital logic circuitry that in previous years might have been implemented with individual gates, flip-flops, and MSI circuits. Dedicated microcomputer controllers are found in all kinds of equipment, such as TV sets, stereo hi-fi systems, auto dashboards and emission control systems, photocopiers, and so on.

In any case, the key distinguishing characteristic of a microcomputer is that it is implemented with a special LSI device known as a microprocessor.

Digital Computer Organization

As shown in Fig. 2, a digital computer is made up of four basic sections: the memory, the control section, the arithmetic/logic unit, and the input/output unit. Let's take a brief look at each of these sections.

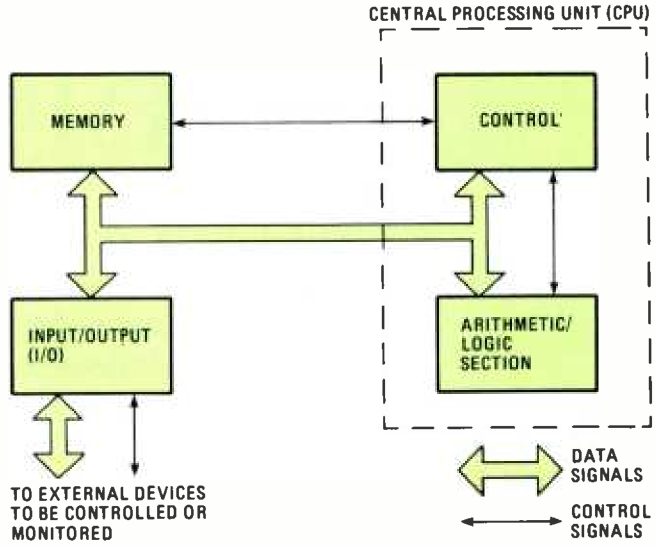

Fig. 2—Regardless of its type, mini, micro, or whatever, a computer is made up of four sections: the memory, a control section, an arithmetic/logic unit, and an input/output unit. The control section can be a central processing unit (CPU), or a microprocessor.

Memory

The memory in a microcomputer is usually a combination of both RAM and ROM. The semiconductor memory devices described in a previous lesson are those used with microcomputers.

The memory is used to store two types of information: data and instructions.

Data represents those binary numbers or words that are to be processed. They may be numerical values, ASCII codes for the text of a written document, or simply random collections of binary signals that represent inputs or outputs that are collected and organized as binary words. In any case, it is the data words stored in the memory that will be manipulated by the computer.

Instructions, which are stored in either RAM or ROM, are unique to computers. They are special binary codes that tell the computer how to manipulate the data. For example, an instruction may be an 8-bit binary number. With 8-bits, 256 different instructions could be represented, which might specify arithmetic operations such as addition and subtraction, a logical operation such as AND or XOR, or data movement operations that cause binary words to be moved into or out of memory or cause transfers between registers. All computers have a special repertoire of these special codes known as an *instruction set*. They define the architecture of the computer and provide a wide range of ways in which the data can be manipulated.

To process data, a number of instructions are written sequentially and stored away in memory. Such a sequential list of instructions is called a *program*. A program defines a specific sequence of operations that process the data in some way. The purpose of the computer is to sequentially interpret and execute these instructions stored in memory and this, in turn, accomplishes the processing.

This approach to digital processing is generally known as the stored program concept. It was invented by a mathematician, John Von Neumann, and is the basis of operation for all digital computers.

Control

The control section of the digital computer fetches the instructions stored in memory one at a time, interprets them, and executes them in sequence. The control unit gets one instruction from memory, decodes it and determines which function is to be performed. It then issues control signals to the other sections of the computer so that the specified operations are carried out.

Arithmetic-Logic

The arithmetic/logic section is the section of the digital computer that generally carries out most processing operations. It is usually made up of a set of registers where the data to be manipulated is temporarily stored. In turn, these registers drive an *arithmetic/logic unit* (ALU), which is a collection of logical circuits that perform mathematical and logical operations. Serial shift and rotate operations can also be performed. It is usually the ALU that receives signals from the control unit to perform the operation specified by the instruction.

As shown in Fig. 2, the control and ALU's are closely related and interconnected. For the most part, they can be treated as a single block or section. The combination is usually called a *central processing unit*, or CPU. A microprocessor is simply a single chip LSI integrated circuit CPU, which is sometimes referred to as a *microprocessing unit*, or MPU.

I/O

The input/output section of a digital computer is used to communicate with external circuits and equipment. Inputs to be processed are fed to the I/O section and either stored in memory or processed directly by the CPU. Binary words that are to be transferred to some external circuit or device are transferred from the memory or the CPU to the external equipment via the I/O section. The I/O section is, of course, controlled by the CPU by way of special input/output instructions.

A Typical Micro

The typical microcomputer consists of a single chip microprocessor, a set of RAM chips, and one or more ROM's that contain a dedicated control program. The input/output section is usually implemented with multiple integrated circuits specifically designed to interface the microcomputer to the external circuits or equipment involved in the application. Most microcomputers, therefore, are made up of multiple integrated circuits mounted on a printed-circuit board which is part of the equipment being controlled. Usually there are no floppies, CRTs, or the like.

For small, dedicated applications, special single-chip microcomputers can be used. These single chip LSI devices contain not only the CPU, but also ROM where the dedicated control program is stored, a small amount of RAM where data can be stored temporarily, and a variety of input/output circuits, which attach to the equipment being controlled. A good example of an application is the microcomputer used in most printers.

How a Microprocessor Works

Figure 3 shows a block diagram of a generic microprocessor, or central processing unit (CPU). The microprocessor has been divided into its two primary sections: the arithmetic/logic section and the control section.

The control section of the CPU contains the instruction register and the program counter. The program counter holds the address of the memory location where an instruction is stored. To execute a program, the program counter is set to the address that designates the location of the first instruction in the program. The contents of the program counter is then transferred to an address register in memory. The address is decoded, usually on the RAM or ROM chips, and that location in memory is enabled. The instruction stored there is transferred over the data bus into the instruction register. The instruction decoder looks at the instruction word and identifies the function to be performed. The timing and control circuits in the control section then generate the appropriate control pulses that cause the desired action to be carried out. Once the instruction has been executed, the program counter is incremented so that the next instruction in sequence is fetched, then executed. This process continues until the program is fully executed.

The arithmetic/logic section of the computer consists of a main working register called the accumulator and the arithmetic/logic unit (ALU). The arithmetic/logic section carries out most of the operations designated by the computer's instruction set. All data transfers and arithmetic/logic operations take place in the accumulator.

Most arithmetic and logic operations involve two operands. (Operand is just the name of a number to be involved in an arithmetic or logic computation.) For example, an *add* operation involves the two numbers to be summed. One of the two operands is stored in the accumulator while the other is stored in memory. The two operands are then used in the desired operation. The result of the operation, in this case the sum, is stored back in the accumulator. The operand previously stored in the accumulator is lost.

The ALU in most microprocessors is capable of carrying out addition and subtraction as well as the basic logic operations AND, OR, XOR, and complement. Other computer instructions are used to manipulate data in the accumulator. For example, the accumulator can be cleared (set to zero), incremented, or decremented. Also, data can be transferred from a desired memory location to the accumulator or taken from the accumulator and stored in a desired memory location.

The arithmetic/logic section also permits data in the accumulator to be shifted or rotated to the right or to the left of a given number of bit positions.

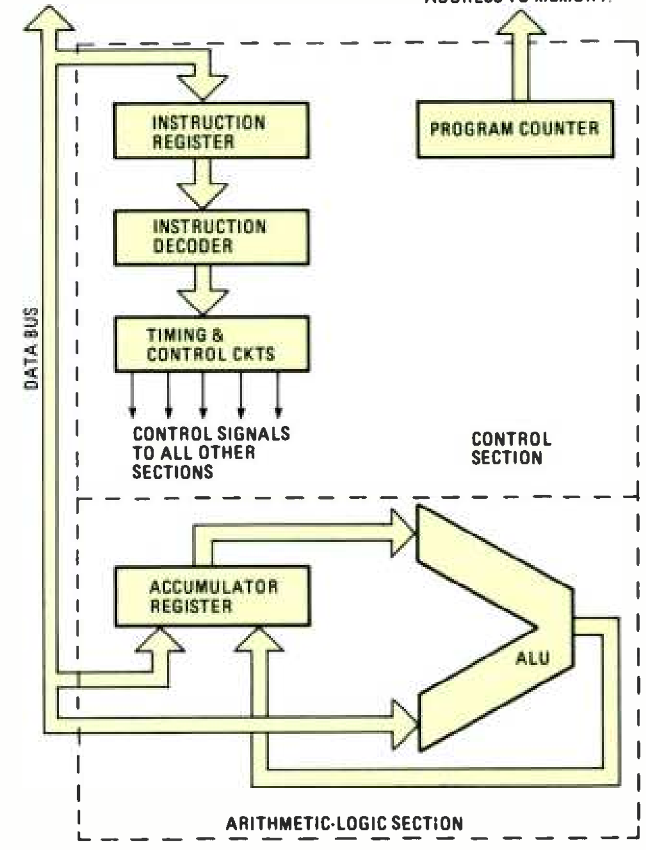

Fig. 3—A CPU generally provides two independent functions: a control section and an arithmetic/logic unit which are interconnected through an external data bus.

Typical Microprocessors

Now let's take a look at a real microprocessor: in fact, we will examine two units which are similar in architecture and design. The first is the 6800. (Although introduced in the mid-1970's, it is still in use today.) The 6800 was used in some of the earlier personal computers, among them the MITS Altair 680, Southwest Technical Products SWTP

6800, and the Wavemate, but it has virtually disappeared in this application. One of its successors, the 6809, is used in some of Radio Shack's less expensive personal computers (e.g. Color Computer). However, the 6800 is widely used as a dedicated controller.

The other microprocessor we will look at is the 6502. This CPU was designed by the same group who created the 6800. They left Motorola and developed the 6502 for MOS Technology. The 6502 is an improved or optimized version of the 6800. It, too, was widely used in early personal computers, among others the KIM-1, Apple I, Commodore PET, and Atari 400/600. It, or one of its variations, is still used in personal computers such as the Apple IIe/c and Commodore 64/128.

Both the 6800 and 6502 have an architecture and operation that is simple and straightforward. In fact, it is essentially the same as the generic CPU described earlier, which makes it easy to understand and use.

The 6800 and 6502 are 8-bit microprocessors. (All microprocessors are rated or ranked by the basic number of bits they process simultaneously.) That is, data transfers and arithmetic or logic operations are made on parallel 8-bit binary numbers or words. The 6800 and 6502 have 8-bit internal registers, an 8-bit ALU and an 8-bit data bus over which all data transfers between CPU, memory and I/O take place. (There are also 16 and 32-bit microprocessors.)

A general block diagram of each of these microprocessors is shown in Fig. 4. Note that only the main registers are shown. These will be explained next.

CPU Registers

The most predominant circuit in a microprocessor is the register, which is capable of storing one binary word. Some registers can also perform auxiliary operations such as counting or shifting. The register is the main processing element in a CPU. As the various data and instruction words are moved from one place to another they are typically passed through or temporarily stored in the various registers. As data is processed, words are transferred into and out of these registers from external sources such as the memory and I/O devices. In addition, interregister transfers in the CPU also occur during processing. The registers make up a major portion of any CPU and, therefore, set its architecture.

All microprocessors have three basic registers: the program counter (PC); the instruction register (IR); and the accumulator (ACC). Figure 4 shows the register structure for the 6800 and 6502. Let's look at each.

Program Counter

The program counter (PC) contains the address of the next instruction to be fetched. As each instruction in a program is fetched and executed, the program counter is incremented so that it points to the next instruction in sequence. The program counter also specifies how many bytes of RAM and ROM a CPU can address. The PC's output is sent to the memory where it selects a desired word. In the 6800 and 6502, the PC holds a 16-bit word, therefore, 2 raised to the the 16th power, or 65,536 (64K) words of RAM and/or ROM can be addressed.

Instruction Register

When the CPU fetches an instruction word from memory to be executed, that word is stored in the instruction register (IR). The word is then decoded to determine which operation is to be performed. In the 6800/6502 the instruction register holds an 8-bit instruction word or *op code* as it is called.

Accumulator

The accumulator is the basic processing register of the microcomputer. Words to be used in arithmetic or logic operations are stored in the accumulator. Data transfers to or from memory and input/output devices are also passed through the accumulator. The accumulator size in the 6800 and 6502 is 8-bits.

While all microcomputers contain at least one accumulator register, some contain multiple accumulators. By using more than one accumulator significant increases in computer speed can be achieved. Also, programs written for multiple accumulator machines typically involve fewer instructions and less programming effort, which significantly improves utilization of available memory space. The 6800 has two accumulators, the 6502 has one. Some CPU's have sets of 8 or 16 accumulators usually called *general-purpose registers*.

All microcomputers feature these basic registers or some combination of them. However, all modern microprocessors feature additional registers, which further improve operations. Let's look at some of these additional registers that improve efficiency and performance.

Index Register

An index register stores a binary word that is used in address-modification operations. Typically, the contents of the index register is added to or subtracted from the address associated with an instruction. The index register contents can be loaded from memory, stored in memory, incremented,

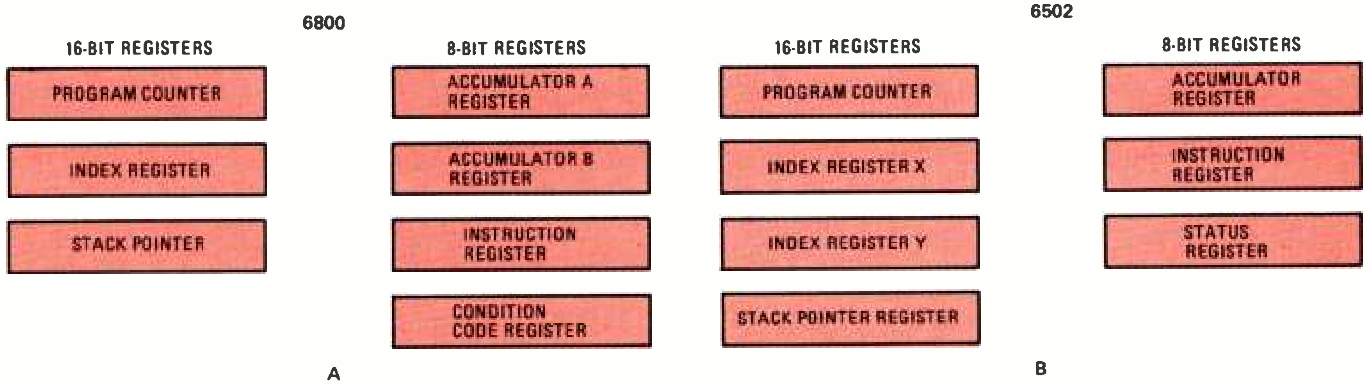

Fig. 4—Although there are differences in the internal architecture of the 6800 and 6502, both use the program counter to point to the next instruction in sequence.

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Hands-on Electronics

10 Hands-on Electronics FactCard — Wire Table

COPPER-WIRE TABLE

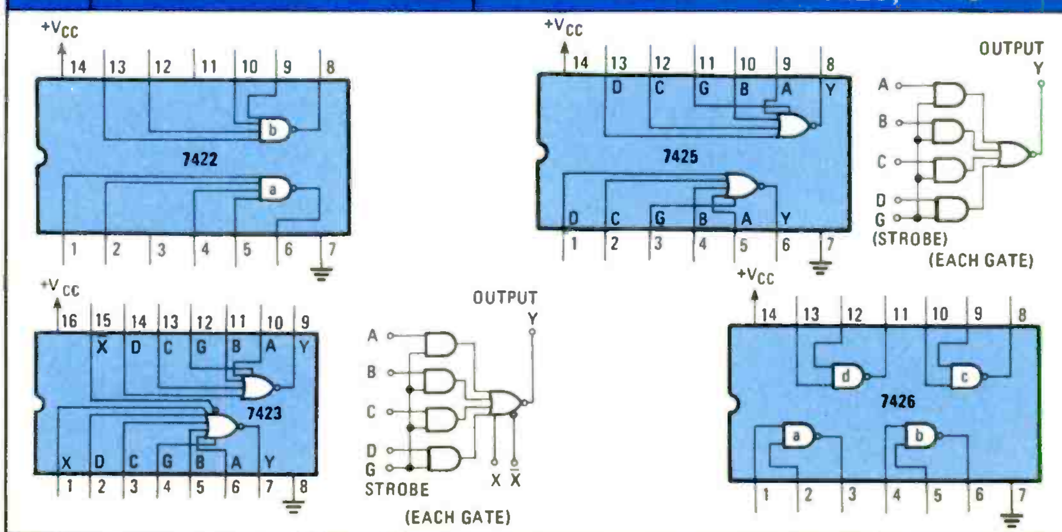
Wire Size A.W.G. (B&S)	Diam. in Mils	Circular Mil Area	Turns per Linear inch (25.4 mm)			Ohms per 1000 ft. 20°C	Current Carrying Capacity at 700 C.M. per Amp	Diam. in mm.
			Enamel	S.C.E.	D.C.C.			
1	289.3	83690	—	—	—	.1239	119.6	7.348
2	257.6	66370	—	—	—	.1563	94.8	6.544
3	229.4	52640	—	—	—	.1970	75.2	5.827
4	204.3	41740	—	—	—	.2485	59.6	5.189
5	181.9	33100	—	—	—	.3133	47.3	4.621
6	162.0	26250	—	—	—	.3951	37.5	4.115
7	144.3	20820	—	—	—	.4982	29.7	3.665
8	128.5	16510	7.6	—	7.1	.6282	23.6	3.264
9	114.4	13090	8.6	—	7.8	.7921	18.7	2.906
10	101.9	10380	9.6	9.1	8.9	.9989	14.8	2.588
11	90.7	8234	10.7	—	9.8	1.26	11.8	2.305
12	80.8	6530	12.0	11.3	10.9	1.588	9.33	2.053
13	72.0	5178	13.5	—	12.8	2.003	7.40	1.828
14	64.1	4107	15.0	14.0	13.8	2.525	5.87	1.628
15	57.1	3257	16.8	—	14.7	3.184	4.65	1.450
16	50.8	2583	18.9	17.3	16.4	4.016	3.69	1.291
17	45.3	2048	21.2	—	18.1	5.064	2.93	1.150
18	40.3	1624	23.6	21.2	19.8	6.385	2.32	1.024
19	35.9	1288	26.4	—	21.8	8.051	1.84	.912

11 Hands-on Electronics FactCard — Bipolar Transistors

TRANSISTOR SELECTION GUIDE

Transistor Number	Cross-Ref. to ECG	V_{CEO} (Min)	V_{CE} (Sat.) Max.	h_{FE} (Min-Max)	Type	Transistor Number	Cross-Ref. to ECG	V_{CEO} (Min)	V_{CE} (Sat.) Max.	h_{FE} (Min-Max)	Type
2N3702	159	40	.25	60-300	PNP	2N4249	159	60	.25	100-300	PNP
2N3704	123AP	30	.6	100-300	NPN	2N4400	123AP	40	.4	50-150	NPN
2N3705	123AP	30	.8	50-150	NPN	2N4401	123AP	40	.4	100-300	NPN
2N3706	123AP	40	1	30-600	NPN	2N4402	159AP	40	.4	50-150	PNP
2N3711	123AP	30	1	180-660	NPN	2N4403	159AP	40	.4	50-150	PNP
2N3724	235	30	.25	60-150	PNP	2N4409	194	50	.2	60-400	NPN
2N3725	128	50	.25	60-150	NPN	2N5086	159	50	.3	150-500	PNP
2N3903	123AP	60	.3	50-150	NPN	2N5087	159	50	.3	250-800	PNP
2N3904	123AP	40	.3	100-300	NPN	2N5088	123AP	30	.5	300-900	NPN
2N3905	159	40	.25	50-150	PNP	2N5089	123AP	35	.5	400-1200	NPN
2N3906	159	40	.25	100-150	PNP	2N5129	128	12	.25	20-250	NPN
2N4013	123AP	30	.25	30-150	NPN	PN5134	123AP	10	.25	20-150	NPN
2N4123	123AP	30	.3	50-150	NPN	PN5138	159	30	.3	50-800	PNP
2N4124	123AP	25	.3	120-360	NPN	2N5139	193	20	.5	40-350	PNP
2N4125	159	30	.4	50-100	PNP	2N5210	123	50	.7	200-600	NPN

12 Hands-on Electronics FactCard — TTL Gates: 7422, 7423 7425, 7426



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20	32.0	1022	29.4	25.8	23.8	10.15	1.46	.812
21	28.5	810	33.1	—	26.0	12.8	1.16	.723
22	25.3	642	37.0	31.3	30.0	16.14	.918	.644
23	22.6	510	41.3	—	37.6	20.36	.728	.573
24	20.1	404	46.3	37.6	35.6	25.67	.577	.511
25	17.9	320	51.7	—	38.6	32.37	.458	.455
26	15.9	254	58.0	46.1	41.8	40.81	.363	.405
27	14.2	202	64.9	—	45.0	51.47	.288	.361
28	12.6	160	72.7	54.6	48.5	64.9	.228	.321
29	11.3	127	81.6	—	51.8	81.83	.181	.286
30	10.0	101	90.5	64.1	55.5	103.2	.144	.255
31	8.9	80	101	—	59.2	130.1	.114	.227
32	8.0	63	113	74.1	61.6	164.1	.090	.202
33	7.1	50	127	—	66.3	206.9	.072	.180
34	6.3	40	143	86.2	70.0	260.9	.057	.160
35	5.6	32	158	—	73.5	329.0	.045	.143
36	5.0	25	175	103.1	77.0	414.8	.036	.127
37	4.5	20	198	—	80.3	523.1	.028	.113
38	4.0	16	224	116.3	83.6	659.6	.022	.101
39	3.5	12	248	—	86.6	831.8	.018	.090

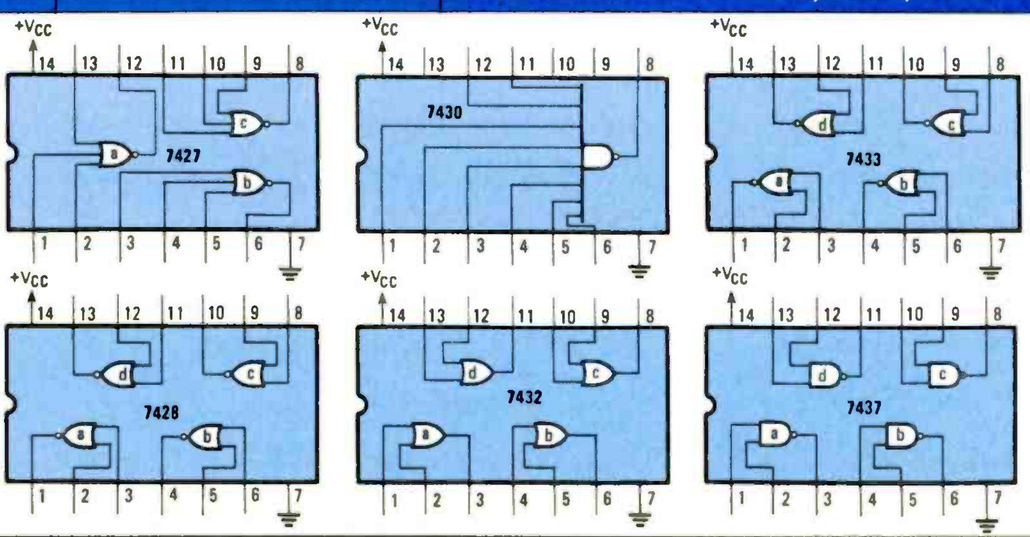
11 Hands-on Electronics FactCard — Bipolar Transistors

TRANSISTOR SELECTION GUIDE

Transistor Number	Cross-Ref. to ECG	V_{CEO} (Min)	V_{CE} (Sat.) Max.	h_{FE} (Min-Max)	Type
MPSA05	123AP	60	.25	50-150	NPN
MPSA06	128	80	.25	50-150	NPN
TIP29A	152	60	.7	15-150	NPN
TIP30A	153	−60	−.7	15-150	PNP
TIP31A	152	60	1.2	10-50	NPN
TIP32A	153	−60	−1.20	10-50	PNP
TIP41A	331	60	2.0	15-150	NPN
TIP42A	332	−60	−2.0	15-150	PNP
TIS97	107	40	1	250-700	NPN
TIS98	107	60	1	100-300	NPN
2N918	108	15	.4	20	NPN
2N2219A	123AP	40	.3	100-200	NPN
2N2221A	123AP	40	.3	40-120	NPN
PN2222	123AP	40	.3	100-300	NPN
2N2222A	123AP	40	.3	100-300	NPN

Transistor Number	Cross-Ref. to ECG	V_{CEO} (Min)	V_{CE} (Sat.) Max.	h_{FE} (Min-Max)	Type
MPSA05	123AP	60	.25	50-150	NPN
2N5771	194	4.5	.18	50-120	PNP
MPS2369	107	15	.25	20-120	NPN
2N2484	123AP	60	.35	100-500	NPN
2N2906A	159	60	.4	40-120	PNP
PN2907	159	60	.4	100-300	PNP
PN2907A	159	60	.4	100-300	PNP
2N2925	123AP	25	.3	150-300	NPN
MJE2955T	183	60	1.1	20-70	PNP
2N3053	128	40	1.4	25-150	NPN
2N3398	123AP	25	—	55-800	NPN
2N3567	128	40	.25	40-300	NPN
PN3568	128	60	.25	40-300	NPN
PN3569	128	40	.25	100-300	NPN
2N3638A	159	25	.25	20-100	PNP
MPS3640	159	12	.2	30-120	PNP

12 Hands-on Electronics FactCard — TTL Gates: 7427, 7428, 7430, 7432, 7433, 7437



or decremented with special index register instructions. This process of using an index register for address modification operations is called indexing. By using an index register, the number of instructions used in some programs can be significantly reduced. This is particularly true where sequential operations on a list or table of data are to be performed. The 6800 has one 16-bit index register, the 6502 has two.

