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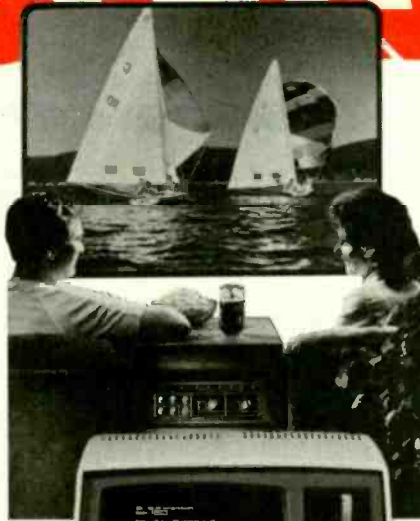
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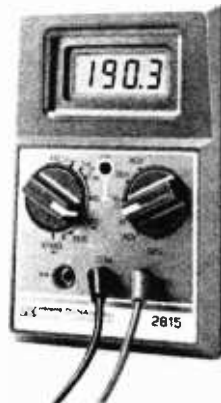


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the supplied earphone only and the receiver is powered by two hearing-aid type batteries (included). The EP-8 has built-in Ferrite Rod antennas for both bands. Shortwave reception is satisfactory for powerful stations such as the BBC, Radio Canada International, Radio Nederland, Deutsche Welle and others. Priced at \$24.95 the Model EP-8 is available from Radios International, P.O. Box 6053, Richardson, TX 75080.

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stand, detailed operating manual and spare fuses. For additional information, contact your local distributor or B&K-Precision, 6460 West Cortland Street, Chicago, IL 60635.

(Continued on page 6)

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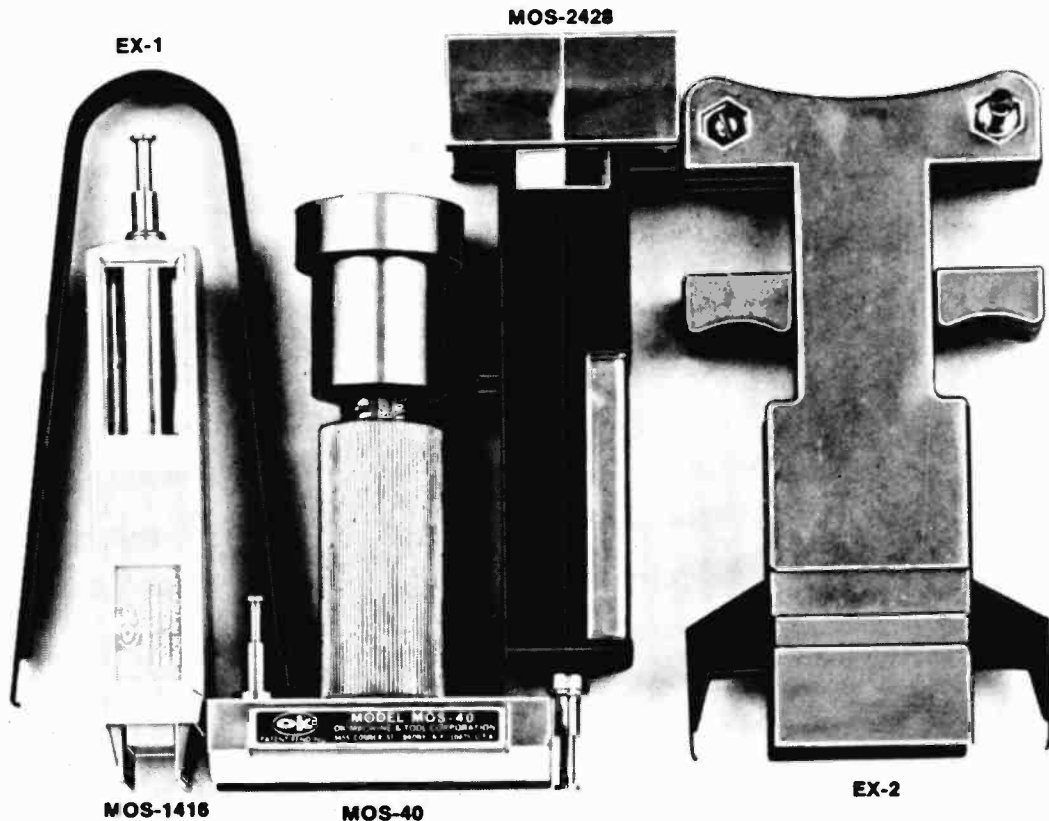


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(Continued from page 4)

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CIRCLE 35  
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ally. Three pedals modify one-finger-selected automatic chords to produce a total of 60 different harmonies. Five melody voices, including a wah-wah instrument, can be used alone or mixed. Delayed, regular, and wah-wah vibratos are provided. The Schober Automatic Electronic Organ Kit, priced at \$650 (bench included), is available from The Schober Organ Corporation, 43 West 61st Street, New York, NY 10023.

### Mobile Disguise Antennas

Antenna Incorporated has a new line of Mobile Disguise Antennas that are visually indistinguishable from standard broadcast antennas. The Mobile Disguise Antennas are available in two mounting configurations, old style or standard universal cowl mount, for either the single band or combination AM/FM land mobile models. A special matching harness is included with either model. Offered

in three frequency ranges—25-54 MHz, 130-174 MHz and 406-512 MHz—the Disguise Antennas are factory tuned to the frequency the customer specifies. Maximum power is over 150 watts for the single band model, or 100 watts for the combination AM/FM land mobile model. The radiation pattern is essentially omnidirectional,



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dependent on vehicle and mounting location. VSWR is 1.5:1 or less. The standard mount is priced at \$47.07. For further information on the Mobile Disguise Antennas, contact Antenna Incorporated, 26301 Richmond Road, Cleveland, OH 44146.

### 9-Digit Frequency Counter

A unique 50 Hz to 550 MHz nine digit Frequency Counter is now available from DSI Instruments. Called the 5600A, it combines a 10 MHz Proportional-Oven Time Base accuracy of 0.2 PPM, from 10° C to 40° C, with a 10 mV sensitivity and resolutions to 0.1 Hz. Its large character, 0.5 inch high



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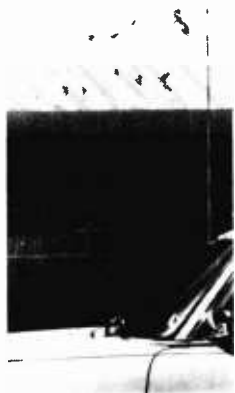
9-digit LED array—with automatic zero blanking—provides enhanced readability at a distance and at wide viewing angles, even under high ambient light conditions. Two input channels are provided. One covers the 50 Hz-to-50 MHz range while the other is for the 50 MHz-to-550 MHz frequency spectrum. The user can quickly select a desired resolution from 0.1 Hz to 1.0 KHz with convenient push-button



ease. Additional features include an RF pre-amplifier and a 550 MHz prescaler. In 95% factory assembled kit form, the instrument sells for \$149.95. For additional information, contact DSI Instruments, Inc. at 9550 Chesapeake Drive, San Diego, CA 92123, or call toll free by dialing 800-854-2049. In California: 800-542-6253.

### Glass-Mounted Antenna

A  $\frac{5}{8}$  wave mobile antenna by Avanti especially designed for CBers is called Moon-Fantom. The device operates as a true  $\frac{5}{8}$  wave antenna, yet can be conveniently mounted on glass without tools in a matter of minutes. There are no holes to drill; no car body patching at resale time. Since no ground plane is required, the Moon-Fantom has a better radiation pattern than other mobile antennas. Exclusive co-inductive coupler at-



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taches to the opposite side of the windows and establishes a highly tuned circuit to transmit and receive radio frequency directly through glass. A new aerospace adhesive discovery, which has the strength of a  $\frac{1}{4}$  x 20 metal bolt, bonds the mounting foot securely to glass and both whip and mount can be adjusted to any glass angle. It sells for \$39.95. For more information, contact Avanti Research and Development, Inc., 340 Stewart Ave., Addison, IL 60101.

### Aero Band Pocket Scanner

The Bearcat pocket-size scanner radio is capable of receiving both the VHF-AM aircraft channels and UHF-FM channels. Airport officials, operating personnel, pilots and others interested in airport operations can now carry a radio which will keep them informed of both tower-to-plane and ground

control communications. This Bearcat Aircraft scanner weighs a mere 10 ounces, and is capable of receiving up to 4 channels in any mix of the two bands covered



CIRCLE 39  
ON READER  
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with by-passing built-in. A flexible "rubber ducky" antenna is supplied, but the radio can also be used with a wire antenna. The Thin Scan is priced at \$149.95 (less crystals and batteries), and is a companion to the "Bearcat 220" scanner introduced earlier this year. The Bearcat 220 is designed for desk-top or vehicle installation and has 20 channels which can be programmed by keyboard entries. It is also capable of receiving VHF-AM aircraft and UHF-FM ground control communications, as well as scores of other services on low and high VHF, UHF-T and amateur bands. Complete information on the Bearcat Thin Scan Aircraft scanner is available from Bearcat scanner suppliers or directly from Electra Company, P.O. Box 29243, Cumberland, IN 46229.

### Automatic Wire-wrapping

The new BW-2630 by OK Machine and Tool is a revolutionary wire-wrapping tool which operates on 2 standard C-size NiCad batteries (not included) and accepts either of two specially designed bits. Bit model BT-30 is for wrapping 30 AWG wire onto .025-inch square pins; BT-2628 wraps 26-28 AWG wire. Both produce the preferred "modified" wrap and are priced at \$3.95 and \$7.95 respectively. Designed for the serious amateur, BW-2630 even includes both positive indexing and anti-overwrapping mechanisms—features usually found only in expensive industrial tools. Pistol grip design and rug-

(Continued on page 9)

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Birth defects  
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THIS SPACE CONTRIBUTED BY THE PUBLISHER

# Lab Test Elementary Electronics For Yourself

## Get switched on

In case you're not all that familiar with us, we're not a publication for electrical engineers and other wizards. No way. ELEMENTARY ELECTRONICS is expressly for people who like to build their own projects and gadgets—and maybe get a little knee-deep in tape, solder and wire clippings in the process.

In fact, we have a sneaking suspicion that our readers like us because they think we're just as bug-eyed and downright crazy over great new project ideas as they are. And I guess they're right!

E/E thinks of you who dig electronics as the last of a special breed. It's more than just the "do-it-yourself" angle—it's also the spirit of *adventure*. In this pre-packaged, deodorized world, building your own stereo system, shortwave receiver, darkroom timer or CB outfit is like constructing a fine-tuned little universe all your own. And when it all works perfectly—it really takes you to another world.

**ELEMENTARY ELECTRONICS** knows the kinds of projects you like—and we bring 'em to you by the truckload!

Ever hanker to build a sharp-looking digital clock radio? Or to hook up an electronic game to your TV? Or an easy-to-build photometer that makes perfect picture enlargements? Or a space-age Lite-Com so you and the family can talk to each other on a light beam? We've got it all to get you started.

**WHEN IT COMES TO REPAIRS** E/E can save you time, trouble and a pile of money!

Has your sound system gone blooey just when the party's going great? Do you shudder when your friendly neighborhood electrician hands you the bill? E/E can help.

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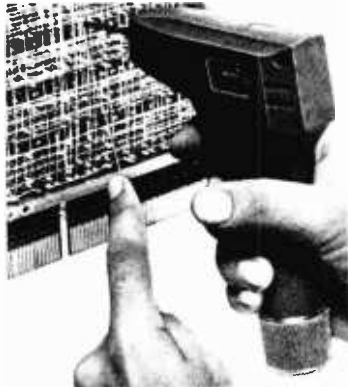
Please allow 6 to 8 weeks for delivery of your first copy.

**HOD245**

# New Products

(Continued from page 7)

ged construction assure performance and durability. Available for only \$19.95, the BW-2630 can be purchased at local electronic re-

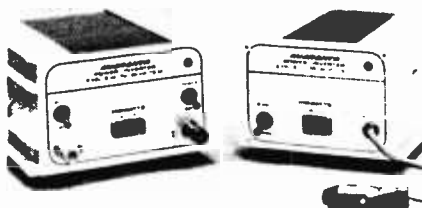


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tailers or directly from O.K. Machine and Tool Corp., 3455 Conner Street, Bronx, New York 10475.

## AC on the Road

Two new Micronta Power Inverters by Radio Shack convert 12 VDC to 120 VAC to power AC appliances from your car, boat or rec-



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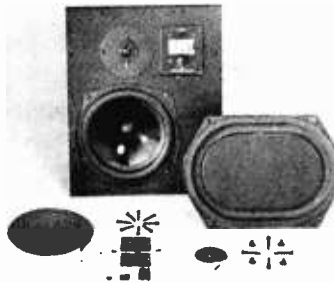
reational vehicle battery. The 300-watt inverter is said to be capable of powering color TV's, electric typewriters, small hand drills, sewing machines and many other items requiring no more than 300 watts continuous power. The 100-watt inverter is suitable for powering small TV sets, electric razors, transistor radios, Amateur and CB two-way radio equipment and other small appliances. Both inverters feature a Normal/Boost switch to provide extra power to compensate for low battery input voltage. The Circuit breaker automatically resets 3-4 seconds after the overload has been removed. Full load input current is given as

25 amps for the 300-watt model; 12 amps for the 100-watt inverter. The Micronta 300-watt Power Inverter is priced at \$79.95; the 100-watt Inverter, complete with cigarette lighter plug is, priced at \$39.95. Micronta Power Inverters are available exclusively from participating Radio Shack stores and dealers, nationwide.

## Speaker System Kits

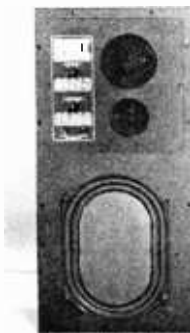
Two of KEF's speakers—the Model 104aB and the Cantata—are now available in kit form, enabling the consumer to easily assemble a top quality product at a significant cost-savings. The kits are packed in pairs, with the appropriate drive units and crossover circuits already mounted, wired and tested on the front baffles. Assembly is simple, requiring only construc-

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tion of recommended enclosures and installation of the baffles. The 104aB kit (\$250) comprises a mid-bass drive unit, tweeter and Acoustic Butterworth filter, and when completed is a closed box loudspeaker system with an impedance of 8 ohms and a maxi-

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mum power rating of 150 watts. Both kits include fuse units to protect the appropriate drive units and contour controls to adjust the acoustic output to match the environment of the listening room. For further information, write to Intratec, P.O. Box 17414, Washington, D.C. 20041.

# AMAZING DEVICES

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PPF-1 PHASER PAIN FIELD — This device recently developed and patented in our labs is being evaluated by law enforcement agencies for riot and crowd control. It is now available but soon will come under the jurisdiction of weapons and internal machine control making it unavailable to the public. The device is hand-held and looks like a BUCK ROGERS ray gun. It is hazardous if not used with discretion.

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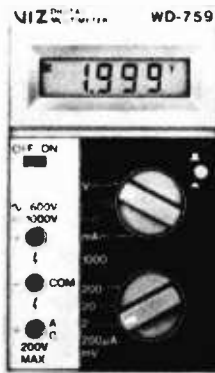
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# New Products

## Hand-Held 3½ DMM

With a choice of either LCD or LED displays, two new VIZ 3½ digital multimeters provide an accuracy of 0.1% (DCV) with an input impedance of 10 megohms. The LCD model, WD-759, offers the advantage of a visual indication of function (DC or AC voltage, ohms or amperes) in the display window, as well as the measurement value. The suggested price is only \$159. Measurement ranges are from 100-microvolts to 1000-VDC and up to 600-VAC; from 0.1-ohm to 20-megohms and from 0.1-microamp to 1-amp, DC and AC. The units also provide for measurement of either high or low power ohms in all ranges, switch selectable. For easy service in the field, there is a 1-amp fuse, plus spare, located in the rear battery compartment. An optional AC adaptor is available for bench operation. A carry-

ing case is available that permits use of the instrument while in the case. Another optional accessory is a high-voltage probe (50-KV DC). The LED model, WD-758, is

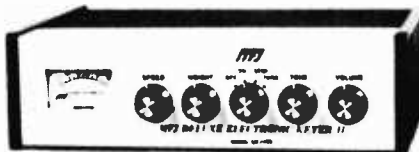


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identical in electrical performance except that it doesn't provide function indication in the display. Price for this model is only \$149. For additional details, contact any VIZ distributor or write to VIZ Mfg. Co., 335 E. Price St., Philadelphia, PA 19144.

## Electronic Keyer

The new MFJ-408 Deluxe Electronic Keyer II has a readout meter and a socket for Curtis accessories. The MFJ-408 lets you read your sending speed to 50 WPM, and the accessory socket allows you to use the following Curtis accessories: external memory, random code generator, or keyboard. (These are accessory PC boards or boxes.) The MFJ-408 is based on the proven Curtis 8044IC keyer chip, and sends iambic, automatic, semi-automatic, or manual CW. Dot-dash memory provides self-completing dots and dashes with jam proof spacing.



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The MFJ-408 provides solid state keying for grid block, cathode or solid state transmitters (-300-V, 10-ma. max, +300-V 100-ma. max). The MFJ-408 is completely portable; it operates up to 1 year on 4 C-cell batteries. It has a 2.5 mm phone jack for external power (6 to 9-VDC) or order the optional AC adaptor for \$7.95. The MFJ-408 Deluxe Keyer II is available

from MFJ Enterprises, Inc. for \$79.95 plus \$3.00 shipping and handling, accessory cable with plug is \$3.00. To order call toll free 1-800-647-1800 or mail order to MFJ Enterprises, P.O. Box 494, Mississippi State, MS 39762.

## Custom Mount

The new Model K-4A-DD Firestik Super Stud Disco-Disc Mount uses a chrome-plated steel disc for strength and beauty. It comes complete with SO-239 base, heavy-duty mounting stud and ¾-24 solid brass threaded shank. The K-4A-DD accepts PL-259 terminated cables: A low-profile deck mount (less than ¼-in. from deck to stud) must be used with spring. The unit is designed to hold



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heavy duty Firestiks or similar antennas up to 4 ft. in length. Excellent for use with CB, VHF or amateur antennas for installation on trucks, boats, automobiles, RV's, etc. Sells for \$5.95. For more information, write to Firestik Antenna Corporation, 2614 East Adams, Phoenix, AZ 85034.

## Wide-Bandwidth Equalizer

A new graphic equalizer from Sansui, with a suggested retail price of just \$230, boasts a flat frequency response of 0-100,000-Hz +0, -1-dB to ensure that any alteration in frequency balance is limited to changes deliberately made by the listener. The new



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Sansui SE-5 provides equalization in eight frequency bands, centered on 80, 160, 315, 630-Hz, and 1.25, 2.5, 5 and 10-kHz, for precise con-

*(Continued on page 114)*

## HOBBY COMPUTER HANDBOOK

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IN THIS, THE 1980 EDITION OF 101 ELECTRONIC PROJECTS, we've assembled a truly exciting collection of new circuits for your enjoyment. Each one has been built and thoroughly tested to insure that it will work exactly as intended—provided, of course, that you follow directions *precisely* and employ good construction techniques. In case you're unfamiliar with standard construction methods, or nervous about building "from scratch," the remaining paragraphs of this introduction are dedicated to you. In them you will find all the tips, techniques and background information needed for a successful project. Even "old hands" are urged to review this section before building anything; remember, it takes just *one* forgotten detail to spoil an otherwise perfect project.

**Construction Methods.** There are three foundations on which to build an electronic project: a solderless breadboard (SBB), perfboard (with or without wire-wrap) or printed circuitry. Solderless breadboarding is the ideal method when you intend to tear down a circuit after experimenting, or when you wish to see how well a circuit works before committing it to one of the more permanent types of construction. Using an SBB is simplicity itself: just push component leads into the grid atop your SBB, and connect the appropriate terminals together by inserting jumper wires. Both the wires and the component leads are gripped snugly by contact springs embedded beneath the breadboard's matrix of holes. After experimenting, you can dismantle the circuit by pulling out the components and jumper wires. Almost every major electronics retailer carries some solderless breadboard.

Perfboard and printed circuitry are more permanent methods of construction. Perfboard consists of a sheet of phenolic plastic perforated with a grid of holes, into which small terminals can be inserted. Construction consists of mounting terminals in an appropriate pattern, soldering component leads to the terminals, and then soldering (or wrapping) wires to interconnect specific sets of terminals. Perfboarding is a reasonably quick process that works well with discrete components (transistors, resistors, etc.).

You can use perfboard to mount ICs, but printed circuitry is probably the better method here. That's because it is usually easier to accommodate the closely-spaced pins of integrated circuitry on a PC board. Although printed circuits require more time to lay out and prepare, it's actually easier to mount and solder components on a printed circuit than on a perfboard. Furthermore, a printed circuit is generally more rugged, and certainly neater than a comparable perfboard. If you feel a project warrants printed circuit construction, various PC kits are available. The so-called direct method is the cheapest, making it attractive to beginners, but kits based on photo-sensitive boards are much more versatile and, in the long run, usually a better investment. Both types of kits are widely available.

**Component Sources.** All the projects presented here can be built with readily available components; rare birds will not be found roosting in the parts lists. However, don't expect any particular retailer to stock each and every part you need. Local electronics outlets can usually supply basic items such as resistors, transformers, capacitors, diodes and cabinets. For transistors, integrated circuits, special devices and the like, your best chance of locating a specific part lies with the mail-order retailers. But here again, not every dealer can be expected to carry all the components you need—especially semiconductors—so shop around.

You may at times be tempted to make component substitutions. For example, the readily available Motorola HEP S9001 programmable unijunction transistor makes a good substitute for a 2N6027. However, substitution is a tricky game best played by those with experience. It helps to have

# Electronic Projects

full data sheets for both the original part and the intended substitute. Compare all important specifications of the two devices carefully before making a decision. If your substitute does not provide adequate performance, you have no one to blame but yourself.

**Test Equipment.** Expensive electronic test equipment is not required for testing or tune-up of the projects in this book. However, it is wise to have at least a VOM on hand, since it can prove invaluable during troubleshooting. An electronic multimeter with its high input impedance provides even more versatility and accuracy. You can obtain one of these in kit form for around \$80. Assuming that your interest in electronics is more than casual, such a meter makes a very worthwhile investment.

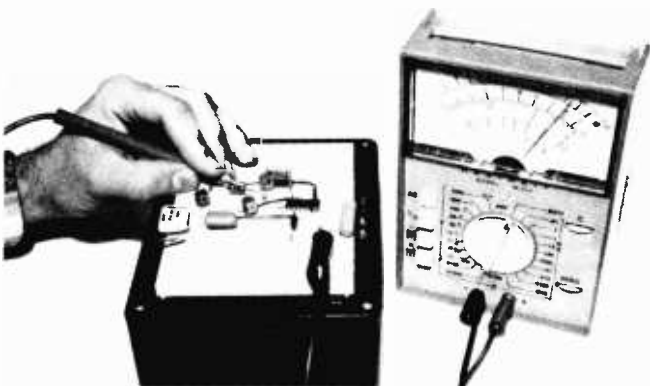
**DOs and DON'Ts.** Here is a brief collection of tips intended to help you sidestep a variety of pitfalls, some shallow and some deep: Use a heat sink when soldering transistors, diodes and other devices susceptible to damage from heat. Do not solder your ICs; use sockets instead. This makes troubleshooting much less agonizing should it become necessary. It also protects sensitive integrated circuits (like CMOS types) from damage due to excessive soldering iron leakage currents. Observe proper device polarities, especially when installing electrolytic capacitors and diodes. Be wary of line-voltage circuitry, especially with Triac projects. If possible, pull the plug when troubleshooting such a circuit. If it must remain "live," at least keep one hand in your pocket when making measurements. This reduces the risk of bridging the power line with your hands, and thereby shorting out a promising career in electronics. Be certain that capacitor working voltages and diode PIV ratings equal or exceed whatever is specified in the parts lists. Audio-taper and linear-taper pots are generally *not* interchangeable. Use precision components where needed. For instance, suppose that an oscillator is to be built, and that the oscillator's frequency is determined by one resistor and one capacitor. If a 5% resistor and a 5% capacitor (i.e., polystyrene or mica) are called for, your oscillator's frequency is likely to deviate no more than  $\pm 10\%$  from its intended value. Substituting a 10% resistor and a 20%-tolerance capacitor, you might cause the frequency to vary from its intended value by as much as  $\pm 30\%$ , roughly speaking. Certainly there are circuits where such a variation would be inconsequential, but

if components with a certain level of precision are specified, be sure to use them for best results. MOSFET transistors can be damaged by static discharge just like CMOS ICs. The surest way to safeguard a MOSFET is by using a socket. Plug the transistor in only after all soldering is complete, and remove its protective shorting wire only after it is securely seated. Note that the junction field-effect transistor (JFET) is much harder than its MOS cousin, so a socket is not mandatory in this instance.

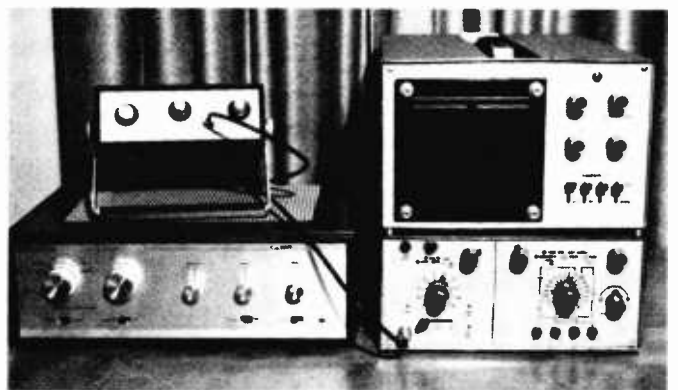
**Interfacing.** Most experimenters like to combine circuits together in order to produce customized projects. Ordinarily this is a lot of fun, but problems can arise when you try to interface several stages not inherently compatible with one another. For example, suppose that it's necessary to interface circuit A (designed for a 12-volt DC supply) with circuit B, which operates on 9-volts DC. We're assuming now that the circuits are both negative-ground (or both positive-ground) and not a mixture of the two. Generally speaking, most projects will function at supply potentials other than those specified, though the performance may be degraded somewhat. A transistor or UJT oscillator might shift to a lower frequency on reduced voltage, while an amplifier stage could exhibit diminished gain under the



A deluxe version of the solderless breadboard, CSC's ProtoBoard has binding posts for bringing in power to the bus strips which run along the outside edges of the breadboard. The heavy base with its rubber feet can allow the builder to work virtually anywhere without creating damage to table tops and other furniture.



One of the most important aids in circuit design, construction and troubleshooting is the volt/ohmmeter (VOM). When a circuit doesn't work properly the first time through, a VOM can be used to check voltage levels at any point in the circuit to detect either faulty components or wiring (and PC foil) errors or both.



The ultimate aid in diagnosing flaws in circuitry as well as digital logic errors is the oscilloscope. In the photo above, the oscilloscope is being used to read the waveform output of a stereo amplifier to detect flaws in the final amplifier which might be the source of distortion. If you can't afford to buy, borrow one.

same conditions. However, simple op-amp feedback amplifiers and 555-type oscillators perform with remarkably little influence from supply potentials.

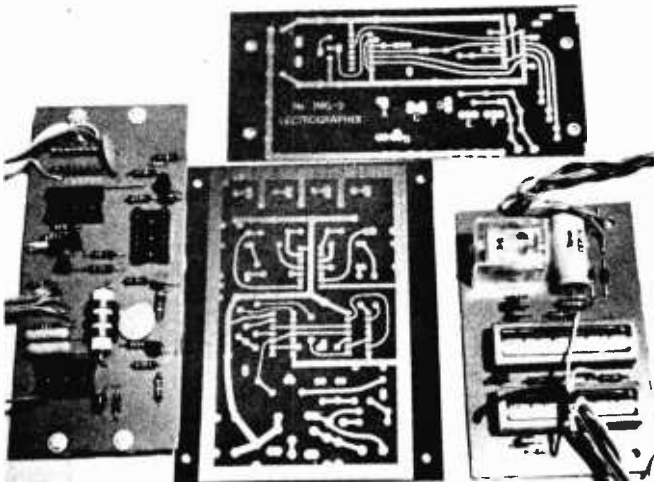
When combining two circuits designed for different supply potentials, it's probably safer to use the lower of the two voltages for the common supply. If the potentials are reasonably close, say 12-VDC and 15-VDC, performance should be adequate. Should a noticeable frequency shift occur in an RC oscillator, substitute different timing capacitor(s) to compensate, if necessary. Circuits with widely separated supply potentials should not be combined, unless you intend to operate each from a separate supply (in which case, make sure the interstage signals are *capacitively* coupled) voltage source.

You should also make sure that signal levels are compatible when combining circuits. Feeding too large an input signal to an amplifier stage will cause clipping and distortion, which are undesirable effects in most cases. Excessive input levels can be cut down with a simple resistive voltage divider. On the other hand, input signals that are too small may require a stage of preamplification to boost them up to usable levels. Watch your input and output impedances, too. If stage A is a signal source and

stage B is a voltage amplifier, B's input impedance should be several times greater than A's output impedance. However, when it is necessary to transfer the maximum amount of power from stage to stage, A's output impedance should be *equal* to B's input impedance. Stereo buffs utilize this principle when matching 8-ohm speakers to an amplifier's 8-ohm speaker outputs.

Interfacing logic circuitry is a task that warrants special attention. CMOS and TTL are the two predominant logic families, and although both types can perform the same logical functions, they differ significantly in several electrical parameters. First, TTL requires a 5-volt DC supply, while CMOS is content with anything from 5 to 15-volts DC. Power supplies from TTL must be tightly regulated, while those for CMOS do not always need strict control. Comparing CMOS at 5-volts with TTL, note that signals in a CMOS system should swing above 3.5-VDC when high, and below 1.5-VDC when low; by contrast, TTL signals must rise above 2-VDC in the high state and drop beneath 0.8-VDC in the low state. So, a 2.5-volt signal input would be high enough to register as a logical 1 to TTL, but probably not in CMOS. Combine the disparities in logic levels with the fact that most CMOS devices are too feeble to drive standard TTL ICs, and it's obvious that interfacing the two families is a job best left to the experts. Where applicable, we have indicated which projects interface well with CMOS, TTL or both.

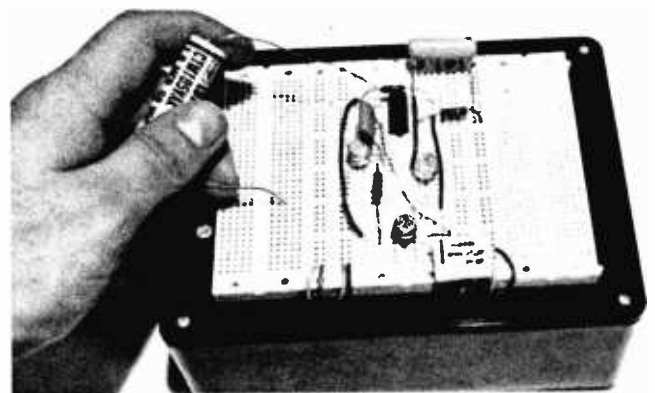
**Power Sources.** Two general power source options are available—either a line-operated supply or batteries. For purposes of experimentation with a number of different circuits, the line-operated supply ought to have an adjustable output, and if it happens to be regulated, so much the better. Batteries can always be series-connected to obtain different potentials. No matter what kind of power source you use, be certain it can handle all the current required by your project. Recommended load currents for some common batteries are as follows: 8-mA for a 9-volt transistor battery, 25-mA for an "AA" penlite cell, 80-mA for a "C" cell, and 150-mA for a "D" cell. Series hookups retain the same current capability as a single cell; for example, 8 "AA" cells in series can provide 12-volts @ 25-mA. Alkaline types can supply 2 to 3 times more "juice" than standard batteries, and all batteries, regardless of type, can supply much more than the rated current when used on an intermittent basis. You can check how much current a circuit is extracting from your batteries by inserting a DC milliammeter in series with one of the power leads.



Printed circuitry offers the most rugged construction format as well as being the most compact of all available types of construction media. It takes a little more time to build a printed circuit, but the final results are well worth the extra effort and time involved in the process. PC kits are available at very low cost.



An adjustable, regulated DC power supply is almost a "must have" item for any circuit builder's bench. As battery prices soar to astronomical levels, the initially greater cost of a power supply becomes more and more affordable. Tight regulation is required for TTL IC circuitry and you can only get it this way.



Using a solderless breadboard couldn't be easier—to install a component, simply determine where its leads must go, and then push them down into the proper hole. A spring-loaded grid underneath the board grips the leads tightly to insure good electrical contact, yet allows quick and easy removal as well.

# Electronic Projects

If you decide to keep a project for permanent use after experimenting with it, a fixed-output line-operated supply may be just the thing to power it. In this issue, we've included an article on the design and construction of a variety of AC supplies to help you out. With a line-operated supply, you pay more initially, of course, but it turns out to be cheaper than batteries in the long run.

**Troubleshooting.** Regardless of how careful you are, sooner or later you will produce a project that seems plagued by gremlins. However, with patience and a logical attitude you can exorcise these pests. The first thing to do when a circuit acts up is to re-check the wiring against the schematic diagram. Then, look for defective components. Resistors are easy to check on a VOM or multimeter. The same goes for batteries. Capacitors can be checked on a capacitance meter, and if you lack one, why not construct the one described elsewhere in this issue? If you do much experimenting, a capacitance meter is more of a necessity than a luxury.

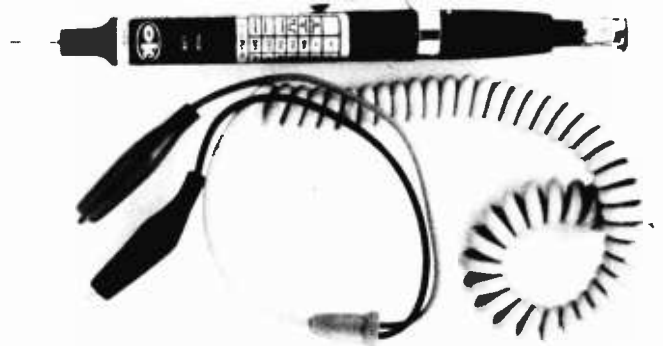
ICs and transistors are somewhat more difficult to analyze accurately without either some expensive test equipment or a great deal of ingenuity. The simplest course of action with these devices is to substitute another IC or transistor of the same type and see if the circuit responds positively. Incidentally, when building a multi-transistor project, it's very easy to interchange two transistors accidentally, or to get the emitter, base and collector leads of a given device mixed up. Remember, the location of the E, B and C leads is not always the same for all transistors.

Logic probes can be of assistance when trying to debug logic circuitry. Some of the cheaper probes are limited to use in TTL systems, while more costly devices can accommodate CMOS as well. The probe's basic function is to display the logic status at some selected point in a digital circuit; one LED lights if a logical 0 is present, and another one lights up to indicate a logical 1. The better, and hence

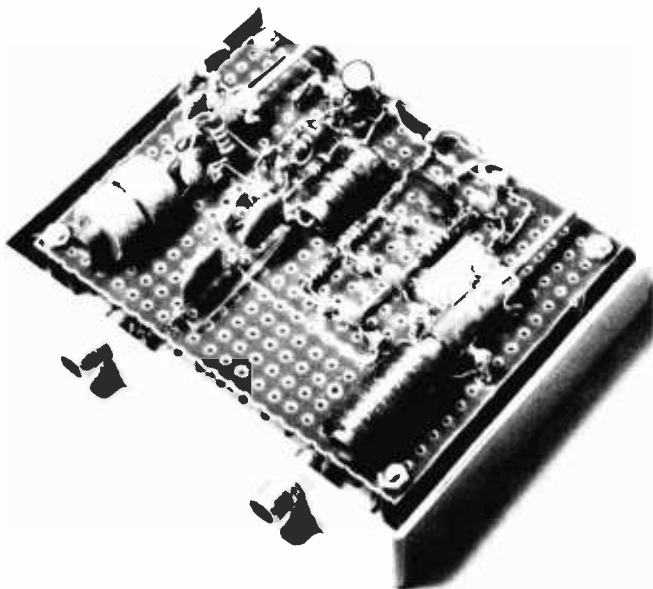
more useful, probes have a pulse-catching feature, which records the presence of even fleeting glitches that a scope might miss. Because a probe is much lighter and less expensive than a scope, it's a fairly popular item with experimenters. Nevertheless, the oscilloscope remains the ultimate test instrument in both digital and analog circuit analysis. When all else fails, get hold of an oscilloscope, even if you have to borrow it.

While troubleshooting, keep in mind the fact that diodes and electrolytic capacitors are easy to install with reversed polarities. Tantalum electrolytics will heat up and sometimes "pop" if accidentally reversed. Uncalled for component substitutions are yet another common cause of disaster; when in doubt, do not substitute. Finally, before giving up on a troublesome circuit, consider getting some assistance from a friend. It's often amazing how squickly someone with a fresh perspective can spot an error.