Status Register

The status or condition-code register is a group of flip-flops that are either set or reset—depending upon the outcome of processing operations in the ALU. As arithmetic, logic or shift operations are performed, the various status flip-flops are set or reset to indicate a specific machine state. The status word may be monitored and stored so that the condition of the computer at a given time can be determined.

The various flip-flops in that status word can also be tested under program control so that the program being executed can be modified. Jump or branch conditions that change the program sequence are usually determined by the information stored in the status register. Some of the conditions monitored by the condition-code register are arithmetic operations, such as: accumulator equals zero, carry out of most significant bit of the accumulator, accumulator overflow, and accumulator negative. In the 6800 and 6502, the status or condition code register contains 8-bits.

Stack Pointer

The stack pointer is a 16-bit address register that is used to reference some particular part of the microcomputer's random-access memory. The stack itself is a specific portion of memory set aside to temporarily store data in a particular sequence. The stack pointer is used to address this data when it is being stored or retrieved.

The stack is set aside especially for stack operations and is not used to store ordinary sequences of instructions or data. The stack itself has no fixed size. The number of memory locations used by the stack depends upon how it is used.

The stack is a last-in, first-out (LIFO) memory. The data words to be stored in the stack are written and retrieved sequentially so that the last item stored is the first item to be retrieved; the first data item stored will be the last retrieved.

The stack pointer register is used to determine the limits of the stack and to identify specific word locations in the stack. In the 6800 and 6502 microprocessors, the stack pointer register is 16-bits, and can point to any one of 65,536 different memory locations. This means that the stack can be located anywhere within the maximum addressing range of the microprocessor. To set up the boundaries of the stack, the stack pointer register is usually loaded under program control with special instructions used for this purpose. Once the stack pointer has been initialized, it is then incremented or decremented to access sequential memory locations. Stack store and retrieve operations are called push and pull (or *pop*) respectively.

The Instruction Set

The instruction set is the complete list of instructions that a microcomputer is capable of executing. Each instruction defines a unique set of operations that takes place each time the instruction is executed. The programmer uses the instruction set to develop complete programs that perform a desired process, calculation, or control function.

It is the instruction set that really defines the architecture of a microcomputer. It determines the number and types of registers and the logic circuits and how they are all interconnected. The instruction set for each microcomputer is fixed and is unique to that device.

Types of Instructions

There are two basic types of instructions used in microcomputers: memory reference and non-memory reference. A memory-reference instruction identifies some particular memory location where the operand to be used by that instruction is stored. The instruction usually contains an address that designates the location of the operand. For example, an ADD instruction contains an address that points to one of the operands to be added. The other operand is usually in the accumulator. A non-memory reference instruction does not have an address associated with it. This type of instruction simply defines a type of operation to be performed somewhere in the computer. The location of any data to be used, if any, is usually in a CPU register.

Instructions are further classified by the types of operations that they perform. Some of the specific types of instructions are listed below.

Data Movement Instructions—specify data transfers from one location to another. The transfers can take place between internal registers or between the internal registers and the computer's memory.

Arithmetic/Logic Instructions—identify unique arithmetic and logic operations such as add, subtract, logical AND, compare, or other operations. Data shift and rotate operations are usually included in this class of instructions.

Decision-Making Instructions—test for certain conditions in the machine and cause the sequence of the program to be modified. If the test condition is met—the operation specified by the instruction is performed, otherwise, the next instruction in sequence is executed. Usually, the operation is a jump or branch operation that causes the microcomputer to begin executing a sequence of instructions different from the normal sequence specified by the program. Such instructions give the computer intelligence by allowing it to make decisions based on conditions that exist in the CPU or external circuits.

Input/Output Instructions—cause data transfers to take place between the CPU and the I/O interface. Instructions for handling interrupts are usually included in this instruction class. Not all microprocessors have I/O instructions. For example, the 6800 and 6502 do not have I/O instructions as such; they simply use the data movement instructions to implement data transfers to external devices and circuits.

Instruction-Word Formats—All microcomputers have a basic fixed word length. The 6800 and 6502 microprocessors feature an 8-bit word. The memory is organized as many sequential storage locations for 8-bit words. These words (bytes) may be data or instructions. Usually data words are 8 bits or less in length. However, this limits the number size to a maximum of 255; additional memory locations may be allocated if greater number sizes are required. For example, two sequential memory locations can be used to store a 16-bit word, thereby increasing the number size up to 32,767. (One-half of the word would be stored in each of the two adjacent memory locations.) However, keep in mind that the microcomputer will only process 8 bits of data at a time.

Instruction words are similar. Some instructions can be defined by a single 8-bit word. Others require two or three sequential 8-bit words. Figure 5 shows the three most com-

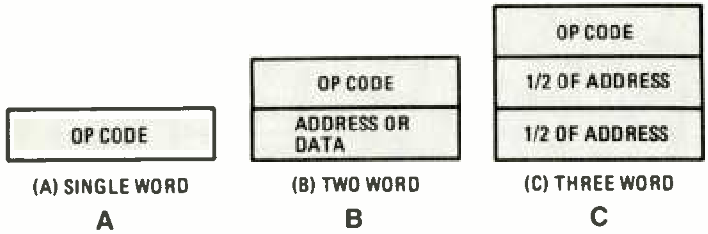


Fig. 5—The number of 8-bit (byte) instruction words depends on the particular computer. A one byte word provides only the op code. A two byte word provides the op code and an address or operand to be processed. A three byte word provides both the op code and a 16-bit address.

monly used instruction word formats. In Fig. 5A, a single 8-bit word defines an instruction. This byte usually contains the op code—a specific bit pattern that causes some unique operation to take place. Such single-word instructions are usually non-memory reference instructions since they do not contain an address. Figure 5B shows a two-byte instruction. The first 8 bits define the op code. The second 8-bit word in an adjacent memory location usually contains an address or the operand to be processed. When the instruction is executed, the operand stored in the second word location is used. If the second word is an address, it references some location in memory where the operand is stored. Figure 5C shows a three-byte instruction. As usual, the first 8-bit word contains the op code. The next two 8-bit words contain a 16-bit address. This 16-bit address identifies the memory location where the operand is stored.

Addressing Modes

Another important part of the architecture of a microcomputer is the way that it addresses data or instruction words. The more different ways that memory words can be referenced, the more powerful and flexible the computer is. Many of the addressing modes greatly speed up and simplify the processing operations. The following is a description of the addressing modes used in most microcomputers including the 6800 and 6502.

Implied

No specific address is used with implied addressing, instead, the location of the operand to be used in the processing is implied by the instruction itself. Implied addressing is used with non-memory reference instructions. With these instructions, the operand is usually already stored in a register that is the subject of the given instruction. For example, accumulator increment, decrement, or shift instructions imply that the operation is to take place on the operand stored in the accumulator.

Immediate

Immediate addressing assumes that the operand is contained within the instruction itself, usually as the second byte of a two-byte instruction word. With this arrangement, the operand is available immediately for processing, thereby eliminating the need to address memory and to perform a read operation prior to executing the instruction. Immediate instructions speed up computation.

Direct

When the direct addressing mode is used, the address bits are a part of the instruction word. The address may be simply the second 8-bit byte of a two-byte instruction, or the address may be defined as the second and third bytes of a three-byte instruction. Direct addressing is the simplest and most intuitive of all the address modes, and it is the one most often used. Remember, the total number of address bits determines the maximum number of memory locations that can be referenced. In the 6800 and 6502, the address word size is 16 bits, thereby permitting a total of 65,536 words (64K bytes) to be addressed. Direct addressing is sometimes referred to as absolute addressing.

Register

In register addressing, the op code specifies a register where the operand is stored.

Register Indirect

In this address mode, the instruction op code specifies a register that contains the address of the operand. This register must be loaded with the proper memory address prior to executing the instruction.

Relative

In the relative addressing mode, the effective address of the operand to be used by the instruction is computed by adding the direct address in the instruction word itself to the contents of the program counter. The address in the instruction word is used to specify a displacement from the address of the instruction currently being executed. This address, of course, is contained in the program counter. The position of the operand is located with respect to the instructions being executed by the amount of the displacement of the instruction word. This method of addressing permits the program and the associated data to be relocated anywhere in memory without changing the direct addresses in the program. The relocation of the program is simply a matter of adjusting the value of the program counter.

Indexing

Indexing or indexed addressing was discussed earlier in connection with the index register. As you recall, the effective address designating the storage location of the operand is formed by adding the address in the instruction word to the contents of the index register. Index registers can be loaded, stored, incremented, or decremented by using special index-register instructions. In addition, the contents of the index register may also be tested by decision-making instructions.

Making a Microcomputer With a Microprocessor

The microprocessor, or MPU, is just a CPU. To form a complete computer, memory, I/O and other circuits must be added.

The MPU is usually indicated as a single box, as shown in Fig. 6. The MPU communicates with the other circuits by way of many input and output lines. These lines are typically organized as buses. For example, all 8-bit data transfers into and out of the MPU take place over the data bus. (The data bus is 8 lines over which data can travel in either direction.)

Another group of 16 lines on the MPU forms the address bus. An address from the program counter or other source in the MPU is put on the bus and sent to RAM, ROM, or an I/O

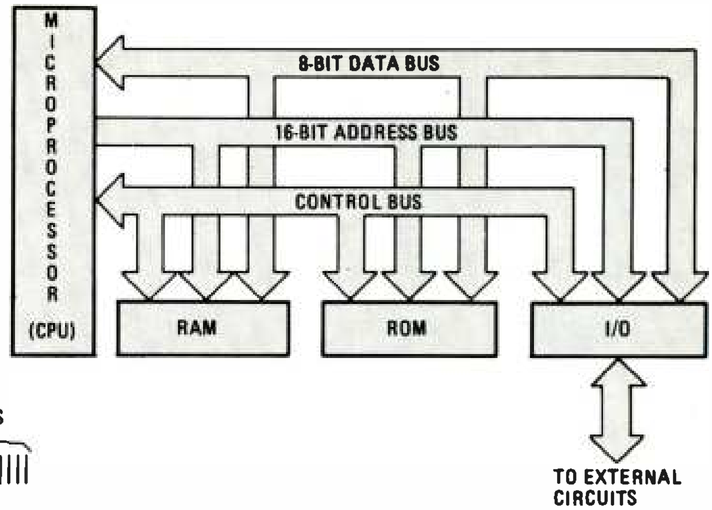


Fig. 6—The microprocessor communicates with the memory and input/output functions through a data bus, an address bus, and a control bus. The control bus provides the functions other than data transfers and memory addressing.

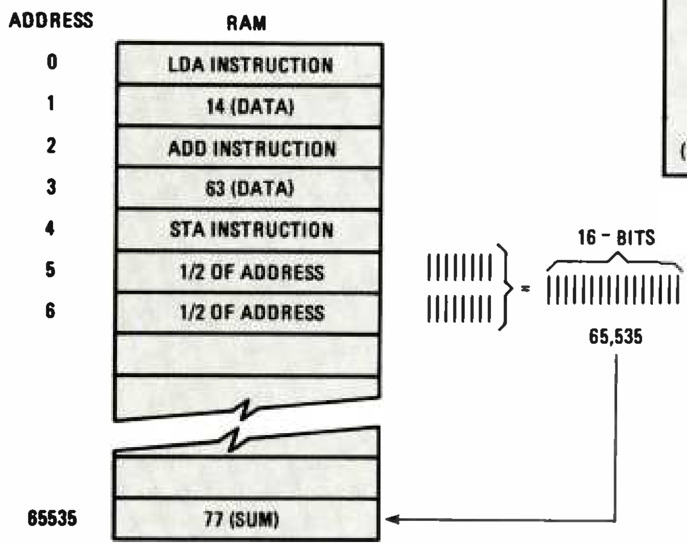


Fig. 7—Program instructions for the computer are stored in memory in sequential order. An individual address might contain an op code, a data value, or another address where the program stores or retrieves data.

device. The address identifies and enables a memory location or I/O circuit, which will accept data from or send data to the MPU.

The remaining lines of the MPU are collectively known as the control bus. These input and output signals are used to control MPU operation.

Executing a Program

To complete our discussion of microprocessor operation, let's take a look at how a 6800 or 6502 would execute a simple program. Refer to Fig. 7. This shows several bytes of RAM where the program is stored. In memory locations 0 and 1, a load accumulator (LDA) instruction is stored. The first byte contains the op code, the second contains the data value (14) to be transferred to the accumulator. This instruction uses immediate addressing.

Locations 2 and 3 hold an add (ADD) instruction. Byte 2 is the op code, byte 3 is the data word (63) to be added to the value in the accumulator.

Locations 4, 5, and 6 hold a store (STA) instruction. Byte 4 is the op code, while bytes 5 and 6 form a 16-bit address that tells where in RAM the contents of the accumulator will be stored.

To start the program, the program counter—the PC—is loaded with 0 so that it will access the first instruction in the program. Byte 0 is loaded into the instruction register and decoded. The PC is incremented and the data in byte 1 is loaded into the accumulator.

The PC is incremented again. The ADD instruction is fetched from byte 2 and put into the instruction register. After decoding, the PC is incremented and the data in byte 3 is accessed, then added by the ALU to the data word in the accumulator. The sum 77 appears in the accumulator.

The PC is incremented again to fetch the STA instruction in byte 4. The op code is loaded into the instruction register. Next, the PC is incremented twice to bring in bytes 5 and 6. Together they form a 16-bit address (65,535) that is sent to the RAM instead of the PC content. This enables the selected RAM location. The sum in the accumulator is sent via the data bus to this location. The program ends at this point.

The Next Lesson

In the next lesson we will cover I/O operations. Then, in the final lesson, we will examine other 6800 and 6502 instructions and show you the processes used to create programs that perform a variety of functions. ■

SHORT QUIZ ON DIGITAL FUNDAMENTALS—LESSON 8: INTRODUCTION TO MICROPROCESSORS

1. A microprocessor is an LSI ______ ______ ______.

2. The four major parts of a digital computer are:
a. ____________ b. ____________
c. ____________ d. ____________

3. A CPU is made up of the ________ section and the ________ section.

4. The two kinds of information stored in a computer memory are ________ and ________ words.

5. A program is a sequential list of ________ that performs a specific function.

6. The main processing register in a CPU is the ________.

7. The register that points to the next instruction to be fetched and also determines maximum memory size is called the ________ ________.

(Continued on page 99)

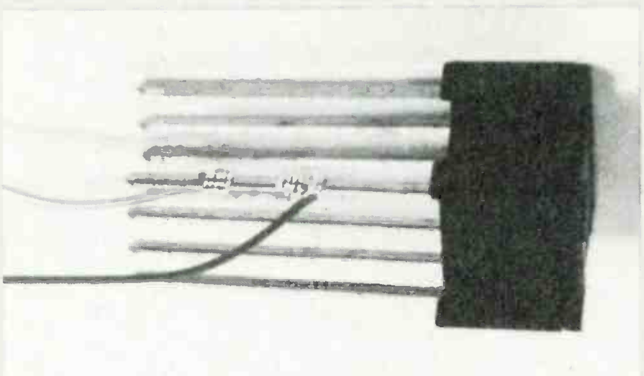
Wirewrap Your Projects

By Herb Friedman

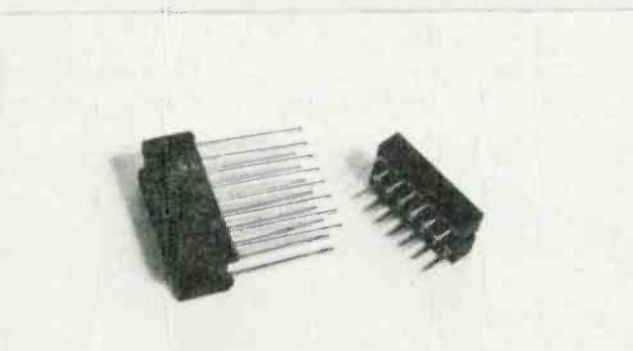
For designing, prototyping, and components, the wirewrap approach

THERE'S NOTHING THAT INSURES THE RELIABILITY AND integrity of solid-state projects as well as printed-circuit construction. However, there are times when making a printed-circuit board simply isn't worth the time and effort; for instance, when building a prototype of your design.

If you only want to experiment with a small part of a project in an entirely different circuit, or you want to fiddle with and tweak various circuit values and parameters before you lock in a design on a printed-circuit board, you'll probably find that it's faster and more convenient to use *wirewrap* connections.



Several wrapped connections can be stacked on each terminal. If you think you'll need to remove a connection, make certain it's on top of the stack; it's difficult to unwrap connections from the bottom.



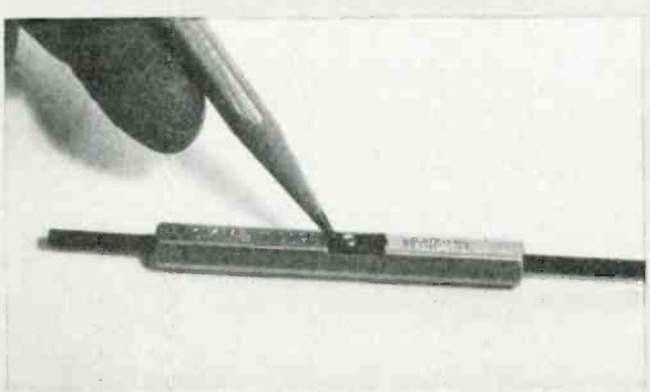
Except for the relatively long terminals having square corners, which bite into the tightly wrapped wire, wirewrap IC sockets are similar to conventional sockets.

Wirewrap Technique

Wirewrap is a wiring system in which the various circuit components are interconnected by literally wrapping (see photos) exceptionally-thin, solid, insulated wires around individual components and terminals. Several wrapped connections can be stacked on each terminal. Since the interconnections are generally unsoldered, they can be readily changed, or even opened, so that additional components can be easily added to the circuit. If you think you'll have need to remove a connection, make certain it's on top of the stack because it's difficult to unwrap connections from the bottom. The connections are so reliable and so convenient to modify that it is usually the method by which most electronic projects are originally prototyped by their designers.

Unfortunately, wirewrap connections cannot be made to conventional terminals and leads, which are primarily intended for soldering; the technique requires sockets and terminal pins specifically intended for wrapped connections. Although the socket leads and terminals appear similar to conventional hardware meant for soldering, on close inspec-

If you're using non-foil perfboard, place a drop of adhesive in the center of the socket and "squish" the socket onto the board. When the adhesive dries the socket will be secure.



Although somewhat expensive, automated tools are used for commercial wirewrap connections. But, hobbyists can do an equally good job with a simple (manual) hand tool. The longer end wraps the connection, the shorter end unwraps. A small stripper in the center of the wirewrap tool is used to safely remove the Kynar insulation.

building circuits containing only a few to circuit construction is hard to beat.

tion, you'll find that wirewrap leads and terminals are relatively long and square (having four sharp corners that bite into the wrapped wire connection).

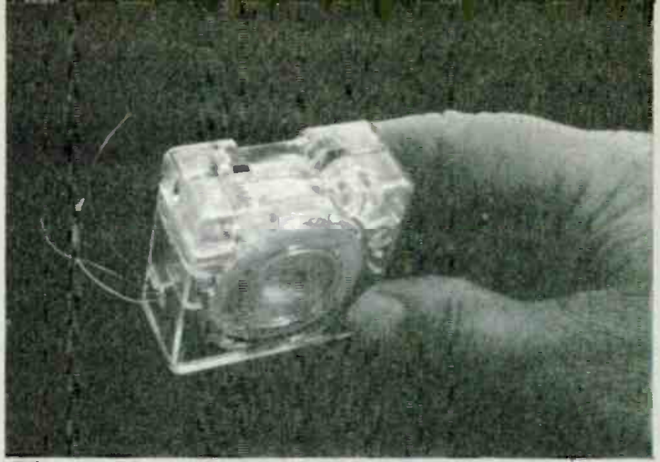
The wire used for the wirewrap connections is usually solid #30 wire covered with Kynar—a thin, unusually rugged, plastic insulation that must be removed with a special tool because it's so tough. Trying to strip Kynar insulation from #30 wire with conventional diagonal cutters or a wire stripper, you are almost guaranteed to cut through the wire every time. While a high-speed, automatic wrapping tool is usually used by engineers when prototyping, the wire can be manually wrapped on terminals using an inexpensive tool, like that shown, which is available from local electronic parts distributors and Radio Shack.

Tools and Materials

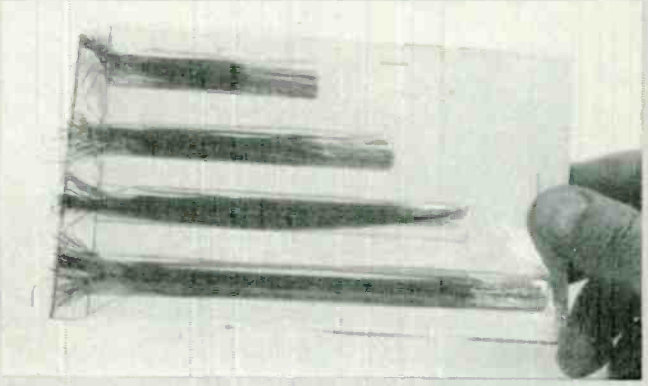
Although automated tools used for commercial wirewrap connections are somewhat expensive, hobbyists can do an equally good job with a manual wirewrap tool. One side of the tool (the longer end) is used to wrap the wire, the other side (the short end) is for unwrapping. (It's very difficult to unwrap a wire without causing damage if you don't have an "unwrap" tool.) In the center of the tool is a small wire stripper specifically designed to remove the Kynar insulation without damaging the wire. To make a wirewrap connection, the wire is first inserted in the tool, then the tool is slipped over the terminal, spun a few times, and then removed, leaving behind a tightly wrapped wire connection that's every-bit as reliable as a solder connection.

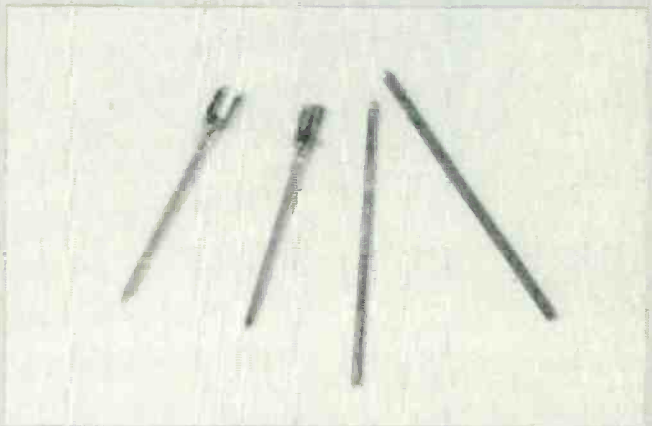
Oh yes, when you're planning your wirewrap project, keep in mind that you can't pass heavy current through #30 wire;

(Continued on page 93)

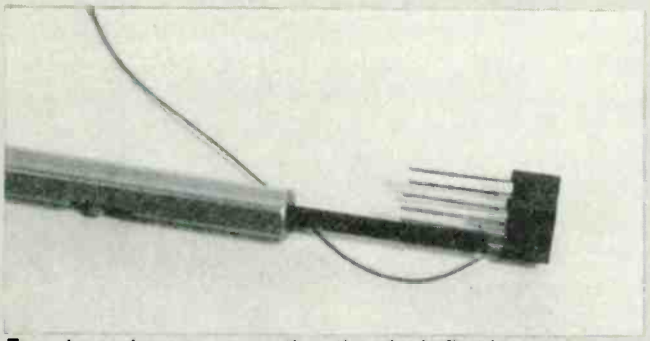


Wirewrap wire can be purchased on rolls (with or without a plastic case, containing a cutter and stripper) or ◆ in packs of pre-cut and pre-stripped lengths, which ◆ come in assorted colors.



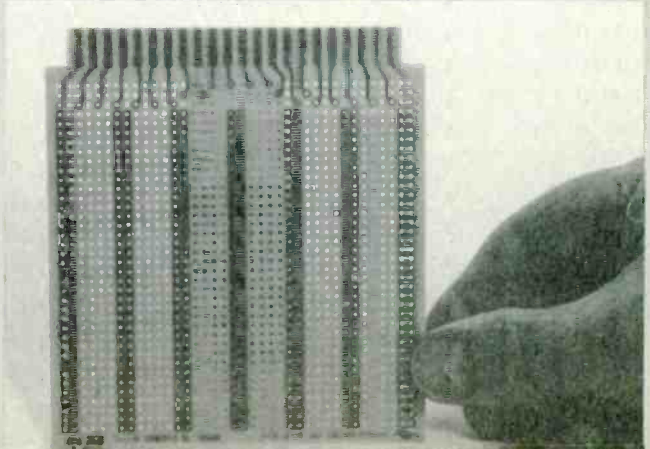


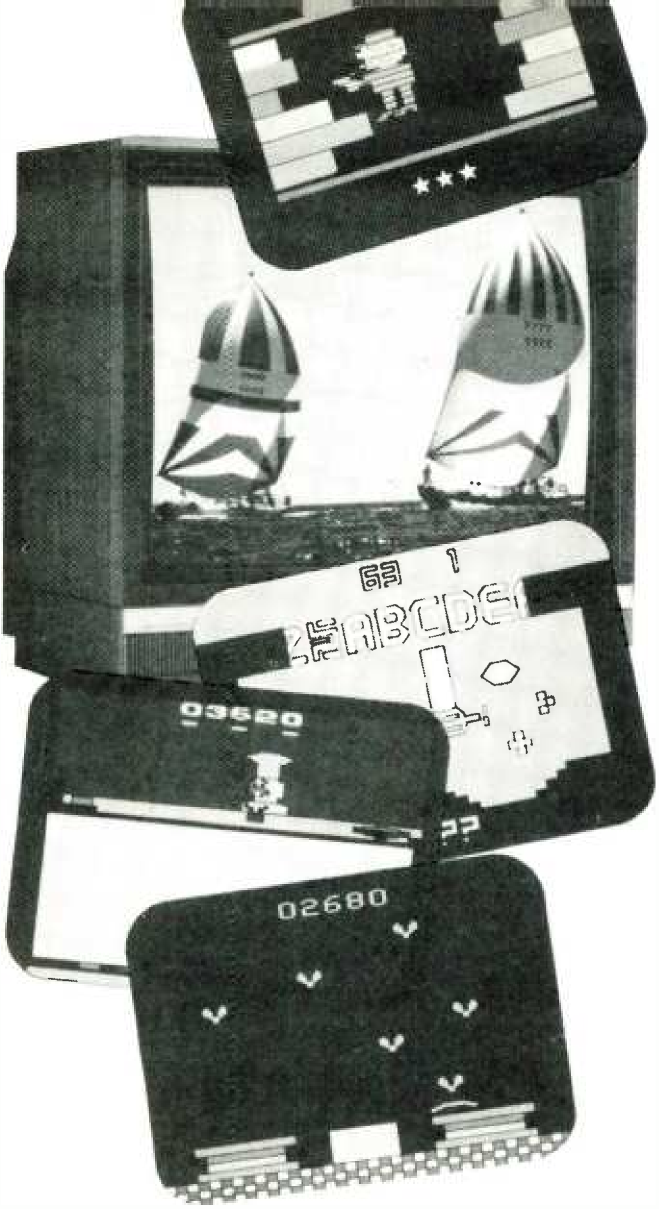
Two kinds of "pass-thru" terminals are commonly available, both of which are intended for PC wiring boards and must be soldered in position. One kind permits wirewrap connections on both ends, hence, both sides of the board. The other kind has a U-clamp on one end, which can be used to support small soldered components like resistors, or connections to external equipment. The opposite end is for conventional wirewrap.



To make a wirewrap connection, the wire is first inserted in the tool, then the tool is slipped over the terminal, spun a few times, and then removed. What remains is a tightly wrapped wire connection that's every-bit as reliable as a solder connection.

While you can install wirewrap sockets on conventional perforated wiring board, it's a lot easier and more convenient if you use a special *Universal Pattern* PC Board, which has many different patterns of printed circuit foils connecting limited groups of holes. The foils provide bus connections and solder pads for small components such as resistors, capacitors, etc. ▶





VIDEO SWITCH

If you're tired of the irritation usually encountered when switching one video source for another, try this automatic video switch on for size.

By John and Gail Keker

☐ANYONE WITH A VIDEOGAME, HOME COMPUTER, OR ANYthing that uses one's television set as the monitor is familiar with the standard slide-switch that is used to disconnect the antenna when connecting the TV's RF input to a game or computer output. Taped to the back of the television set, the switch is often difficult to get at. Other types of switching units have multiple inputs and outputs, but they can be confusing to someone who is not familiar with what input corresponds to which position on the control panel. Well, if that little scenario sounds familiar to you, then you'll probably be interested in the *Video Switch*.

With the Video Switch, no longer is it necessary to dig through a rat's nest of wires (behind the TV set) to find the switcher that pulls your video system together. Nor do you have to remember (or figure out) the switch settings on commercial gadgets in order to use your system. The Video Switch automatically does it for you; whenever you turn on your game, computer, videodisc player, or whatever, its output takes priority over the antenna-derived signal (i.e., the antenna is disconnected and the alternate source is fed to the monitor). And when the alternate video source is no longer detected, this little gizmo disconnects your video gizmo and reconnects the antenna.

About The Circuit

Figure 1 shows a schematic diagram of the Video Switch circuit. At the heart of the circuit is a MC3356 FSK receiver from Motorola. Although the unit is capable of many other functions, in this application, it is used only to detect the presence of a channel 3 carrier signal at the GAME IN input (J3). The operation of the unit is simple: When the RF carrier is detected, a high logic output appears at pin 15 of U1 (Squelch Status). The signal is then buffered to the VMOS FET, Q1, which can drive the CMOS inverter/buffer (U2), or can be used as an "open-drain" output to drive a relay, or can convert to a 5-volt logic level.

When pin 15 of U1 goes high, Q1 turns on, pulling pin 11 of U2-e low; in turn, pin 12 goes high. The output of U2-e is fed to U2-f, forcing its output at pin 15 low. When U2 pin 12 is high, D1 is biased on, allowing the signal at J3 to flow through C14, D1, and out to J2 through C13. But when the signal at J3 is removed, U1 pin 15 goes low. That causes U2 pin 12 to go low and U2 pin 15 to go high. When U2 pin 15 is high, it biases D2 on, allowing the signals at J1 to flow through C12, D2 and out to J2 through C13.

Construction

The circuit board should be mounted in a metal case and all RF inputs and outputs *must* be standard F-type connectors. The case can be grounded to the circuit through the connectors, and the mounting screw by using a conductive metal standoff. The circuit grounding and the proper placement of

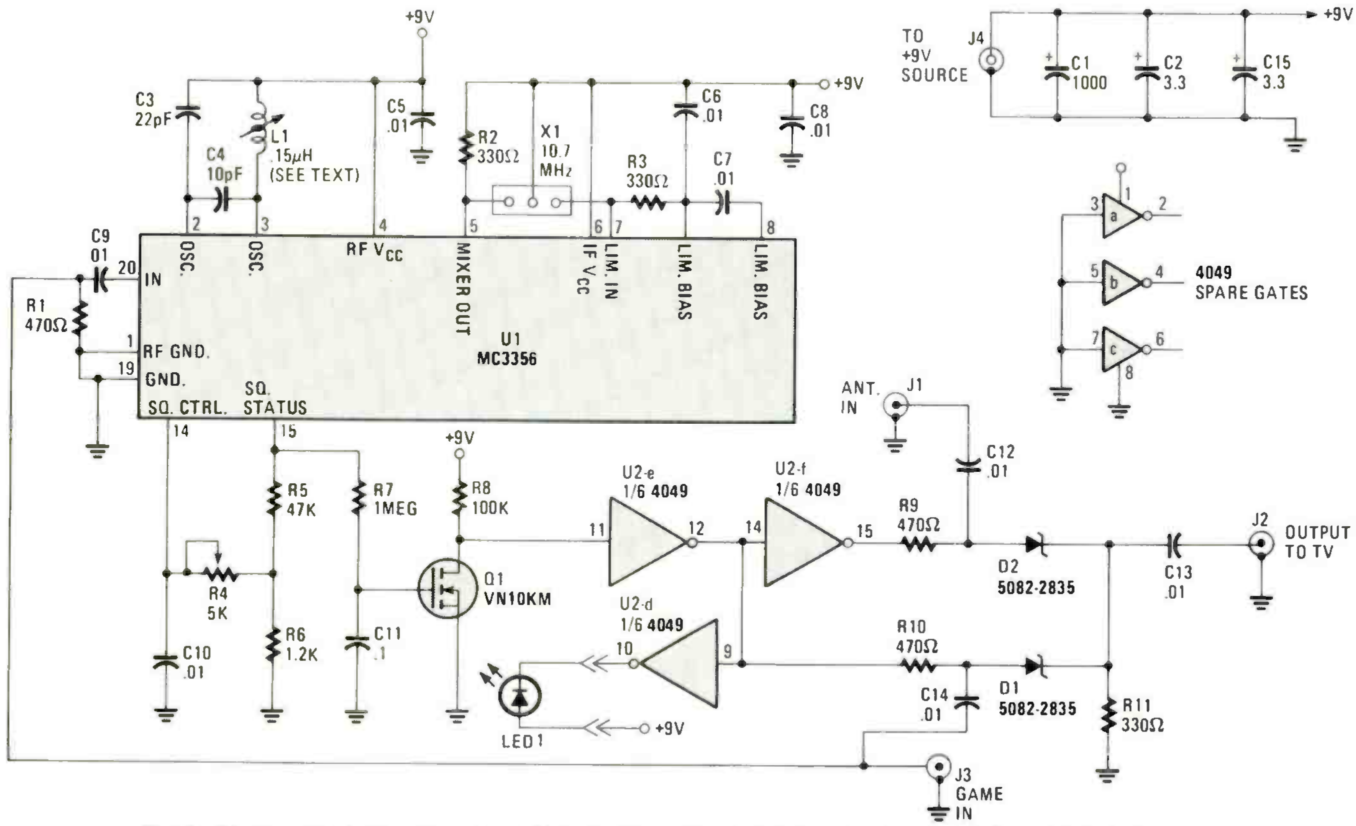


Fig. 1—The schematic diagram of the Video Switch shows how truly simple the circuit really is. Contrary to what you might have expected, the circuit uses very few parts, making it economical as well as convenient.

PARTS LIST FOR THE VIDEO SWITCH

SEMICONDUCTORS
D1, D2—5082-2835 (Radio Shack #276-1124) Schottky diodes H.P.
Q1—VN10KM N-channel VMOS FET
U1—MC3356P wideband FSK reciever, integrated circuit
U2—MC4049UBCP hex inverter/buffer, integrated circuit

RESISTORS
(All resistors ¼-watt, 5% fixed units, unless otherwise noted.)
R1, R9, R10—470-ohm
R2, R3, R11—330-ohm
R4—5000-ohm, linear-taper potentiometer (Bourns type 3299W)
R5—47,000-ohm
R8—100,000-ohm
R7—1-Megohm

CAPACITORS
C1—1000-µF, 35-WVDC, aluminum electrolytic
C2, C15—2.2-µF, 35-WVDC, tantalum
C3—22-pF, NPO, ceramic disc
C4—10-pF, NPO, ceramic disc
C5—C10, C12—C14—0.01-µF (Z5U) ceramic disc
C11—0.1-µF, monolithic

ADDITIONAL PARTS AND MATERIALS
L1—#L33-10 Amidon coil-form and #26 gauge magnet wire
X1—SFE10.7MAS-Z 272-1301 Maurata Erie ceramic filter
J1–J3—F-type connectors, PC-mount (or Panel mount)
Printed-circuit materials, metal cabinet (Radio Shack #270-251), 9-volt battery-eliminator (power supply), coax power jack, hook-up wire, hardware, solder, etc.
The following is available from Electronics Parts Outlets, 2815 Fondren, Houston, Texas, 77063:

Etched, drilled, and silkscreened printed-circuit board for $8.00; MC3356P wideband receiver for $4.00; complete kit, containing all parts, except the case, power supply, and power jack for $24.00. Texas resident please add 5% sales tax. Please allow 6 to 8 weeks for delivery.

all RF lines and components are critical, which makes point-to-point wiring of the circuit difficult.

Figure 2 shows an example of an acceptable printed-circuit board, with a parts-placement diagram for the board appearing in Fig. 3. Capacitor C1 is an aluminum electrolytic unit that should remove (filter) any 60-Hz ripple from the power supply. C2 and C15 are tantalum units, which are used for decoupling power-line spikes and high-frequency noise. These three capacitors must be installed with the correct polarity. C3 and C4 should be NPO (temperature stable) type capacitors for stability.

The values of R4 and R6 are chosen using the following criteria: As the amplitude of the RF input signal at J3 increases, the current out of U1 pin 14 increases. The circuit will actually switch (U1 pin 15 going high) when the voltage at U1 pin 14 equals approximately 800 mV. When R6 equals 1200 ohms and R4 is a 5000-ohm potentiometer, switching sensitivity can be set anywhere from 25 µV rms to 300 mV rms. Resistor R5 provides a small amount of hysteresis to the switching action.

F-type connectors J1–J3 are printed-circuit board mountable in the author's prototype, which, when attached to the case, provide all the support needed to hold the printed-circuit board in place. You can use regular panel-mount

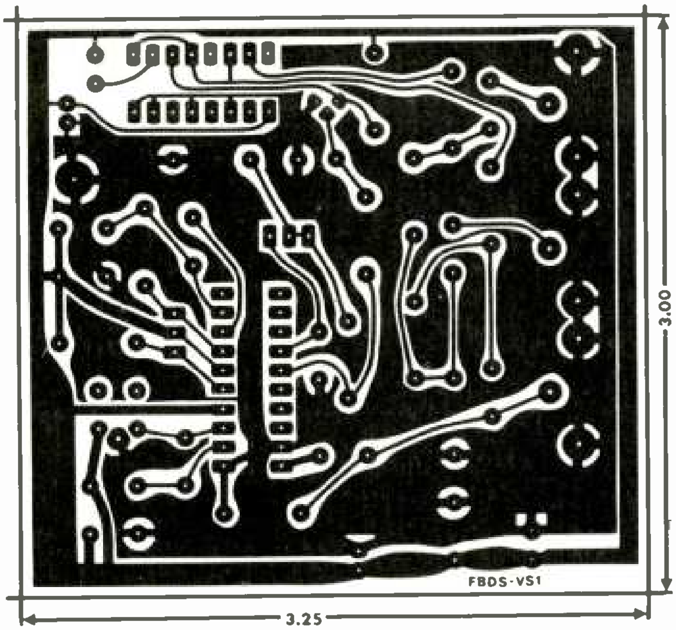


Fig. 2—The printed-circuit board for the Video Switch project is shown here full-scale for photocopying.

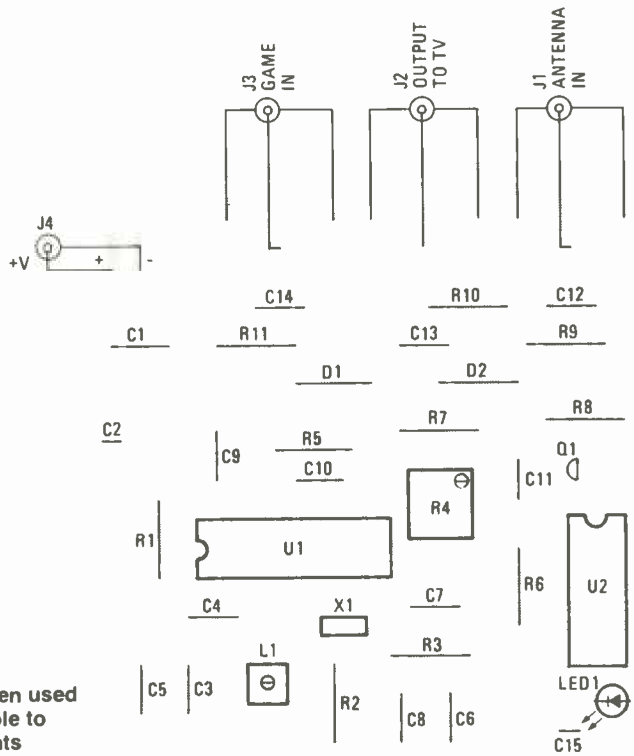


Fig. 3—The parts layout for the Video Switch, when used in conjunction with the photos, is extremely simple to follow. Just make sure that the polaric components (capacitors, diodes, etc.) are properly oriented.

connectors instead, as long as you keep the wires as short as possible and connect all the coax shields to ground. The extra holes on the board for the F connectors can then be used for mounting the board. If you would like to use an LED as a switching-action indicator, you can connect it between U2 pin 10 and the +9V supply (as shown in Fig. 1). Remember to use a current-limiting resistor or an LED with built-in current limiting.

The VMOS FET (Q1) can be replaced by an NPN Darlington transistor with similar results. Inductor L1 is an Amidon type L33-10 and should be wound with 5-⅔ turns of #26 gauge wire to produce an inductance of about .152 µh. That value along with C3 (a 22-pF unit) and C5 (10 pF) causes the oscillator to operate at 71.95 MHz, which is equal to the channel 3 carrier of 61.25 MHz, plus the 10.7 MHz IF. The ceramic filter (X1) has a frequency stability between that of an LC circuit and a crystal filter, but has an advantage over a crystal in this application due to its lower input and output impedances.

Calibration

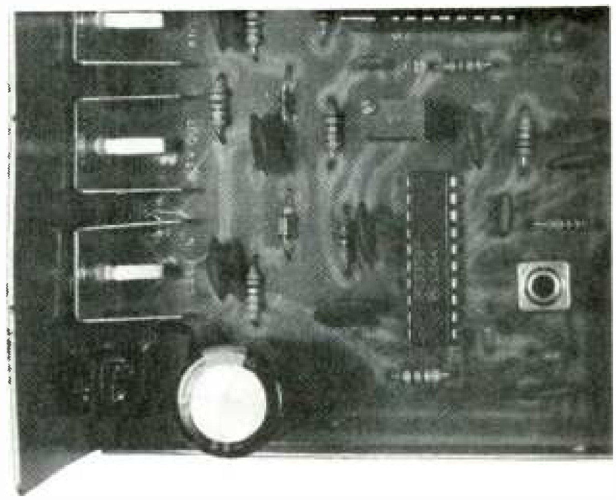
Since there are only two adjustments to make, calibration is very simple. If you have an oscilloscope, place your probe on U1 pin 7 and, with the power on and the signal source connected to J3, adjust L1 for a peak in the 10.7-MHz IF signal. Then simply adjust R4 for good, positive switching action when you turn the signal source (game, computer, etc.) on and off. If no scope is available, remove R5 and set R4 to its middle point. Now with the signal applied at J3, tune L1 for a peak in the DC voltage at U1, pin 14. If no discernible peak is present, raise the resistance of R4 and try again. Then install R5 and adjust R4 to switch when you turn the source off and on.