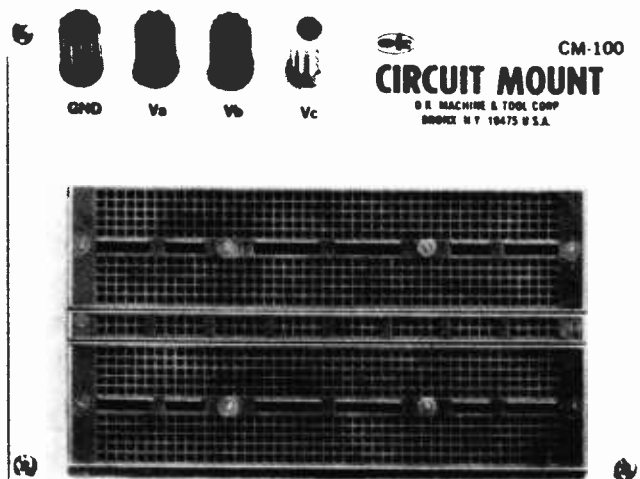
At this point, you should be well enough prepared to tackle every one of the great projects in this book. Some of them may be mystifying, and others will be practical, but all should be fun to build and operate. Go ahead and enjoy yourself. ■



The next best thing to owning or borrowing an oscilloscope for use in working with digital circuitry is the digital logic probe. The probe can detect the presence of either logic state at an IC's output, and is so sensitive that it can, in some cases, detect unwanted "phantom" pulses missed by an oscilloscope.



Breadboard construction has the advantage of allowing you to cut a board to exactly the size needed for a particular project. Larger components are accommodated easily where they might prove troublesome to mount on solderless breadboards or printed circuits. Wirewrapping can be used for interconnections.



Another deluxe solderless breadboard is OK Machine & Tool's "Circuit Mount." The CM-100 shown here has a common bus strip running between the two main matrices, while another configuration has two bus strips running parallel to and outside of a central matrix. Rubber feet allow its use almost anywhere.



# Solderless Breadboarding

The neat, easy, quick way to go for the experimenter

THERE ARE A LOT OF WAYS to put electronic circuits together, among them point-to-point wiring on a chassis with sockets and terminal strips, perf-boards and printed-circuit boards, to name the most familiar conventional methods, all of them depending heavily on soldering. But over the last few years, assembling and testing circuits on *solderless* breadboards has become increasingly popular. And little wonder, because this technique offers hobbyists and professionals alike a way to save considerable amounts of time, as well as saving sizeable amounts of money, since parts can be used and reused over and over again.

**More Work in Less Time.** To the electronics professional, engineering and technician time is a valuable resource, and it's really no different for electronics enthusiasts who spend late weekday hours or entire weekends experimenting with new circuits. But how, exactly, is the time spent? With solder in one hand and a soldering iron or gun in the other, which should really be no surprise, when you think about it, since even a simple amplifier can have well over a dozen connections. Add the fact that today's projects, with their 14-, 16-, 24- and 40-pin ICs, multiple LEDs, plus the usual assortment of transistors, capacitors, resistors, potentiometer, etc., are often considerably more sophisticated, and your newest labor of love can involve a lot of manual labor.

**A Better Way.** In their search for a better way to assemble circuits, a number of engineers and technicians came up with crude solderless breadboarding systems, using such ingredients as alligator clips, springs, fahnestock clips perforated masonite, and the like. These were awkward and often unreliable, particularly when multiple connections were necessary at a given point in the circuit. Happily, like semiconductor technology, solderless breadboarding technology has come a long way since the early days. Precision and versatility have increased, while prices have decreased to the point that the many advantages of solderless breadboarding are now easily affordable by even the most budget-conscious electronics buff. Today, complete solderless breadboarding sockets carry manufacturer's recommended retail prices as low as \$2.50.

With solderless breadboarding, connecting, disconnecting and reconnecting components and leads is nearly as fast and easy as plugging a conventional AC line cord into a wall socket. Just about the only preparation necessary is to strip the insulation from hookup wires, because no connectors are required. Leads from all types of components (ICs, transistors, resistors, capacitors, etc.) plug in directly, and interconnect just as easily.

We're getting ahead of ourselves. A better way to understand the way solderless breadboarding sockets function is to remember the old days before transistors, when electron tubes plugged into chassis to make things work. Manufacturers of breadboarding sockets have taken this basic idea and extended it. Instead of round sockets, holes are placed in a rectangular grid, spaced at regular intervals, corresponding to the spacing of standard components, such as ICs. And instead of terminating in soldering lugs, the lugs beneath these holes are interconnected in larger or smaller groups. Smaller groups (usually five or so), used to connect a few component leads together, are called "terminals." Larger groups, often of 25, 40 or more, which are used to connect large numbers of leads to a single point in the circuit (such as supply voltage, ground or common signal paths), are called "buses." By using these terminals and buses, circuits can be easily and quickly assembled *in as little as one-tenth the time of conventional wiring techniques*. Let's see why.

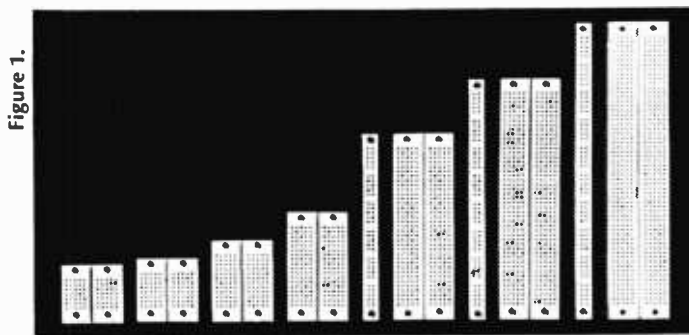


Figure 1.

Figures 1 and 2 illustrate typical solderless breadboarding sockets and bus strips used to build and test electronic circuits. As you can see from Figure 3, these can be combined together and "grown" to accommodate virtually any size circuit, using a variety of components

Leads from all components, including DIP (dual-inline

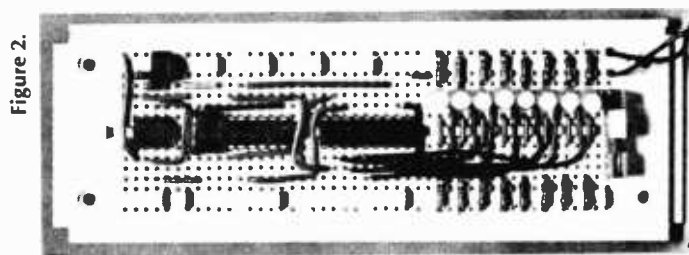


Figure 2.

# Breadboarding

package) integrated circuits, are inserted directly into the sockets, and interconnections are accomplished with short lengths of #22-30 AWG solid hookup wire, stripped of insulation at either end. The result is a neat, compact layout that can be used for testing, or built into a housing.

**Adding up the Advantages.** By now, if you're like most experimenters who've been exposed to solderless breadboarding for the first time, you're probably already interested in trying this fun way to build circuits for yourself, just on the basis of the time you'll save. But speed isn't the only nice thing about solderless breadboarding. Here are some of the other major advantages.

You can translate circuits directly from schematic or pictorial diagrams directly to working circuits. There's almost never a need to come up with a separate wiring diagram or go through other intermediate steps. And if you're designing a circuit yourself, you can go from rough sketch right to assembled unit, to check your ideas in minutes. Once you're finished, you can easily translate the working circuit back into a schematic, too.

These are two of the most underrated factors in designing and building circuits. On a solderless breadboard, all components are right there in front of you, so it's hard to miswire a circuit. It's also easy to change component values or connections, especially if you're improving or otherwise modifying a circuit. Component values and parts designations are right there in front of you. And it's rare that you have to move any components to get at others.

Want to add a stage? Feed one circuit into another? Compare two different ways to do things, side-by-side? With modular solderless breadboarding, it's easy. Just keep adding sockets or bus strips as you need them!

Quality breadboarding sockets and bus strips have molded-in mounting holes that let you put them anywhere you need them; on a chassis, the surface of a cabinet or workbench. You name it! Be sure the sockets have insulated backing, to prevent shorting if you mount them on metal, or your circuits will be *short-lived!*

**Utilize Your Junkbox.** Even components with larger leads can be connected to solderless breadboards by using short lengths of hookup wire soldered to their terminals. And since the better solderless sockets are made of materials that withstand 100°C or more, you can even use heat-dissipating devices in close proximity to the sockets without fear of damage. You can even solder to components while they are still connected to the sockets. Note: consult manufacturers' specifications before you do, though.

For many experimenters, particularly those with tight budgets (and who hasn't one these days?), solderless breadboarding offers one more advantage that outweighs all the rest. Instead of giving components a lead-length "haircut" each time you use them, components are intact, so you can use them over and over again. And, because there's no soldering involved, there's no chance of accidentally overheating a delicate diode or expensive IC chip with an accidental touch of the soldering iron. Instead of shrinking your junkbox with each new project you build, your junkbox grows. So you can spend that hard-earned money on *new* components, and build a larger variety of new projects!

**When, Where and How.** Quality solderless breadboarding systems are compatible with a wide range of circuit types, including digital, and analog audio, all the way up to video



Figure 3.

and RF, if proper wiring practices are followed. Capacity between adjacent terminals should be less than 10 pF, which gives you the ability to work up to about 20 MHz, for most applications. Virtually any type of component can be used, though with components having very small diameter leads, stranded leads, or leads larger than .033-inch diameter, you should solder a small length of #22 hookup wire to them, using spaghetti or electrical tape where necessary, to prevent shorts.

**Wiring and Hookup Hints.** While most of the points raised below are good basic wiring practices, it especially pays to keep them in mind when using solderless breadboards, because the speed and ease with which your circuits go together may tempt you to overlook some of them.

Leads in general should be as short as possible, particularly with high-frequency circuits. Keep component leads and jumpers as direct as possible, since excessive leads can add inductance or stray capacitance to circuits, sometimes producing unwanted oscillation. Neat lead layout, lead bending, etc., also makes components easier to insert, and helps you trace the circuit for later diagramming, debugging, etc.

To jump two or more tie-points, you'll need short lengths of wire. Almost any #22-30 solid hookup wire will do. Strip insulation a bit more than  $\frac{3}{8}$  inch from each end, to allow for insertion and bending, and be careful not to nick the wire when stripping it. When estimating jumper length, allow a total of a bit more than  $\frac{3}{4}$  inch (for the  $\frac{3}{8}$  inch-plus of bare wire you'll need at each end), plus any extra wire required for bending, to make a neat layout. And don't throw those jumpers away! They can be re-used again and again, so store them on an unused portion of your socket, or in a plastic box.

When laying out circuits, allow several rows of tie-points between components, especially ICs. This will give you plenty of maneuvering room to add extra components, run wires, etc., as well as yielding a more open, neater layout.

One of the nice things about solderless breadboarding is that you can lay out a circuit just the way it's drawn on a schematic, with supply buses at the top, signal buses in the middle, and ground buses at the bottom. With high-frequency circuits, be sure those ground buses are handy, since you'll want to run bypass capacitors with short leads directly to them. And speaking of bypassing, remember that leads to and from the socket can sometimes pick up stray signals, so you might want to bypass power lines to ground right where they connect. ■

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# 101 ELECTRONIC PROJECTS

## 1 Moose Call

□ If "Hey, Bullwinkle" is your idea of a moose call, you're in for a surprise. The little circuit diagrammed here produces deep, resonant grunts and bellows when used in conjunction with a PA or stereo amp. Q1, a programmable unijunction transistor (PUT) functions as a relaxation oscillator. The sawtooth voltage produced across capa-

ditor C1 is buffered by Q2 and fed through level control R6 to the output jack. The signal at J1 has a peak-to-peak amplitude of about 1.5-volts, which can be fed into the TUNER or AUX inputs of your amp.

To use the device, manipulate pitch control R3 and level control R6 in unison. During the sound's attack per-

iod, rotate R3 to boost the pitch as the level increases. During decay, let the pitch drop. The circuit is also capable of realistic imitations of horns of all kinds; just remember that a horn's attack is usually much more abrupt than its decay. Finally, apartment dwellers should note that this circuit attracts police as well as moose.

### PARTS LIST FOR MOOSE CALL

B1—9-volt transistor battery

C1—0.39- $\mu$ F, 25-VDC mylar capacitor

C2—1.0- $\mu$ F, 25-VDC non-polarized mylar capacitor

J1—RCA-type phono jack

Q1—2N6027 programmable unijunction transistor

Q2—2N3904 NPN transistor

Note: All resistors rated  $\frac{1}{2}$ -watt, 10% tolerance unless noted otherwise.

R1—3,000-ohms

R2—1,200-ohms

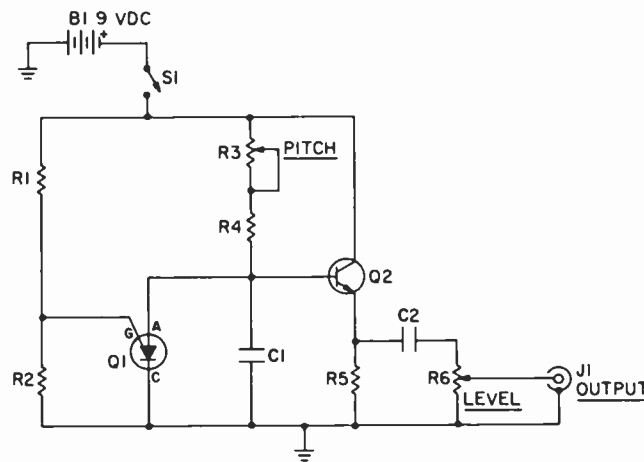
R3—100,000-ohm linear-taper potentiometer

R4—33,000-ohms

R5—10,000-ohms

R6—10,000-ohm linear-taper potentiometer

S1—SPST toggle switch



## 2 Shaped Output Code Oscillator

□ Most code-practice oscillators are keyed by switching the oscillator transistor's supply voltage on and off or by driving the transistor into and out of saturation. This has the advantage of being simple, and it provides tolerable results if a speaker is to be driven.

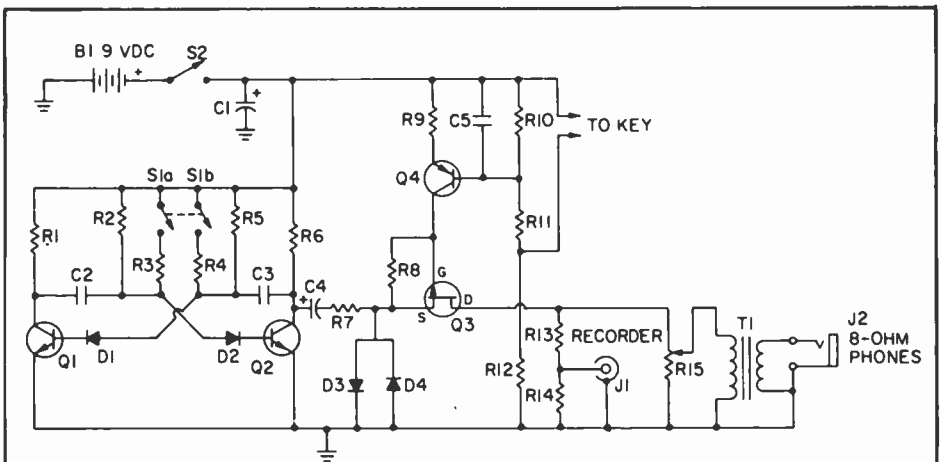
However, the sound of a CPO is like Chinese water torture to the uninitiated, so public opinion usually dictates that you practice with headphones. What you hear then is the "kerchunk" that occurs each time the key is opened or closed. If you want a nice, pure tone

signal devoid of "kerchunks," you have to shape the rise and decay of the tone. Here's a circuit that does just that.

The basic tone is generated by a multivibrator (Q1 & Q2) at a pitch determined by S1; low pitch with S1 open, high with S1 closed. This tone

is fed through C4 to a clipper (D1, D2) and FET Q3, which functions as a signal attenuator. How much of a signal passes through the FET is determined by its gate potential, controlled by current source Q4 together with capacitor C5, the associated resistors, and your key. With the key down, the signal from Q3's drain is available for recording (J1) and for headphone listening (J2). R15 controls the volume.

Smaller values of C5 will yield a more abrupt attack and decay, while larger values can be used to produce mellow results. If you cannot find a 2N3994 FET for Q3, substitute a 2N5461. The great majority of these will work fine, but if you still hear a tone with the key up, try a different 2N5461.



**PARTS LIST FOR  
CODE OSCILLATOR**

- B1**—9-volt transistor battery
- C1**—220- $\mu$ F, 25-VDC electrolytic capacitor
- C2, C3**—0.22- $\mu$ F, 25-VDC mylar capacitor
- C4**—2.2- $\mu$ F, 10-VDC tantalum capacitor
- C5**—0.22- $\mu$ F, 25-VDC mylar capacitor
- D1, D2, D3, D4**—1N914 diode
- J1**—RCA-type phono jack
- J2**—standard 2-conductor phone jack

- Q1, Q2, Q4**—2N3904 NPN transistor
- Q3**—2N3994 or 2N5461 p-channel JFET (junction field-effect transistor)
- Note:** All resistors rated  $\frac{1}{2}$ -watt, 5% tolerance unless otherwise noted.
- R1, R6**—1,000-ohms
- R2, R3, R4, R5, R8, R10**—56,000-ohms
- R7**—4,700-ohms

- R9**—22,000-ohms
- R11**—33,000-ohms
- R12**—82,000-ohms
- R13**—51,000-ohms
- R14**—22-ohms
- R15**—1,000-ohm audio-taper potentiometer
- S1**—DPST slide switch
- S2**—SPST toggle switch
- T1**—1,000-ohm to 8-ohm audio transformer

## 3 Zener Diode Tester

□ If you're at all familiar with the surplus market, you know that zener diodes presently abound in surplus—at tremendous discounts, too. The problem with buying surplus, however, is that many diodes are unmarked or incorrectly marked. Consequently, these must be tested to verify their working voltages. Another problem crops up when you buy so-called "grab bags" of

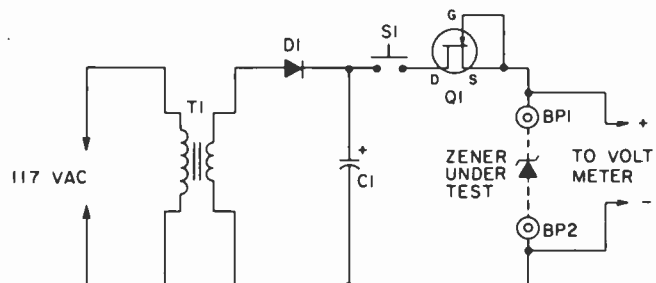
components. The zeners you find may be legibly marked, but unless you happen to have a data sheet for those particular diodes, they will require testing to identify the zener voltages. You can do your testing quickly and easily with the circuit presented here.

T1, D1 and C1 comprise a simple half-wave rectifier system. Pressing S1 sends a DC current through current

limiter Q1 and the diode under test. Q1 regulates the current to a value of about 10 mA regardless of the zener voltage. You can use your VOM or voltmeter to monitor the voltage drop across the zener; values as high as 25-volts can be reliably tested in this circuit. If you get a very low reading, say 0.8-volts, you have the diode in reverse. Interchange the zener's connections.

**PARTS LIST FOR ZENER  
DIODE TESTER**

- BP1, BP2**—binding posts
- C1**—500- $\mu$ F, 50-VDC electrolytic capacitor
- D1**—1N4002 diode
- Q1**—2N5363 n-channel JFET (junction field effect transistor)
- S1**—normally open SPST push-button switch
- T1**—120-VAC to 24-VAC @ 300-mA power transformer



# 4 Fluid Detector

For those of you anticipating the melting of the polar ice caps, we present a handy device to warn you of the deluge. Many other useful, though less dramatic, applications should be obvious as well. Basically, this a circuit capable of detecting the presence of any ionic fluid, that is, any fluid that can conduct an electrical current. Ultra-pure water will not be detected

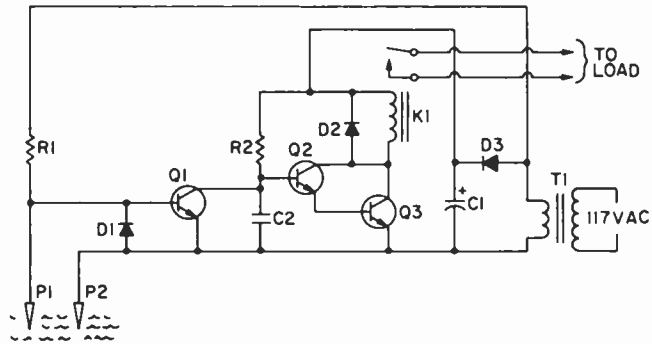
because so few ions exist that scarcely any current can flow. However, the water that seeps into your cellar, the water that overflows from your washing machine and most aqueous solutions are all readily detectable.

With no fluid between the probes, AC current flows through R1 into Q1's base, turning the transistor on at a 60 Hz rate. C2 filters the signal at Q1's

collector to a low DC potential. Should the probes be immersed, base current is shunted away from Q1 by the fluid's resistance. Consequently, Q1's collector potential rises, thereby turning on the Q2-Q3 Darlington pair. This causes K1 to pull in and turn on a pump or whatever load you attach. Because only a small AC voltage exists between the probes, no troublesome plating occurs

### PARTS LIST FOR FLUID DETECTOR

- C1—500- $\mu$ F, 25-VDC electrolytic capacitor
- C2—0.5- $\mu$ F, 25-VDC mylar capacitor
- D1, D2, D3—1N4002 diode
- K1—relay with coil rated 6-VDC @ 250 to 500-ohms, with SPST contacts
- P1, P2—stainless steel or aluminum probes
- Q1, Q2, Q3—2N3904 NPN transistor
- R1—300,000-ohm, 1/2-watt, 5% resistor



- R2—470,000-ohm, 1/2-watt, 5% resistor

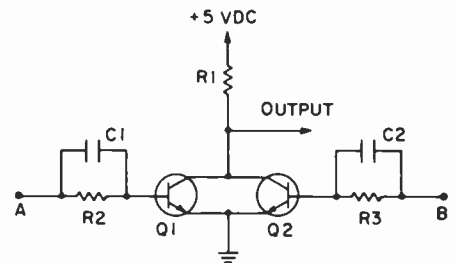
- T1—120-VAC to 6.3-VAC @ 300-mA power transformer

# 5 Basic NOR Gate

Integrated logic is certainly a wonderful thing, but we often lose sight of how logical operations are performed when dealing with integrated devices. The circuit diagrammed here is a throwback to pre-IC days when all logic was implemented with discrete devices (resistors, transistors and diodes for the most part). This NOR gate is typical of the circuitry used. Whenever base drive is applied to either input A or input B, the output drops to a low potential. If desired, extra inputs could be added simply by adding more transistors and tying their collector terminals to R1. In high-speed applications, capacitors C1 and C2 could be added to speed up switching of the

### PARTS LIST FOR BASIC NOR GATE

- C1, C2—optional (see text)
- Q1, Q2—2N3904 NPN transistor
- R1—1,000-ohm, 1/2-watt resistor, 5%
- R2, R3—10,000-ohm, 1/2-watt resistor, 5%



transistors, but for clock rates of less than 1 MHz or so, you can forget about the capacitors. Generally, if speed-up capacitors were to be used, their values would have to be determined experimentally with a 'scope.

Is this circuitry just a museum piece? Definitely not. Try it the next time you need something strange like a 6-input NOR or when there are no ICs at hand. With the values shown, this NOR gate interfaces directly with TTL circuitry.

# 6 General Purpose Pulser

Here is a simple pulse generator that can be useful in a variety of applications, from audio to logic. The heart of the circuit is the familiar UJT (uni-junction transistor) relaxation oscil-

lator, Q1. Potentiometer R1 adjusts the repetition rate over a range of one decade, while range switch S1 allows selection of one of four decade ranges. The total range of adjustment goes

from 0.5 ppS (pulses per second) to 5000 ppS, which is more than enough for most purposes. Voltage spikes across resistor R4 are amplified and "squared up" by transistor Q2. The

output consists of 5-volt-high pulses that may be used to drive TTL, CMOS (if a 5-volt supply is used) or an audio circuit (in which case, you can couple

the pulses through a 1.0- $\mu$ F capacitor).

Range "A" is slow enough to be useful when breadboarding logic circuitry, since slow clocking allows you to ob-

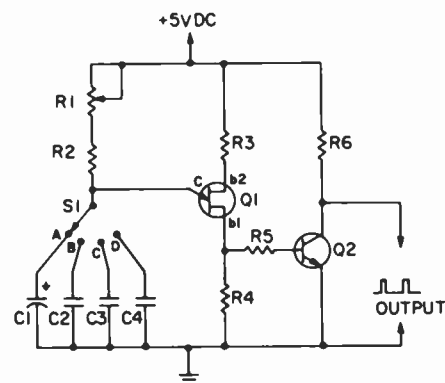
serve circuit operation easily. If you attach a wire lead to the output and set S1 to range "D", you can generate harmonics up to several MHz.

### PARTS LIST FOR GENERAL PURPOSE PULSER

- C1—15- $\mu$ F, 10-VDC tantalum capacitor
- C2—1.5- $\mu$ F, 25-VDC non-polarized mylar capacitor
- C3—0.15- $\mu$ F, 25-VDC mylar capacitor
- C4—0.015- $\mu$ F, 25-VDC mylar capacitor
- Q1—2N2646 unijunction transistor
- Q2—2N3904 NPN transistor
- Note: All resistors rated 1/2-watt, 5% tolerance unless otherwise noted.

- R1—25,000-ohm linear-taper potentiometer
- R2—2,700-ohms
- R3—470-ohms
- R4—47-ohms
- R5—100-ohms
- R6—1,000-ohms
- S1—single pole, 4-position rotary switch

RANGE	FREQUENCY
A	0.5 to 5 Hz
B	5 to 50 Hz
C	50 to 500 Hz
D	500 to 5,000 Hz



## 7 MOS-to-TTL Logic Interface

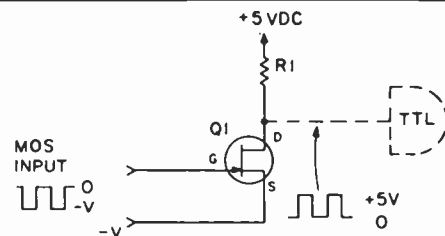
Here is a problem encountered from time to time by the advanced computer hobbyist: How do you mate the signals from MOS logic (the foundation of many microprocessor and peripheral ICs) to TTL logic (the most convenient and readily available logic form from which to construct add-on circuitry)? The problem stems from the fact that MOS signals swing between ground and some negative voltage ( $-V$  in the diagram), while signals for TTL should swing from ground to something greater than +2.8-VDC (+3.5-VDC usually). One of the easiest solutions requires just one resistor and one n-channel field effect transistor. Note that

Q1's source (S) lead goes to the negative supply potential of the MOS circuitry, and its gate (G) gets driven by the MOS input signal. TTL loads can be driven directly by the output signal available at Q1's drain (D). Finally, note that R1 is tied to the +5-VDC TTL supply and that the

level-shifted output signals have been inverted: negative-going input pulses swing positive at the output, and vice versa. The circuit works well at data transmission rates less than 1 or 2 MHz. To interface faster clock signals or very abrupt pulses, use one of the commercially available level-shifter ICs.

### PARTS LIST FOR MOS-TO-TTL LOGIC INTERFACE

- Q1—2N3971 n-channel JFET (junction field effect transistor)
- R1—2,200-ohm, 1/2-watt resistor, 5%



## 8 Constant Current Ohms Adapter

Ever notice how confusing it is to read the OHMS scales on your multimeter? The numbers are so crowded together at the high end that meaningful readings are almost impossible to make. Top-of-the-line meters get around the problem by employing a constant-current source, and so can you with this adapter. You'll be able to read resistances accurately and unambiguously on the linear voltage scales of your meter.

In the schematic, note that the resistor under test is tied between BP1 and BP2. Whenever S2 is pressed, a regu-

lated current flows out of Q1's collector and through the resistor. By Ohm's Law, this current generates a voltage across the resistor that's directly proportional to its resistance. Any one of five test currents—from 10-mA to 0.001-mA—can be selected via S1.

To calibrate the test currents, hitch a multimeter to the adapter's output terminals; make sure the meter is set to measure current. Press S2 and adjust the trimmers one at a time to obtain the five required currents. No resistor should be connected to BP1 and BP2 during calibration.

When measuring resistance, use the following conversion formula:

$$\text{RESISTANCE (kilOhms)} = \frac{\text{VOLTAGE}}{\text{CURRENT (mA)}}$$

For example, a resistor that produces a 7.56-volt reading when fed a current of 0.01-mA must have a resistance of 756-kilOhms (756K). Use smaller currents with larger resistances, and don't exceed a level of 10-volts during testing. If you do, switch S1 to the next smaller current. Finally, for best ac-

curacy, make sure that the input resistance of your meter is much greater

than that of the resistor under test. With a 10-megOhm meter, the resistor

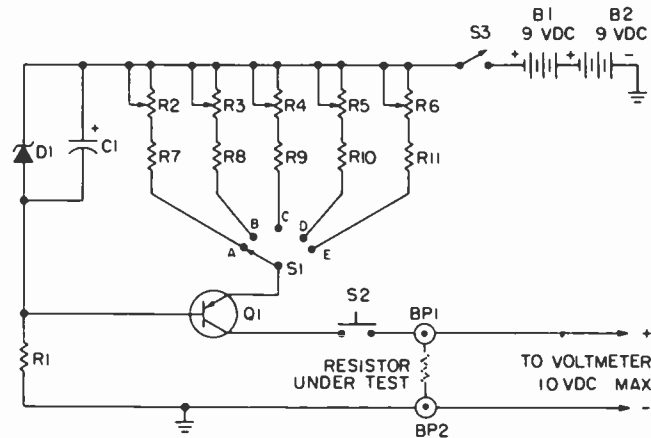
under test should be no larger than 1-megOhm to keep errors under 10%.

### PARTS LIST FOR CONSTANT CURRENT OHMS ADAPTER

- B1, B2**—9-volt transistor battery  
**BP1, BP2**—binding posts  
**C1**—10- $\mu$ F, 20-VDC tantalum capacitor  
**D1**—1N748A, 3.9-volt,  $\frac{1}{2}$ -watt zener diode  
**Q1**—2N3676 PNP transistor  
**Note:** All resistors rated  $\frac{1}{2}$ -watt, 5% tolerance unless otherwise noted.  
**R1**—2,200-ohms  
**R2**—100-ohm trimmer potentiometer  
**R3**—1,000-ohm trimmer potentiometer  
**R4**—10,000-ohm trimmer potentiometer  
**R5**—100,000-ohm trimmer potentiometer  
**R6**—1,000,000-ohm trimmer potentiometer

- R7**—270-ohms  
**R8**—2,700-ohms  
**R9**—27,000-ohms  
**R10**—270,000-ohms  
**R11**—2,700,000-ohms  
**S1**—single pole, 5-position rotary switch  
**S2**—normally open SPST pushbutton switch

**S3**—SPST toggle switch



RANGE	CURRENT
A	10 mA
B	1 mA
C	0.1 mA
D	0.01 mA
E	0.001 mA

## 9 Low Pass Audio Filter

□ If you own an old inexpensive receiver, chances are it could use a little extra selectivity. In that case, you should consider adding a filter. You could add an IF filter, but it's probably easier, and certainly less expensive, to tack on the simple low-pass audio filter diagrammed here. With the constants shown, it has a corner frequency of 1000 Hz—perfect for CW (code) reception. For voice, reduce the values of R5, R6, R9 and R10 to 1200-ohms. The filter's voltage gain is unity (1) so it won't upset things no matter where you insert it. Input impedance is about 30K-ohms—high enough to cause negligible loading.

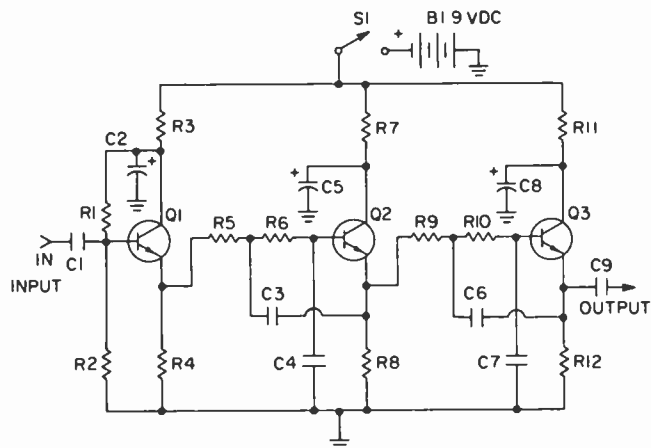
To install the filter, break into the receiver's audio chain at some convenient point—preferably at a point where the audio voltage is small, say, 1-volt peak-to-peak or less. You may wish to include a bypass switch, too. This will allow you to shunt the signal around the filter and restore the original performance of the receiver.

- B1**—6 to 12-volt battery  
**C1, C3, C6**—0.1- $\mu$ F, 25-VDC mylar capacitor

- C2, C5, C8**—22- $\mu$ F, 20-VDC tantalum capacitor  
**C4, C7**—0.02- $\mu$ F, 25-VDC mylar capacitor  
**C9**—1.0- $\mu$ F, 25-VDC non-polarized mylar capacitor  
**Q1, Q2, Q3**—2N3391 NPN transistor  
**Note:** All resistors rated  $\frac{1}{2}$ -watt,

### PARTS LIST FOR LOW PASS AUDIO FILTER

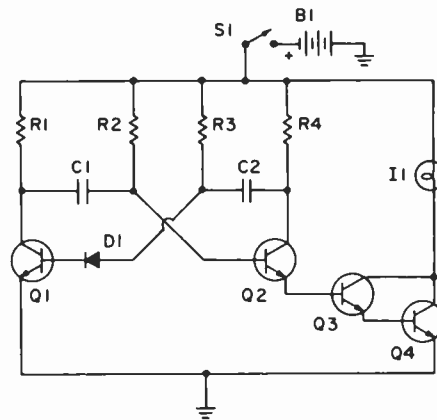
- 5% tolerance unless otherwise noted.  
**R1**—56,000-ohms  
**R2**—100,000-ohms  
**R3, R7, R11**—100-ohms  
**R4, R8, R12**—1,800-ohms  
**R5, R6, R9, R10**—3,000-ohms  
**S1**—SPST toggle switch





# 10 Portable Emergency Flasher

□ For camping or highway emergencies, here is a solid-state light flasher that's compact and reliable. Q1, Q2 and the associated resistors and capacitors comprise a conventional 2-transistor multivibrator. Q2's emitter signal drives the Q3-Q4 Darlington pair, which turns on high-current lamp I1. The light flashes on for about 0.4-second, then darkens for about the same period of time before turning on again. Power for the circuit comes from a standard 6-volt lantern battery. You could probably build the entire flasher circuit inside the housing of your lantern, and actuate it only when necessary. If longer battery life is desired, and decreased illumination is acceptable, you could substitute a less power-hungry 6-volt lamp for I1.



**PARTS LIST FOR PORTABLE EMERGENCY FLASHER**

**B1**—6-volt lantern (heavy-duty) battery  
**C1, C2**—1.0- $\mu$ F, 25-VDC non-polarized mylar capacitor  
**D1**—1N4002 diode

**I1**—#82 lamp rated 6.5-VDC @ 1-amp  
**Q1, Q2, Q3**—2N3904 NPN transistor  
**Q4**—2N3724A NPN transistor

**R1, R4**—10,000-ohm, 1/2-watt resistor, 5%  
**R2, R3**—390,000-ohm, 1/2-watt resistor, 5%  
**S1**—SPST toggle switch

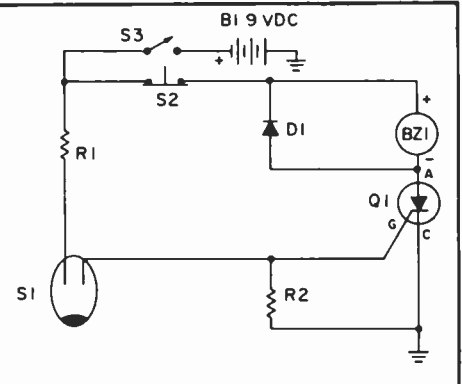
# 11 Equipment Theft Alarm

□ As an electronics hobbyist, you very likely own one or more pieces of expensive equipment, and these can be very tempting targets for thieves or vandals. To protect your investment, why not install the simple alarm pictured here in some of your more valuable possessions? Things like Amateur or CB transceivers, computers, oscilloscopes and stereo equipment are all excellent candidates.

In the schematic, mercury switch S1 is normally open. However, should the equipment in which the alarm has been installed be picked up and tilted, S1 closes and thereby supplies gate current to the SCR, Q1. Q1 then latches in a conducting state, causing current to

**PARTS LIST FOR EQUIPMENT THEFT ALARM**

**B1**—6, 9, or 12-volt battery  
**BZ1**—6, 9, or 12-volt buzzer  
**D1**—1N4002 diode  
**Q1**—2N5060 SCR  
**R1, R2**—4,700-ohm, 1/2-watt resistor  
**S1**—normally open SPST mercury switch  
**S2**—normally closed pushbutton switch  
**S3**—SPST toggle switch



flow through buzzer BZ1. The buzzer will sound until pushbutton S2 is pushed to reset the circuit. For best

results, use an electromechanical, rather than piezoelectric buzzer, since it will emit more noise.