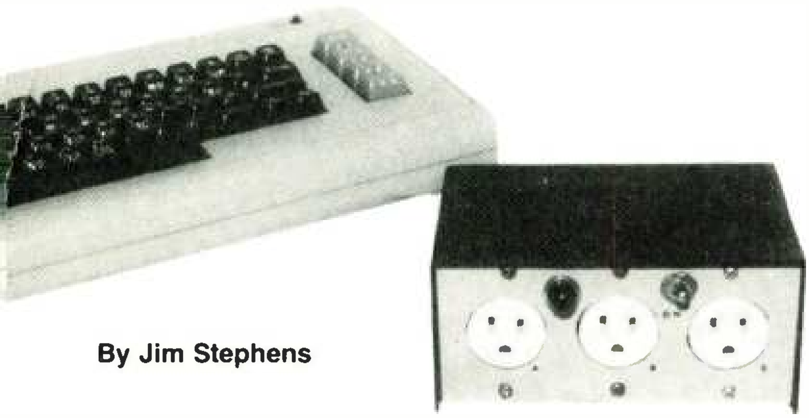
Troubleshooting

If the circuit does not work, first check the printed-circuit board for solder bridges, shorts, and cold-solder joints. Then with all the RF lines disconnected, apply power, and check for the supply voltage at U1, pins 4 and pin 6, and U2, pin 1. If there is no voltage present, check your power supply and re-inspect your solder job. If the voltage is low, be sure that C1, C2, C15, and the IC's are installed with the correct polarity. If the power looks good, then determine whether U2, pin 12 or pin 15 is high. If pin 12 is high (and pin 11 is low), set R4 to zero ohms. If U2, pin 12 is still high, see if U1, pin 15 is high, if it isn't, check R7, R8, C11, and Q1. If it is, check R4 and R6.

If U1, pin 15 is high, then connect your game (computer, etc.) to J3 and apply power. If U2, pin 15 stays high, check

(Continued on page 94)


The use of bracketed, printed-circuit-mounted connectors allows the circuit to be easily mounted in its enclosure. When the barrel of the connector is inserted through the front-panel mounting hole and secured, the board is held stationary and no additional mounting hardware is needed.



By Jim Stephens

3-CHANNEL APPLIANCE CONTROLLER

Make your personal computer earn its keep by programming it to do repetitive tasks around the home, office, and workshop!

THE ABILITY OF A PERSONAL COMPUTER TO CRUNCH NUMbers and dazzle you with colorful game animations is fascinating indeed. However, I have to admit that although I was impressed for a while (as were so many others), I soon tired of the *beeps*, *chirps*, and the endless *space critters* scurrying across the screen. Surely, I thought, there was more to this magic box than games and blinking lights. Then it dawned on me: "Why not have the personal computer do its mechanical share around the house?"

Placing household appliances under computer guidance is not as difficult as you might think. With the right electronics, all it took was a little imagination and a few hours of tinkering to produce *The 3-Channel Appliance Controller*. The Controller, designed for use with the Commodore 64, is activated by positive signals from the output port, and can easily be used with most any home computer with the proper connections and program changes. The real problem is finding things that easily lend themselves to computer control.

Since I hate mowing the lawn, that job headed the list of tasks to be delegated to computer control. But, I soon realized that there had to be much simpler tasks (like making coffee, turning on the radio or television, home-security control, or the control of home lighting) that were just as important and could be accomplished with less difficulty. If I could get the computer could do that (I thought), other more complicated tasks, like warming the auto engine on cold Winter mornings, had to be only a few solder joints away.

My Plan of Attack

The main task of the computer in this control scheme is to control, through external hardware, the 117-volt AC line voltage, allowing many appliances to be started and stopped according to the user's needs. The final project, a three-channel control circuit, is connected as an interface between the appliance and the host computer, which is programmed to perform many of the constant repetitive tasks around the home. With the ability to control three separate appliances at once, things such as lights, recorders, and a television set might be used as a simple home security (*scare-alarm*) system. Additionally, a radio, coffee pot, and overhead light could sound the morning wakeup call or start breakfast.

But, I must admit that the thought of trying to control 117 volts with a Commodore did give me some concern—after all, I was asking a lot of a little five-volt computer. Since 10 amperes at 117 volts could fry the computer, it needed some sort of protection scheme; not to mention that user safety is also a prime consideration.

A Look at the Circuit

Figure 1 is a complete schematic diagram of the 3-Channel Controller circuit. Note the simplicity of the circuit. Since the bits on the user port of the Commodore 64 are normally at ground potential, and the optoisolator/couplers are connected such that a low is needed at pin 2 to turn them on, the output of the computer is inverted before being fed to optoisolator/couplers. The optoisolator/couplers are used to separate the user port from the high voltage; thereby insuring that no high voltage ever reaches the port if a short occurs in one of the components.

Signals from the computer's output port are routed to individual gates of a 4049 hex inverter buffer (U1). The buffers (depending on which one is activated), in turn, output a complementary signal that's fed to an MOC3010 optoisolator/coupler. Within each MOC3010 optoisolator/coupler is a light-emitting diode (LED) input and a light-sensitive bilateral switch (diac) output. There are no physical connections between the input and the output devices. The output device is turned on by light radiation falling on the light-sensitive area of the bilateral switch. By connecting the computer to the triac only by a light beam, the computer is completely isolated from the AC line voltage.

Let's analyze one channel, since all three are identical. With the PB0's normally-low output applied to the input of the inverter (U1a) at pin 3, its output is forced high. That high, which is tied to pin 2 of U2, acts as a blocking voltage and the optoisolator/coupler's internal LED remains off. But when the incoming logic level goes high, the output of the inverter is forced low, forward biasing the internal LED. With

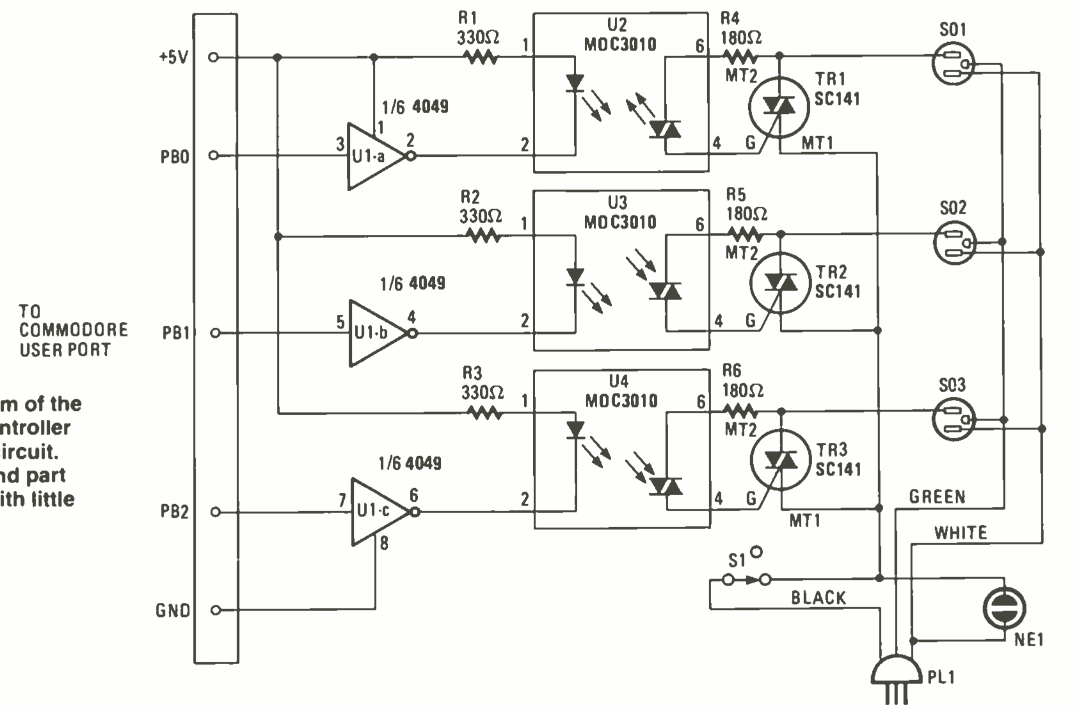


Fig. 1—The schematic diagram of the Three-Channel Appliance Controller shows an extremely simple circuit. Nothing about it is critical, and part substitutions can be made with little or no trouble.

the LED turned on, radiation falls on the light-sensitive area of the bilateral switch, causing it to conduct. With the optoisolator/coupler now conducting, a trigger is applied to the gate of triac TR1. That causes the triac to turn on, applying AC power to the appliance connected to SO1.

Although heavy-duty relays seemed the logical route to take, the expense of units capable of the power-handling capacity necessary convinced me that triacs with a rating of 6-amperes at 200-volts (more than enough power for most home appliance) had to be a *cheaper* way to go. Triacs are solid-state devices that, effectively, perform like relays, in that they can be used to cut power on and off.

The neon lamp, NE1, is used to indicate that AC power (which is controlled by S1) is being fed to the circuit. The small 180-ohm resistors (R4–R6) are placed between pin 6 and the AC line to limit current to the optoisolator/coupler.

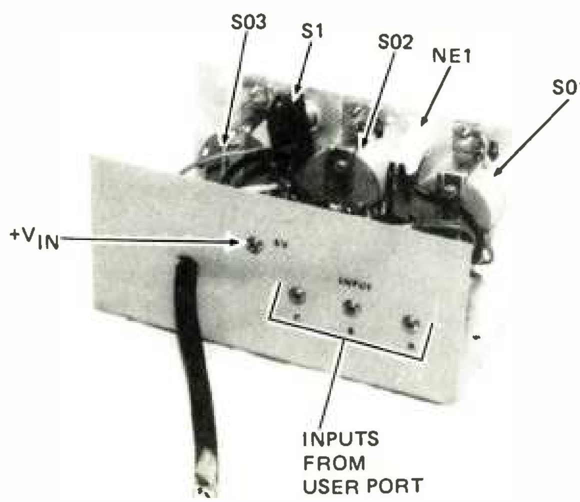
More channels could easily be added by repeating the same pattern shown in Fig. 1 and using the remaining bits of the output port along with the left over gates from U1.

Construction

The final circuit is hard-wired on heavy perfboard. Since there are so few connections, this type of point-to-point wiring is a natural. The component layout on the perfboard is not critical and can be done to suit the user. The optoisolator/couplers and inverting buffers can be mounted in wirewrap sockets and all of the low-voltage connections can be made using wirewrapped techniques. Since the wires connected to MT1 and MT2 of the triac are expected to carry a good deal of current, the use of heavy, stranded wire (AWG #16 is recommended) is a necessity. And because the triac can get very warm when heavy current is drawn, it's a good idea to use heatsinks; we don't want your circuit to go into *thermal meltdown*, now, do we? Silicon grease should be used between the heatsink and triac for better heat transfer.

Figure 2 shows pinout diagrams of the semiconductor devices used in the project, as well as those of the Commodore 64's user port. Note that only three of the port bits are used for control signals. The other bits of the port could be used later as inputs sensors in more elaborate applications. The only other connections required at the port are the +5 volt and ground for the buffers and optoisolator/couplers. A total of five wires are required from the computer to the Appliance Controller in order to use all three channels.

The connector for the user port can be a standard 44-pin edge connector cut down to 24 pins, saving considerably on the expense of buying a special 24-pin connector. **Caution**: Always be certain that the connector is properly oriented and double-check your wiring before applying power to the Controller. A shorted wire from the triac to the output port can damage the computer no matter how many buffers you include.



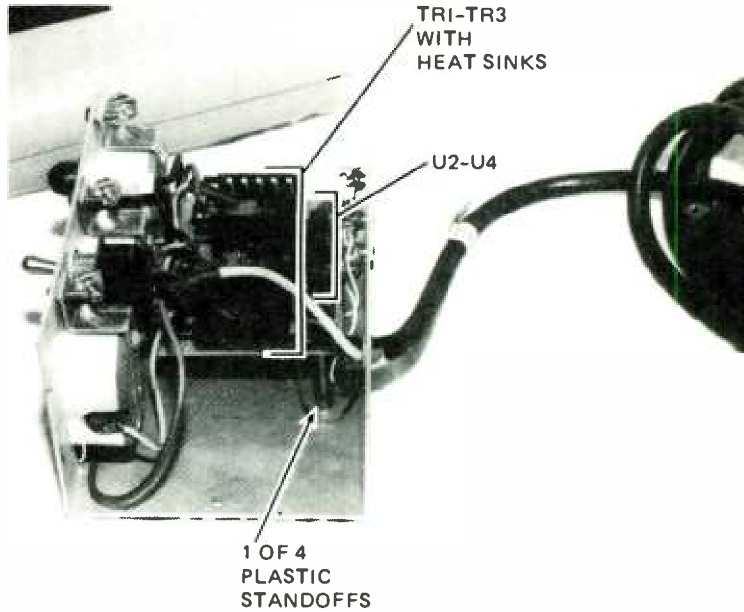
The Three-Channel Appliance Controller fits neatly into almost any type enclosure. All inputs and outputs, the power switch, and indicator mount to the walls of the enclosure. Phone jacks are mounted on the rear panel, through which power and input signals feed to the Controller.

PARTS LIST FOR THE 3-CHANNEL APPLIANCE CONTROLLER

J1–J4—Subminiature 3/32-inch, phono jack (optional)
NE1—Amber, neon panel lamp assembly (RS #272-707)
P1—3-conductor AC power plug with line cord
R1–R3—330-ohm, ¼-watt, 5% fixed resistor
R4–R6—180-ohm, ¼-watt, 5% fixed resistor
S1—Single-pole, single-throw 6-A, 125-volt switch
TR1–TR3—4-ampere, 200-PIV (Radio Shack #276-1001 or similar) triac
U1—4049 CMOS hex inverter/buffer, integrated circuit
U2–U4—MOC3010 bilateral output, optoisolator/coupler

ADDITIONAL PARTS AND MATERIALS

Perfboard or printed-circuit materials, enclosure, electrical cord (for high-voltage connections), wirewrap wire, solder, hardware, etc.



The Controller's circuit board should be mounted on standoffs, and all wiring insulated and kept away from the enclosure walls to prevent shock hazard. Although not necessary in all cases, it a good idea to mount the triacs (TR1–TR3) in heatsinks as shown—if you don't, you could be inviting thermal breakdown.

The Enclosure

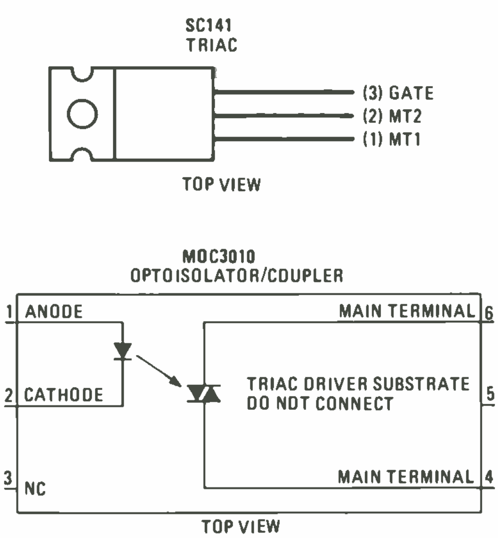
The finished board must be mounted inside an enclosure. Although the author used an aluminum utility box, the heavy-plastic type is probably the best way to go (non-conductive material and all that). Since some of the wiring carries 117-volts AC, it's extremely important that the components and solder connections not be allowed to contact the enclosure. To reduce the hazard, connections to the triacs should have lengths of heat-shrinkable tubing covering them, and all conducting surfaces should be isolated from the walls of metal cabinets by the use of insulating standoffs.

The appliance outlets, as well as the neon lamp and on/off switch (S1) are mounted through the front panel of the enclosure, with the outlets attached directly to the triacs' MT1 and MT2 terminals. The connections at the outlets should be covered liberally with clear, silicon-rubber compound. (Never remove the cover of the enclosure while the Controller is plugged into an electrical outlet.)

The signals from the user port are provided through the enclosure by means of three small earphone jacks on the back panel of the enclosure, and is the same method used to get +5-volt supply to the Controller's circuitry. Simply solder four small phono plugs at the end of the ribbon cable running from the port connector.

Testing The Controller

Once the Controller is completely wired and in its case, it should be tested before being connected to the computer. If a wiring error does exist you can correct it before it causes any harm. With the Controller unplugged from the wall outlet and the computer, turn power switch S1 on, and with a VOM (set to the R × 100 scale) connected across the terminals of PL1,



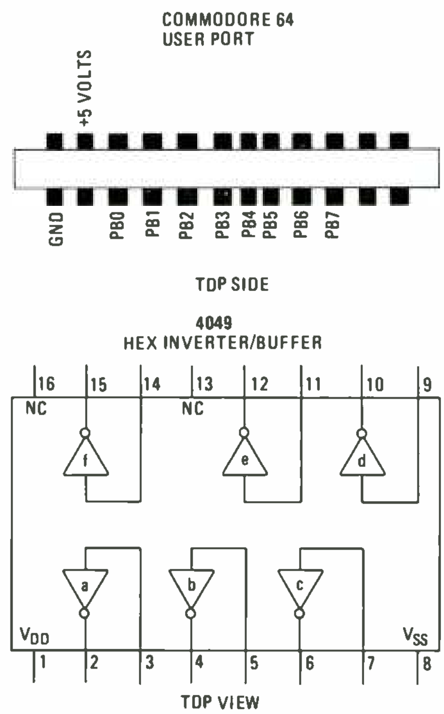


Fig. 2—These pinout diagrams, when used along with the schematic diagram in Fig. 1, make the construction of the Three-Channel Appliance Controller both fast and simple.

TABLE 1—PROGRAM FOR 3-CHANNEL APPLIANCE CONTROLLER

```
100 REM THREE-CHANNEL APPLIANCE CONTROLLER
110 REM JIM STEPHENS - 1985
115 POKE 56579 ,255:POKE 56577 ,0
120 PRINT "ENTER PRESENT TIME - HR,MIN,SECS - 6 DIGITS":INPUT TI$
130 GOSUB 620:GOSUB 640: PRINT "RESTART IF TIME IS INCORRECT"
140 PRINT "(CURS DWN 3)":PRINT "ENTER  1 FOR CHANNEL ACTIVATION"
150 PRINT "ENTER 0 FOR NO ACTIVATION"
160 PRINT "CHANNEL A-":INPUT A:PRINT "CHANNEL B-":INPUT B
170 PRINT "CHANNEL C-":INPUT C
180 GOTO 510
190 PRINT "ENTER NUMBER OF DAYS UNTIL ACTIVATION": GOSUB 580
200 GOSUB 620: GOSUB 710
210 PRINT "PLEASE READ CAREFULLY -ENTER S FOR START": INPUT X$
220 IF X$="S" THEN GOTO 310:PRINT "ENTER S OR BREAK": GOTO 210
225 IF TI$="235959" THEN GOTO 325
300 REM ACTIVATION CHECK ROUTINE
310 GET X$:IF X$="R" THEN GOSUB 620: GOSUB 720
320 IF TI$="235959" THEN P=P-1:Q=Q-1:R=R-1
330 IF A=1 AND D=0 AND P=0 AND D<3 AND TI$>=G$ THEN GOSUB 480:GOSUB 410
340 IF TI$>=J$ AND D=1 THEN GOSUB 480:GOSUB 450: D=3
350 IF B=1 AND E=0 AND Q=0 AND E<3 AND TI$>=H$ THEN GOSUB 480:GOSUB 420
360 IF TI$>=K$ AND E=1 THEN GOSUB 480:GOSUB 460: E=3
370 IF C=1 AND F=0 AND R=0 AND F<3 AND TI$>=I$ THEN GOSUB 480:GOSUB 430
380 IF TI$>=L$ AND F=1 THEN GOSUB 480:GOSUB 470: F=3
390 GOSUB 640: GOTO 310
400 REM CHANNEL ACTIVATION
410 LET X=X+1:POKE 56577 ,X:D=1:PRINT "A ON ":RETURN
420 LET X=X+2:POKE 56577 ,X:E=1:PRINT "B ON ":RETURN
430 LET X=X+4:POKE 56577 ,X:F=1:PRINT "C ON ":RETURN
440 REM CHANNEL DE-ACTIVATION
450 LET X=X-1:POKE 56577 ,X:PRINT "A OFF":RETURN
460 LET X=X-2:POKE 56577 ,X:PRINT "B OFF":RETURN
470 LET X=X-4:POKE 56577 ,X:PRINT "C OFF":RETURN
480 POKE 56579 ,255:LET X=PEEK(56577 ):RETURN
500 REM INPUT ON/OFF TIMES
510 IF A=1 THEN PRINT "CH-A ON TIME":INPUT G$:PRINT "CH-A OFF TIME": INPUT J$
530 IF B=1 THEN PRINT "CH-B ON TIME":INPUT H$:PRINT "CH-B OFF TIME": INPUT K$
550 IF C=1 THEN PRINT "CH-C ON TIME" INPUT I$:PRINT "CH-C OFF TIME": INPUT L$
560 GOTO 190
570 REM CHANNEL ADVANCE DAYS
580 IF A=1 THEN PRINT "CHANNEL A-":INPUT P
590 IF B=1 THEN PRINT "CHANNEL B-":INPUT Q
600 IF C=1 THEN PRINT "CHANNEL C-":INPUT R
605 RETURN
610 REM CLEAR SCREEN
620 FOR X=1 TO 22:PRINT CHR$(17): NEXT X: RETURN
630 REM PRINT TIME
640 PRINT "(CLEAR HOME)"
650 A$=RIGHT$(TI$,2):B$=MID$(TI$,3,2):C$=LEFT$(TI$,2)
660 PRINT C$;":";B$;":";A$:RETURN
700 GOSUB 610:GOSUB 640
710 REM PRINT REPORT
720 PRINT "(CURS DWN 3)":PRINT "CH   AC  START  DAYS    STOP  OFF
730 PRINT "A   ";A;" ";G$;"   ";P;"   ";J$;"   ";D
740 PRINT "B   ";B;" ";H$;"   ";Q;"   ";K$;"   ";E
750 PRINT "C   ";C;" ";I$;"   ";R;"   ";L$;"   ";F
760 PRINT "(CURS DWN 3)":PRINT "ENTER R FOR CURRENT REPORT":RETURN
```

measure the resistance. It should be very high (infinite). If a resistance is read, you probably have a wiring error or short. Check the wiring again until an infinite reading is obtained.

If the Controller passes the resistance check, leave it disconnected from the computer and wall outlet, and temporarily insert a small phone plug into one channel of the Controller. The phone jack should have only one wire attached to it, which connects to the control input (pin 2) of the optocoupler. Now insert a phone plug into the phone jack going to the 5-volt and ground connections on the Controller. The two wires from the plug can be temporarily attached to a

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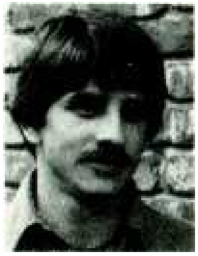


SAXON ON SCANNERS

By Marc Saxon

SEVERAL READERS RECENTLY WROTE to ask me to give them information on how they could hear the marine band. I must admit that my natural inclination was to suggest that they visit the parade grounds at Camp Pendleton or Parris Island any Sunday afternoon. As I recall from the days when I was there, the Marine Band helped to entertain us while we marched.

On second thought, however, I guessed that readers would probably like some information on how to scan the activities taking place between 156.275 and 157.375 MHz, commonly called the VHF marine band. Welcome aboard!

Contrary to what many scanner owners come to believe after a cursory examination of this band, it is divided into a number of specific (or discrete, as they are known) channels. Each of these channels is designated or reserved for a specific maritime communications purpose. Admittedly, at the peak of the boating season near a busy port the whole band starts to sound like a free-for-all. Abuses of the orderly system sometimes become rampant! The channel numbers are arbitrarily assigned, like the TV channel numbers. This was found to be a convenient way for maritime folk to sort out one from the other as opposed to cumbersome four to six figure frequencies stated in MHz.

Now I'll give you some pointers on the best frequencies to punch-up on your scanner!

The Best Frequencies

The most important frequency in this band is Channel 16 (156.80 MHz), used for calling and (more importantly) emergency use. A vessel sending out a "Mayday" call here will often be requested by the Coast Guard to shift communications over to Channel 22 (sometimes called 22-Alpha) on 157.10 MHz. Certainly, monitor both of these frequencies if you're near the ocean, a large bay, lake, inland or other navigable waterway.

Around larger ports accommodating commercial vessels (liners, tugs, freighters, tankers, and trawlers), check out Channels 5, 12, 14, 20, 65, 66, 73, 74, and 77 (156.25, 156.60, 156.70, 157.00, 156.275, 156.325, 156.675, 156.725, and 156.875 MHz, respectively).

No matter where you're located within range of vessels afloat, you should be able to hear commercial vessel activity on Channels 7, 8, 9, 10, 11, 18, 19, 67, 79, 80, and 88 (that means 156.35, 156.40, 156.45, 156.50, 156.55, 156.90, 156.375, 156.975, 157.025, and 157.425 MHz).

Chatter between recreational boats (yachts), and communications to marinas, boat yards, yacht clubs, racing committees, etc., are usually happening on Channels 9, 68, 69, 70, 71, 72, and 78 (listen on 156.45, 156.425, 156.475, 156.525, 156.625, and 156.925 MHz). The busiest of these are 68 and 70 (156.425 and 156.525 MHz).

Government Use.

Certain frequencies are set aside for governmental uses, and here's where you'll be able to monitor the Coast Guard (including its Auxiliary) and sometimes the Army Corps of Engineers, the EPA, and other agencies. Try listening on Channels 21, 23, 81, 82, and 83 (157.05, 157.15, 157.075, 157.125, and 157.175 MHz).

Ship-to-shore telephone calls are handled by marine operator stations. In all cases, the vessels transmit on one channel while the marine operators (the shore stations) transmit on another channel. Since you can hear both sides of the conversation only if you monitor a shore-station channel, our listing is for only those: Channels 24, 25, 26, 27, 28, 84, 85, 86, 87, and 88 (161.80, 161.85, 161.90, 161.95, 162.00, 161.825, 161.875, 161.925, 161.975, and 162.025 MHz). Note that Channels 26 and 28 (161.90 and 162.00 MHz) are the most active around the nation, but you'll have to see which of the ten available channels are active in your own area. Note, also, that the Great Lakes and St. Lawrence Seaway are the only areas where Channel 88 (162.025 MHz) is used by marine operators; elsewhere,Channel 88 is 157.425 MHz and is used by commercial vessels talking to one another (sometimes by fishing trawlers communicating with fish-spotter aircraft).

Safety and Navigation

Although they are greatly abused, there are two other VHF maritime channels worthy of monitoring. Channel 6 (156.30 MHz) is supposed to be used only for intership safety purposes: ships tell one another about navigational and weather hazards.

(Continued on page 105)

Even if you don't own your own yacht you can still capture the picturesque seashore. Do it with your scanner (hand-held or base unit) on 157.10 MHz.

CIRCUIT CIRCUS

By Charles D. Rakes

Infrared—The silent sound

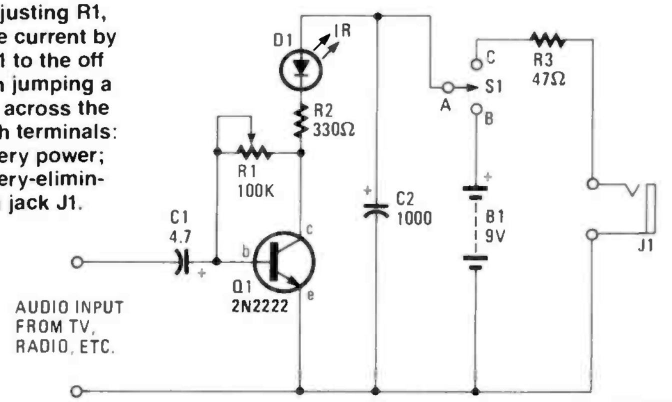
CIRCUIT CIRCUS IS ESPECIALLY WRITTEN for and directed toward you, the electronics experimenter, who enjoys building a new circuit without its cost adding to the *national debt*. It doesn't matter whether you do your experimenting on the kitchen table or in a fully equipped lab, we intend to keep you supplied with *inexpensive* circuits that will help keep your experimenting habit *alive* and *well*. And if we get lucky, one of the circuits is certain to be just what's needed for that special project that you've been wanting to build. (The project needed a nudge in the right direction.) But most of all, we want to present circuits that will interest *you*; so please write and let us know the kind of circuits you would like to see in our *circus of circuits*.

Our first series of circuits deals with the use of *infrared*—better known as IR—for both voice communication and the basic testing of IR remote-control units.

The Receiver

The IR receiver circuit shown in Fig. 1 consists of Q1—a special kind of phototransistor that responds to an intensity of amplitude-modulated IR light source—and a three-stage, high-gain audio amplifier. Transformer T1 is used to match the output impedance of the receiver to today's popular low-impedance (low-Z) headphones; but if a set of 1000-2000-ohm, magnetic (not crystal), high-impedance (high-Z) phones are to be used, remove T1 and connect the high-Z phones in place of T1's primary winding—the 1000-ohm winding.

Fig. 2—When adjusting R1, measure the diode current by setting switch S1 to the off position and then jumping a DC-milliammeter across the appropriate switch terminals: A and B for battery power; A and C for battery-eliminator power via jack J1.



To obtain the best possible performance from the receiver the circuit should be housed in a small, opaque-plastic case with the phototransistor located at least 1/2-inch from one end of the cabinet. Drill or punch a 1/4-inch hole in the case in line with phototransistor Q1 so that only light arriving in a direct line can strike the transistor. Because IR phototransistors are not perfect in detecting only IR light—and do respond in a lesser degree to a range of visible light—this kind of installation for Q1 will reduce the interference from lamps used for general room lighting.

Experiment

To increase the range of the receiver try experimenting with different filters in front of transistor Q1, and with lenses that focus the light on the sensitive area of the phototransistor. With the proper light filter and lens system the receiver's range of detection can be several hundred feet; but, as shown, it will receive at a range of 40 feet or more depending on the IR source used.

A simple way to check out your receiver before building one of the IR transmitters is to locate a TV or VCR infrared remote-control unit, aim it toward the receiver, and hit any of its control buttons. You should instantly hear a rapid number of pulses, or a buzzing sound, as the remote spits out its digital command.

Your Own Broadcaster

The ultra-simple one-transistor, IR transmitter shown in Fig. 2 is designed to transmit the sound from any 8 or 16-ohm audio source, such as a TV, radio, or tape recorder on an infrared beam of light. While it can be powered by a 9-volt transistor-radio battery, you can sharply decrease battery-replacement costs by substituting a 9-volt battery eliminator for B1. Switch S1 is a small toggle switch with a center-off position that allows you to operate the transmitter either from the battery or the power line.

Since battery eliminators vary in the amount of output ripple, capacitor C2 should be made large enough to take care of the problem. Resistor R3 helps to reduce the ripple and could be increased somewhat in value. Those are just two more areas in which you can experiment to determine the best method of use to obtain the best possible results.

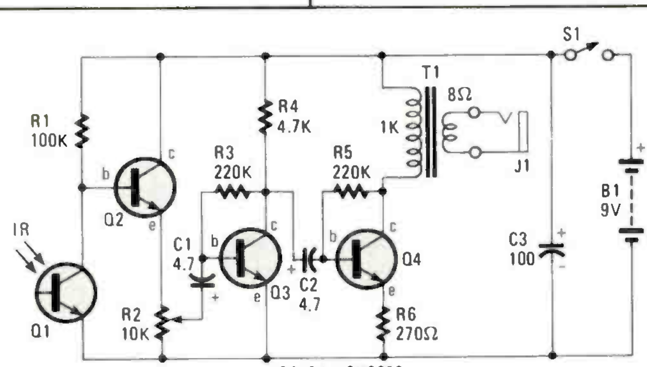


Fig. 1—Basically, the IR receiver is a conventional three-stage amplifier with the input signal provided by an infrared sensitive transistor. Transformer T1 can be replaced by a 1000- 2000-ohm magnetic earphone, or magnetic headphones.

Easy to Build

The circuit can be housed in a small plastic case with potentiometer R1 mounted inside, because once you determine its setting, it will not need re-adjusting. The desired input cables or jacks needed to match those of the audio source can be mounted on the case.

To adjust the idle current of the IR diode (D1), set switch S1 to its center-off position, connect a current meter across the switch terminals, and adjust R1 for a current reading of 15-mA. That will give a current swing of approximately 30-mA, which is within diode D1's specifications. Always try to stay within the current rating of the device you use, and don't try to push the diode beyond its rating unless you want to *smoke* it.

To increase the operational range of the IR transmitter, try experimenting with different lenses to better direct the light toward the receiver. How about adding an IR filter?

A Wireless Telephone Eavesdropper

The IR transmitter circuit in Fig. 3 connects to your telephone circuit, and, at no cost to you, transmits both sides of all telephone conversations to any line-of-sight location within 40 feet. Now that's *something* for *almost nothing*!

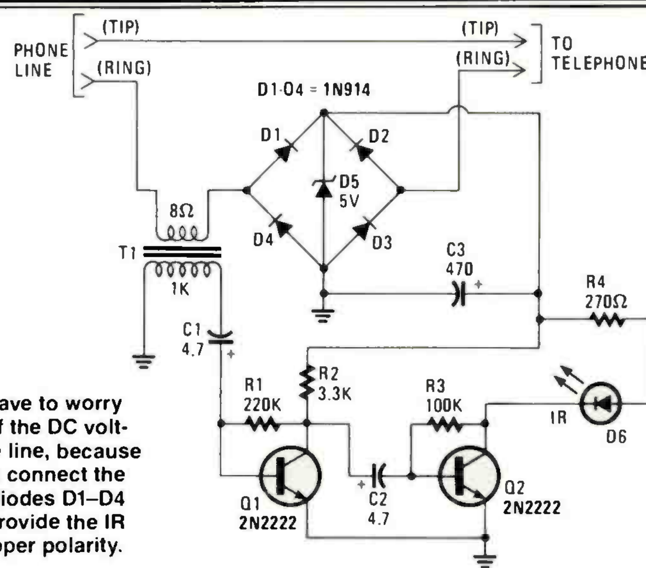


Fig. 3—You don't have to worry about the polarity of the DC voltage on the telephone line, because regardless how you connect the project to the line diodes D1–D4 will automatically provide the IR project with the proper polarity.

To understand just how we got *Ma Bell* to pay the freight, take a close look at Fig 3. In a normal telephone circuit, two wires (tip and ring) carry all of the information and operating voltages from the central telephone office to your phone's location. A DC source of 48 volts is supplied to the tip and ring wires going to your home from the telephone company's central office. The 48-volt source powers all of your phones. No power is taken from the central office as long as all phones remain on-hook; but as soon as a phone goes off-hook, current flows through the phone and back to the central office, thereby keying their equipment.

The phone wires into your home are called tip and ring; their original operator

(Continued on page 102)

PARTS LIST FOR FIGURE 1

SEMICONDUCTORS
Q1—Infrared Photodetector (Radio Shack Cat. 276-142, or equivalent)
Q2, Q3, Q4—2N2222, 2N5249, or equivalent, NPN silicon transistor

CAPACITORS
C1, C2—4.7-µF, 16-WVDC, electrolytic
C3—100-µF, 16-WVDC, electrolytic

RESISTORS
R1—100,000-ohm, ¼-watt, 10%
R2—10,000-ohm, linear-taper potentiometer
R3, R5—220,000-ohm, ¼-watt, 10%
R4—4700-ohm, ¼-watt, 10%
R6—270-ohms, ¼-watt, 10%

ADDITIONAL PARTS AND MATERIALS
T1—Miniature audio transformer; 1000-ohm primary, 8-ohm secondary
J1—Phone jack, open-circuit
B—9-volt transistor-radio battery
S1—SPST toggle or slide switch
Low-Z headphones, small plastic case, battery snap, wire, solder, hardware, etc.

PARTS LIST FOR FIGURE 2

SEMICONDUCTORS
D1—Infrared-emitting diode (Radio Shack Cat. 276-142, or equivalent)
Q1—2N2222, 2N5249, or equivalent, NPN silicon transistor

CAPACITORS
C1—4.7-µF, 16-WVDC, electrolytic
C2—1000-µF, 16-WVDC, electrolytic (see text)

RESISTORS
R1—100,000-ohm, linear-taper potentiometer
R2—330-ohm, ¼-watt, 10%
R3—47-ohm, ¼-watt, 10%

ADDITIONAL PARTS AND MATERIALS
S1—SPST, center-off, toggle switch
B1—9-volt, transistor-radio battery
J1—Normally-open jack to match plug on power-supply cable
Plug-in power pack rated at 9-VDC at 200-mA, plastic case, wire, solder, hardware, etc.

PARTS LIST For FIGURE 3

SEMICONDUCTORS
D1–D4—1N914 silicon signal diode
D5—5-volt Zener diode, 1-watt
D6—Infrared-emitting diode (Radio Shack Cat. 276-142, or equivalent)
Q1, Q2—2N2222, 2N5249, or equivalent, NPN silicon transistor

CAPACITORS
C1, C2—4.7-µF, 16-WVDC electrolytic
C3—470-µF, 16-WVDC electrolytic

RESISTORS
R1—220,000-ohm, ¼-watt, 10%
R2—3300-ohm, ¼-watt, 10%
R3—100,000-ohm, ¼-watt, 10%
R4—270-ohm, ¼-watt, 10%

ADDITIONAL PARTS AND MATERIALS
T1—Miniature audio transformer, 1000-ohm primary, 8-ohm secondary.
Plastic case, wire, solder perfboard, pins, hardware, etc.

Code Practice Oscillator

It's a simple project that can be expanded!

By Robert F. Scott

☐IF YOU'RE AN ASPIRING HAM OR BOY SCOUT WORKING toward an award in radio or signaling, you'll find this code practice oscillator (CPO) a valuable asset in learning Morse code. Practice tapes and records are valuable aids when learning to receive, but you'll need an oscillator (or buzzer) and a key if you want to learn to send code correctly. Well, we'll show you how to build a circuit that will help you do just that—learn to send correctly.

The inexpensive and easy-to-build Code Practice Oscillator circuit can be layed out on a small piece of printed-circuit board or on half of a Global Specialties 300-PC Experimenters board. Everything can be mounted along with the transistor-radio battery and speaker in a small utility box or instrument case.

A Look At the Circuit

Based on the 555 oscillator/timer (U1), the Code Practice Oscillator has a frequency range, as covered by the PITCH control, from around 200 Hz up to about 12 kHz, which is determined by the values of R3, R4, and C2. Component values are not particularly critical. For instance, the value of capacitor C2 can range anywhere between 0.02µF and 1.0µF. Resistor R3 can have any value between 3300 and 15,000 ohms, while potentiometer R4 (PITCH) may be any convenient value provided its color multiplier band is orange. Output tones between 500 and 800 Hz are the most pleasing and the least tiring if you intend to practice for extended periods.

Almost any combination of R3, R4, and C2 values can be used, but the tuning range will vary. Try about 20,000 ohms for R3 and R4, and 0.1 µF for C2 for a narrow tuning range centered around 1 kHz. The speaker, a 2-inch, 8-ohm unit, provides sufficient volume for group practice in a small room. Greater volume can be obtained from a small 50-ohm speaker of the type recommended for intercoms.

For smooth sending, we suggest that you purchase a quality radio-telegraph key that you will be able to use in your amateur-radio station. Select one with adjustable contact spacing, adjustable tension, and ball bearing pivots. A U.S. Army surplus key is excellent, if you can find one. As stated, there's nothing critical about the circuit; it can be built on printed-circuit or experimenters board (as the author did), or if desired perfboard may be used.

Make a photocopy or cut out Table 1 below and paste it along side the telegraph key or some convenient place where you can refer to it as you practice. Also, make a copy that you can keep in your shirt pocket. Whenever you have a spare moment, give that moment to the learning of the Morse code. In no time, you will be an expert working your speed past the amateur radio license requirement—13 words-per-minute. Good luck! ■

TABLE 1
MORSE CODE

A	= .-	S	= ...
B	= -...	T	= -
C	= -.-.	U	= ..-
D	= -..	V	= ...-
E	= .	W	= .--
F	= ..-.	X	= -..-
G	= --.	Y	= -.--
H	=	Z	= --..
I	= ..	1	= .----
J	= .---	2	= ..---
K	= -.-	3	= ...--
L	= .-..	4	= ....-
M	= --	5	= .....
N	= -.	6	= -....
O	= ---	7	= --...
P	= .--.	8	= ---..
Q	= --.-	9	= ----.
R	= .-.	0	= -----

PARTS LISTFOR THE CODE PRACTICE OSCILLATOR

B1—9-volt, transistor-radio battery
C1—10- to 15-µF, 10- to 25-WVDC, electrolytic capacitor
C2—0.02- to 0.15-µF, ceramic disc or paper capacitor
R1—2000-ohm, any taper, miniature potentiometer
R2—10-ohm, ¼-watt, 5% fixed resistor
R3—10,000-ohm, ¼, 5% fixed resistor
R4—50,000-ohm, any taper, miniature potentiometer
U1—555 oscillator/timer, integrated circuit

ADDITIONAL PARTS AND MATERIALS

Telegraph key, printed-circuit materials, perfboard, or experimenters board, IC socket (optional), small 8- to 50-ohm speaker (see text), enclosure, wire, solder, hardware, etc.

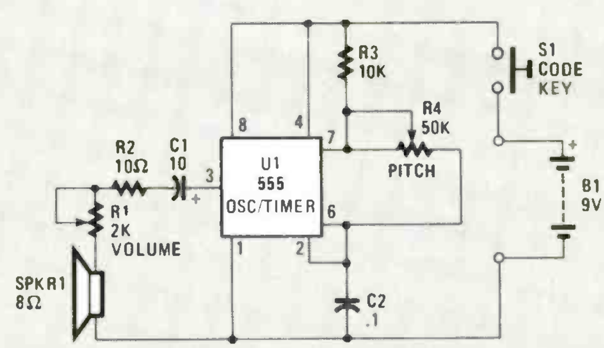


Fig. 1—The Code Practice Oscillator project, based on the 555 integrated oscillator/timer, has PITCH and VOLUME controls that allow you to tailor both tone and loudness to your satisfaction.

WHILE MOST OF US CONSIDER AN ELECTRICAL BLACKOUT or brownout nothing more than a nuisance, some of your appliances don't take it so kindly; particularly, your air conditioner. As most air-conditioner owners have learned, the sudden loss and reappearance of electricity brought about by a brief power outage can do extensive damage to expensive compressor systems. In fact, blackouts and brownouts account for a large percentage of heating and air-conditioning repair problems.

Working Under Pressure

The problem is not in the compressor itself, but with the electric motor that drives the compressor. During normal operation, the electric motor drives a piston that compresses the refrigerant as the first step in the refrigeration cycle. The result is a head pressure that remains high throughout the cycle. If power is lost to the unit, the motor stops and the head pressure begins bleeding off. And that's where the problem lies.

Because of the design of refrigeration systems, the head pressure bleeds off slowly—it takes four minutes or longer for the system to completely equalize itself. If power is applied to the motor before the system is fully equalized, the motor sees a head pressure that represents a sizable starting load—a load that most motors are *unable* to overcome from a dead start. Nevertheless, the motor tries to pull the load, unable to turn over, and within minutes overheats, soon burning itself out.

Brownouts, which also contribute to the problem, normally occur during periods of peak-power usage (like hot summer days) when the power grid can't meet the load demands placed on it. To protect their equipment, utility companies reduce the line voltage—unfortunately, to the detriment of your appliances. While a brownout doesn't normally stall a compressor motor, it does lower the input voltage to the point where the motor must work harder to maintain the same level of head pressure.

Consequently, the motor runs hotter than normal. And while most compressor motors are equipped with thermal shutdown circuits (circuit breakers), the response time of the breaker is often slow enough that the damage is done before the protection device engages. Over a period of time, the heat takes its toll on the motor, and eventually causes it to fail.

Compounding the problem is the fact that the compressor and its drive motor are built as a single, sealed unit that must be replaced as a whole. That means that a perfectly good compressor is tossed out along with the defective motor, leading to an expensive repair bill. Sometimes the circuit breaker becomes defective from excessive arcing and the repair bill for that may be $25 to $50.

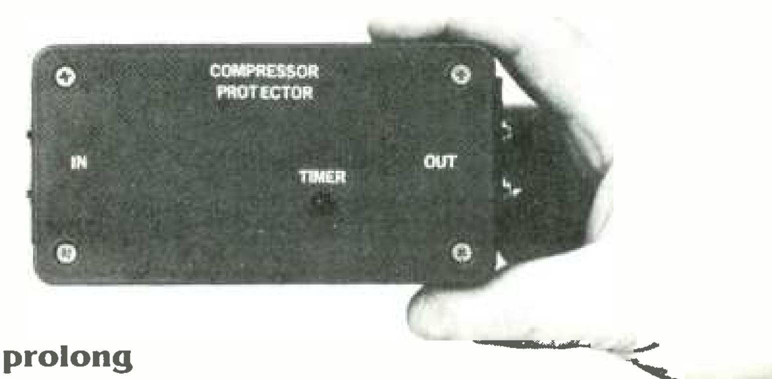
Fortunately, that expensive waste is easily and inexpensively prevented. The solution is to place a timer—the *Compressor Protector*—on the motor so that it is impossible for it to restart before the compressor has had time for the pressure to equalize. Our Compressor Protector accomplishes that by controlling the thermostat relay that drives the motor. The timer circuit is inserted in series with the relay, preventing it from engaging until four minutes have elapsed from the application of power. The controller also incorporates a voltage sensor that resets the timer in the event of a brownout—and holds until the brownout is corrected.