# 12 Vari-Rev Motor Control

□ Old universal appliance motors and shaded-pole induction motors salvaged from inexpensive turntables can be easily converted to slow-speed hobby drills, chemical stirrers, vari-

speed turntables, moveable display drives, etc. It's done with a full-wave Triac speed controller.

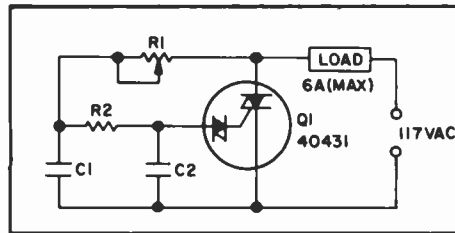
Unlike other speed controllers, which require an external trigger de-

vice, Q1 combines both the Triac and Diac trigger diodes in the same case.

The motor used for the load must be limited to 6 amperes maximum (or 740 watts). Triac Q1 must be

provided with a heat sink, which can be the metal cabinet. Build up a marblesize mound of epoxy on the cabinet and insert Q1's case into the epoxy. When the epoxy hardens the Triac's heat is dissipated to the cabinet. Make certain Q1's case is not shorted to the cabinet and is insulated by the epoxy.

With the component values shown



#### PARTS LIST FOR VARI-REV MOTOR CONTROL

- C1, C2—0.1- $\mu$ F, 200-VDC capacitor
- Q1—RCA 40431 Triac-Diac
- R1—100,000-ohm linear taper potentiometer
- R2—10,000-ohm, 1-watt resistor

on the parts list, the Triac controls motor speed from full off to full on.

## 13 Capacitance Oscillator

□ If you own a triggered-sweep oscilloscope or a frequency counter capable of making period measurements, you can use this PUT (programmable uni-junction transistor) oscillator to measure capacitance. The practical range of measurement extends from 100-pF to about 10 $\mu$ F—wide enough to cover most of your measurement needs.

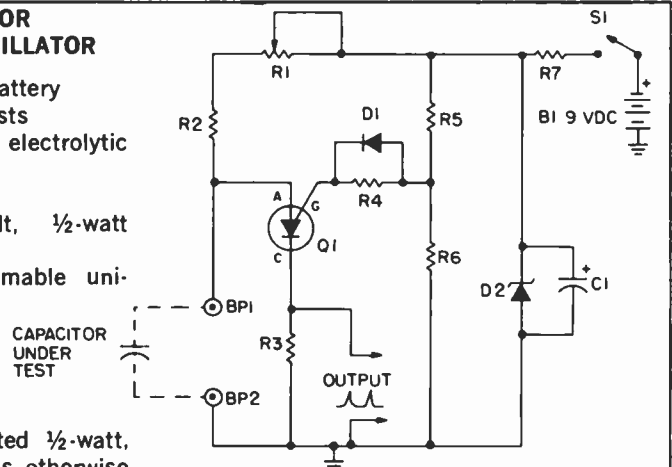
With an unknown capacitor connected across the binding posts, measure the time interval between output pulses on your scope or frequency counter. To convert time to capacitance, use the relationship:

$$\text{CAPACITANCE } (\mu\text{F}) = 10 \times \text{TIME}$$

For instance, a reading of 100-microseconds (.0001-sec.) indicates a capacitance of .001- $\mu$ F (or 100-pF). (NOTE: 1- $\mu$ F = 1,000,000-pF). To calibrate the oscillator, hook a 1000-pF polystyrene capacitor across the binding posts, and adjust R1 until the time between output pulses is exactly 100-microseconds.

#### PARTS LIST FOR CAPACITANCE OSCILLATOR

- B1—9-volt transistor battery
- BP1, BP2—binding posts
- C1—100- $\mu$ F, 10-VDC electrolytic capacitor
- D1—1N914 diode
- D2—1N752A, 5.6-volt, 1/2-watt zener diode
- Q1—2N6027 programmable uni-junction transistor



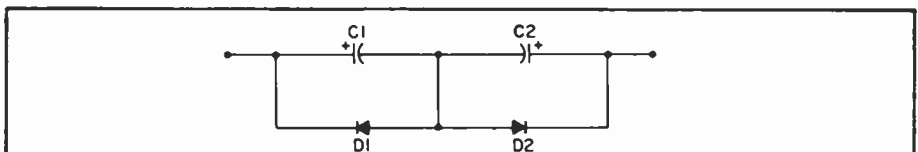
Note: All resistors rated 1/2-watt, 5% tolerance unless otherwise noted.

- R1—200,000-ohm trimmer potentiometer
- R2—390,000-ohms
- R3—22-ohms
- R4—1,000,000-ohms
- R5, R6—2,200-ohms
- R7—560-ohms
- S1—SPST toggle switch

## 14 Home Made NPO Capacitor

□ From time to time, all of us encounter circuits that require large, non-polarized capacitors. Unfortunately, these are scarcer than the proverbial hen's teeth. Looking through some catalogs, you'll soon discover that capacitors larger than 10- $\mu$ F are usually electrolytics, which are polarized devices. Electrolytic capacitors cannot be used in AC circuits, where the voltage undergoes periodic reversals in polarity. Such reversals destroy the insulating layer between the plates of an electrolytic capacitor, and the device soon fails.

So what can be done when you need a non-polarized capacitor for a hi-fi crossover or a motor-starting circuit, and all that you can find are electrolytics? One alternative is to get some aluminum foil and roll your own, but there's an easier way. Just hook two



#### PARTS LIST FOR HOME MADE NPO CAPACITOR

- C1, C2—identical electrolytic capacitors
- D1, D2—identical silicon rectifiers

Note: Be sure to match voltage ratings of rectifiers and capacitors.

electrolytics back-to-back as we've diagrammed here, then add two current-steering diodes. These diodes ensure that each capacitor sees only voltage of the correct polarity. C1 and C2 should be identical, and each one should have a capacitance equal to the

value needed for proper circuit operation. Make sure that the capacitors have working voltages equal to about three times the RMS value of the AC voltage in the circuit. Also, choose diodes having a PIV rating greater than or equal to the capacitor's rating.

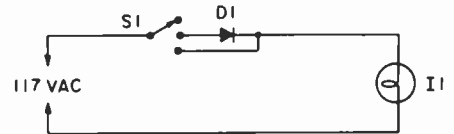
# 15 Photoflood Dimmer #1

□ If you dabble in photography, you know that in addition to natural light, there are two other light sources available: flash or photoflood. Flash units are very popular because of their speed, which allows action to be captured, and their portability. However, it's extremely difficult to visualize a shot with flash because the light appears only at the instant of exposure. High-intensity photofloods, on the other hand, are on continuously; therefore, the photographer can readily compose a shot, paying attention to details such as evenness of illumination across the field and shadow placement.

As the photofloods burn, however, they generate a great deal of heat, which can be discomforting both to the photographer and the subject. In addition, it's wasteful of the photo-

## PARTS LIST FOR PHOTOFLOOD DIMMER

- D1—1N5404 rectifier rated 400 PIV @ 3-amps
- I1—EBV No. 2 500-watt photoflood lamp
- S1—single pole, 3-position switch with contacts rated 10-Amps @ 120 VAC



flood lamp's already limited lifetime (about 8 hours for an EBV No. 2) to have it on any longer than absolutely necessary. You can use this simple dimmer to cut down the lamp's intensity during composition, thereby reducing the heat generated and extending the lamp's useful life. With S1 in its

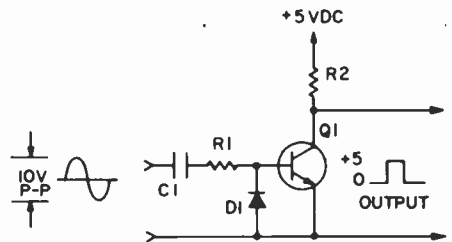
middle position, power to the lamp is cut in half because of rectifier D1. When you're ready to expose, flip S1 to full power. NOTE: On half-power, the lamp's color balance is shifted toward the red, so be careful not to make exposures at half-power with color film.

# 16 Square Wave Converter

□ Got a yen to go digital but few bucks to spend? Well, if you happen to have an old audio signal generator at hand, you can convert its sinewave output to a squarewave and save yourself the expense of a squarewave generator. The converter consists of an ordinary saturating transistor switch which, when driven by a large amplitude (about 10-VDC peak-to-peak or greater) sine-wave, yields squarewaves with reasonably fast rise and fall times. Be certain to use as large an input amplitude as possible. Certain edge-triggered ICs,

## PARTS LIST FOR SINE-TO-SQUARE WAVE CONVERTER

- C1—1.0- $\mu$ F, 25-VDC non-polarized mylar capacitor
- Q1—2N3904 NPN transistor
- R1—4,700-ohm, 1/2-watt resistor, 5%
- R2—1,000-ohm, 1/2-watt resistor, 5%



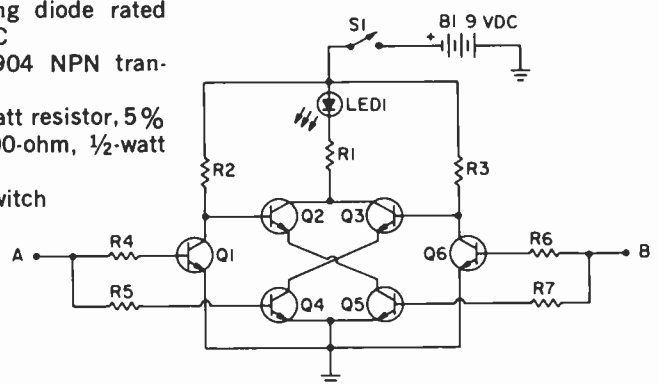
TTL flip-flops in particular, may fail to clock on a waveform whose rise and fall times are too long; however, the

majority of ICs will clock readily when driven by this converter.

# 17 The Brain Teaser

□ Ordinarily, we tell you how the circuit works, but this time the tables are turned. Your job is to figure how to make LED1 light by applying the correct combination (or combinations) of input signals to points A and B. Signals must be either +9-VDC or 0-VDC (gnd). Check your answer by breadboarding the circuit; then, present this quiz to a friend. (HINT: You must consider *four* possible combinations.)

- LED1—light emitting diode rated 20mA @ 1.7-VDC
- Q1 thru Q6—2N3904 NPN transistor
- R1—330-ohm, 1/2-watt resistor, 5%
- R2 thru R7—22,000-ohm, 1/2-watt resistor, 5%
- S1—SPST toggle switch



## PARTS LIST FOR THE BRAIN TEASER

- B1—9-volt transistor battery

# 18 EVM Timing Adapter

□ If, like many other experimenters, you own an electronic voltmeter—VTVM, FETVM or whatever—you might like to try this timely circuit. Connected to a high-impedance voltmeter set to read 10-volts DC full-scale, the adapter permits the measurement of time intervals up to 100-seconds long. Either analog or digital readouts are acceptable, although digital meters do have an edge as far as resolution is concerned. To convert voltage to time in seconds, just multiply by ten.

Referring to the schematic, it is apparent that when TIME button S1 is pressed, constant-current source Q1 will begin to charge timing capacitor C1. Since charging is being done by a constant current, the voltage across C1 rises linearly with time. Once S1 is released, the voltage on C1 remains "frozen" long enough for you to take

**PARTS LIST FOR  
EVM TIMING ADAPTER**

**B1, B2**—9-volt transistor battery  
**C1**—10- $\mu$ F, 20-VDC tantalum capacitor  
**D1**—1N748A 3.9-volt, 1/2-watt zener diode  
**D2**—1N759A 12-volt, 1/2-watt zener diode  
**Q1**—2N3906 PNP transistor  
**R1**—2,700-ohm, 1/2-watt resistor, 5%  
**R2**—10,000-ohm trimmer potentiometer  
**R3**—27,000-ohm, 1/2-watt resistor, 5%  
**R4**—100-ohm, 1/2-watt resistor, 5%

**S1, S2**—normally open SPST push-button switch  
**S3**—SPST toggle switch

a reading. Press S2 to discharge C1 before taking another measurement.

Trimmer R2 can be adjusted so that 10-volts is reached in 100 seconds.

# 19 Phototachometer Adapter

□ If you own a frequency counter, you can use this nifty little circuit to measure the rate of rotation of motors, fans and anything else that revolves and can break a beam of light. In the accompanying schematic, you can see that light from the bulb is chopped by the rotating fan blades. This chopped light beam then falls on the light-sensitive face of phototransistor Q1. Transistor Q2 amplifies the photocurrent from Q1's emitter to yield a rectangular waveform approximately 9-volt in amplitude at the output. Naturally, the frequency of the output is related to the fan's speed of rotation.

RPM = 
$$\frac{\text{Freq. (Hz)} \times 60}{\# \text{ of beam interruptions per second}}$$

**PARTS LIST FOR  
PHOTOTACHOMETER ADAPTER**

**B1**—9-volt transistor battery  
**Q1**—FPT-100 phototransistor (or equiv.)  
**Q2**—2N3904 NPN transistor  
**R1**—10,000-ohm, 1/2-watt resistor, 5%  
**S1**—SPST toggle switch

Suppose we obtain a frequency reading of 100 Hz with the 3-bladed fan illustrated here. Obviously, there are 3 interruptions per revolution. The actual speed is therefore 2000 RPM. For best results, mount Q1 in a small, hollow

tube (an old pen barrel, for example) with its light-sensitive face recessed with respect to one end. This will ensure that only the chopped beam strikes the phototransistor.

# 20 Low-Power Dummy Load

□ For transmitter tune-up and testing, you need some sort of dummy load. As far as your transmitter is concerned, the dummy load looks just like a normal 50-ohm antenna. However, with a dummy load, almost all of the transmitter's output power is dissipated as heat rather than being radiated as RF. This makes little difference to the transmitter itself, but it makes a world of

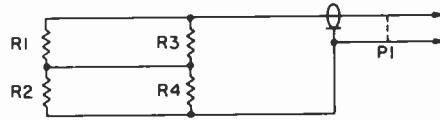
difference to nearby Amateurs or CB-ers because they don't have to contend with the interference generated as you fiddle with your transmitter.

Dummy loads are available commercially, but the Amateur QRP (low-power) enthusiast or CB'er can easily and inexpensively build his own. All you need are four 50-ohm, 2-watt, carbon-composition resistors, a coax plug

and a minibox. (You must *not* use wirewound resistors, even though they are capable of handling more power than carbon resistors, because wirewounds exhibit too much inductance.) Keep the interconnecting wires as short as possible to minimize stray inductance and capacitance. Used on an intermittent basis, this dummy can safely handle about 15-watts.

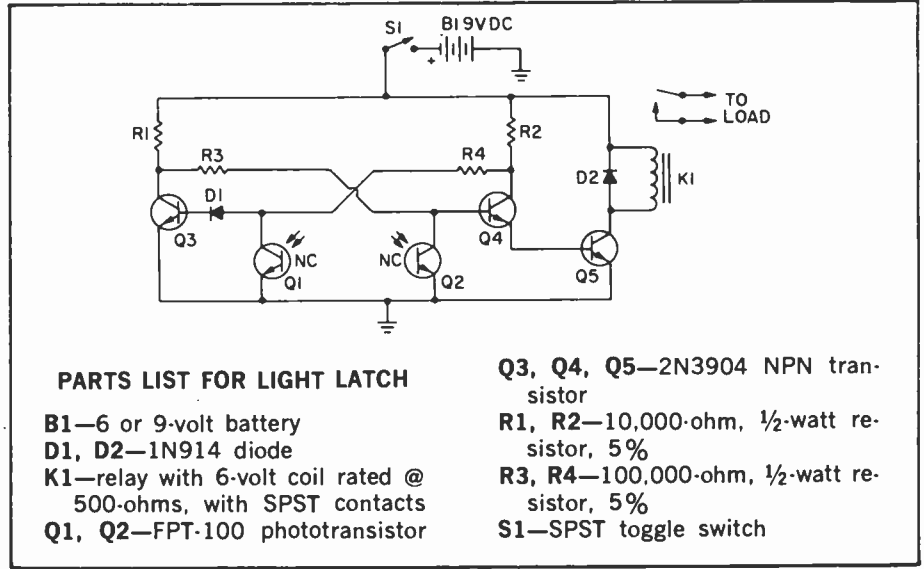
**PARTS LIST FOR  
LOW-POWER DUMMY LOAD**

- P1**—PL-259 coaxial plug  
**R1** thru **R4**—5-ohm, 2-watt carbon composition resistors



## 21 The Light Latch

Looking for a novel way to control electrical apparatus or appliances? Here's a bright idea: Why not use a beam of light? This little light latch can be readily actuated by a flashlight beam and is capable of controlling as much current as your relay's contacts will allow (1 to 3-Amps, typically). When phototransistor Q1 is momentarily illuminated, relay K1 is latched in its closed position and your appliance is ON. To turn your load OFF, shine a beam of light briefly on Q2's light-sensitive face. Feedback between Q3 and Q4 via R3 and R4 is responsible for the latching action. Be sure to mount phototransistors Q1 and Q2 so that room light does not fall on them. Recessing the phototransistors within small-diameter pieces of tubing is a good way to exclude extraneous light.



**PARTS LIST FOR LIGHT LATCH**

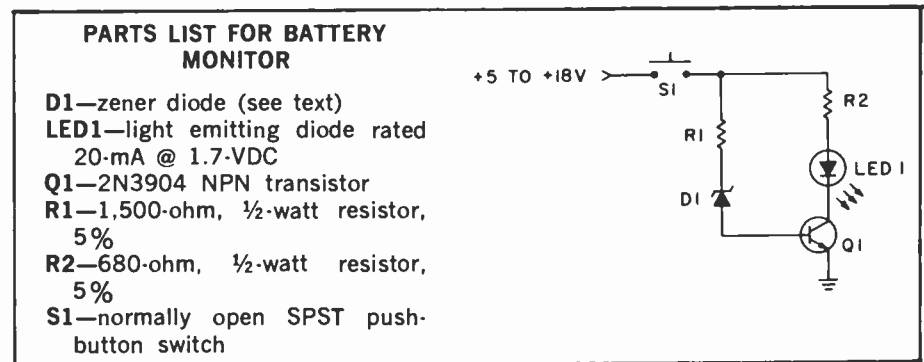
- B1**—6 or 9-volt battery  
**D1, D2**—1N914 diode  
**K1**—relay with 6-volt coil rated @ 500-ohms, with SPST contacts  
**Q1, Q2**—FPT-100 phototransistor

- Q3, Q4, Q5**—2N3904 NPN transistor  
**R1, R2**—10,000-ohm, 1/2-watt resistor, 5%  
**R3, R4**—100,000-ohm, 1/2-watt resistor, 5%  
**S1**—SPST toggle switch

## 22 Battery Monitor

Tired of playing guessing games with your batteries? With this battery-voltage monitor you'll know at a glance whether or not batteries need replacement. The circuit's compact size, which comes about because it's a meterless voltage monitor, makes it easy to build into an existing piece of equipment. To use the device, press S1 and, if LED1 lights up, your batteries are still good. If not, throw them away.

Transistor Q1's gain makes the monitor very sensitive to changes in voltage. Consequently, LED1 is either ON or OFF with little ambiguity most of the time. The voltage level being sensed is determined by zener diode D1's rating and the base-emitter voltage drop of Q1. Specifically, the switching point is equal to the zener voltage plus 0.75-



**PARTS LIST FOR BATTERY MONITOR**

- D1**—zener diode (see text)  
**LED1**—light emitting diode rated 20-mA @ 1.7-VDC  
**Q1**—2N3904 NPN transistor  
**R1**—1,500-ohm, 1/2-watt resistor, 5%  
**R2**—680-ohm, 1/2-watt resistor, 5%  
**S1**—normally open SPST push-button switch

volts. For example, a 5.6-volt zener diode will set the trip level at approximately 6.35-volts. The voltage level you choose should be less than the battery's nominal voltage when fresh. A 9-volt battery, for example, might be

useless when its voltage drops to 7.5-volts; however, the exact point at which a battery becomes useless depends both on the battery and on the application. Finally, it's best to test the battery with a normal load current being drawn

## 23 Simple Pulse Circuits

Need a source of pulses for your digital experimenting? If you already own a squarewave generator, here's a cheap and easy way to convert its out-

put to pulses. All you need are an R/C differentiating network and a rectifier diode. Circuit A gives you positive output pulses, while circuit B furnishes

negative pulses. Pulse duration, measured at a voltage level about one-third of peak value, is one-microsecond in both cases. If you want longer pulse

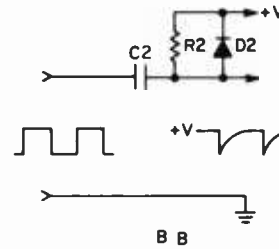
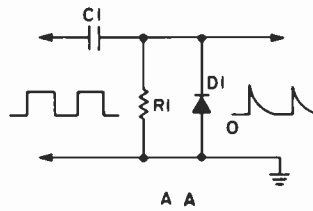
durations, simply increase the value of C1 or C2. When driven by a low-impedance squarewave generator, both

circuits are capable of clocking CMOS or TTL. The amplitude of the square-wave input should be about equal to

the supply voltage of the circuit being driven—5-volts for TTL, 5 to 15-volts for CMOS.

### PARTS LIST FOR SIMPLE PULSE CIRCUITS

- C1**—0.003- $\mu$ F, 35-VDC polystyrene capacitor
- C2**—0.001- $\mu$ F, 35-VDC polystyrene capacitor
- D1, D2**—1N914 diode
- R1**—330-ohm, 1/2-watt resistor, 5%
- R2**—1,000-ohm, 1/2-watt resistor, 5%



## 24 Solar-Powered Metronome

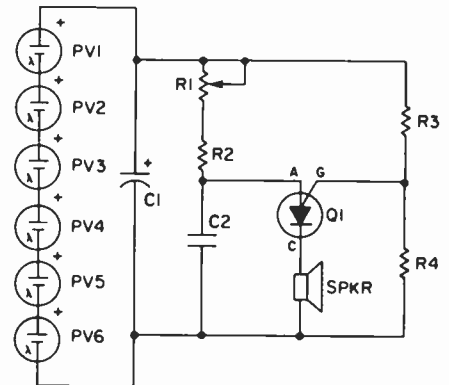
You'll never miss a beat because of dead batteries with this metronome. As long as there is a little sunlight or lamp-light to illuminate the silicon solar cells, the circuit will keep ticking away

merrily. The six series-connected solar cells provide a supply potential of 3-volts for the PUT relaxation oscillator. Potentiometer R1 can be adjusted to yield the desired pulse rate. Should you

wish to lower the output volume, a small resistor on the order of 10-ohms may be installed in series with the speaker.

### PARTS LIST FOR SOLAR-POWERED METRONOME

- |                                                                                   |                                                     |
|-----------------------------------------------------------------------------------|-----------------------------------------------------|
| <b>C1</b> —220- $\mu$ F, 25-VDC electrolytic capacitor                            | <b>R1</b> —2,000,000-ohm linear-taper potentiometer |
| <b>C2</b> —0.39- $\mu$ F, 25-VDC mylar capacitor                                  | <b>R2</b> —470,000-ohm, 1/2-watt resistor, 5%       |
| <b>PV1 thru PV6</b> —0.5-VDC silicon solar cells (Radio Shack #276-120 or equiv.) | <b>R3</b> —1,500,000-ohm, 1/2-watt resistor, 5%     |
| <b>Q1</b> —2N6027 programmable uni-junction transistor                            | <b>R4</b> —2,400,000-ohm, 1/2-watt resistor, 5%     |
|                                                                                   | <b>SPKR</b> —8-ohm PM miniature speaker             |



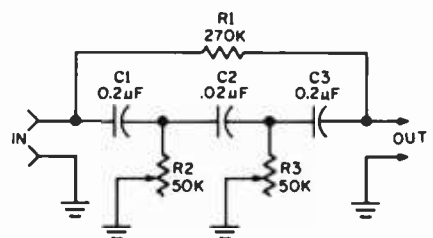
## 25 Record Restorer

Old 78-rpm collector's-item records cut back in the early days when performers sang in front of a large horn usually have a peak in the mid-band that drives the sound into your mind like a fingernail scratched across a blackboard. The overall sound quality is easily tamed, and made more natural and modern, by attenuating the shrill peaks with a Record Restorer, a device that suppresses, by hi-fi standards, the mid-band frequencies.

The Record Restorer should be assembled in a metal cabinet to prevent hum pickup. Connect the output of

### PARTS LIST FOR RECORD RESTORER

- C1, C3**—0.25- $\mu$ F mylar capacitor
- C2**—0.02- $\mu$ F mylar capacitor
- R1**—270,000-ohm, 1/2-watt resistor
- R2, R3**—50,000-ohm potentiometer, linear taper



your phonograph to the restorer input. Connect the output of the restorer to your tape recorder. Set potentiometer R2 to maximum resistance and adjust potentiometer R3 for

the most pleasing sound. If R3's adjustment is too little, or too much as evidenced by a "hole" in the sound quality, trim the restorer with R2 until you get the optimum equalization.

## 26 Three-Dial Combination Lock

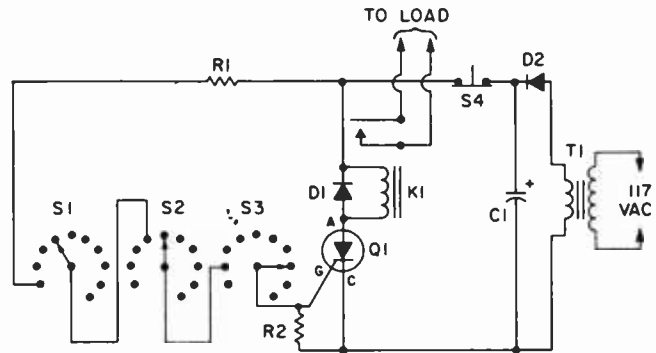
□ Here's an effective little combination lock that you can put together in one evening's time. To open the lock, simply dial in the correct combination on the three rotary or thumbwheel switches. With the correct combination entered, current flows through R1 into

Q1's gate terminal, causing the SCR to latch in a conductive state. This sends a current through relay K1, which responds by closing its contacts and actuating whatever load is attached. After opening the lock, twirl the dials of S1 through S3 away from

the correct combination so that nobody gets a look at it. The lock will remain open and your load will remain on because the SCR is latched on. To lock things up, it's only necessary to interrupt the flow of anode current through the SCR by pressing pushbutton S4.

### PARTS LIST FOR THREE-DIAL COMBINATION LOCK

- C1—500- $\mu$ F, 25-VDC electrolytic capacitor
- D1, D2—1N4002 diode
- K1—relay with 6-volt coil rated @ 250-ohms, with SPST contacts
- Q1—2N5050 SCR
- R1, R2—4,700-ohm,  $\frac{1}{2}$ -watt resistor, 5%
- S1, S2, S3—single pole, 10-position rotary or thumbwheel switches
- S4—normally closed SPST push-button switch
- T1—120-VAC to 6.3-VAC @ 300mA power transformer

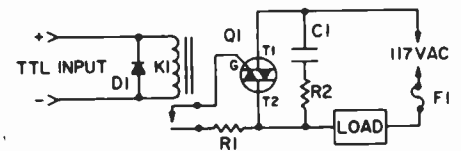


## 27 Microcomputer/AC Interface

□ Here's one of the simplest and best ways to harness your microcomputer for the purpose of appliance control. Let an output line drive relay K1, a small, 5-volt device designed expressly for TTL. The relay's contacts supply gate drive to Triac Q1 which, in turn, does the hard job of controlling the relatively large load current. Besides controlling the Triac, relay K1 also isolates the logic circuitry from the AC line. C1 and R2 prevent false turn on of the Triac with inductive loads, and F1 protects the Triac should the load short out. Of course, this circuit can be used to interface any type of logic circuit—not just a microcomputer—to the AC line.

### PARTS LIST FOR MICROCOMPUTER/AC INTERFACE

- C1—0.1- $\mu$ F, 50-VDC ceramic capacitor
- D1—1N4002 diode
- F1—3AG 10-amp fuse (fast-acting type only)
- K1—relay with coil rated 5-VDC @ 50-ohms, with SPST contacts (use  $\frac{1}{2}$  of Radio Shack part #275-215). Note: For very high speed switching applications, use a reed relay with similar specifications.



- Q1—Triac rated 200-volts @ 10-Amps (Motorola part #MAC11-4, Sylvania part #ECG5624)
- R1—1,000-ohm, 1-watt, 5% resistor
- R2—10-ohm, 1-watt, 5% resistor

## 28 Hi-Temp Alarm

□ Has a temperature-control problem got you hot under the collar? Well, this little temperature alarm/thermostat may be just the thing to cool you down. Temperature-sensing is done by thermistor RR5, a negative-temperature-

coefficient device whose resistance varies between 10K-ohms at 77° F, and about 1000-ohms at 200° F. Potentiometer R1 sets the exact temperature at which the Q1-Q2 Darlington pair gets turned on by the thermistor's

signal. Whenever ambient temperature rises above the alarm setting, the transistors conduct current through the buzzer, which then emits an attention-getting shriek.

Note that the thermistor must be

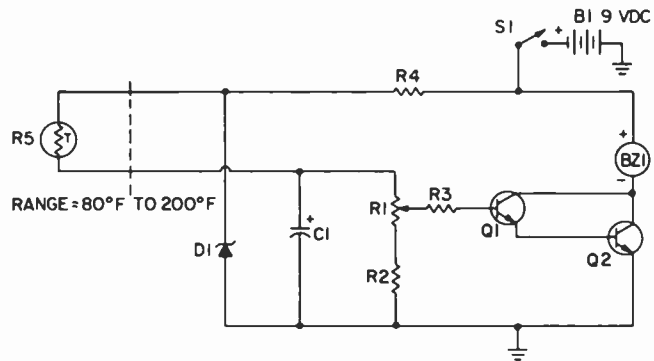
located away from the control circuitry—as indicated by the dashed line in the schematic—so that the operation of the

control circuit is not adversely affected by temperature extremes. If a 6-volt, 500-ohm relay is substituted for the buz-

zer, you get a thermostat capable of turning on a fan or turning off a small electric heater.

### PARTS LIST FOR HI-TEMP ALARM

- B1**—9-volt transistor battery
- BZ1**—9-VDC buzzer (Radio Shack #273-052)
- C1**—220- $\mu$ F, 10-VDC electrolytic capacitor
- D1**—1N752A, 5.6-volt,  $\frac{1}{2}$ -watt zener diode
- Q1, Q2**—2N3904 NPN transistor
- R1**—2,000-ohm trimmer potentiometer
- R2, R3**—1,000-ohm,  $\frac{1}{2}$ -watt, 5% resistor
- R4**—820-ohm,  $\frac{1}{2}$ -watt, 5% resistor
- R5**—thermistor rated 10,000-ohms @ 25°C (Fenwal part #RB41L1)
- S1**—SPST toggle switch



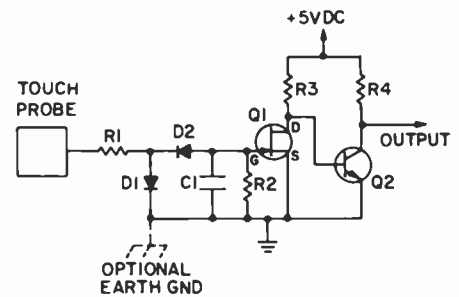
## 29 Simple Touch Switch

Looking for a way to add a touch of class to your digital projects? Try this touch switch. Not only does it add a note of distinction to a project, but it's bounce-free as well. Whenever a finger touches the contact plate, stray 60 Hz powerline interference is coupled into the circuit due to the antenna effect of your body. The 60 Hz pickup is rectified and filtered to provide a negative bias on Q1's gate, thus causing Q1 to turn off and Q2 to turn on. As a result, Q2's collector drops to ground potential. When the touch plate is released, the potential at Q2's collector terminal once again jumps high. You can use the output to drive either CMOS or TTL with ease.

Note that if you do your experimenting in a place devoid of 60 Hz powerline radiation—in the middle of a field

### PARTS LIST FOR SIMPLE TOUCH SWITCH

- C1**—0.1- $\mu$ F, 50-VDC ceramic capacitor
- D1, D2**—1N914 diode
- Q1**—2N5953 n-channel JFET (junction field effect transistor)
- Q2**—2N3904 NPN transistor
- Note:** All resistors rated  $\frac{1}{2}$ -watt, 5% tolerance unless otherwise noted.
- R1**—100,000-ohms
- R2**—22,000,000-ohms
- R3**—27,000-ohms
- R4**—1,000-ohms



TP—copper or aluminum touch plate

of wheat, for example—the circuit will not work. The average home is full of 60 Hz radiation, however, so the switch should function well. If you have some

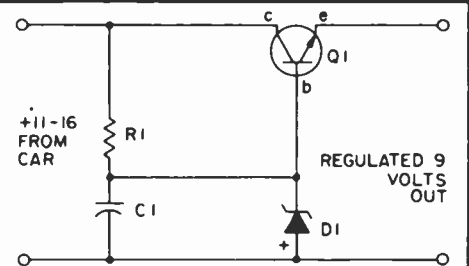
difficulty, connect your system's electrical ground to an earth ground (the screw on your AC outlet's cover plate). This will boost the signal pickup.

## 30 Cigar Lighter Power

When you want to run your radio or some other low-power 9 volt device in your car, here's a way you can do it and save on batteries. This is a simple shunt regulator using a 2N-2222 and 9.1 Volt Zener. With a 2N2222, you can power devices requiring as much as 800 ma; to drive devices requiring more current, use a

### PARTS LIST FOR CIGAR LIGHTER POWER

- C1**—100- $\mu$ F capacitor
- D1**—Zener diode, 9.1 V at  $\frac{1}{4}$ -watt equiv.
- Q1**—NPN transistor, 2N2222 or equiv.
- R1**—560-ohm resistor,  $\frac{1}{2}$ -watt





2N3055. With either device, unless the equipment you are driving is very low power, use a heat sink.

There are two easy ways to determine how much current your transistor radio or whatever draws (more to the point, whether or not the amount

of current it draws will necessitate heat sinking). One is to connect your VOM in series between one of the battery posts and its associated clip connector. You will want to check the *maximum* amount of current drawn. Another way is to connect

this circuit for only a few seconds and touch Q1 with your finger. If it gets too hot to hold your finger on, use a heat sink. You may want to use a heat sink in any case. You may also want to include a small fuse (try 1/2 amp).

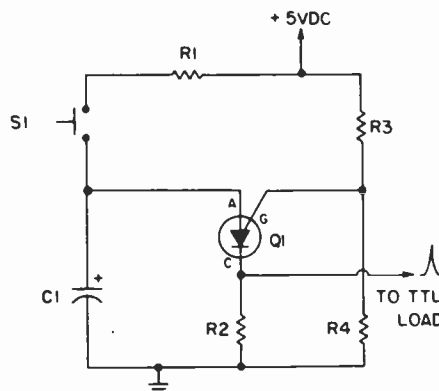
## 31 Tom Thumb's Timer

□ We've found a timer circuit that little Tom would have approved of—it's small both in size and in cost. With S1 in contact with +9VDC, capacitor C1 gradually charges through R1 and R2. When the potential across C1 reaches 5.5-volts, base drive flows into the Q1-Q2 Darlington pair through zener diode D2. This causes the transistors to conduct collector current and activate buzzer BZ1, a miniature device that emits a pleasant, shrill tone to signal the end of the timed interval. To reset the timer, flip S1 so that it contacts R3, which functions to discharge timing capacitor C1 through diode D1.

Using trimmer R1, you can adjust the timed interval to any value between 30 and 120-seconds. We use this timer to control the development of Polaroid instant films, but you can probably find dozens of other uses, too.

### PARTS LIST FOR TOM THUMB'S TIMER

- B1**—9-volt transistor battery
- BZ1**—9-VDC buzzer (Radio Shack #273-052)
- C1**—470- $\mu$ F, 25-VDC electrolytic capacitor
- D1**—1N4002 diode
- D2**—1N748A, 3.9-volt, 1/2-watt zener diode
- Q1, Q2**—2N3904 NPN transistor
- R1**—200,000-ohm trimmer potentiometer
- R2**—62,000-ohm, 1/2-watt, 5% resistor
- R3**—330-ohm, 1/2-watt, 5% resistor
- S1**—SPDT slide switch



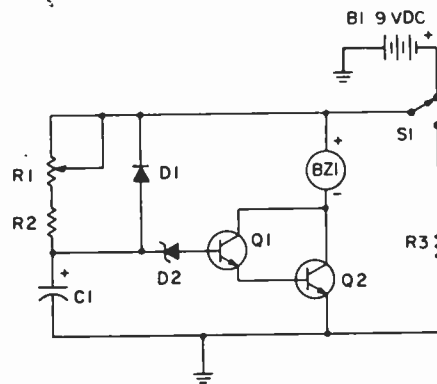
## 32 Bounce-less Digital Switch

□ When it comes to feeding information to a digital circuit, the simplest way to accomplish the job is with a switch of some sort. Unfortunately, except for the mercury switch, every other commonly available switch bounces like a bad check. When you press a "bouncy" switch expecting just one closure, you get surprised with a multitude instead. Since the reaction time of digital logic is so swift, each bounce is treated as a separate input—often with disastrous results.

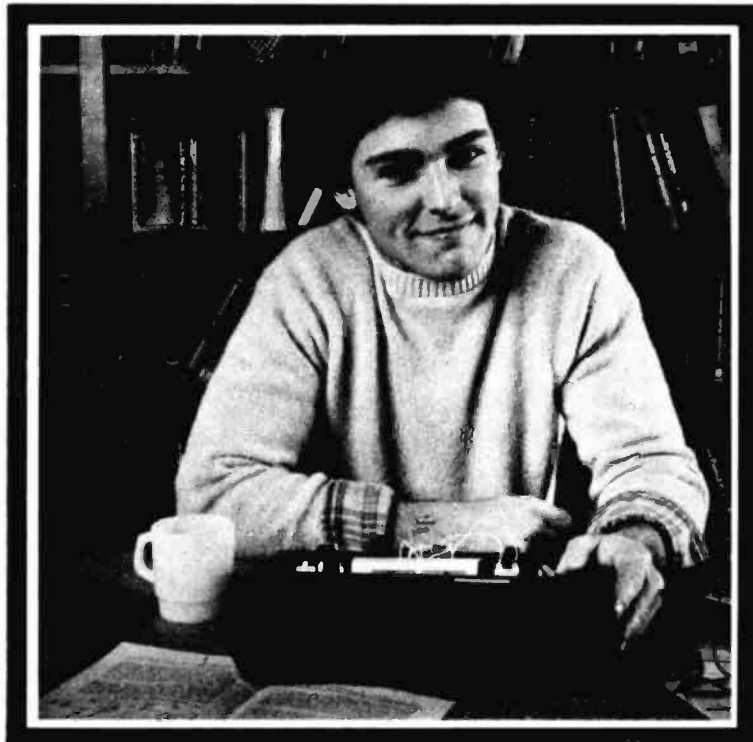
Consequently, it's usually necessary to de-bounce switches in logic circuits. The circuit diagrammed here is a simple and effective way to do the job. Press S1, and about 30-milliseconds later you get one and only one pulse at Q1's output. This bounce eliminator is well suited for incorporation into any TTL circuit.

### PARTS LIST FOR BOUNCE-LESS DIGITAL SWITCH

- C1**—2.2- $\mu$ F, 10-VDC tantalum capacitor
- Q1**—2N6027 programmable uni-junction transistor
- Note:** All resistors rated 1/2-watt, 5% tolerance unless otherwise noted.
- R1**—10,000-ohms
- R2**—47-ohms
- R3**—390,000-ohms
- R4**—1,200,000-ohms
- S1**—normally open SPST pushbutton switch



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## 33 Multivibrator Tone Hummer

□ This multivibrator produces an audio tone rich in harmonics. If you were to look at the output on an oscilloscope, you would see it is a square wave. Because it is so rich in harmonics, you can use this circuit as a signal injector for tracing signals in audio, if (intermediate frequency),

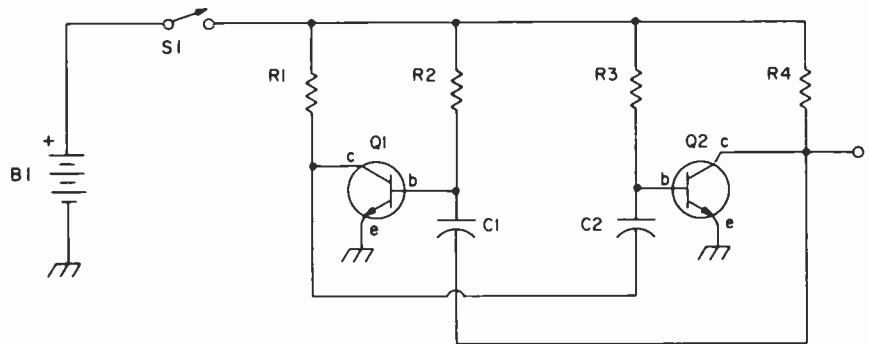
and even some rf stages. Just how high the harmonics will go depends on the particular transistors you choose, the voltage you operate them at, and the specific values of the other components.

You can also use this circuit to provide very fast clock pulses to logic

circuits, with pulse width in the fraction-of-a-millisecond range, if you like. Remember, the higher in pitch the tone that you hear, the shorter each pulse width. You can also use this as a signal injector or signal source in setting up stereo or intercom systems.

### PARTS LIST FOR MULTIVIBRATOR TONE HUMMER

- B1—6-15 VDC
- C1, C2—.05-.5- $\mu$ F capacitors
- R1, R4—2200-4700-ohm resistors, 1/2-watt
- R2, R3—4700-100,000-ohm resistors, 1/2-watt
- S1—SPST switch
- Q1, Q2—NPN transistor (2N2222, 2N3904 or equiv.)



## 34 Basic Color Organ

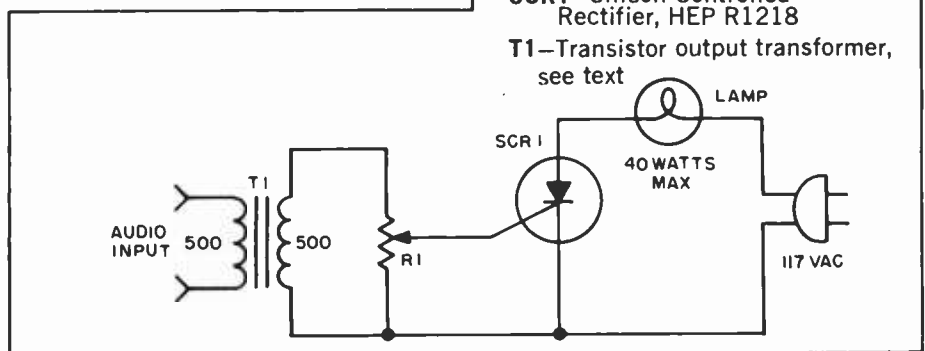
□ This simple color organ is certain to keep your party from becoming a drag. Connected to your hi-fi amplifier's speaker output (across the speaker terminals) it will throb in time to the music. Paint the bulb red or deep blue and your party room will take on the atmosphere of a rock club.

Transformer T1 can be any matching transistor type in the range of 500/500 to 2500/2500 ohms. Note that none of the connections from SCR1 or its components are connected to ground. For safety's sake, you must keep the 117-volt line voltage from the amplifier connections—that's the reason for T1. To adjust, set po-

tentiometer R1 "off" and adjust the amplifier volume control for a normal listening level. Then adjust R1 until lamp I1 starts to throb in step with the beat.

### PARTS LIST FOR BASIC COLOR ORGAN

- I1—117V lamp, not to exceed 40 watts.
- R1—Potentiometer, 500 to 5000 ohms
- SCR1—Silicon Controlled Rectifier, HEP R1218
- T1—Transistor output transformer, see text



## 35 Nine Volt Neon

□ Wait a minute! Don't neon lamps need ninety volts to fire? Neon lamp I1 gets that kind of voltage—possibly more, depending on the state of your battery and the actual value of T1. Because T1 and Q1 act together to form a DC-to-AC converter.

R1 and C1 set the frequency of UJT oscillator Q1 to about 1000 Hertz. Actually, any frequency near the middle of the audio range (300-5,000 Hz) would be okay, so feel free to take some liberties with R1 and C1's values. That's because those

are the frequencies that are easiest to handle for T1, a transistor-type interstage transformer. You may find something suitable in one of your old junker radios or amplifier boards.

T1 acts as a step-up transformer, raising the input voltage to a level

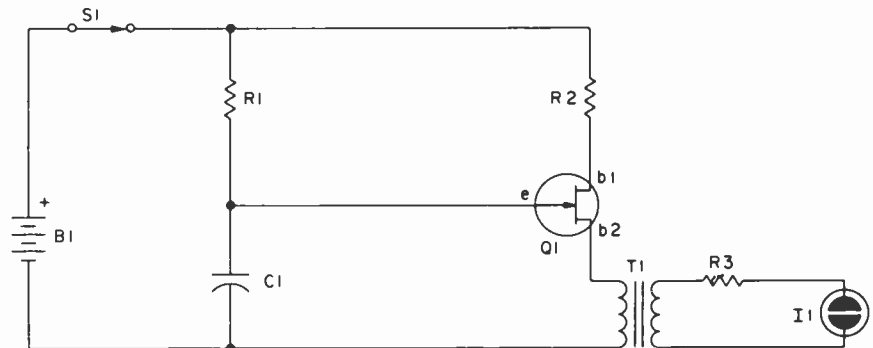
where it can fire the NE-2. You may not need R3, but it limits the amount of current that I1 has to handle. For an interesting variation, use a large electrolytic capacitor between about

10 and 1000 microfarads for C1, or increase the value of R1 to 1-10 Megohms (this won't work with every UJT you try). This will cause the UJT oscillator to pulse at a rate some-

where between a few pulses a second and a pulse every few seconds. You'll know because I1 will flash with every pulse.

#### PARTS LIST FOR NINE VOLT NEON

- B1**—9 VDC battery
- C1**—.1-uF capacitor
- I1**—Neon bulb, NE-2 type
- Q1**—UJT (Unijunction Transistor), 2N2646 or equiv.
- R1**—10,000-ohm resistor, ½-watt
- R2**—100-ohm resistor, ½-watt
- R3**—470,000-ohm resistor
- S1**—SPST switch
- T1**—Transformer, 10,000-ohm primary and 100,000-ohm secondary

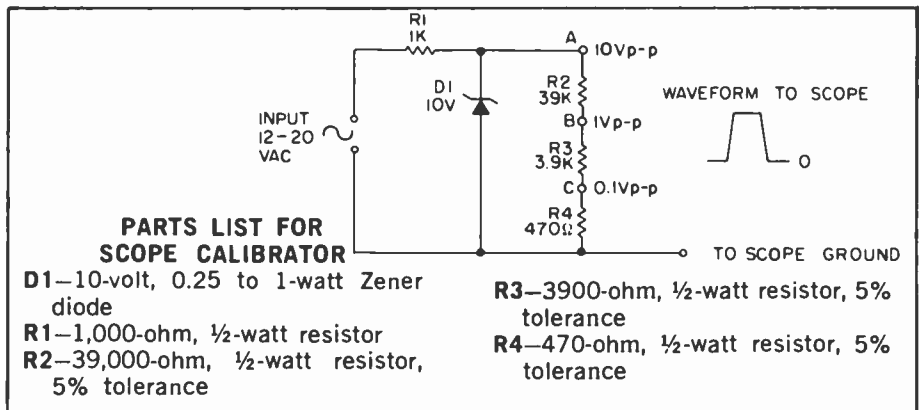


## 36 Scope Calibrator

□ One thing which all lab-grade scopes have, and which is usually missing from general purpose scopes, is a vertical input calibrator. Inexpensive scopes usually have a variable vertical input attenuator with some form of stepped 10X multiplier, but because of the variable control, most experimenters have no idea what the graticule calibrations represent in terms of voltage at any given moment.

With this easy-to-build circuit, you can instantly calibrate your scope, because you will have a positive peak-to-peak reference of 10, 1, and 0.1-volts. Using ordinary 5% tolerance resistors will give you more than adequate accuracy. If price is no object, you can use 1% resistors, but they won't afford much of an advantage.

To calibrate your scope, simply ad-



just the variable attenuator for a convenient reference. For example, if you connect the vertical input to point A (10V peak-to-peak) and adjust the variable attenuator so the "square waveform" fills one vertical division,

the scope is calibrated for *10-volts-per-division*. (Get the idea?) The input to the calibrator can be any AC transformer, of virtually any current rating, with a secondary rating of 12 to 20 volts RMS.

## 37 Blinking Neon Night Light

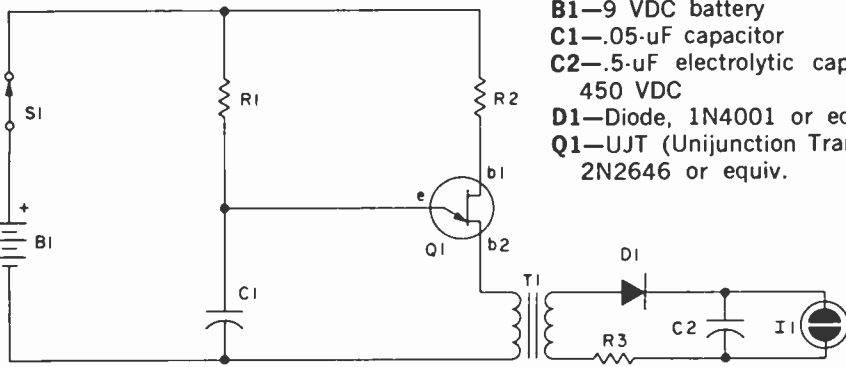
□ UJT oscillator Q1 feeds a tone of about 2000 Hz to transistor transformer T1, which steps it up to a level where it can fire a neon lamp, I1. But the circuitry to the right of T1 does something a little more interesting. Diode D1 (which makes this circuit a true DC-to-DC converter) rectifies the AC signal and applies it to C2. Resistor R3 limits the

rate at which C2 can charge. When C2 finally reaches a voltage high enough to allow I1 to light, I1 fires and discharges C2, starting the action over again.

Use a 200 PIV diode for D1 and a 250 Volt (or more) capacitor for C2, or just make sure both are rated for more voltage than appears across the secondary of T1. D1, C2, R3 and

I1 form a circuit called a relaxation oscillator. Interestingly, that is exactly the kind of oscillator Q1 is. Both rely on some R-C combination charging a capacitor at a restricted rate, then discharging it at some determined time. Just as you can multiply the values of R1 and C1 to get a fix on the frequency of Q1 ( $f=1/R1C1$ , more or less), you can mul-

**PARTS LIST FOR  
BLINKING NEON NIGHT LIGHT**



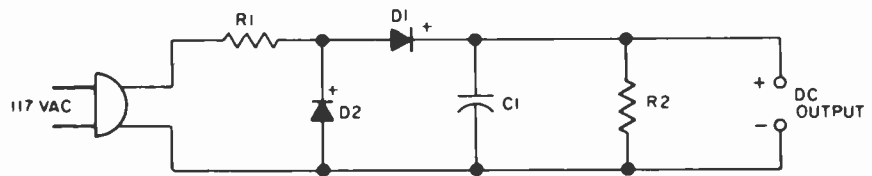
- B1**—9 VDC battery  
**C1**—.05- $\mu$ F capacitor  
**C2**—.5- $\mu$ F electrolytic capacitor, 450 VDC  
**D1**—Diode, 1N4001 or equiv.  
**Q1**—UJT (Unijunction Transistor), 2N2646 or equiv.  
**R1**—10,000-ohm resistor, 1/2-watt  
**R2**—100-ohm resistor  
**R3**—470,000-ohm resistor, 1/2-watt  
**S1**—SPST switch  
**T1**—Transformer, 10,000-ohm primary and 100,000-ohm secondary

multiply R3 and C2 to determine that the NE-2 will blink about four times a second. You can also connect the circuit to the right of T1 to 110 Volt household power to see the same action.

## 38 Lo Hum Power Supply

Just a handful of components are needed for a line-powered low-voltage low-current supply for powering audio preamplifiers.

The values for different voltage and current outputs are given in the Parts List. Pick the set you need and wire up. D1 and D2 are silicon rectifiers rated at a minimum of 200 PIV at any current.



**PARTS LIST FOR  
LO HUM POWER SUPPLY**

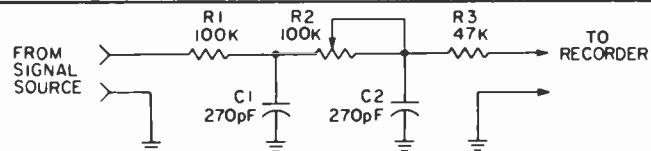
Output V	I max*	R1	C1	R2
12	1 mA	43,000-ohm, 1/2-watt	250- $\mu$ F, 15-VDC	180,000-ohm, 1/2-watt
12	2 mA	22,000-ohm, 1/2-watt	250- $\mu$ F, 15-VDC	100,000-ohm, 1/2-watt
25	2 mA	18,000-ohm, 1/2-watt	250- $\mu$ F, 30-VDC	180,000-ohm, 1/2-watt

\*For lower current, decrease value of R2

## 39 Scratch Filter

Next time you're dubbing some "oldies but goodies" to tape, there's no need to put up with the scratches and noise that have accumulated over a good number of years of usage. Just pass the signals from the records through this scratch filter, and you'll get rid of much of the noise without too much loss of music frequencies.

The filter connects between the signal source, such as a record player or an amplifier's tape output, and the line input of a tape recorder. It's cut-off frequency is slightly higher than 5000 Hz, with attenuation increasing as the frequency goes up. Potentiometer R2



**PARTS LIST FOR SCRATCH FILTER**

- C1, C2**—260-pF silver mica capacitor, 5% or better tolerance  
**R1**—100,000-ohm, 1/2-watt resistor  
**R2**—100,000-ohm, linear taper potentiometer  
**R3**—47,000-ohm, 1/2-watt resistor

permits you to vary the "corner" frequency slightly to attain more or less high frequency attenuation as required by the individual record. (Or, you can

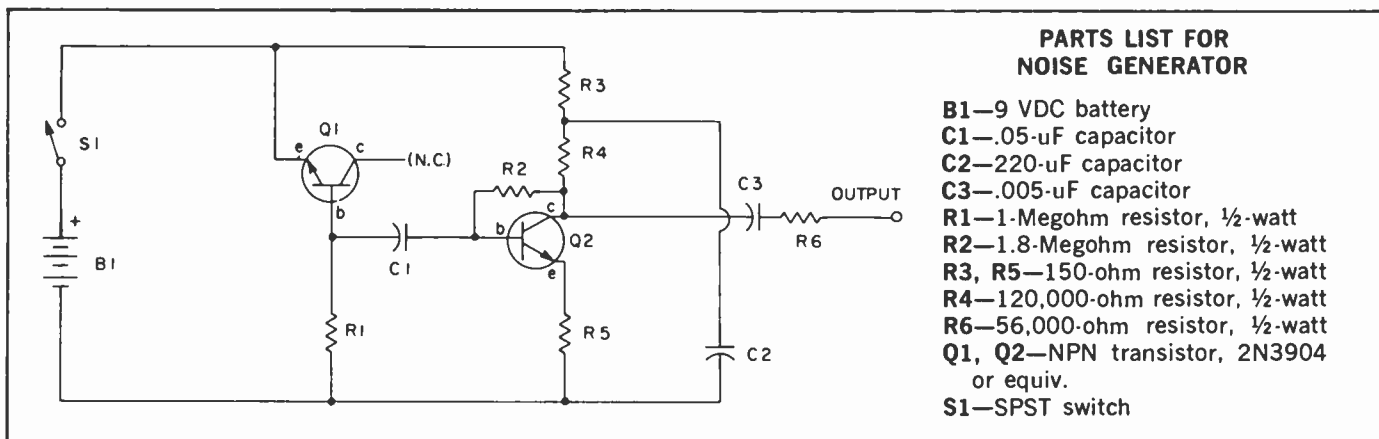
just set the control to the approximate center and forget about it.) For proper operation, the input impedance of the recorder should not be less than 40,000

ohms—a common minimum value for most recorders. Do not eliminate R3 in an attempt to increase the output level

of the filter, because it provides part of the filter's output impedance matching in conjunction with the recorder's

input impedance. A metal enclosure is suggested, with RCA-type phono jack connectors.

## 40 Noise Generator



□ Audio buffs often refer to their systems as having color or temperature. One that is rich in low end response is said to be warm and red; a bright high end on a system means it's cool and blue.

The mixture of all these characteristic colors is white, and white noise generators produce a whooshing

sound that is randomly distributed throughout the spectrum. Likewise, pink noise generators are just a bit warmer. This simple noise generator is one we might call off-white. It takes advantage of the junction noise generated in a reverse-biased semiconductor junction (here, a base-emitter junction in NPN transistor

Q1).

The noise generated by current through Q1 is amplified by Q2 and made available at the output. For a simple demonstration of tonal coloring, patch this noise into your sound system and see how manipulating your tone controls alters the nature of the noise you hear.

## 41 Budget Lamp Dimmer

□ Using almost all "junk box" parts, or those easily found at local parts distributors, this budget-priced lamp dimmer can be assembled directly inside a lamp socket, lamp base, or electrical outlet box (replacing a wall switch).

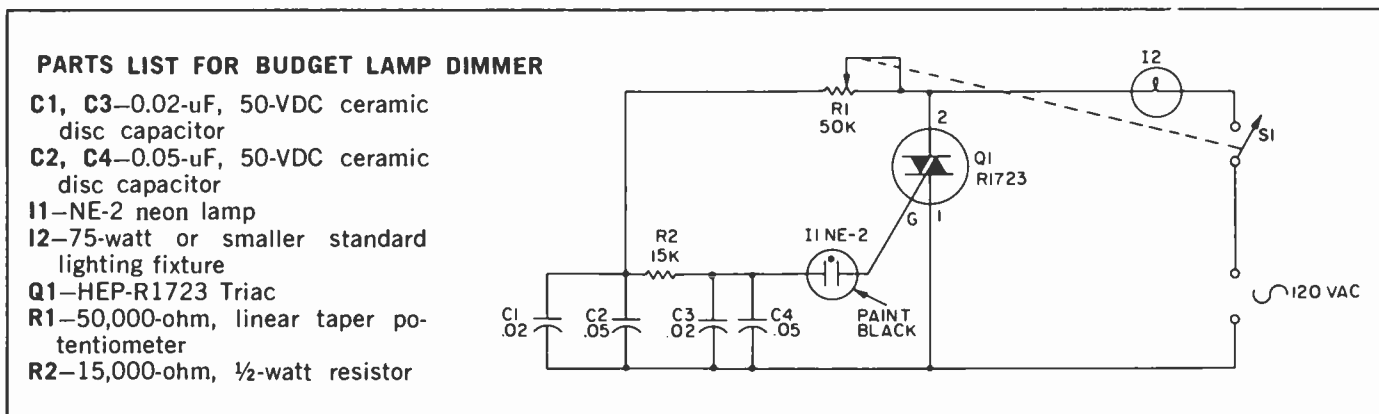
Triac Q1 can handle up to 75-watts without a heat sink. Over 75 watts, sink Q1 to the metal enclosure, or a small heat sink insulated from the socket (if

you build the dimmer into a socket). If you mount Q1 on the enclosure, make certain none of the Triac's leads "short" to the enclosure. Use silicon heat sink grease between Q1 and the sink.

I1 is an ordinary NE-2 neon lamp. If it will somehow be exposed to light, paint the lamp black, or some other opaque color. (I1's "trigger" voltage

threshold is affected by light.)

Because the neon lamp has a firing threshold above zero volts, the lamp cannot be turned fully off with the control. Rather, switch S1 snaps the lamp on to a very subdued brilliance which can be faded up to almost maximum lamp brilliance. Make certain R1 is wired so it is a maximum resistance just before S1 switches from on to off.



# 42 High Performance Transistor Radio

Here's a neat way to update your crystal set, assuming you can still find it. Or use these few inexpensive parts to build from scratch. Instead of using a cat's whisker or a diode, this radio uses the very sensitive junction of a junction FET as its detector. This makes it a very "hot," very sensitive high impedance detector. Then the JFET does double duty by con-

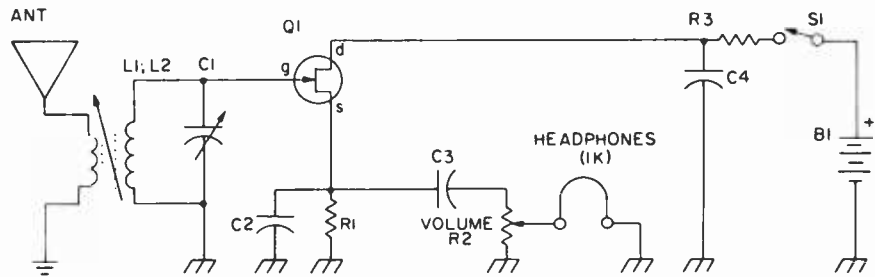
verting the high input impedance to a lower output impedance—low enough and with enough drive to power a set of high impedance headphones or a high impedance earphone (about 1K or so).

The antenna coil is one of those simple loopsticks you've seen at the parts stores. (Or you might want to wind your own on an oatmeal box.)

The broadcast variable capacitor is one of the tuning capacitors taken from an old, defunct radio. You can use any long wire for the antenna, but if you string it outdoors, be sure to use a lightning arrestor. You can also clip an alligator clip to your bed-spring, a window-spring, or the metal part of a telephone.

## PARTS LIST FOR HIGH PERFORMANCE TRANSISTOR RADIO

- B1—6-15 VDC battery
- C1—Approx. 356-pF broadcast-type variable capacitor
- C2—300-600-pF capacitor
- C3—.05-.5-uF capacitor
- C4—.22-1.0-uF capacitor
- L1/L2—Ferrite loopstick, or ferrite-bar BCB antenna coil
- Q1—N-channel JFET (Junction Field Effect Transistor) (2N-5458, MPF102 or equiv.)



- R1—18,000-47,000-ohm resistor, 1/2-watt
- R2—20,000-100,00-ohm potentiometer

- R3—4700-10,000-ohm resistor, 1/2-watt

# 43 Wire Tracer

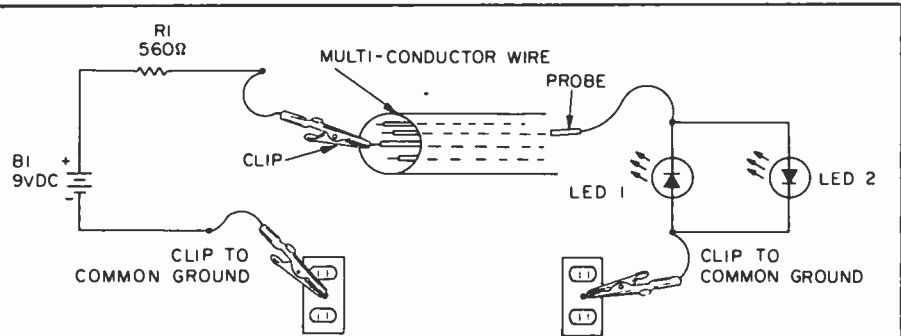
Problem! You've just snaked a multi-wire computer and/or intercom cable through two floors, five bends, and two "pull" boxes, and you have the creepy feeling that one of the wires broke in the process. Then, you discover upon trimming away the outer jacket, that all of the wires are the same color. What to do? Simple, just check 'em all with this simple wire tracer. Clip one end of

the LED1/LED2 circuit to the same ground source and touch the other end to each wire. When you find the wire being tested, one of the two LEDs will light.

It doesn't matter which LED lights.

We use two only to prevent confusion in the event a polarity gets reversed. This way, one LED is certain to light. The LEDs can be any "general purpose" type available. Battery B1 is a 9-volt transistor radio-type.

- ## PARTS LIST FOR WIRE TRACER
- B1—9-volt transistor radio battery
  - LED1, LED2—general purpose LED, 0.02 mA
  - R1—560-ohm, 1/4-watt resistor
  - Misc.—3 alligator clips, 1 test probe



# 44 Poor Man's Hold Switch

This is just one step more sophisticated than holding your hand over the telephone mouthpiece. We all

find occasions when we would like to discuss something with the people in the room without sharing it with

the party on the phone. This circuit provides dc continuity for the phone line to keep from losing a call when

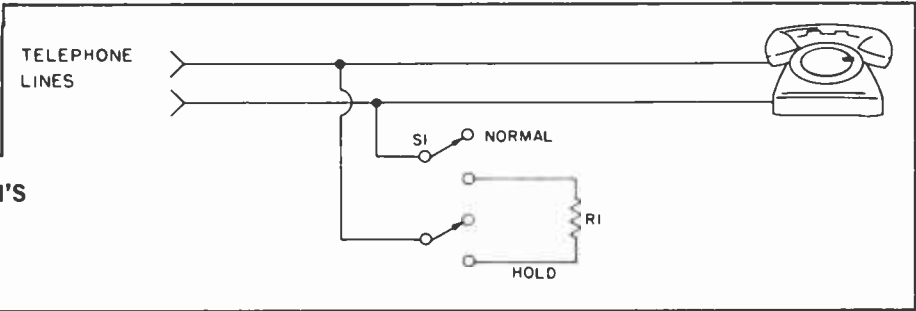


you hang the phone up. There is some danger, though, of putting the phone on "terminal hold," if you forget. Because as long as you are switched to hold, it's just like leaving a phone off the hook: no one can call in, you can't call out.

Only two of the lines that reach your telephone are really part of the phone line, and these are most often the red and green wires that are in

the cable between your phone and the wall. Other wires in the cable may carry power for lighting your phone, or may carry nothing. Check carefully. Also understand that if you make a connection to the phone

line that inhibits the phone company's ability to provide service, they have the right to disconnect you for as long as they like. This is a proven, simple circuit that should cause no difficulty. But be careful.



**PARTS LIST FOR POOR MAN'S PHONE HOLD SWITCH**

- R1—650-ohm resistor, 1/2-watt
- S1—DPDT switch

# 45 Transistor Squelch

Here's a simple squelch circuit you can add on to most radios and it's as versatile as any.

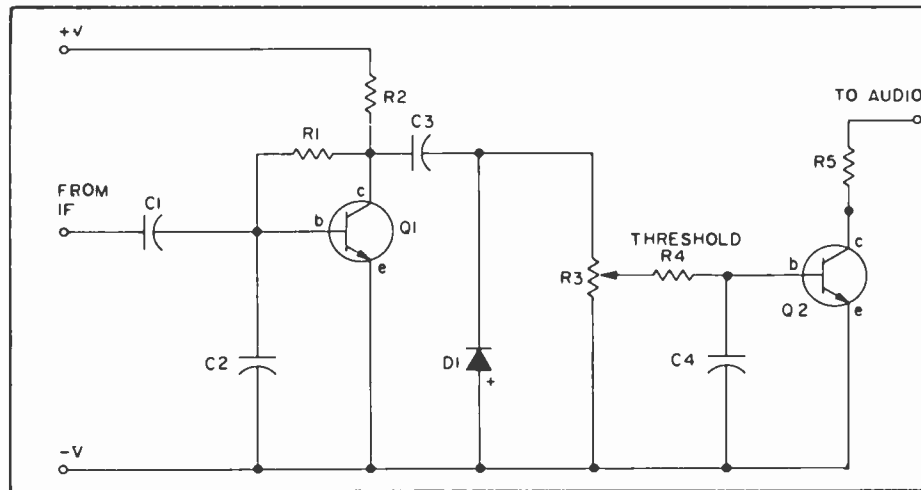
Transistor Q1 acts as a noise amplifier, operating on signals from the receiver IF. The noise signal is amplified, then detected by D1. The resultant voltage appears across R3, which acts as a voltage divider at the input of switch Q2. When enough

signal-derived voltage reaches Q2's base, it turns on, switching off the receiver audio output.

This audio squelching can be accomplished simply by connecting the input terminal of the receiver's audio stage to the R5 connection. This is a noise-operated squelch best suited for use with FM communications systems. On FM, signals tend to quiet

the ever-present noise, and FM IFs are designed with noise outputs.

For use with AM systems, use the IF or detector signal output as the squelch input. Locate the -V connection of your receiver's first audio amplifier, break it, and connect it to the top of R5. Then increasing signal will enable receiver audio, and that's what squelches are supposed to do.



**PARTS LIST FOR TRANSISTOR SQUELCH**

- C1, C3—.1-uF capacitor
- C2—.01-uF capacitor
- C4—33-uF capacitor
- D1—Diode, 1N914 or equiv.
- Q1, Q2—NPN transistor, 2N3904 or equiv.
- R1—180,000-ohm resistor, 1/2-watt
- R2, R3—10,000-ohm resistor, 1/2-watt
- R4—680-ohm potentiometer
- R5—330-ohm resistor, 1/2-watt

# 46 Stereo Beat Filter

Many early stereo tuners, and quite a number of modern budget priced stereo tuners, have considerable output at 19 kHz and 38 kHz from the stereo pilot system. While these frequencies aren't heard, they can raise havoc if they leak through to a

Dolby noise reduction encoder, or if the frequencies beat with a tape recorder's bias frequency or its harmonics. Normally, Dolby-equipped units have a 19 kHz filter specifically to avoid the problem of pilot leakage from the tuner, but often the pilot

interference is so high it still gets through.

This filter, which can be powered by an ordinary transistor radio type battery, is connected to the output of the FM stereo tuner, and provides approximately 12 to 15 dB additional

attenuation at 19 kHz and about 25 dB attenuation at 38 kHz. It has virtually no effect on the frequency response below 15 kHz, the upper limit of frequencies broadcast by FM stations.

The only really critical components are C1, C2 and R4, and no substitutions should be made.

A signal generator is required for

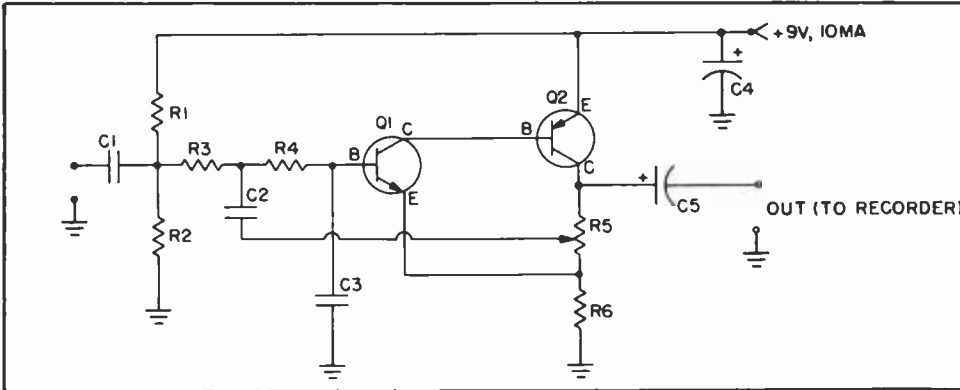
alignment. Feed in a 1 kHz signal and note the output voltage. Then change the generator to 10 kHz and adjust R5 so the output level at 10 kHz is the same as for 1 kHz. You might have to check the measurements several times to get R5 set correctly. When properly adjusted there will be perhaps 1 dB loss at 15 kHz.

The input signal should be in the

range of 0.1 to 1 volt—typical level from a tuner's tape output jack.

#### PARTS LIST FOR STEREO BEAT FILTER

- Resistors ½-watt, 10%, unless otherwise specified  
**R1**—470,000-ohms  
**R2**—220,000-ohms  
**R3**—33,000-ohms  
**R4**—33,000-ohms, 5%  
**R5**—5,000-ohm linear taper potentiometer  
**R6**—3,300-ohms  
 Capacitors rated 10-VDC or higher  
**C1**—0.047-μF  
**C2, C3**—220-pF, 2% silver mica or equiv.  
**C4**—25-μF  
**C5**—1-μF  
**Q1**—Transistor, Radio Shack 276-2009  
**Q2**—Transistor, Radio Shack 276-2021



## 47 Sidetone Oscillator

□ CW (continuous wave, the form of modulation involving a simple turning on and off of the RF carrier) is the simplest way for a beginning ham to transmit to his fellow hams. And the famous Morse Code is how he gets his message across. But Morse is

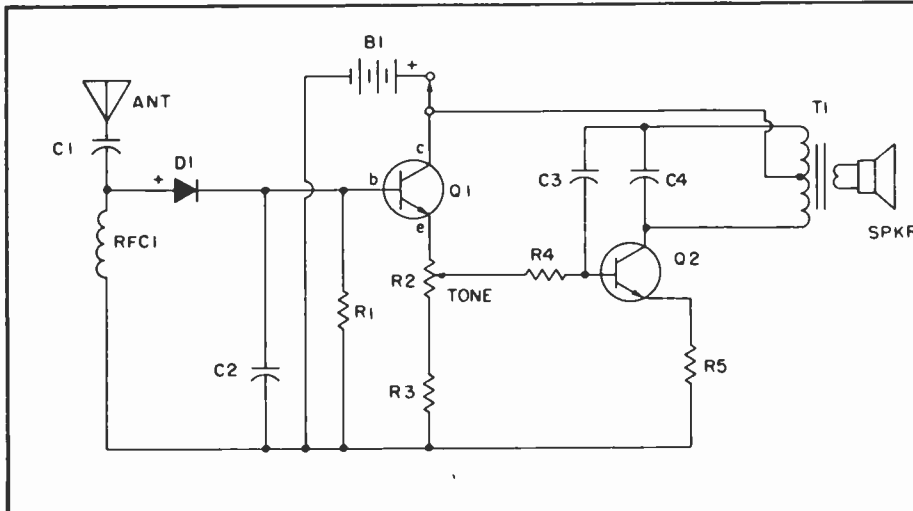
a lot easier to send if you can hear what you're sending. This circuit lets you do just that.

A short length of wire near the transmitter picks up RF as it's transmitted and acts as the antenna for our circuit. This RF is detected by D1,

smoothed by C2, and used to turn Q1 on and off, following the transmitted signal exactly. Q1 switches the positive supply through R2 to beep oscillator Q2 through the center tap of T1. The values shown produce a pleasant, easily distinguishable tone.