How It Works

At the heart of the timer circuit is, as Fig. 1 shows, a 555 oscillator/timer, U1. That chip is configured as a single-shot, monostable multivibrator (oscillator), which provides a delay period of about five minutes with the component values specified for R4 and C4—more than enough time for the head pressure to equalize itself in the event of a power failure.

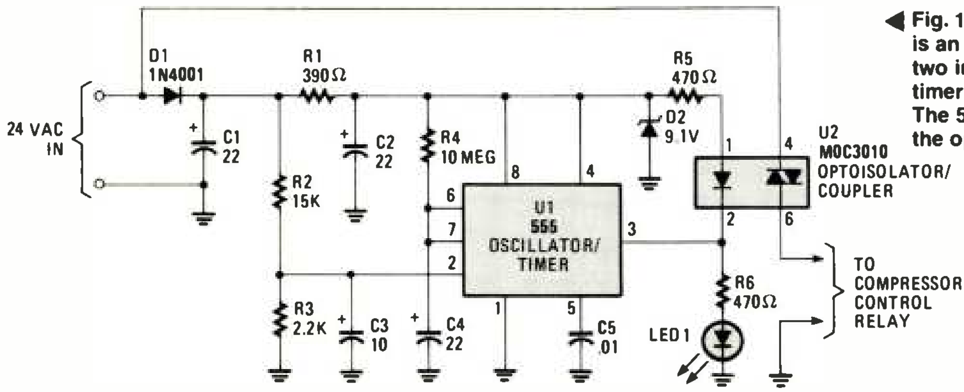
The circuit draws power from the 24-volt control transformer used in most heating/cooling systems. The AC voltage is rectified by D1 and stabilized at 9.1-volts DC by a Zener diode, D2, establishing a reference level for the oscillator. The timer is set when power is first applied to the

COMPRESSOR PROTECTOR



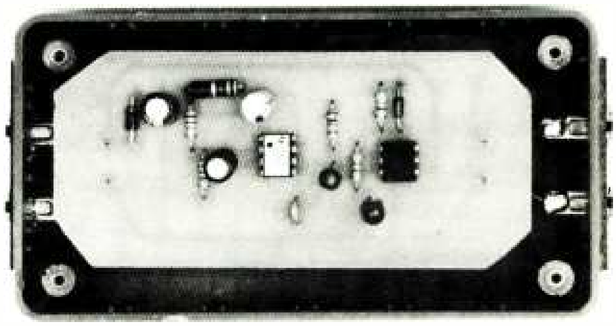
By TJ Byers

Just a little imagination is all it takes to prolong the life of your air-conditioning unit!



◀ **Fig. 1—The diagram reveals that the circuit is an extremely simple one, based entirely on two integrated circuits—a 555 oscillator-timer and a triac output, optoisolator/coupler. The 555 provides the timing function, while the optoisolator/coupler acts as a switch.**

Compare this photo to Fig. 3 and you will gain the confidence you need to assemble the circuit—even novices will find it easy to do! Just be sure that the polarity of the capacitors and diodes are correct and that the integrated circuits are correctly oriented. ▼



circuit. Capacitor C3 provides the trigger pulse necessary to start the timer by holding pin 2 at ground until C3 has had time to charge via R2. During the timing cycle, pin 3 is high, thereby causing LED1 to glow.

At the end of the timing cycle, pin 3 goes low. That extinguishes LED1, and causes the LED housed inside U2 (the MOC3010 triac-output optoisolator/coupler) to illuminate. The optoisolator/coupler is nothing more than a light-sensitive triac mounted next to a light-emitting diode (LED) and sealed in a standard 6-pin DIP (dual in-line package). When the LED is activated, radiation from the LED falls on the light-sensitive area of the triac, causing it to turn on. Notice that the triac has been wired in series with the "hot side" of the 24-volt line.

When pin 3 goes low the U2's internal LED conducts, which causes the triac to become a virtual short circuit, supplying AC power to the compressor relay through the thermostat contacts. The circuit remains in that state until a power outage resets U1 and the cycle begins anew. During the time-out period, LED1 remains lit, and can be used as an indicator for troubleshooting the system. To prevent the relay from engaging during a brownout, a voltage-divider network, consisting of R2 and R3, monitors the line voltage. The output of the divider is fed to pin 2 of U1, which connects internally to the inverting input of a comparator.

As long as the voltage to pin 2 remains above 3.0 volts, the circuit is stable and the triac supplies power to the thermostat controller. But, let the voltage dip just a bit, and things begin to happen. First, the comparator resets the flip-flop inside U1, causing pin 3 to go high and the triac to disengage. Furthermore, it remains in that state until pin 2 again exceeds the threshold input of the comparator. Once normal voltage conditions are re-established, U1 begins its 5-minute timing cycle, after which, the compressor may resume normal operations.

Construction and Installation

The protector circuit was built on a small printed-circuit board, a full-blown template of which is shown in Fig. 2. The template may be "plucked" from the page with a sheet of Lift-it transfer film, and then used to etch your own printed-circuit board. Then, following the parts layout diagram in Fig. 3, place and solder each component into its respective position. Be sure to observe the proper orientation of the capacitors, diodes, and IC's. They can be inserted in more than one direction—but, only one is correct.

Also, notice that C4 is a tantalum capacitor. Tantalum capacitors have very-low leakage currents, such as required in delay-timing circuits. *Do not substitute that part.* The finished board can be mounted inside the air conditioner's relay box where the thermostat connects to the central unit.

Refer to Fig. 4. The easiest way to install the timer is to locate the 24-volt control transformer that powers the motor relay and thermostat. With power removed, break the low-voltage output wires coming from the transformer and insert the timer as indicated.

PARTS LIST FOR THE COMPRESSOR PROTECTOR

SEMICONDUCTORS
D1—1N4001 1A, 50-PIV, rectifier diode
D2—9.1-volt, 400-mA, Zener diode
LED1—Jumbo red light-emitting diode
U1—555 oscillator/timer integrated circuit
U2—MOC3010 triac-output optoisolator/coupler integrated circuit

RESISTORS
(All resistors are ¼-watt, 5%, fixed units unless otherwise noted)
R1—390-ohm, 1-watt
R2—15,000-ohm
R3—2200-ohm
R4—10-Megohm
R5, R6—470-ohm

CAPACITORS
C1, C2—22-µF, 35-WVDC, electrolytic
C3—10-µF, 35-WVDC, tantalum
C4—22-µF, 35-WVDC, tantalum
C5—0.01-µF, ceramic disc

ADDITIONAL PARTS AND MATERIALS
Printed-circuit material, hook-up wire, hardware, solder, double-sided tape, etc.

An etched and drilled circuit board is available from Danocinths, Inc. (P.O. Box 261, Westland, MI 48185) for $12. Ask for part number RW-131. A kit of parts (RW-131K) including board is available for $21.50, and an assembled board (RW-131A) is $31.50; all prices include postage. Michigan residents add 4% state sales tax. Please allow six to eight weeks for delivery.

Fig. 2—This full-blown template of the Compressor Protector's printed-circuit board may be photo lifted from the page and used to etch a direct copy of the project's printed circuit.

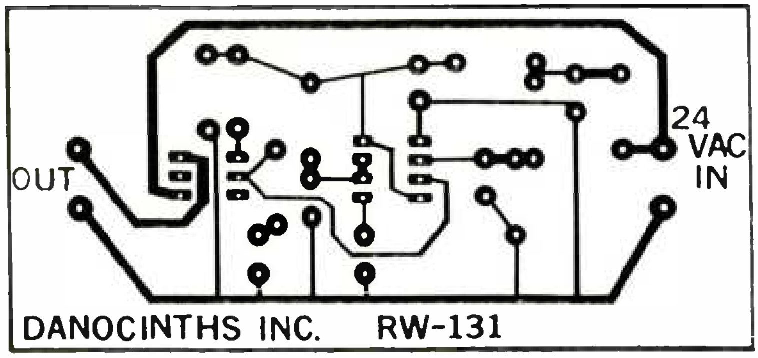
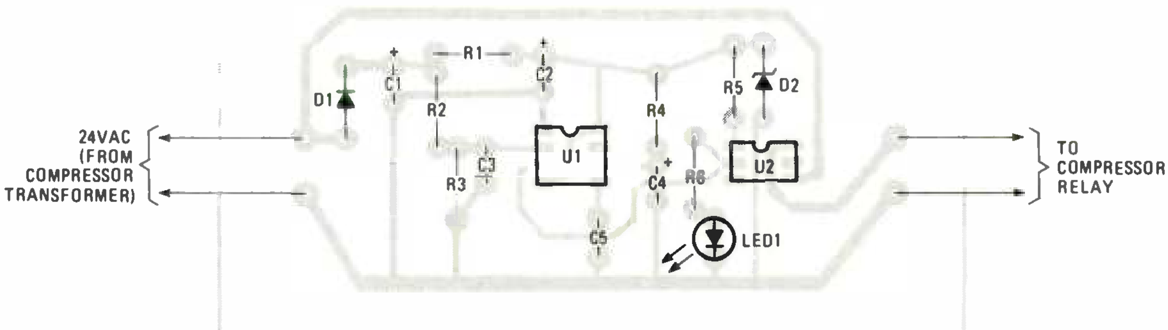


Fig. 3—The Compressor Protector's printed-circuit board layout is a snap. When installing the components on the board, be careful about component orientation—one mispositioned part and zap—it's back to your local electronics supplier.



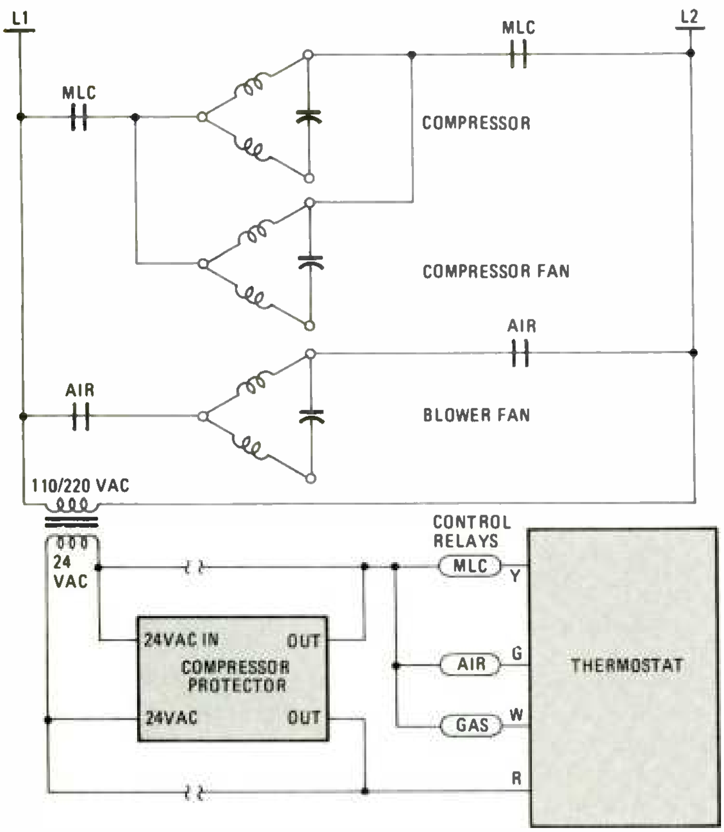
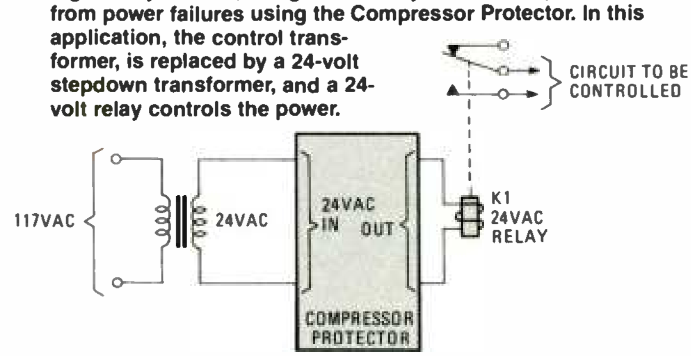


Fig. 4—The installation of the Compressor Protector is a snap if you follow the proper procedure. Break the wires feeding power to the control relays, and insert the circuit.

Next, find a suitable place to mount the circuit board. (I find double-sided foam tape strips ideal for that purpose.) Simply attach a strip or two of double-sided tape to the back of the board and stick it to any smooth, clean surface. Take care that no part of the board touches metal. The Compressor Protector needs no setup and is ready to use the moment you

Fig. 5—If you wish, refrigerators may likewise be protected from power failures using the Compressor Protector. In this application, the control transformer, is replaced by a 24-volt stepdown transformer, and a 24-volt relay controls the power.



apply power. The first time you apply power, it will take about five minutes before the air conditioner becomes operational. After that, it will come on immediately—provided that you haven't lost power to the unit within the last five minutes.

You may now bask in climatic luxury, secure in the knowledge that power fluctuations can no longer damage your cool investment.

Using the Controller with Refrigerators

While home refrigerators and freezers suffer less than air conditioners from power fluctuations, they too can be damaged. If you wish to protect your other compressor-operated appliances, the circuit can be easily modified to accommodate them. First, you must replace the control transformer (as shown in Fig. 5) with a 24-volt power transformer. Any small transformer, such as Radio Shack catalog number 273-1386, will do.

Next, a 24-volt AC relay is connected across the output circuit. If you wish, both the transformer and relay can be salvaged from an old heating or air-conditioning unit. Finally, wire the relay's normally-open (N.O.) contacts in series with the appliance to be protected. A small drop-cord utility box can be used to house the transformer and PC board while providing a controlled outlet for the appliance. ■

FUNCTION GENERATOR

(Continued from page 63)

The output signal desired is selected via S3, before application to the output driver (a common video configuration), composed of Q1, Q2, and Q3. The lowest THD sinewave, typically below .01%, is available at the filter output, J7. The reason for that is any post amplification must add some finite distortion. However, the amplifier circuit shown adds an almost unmeasureable amount of distortion when properly adjusted.

That video-amplifier configuration is used as an output driver, providing voltage amplification almost equal to the ratio of feedback resistance, R40, to signal-source impedance. Thus, the gain of the amplifier is given by:

$$\alpha_E = R_f/Z_S$$

where R_f is the feedback resistance and Z_S is the source impedance, which allow typical maximum gains of under 10 to be achieved. The output impedance of Q2 is be determined by the source impedance it sees and its Beta (β), which is approximated by:

$$Z_{Q2} = Z_S/\beta_{Q3} + 1$$

The output impedance of Q3 is given by:

$$Z_{Q1out} = Z_S/\beta_{Q3} + 1$$

which provides a driver output impedance that's typically under 0.5 ohms, with the final output impedance determined by resistor R41, which, for lab grade instruments, should be 50 ohms.

Construction

The 41-position, 3-gang potentiometer, R2, eliminates the need for three separate units and maintains uniform tracking across the circuits it controls. By cutting the shaft off an *el cheapo* dual, 41-position detented potentiometer and epoxying it to the back side of another dual unit, you can make a four-section device (which brings to mind adding still another filter section). In addition, by ever so slightly offsetting one unit or the other, you can actually get 80 or so detented positions.

But, a simpler solution is to yank what's needed from an existing *clunker* or get one at the local surplus store. Still another solution (allowing you to play with the filter and Function Generator in some pretty wild ways) is to use three of the newer potentiometers with calibrated dials. Bourns and other manufacturers produce a line of calibrated-dial potentiometers with 1% and 2% tolerances. By using three separate potentiometers, you could just dial up like resistances. Also, with R2a–R2c split in that manner, you can put the filter section thru some pretty strange changes.

When it comes to the capacitors, the match between units is more important than their absolute value. They should be temperature stable types—mylar, polystyrene, polycarbonate, styrol, mice, tantalum, etc. You can also use 2% tolerance units here, but a better way to go is select them from your Junk box and use a capacitance meter to get matched pairs.

In any case, the circuit may be wirewrapped, hardwired, or you can design your own printed-circuit board—the choice is yours. It's a good idea to isolate U1 and U2 from the filter and output driver sections. And, since hum and noise pickup could degrade performance by as much as .01% when using the best regulated power-supply, it's a good idea in critical applications to power the circuit from a couple of 9-volt nickel-cadmium (NiCad) or better battery. That virtually assures that you won't pick up the hum and noise components.

PARTS LIST FOR THE FUNCTION GENERATOR

SEMICONDUCTORS
D1–D8—1N914 (or equivalent) general-purpose, small-signal, silicon diode
U1–U7—LM318 op-amp integrated circuit (or TL074, TL084, or equivalent quad op-amp)

RESISTORS
(All resistors ¼-watt, 5% fixed units unless otherwise noted.)
R1, R37—4700-ohm
R2—1000-ohm, 3-gang potentiometer (see text)
R3, R25, R26—100-ohm
R4, R7, R23, R24, R28, R29, R32, R33, R38—1000-ohm
R5, R6, R30, R31, R35—10,000-ohm
R8—5000-ohm, trimmer potentiometer
R9—56,000-ohm
R10, R19—910,000-ohm
R11, R20—150,000-ohm
R12, R21—22,000-ohm
R13, R16—220,000-ohm
R14, R18—68,000-ohm
R15, R17—12,000-ohm
R22, R27—47,000-ohm
R34—10,000-ohm, audio-taper, potentiometer
R36—6800-ohm
R37—4700-ohm
R39—330-ohm
R40—10,000-ohm, trimmer potentiometer
R41—50-ohm

CAPACITORS
C1, C7, C13—10-µF, 25-WVDC, electrolytic
C2, C8, C14—1-µF, 25-WVDC, electrolytic
C3, C9, C15—0.1-µF, ceramic disc
C4, C10, C16—0.01-µF, ceramic disc
C5, C11, C17—1000-pF, ceramic disc
C6, C12, C18—100-pF, ceramic disc
C19—100-µF, 25-WVDC, electrolytic
C20–C32—0.01-µF, ceramic disc

ADDITIONAL PARTS AND MATERIALS
J1–J10—Banana jack, multi-way connector, or equivalent
S1—3-pole, 6-position (3P6T), rotary switch
S2—Single-pole, double-throw (SPDT), toggle switch
S3—Single-pole, 3-throw (SP3T), rotary switch
Printed-circuit materials or breadboard, enclosure, optional 9-volt NiCad battery, hookup wire, solder, hardware, etc.

Finishing Touch

Once the circuit is completely assembled and checked for correctness, the only thing left to do is to adjust R8, DISTORTION ADJUST, for minimum output THD and R40, the FEEDBACK ADJUST, for an acceptable level of feedback in the output driver. The easiest way to make the adjustments is with a THD analyzer. However, if you don't have access to a THD analyzer (which most of us do not), you can use a notch filter, with a scope or AC voltmeter to measure THD out. To do so, turn the GAIN control R34 wide open before adjusting R40, the feedback resistor in the driver circuit. R40 will affect both the gain and the distortion you get. It should be set for a maximum of around 5 volts when powered by a 9-volt NiCad, which is the recommended way to go. The voltage adjustment may be made rather simply with a squarewave output. ■

FRIEDMAN ON COMPUTERS

(Continued from page 18)

At the receiving equipment, either the TTY or complex electronic circuits kept track of parity, alerting the receiving station as to what characters might be incorrect. It was hoped that if interference garbled a character, it would change the bit pattern and upset the parity. However, in modern computerized modem communications we rarely have use for, or need of the parity bit. In fact, until recently, it simply went along for a free ride; generally serving no useful purpose.

Because 7 bits limits modem communications to the conventional ASCII character set, there had to be some way to accommodate the ASCII codes above 127 if we were to exchange graphic characters and symbols. The only way that can be done easily is to use an 8 bit character code, which means eliminating the parity check and using the eighth bit for the character code. That's exactly what is done. Theoretically, or at least on paper, 8 bits is the way to go for modern modem communications. But now there is equipment out in the real world that, depending on the particular kind of data being exchanged, uses either 7 or 8 bit characters.

It's difficult to reconcile both 7- and 8-bit character codes because, as a general rule, both the sending and receiving computers must use the same data format. Sometimes a computer set for 8 bits can receive a 7-bit character, but not vice versa. So communications software allows the user to select the number of character bits (usually 7 or 8), the number of stop bits (usually 1), and parity. If the character code takes 8 bits, no parity is used. But if only 7 bits make up the character code, heaven help the user because many of the programmers who wrote communications software didn't know what to do with the parity bit—their area of expertise was computers, not communications.

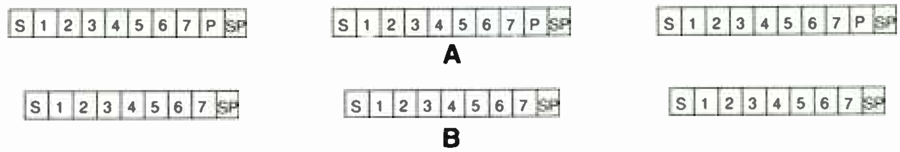


Fig. 2—The parity problem is illustrated by this simple diagram; Figure 2A shows the bit pattern for three 7-bit characters having a parity bit: with the start and stop bit, the transmission is 10-bits long. Figure 2B shows the same three characters with a missing parity bit, which reduces the number of bit to nine. You can easily see why the computer has no idea of what's happening when the second character (bit stream) is received. To avoid the problem, the received signal's parity bit must always be accounted for.

The best of "modem software" allows the user to select *odd*, *even*, or *ignore* parity. Ignore parity usually eliminates all problems when receiving by accounting for the parity bit without being limited to a choice of odd or even. Other software allows odd, even, or *no parity*—and it's no parity that's the problem. If you select no parity, it generally means that the eighth character bit isn't used at all.

At 300 baud (and higher) using one stop bit, the complete character now has only 9 bits, instead of 10. If that is what you're sending, the receiving computer might "read" the stop bit as the eighth character bit—it doesn't "read" a stop bit—and thus, has no idea what's happening when the next start bit comes along. The receiving computer accepts the first high bit of the following character as a stop bit, it gets hopelessly confused by the second character, and starts to display random characters on the screen.

A Missing Bit

The problem is illustrated in Fig. 2. In Fig. 2A, the bit pattern shown is for three 7-bit plus parity characters. Figure 2B shows the same three characters with a missing parity bit. You can easily see why the computer has no idea of what's happening when the second character in Figure 2B is received.

To avoid the problem illustrated by Fig. 2B, it is necessary to always account for the parity bit. It must be *even*, *odd*, or *ignore*, but cannot be *no parity* unless all computers in the circuit are similarly set for the same condition, and that is rare.

If your software doesn't give you the option of ignore parity—which is what you really want—then the best thing is to use even parity because almost all modem software is set that way when only 7 bits are used for the character, even if the same computer is set to ignore parity when receiving.

But keep in mind that regardless of how you might arrange the parity in your own communications network, most personal computers working through modems at 300 baud and higher look for a total of 10 bits; either 7 character bits plus parity, or 8 bits without parity. And all bits must be accounted for. ■

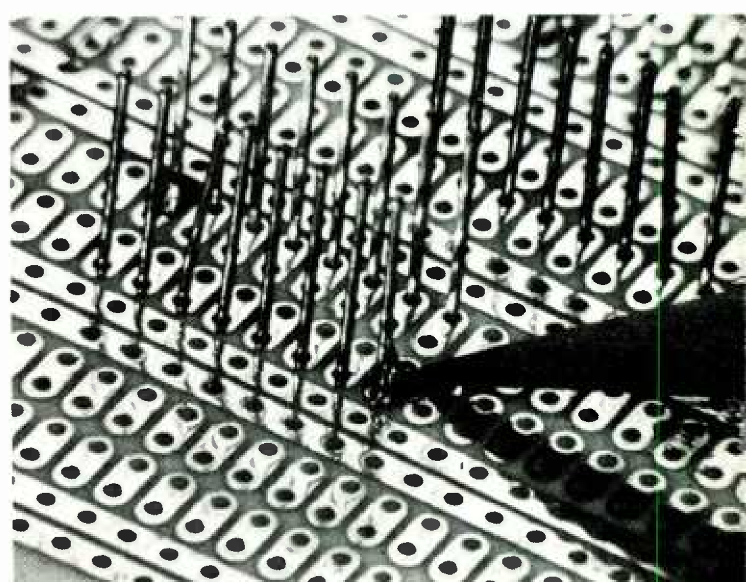
WIREWRAP YOUR PROJECTS

(Continued from page 77)

100 milliamperes is a nice safe value. Anything measured in amperes vaporizes the wire like a blast from Captain Kirk's "Phazor." If you're into precise values, #30 wire has a resistance of about 0.1-ohm per foot. Available in several insulation colors, the wire comes on single reels with or without a special plastic holder that includes a cut-off knife and an insulation stripper (see photos); in a larger version of the plastic holder having three spools of wire, each with a different insulation color, and in an assortment of various precut/pre-stripped lengths.

There's a similarly broad assortment of wirewrap sockets and terminals. Every size IC is available with long wirewrap leads. Sockets are also available with long pass-thru terminals that allow connections to be made on both sides of the wiring board, and there are individual board terminals that

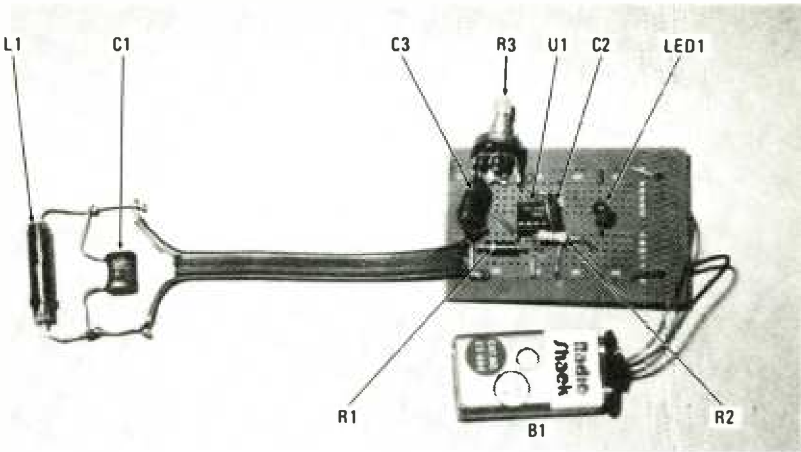
(Continued on page 95)



The easiest way to install wirewrap sockets is to tack-solder diagonal terminals to a printed foil.

STUD FINDER

(Continued from page 51)



The Stud Finder was laid out on a solderless breadboard, tested, and then copied onto an identical pre-drilled, printed-circuit board—the boards designed to compliment each other. Several breadboarding types are available in the market; each very much like the other. The layout is the photo parallels that in Fig. 2 below. You may want to cement the assembly to a clear plastic strip, making it sturdier.

coping saw or with a hacksaw with a 32-tooth-per-inch blade. Also, you can snap the board cleanly into two pieces if you score both sides heavily along the "break line" with a utility knife.

The RF choke specified for L1 is easy to obtain, and its Q is right for the job. The application note on the CS209 (U1) specifies a 20,000-ohm multi-turn potentiometer such as the Bourns 3006P-1-203. However, an engineer at Cherry says that a value around 6000 ohms is preferable. A low-cost multi-turn potentiometer was not immediately available, so a miniature 10,000-ohm unit was substituted. It works quite well, but I'm sure that a multi-turn unit would make it a lot easier to adjust the Stud Finder for maximum sensitivity. ■

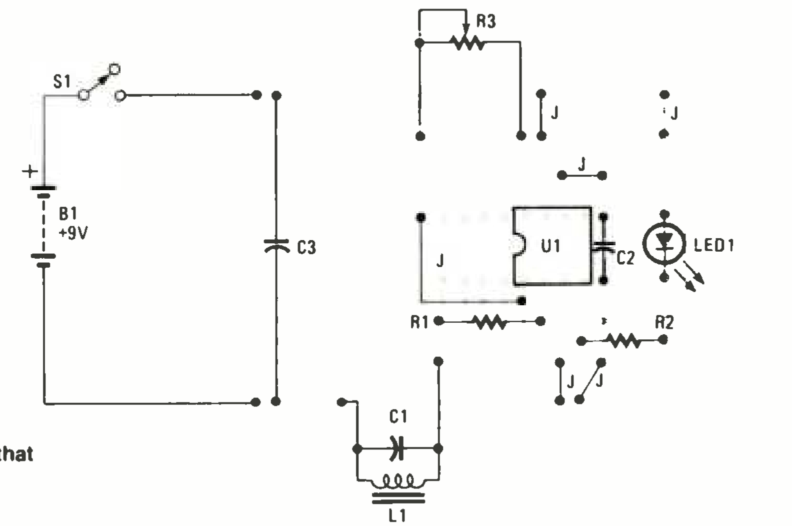


Fig. 2—The component count of the circuit is so low that it can be layed out on half (if not less) of a Global Specialties Type 300 Experimenters Board.

VIDEO SWITCHER

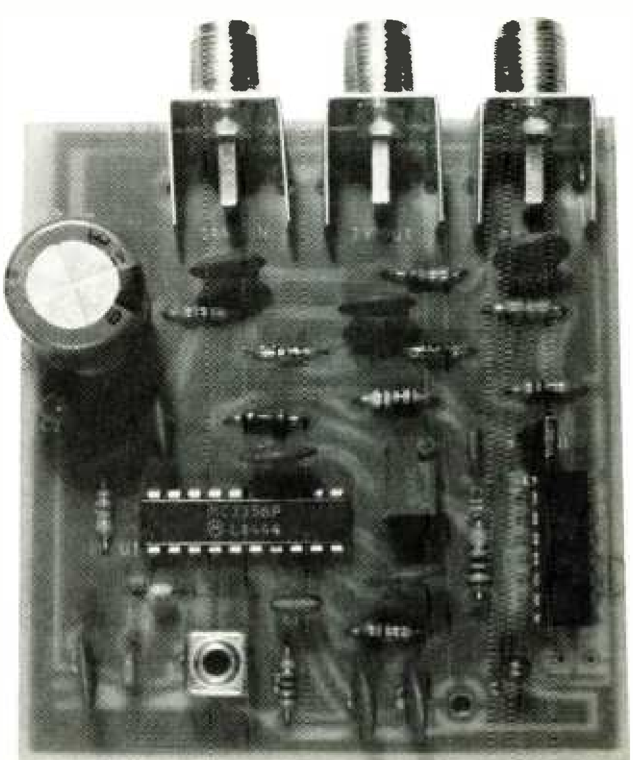
(Continued from page 80)

the voltage at U1, pin 15. If it's high, check R7, R8, C11, and Q1. Also check both inverters, U2-e and U2-f. If U1, pin 15 is low, make sure that your device is plugged in and check all your cabling, then try the calibration procedure again. If you have an oscilloscope, check for oscillations at U1, pin 2 of 71.95 MHz, but be aware that your scope probe may cause a shift in the oscillating frequency. If the circuit is oscillating at the correct frequency, place the scope probe on U1, pin 20 and check for the RF signal. If the RF signal is there, then check X1, R2, R3, C6, C7, and C8.

If you don't have an oscilloscope and U1, pin 15 will not go high, try adding or deleting a turn from the inductor, L1; the inductance varies depending on the tightness of the turns and the exact type of wire used.

Conclusion

With the ability to generate a logic level when an RF carrier is present, many other applications are possible. For instance, a multiple input-switching arrangement that's set up as a priority system, where each input is assigned a priority and would override any inputs below it. Or, possibly a system that would connect the last device that was turned on. ■



In the author's prototype, bracketed, printed-circuit-mounted, F-type connectors are used to connect the Video Switch to cables from your video-system components.

ELECTRONIC PEDOMETER

(Continued from page 28)

U1. Once all the components have been installed, all jumper connections made, and your work checked for accuracy, the boards can be housed in any suitable container. The author chose a Radio Shack experimenters cabinet (catalog No. 270-230).

Check-out and Calibration

Attach the unit to your belt, turn it on and walk. The unit should begin registering after a few paces. Now walk a known distance. To be exact, the known distance should be 52.8-feet. Check your counter reading. If the displayed value is too low, turn R1 about a 1/3 of a turn counterclockwise. If too high, go 1/3 of a turn clockwise. Repeat that bracketing procedure, limiting the rotation of R1 to 1/6 of a turn on each subsequent adjustment. If you still have problems obtaining accurate readings then you may have to try a substitute value for C1. The exact value will depend on the nature of the reading error.

Troubleshooting

If the finished product fails to function at turn on, don't panic. Go over all the visible areas, checking for cold solder joints, solder bridges, parts mounted backwards. Next, try applying a 5-volt pulse to the counter/display driver (U2) input at pin 8. The display should advance one count for each pulse. If not, check the continuity of the various traces that connect U2 to the display modules.

If the counter is working (incrementing in a predictable manner), then proceed to the stride adjustment circuit. With power applied, activate the unit by tilting the it back and forth. Note what happens on the output of U1 at pin 3. If there's no output, make sure that +5-volts is present at pin 4 of U1. If so, you've probably got a bad chip. ■

The proof is in the walking. Attach the Pedometer to a hip and take off. After a measured course has been run you may need to return to some fine adjustment. Also, be sure that the mercury switch flips and flops on each step or stride. If not, it too may need some adjustment.

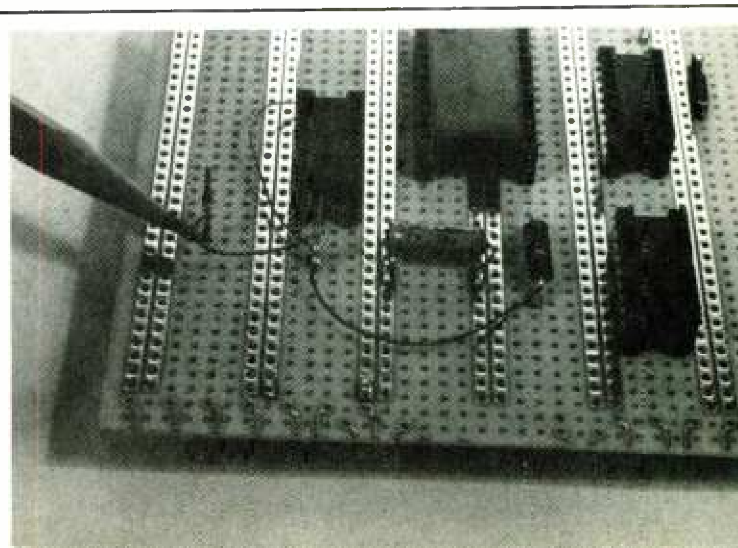
WIREWRAP YOUR PROJECTS

(Continued from page 93)

have small "indents" or U's (see photos) on one end to which resistors, capacitors, and heavy wires can be soldered.

Wirewrap projects can be assembled either on plain perfboard, or on a special wirewrap perforated "hobby board," of the type shown, with printed-circuit foils on both sides that

(Continued on page 96)



Nothing stops you from using any kind of component mounting. Here, a small electrolytic capacitor is soldered directly across two foil strips being used for the power supply bus, a resistor passes through the board to foils on the opposite side, while two pass-thru terminals shorted by a wire-loop allow the builder to easily break into the circuit to modify connections, measure current, change the resistances, etc.

span 0.1-inch center-spaced hole patterns. The foils provide bus connections and solder pads for socket leads and terminals, and also allow small components (such as resistors, capacitors, etc.) to be soldered directly to the foils if necessary. The usual way to secure a socket is to tack solder two diagonal leads to the foil pads on the board. Alternately, the socket can be cemented to the board in the same way it is done for conventional insulated perfboard.

The product to use for gluing sockets to the board is an adhesive called *Barge*, which is available from many shoe repair stores. Barge (see photos) is what a cobbler uses to glue the soles and heels on shoes; if it can hold soles and heels when you walk and run, it can certainly secure a socket. You must avoid getting Barge on socket terminals because it will function as an insulator. Your best bet is to place a small drop of Barge on a toothpick and then apply the adhesive in the center of the socket where it will "squish" and spread when you press the socket to the board. ■

EASY-TO-BUILD ELECTRONIC THERMOMETER

HERE IS AN INEXPENSIVE ELECTRONIC thermometer than can be built in just one evening. It is capable of measuring temperatures over a range of from −30°F to +120°F.

The circuit is shown in Fig. 1; its operation is fairly straightforward. A diode-connected 2N3904 transistor forms a voltage divider with R1. The transistor is used as the temperature sensor and, for best results, should be connected to the rest of the circuit using twisted wire as shown. As temperature increases, the voltage drop across the transistor changes by approximately −1.166 millivolts-per-°F. As a result, the current at pin 3 of IC1, a 741 op-amp with a gain of 5, decreases as the temperature measured by the sensor increases.

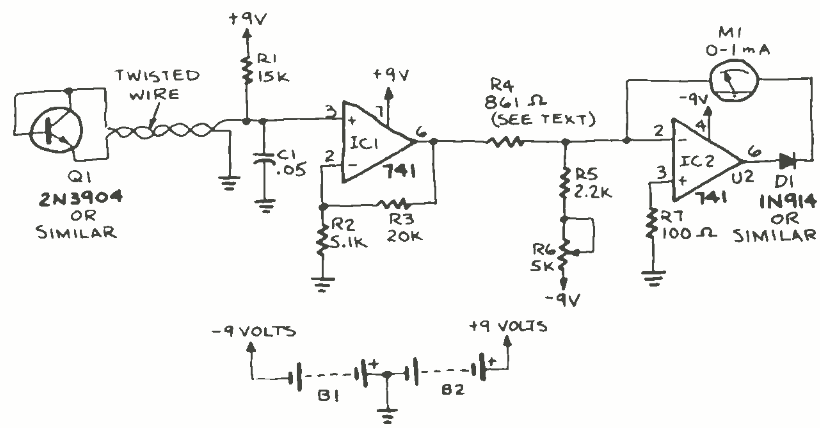


Fig. 1—This one-evening project can be assembled on a solderless circuit board at first.

A second 741 op-amp, IC2, is configured as an inverting amplifier. Since pin 3 of that IC is grounded, pin 2 is at a virtual ground and the sum of all currents into that pin must be zero. Resistors R5 and R6 are used to calibrate the circuit. Once R6 is adjusted (more on that later), the current flow through those resistors will be constant. At a temperature of about −30°F, the current through R4 (that resistor is formed by connecting a 910- and a 1600-ohm resistor in parallel) should equal the current through R5 and R6.

At higher temperatures, the current through R4 will be less than the current through R5 and R6. Since the sum of the currents at pin 2 of IC2 should be zero, current will be drawn from the output (pin 6) of that IC to offset the difference. That current must pass through M1, and the amount of current drawn is, of course, measured by the meter. As the relationship between the amount of current drawn and the measured temperature is linear, it is relatively easy to calibrate the meter to indicate measured temperature.

If the temperature goes below −30°F a reverse current will be generated. As that reverse current is undesirable, its flow is prevented by inserting D1 into the circuit as shown.

Calibration is also straightforward. When properly done, a temperature of −30°F will result in a meter reading of 0 milliamps, while a temperature of 120°F will result in a meter reading of 1 milliamp. Divide the scale between those points into equal segments and mark the divisions with the appropriate corresponding temperatures. Note that dividing the scale into more parts will result in greater accuracy; if you divide it into 150 equal segments, for instance, each division will equal one degree. The calibration is completed by placing the sensor in an environment with a known temperature, such as an ice-point bath. The ice point of water is approximately 32°F. That is the temperature at which water and ice can co-exist in the same container. To prepare the bath, place water and ice in a large glass beaker or similar container, wait a few minutes for the temperature of the bath to stablize, and verify that the temperature is indeed 32°F using another thermometer that is known to be accurate. Then, simply place the sensor in the bath and adjust R6 until you get the correct meter reading. ■

DOLBY NR SYSTEM

(Continued from page 66)

They all "work," in the sense that they will all record and play back but their ultimate performance in any given deck will depend on how compatible they happen to be.

Optimum bias for a tape is normally considered to be slightly above the level which produces maxiimum sensitivity and minimum distortion at 333 Hz. This same level offers an acceptable compromise between falling noise and rising distortion, without excessive loss of high-frequency response.

Fairly obviously, bias in excess of the optimum will reduce the effective sensitivity and output of the tape (to the detriment of Dolby tracking), while at the same time, causing a disproportionate loss of treble response.

Over and above metering problems and differences in the sensitivity of cassette tapes, non-optimum bias may have to take a significant share of the blame for imperfect Dolby tracking and poor treble response.

And how do you end up with non-optimum (particularly too-high) bias? Easily and without knowing it: By using types or brands of cassette tape requiring less bias than what your deck has been set up to provide in the respective categories (Fe, Cr, Metal, etc). Much the same remark applies to Dolby mistracking: You can run into that problem by using cassettes having a different sensitivity from that for which the Dolby circuits were adjusted.

Unfortunately, it is easier to spell out the warning than to

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DIGITAL FUNDAMENTALS

(Continued from page 75)

8. An area of RAM used to temporarily store data is called the ________. The register that contains the address of this area is called the ________ ________.
9. The address of the operand to be used in a computation is usually contained within the ________.
10. A microcomputer that replaces conventional logic circuits in performing a specific function is often called a ________ ________.
11. Communications with the world external to a microcomputer takes place via the ________ section.

ANSWERS

1. central processing unit
2. a. memory
   b. control
   c. arithmetic-logic
   d. I/O
3. control, arithmetic-logic
4. data, instructions
5. instructions
6. accumulator
7. program counter
8. stack, stack pointer
9. instruction
10. dedicated controller
11. I/O

NEW PRODUCT SHOWCASE

(Continued from page 13)

trol and thumbwheel channel selector switches with +5-kHz switch. The operating frequency range is 144-MHz to 145.995-MHz and sensitivity is 0.25μV. The mobile console unit, HWA-6502-2, houses the transceiver and is able to provide 25-watt mobile operation with the optional 25-watt 2-meter amplifier.

CIRCLE 15 ON FREE INFORMATION CARD

There are over 400 electronic products offered in the new Heathkit Catalog. To receive this colorful catalog free of charge, write to Heath Company, Dept. 150-735, Benton Harbor, MI 49022. In Canada, write Heath Company, 1020 Islington Avenue, Dept. 3100, Toronto, Ontario, Canada M8Z 5Z3.

Soundfield Speaker System

A new generation of dbx's Soundfield One loudspeaker system —the Model 1A—is available. The Controller for the new model can now be used with other speaker brands; therefore, a second pair of speakers in the listening room, or extension speakers in other locations, can be operated through the Sound field Model 1A Controller.

At the touch of a button on the unit, the Controller provides unusual tone-shaping controls and filters and a "Rumble Suppress" function for all speakers connected to it. The Soundfield 1A speaker system incorporates the same technology and achieves the same Soundfield Imaging properties as the earlier Model One.

Soundfield Imaging, a dbx-developed technology, provides a significant improvement in the spatial perspective of music reproduction in the home. The system, which can reproduce the full dynamic range of digital Compact Discs, creates a sonic image with a realistic breadth and depth of field that is identical for virtually any listening position.

With a three-dimensional sound field and musically accurate tonal balance that remains stable throughout an extremely broad listening area, a listener need not sit midway between two speakers to experience proper tonal balance and satisfactory stereo imaging.

(Continued on page 102)

3-CHANNEL APPLIANCE CONTROLLER

(Continued from page 84)

six-volt lantern battery, which will be used to temporarily supply power to the inverting buffers and optoisolator/couplers.

Plug a small table lamp into outlet A of the Controller. Turn the lamp switch on. The lamp will remain off since the Controller is not yet plugged into the wall outlet. Plug the Controller's line cord into an AC wall-outlet and turn on the Controller's switch S1. The neon lamp should come on but the table lamp should remain off. With the six-volt battery connected, touch the end of the wire from the control pin of the optocoupler to the ground or negative side of the battery. The table lamp should immediately come on, and the brightness of the lamp should be the same as if it were plugged directly into the wall outlet. If not, recheck the wiring.

Repeat the above steps for all channels. The results should be the same. If the Controller passes the electrical check, you can now program the computer to take control.

Programming The Controller

The complete program for the Three-Channel Appliance Controller is shown in Table 1. The program allows you to tell the Controller when each channel is to be activated or deactivated, and to specify the day, hour, minute, and second that activation is to occur. The Controller can also be programmed in advance. (However, I personally don't like to leave my Commodore running on its own for more than 10 or 12 hours.)

Each channel is activated by entering a "1" when the program requests activation instructions on the channel. Entering zero here allows the program to disregard the channels that are not to be programmed. The channel can be set to activate at the precise second. You can tell the Controller how long each channel is to remain on or off. The functions can be obtained by the simple answers given to the list of prompt questions at the start of the program. With a few additional lines of program, the Controller could be made to cycle an appliance for a specified period, flash strobe lights, and operate display lighting in most any manner desired.

When the time of day is requested, you must enter the time in 24-hour or military time notation, which is in *hundred hours* starting at midnight and beginning with 0000. That is, 9 A.M. would be entered as 0900 (zero nine-hundred hours); 12 o'clock (noon), 1200 hours; and 2 o'clock would be 1400 hours (see how it works?). Any number after 1200 would be afternoon until midnight. If the minutes are included as they would be in 1:30 P.M., 1330 hours would be entered. However, the clock also wants to know the seconds. You must also enter two more digits for a total of six. If you wanted the Controller's channel A to activate at exactly 1:30 P.M., then you would enter 133000 in response to the request for the time. The last two digits (00) represent seconds. Unless the full six digits are input, an error message will appear and the program will have to be restarted.