#### PARTS LIST FOR SIDETONE OSCILLATOR

- B1**—9VDC battery  
**C1**—50-pf capacitor  
**C2**—470-pf capacitor  
**C3, C4**—.01-μF capacitor  
**D1**—Diode, 1N914  
**Q1, Q2**—NPN transistor, 2N2222 or equiv.  
**R1**—470,000-ohm resistor, ½-watt  
**R2**—5000-ohm potentiometer  
**R3**—4700-ohm resistor, ½-watt  
**R4**—100,000-ohm resistor, ½-watt  
**R5**—100-ohm resistor, ½-watt  
**RFC1**—2.5-mH choke  
**T1**—1000; 8-ohm transformer, centertapped  
**SPKR**—8-ohm speaker



## 48 Idiot's Delight

□ Sometimes the dashboard idiot lights aren't warning enough that something's gone awry. Bright sun-

light, a burned-out lamp or simply a lack of attention can obviate Detroit's brilliant efforts. But this sim-

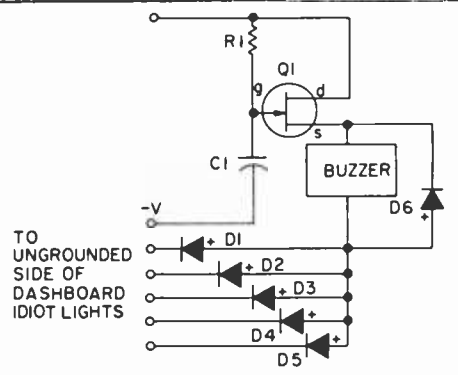
ple gizmo adds a buzz to their blink, plus a luxurious extra. R1, C1 and

Q1 give you about 7 seconds when you first get into the car to get yourself going and let the idiot lights douse before the buzzer can sound.

D1-D5 can be added to or subtracted from to fit the number of dashboard dimwits on your car. You can use something other than a buzzer, if you wish, to help you keep from getting confused about your door being ajar, your key being in, or your lights being left on.

### PARTS LIST FOR IDIOT'S DELIGHT

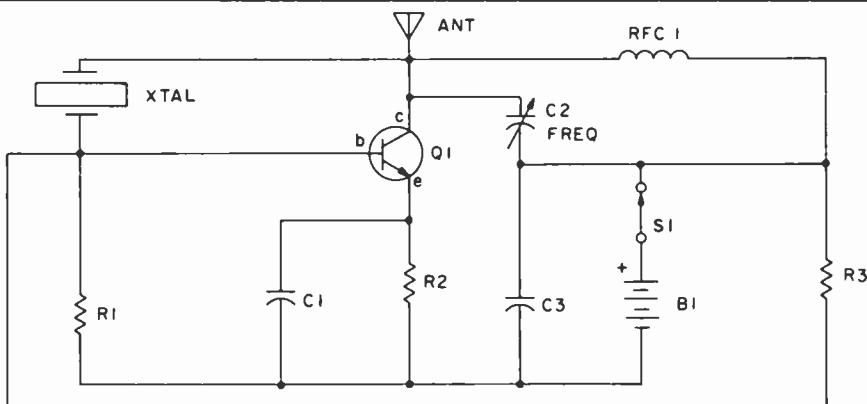
- C1—15- $\mu$ F capacitor
- D1, D2, D3, D4, D5, D6—Diode, 1N914 or equiv.
- Q1—FET (Field Effect Transistor), 2N5458 or equiv.
- R1—470,000-ohm resistor, 1/2-watt



## 49 Fox Hunt Transmitter

### PARTS LIST FOR FOX HUNT TRANSMITTER

- B1—9 VDC battery
- C1, C3—.001- $\mu$ F capacitor
- C2—90-pF variable capacitor
- Q1—NPN transistor, 2N2222 or equiv.
- R1—10,000-ohm resistor, 1/2-watt
- R2—470-ohm resistor, 1/2-watt
- R3—47,000-ohm resistor, 1/2-watt
- RFC1—2.5 mH radio frequency choke
- S1—SPST switch
- XTAL—crystal cut for the 49 MHz band



Ever been to a radio foxhunt? Everyone brings a portable radio and a very directional antenna and tries to find where a small transmitter has been hidden. First one to find it wins. And here's just the transmitter to bring this old ham radio game to the rest of us. Transistor Q1 acts as a

crystal oscillator in the new 49 MHz walkie-talkie band. The output of this oscillator is very low, and no license is required if you keep your antenna down to just a few inches in length.

Trimmer capacitor C2 lets you tweak the frequency of this transmitter right into the middle of the chan-

nel. Use a walkie talkie and listen for carrier; when you hear it best, you're on frequency. This same circuit can be used as a wireless mike. Connect a carbon microphone, like an old telephone handset mike, in series with R2 and ground.

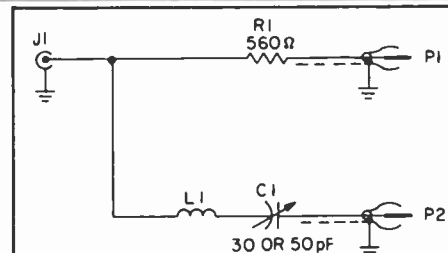
## 50 Disguised CB Antenna Matcher

If you're tired of your CB antenna acting like a beacon to every creep and hoodlum in your neighborhood (or wherever you travel) simply install a disguised CB cowl mount antenna in place of your car's existing auto antenna, and then use this matcher to connect the antenna to both your auto radio and CB, without need for any switching system between the two radios. The matcher automatically connects the antenna to the proper radio.

When transmitting on CB, the C1/L1 series-tuned circuit passes the RF to the antenna, while R1 keeps the RF out of

the radio. When receiving broadcast stations, the C1/L1 combination represents a high impedance, keeping the signals out of the CB where they would be "shorted" by the receiver's "front end." The broadcast signals pass through R1 to the auto radio.

Build the matcher in a metal enclosure. Jack J1 and plugs PL1 and PL2 should match your existing equipment. The matcher must be adjusted to your antenna system for maximum CB performance. Connect an SWR meter between the CB rig and the matcher (PL2), adjust C1 for minimum SWR.



### PARTS LIST FOR DISGUISED CB ANTENNA MATCHER

- C1—30-pF or 50-pF trimmer capacitor
- L1—RF choke (Ohmite Z-144 or equivalent)
- R1—560-ohm, 1.2-watt resistor

# 51 Crystal Checker

□ A fast way to see if the crystal from your transmitter or receiver is properly "active" is to compare its output against that of a known good crystal. This crystal checker will handle both

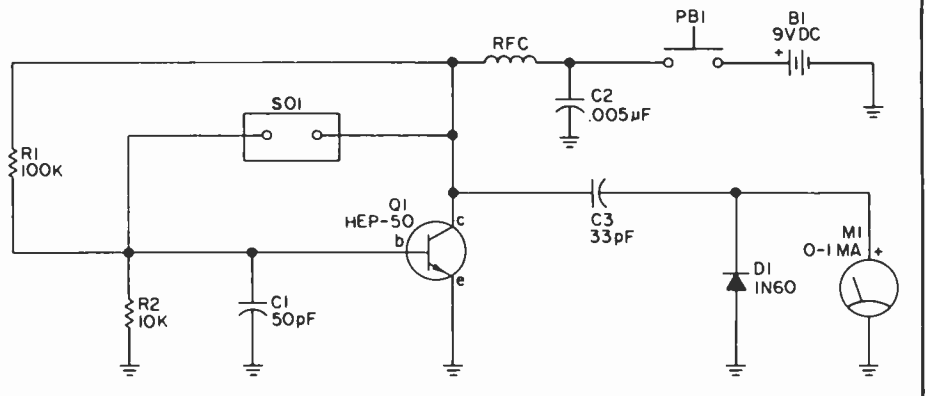
fundamental and overtone type crystals. Socket SO1 should match the pins on your crystals. If you use more than one type of crystal, install two (or more) sockets in parallel. The unit can be assembled in any type of cabinet.

To test a crystal's activity, first plug in a known good crystal, depress push button switch PB1 and note the meter reading. Then install the ques-

tionable crystal, press PB1 and note its meter reading; if it's good its output should approximate that of the reference crystal. Take care that you don't compare apples with oranges; the reference crystal should be the exact same type as the crystal to be tested. If good crystals drive the meter off scale, install a 1000-ohm, 1/2-watt, 10 percent resistor in series with meter M1.

## PARTS LIST FOR CRYSTAL CHECKER

- B1**—9-volt transistor radio battery
- C1**—50-pF disc capacitor, 100 VDC or better
- C2**—0.005- $\mu$ F disc capacitor, 25 VDC or better
- C3**—33-pF disc or mica capacitor, 100 VDC or better
- D1**—Diode, 1N60
- M1**—Meter, 0-1 mA DC
- PB1**—Normally open push button switch
- Q1**—NPN transistor, HEP-50 (Radio Shack 276-2009)
- R1**—100,000-ohm, 1/2-watt resistor
- R2**—10,000-ohm, 1/2-watt resistor
- RFC**—2.5-mH RF choke
- SO1**—Socket to match crystals, see text

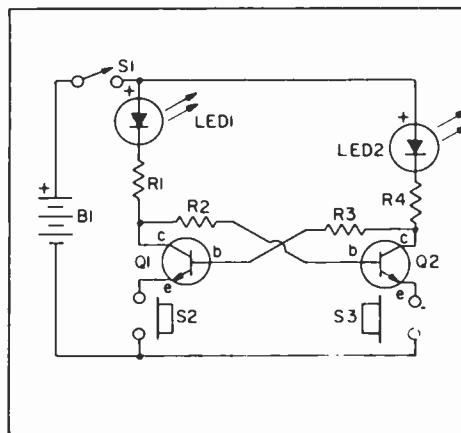


# 52 Quick Draw Game

□ Okay, podner, the fust one to push the button lights the light on his side, and blocks the other light from turning on.

You can yell "draw" by closing S1. But instead of a switch, you can find a trickier way of closing the contacts.

Try rolling a steel ball bearing down a channel with the contacts on the bottom. When the ball completes the circuit, go for your trigger buttons. Or you can just leave S1 closed. Once both "triggers" (S2 and S3) are released, this game is automatically set to be played again.



## PARTS LIST FOR QUICK DRAW GAME

- B1**—6-15 VDC battery
- LED1, LED2**—Light emitting diodes
- Q1, Q2**—NPN transistors (2N2222 or similar)
- R1, R4**—150-390-ohms resistors, 1/2-watt
- R2, R3**—22,000-56,000-ohm resistors, 1/2-watt
- S1**—SPST switch (see text)
- S2, S3**—Normally open momentary, or micro, switches

# 53 12 to 9 for Transistors

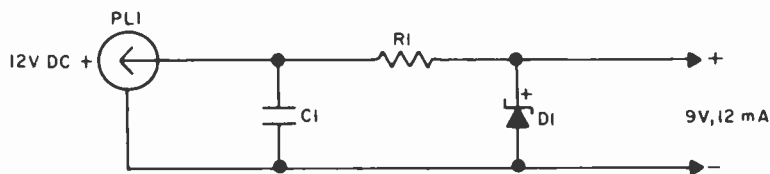
□ When your auto radio poops out, this regulated voltage adapter keeps you in music from a transistor portable until you're ready to climb under the dash to get at the trouble and fix it.

Power is taken from the 12-volt

auto battery through a cigar lighter plug. The zener diode can be anything with an approximate rating of 9 volts. For example, you can use a 9.1-volt unit (common in Zener kits), or even one rated at 8.6 volts. Make certain the Zener is correctly installed; the

end marked with a band is the cathode.

The adapter is rated for a current of 12 mA maximum. A good rule of thumb is that a radio powered by a Burgess type 2U6 battery can safely operate on the adapter.



**PARTS LIST FOR  
12 TO 9 FOR TRANSISTORS**

- C1—0.05- $\mu$ F, 400-VDC capacitor
- D1—1-watt, 9.1-V Zener diode—  
HEP-104 (Radio Shack 276-562)
- PL1—Cigarette lighter plug  
(Calectro N4-029)
- R1—150-ohm, 1/2-watt resistor

## 54 Audio Utility Amp

□ This circuit may look familiar if you're in the habit of glancing at the schematics of your portable radios and recorders. This is a very popular way of getting a signal to a speaker. Transistor Q1 acts as a driver for complementary pair Q2 and Q3. Q2 and Q3 take turns conducting as they follow the input signal, so they can deliver a healthy signal through C2 to

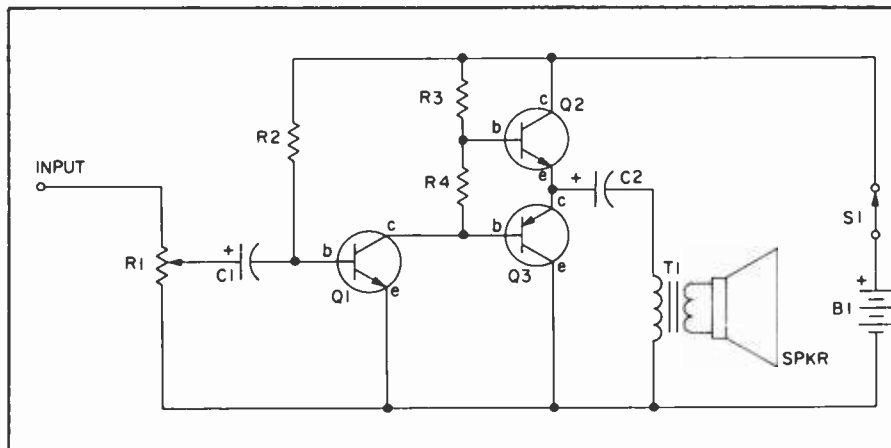
T1. T1 is suggested to reduce the loading that a low speaker impedance would cause if connected directly between C2 and ground; a higher impedance speaker or headphone could connect directly.

You can also use this circuit as a signal tracer to listen in on what's happening inside some of the other circuits on these pages. Just clip a

lead between the minus leads of both projects and use one lead of a .01 microfarad capacitor in series with the input as a probe.

**PARTS LIST FOR  
AUDIO UTILITY AMP**

- B1—9 VDC battery
- C1—15- $\mu$ F electrolytic capacitor, 15 VDC (or greater than needed)
- C2—100- $\mu$ F electrolytic capacitor, 15 VDC (or greater than needed)
- Q1, Q2—NPN transistor, 2N3904 or equiv.
- Q3—PNP transistor, 2N3906 or equiv.
- R1—1-Megohm potentiometer
- R2—270,000-ohm resistor, 1/2-watt
- R3—1200-ohm resistor, 1/2-watt
- R4—100-ohm resistor, 1/2-watt
- S1—SPST switch
- T1—500:8-ohm matching transformer
- SPKR—8-ohm speaker



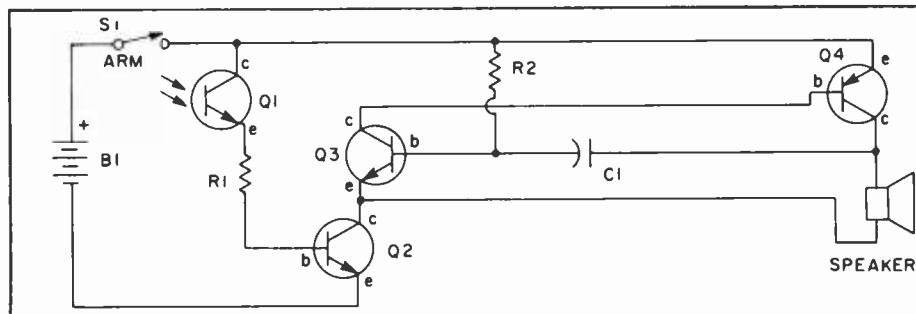
## 55 Attache Alarm

□ Who knows what evils lurk, ready to pilfer the Twinkies out of your attache case when you're not looking? This squealer does. Because when you arm the alarm by turning on S1,

the lightest touch will set it off. More accurately, the touch of light striking Q1 turns on transistor switch Q2, which energizes oscillator Q3-Q4. And that blows the whistle.

**PARTS LIST FOR ATTACHE ALARM**

- B1—9 VDC battery
- C1—.01- $\mu$ F capacitor
- Q1—Photoelectric transistor, FPT 100 or equiv.
- Q2—NPN transistor, 2N2222 or equiv.
- Q3—NPN transistor, 2N3904 or equiv.
- Q4—PNP transistor, 2N3906 or equiv.
- R1—2200-ohm resistor, 1/2-watt
- R2—100,00-ohm resistor, 1/2-watt
- S1—SPST switch
- SPKR—8-ohm speaker



# 56 Pro Burglar Alarm

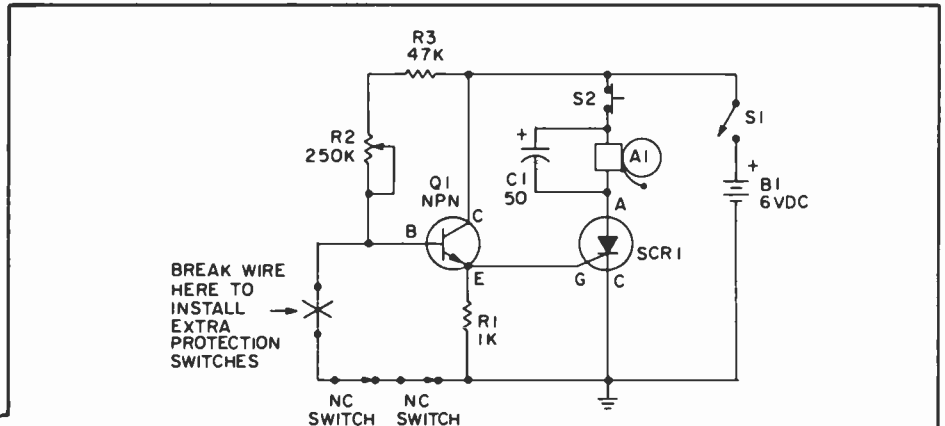
□ Almost without exception, professional burglar alarms are the so-called "supervised" type, meaning a closed circuit loop in which current, no matter how low a value, always flows so that cutting any of the wiring causes the alarm to sound. Early closed circuit alarms were entirely relay operated, and a high resistance which developed anywhere in the circuit usually caused the alarm to false-trip, which always seemed to happen in the wee hours of the morning. Solid-state supervised circuits, such as this Pro Burglar Alarm, are relatively insensitive to the high resistance developed in contacts through normal aging.

The switches shown as "N.C. (normally closed) Switch" can be any normally closed or continuous device, such as window foil. Battery B1 is a 6-volt lantern battery which will give service for almost as long as its shelf-life be-

cause the continuous current drain is only about 100  $\mu$ A. Once the alarm is tripped, it can be turned off only by opening master power switch S1, or "bell stop" PB1, a normally-closed pushbutton switch. (Both switches should be concealed.)

To adjust: Open the protective cir-

cuit. While measuring the voltage across R1, advance R2 so the meter reading rises from zero towards 1-volt. At less than 1-volt, the alarm bell should trip. If it doesn't, you have made an assembly error. Finally, adjust R2 for a 1-volt reading, disconnect the meter and restore the protective circuit.



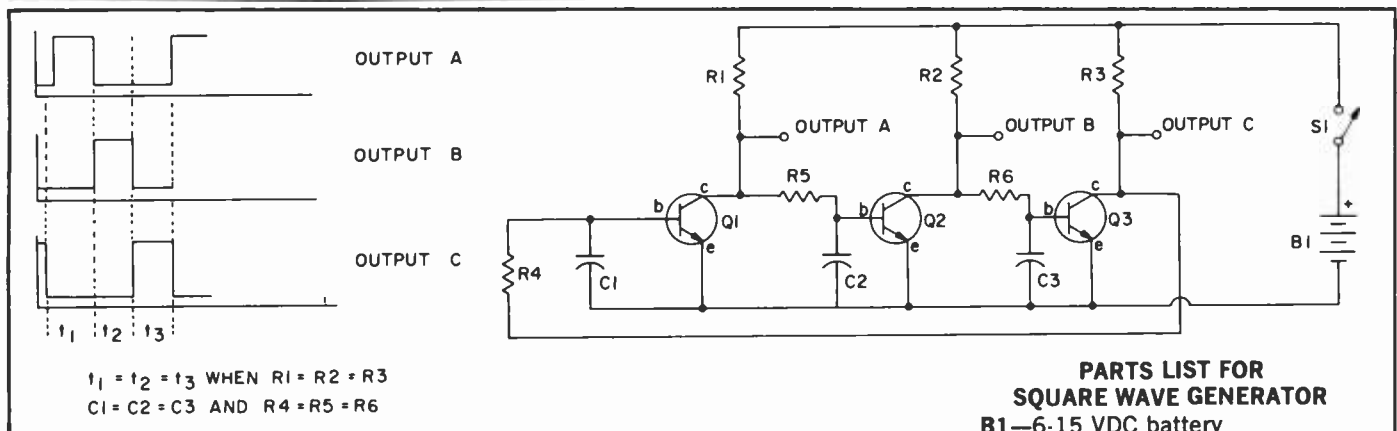
## PARTS LIST FOR PRO BURGLAR ALARM

A1—6-VDC alarm bell or siren  
 B1—6-volt lantern battery  
 C1—50- $\mu$ F, 6-VDC electrolytic capacitor  
 Q1—2N2222A NPN transistor or

equivalent  
 R1—1,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R2—250,000-ohm linear taper potentiometer  
 R3—47,000-ohm,  $\frac{1}{2}$ -watt resistor

SCR1—GEMR-5 silicon controlled rectifier  
 S1—SPST switch  
 S2—normally-closed SPST pushbutton switch

# 57 Square Wave Generator



$t_1 = t_2 = t_3$  WHEN  $R_1 = R_2 = R_3$   
 $C_1 = C_2 = C_3$  AND  $R_4 = R_5 = R_6$

□ Here is a versatile square wave generator capable of surprising performance. It can deliver clock or switching pulses, act as a signal source, and more. And because the outputs take turns switching, it can be used as a simple sequence generator or as a multiple-phase clock.

The component values indicated will support a range of output frequencies from a few pulses per second up into the high audio range. And this square wave output is rich in harmonics. If you use a 5-volt power supply, this circuit can trigger TTL logic directly.

## PARTS LIST FOR SQUARE WAVE GENERATOR

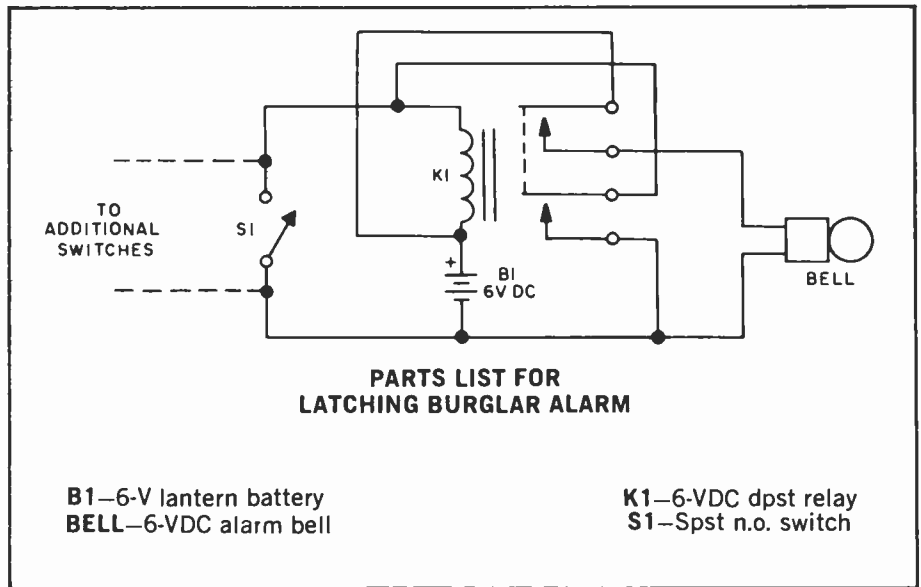
B1—6-15 VDC battery  
 C1, C2, C3—.5- $\mu$ F capacitor  
 Q1, Q2, Q3—NPN general purpose transistor (2N2222, 2N3904 or equiv.)  
 R1, R2, R3—500-2700-ohm resistors,  $\frac{1}{2}$ -watt  
 R4, R5, R6—10,000-47,000-ohm resistor,  $\frac{1}{2}$ -watt  
 S1—SPST switch

# 58 Latching Burglar Alarm

□ Open a fancy commercial burglar alarm and all you'll find inside is this ordinary relay latching circuit.

The input terminals are connected to parallel-wired normally open (N.O.) magnetic switches, or wire-type security switches stretched across a window that *close* a bell contact circuit when the wire is pushed or pulled.

When a security switch closes the series battery circuit, relay K1 pulls in. One set of contacts closes the alarm bell circuit, while the second set "latches" the battery circuit. Even if the security switches are opened, the alarm remains on. To disable the alarm, or for reset, install a concealed switch in series with one battery lead.

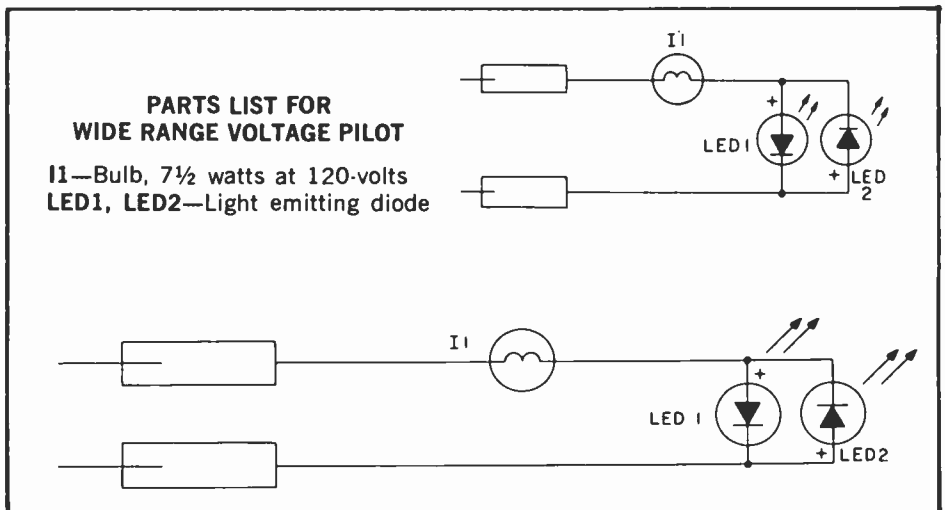


# 59 Wide Range Voltage Pilot

□ Believe it or not, this simple tester will verify voltages between 2 and 120 Volts, AC or DC—and tell you which!

It's easy to understand if you can think of the filament of a small night-light bulb as being a wirewound resistor. It provides the current limiting that LED 1 and LED 2 need to operate safely. And, of course, when the voltage at the probe tips is high enough, I1 lights as well.

You can choose different colors for LED 1 and LED 2 and the probe tips for very quick polarity indications in the case of DC voltages. And seeing both LEDs glow is quick confirmation of an AC voltage.

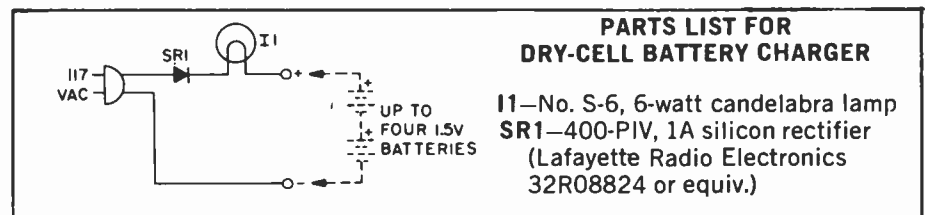


# 60 Dry-Cell Charger

□ This circuit in a fancy commercial package will cost you about \$5. Build a lamp bulb charger yourself and 50¢ may just about do it.

The lamp maintains constant charging of approximately 20 mA through one to four 1.5-volt batteries. But you can go as high as 22.5 volts for either batteries in series or a single battery.

Give small penlight batteries about



10 hours charge, the C and D cells about 20 hours. Yes, you can recharge

NICads stamped with a charge rate of approximately 20 to 25 mA.

## 61 Photoflood Dimmer #2

Professional quality photographic lighting requires complete control of the studio lights, and that's just what you'll get with the pro-type, full-range 500-watt dimmer. Each one can handle one 500-watt #2, or two 100-watt #1 photoflood lamps, and the lighting range can be adjusted from full off to full on.

Triac Q1 must be mounted to a large heat sink, preferably the metal cabinet used to house this dimmer. Make cer-

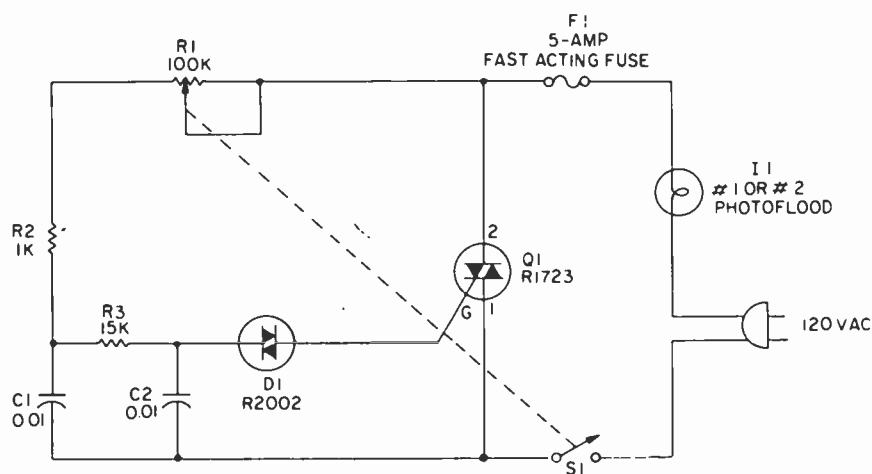
tain you insulate Q1 from the cabinet.

Fuse F1 *must* be used, otherwise, the surge current that occurs when 500-watt photofloods burn out will instantly destroy Q1. F1 must be a fast-acting fuse such as the type 8AG. The slower fuses such as the 3AG and the slo-blo offer no protection. Switch S1 is part

of intensity adjustment R1, and R1 should be wired so it represents maximum resistance just before S1 switches off. (While S1 cannot normally handle a 500 watt load, in this circuit, it switches when the lamp is off and has no trouble handling any size photoflood.)

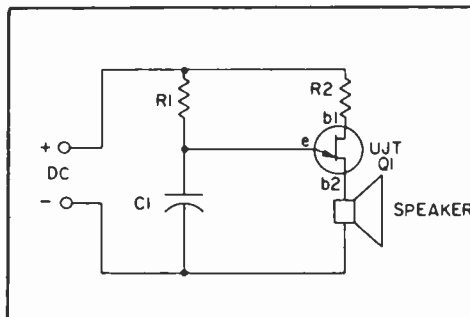
### PARTS LIST FOR PHOTOFLOOD DIMMER #1

- C1, C2—0.01-uF, 50-VDC ceramic disc capacitor
- D1—HEP-R2002 bi-directional trigger diode
- F1—8AG 5-Amp fast-acting fuse
- Q1—HEP-R1723 Triac
- R1—100,000-ohm, linear taper potentiometer w/SPST switch
- R2—1,000-ohm, ½-watt resistor
- R3—15,000-ohm, ½-watt resistor
- S1—SPST switch, part of R1



## 62 Voltage Controlled Oscillator

Unijunction transistors are very interesting. They love to be used in oscillators, and it doesn't take too many parts or very much coaxing to get their sawtooth outputs going. This little squealer will tell you how much voltage it's connected to. The higher the voltage, the lower frequency output you'll hear. 5 or 6 Volts should start its high squeal going; 25 or 30 volts and it'll be ticking like a metronome. You can take advantage of this voltage to frequency conversion and use this circuit as an audible voltmeter. Or, with a resistor across the input, it can be an audible current



### PARTS LIST FOR VOLTAGE CONTROLLED OSCILLATOR

- C1—.5-2.2-uF capacitor
- R1—10,000-47,000-ohm resistor, ½-watt
- R2—82-150-ohm resistor, ½-watt
- Q1—unijunction transistor (2N-2646 or equiv.)
- SPKR—8-40-ohms

meter.

For a slightly stranger effect, connect a large value capacitor (say 50-100 uF with a voltage rating larger than the voltages you intend to ap-

ply). You'll hear a swooping effect. Many different components can be placed across the input for different effects when voltage is applied. Experiment and have fun.

## 63 Highway Nightfall Alert

When it gets dark out, you don't always notice the change. So it isn't hard to get caught driving in the dark without your headlights on. This little project buzzes a friendly reminder until you turn the lights on, turn the

car off, or morning comes.

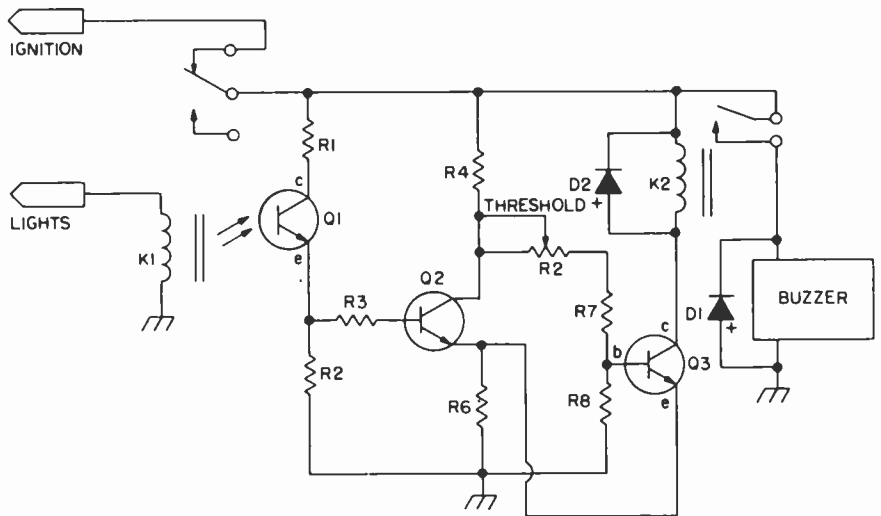
K1 turns on with your headlights. When it's on, it disables the rest of the circuit. So a warning can only sound with your headlights off. As long as light strikes Q1, Q2 remains

on, holding Q3 off. Voltage divider R5-R7-R8 determines the turn-on point for Q3. Q3 drives K2, which triggers a buzzer or other signalling device. A photoconductor may be substituted for R1-Q1, if desired.



### PARTS LIST FOR HIGHWAY NIGHTFALL ALERT

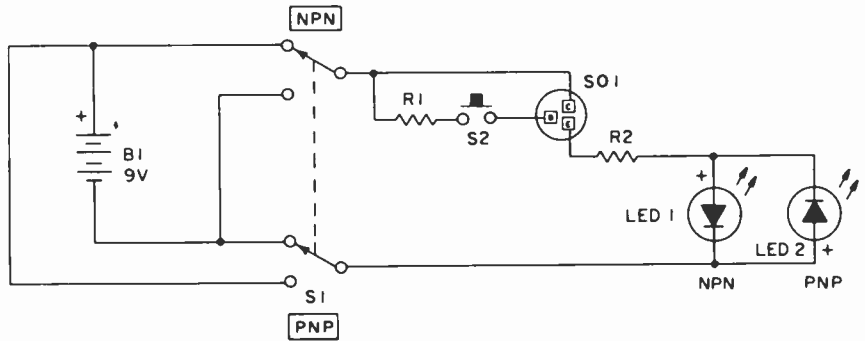
- D1, D2—diode, 1N914 or equiv.
- K1—SPDT relay, 12VDC
- K2—SPST relay, 12VDC
- Q1—Phototransistor, FPT100 or equiv.
- Q2—NPN transistor, 2N3904 or equiv.
- Q3—NPN transistor, 2N2222 or equiv.
- R1, R4, R7—4700-ohm resistor, ½-watt
- R2—560-ohm resistor, ½-watt
- R3, R5, R8—10,000-ohm resistor, ½-watt
- R6—220-ohm resistor, ½-watt



## 64 Transistor Checker

### PARTS LIST FOR TRANSISTOR CHECKER

- B1—9 VDC battery
- LED1, LED2—Light emitting diode
- R1—1000-ohm resistor, ½-watt
- R2—470-ohm resistor, ½-watt
- S1—DPDT switch
- S2—Momentary push button switch
- SO1—Transistor socket



□ It's pushbutton-easy to check transistors with this tiny marvel. Just plug the transistor in and push S2. If it's good and you set the PNP-NPN switch S1 properly, the appropriate LED

will light.

Don't know the type? That's okay. Plug it in and try both S1 switch positions while you watch for the appropriate LED to light. You can

even test diodes using the collector-emitter leads on the socket. The collector-emitter leads can also be used to check continuity.

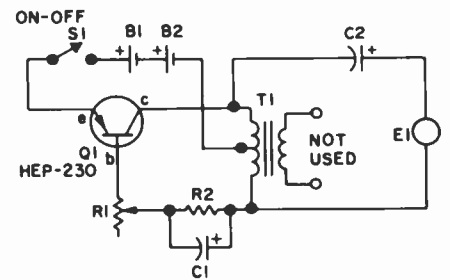
## 65 Angler's Bite Booster

### PARTS LIST FOR ANGLER'S BITE BOOSTER

□ Click-click might not sound like much to you but to a fish it's the dinner bell. That's the lure of this electronic circuit. Shove the whole works in a watertight container, lower it over the side, and wait for the fish to hit the hooks.

For proper operation T1 must be subminiature type about half as large as your thumb. E1 must be a crystal headphone.

- B1, B2—1.5-V AAA battery
- C1, C2—50- $\mu$ F, 12-VDC electrolytic capacitor
- E1—Crystal earphone
- Q1—Motorola HEP-230 pnp transistor
- R1—5000-ohm pot
- R2—27,000-ohm, ¼-watt resistor
- S1—Spst switch, part of R1
- T1—Subminiature transistor output transformer; 500-ohm center

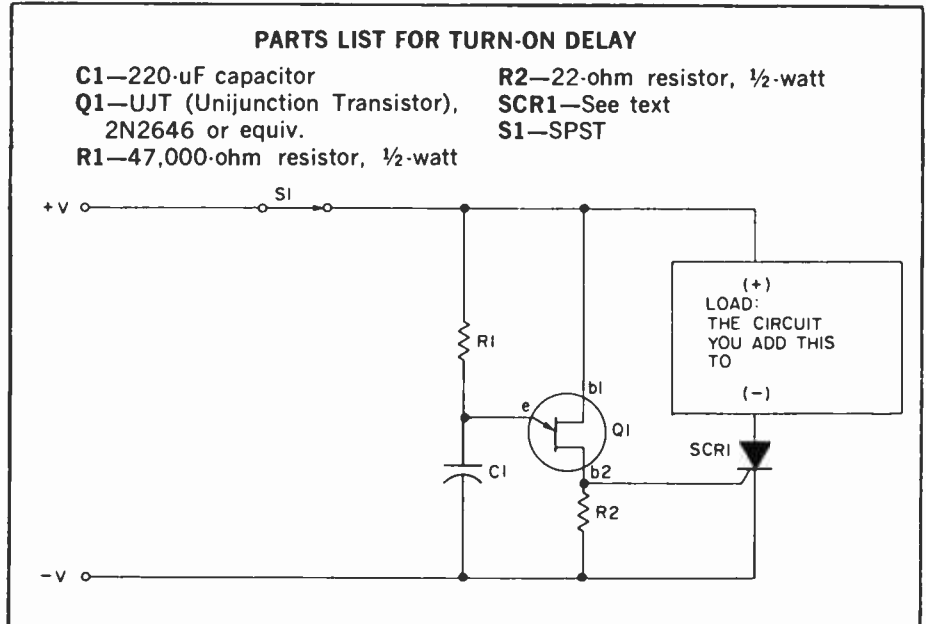


tapped primary to 8-ohm secondary

# 66 Turn-On Delay

□ Turn the switch on and the circuit you're controlling (LOAD) won't turn on until 10 seconds later with this UJT delay. The SCR is the "switch" that eventually permits current to flow through the load. But the SCR won't turn on until the UJT timer circuit delivers a pulse to its gate. This happens after a time delay determined by the product.

Choose a value for SCR1 that can easily handle the maximum current the load will draw, plus a margin for safety, and the voltage of the power supply, plus a margin for safety. For a 9-12 Volt circuit drawing up to ½ amp or so, a 20 Volt 1 Amp SCR should do nicely. Since S1, when turned off, interrupts the flow of current through the SCR, turn-off for the load happens immediately.



# 67 A Vom Thermometer

□ Almost all electronic components change characteristics as temperatures change. In the case of silicon diodes, like the 1N914, the characteristic that changes is the amount of *forward voltage drop*.

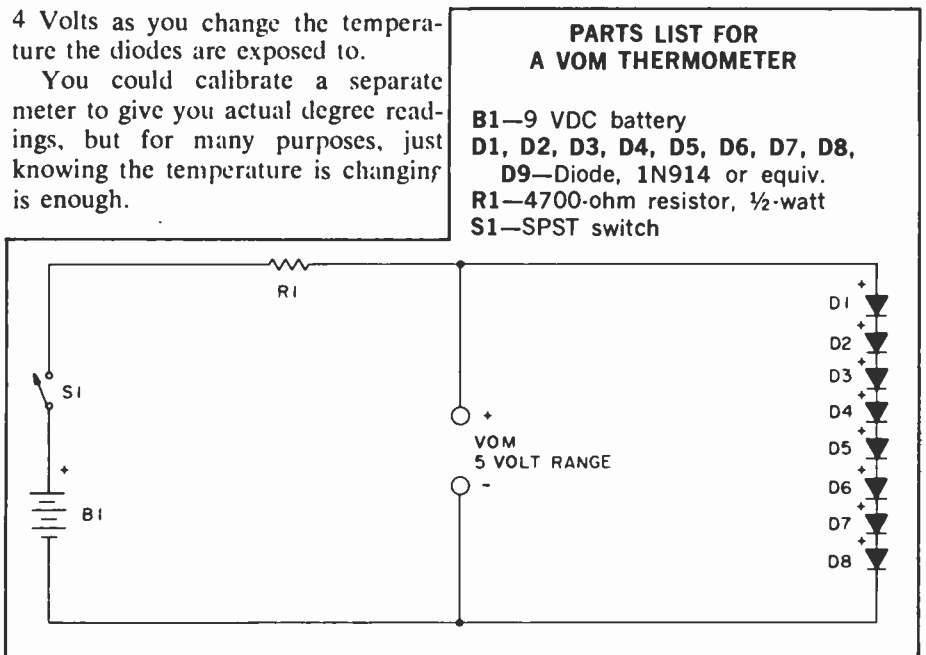
Diodes aren't perfect conductors, you see, because they must take advantage of the bias (voltage) across a semiconductor junction (the place where the two different kinds of semiconductor material, *p* and *n*, meet) in order to operate.

Almost every semiconductor device shows a junction voltage drop of about ½ Volt when forward biased, as the diodes here are.

So if you string eight diodes in series, like these, and measure the voltage across the string on the 5 Volt scale of your VOM, you'll see the voltage varying up and down around

4 Volts as you change the temperature the diodes are exposed to.

You could calibrate a separate meter to give you actual degree readings, but for many purposes, just knowing the temperature is changing is enough.



# 68 Overvoltage Protector

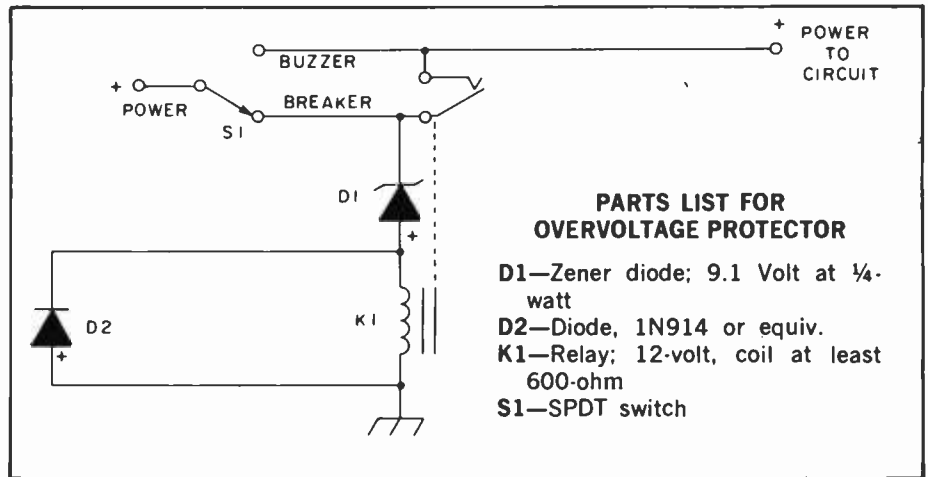
□ Too high a voltage can damage any number of electronic components. Many other components can

withstand high voltages, but only for a limited time. This circuit provides either protection against too much

voltage in much the same way a circuit breaker protects against too much current, or a warning that an

overvoltage condition is occurring.

In the *Breaker* position, power is applied to the protected circuit only so long as relay K1 is not energized. K1 will energize whenever the input voltage exceeds the Zener voltage of diode D1, because above its zener voltage, a reverse-biased Zener diode like this one will conduct. In the *Buzzer* position, power remains applied to the circuit through the relay itself. When an overvoltage is present, the relay pulls in, disconnecting itself, which allows it to release and re-establish connection, which causes it to pull in and break connection and so on—exactly the action of a buzzer. And that's exactly the sound the relay



**PARTS LIST FOR OVERVOLTAGE PROTECTOR**

- D1—Zener diode; 9.1 Volt at ¼-watt
- D2—Diode, 1N914 or equiv.
- K1—Relay; 12-volt, coil at least 600-ohm
- S1—SPDT switch

will make—with enough noise generated to carry the buzz into the audio

and IF circuits of almost anything connected or nearby.

## 69 High Impedance Mike Amplifier

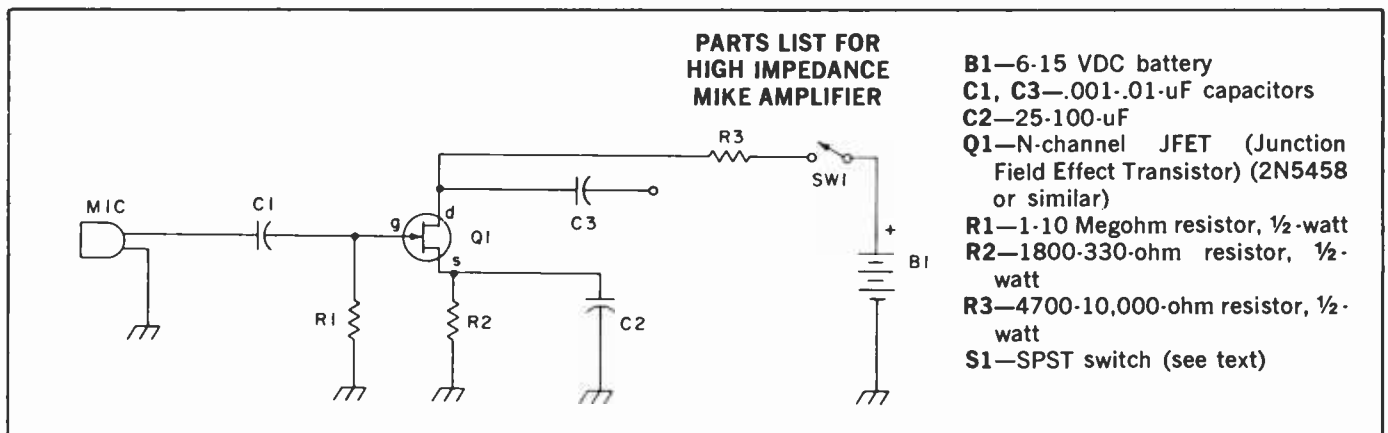
□ This high-to-low impedance converter will let you use a high impedance crystal, ceramic or dynamic microphone with conventional (around 5K) microphone inputs. It will also let you use a high impedance mike over a longer run of cable with less danger of introducing

hum.

Q1 is a general purpose N-channel JFET, like the Siliconix 2N5458, Motorola MPF102 or similar. Choose R1 to match the impedance of your microphone.

If you choose to mount this circuit in or near the microphone case

(where it will do the most good), and the microphone is a push-to-talk type, investigate using the PTT switch in place of S1. This may work better if S1 is placed in the negative battery lead rather than the positive (as shown).



**PARTS LIST FOR HIGH IMPEDANCE MIKE AMPLIFIER**

- B1—6-15 VDC battery
- C1, C3—.001-.01-µF capacitors
- C2—25-100-µF
- Q1—N-channel JFET (Junction Field Effect Transistor) (2N5458 or similar)
- R1—1-10 Megohm resistor, ½-watt
- R2—1800-330-ohm resistor, ½-watt
- R3—4700-10,000-ohm resistor, ½-watt
- S1—SPST switch (see text)

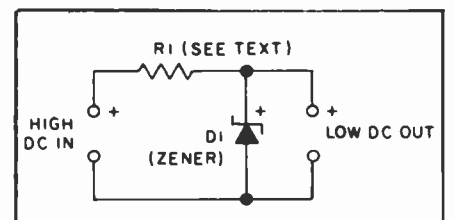
## 70 Zener Regulator

□ When the output from an AC power supply is too high for a solid-state project, chop it down to size with a zener diode voltage regulator and keep it on the button.

To calculate R, first add the load current and 1/20 of the load current for the zener's idling current. Then use Ohm's Law ( $R = E/I$ ) to calculate R. The resistor's power rating

should be twice the calculated power.

The power rating for the zener diode is determined by the voltage across the diode squared, divided by diode's nominal internal resistance. You can calculate the internal resistance by working backwards from the zener's power rating. As an example: a 9-volt, 1-watt zener would have a nominal internal resistance of  $R =$



$E^2/W$ ,  $81/1$ , or 81 ohms. It's not precisely accurate, but close enough.

# 71 Balanced Input Mike Preamp

□ Once the length of a "single ended" (one shielded wire) microphone cable exceeds 25-feet, it becomes highly susceptible to hum and noise pickup. One way the pros get around the problem is by using low-impedance *balanced-output* microphones. The Low-Z mike is less susceptible to noise pickup to start with, and what noises picked up by the line are picked up equally in both wires, so they cancel if the

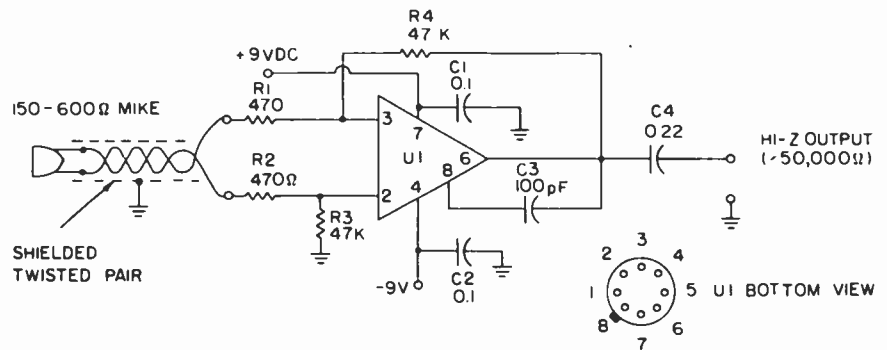
mike feeds a balanced input amplifier.

About the easiest way to get a balanced input is to use an operational amplifier as a preamp, because the op amp starts out with a *differential* (balanced) input. Virtually any op amp can be used, although the Signetics SE/NE-531 is a good choice because it's very stable. In addition to providing a balanced, noise-cancelling input, this circuit delivers a nominal 40 dB gain.

Aside from using a metal enclosure, there is no special assembly precaution, other than installing C1 and C2 as close as possible to the IC terminals. The 531 is available in both the "round" package shown and in a DIP. Either packaging type can be used. Any microphone with a balanced output up to 1000 ohms can be used, though the more common impedances of 150 to 600 ohms will produce optimum fidelity.

## PARTS LIST FOR BALANCED MIKE PRE-AMP

- C1, C2**—0.1- $\mu$ F, 15-VDC mylar capacitor
- C3**—100-pF, 500-VDC ceramic disc capacitor
- C4**—0.22- $\mu$ F, 15-VDC mylar capacitor
- R1, R2**—470-ohm,  $\frac{1}{2}$ -watt resistor, 5% tolerance
- R3, R4**—47,000-ohm,  $\frac{1}{2}$ -watt resistor, 5% tolerance
- U1**—Signetics NE or SE-531 op amp



# 72 Doorknob Security Alarm

□ Here's security for the traveler. Just connect this alarm to the doorknob of your motel room and a loud buzzer will sound if anyone touches the doorknob.

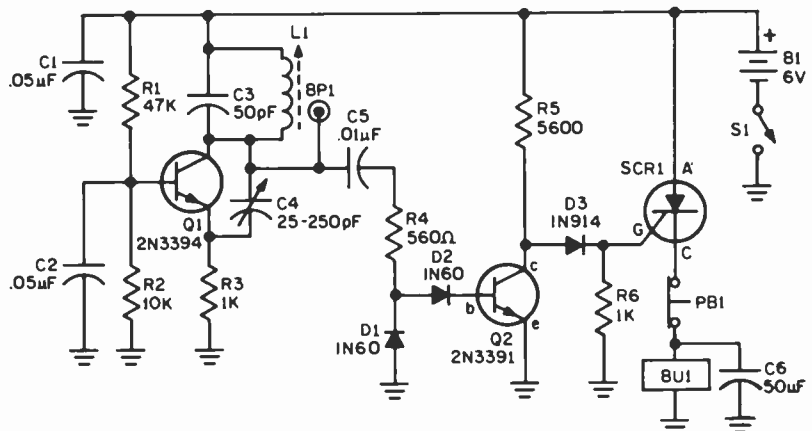
Transistor circuit Q1 is an oscillator with a connection through bind-

ing post BP1 to the doorknob. As long as Q1 oscillates, its rectified out-

put is applied to Q2 which holds the SCR1 gate almost at ground poten-

## PARTS LIST FOR DOORKNOB SECURITY ALARM

- B1**—6-volt battery, Burgess Z4 or equiv.
- BP1**—Binding post
- BU1**—6-volt buzzer
- C1, C2**—0.05- $\mu$ F disc capacitor, 25 VDC or better
- C3**—47-pF silver mica capacitor (Allied Electronics 782-0860)
- C4**—300-pF trimmer capacitor
- C5**—0.05- $\mu$ F, 25 VDC capacitor
- C6**—50- $\mu$ F electrolytic capacitor, 25 VDC or better
- D1, D2**—Diode, 1N60
- D3**—Diode, 1N914



- L1**—15- $\mu$ H adjustable RF coil (Miller 4205, or equiv.)
- PB1**—Pushbutton switch (reset)
- Q1**—2N3394
- Q2**—2N3391
- R1**—47,000-ohm,  $\frac{1}{2}$ -watt resistor
- R2**—10,000-ohm,  $\frac{1}{2}$ -watt resistor

- R3, R6**—1000-ohm,  $\frac{1}{2}$ -watt resistor
- R4**—560-ohm,  $\frac{1}{2}$ -watt resistor
- R5**—5600-ohm,  $\frac{1}{2}$ -watt resistor
- S1**—Switch, spst (on-off)
- SCR1**—800-mA/30-V silicon controlled rectifier, HEP R1001

tial. When someone touches the door-knob, hand capacitance "kills" the oscillator, thereby removing that cut-off (holding) bias from the SCR1 gate; the SCR conducts and sounds alarm buzzer BU1. The alarm can only be turned off by opening reset

switch PB1.

The alarm should be assembled in a small metal cabinet with insulated binding post BP1 at the top. A small wire loop attached to BP1 secures the alarm to the doorknob—the alarm actually hangs on the knob. To adjust,

carefully set C4 in small increments until touching your finger to BP1 causes the buzzer to sound. If C4 is overadjusted, hand capacitance will not "kill" the oscillator. Best operation is obtained if the door is made of wood.

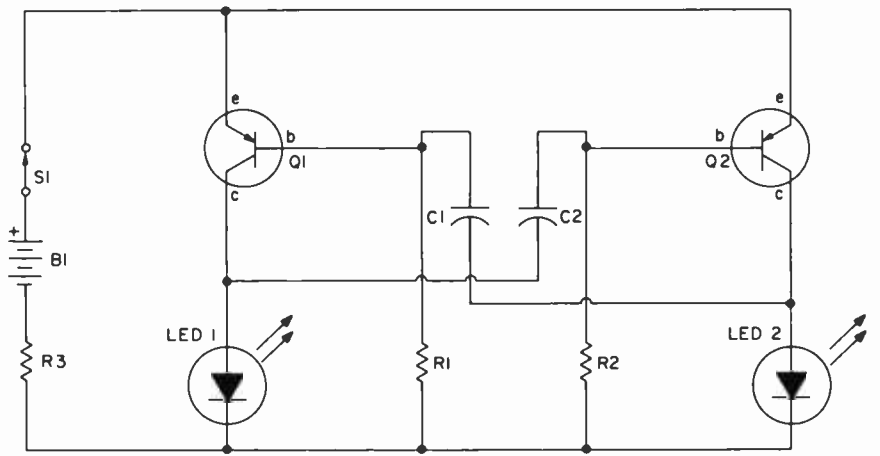
## 73 The Bamboozler

Officially, this is a slow speed astable multivibrator with state-indicating photo-optic outputs. Unofficially, it's just a circuit to alternately flash two L.E.D.s. But you don't have to tell anybody that. Tell them it's counting Ekno Rays from the planet Nerd. Or it remotely controls your pacemaker. Or it can tell a person's innermost secrets. Or you'll think of something. R3 limits the current the whole circuit can draw. If you find the flashing too dim or unreliable, reduce the value of R3 to 150, 100 or 47 Ohms. If you could handle even dimmer blinks, increase R3 to a maximum of about 100 Ohms.

You could also use different color LEDs, add a magnetic reed switch in series with each capacitor, and hide a magnet between your fingers. Then, by careful positioning, you can control whether both flash, one stays on or both stay on.

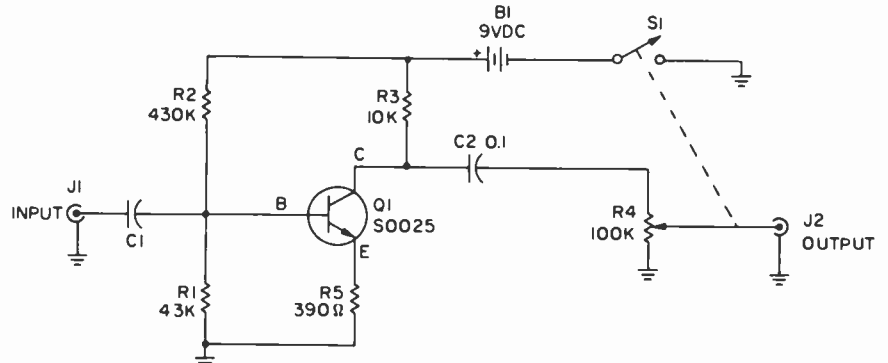
### PARTS LIST FOR THE BAMBOOZLER

- |                                                 |                                            |
|-------------------------------------------------|--------------------------------------------|
| <b>B1</b> —9 VDC battery                        | <b>R1, R2</b> —47,000-ohm resistor, ½-watt |
| <b>C1, C2</b> —10-μF capacitor                  | <b>R3</b> —220-ohm resistor, ½-watt        |
| <b>LED1, LED2</b> —Light emitting diode         | <b>S1</b> —SPST switch                     |
| <b>Q1, Q2</b> —PNP transistor, 2N3906 or equiv. |                                            |



## 74 Rucker's Mike Booster

Between the lead and rhythm guitars, and the organ or synthesizer, the lead vocalist's mike often gets buried under the instruments if they all use a common amplifier. One way to get the vocalist up and out front is to give the mike some extra sock with a preamp. This one, specifically designed to handle most of the impedances commonly used by rock-group mikes, will give enough extra gain to project the singer's voice out to the last row of the balcony! Build it any way you wish, just as long as it's inside a metal cabinet.



### PARTS LIST FOR RUCKER'S MIKE BOOSTER

- B1**—9-volt transistor radio battery, see text  
**C1**—10-μF capacitor

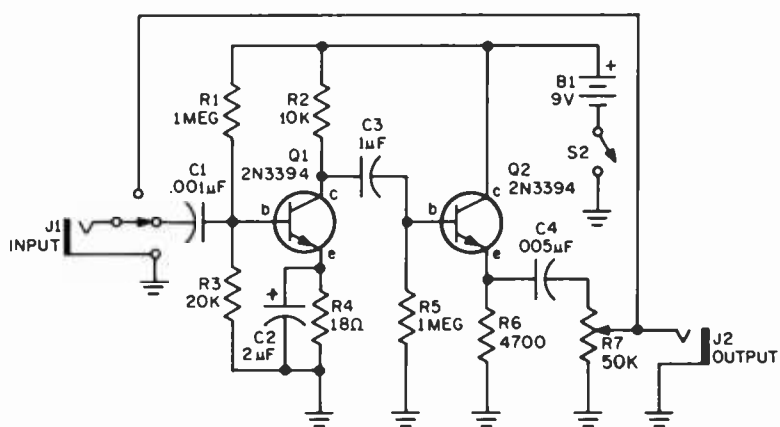
- C2**—0.1-μF, 10-VDC mylar capacitor  
**J1, J2**—jacks to match existing cables  
**Q1**—HEP-S0025 NPN transistor  
**R1**—43,000-ohm, ½-watt resistor

- R2**—430,000-ohm, ½-watt resistor  
**R3**—10,000-ohm, ½-watt resistor  
**R4**—100,000-ohm, audio taper potentiometer w/SPST switch  
**S1**—SPST switch, part of R4

## 75 Twang-A-Matic

□ It seems no one cares for the sound of a plain, unadorned guitar. First they added fuzz, then big-boom bass, next it was reverberation and screaming highs. Now the in sound is *twang*, a guitar sound that more or less approximates a banjo or mandolin. A Twang-A-Matic produces these unusual sounds from an ordinary electric guitar by cutting the bass, severely distorting the midband and highs, and then amplifying the distortion. It might read "bad" to you, but it sure sounds good!

You can assemble the Twang-A-Matic in any type of cabinet. Switch S1 cuts the effect in and out while switch S2 turns the unit on and off. Output control R7 should be set so the Twang-A-Matic has the same volume level as the straight guitar feed-through. Various degrees of twang are obtained by varying the output so the guitar picks up with the level controls built into the guitar.

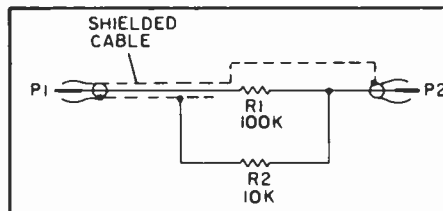


PARTS LIST FOR TWANG-A-MATIC

- |                                                        |                                             |
|--------------------------------------------------------|---------------------------------------------|
| B1—9-volt battery (Eveready 246 or equiv.)             | Q1, Q2—NPN transistor, 2N3394               |
| C1—0.001- $\mu$ F disc capacitor 25 VDC or better      | R1, R5—1 megohm, 1/2-watt resistor          |
| C2—2- $\mu$ F electrolytic capacitor, 15 VDC or better | R2—10,000, 1/2-watt resistor                |
| C3—1- $\mu$ F electrolytic capacitor, 15 VDC or better | R3—20,000-ohm, 1/2-watt resistor, 5 percent |
| C4—0.005- $\mu$ F disc capacitor, 15 VDC or better     | R4—18-ohm, 1/2-watt resistor                |
| J1, J2—Phone jack                                      | R6—4700-ohm, 1/2-watt resistor              |
|                                                        | R7—50,000-ohm potentiometer                 |
|                                                        | S1—Switch, spdt (twang in-out)              |
|                                                        | S2—Switch, spst (on-off)                    |

## 76 Computer Recording Attenuator

□ Most personal computers use a low-cost cassette recorder as the data storage medium, the data generally being stored on tape as alternating audio frequencies. There is no standard output level for personal computer data signal levels, and the computers rely on the recorder's automatic record level control to prevent tape overload and saturation. The auto-level control generally works well. Unfortunately, the signal level from many computers is often sufficiently high to overload the recorder's input before the level control gets a chance to work, and thus the storage of data becomes intermittent, or even im-



possible.

If you have trouble recording your programs, try installing this attenuator cable between the computer's "output to recorder" and the recorder's *auxiliary* or *high-level* input. The 10:1 voltage ratio of the cable represents a 20 dB signal attenuation, usually just the

right value to prevent overload of the recorder.

Resistors R1 and R2 should be installed directly behind plug PL2. Shielded audio cable must be used between PL1 and PL2. Plugs PL1 and PL2 should match your existing computer and recorder jacks.

PARTS LIST FOR COMPUTER RECORDING ATTENUATOR

- P1, P2—plugs to match existing equipment  
 R1—100,000-ohm, 1/4-watt resistor  
 R2—10,000-ohm, 1/4-watt resistor

## 77 Current Tattletale

□ Ever have to check a line to see whether or not any current was flowing within it, and which way? Here's an easy answer. Any current flow here will build up a voltage in R1. If the voltage in R1 is more than

about 2 volts, one or the other (or both, if AC) of the LEDs will light.

Different systems may require different values for R1. Use Ohm's Law to calculate R1. For example, if we wanted to know whether or not a

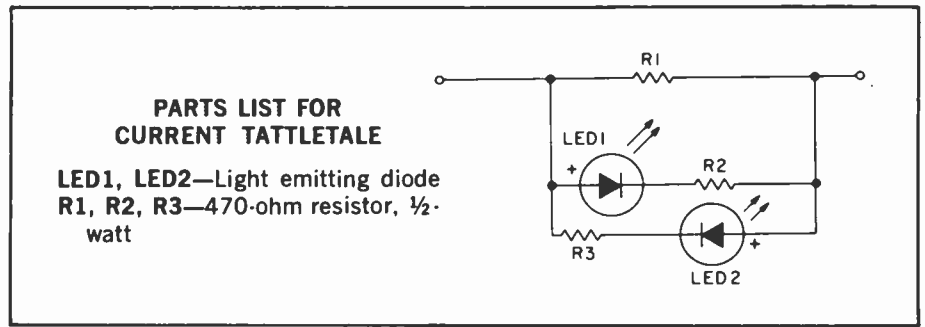
car's taillight bulb had burned out, we could connect this circuit in series with the lamp's supply lead. Assume the particular lamp requires typically 1/2 Amp to light. We then need to know what value for R1 will provide

a 2 Volt drop.

Using Ohm's Law,  $E=I \times R$ , or  $R=E/I=2+1/2=4$  Ohms (you would want to use a 4 or 5 Watt resistor to comfortably handle this 1 Watt power dissipation).

In a 100 Volt B+ supply drawing 100 ma,  $R=E/I=2/.100=20$  Ohms.

The circuit drawn above is sensitive enough to detect a few milliamperes of current flow.



## 78 Speaker-MIC

**PARTS LIST FOR SPEAKER-MIC**

**B1**—9-volt transistor radio battery  
**C1**—4.7- $\mu$ F, 10-VDC electrolytic capacitor

**C2**—0.22- $\mu$ F, 10-VDC mylar capacitor

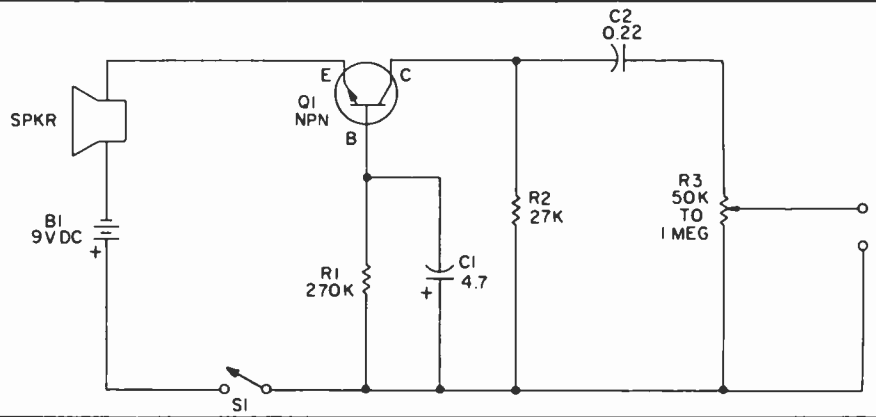
**Q1**—general purpose NPN transistor, see text

**R1**—270,000-ohm, 1/2-watt resistor

**R2**—27,000-ohm, 1/2-watt resistor

**R3**—audio taper potentiometer, see text

**S1**—SPST switch



□ A "junk box" speaker and a general purpose transistor, plus a few other "general purpose" components are all that are required for a high-output microphone substitute. While not hi-fi quality by any stretch of the imagination, the Speaker-Mic handles voice frequency signals very well.

Transistor Q1 can be just about any general-purpose NPN with a Beta of

about 50 to 150. The speaker can be anything you have lying around of virtually any impedance rating in the range of 3.2 to 42-ohms. If the entire circuit, including battery, is assembled in a small metal enclosure, you'll end up with a hand-sized "amplified microphone."

The volume level is adjusted with potentiometer R3, which can be any audio taper unit from 50,000-ohms to 1-megohm. You can substitute a linear taper potentiometer if you have one lying around, but you'll find the adjustment range is scrunched together on one end of the shaft's rotation.

## 79 Quick Diode Checker

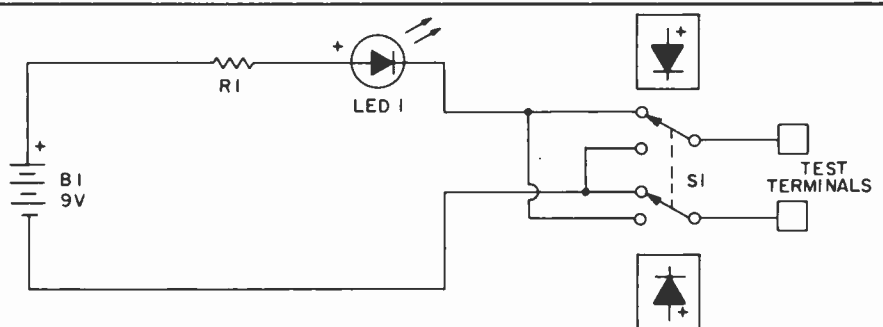
**PARTS LIST FOR  
QUICK DIODE CHECKER**

**B1**—9VDC battery

**LED1**—Light emitting diode

**R1**—470-ohm resistor, 1/2-watt

**S1**—DPDT switch



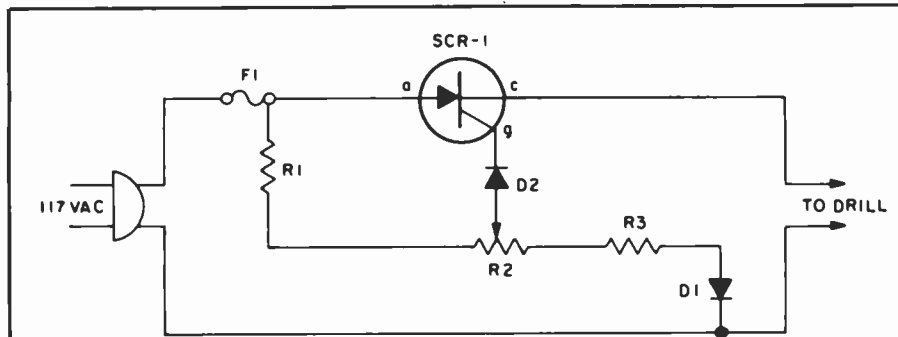
□ This not only tells you whether or not a diode is good, it checks the polarity for you.

The diode under test completes the circuit through B1, R1 and the LED

when inserted in the proper polarity. Switch S1 reverses the polarity of the diode under test. A good diode will light the LED only in one switch position. An open diode will not light it in either position. A shorted

diode will light it in both positions. To use the circuit as a polarity indicator, connect the diode to the test terminals. The diagrams above refer to the polarity of the diode when the LED lights in the switch positions.

# 80 Power Tool Torque Control



**PARTS LIST FOR  
POWER TOOL TORQUE CONTROL**

- |                                                                          |                                                                    |
|--------------------------------------------------------------------------|--------------------------------------------------------------------|
| <b>D1, D2</b> —1A, 400 PIV silicon rectifier (Calectro K4-557 or equiv.) | <b>R2</b> —250-ohm, 4-watt potentiometer                           |
| <b>F1</b> —3-A "Slo-blo" fuse                                            | <b>R3</b> —33-ohm, ½-watt resistor                                 |
| <b>R1</b> —2500-ohm, 5-watt resistor                                     | <b>SCR1</b> —8-A, 400-PIV silicon controlled rectifier (HEP R1222) |

□ As the speed of an electric drill is decreased by loading, its torque also drops. A compensating speed control like this one puts the oomph back into the motor.

When the drill slows down, a back voltage developed across the motor—in series with the SCR cathode and gate—decreases. The SCR gate voltage therefore increases relatively as the back voltage is reduced. The "extra" gate voltage causes the SCR to conduct over a larger angle and more current is driven into the drill, even as speed falls under load.

The only construction precaution is an extra-heavy heat sink for the SCR. The SCR should be mounted in a ¼-in. thick block of aluminum or copper at least 1-in. square; 2-in. if you drill for extended periods.

# 81 Photo Print Meter

□ Every print a good print! That's what you get with the photo print meter.

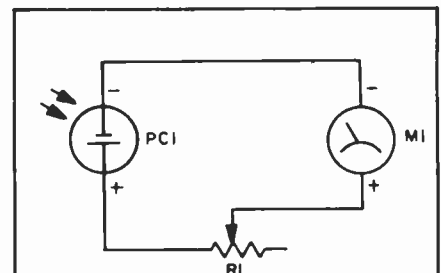
Meter M1 can be just about anything up to 0-1 DC mA. But if you prefer low light levels and long exposures, install a sensitive meter of 500  $\mu$ A or less.

When light from the enlarger falls on the solar cell (PC1), a voltage is generated that is in proportion to the amount of light. Sensitivity control R1 allows the user to set the meter indication to a convenient value.

To use the meter, first make a good normal print in your normal manner from a No. 2 or No. 3 nega-

tive. Then, do not disturb the enlarger setting, but integrate the light by placing a diffusing disc or opal glass under the lens. Place the solar cell on the easel and adjust R1 for a convenient meter reading, say, full scale. The meter is now calibrated.