If activation is to be after midnight or any day during the next week, the program requests that you tell it the number of days it must wait before activation. Therefore, if it was Friday afternoon, and you wanted to turn on the table lamp on Saturday morning, you would enter a "1" when asked how many days it must wait. Since Friday is not yet past, Friday is counted as one whole day and Saturday is not counted. If a "2" were entered, activation would not occur until Sunday morning. The days are reduced for each channel in line 320 of the program. Avoid activation at 23:59.59 hours, since the program reads that time only for the days decrement.

Most of the program length is the text that generates the required prompts. Many of the remaining program lines are checks to determine the time of day and compares that information to the various times that have been set up. The program continually compares the data until an activation time is reached.

Lines 115 and 480 are the part of the program that sets the bits of the port to output. Line 410 sends a "1" to channel A for activation. Line 420 and 430 activate channels B and C. The RETURN in lines 410 through 470 simply returns the program from the activation subroutine back to the part of the program that continually checks for activation/deactivation times. The port bit is deactivated by placing an "0" into that bit of the port. The PRINT commands in lines 140, 640, 720 and 760 are screen commands. If the program line indicates "CURS DWN 3," the down arrow is pressed three times when entering those lines. The CLEAR HOME key is pressed in the PRINT command of line 640.

Each of the three channels can be programmed separately. Their operation will be independent of each other. Once all of the channels have been selected, a list of the channels and their activation times are printed on the screen for a final check. If there is an error, you may restart the program by pressing BREAK. The program is not *goof proof* so check your times and sequences closely before starting the program. Once all of the times and channels are correct, enter "S" for START.

The monitor or television should be turned off when the Controller is left unattended. The program continues to operate without the use of the screen. You may turn the monitor back on at any time to view the list of times and the present status of the various channels. Press "R" to bring up a new status report. The report shows a "1" in the A column to indicate that that channel has been selected. An "0" indication means that the channel is not selected for the run. The STOP column indicates the status of the channel. An "0" here indicates off and a "1" indicates that the channel is presently on. A status of "3" means that the channel has completed its cycle and is now inactive.

Do not operate too many heavy current appliances at once, and make sure that the outlet you operate the Controller from does not have several other home appliances already operating from it. I've operated a radio, lamp, and coffee pot all at once with no problem. Too many high wattage devices (like a toaster) may cause a blown fuse since all of the devices are on one circuit. The project is a simple one, but should be treated with some respect (and only put together by those who with some experience wiring high-voltage projects). For those beginners who feel uncomfortable with their wiring skills, most neighborhoods have those electronic wizards who'd jump at the chance to help if asked.

If you can't locate one of these wizards on your own, check with the electronics shop teacher at your local high school. He probably has a list of qualified students looking for some extra after-school work. And let us not forget Murphy's Law: Anything that can go wrong, will. In other words, don't trust the Controller completely—I still set the old alarm clock as a back-up. As an example of the *best laid plans of mice and men going astray*, I came home from work one afternoon to find a blaring radio, a pot of dried coffee, and my landlady all waiting patiently. And needless to say, she was not happy. ■

CIRCUIT CIRCUS

(Continued from page 87)

plug connections.

We tap into the telephone line by connecting our IR transmitter circuit in series with either the tip or ring. When the telephone is off-hook current will flow through the diode bridge polarity protector and supply the power for the IR transmitter. The phone's audio information is taken off the line by transformer T1. The 1000-ohm winding of the transformer connects to a two-stage transistor audio amplifier/modulator. The circuit shown worked just fine at our location, but a 2000-ohm potentiometer could be added to the input of the two-stage amplifier to control the modulation level; and another potentiometer could be added in place of R3 to adjust the IR's idle current.

To increase the operational range of the IR transmitter, try experimenting with different lenses to better direct the light toward the receiver. How about adding an IR filter?

Earlier I invited you to write offering suggestions, asking for help, and (most important) offering unusual circuits that you had assembled and tested to this column—*Circuit Circus*. Please address all correspondence to: Charles D. Rakes, Circuit Circus, HANDS-ON ELECTRONICS, 500-B Bi-County Boulevard, Farmingdale, New York 11735. In almost all cases your mail can not be answered personnaly, because the volume of it arriving at this office makes that task impossible. However, I do survey all the mail and in one way or another most of it will be answered in future columns. Let's hear from you! ■

NEW PRODUCT SHOWCASE

(Continued from page 99)

Model 1A adds to this basic technology by making the eight woofers more rugged and enhancing the features of the Controller. The Controller provides overall system equalization by dealing with room acoustics problems and compensating for various sonic deficiencies of recordings. It is an outboard line-level analog signal processor that connects to the tape monitor, EPL (external processor loop), or preamplifier output jacks of a stereo system. It incorporates high and low frequency compensation, ambience control, tape monitor and bypass controls. In addition, the Controller now features a wall equalization switch to compensate for the effect that against-the-wall placement has on loudspeakers.

CIRCLE 24 ON FREE INFORMATION CARD

The Model 1A speaker system offers a flat, smooth power response, 20-Hz–20-kHz ±3dB.

Each 16-W × 16-D × 42-in. H Model 1A speaker incorporates 14 drivers: four 10-in. cone woofers and four 4-in. cone mid-range, with two of each placed on each side, and six ½-inch dome tweeters positioned around the upper portion of each columnar-shaped enclosure.

Suggested retail price for the dbx Model 1A Soundfield Speaker system is $2950. For more information write to dbx, P.O. Box 100C, Newton, MA 02195.

DOLBY NR SYSTEM

(Continued from page 96)

new releases which the user may find attractive.

Again, some decks have in-built facilities for optimizing the bias level and even aligning the Dolby system on test tone—which is fine for those who can afford them.

For the rest of us, the most obvious recourse is to recognize the fact that the tape in audio cassettes does vary considerably in technical specifications, despite the continuing efforts of tape manufacturers to achieve greater uniformity in the various categories.

An Interesting Note

Here is a statement copied from a 1985-1986 cassette deck user manual:

"The FL (Fluorescent Level) meter lighting position may differ during recording and playback. This is caused by a difference in the tape's sensitivity and a slight deviation will have no adverse effects."

Now the question that remains is: How large is a –slight deviation?

They all "work", in the sense that they will all record and play back but their ultimate performance in any given deck will depend on how compatible they happen to be.

If the aim is to produce consistent, top-quality recordings, it seems to me that it is going about it the hard way to attempt to do so using a variety of cassettes, even if they are good, reliable brands. The chances are that some of those cassettes will not be wholly compatible with any one deck. The concept stated earlier of having an extra level control (or using the preset that may be there already) is acceptable as it goes, but it wouldn't solve the problem of non-optimum bias.

Surely, the logical recourse is to try a few likely cassettes in the deck, as is, in an effort to locate one that does appear to track, in Dolby terms, does retain normal high-frequency response and does perform satisfactorily in other respects. Then use that brand and type until further notice! ■

AUTO IGNITION SYSTEMS

(Continued from page 32)

way speeds when the car reached operating temperature. As you might expect, that threw a lot of *crud* (*pollution* in polite society) into the atmosphere.

In order to reduce pollution, the compromises had to be eliminated and the engine operated under the most favorable parameters at all times. The only device capable of keeping track of several functions at once, and instantly tweak individual parameters to optimize performance, is the computer (actually, a microprocessor formulated solely for a particular engine's performance). As shown in Fig. 6 (the sensor/control system of one of an early computerized Ford engine) the computer receives its data from sensors installed at critical locations, measuring such things as engine and coolant temperatures, EGR valve positioning, crankshaft position, vacuum, and throttle position.

Modern computers also measure air/fuel ratio and exhaust-gas temperature, among other things. The computer itself is pre-programmed with the optimum parameters for all engine conditions, allowing the computer to control both the ignition system and the air-fuel mixture in accordance with the preset parameters. For example, when the engine is started, the computer adjusts the air-fuel mixture and the ignition timing to correspond to the measured engine and carburetor inlet air temperature. When the throttle is opened to accelerate, the computer compensates for the increased downdraft.

Summing Up

Regardless of how the ignition in your car is handled, when you come right down to the nitty-gritty, the primary purpose of all ignition systems is to fire the spark near TDC for each piston; efficiency really doesn't count for much if the car won't move. Even if you won't, or can't, make your own emergency repairs, it's wise to know how your particular car works so that you can, at the very least, understand what the mechanic is talking about! ■

HANDS-ON MARKETPLACE

FOR SALE

ELECTROLYTIC capacitors 10,000µF 70WVDC computer-grade, individually tested. Great for amps, power supplies. $3.50 each, $12/4. Add $1.00 postage per order. **C.L. MARCH**, 3010 Briarwood, Hornlake, MS 38637.

LASERS: surplus parts and units. Power supplies for your laser! Free catalog. **MEREDITH INSTRUMENTS**, P.O. Box 1724, Glendale, AZ 85311.

WORLD'S best channel 3 notch filter. $39.95, (dealer inquiries invited). **CROSLEY (F)**, Box 840, Champlain, NY 12919.

FREE transistors. Sample of **PN2222** and **2N3904** with our **Catalog** of **Budget Priced Electronic Components** for hobbyists and industry. Send $2.00 P&H (refundable) **BUDGET ELECTRONICS**, Dept-H, Box 1477, Moreno Valley, CA 92388 (714) 653-1663.

CLASSIFIED AD ORDER FORM

To run your own classified ad, put one word on each of the lines below and send this form along with your check to:

Hands-on-Electronics Classified Ads, 500-B Bi-County Boulevard, Farmingdale, N.Y. 11735

PLEASE INDICATE in which category of classified advertising you wish your ad to appear. For special headings, there is a surcharge of **$10.00.**

( ) Plans/Kits ( ) Business Opportunities ( ) For Sale
( ) Education/Instruction ( ) Wanted ( ) Satellite Television
( ) ________________

Special Category: $10.00

PLEASE PRINT EACH WORD SEPARATELY, IN BLOCK LETTERS.
(No refunds or credits for typesetting errors can be made unless you clearly print or type your copy.) Rates indicated are for standard style classified ads only. See below for additional charges for special ads. **Minimum: 15 words.**

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15 ($18.75)
16 ($20.00)	17 ($21.25)	18 ($22.50)	19 ($23.75)	20 ($25.00)
21 ($26.25)	22 ($27.50)	23 ($28.75)	24 ($30.00)	25 ($31.25)
26 ($32.50)	27 ($33.75)	28 ($35.00)	29 ($36.25)	30 ($37.50)
31 ($38.75)	32 ($44.00)	33 ($41.25)	34 ($42.50)	35 ($43.75)

We accept MasterCard and Visa for payment of orders. If you wish to use your credit card to pay for your ad fill in the following additional information (Sorry, no telephone orders can be accepted.):

Card Number ________________ Expiration Date ________

PRINT NAME ________________ / SIGNATURE ________________

IF YOU USE A BOX NUMBER YOU MUST INCLUDE YOUR PERMANENT ADDRESS AND PHONE NUMBER FOR OUR FILES. ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.

CLASSIFIED COMMERCIAL RATE: (for firms or individuals offering commercial products or services) $1.25 per word prepaid (no charge for ZIP code)...**MINIMUM 15 WORDS.** 10% discount for same ad in 6 issues within one year; if prepaid. **NON-COMMERCIAL RATE:** (for individuals who want to buy or sell a personal item) $1.00 per word, prepaid....no minimum. **ONLY FIRST WORD AND NAME** set in bold caps at no extra charge. Additional bold face (not available as all caps) **25¢ per word additional (20% premium).** Entire ad in boldface, **add 20% premium** to total price. **TINT SCREEN BEHIND ENTIRE AD: add 25% premium** to total price. **TINT SCREEN BEHIND ENTIRE AD PLUS ALL BOLD FACE AD: add 45% premium** to total price. **EXPANDED TYPE AD: $1.85 per word prepaid.** All other items same as for STANDARD COMMERCIAL RATE. **TINT SCREEN BEHIND ENTIRE EXPANDED TYPE AD: add 25% premium** to total price. **TINT SCREEN BEHIND ENTIRE EXPANDED TYPE AD PLUS ALL BOLD FACE AD: add 45% premium** to total price. **DISPLAY ADS:** 1" × 2¼"—$135.00; 2" × 2¼—$270.00; 3" × 2¼"—$405.00. **General Information:** Frequency rates and prepayment discounts are available. **ALL COPY SUBJECT TO PUBLISHERS APPROVAL. ADVERTISEMENTS USING P.O. BOX ADDRESS WILL NOT BE ACCEPTED UNTIL ADVERTISER SUPPLIES PUBLISHER WITH PERMANENT ADDRESS AND PHONE NUMBER. Hands-on Electronics** is published bi-monthly, therefore copy to be in our hands for July/Aug. 86, 4/4; Sept./Oct., 6/4; etc.

PLANS/KITS

DIGITAL Klock Kit plays 1-of-12 melodies each quarter hour. Displays time, date, and other features. Send $2.50 for assembly plans and pricing to **KERBER KLOCK KO.**, 36117 Hillcrest Drive, Eastlake, OH 44094.

CATALOG:Hobby, radio broadcasting, CB, lowfers. Transmitters, linears, active antennas, converters, scramblers, bugging devices, more! **PANAXIS**, Box 130-HO10, Paradise, CA 95969.

BUILD this five-digit panel meter and square wave generator including an ohms, capacitance and frequency meter. Detailed instructions $2.50, refundable plus 50 cents, **BAGNALL ELECTRONICS**, 179 May, Fairfield, CT 06430.

CRYSTAL radio sets, plans, parts, kits. Catalog $1.00. **MIDCO**, 660 North Dixie Highway, Hollywood, FL 33020.

SB3 descrambler parts to construct project in Feb./84 Radio-Electronics. $49.95 (dealer inquiries invited). **CROSLEY (F)**, Box 840, Champlain, NY 12919.

007 gadgets, miniature devices, bugs, plans, kits. S.A.S.E. **AMERICAN MICRO PRODUCTS**, 8280 Janes, Suite 105B, Woodbridge, IL 60517.

LOW noise preamp, power amplifier, electronic crossover, more, kits, bare boards. Free catalog. **MARCHAND ELECTRONICS**, 1334 Robinhood Lane, Webster, NY 14580.

MICROWAVE T.V., down converter kits complete with PC board–layout electronic components,–connectors,–easy, step-by-step instructions and enclosure. $24.95. Call or write **K & S ELECTRONICS**, P.O. Box 34522 HO, Phoenix, AZ 85067. (602) 230-0640.

PAY TV and Satellite Descrambling. All systems. Schematics. America and Canada. Fantasy, Anik etc. 73 pages $12.95. Stungun schematics $5.00. MDS microwave manual including schematics $9.00. Build Excellent Satellite System under $500. $11.95 kits catalogue. $2 (refundable). SHOJIKI ELECTRONICS CORP., 1327H Niagara St., Niagara Falls, NY 14302. C.O.D. s/ 716-284-2163.

SATELLITE TV

SATELLITE Handbook and Buyers Guide tells everything you need to know, $10.00. **SVS**, Box 422, Seaford, NY 11783.

BUILD your own Satellite TV receiving system and save! Instruction manuals, schematics, circuit boards, parts kits! Send stamped envelope for complete listing: **XANDI**, 201 E. Southern, Suite 100, Dept. 32C, Tempe, AZ 85282.

BUSINESS OPPORTUNTIES

US$8.00 including disk thousand name brand programs for Apple, IBM-PC. Details, US$1.00 **RELIANT**, P.O. Box 33610, Sheungwan, Hong Kong.

$10-$360 weekly/up, mailing circulars! No quotas. Sincerely interested, rush stamped envelope: **NATIONAL MAILING**, Box 20728-HE7, San Diego, CA 92120.

BUY BONDS

ADVERTISING INDEX

HANDS-ON ELECTRONICS magazine does not assume any responsibility for errors that may appear in the index below.

SAXON ON SCANNERS

(Continued from page 85)

Also, there is Channel 13 (156.65 MHz), used primarily by 1-watt units (including hand-helds) for navigational purposes. This is intended as a short-range frequency, such as ships in contact with the tugboats that the tugboats that are helping maneuver into or out of a docking area. It's also used for vessels to communicate with drawbridges. If you're located in an area where these activities take place you may find Channel 13 active and used as it should. Otherwise, and in other areas, you're liable to hear just about anything on the frequency.

Channel 15 (156.75 MHz) was set aside for one-way shore-station broadcasts of weather and navigational bulletins. Mostly, it is inactive since this information is generally available on other frequencies, such as the 157.10 MHz or the 162 MHz NOAA broadcast channels.

Channel 17 (156.85 MHz) is allocated for *State Control* purposes: 1-watt communications between vessels and municipal or state operated shore stations. Nothing happening here!

Hand Held

Just the thing for monitoring these frequencies is the Regency HX-1000 portable hand-held 30-channel programmable scanner. You can take it along on a boat trip, or you can bring it with you to the shore as you survey the maritime activities.

The HX-1000 receives more than 15,000 frequencies in the 30–50, 144–174, and 440–512 MHz frequency ranges. That takes in not only maritime, but business, industrial, public safety, federal, land transportation, and even Amateur Radio bands.

You don't need crystals for this unit. You just push a couple of buttons to select the frequencies you want; the information appears on the LCD display and you're all set. The LCD's also serve a dual-purpose as a clock

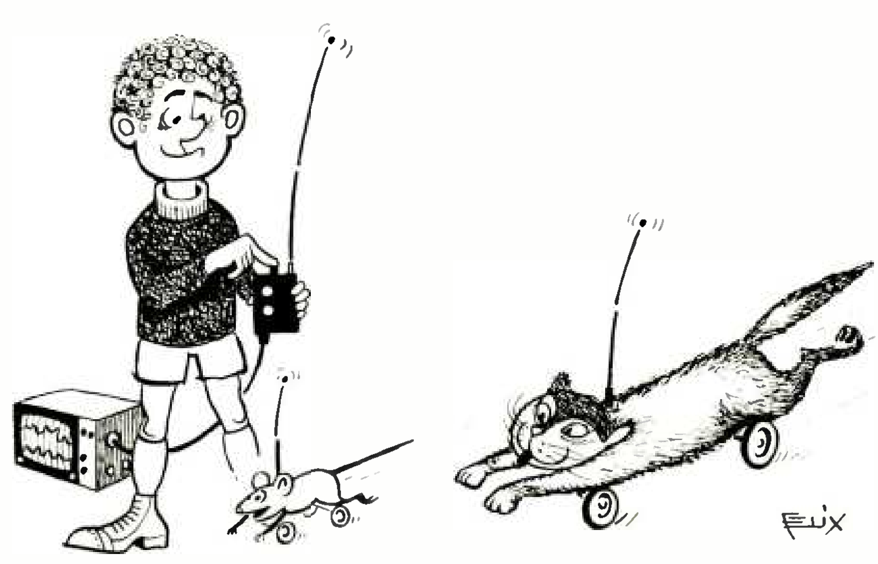
CIRCLE 20 ON FREE INFORMATION CARD

Pick a frequency—any frequency from 1500 available channels built into the Regency HX-1000.

Hey, this thing has all of the features you'd expect to find only in a large base station type scanner: priority channel, lockouts, scan/search, dual AC/battery power (with rechargeable nickel-cadmium batteries). It's also got a *rubber ducky* antenna, a belt clip and a carrying case. Suggested retail is in the $330 ballpark. Nice!

For more information write to Regency Electronics, Inc., 7707 Records Street, Indianapolis IN 46226-9989.

We're looking for your comments, station photos, and questions. Send them to: Mark Saxon, Saxon on Scanners, Hands-On Electronics, 500-B Bi-County Blvd., Farmingdale, NY 11735. While we can't answer every letter, your comments and contributions are sorted and studied, and trends are spotted by our slick editor; that's how we decide what to cover and answer. Til next time. ■



JENSEN ON DX'ing

(Continued from page 24)

The Right Stuff

If you're are a relative newcomer to the hobby of DXing (listening to distant shortwave signals), maybe you have some questions about this longtime practice of QSL'ing.

Like what is it?

Briefly, since the very early days of radio broadcasting the listening experience is both fleeting and lonely.

Lonely? By that I mean it tends to be a one-on-one sort of thing, one listener, one radio. Not exactly a social phenomenon.

Secondly, once you've heard a program, it's over and gone, that is, unless you tape record your loggings. Back when radio began, of course, such recording wasn't technically possible. So listeners would write to the station reporting their reception, with details of what they heard and how well they heard it. The stations replied with QSL's: cards or letters confirming the reception report.

Thus, the SWL had a tangible memento of his fleeting radio reception, and he also had something to show his friends and brag about.

"How 'bout that, Jack, that QSL card came all the way from Australia! Proves I heard their station half a world away!"

Things are, perhaps, a bit more sophisticated these days, but still, as a longtime QSL collector I get a blast out of hearing a new and difficult-to-hear SW station...and another when I find in my mailbox a QSL reply from the broadcaster in response to my reception report, confirming my logging.

Gerry Dexter is one of the world's most sucessful practitioners of the art of collecting QSL's from the stations he hears. He has verifications from more than 1,200 different shortwave broadcast stations, obtained during 35 years of DX'ing.

He has detailed his experiences, and his tips for other listeners who would like to duplicate his feats, in a new book, *Secrets of Successful QSL'ing*.

Dexter's book is subtitled *The Complete Guide to Reception Reports and QSL Collecting*. And it is both for the beginning SWL and the veteran DX fan.

The 114-page, softcovered, how-to book is available for $9.95, plus $1 shipping and handling ($2 extra for shipping foreign orders), from Tiare Publications, P.O. Box 493, Lake Geneva, WI 53147.

Down the Dial

There is a lot of interesting listening on the shortwave frequencies. Here are some that have been heard recently by some of our SWL friends. Let me know what you're logging. The address is: Jensen on DX'ing, **Hands-On Electronics**, Gernsback Publications Inc., 500-B Bi-County Boulevard, Farmingdale, New York 11735. In the listing below, all frequencies are in kilohertz; times are in UTC:

French Guiana, 3,385—This is a little bit of France in an out-of-the-way corner of South America. You can hear the local SW station, *Radiodiffusion Francaise d'Outre-Mer* when conditions are right around 0100 hours, until sign-off shortly after 0200.

USSR, 5,905—The program, in English, is produced by *Radio Kiev*, in the Ukraine, but it can be aired by other transmitters anywhere in the USSR. In this case, the transmitter is said to be located near the city of Simferople. Listen around 0030.

Pakistan, 11,635—*Radio Pakistan* broadcasts English news and commentaries, plus some rather exotic music. Tune in about 1700.

Japan, 15,420—"Japan Scenes," a current-events program, is one of a number of interesting English programs broadcast from the Tokyo studios of *Radio Japan*. Listen around 0100.

(Credits: Don Moman, Alberta, Canada; Ronald Purdue, MN; Robert Zilmer, NM; Bryan Sharpe, CA; North American SW Association, 45 Wildflower Road, Levittown, PA 19057.) ■