When using it, focus the enlarger, use the diffuser, and adjust the lens diaphragm until you get the reference meter reading. Then use the exposure time previously found for the calibration print. Suggested reading: *Ilford Manual of Photography*, obtainable from any photo store. Also, check Kodak publications available at the same place.



**PARTS LIST FOR  
PHOTO PRINT METER**

- |                                                |
|------------------------------------------------|
| <b>M1</b> —100, 250, or 500- $\mu$ A DC meter  |
| <b>PC1</b> —Solar cell (Calectro J4-801)       |
| <b>R1</b> —5000-ohm potentiometer linear taper |

# 82 LED Bar Graph Display

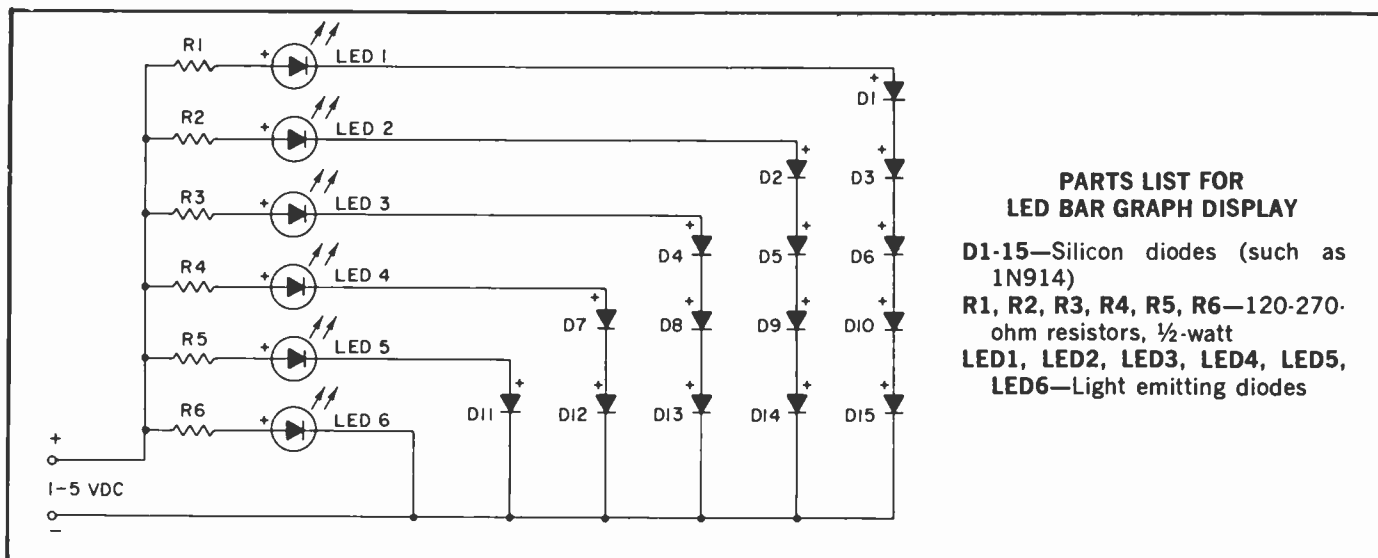
□ This circuit takes advantage of the forward voltage drop exhibited by silicon diodes. Each leg of the circuit shows a light emitting diode in series with a current limiting resistor and a different number of diode voltage drops, from 0 to 5. You may use any kind of diode you wish, including ger-

manium, silicon, even expensive hot carrier types (although they won't exhibit quite as much drop, they're very expensive, and too large a current could burn them out).

Depending on the diodes you choose, each will exhibit a forward voltage drop between 0.3 and 0.7

volts. For consistency, stay with diodes of the same type, or at least the same family. Those twenty-for-a-dollar "computer" diodes will do just fine. To expand the range of this LED "meter," use two resistors as a voltage divider at the input. Connect one across the + and - terminals, the





**PARTS LIST FOR LED BAR GRAPH DISPLAY**

- D1-15—Silicon diodes (such as 1N914)
- R1, R2, R3, R4, R5, R6—120-270-ohm resistors, ½-watt
- LED1, LED2, LED3, LED4, LED5, LED6—Light emitting diodes

other from the + terminal to the voltage being measured. The LEDs will then be monitoring a range determined by the ratio of those resistors,

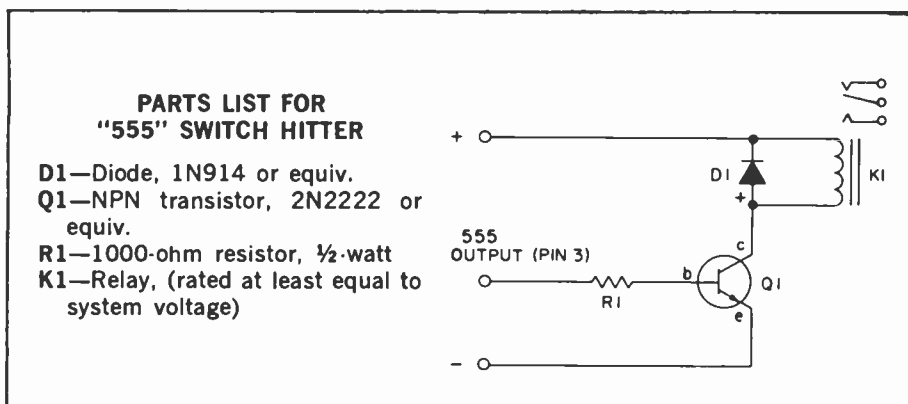
as determined by this formula: The voltage across the input equals the resistance across the output, divided by the sum of the resistances

and multiplied by the voltage being measured. Or:

$$E_{in} = E_m \times \frac{R_{in}}{R_{sum}}$$

## 83 555 Switch Hitter

□ The "555" is a very versatile timer when you need a time delay or any kind of regular timed event. But if you try to draw more than 100 or 200 milliamps through it, you'll soon be drawing a blank and a new 555 from your parts drawer. With these simple additions, you can draw as many amps as your relay's contacts will carry. Q1 acts as a relay driver, triggered by the output of the 555 (pin 3) through a 1000 Ohm resistor (R1). Relay K1 can be driven from the 555's power supply (choose an appropriate coil voltage for K1) or from a separate positive power supply if the 555's supply can't

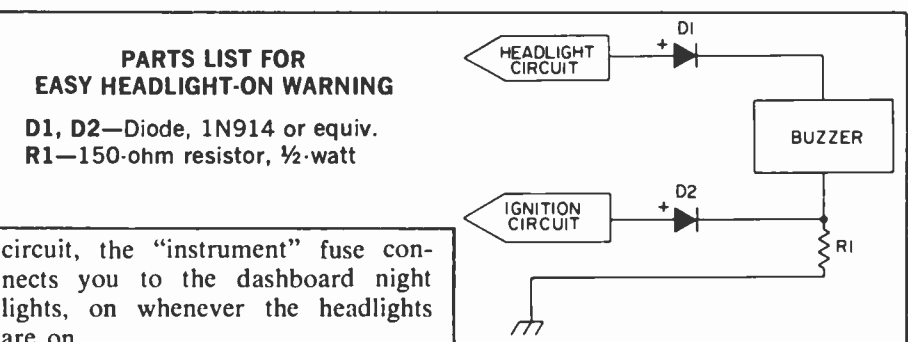


handle the extra load. Q2 can handle up to 800 milliamps itself, so any relay coil that draws less than that

(100 Ohms or so more than satisfies this) will work fine. Similarly, other loads can be substituted for K1-D1.

## 84 Easy Headlight-On Warning

□ Nobody has to tell you about the time and money you can get stuck going through if you forget and leave your headlights on when you leave your car. This circuit reminds you your lights are on the instant you turn your key off. The Detroit warning circuits wait until you open the door. You can connect to the voltages you need right at the fuseblock. Try the "radio" fuse for the ignition



circuit, the "instrument" fuse connects you to the dashboard night lights, on whenever the headlights are on.

## 85 CB Scope Monitor

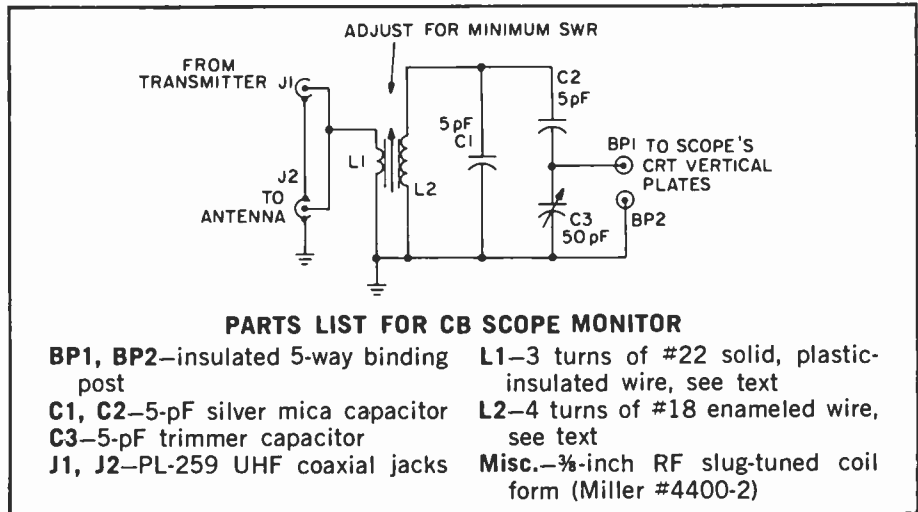
Any scope, from the least to most expensive, with provisions for direct connections to the vertical CRT plates, can be used for direct observation of the modulated RF waveform of a CB transmitter; not just the modulation itself, but the actual RF output at 27 MHz.

Taking virtually no energy from the CB rig's output signal, this scope monitor adaptor continuously samples the RF fed to the antenna system, providing a *real-time* monitor of what's being received on the other end of the two-way communications circuit.

The adaptor must be assembled in a metal cabinet. J1 and J2 are UHF coaxial jacks spaced as close together as possible.

L2 is wound first, in the center of a 3/8-inch, slug-tuned coil form. Then L1 is wound adjacent to the "ground" end of L2. Install the L1/L2 assembly so the tuning slug protrudes through the cabinet.

To use the adaptor, set your scope for direct vertical plate connection, and connect the plate jacks to binding posts



BP1 and BP2. Connect an SWR meter between your CB transmitter and the adaptor, and then connect the adaptor to the transmission line. Key the transmitter and adjust L1/L2 for minimum SWR. (It should read as low as without the adaptor.) Adjust C3 for the desired trace size on the CRT. There is some C3/coil interaction, so it will probably

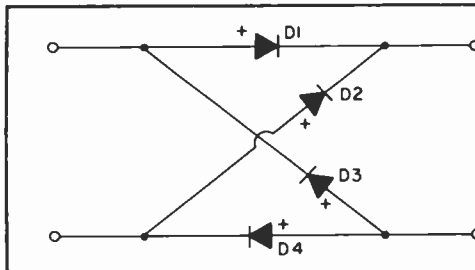
be necessary to readjust L1/L2 for minimum SWR each time you adjust C3.

(Note: The adaptor must connect to a scope's vertical plate connection(s). The 27 MHz RF usually can't pass through a scope's vertical amplifier unless it happens to be a lab-grade RF scope.)

## 86 Wrong-Way Battery Protector

Want to ruin an expensive piece of solid state equipment? Just hook the battery or supply up backwards. But by adding these four diodes to your equipment, you can say goodbye to backwards forever. This diode arrangement is one you may recognize as a full wave bridge. In power supplies, it's used to rectify both halves of the AC waveform.

Here, it makes sure that no matter which way you connect the battery, the positive and negative supply terminals in your equipment get the



right polarity voltage. Remember, since the forward bias of two diodes are introduced, your equipment will be getting about a volt less than your

battery is delivering. And remember, choose your diodes so they're rated for all the current your circuit will draw.

## 87 SWL's Low Band Converter

Ever listen in on the long waves, from 25-500 kHz? It's easy with this simple converter. It'll put those long waves between 3.5 and 4.0 MHz on your SWL receiver.

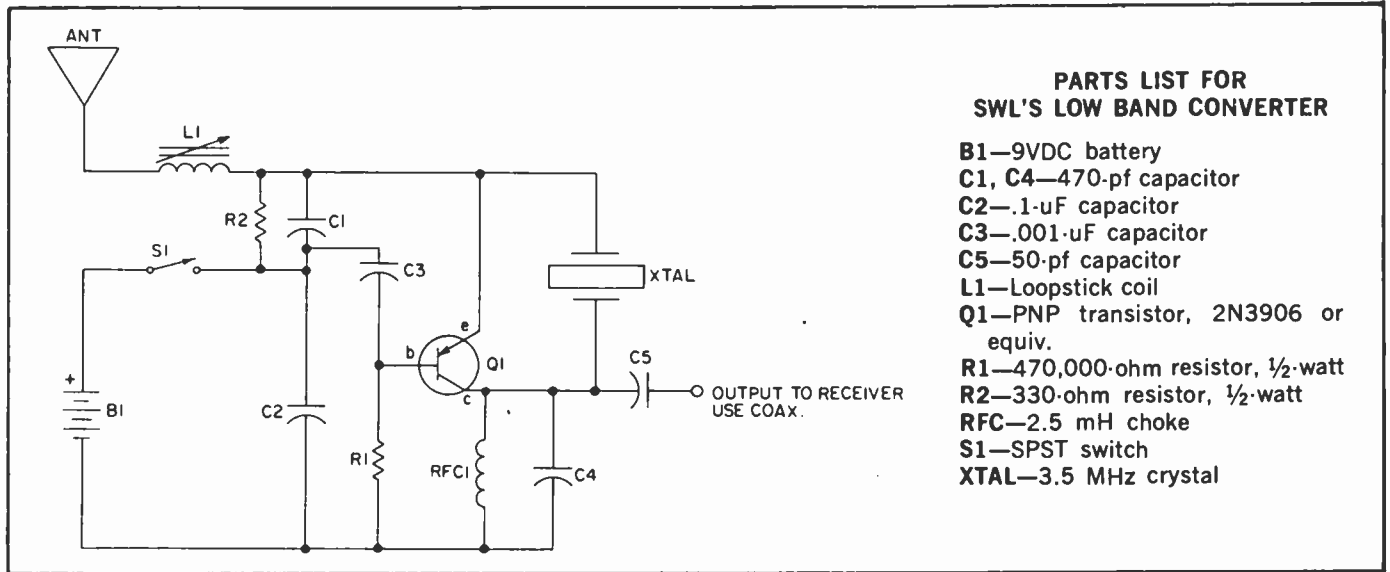
Q1 acts as a 3.5 MHz crystal oscil-

lator, mixing the crystal frequency with the long wave input from the antenna and forwarding the mix to your receiver.

L1 is a standard broadcast loopstick antenna coil. The crystal is

available from many companies by mail order, or is likely to be at a ham radio store near you. You could also use a 3.58 MHz TV color crystal.

Adjust the slug of L1 for your best signal after tuning to a strong station.



**PARTS LIST FOR SWL'S LOW BAND CONVERTER**

- B1—9VDC battery
- C1, C4—470-pf capacitor
- C2—.1- $\mu$ F capacitor
- C3—.001- $\mu$ F capacitor
- C5—50-pf capacitor
- L1—Loopstick coil
- Q1—PNP transistor, 2N3906 or equiv.
- R1—470,000-ohm resistor, 1/2-watt
- R2—330-ohm resistor, 1/2-watt
- RFC—2.5 mH choke
- S1—SPST switch
- XTAL—3.5 MHz crystal

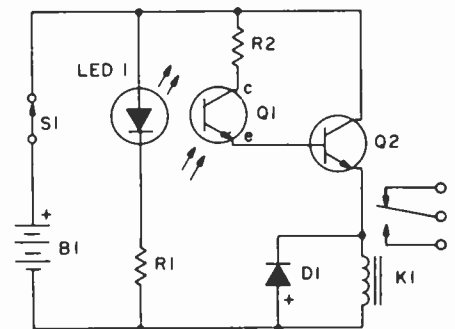
## 88 Photoelectric Tattletale

How would you like to know whether or not the postal person brought you any post? Or how about a circuit to start something going whenever you put a card in a slot? That's what this little photorelay is all about. Whenever the phototransistor sees the LED, it pulls up the base of relay driver Q2 and pulls in the relay. Stick something between the LED and Q1 and the relay releases. D1 shunts out the relay's inductive kickback.

If you point the LED and Q1 in the same direction, they will act together as a reflective sensor. Then if anything comes close enough to

**PARTS LIST FOR PHOTOELECTRIC SOMETHING'S THERE TATTLETALE**

- B1—12VDC battery
- D1—Diode, 1N914 or equiv.
- K1—SPDT relay, 12VDC
- LED1—Light emitting diode
- Q1—Phototransistor, FPT100 or equiv.
- Q2—NPN transistor, 2N2222 or equiv.
- R1—150-ohm resistor, 1/2-watt
- R2—2700-ohm resistor, 1/2-watt
- S1—SPST switch



bounce the light from the LED back into Q1 (assuming both are kept in the dark—any light will trigger Q1),

the relay will pull in. The circuit can also be used without R1 and LED1 as a light- or no-light-operated alarm.

## 89 Flash Tester

Even if you spend \$18 or \$20 for a super-duper professional remote flash tripper, you'll get little more than this two-component circuit. Price is important if the results are equal.

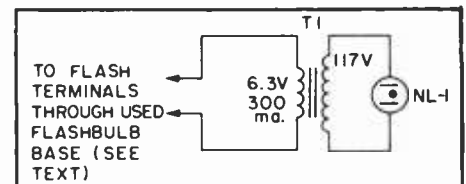
Transistor Q1 is a light-activated silicon-controlled rectifier (LASCR). The gate is tripped by light entering a small lens built into the top cap.

To operate, provide a 6-in. length of stiff wire for the anode and cathode connections and terminate the wires in a polarized power plug that match-

es the sync terminals on your electronic flashgun (strobelight). Make certain the anode lead connects to the *positive* sync terminal.

When using the device, bend the connecting wires so the LASCR lens faces the main flash. This will fire the remote unit.

No reset switch is needed. Voltage at the flash's sync terminals falls below the LASCR's holding voltage when the flash is fired, thereby turning off the LASCR.



**PARTS LIST FOR FLASH TESTER**

- T1—6.3-volt filament transformer
- NL-1—Neon lamp, see text
- Misc.—Used flashbulb base.

# 90 Sensitive Squelch

□ The high sensitivity of this circuit is due to the use of a JFET at Q1. With R2 at just 47K, the high impedance input JFET is just loafing along. (If you need more sensitivity, try values up to 10 Megohms for R2). The signal input from a detector or other audio signal or noise source within your circuit is applied through

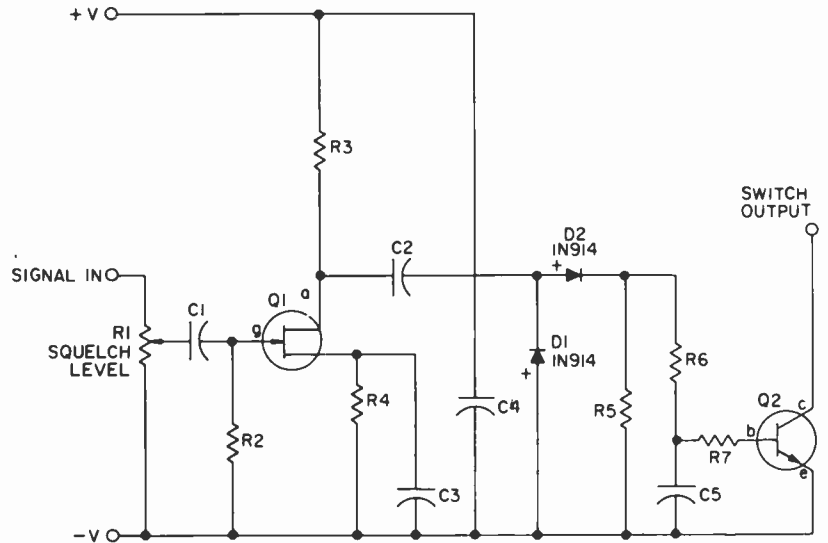
voltage divider R1 and C1 to the gate of Q1. Q1 amplifies this signal and passes it through C2 to D1-D2, which convert it to a DC voltage. This is used to drive switch Q2 on, with a delayed turn-off provided by R7-C5. R6-C5 delay turn-on. These delays prevent picket-fencing.

FM squelches are noise operated,

where the more noise there is, the less signal. So an FM squelch must *disable* with increasing input. In an FM system, Q2 would shunt the audio signal to ground at the first audio stage. An AM system would be designed to *enable* with increasing input. In an AM system, Q2 would be used.

## PARTS LIST FOR SENSITIVE SQUELCH

- C1—33-pF capacitor
- C2—.05-uF capacitor
- C3—4.7-uF capacitor
- C4—10-uF capacitor
- C5—.22-uF capacitor
- D1, D2—Diode, 1N914 or equiv.
- Q1—FET (Field Effect Transistor), 2N5458 or equiv.
- Q2—NPN transistor, 2N2222 or equiv.
- R1—100,000-ohm potentiometer
- R2—47,000-ohm resistor, 1/2-watt
- R3—12,000-ohm resistor, 1/2-watt
- R4—3300-ohm resistor, 1/2-watt
- R5—3.3-Megohm resistor, 1/2-watt
- R6, R7—1000-ohm resistor, 1/2-watt



# 91 Pencil NiCad Charger

□ Packaged in a fancy plastic box, with clips to handle up to four rechargeable batteries, this simple circuit sells for upwards of \$10 in many automotive and hardware stores. In actual fact, it can cost less than \$1 for the components, and will handle up to twelve AA (pencil) size NiCads such as used in CB walkie-talkies. The circuit automatically limits the charging current to a proper value, so you can even recharge just one NiCad at a time, if you must.

The best way to handle the NiCads is to use battery holders such as those sold in many electronic parts stores.

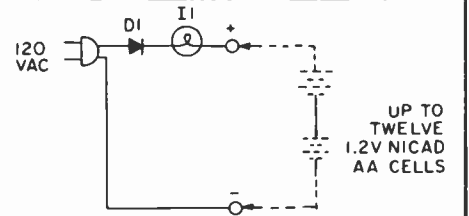
You can get holders that accommodate up to six cells each, and a couple of alligator clip jumpers will allow you to configure the terminals to handle less than six cells per holder. Alternatively, you can build a holder from a strip of

wood with metal, spring-loaded end terminals.

The lamp maintains the charging current at approximately 20-mA, and AA (pencil) Nicads should be charged for about 16-hours.

## PARTS LIST FOR PENCIL NiCad CHARGER

- D1—silicon rectifier rated at 200 PIV @ 0.5-Amps
- I1—type S-6 6-watt candelabra lamp



# 92 Level Detector

□ There are times when voltages are allowed to vary widely in a given system, so long as they do not exceed some preset limit. This might happen

in speed or temperature controls, for example, or even simple R-C timers.

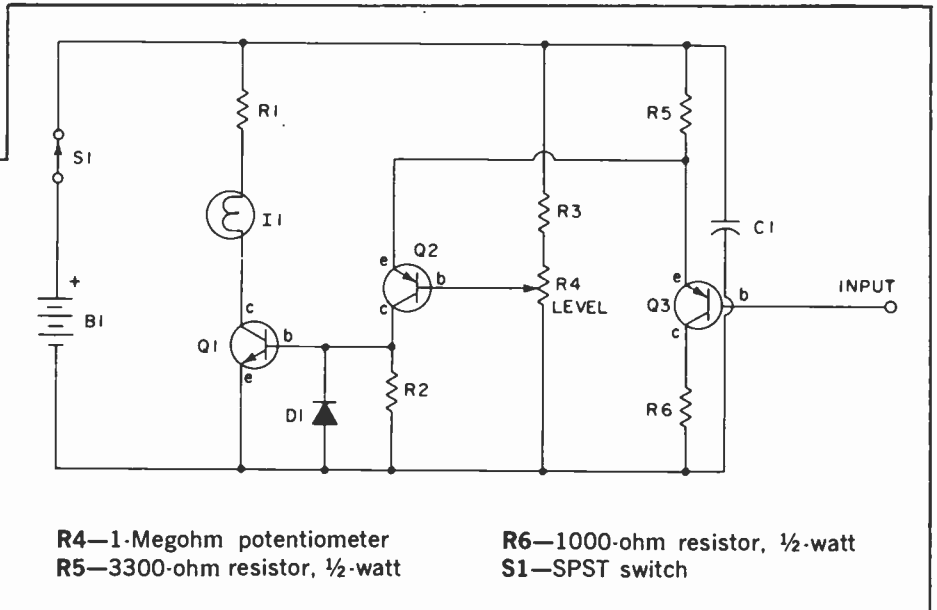
This circuit is based upon a two-transistor comparator. An input volt-

age (which must not exceed B1 in either positive or negative value) at Q3 is compared to a preset divider R3-R4 at Q2. When the input volt-

age equals or exceeds the preset voltage, Q1 turns on, driving pilot lamp I1 on. Resistor R1 permits the use of a #47 type lamp with a standard 9 volt battery.

#### PARTS LIST FOR LEVEL DETECTOR

- B1—9VDC battery
- C1—.1- $\mu$ F capacitor
- D1—Diode, 1N914 or equiv.
- I1—Bulb, #47-type
- Q1—NPN transistor, 2N2222 or equiv.
- Q2, Q3—PNP transistor, 2N3906 or equiv.
- R1—27-ohm resistor, 1/2-watt
- R2—5600-ohm resistor, 1/2-watt
- R3—100,000-ohm resistor, 1/2-watt
- R4—1-Megohm potentiometer
- R5—3300-ohm resistor, 1/2-watt
- R6—1000-ohm resistor, 1/2-watt
- S1—SPST switch

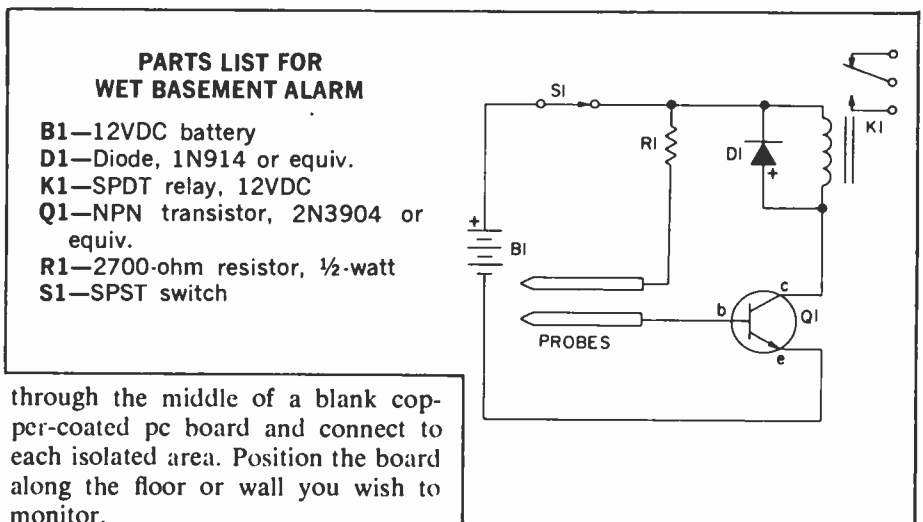


## 93 Wet Basement Alarm

For those of us with basements plagued by dampness, an early warning of wetness is our best, first line of defense. This tiny circuit monitors for wetness between its two metal probes. When it senses the wet, it pulls in relay K1.

Relay K1 can be connected to buzzers, bells, pumps, whatever your situation demands. Just make sure the relay contacts are rated for the load you wish to use.

Where actual liquids are to be sensed, the probes can be simple metal spikes driven into the most moisture-prone section of the basement floor. To monitor for dampness, etch or scrape a zigzag pattern



#### PARTS LIST FOR WET BASEMENT ALARM

- B1—12VDC battery
- D1—Diode, 1N914 or equiv.
- K1—SPDT relay, 12VDC
- Q1—NPN transistor, 2N3904 or equiv.
- R1—2700-ohm resistor, 1/2-watt
- S1—SPST switch

through the middle of a blank copper-coated pc board and connect to each isolated area. Position the board along the floor or wall you wish to monitor.

## 94 Automobile Ignition Maze

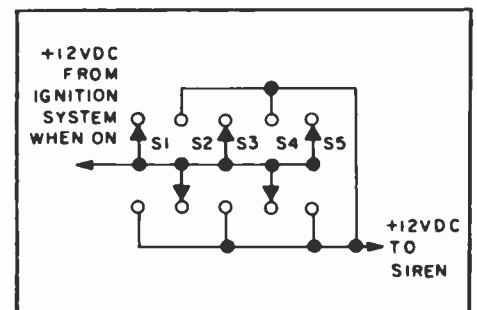
Install a combination lock on your car's dashboard and a thief would have a better chance playing Russian roulette.

Switches S1 through S5 are spdt rather than spst only to keep all external switch markings the same.

Tracing the circuit will show that only if switches S2 and S4 are down is the siren disabled. The siren sounds if any other switch is down or if S2

or S4 is up when the ignition is turned on. A simple wiring change lets you set any combination.

The switches can be "sporty" auto accessory switches sold individually or in switch banks such as G.C. 35-916. Provide labels such as "Carburetor Heater," "Window Washer," etc. and no one will know the car is wired for "sound."



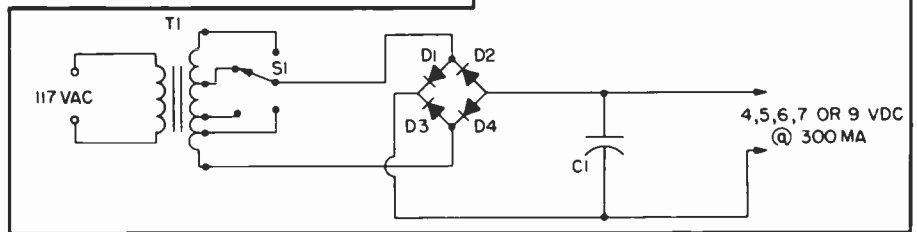
## 95 AC Adaptor

□ It seems that just about everything these days is battery powered, and when something goes bad and you're ready to check it out more than likely the size batteries needed are not in your stock, and it's two hours past store-closing time. But with this universal AC adaptor you can handle just about any battery powered repair job that gets on your test bench. Providing up to 300 mA, you can arrange the output leads of the adaptor to deliver the required polarity connections.

Keep in mind, however, that this AC adaptor is for radios, cassette recorders, and the like. *It is not for calculators.* Some calculators require

an adaptor with an AC output (the rectifier and filter are in the calculator) and this fact isn't indicated anywhere in the instruction manual or on the calculator. Connect an adaptor with a DC output to a calculator requiring an AC input and you probably will be buying a new calculator. So don't claim later you weren't warned.

**PARTS LIST FOR AC ADAPTOR**  
**T1**—Adaptor transformer, Calectro D1-743  
**D1-D4**—Any silicon rectifier rated at least 25 PIV at 0.5 A.  
**C1**—2000- $\mu$ F, 15 VDC capacitor  
**S1**—Any switch that can provide 4PST.



## 96 Slide Show Stopper

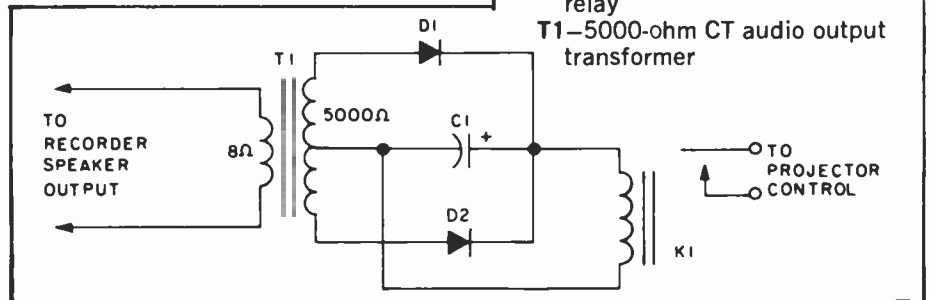
□ Soundless slide shows are dull, dull, dull! But a stereo recorder can automate the whole show so slides change automatically in step with the commentary.

Record your commentary on the left track. At the instant you want slides to change, record a one-second noise or tone burst on the right track. Connect the programmer between the recorder's right speaker output and the projector's remote control cable. Make a test run to determine the right-track volume setting to make noise or tone bursts activate relay K1. No fancy tone generators needed here. Just give a hearty Bronx cheer into the mike of the left channel only!

Then start the tape from the beginning. The audience will hear your commentary or spectacular music-and-sound reproduction through a speaker connected to the recorder's left channel, while the signal on the right channel automatically changes the slides.

**PARTS LIST FOR SLIDE SHOW STOPPER**

**C1**—25- $\mu$ F, 50-VDC electrolytic capacitor  
**D1, D2**—1-A/400-PIV silicon rectifier, Motorola 1N4004  
**K1**—2500-ohm coil plate-type relay  
**T1**—5000-ohm CT audio output transformer



## 97 LED Telephone Ring Indicator

□ Know what makes your phone ring? A 20 Hertz AC signal at anywhere from 60 to 120 Volts, depending on your phone company. That same bell-ringing signal can be used to light an LED with the circuit shown here, without significantly loading the telephone line. C1 provides DC isolation to help foolproof this project. The .1 value shown

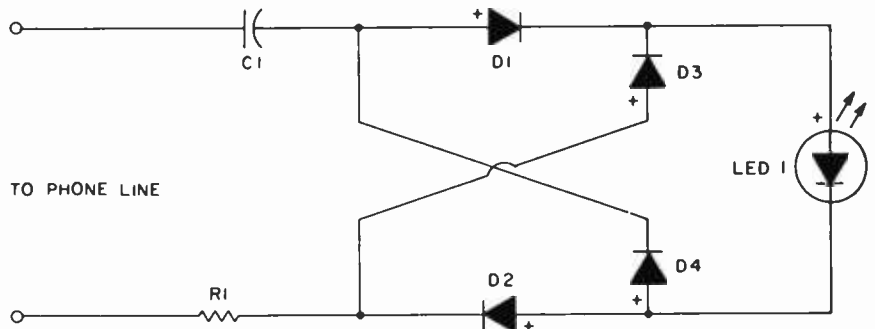
works, but you may want to increase it to .5 microfarads. Use a mylar capacitor (like the Sprague "Orange Drop" series) rated at 250-450 working volts or more.

Why so high? The telephone company keeps its lines clear of ice and trouble by daily sweeping a pulse of high voltage throughout the system. Too low a working voltage could

mean trouble for them, and that is absolutely the last thing you want to cause. We might even suggest connecting to the telephone lines only temporarily to verify circuit operation. This will help avoid accidents and trouble. D1 through D4 act as a full wave bridge to deliver the AC ringing voltage as DC to LED1. R1 limits the current through the circuit.

### PARTS LIST FOR LED TELEPHONE RING INDICATOR

- C1—.1- $\mu$ F capacitor  
 D1, D2, D3, D4—Diode, 1N914 or  
 equiv.  
 LED1—Light emitting diode  
 R1—82,000-ohm resistor, 1/2-watt



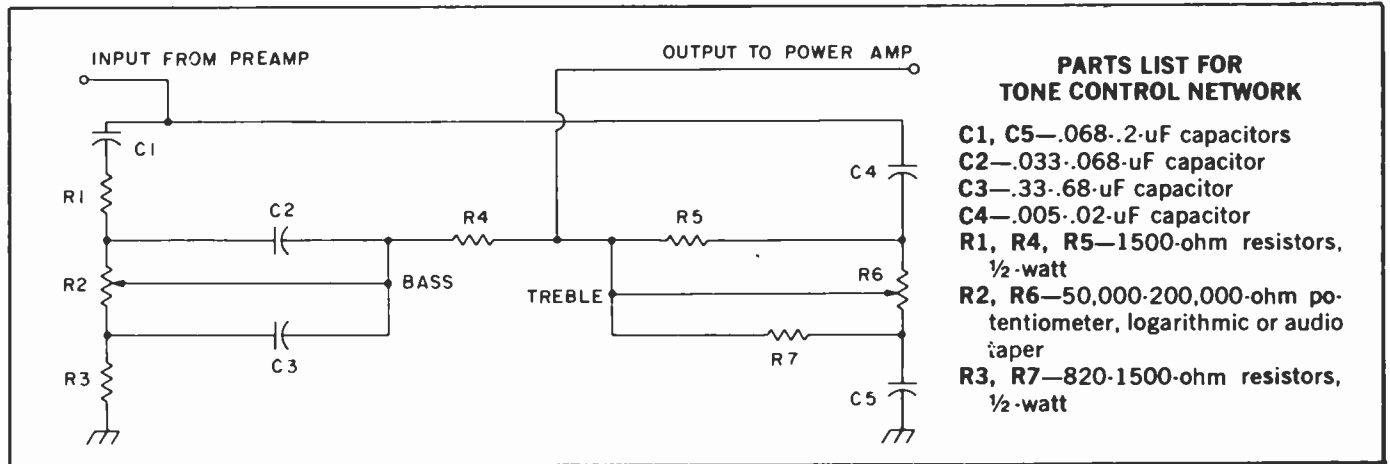
## 98 Tone Control Network

□ Since there are no active devices in this circuit, like transistors or ICs, it can provide no amplification on its own to offset the very lossy characteristics of these networks. Fortunately, most audio systems have more than enough oomph to accommodate this network loss.

Once you have learned, by experi-

menting with the effects of various component values, just how you can alter the characteristics of these networks, you may want to construct your own graphic equalizer. Just include more stages similar to the two basic types of filters you see here: R1, R2, R3, R4, C1, C2 and C3 form one of the filters, the rest of the compo-

nents the other. Just remember, the more stages of passive filtering you add, the more loss you introduce into your system. For that reason, most commercial graphic equalizers include built-in amplifiers. And, of course, you will have to duplicate your filter(s) for each channel if you're working in four or more tracks.



### PARTS LIST FOR TONE CONTROL NETWORK

- C1, C5—.068-.2- $\mu$ F capacitors  
 C2—.033-.068- $\mu$ F capacitor  
 C3—.33-.68- $\mu$ F capacitor  
 C4—.005-.02- $\mu$ F capacitor  
 R1, R4, R5—1500-ohm resistors,  
 1/2-watt  
 R2, R6—50,000-200,000-ohm po-  
 tentiometer, logarithmic or audio  
 taper  
 R3, R7—820-1500-ohm resistors,  
 1/2-watt

## 99 Remote Flash Trigger

□ Even if you spend \$18 or \$20 for a super-duper professional remote flash tripper, you'll get little more than this two-component circuit. Price is important if the results are equal.

Transistor Q1 is a light-activated silicon-controlled rectifier (LASCR). The gate is tripped by light entering a small lens built into the top cap.

To operate, provide a 6-in. length of stiff wire for the anode and cathode connections and terminate the wires in a polarized power plug that match-

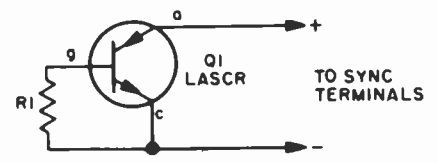
es the sync terminals on your electronic flashgun (strobelight). Make certain the anode lead connects to the *positive* sync terminal.

When using the device, bend the connecting wires so the LASCR lens faces the main flash. This will fire the remote unit.

No reset switch is needed. Voltage at the flash's sync terminals falls below the LASCR's holding voltage when the flash is fired, thereby turning off the LASCR.

### PARTS LIST FOR REMOTE FLASH TRIGGER

- Q1—200-V light-activated silicon-  
 controlled rectifier (LASCR)  
 R1—47,000-ohm, 1/2-watt resistor



# 100 Signal-Operated Switch

□ If a VOX is a voice operated switch, is this signal operated switch a SOX?

You can take a signal, like the ear-phone jack output from a radio or tape player, and use it to trigger the relay operation. If used with an FM wireless mike, an FM radio and a cassette recorder, for example, this circuit could start the recorder whenever the FM radio receives the wireless mike signal. D1-R1-C1 form an R-C delay network that delays the turn-off of the relay until some time (the number of seconds of delay is roughly the number of ohms of R1 times the number of microfarads of C1 divided by a million) after the signal stops.

The signal charges C1 through D1, which keeps it from discharging back through the signal source. C1 then holds the base of Q1 high until it dis-

**PARTS LIST FOR  
SIGNAL OPERATED SWITCH**

**B1**—6.1 VDC  
**C1**—2.2-150-uF capacitor  
**D1**—Silicon diode (1N914 or equiv.)  
**K1**—Small, sensitive relay (reed relays are ideal); voltage compatible with B1; coil impedance greater than B1 voltage by Q1 collector current rating  
**Q1**—NPN switching transistor; collector current rating greater than relay current (2N2222 handles 800 mA and most small relays)  
**R1**—4700-470,000-ohm resistor, ½-watt

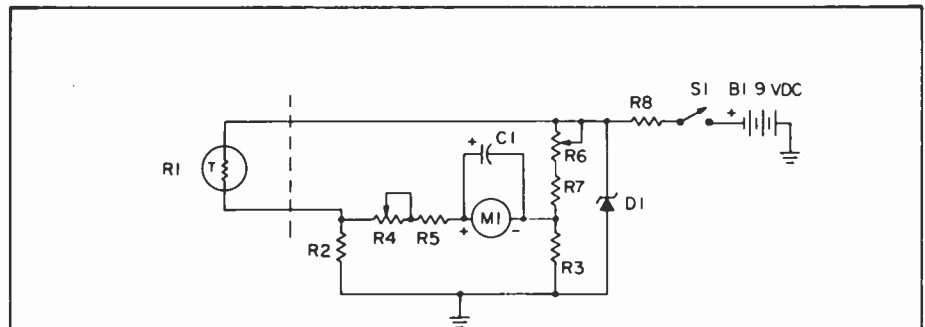
charges enough through R1 and the base-emitter circuit of Q1 to reach a turn-off point. Q1 completes the circuit for K1's coil, and you can do

whatever you want with the contacts (turn on a light, start a motor, honk a horn, fire up a computer, light up your TV).

# 101 Remote Thermometer

□ With this electronic thermometer you can be sitting by a nice, cozy fire and reading the temperature outdoors, however frigid it may be, without ever catching a chill yourself. The circuit is a simple one based on a readily available Fenwal thermistor (Burstein-Applebee, among others, sells them). For the sake of accuracy, only thermistor R1 should be exposed to temperature extremes; the rest of the components should be kept indoors in an environment where the temperature is reasonably constant.

To calibrate, you'll need a thermometer of known accuracy and access to temperatures near 0° and 100° F, the lower and upper limits respectively of this thermometer's range. Set R4 and R6 to their midpoints. Subject R1 to the hot temperature and adjust R4 until M1 reads the correct temperature. Now subject R1 to the cold temperature and adjust R6 to get the right reading on M1. Because the two adjustments interact, repeat the entire procedure two more times.



**PARTS LIST FOR  
REMOTE THERMOMETER**

- B1**—9-volt transistor battery  
**C1**—50-uF, 16-VDC electrolytic capacitor  
**D1**—1N746A, 3.3-volt, ½-watt zener diode  
**M1**—0 to 100 microamp DC ammeter  
**Note:** All resistors rated ½-watt, 5% tolerance unless otherwise noted.

- R1**—thermistor rated 1,000-ohms @ 25° C (Fenwal part #JB31J1)  
**R2, R3**—1,800-ohms  
**R4**—10,000-ohm trimmer potentiometer  
**R5**—12,000-ohms  
**R6**—5,000-ohm trimmer potentiometer  
**R7**—3,900-ohms  
**R8**—820-ohms  
**S1**—SPST toggle switch



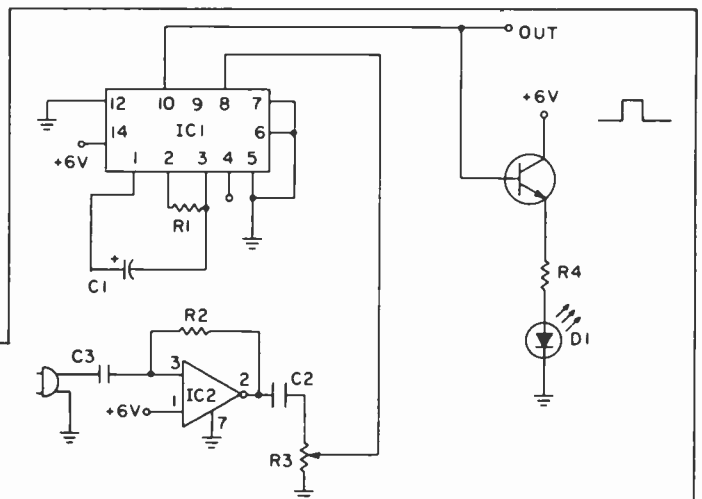
# 40 INTEGRATED CIRCUIT PROJECTS

## I. The CMOS Robot Ear

□ The CMOS chip type 4047 provides a convenient monostable and astable multivibrator circuit in one package, with provisions for either positive or negative-going outputs. A high impedance microphone is boosted via one (or more) stage of gain from a 4009 or 4049 hex inverter section. External R and C components determine the on-time. For  $R1 = 1$  megohm and  $C1 = 1$ -uF, the delay interval is 3 seconds. A sensitivity control can be incorporated at the trigger input. The Robot Ear can act as an intrusion detector, voice-operated transmitter switch, or as an automated baby sitter.

### PARTS LIST FOR THE ROBOT EAR

- C1—1-uF electrolytic capacitor, 25 VDC (see text)
- C2—.01-uF ceramic capacitor, 15 VDC
- C3—0.1-uF ceramic capacitor, 15 VDC
- D1—small LED
- IC1—4047 multivibrator
- IC2—4009 or 4049 hex buffer
- Q1—2N4401
- R1—1,000,000-ohm, ½-watt resistor (see text)



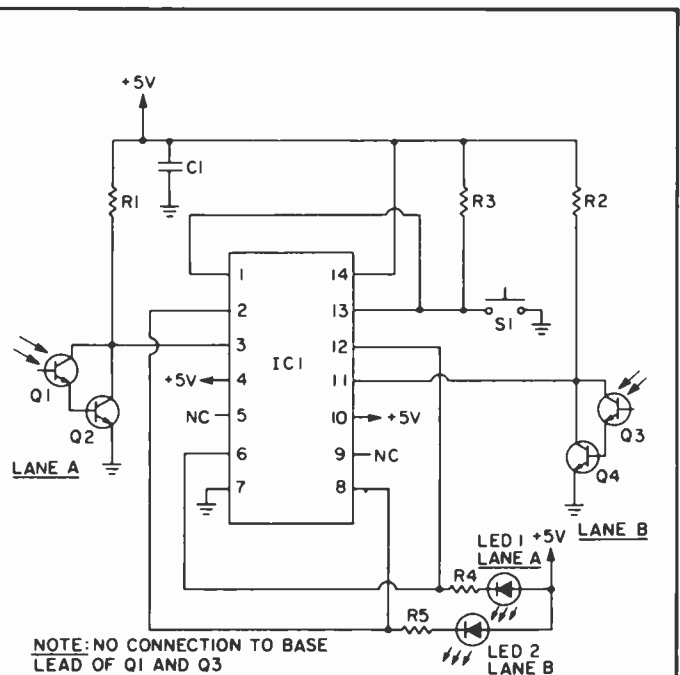
- R2—1,000,000-ohm, ½-watt resistor
- R3—1,000,000 linear-taper potentiometer
- R4—1,000-ohm, ½-watt resistor

## 2. Slot Car Race Referee

□ Build this optoelectronic judge and end forever those quarrels over who really won the race. Install phototransistors Q1 and Q3 at the finish line, but in separate lanes of your slot-car track so that the light-sensitive face of each device is facing upwards. The best method would be to cut a small hole into the track for each phototransistor, and mount each unit flush with the track's surface. Arrange for light to fall on both Q1 and Q3; a small desk lamp will work well, but ambient room light will usually suffice. Press S1 and both LEDs will go off. The first car to cross the finish line interrupts the light beam and causes the appropriate LED to light up.

### PARTS LIST FOR SLOT CAR RACE REFEREE

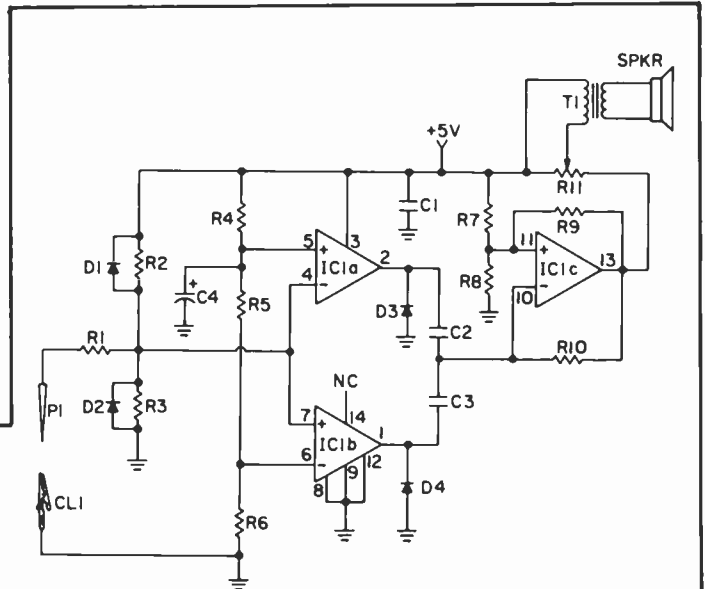
- C1—0.1-uF ceramic disc capacitor, 35 VDC
- IC1—7474 dual D-type flip-flop
- LED1, LED2—light-emitting diode
- Q1, Q3—FPT-100 NPN phototransistor
- Q2, Q4—2N3904 NPN transistor
- R1, R2—18K-ohm ½-watt resistor, 10%
- R3—3900-ohm ½-watt resistor, 10%
- R4, R5—330-ohm ½-watt resistor, 10%
- S1—normally open SPST pushbutton switch



NOTE: NO CONNECTION TO BASE LEAD OF Q1 AND Q3

# 3 IC Audible Logic Probe

Here is the old familiar logic probe but with a new twist. Instead of displaying logic status with LEDs, it does the job aurally. The logic-1 state, 2-volts or greater, is signalled by a high tone. On the other hand, a low tone sounds to indicate the logic-0 state, 0.8-volt or less. Inputs between 0.8 and 2-volts produce no output. (Note that this probe is designed especially for TTL and cannot be used for any other logic family.) The circuit requires a regulated 5-volt supply, which means that it can be powered by the same supply used by the TTL circuitry under test. Output can be taken from a miniature speaker, as shown in the schematic, or you may use a miniature earphone. Potentiometer R11 sets the output volume level.



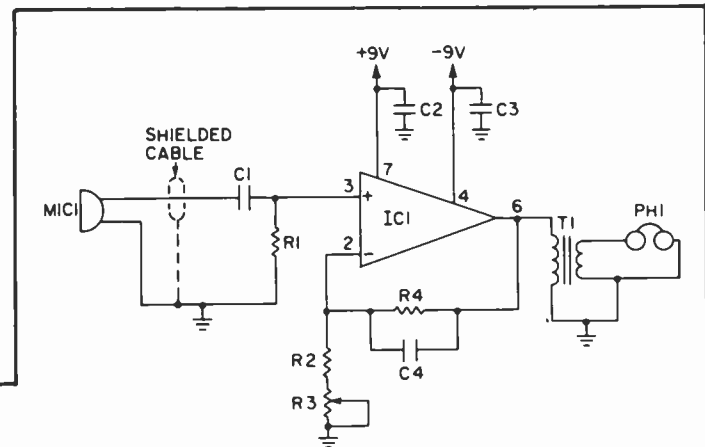
### PARTS LIST FOR IC AUDIBLE LOGIC PROBE

- C1—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C2—0.005- $\mu$ F mylar capacitor, 35 VDC
- C3—0.1- $\mu$ F mylar capacitor, 35 VDC
- C4—1.0- $\mu$ F tantalum capacitor, 10 VDC
- CL1—alligator clip
- D1, D2—1N4001 diode
- D3, D4—1N914 diode
- IC1—LM339 quad comparator
- P1—metal probe tip
- R1—10K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R2, R3—220K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R4—30K-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R5—12K-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R6—8200-ohm  $\frac{1}{2}$ -watt resistor, 5%

- R7, R8, R10—56K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R9—120K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R11—1000-ohm audio-taper potentiometer
- SPKR—8-ohm miniature speaker
- T1—miniature audio output transformer—1,000-ohm primary/8-ohm secondary

# 4. Super Stethoscope

Auscultation is the medical term for the procedure. In simple language, it means having your ribs ticked with an icy cold stethoscope. Should you ever get the urge to play doctor, we prescribe the simple electronic stethoscope diagrammed here. Best results will be obtained using hi-fi or communications-type low-impedance headphones designed to isolate the listener from ambient sounds. Be sure to connect the microphone cartridge to the rest of the circuit using shielded audio cable to keep noise pickup to a minimum. Potentiometer R3 adjusts the gain. Use a socket when mounting IC1 since it has delicate FET inputs.



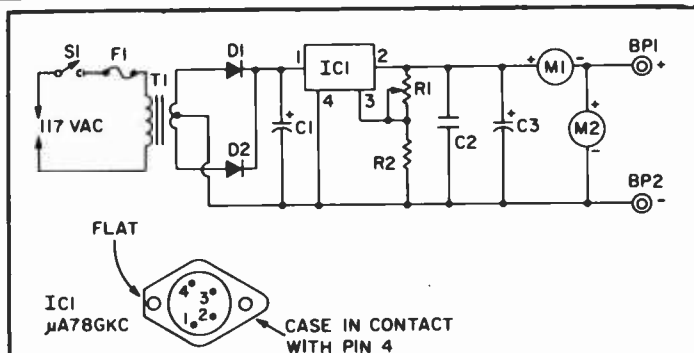
### PARTS LIST FOR SUPER STETHOSCOPE

- C1—0.01- $\mu$ F mylar capacitor, 35 VDC
- C2, C3—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C4—10-pF polystyrene capacitor, 35 VDC
- IC1—RCA CA3140 op amp
- MIC1—crystal microphone cartridge
- PH1—low-impedance headphones, hi-fi or communications type

- R1, R4—1-Megohm,  $\frac{1}{2}$ -watt resistor, 10%
- R2—1000-ohm,  $\frac{1}{2}$ -watt resistor, 10%
- R3—10K linear-taper potentiometer
- T1—miniature audio output transformer—1,00-ohm primary/8-ohm secondary

## 5. Variable Regulated Power Supply

□ These are lots of good power supplies on the market, but why not build your own and save a bundle? This circuit can provide voltages between 5 and 15-volts DC at currents up to one ampere. Be sure to heat-sink the  $\mu$ A78GKC regulator by bolting it to either a commercial aluminum heat sink or to your supply's cabinet (if it's made of aluminum). Mount C2 and C3 as close as possible to pins 2 and 4 of IC1. If you cannot locate a 28VCT transformer, go to something slightly higher, say 32 VCT. The same goes for the transformer's current rating; for example, you could use a 2-amp device.



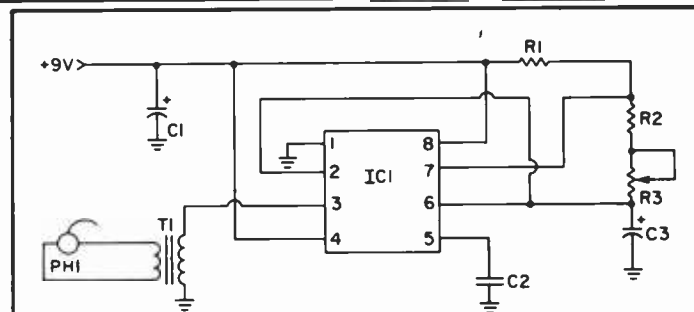
### PARTS LIST FOR VARIABLE REGULATED POWER SUPPLY

BP1, BP2—binding post  
 C1—2200- $\mu$ F electrolytic capacitor, 40 VDC  
 C2—0.1- $\mu$ F ceramic disc capacitor, 35 VDC  
 C3—100- $\mu$ F electrolytic capacitor, 25 VDC  
 D1, D2—1N4003 (1A, 200 PIV) rectifier diode

F1—0.5-Ampere slow-blow fuse  
 IC1— $\mu$ A78GKC adjustable voltage regulator  
 M1—0-to-1 Amp DC meter  
 M2—0-to-15-Volt DC meter  
 R1—10K-ohm linear-taper potentiometer  
 R2—4700-ohm,  $\frac{1}{2}$ -watt resistor, 5%  
 S1—SPST toggle switch  
 T1—28VCT, 1.2-Amp power transformer (see text)

## 6. Jogging Pacesetter

□ One of the problems faced by the beginning jogger, especially on city streets, is that of maintaining a constant pace. Tractor-trailer trucks, careening cars, and ill-mannered dogs can all interrupt your concentration. While there is little that can be done about these nuisances, this little pacesetter may make them less severe. A miniature earphone in your ear driven by a 555 timer produces regularly spaced "ticks" just like a metronome. The pace can be adjusted via R3 from a leisurely one stride per second to a sole-blistering six paces per second. The whole circuit complete with a 9-volt transistor radio battery weighs only a few ounces.



### PARTS LIST FOR JOGGING PACESETTER

C1—100- $\mu$ F electrolytic capacitor, 16 VDC  
 C2—0.1- $\mu$ F ceramic disc capacitor, 35 VDC  
 C3—1.0- $\mu$ F tantalum electrolytic capacitor, 20 VDC  
 IC1—555 timer  
 PH1—8-ohm miniature earphone

R1—10K,  $\frac{1}{2}$ -watt resistor, 5%  
 R2—220K,  $\frac{1}{2}$ -watt resistor, 5%  
 R3—1-Megohm trimmer potentiometer  
 T1—miniature audio output transformer—1,000-ohm primary/8-ohm secondary

## 7. Sobriety Tester

□ It's a curious and unfortunate fact, but many people feel that a drink or two will improve their reflexes. Here's your chance to prove them wrong. Imagine for the moment that S1 is depressed (open circuited), S2 is closed, and C2 has been completely discharged. On command from someone acting as the tester, the person depressing

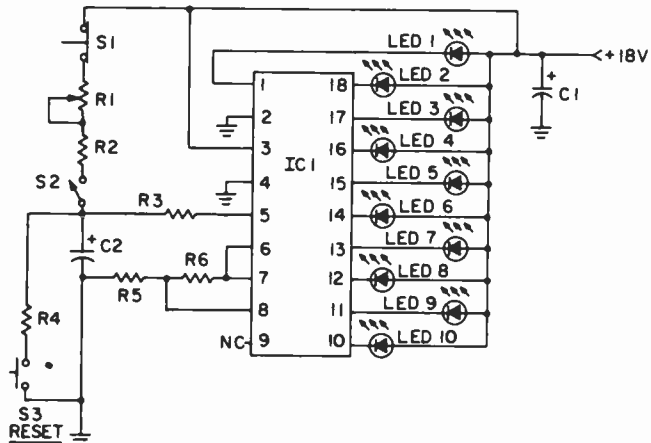
S1 must remove his hand from that switch and use the same hand to open toggle switch S2. When S1 is released, charging current begins to flow into capacitor C2 through R1 and R2. This current is interrupted, however, as soon as S2 has been opened. C2 will have accumulated a voltage directly proportional to the reaction time, which

is the interval between S1's release and the opening of S2. Longer times create higher voltages and cause higher-numbered LEDs to light. For example, a sober person might react quickly enough to light LED 2 or LED 3,

while someone truly sloshed will light up LED 10. To run another test, discharge C2 with S3, then press S1 and, finally, close S2 once more. R1 should be adjusted so that a sober person lights one of the low-numbered LEDs.

#### PARTS LIST FOR SOBRIETY TESTER

- C1—250- $\mu$ F electrolytic capacitor, 35 VDC
- C2—50- $\mu$ F electrolytic capacitor, 35 VDC
- IC1—LM3914 LED display driver
- LED1 through LED10—light-emitting diode
- R1—50K trimmer potentiometer
- R2—5600-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R3—33K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R4—47-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R5—1800-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R6—1000-ohm  $\frac{1}{2}$ -watt resistor, 10%
- S1—normally closed SPST pushbutton switch
- S2—SPST toggle switch
- S3—normally open SPST pushbutton switch

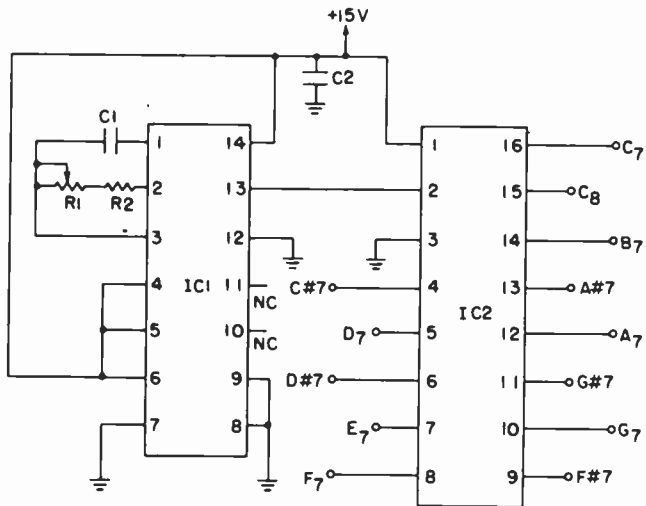


## 8. Top Octave Divider

One of the most difficult tasks in electronic music is generating a perfect, equally-tempered octave. The reason for the difficulty stems from the fact that each note of an octave is related in frequency to the previous note by an unwieldy factor, the twelfth root of 2 (1.059...). This relationship cannot be generated *exactly* with digital circuits, but using the MK50240P, you can generate such an excellent approximation that nobody will ever notice the difference. Here the 50240 is being clocked by a 1 mHz CMOS oscillator, IC1, which you can tune with R1 until the outputs are on the button (a frequency counter is helpful). Outputs are 15-volt square waves that can be used as is or divided with flip-flops to yield the lower octaves. IC2 costs about \$13, so be sure to use an IC socket to protect your investment.

#### PARTS LIST FOR TOP-OCTAVE DIVIDER

- C1—30-pF polystyrene capacitor, 35 VDC
- C2—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- IC1—4047 CMOS multivibrator
- IC2—Mostek MK50240P top-octave generator



- R1—10K trimmer potentiometer
- R2—10K-ohms  $\frac{1}{2}$ -watt resistor, 10%

## 9. The Waveshaper

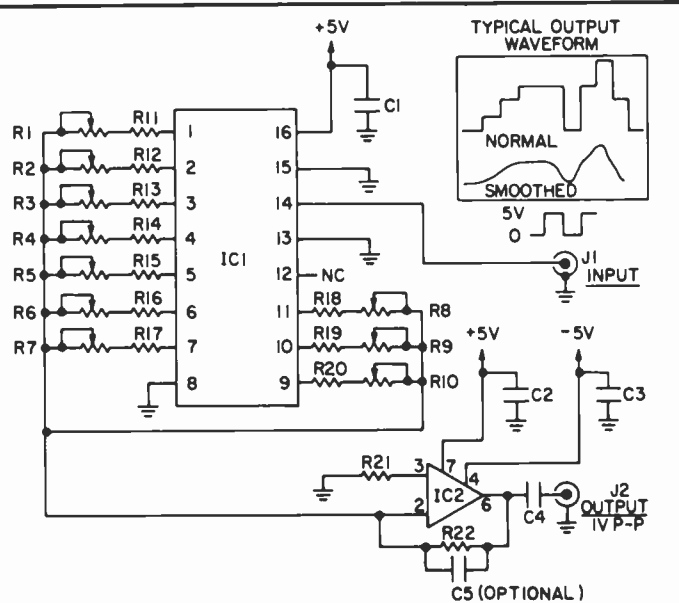
This little circuit illustrates the principle behind multi-kilobuck laboratory-style waveform synthesizers as well as some of the more advanced music synthesizers. Into J1 you should feed a square-wave signal swinging from ground to almost 5-volts. The input signal's frequency should be ten times that of the desired output. Adjusting potentiometers R1 through R10 will enable you to literally design the shape of the output waveform. If you can get

hold of an oscilloscope, use it to observe the effect of R1 through R10 on the output. At the same time, feed the output to an audio amp so that you can hear the changes in timbre that occur as the waveshape is altered. Capacitor C5 can be used to smooth out the chunky shape of the output. With a 10 kHz input, start with a value of 0.1  $\mu$ F for C5 and experiment. Make sure at least one potentiometer is set to maximum resistance and that at least

one is set to minimum. This guarantees a full 1-volt peak-to-peak output. You might also try feeding some interesting waveforms into the Musical Modulator (elsewhere in this issue) and listening to the notes formed.

#### PARTS LIST FOR THE WAVESHAPER

- C1, C2, C3**—0.01- $\mu$ F ceramic disc capacitor, 35 VDC
- C4**—0.5- $\mu$ F mylar capacitor, 35 VDC
- C5**—see text
- IC1**—4017 CMOS decade counter
- IC2**—741 op amp
- J1, J2**—phono jack
- R1 through R10**—2-megohm linear-taper potentiometer
- R11 through R20**—68K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R21, R22**—15K-ohm  $\frac{1}{2}$ -watt resistor, 10%

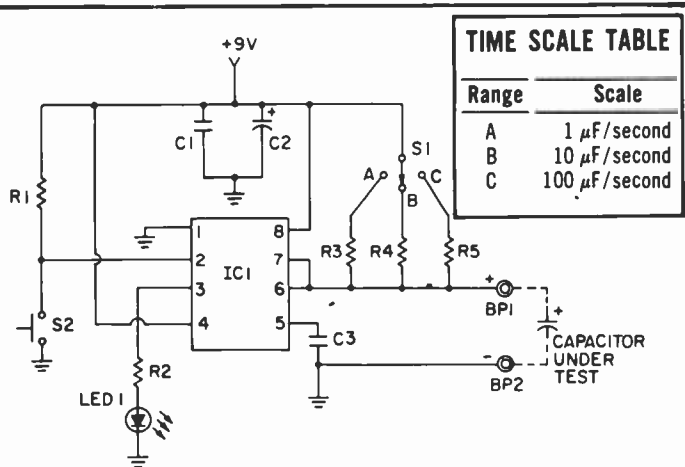


## 10. Electrolytic Capacitor Tester

Here's a quick and simple way to check out all those old electrolytic capacitors in your junkbox. Besides this simple 555 timer circuit, you will need a timepiece with a readout in seconds; the readout may be digital or just an ordinary sweep-second hand. Connect the capacitor to be tested to the binding posts, being careful to observe proper polarities. Now, press S2 and note how long LED 1 stays lit. Multiply the time by the appropriate scale factor to obtain the capacitance. For example, suppose you happen to be checking a very large filter capacitor, which would require that scale C, 100  $\mu$ F/sec, be used. If the LED remains lit for 67 seconds, the capacitance is 67 X 100 or 6700 microfarads.

#### PARTS LIST FOR ELECTROLYTIC CAPACITOR TESTER

- BP1, BP2**—binding post
- C1, C3**—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C2**—100- $\mu$ F electrolytic capacitor, 16 VDC
- IC1**—555 timer
- LED1**—light-emitting diode
- R1**—100K-ohm  $\frac{1}{2}$ -watt resistor, 10%



- R2**—560-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R3**—910K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R4**—91K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R5**—9100-ohm  $\frac{1}{2}$ -watt resistor, 10%
- S1**—single-pole, 3-position rotary switch
- S2**—normally open SPST pushbutton switch

## 11. SST Function Generator

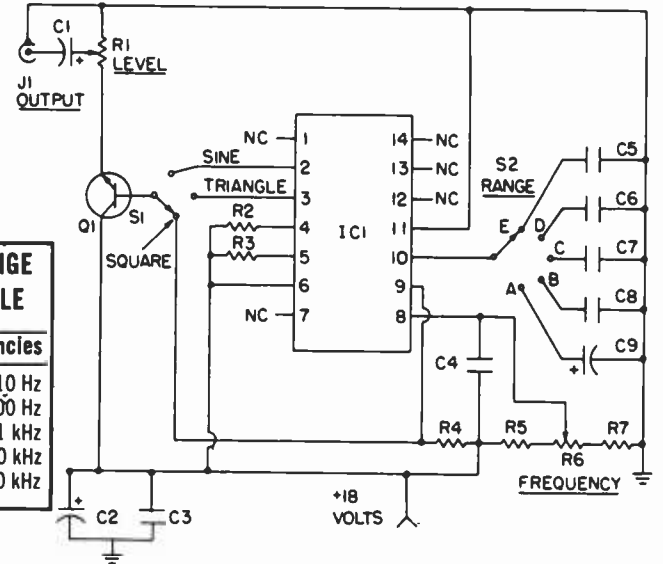
This may well be the world's simplest function generator. You can choose from sinusoidal, triangular or square output waveforms using S1. With S2, any one of 5 frequency ranges, each a decade wide, can be selected, thereby giving complete coverage of everything from a

slowpoke 1 Hz to a whizzing 100 kHz. Also, the output level can be varied with R1. Square waveforms will have the highest maximum amplitudes, followed by triangles and sines. The necessary 18-volts can be obtained from two 9-volt transistor batteries in series.

### PARTS LIST FOR SST FUNCTION GENERATOR

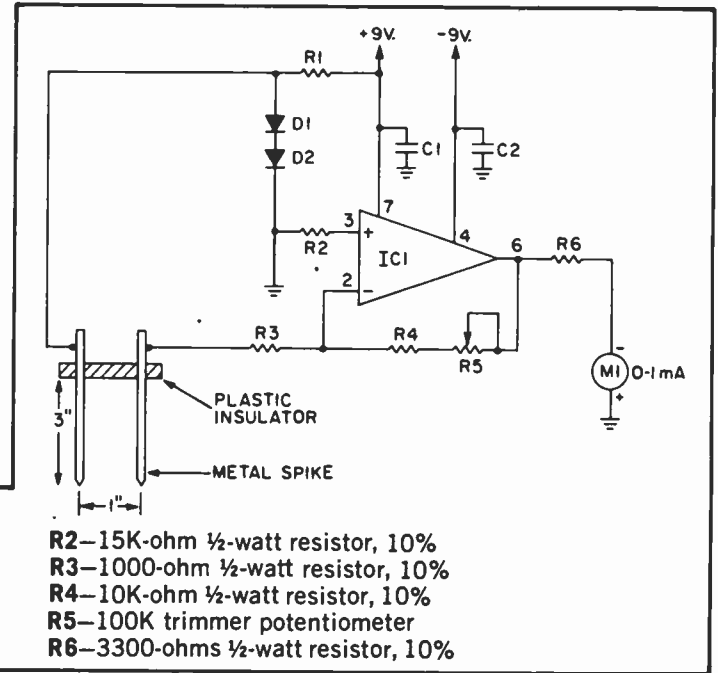
- C1, C2**—100- $\mu$ F electrolytic capacitor, 35 VDC  
**C3, C4**—0.1- $\mu$ F ceramic disc capacitor, 35 VDC  
**C5**—0.001- $\mu$ F polystyrene or mylar capacitor, 35 VDC  
**C6**—0.01- $\mu$ F polystyrene or mylar capacitor, 35 VDC  
**C7**—0.1- $\mu$ F mylar capacitor, 35 VDC  
**C8**—1.0- $\mu$ F mylar capacitor (non-polarized), 35 VDC  
**C9**—10- $\mu$ F tantalum electrolytic capacitor, 35 VDC  
**IC1**—Intersil 8038 function generator  
**J1**—phono jack  
**Q1**—2N3904 NPN transistor  
**R1**—5K linear-taper potentiometer  
**R2, R3**—300-ohm  $\frac{1}{2}$ -watt resistor, 10%  
**R4**—18K-ohm  $\frac{1}{2}$ -watt resistor, 10%  
**R5**—1000-ohm  $\frac{1}{2}$ -watt resistor, 10%  
**R6**—10K linear-taper potentiometer  
**R7**—24K-ohm  $\frac{1}{2}$ -watt resistor, 10%  
**S1**—single-pole, 3-position rotary switch  
**S2**—single-pole, 5-position rotary switch

FREQUENCY RANGE SELECTION TABLE	
Range	Frequencies
A	1 to 10 Hz
B	10 to 100 Hz
C	100 to 1 kHz
D	1 kHz to 10 kHz
E	10 kHz to 100 kHz



## 12. Plant Moisture Meter

Talked to your houseplants recently? Well, if they could talk back, you'd hear plenty of complaints—most of them about water. Too much of the wet stuff is just as bad as too little. To assist you with the watering, try this little moisture meter. Note that you will need to construct a probe assembly consisting of two metal spikes mounted in a wooden or plastic block. For the sake of uniformity, use the dimensions supplied. The spike can be nails or pieces of heavy wire (#8). Stick the probe assembly into the soil surrounding a just-watered plant and adjust R5 for a deflection around mid-scale on M1. Thereafter you can use the meter to tell whether your plants are too wet or too dry. Note that different plants are apt to prefer different degrees of wetness.



### PARTS LIST FOR PLANT MOISTURE METER

- C1, C2**—0.01- $\mu$ F ceramic disc capacitor, 35 VDC  
**D1, D2**—1N914 diode  
**IC1**—741 op amp  
**M1**—0-1 mA DC meter  
**R1**—6800-ohm  $\frac{1}{2}$ -watt resistor, 10%  
**R2**—15K-ohm  $\frac{1}{2}$ -watt resistor, 10%  
**R3**—1000-ohm  $\frac{1}{2}$ -watt resistor, 10%  
**R4**—10K-ohm  $\frac{1}{2}$ -watt resistor, 10%  
**R5**—100K trimmer potentiometer  
**R6**—3300-ohms  $\frac{1}{2}$ -watt resistor, 10%

## 13. Random Sequence Generator

A pseudo-random sequence generator is like a scrambled counter. Instead of counting 1,2,3,4, ..., the PRSG might yield an output of 2,9,7,1... The PRSG shown here supplies a sequence of 255 scrambled numbers, available in binary form at the eight outputs (Q1 through Q8). Some applications:

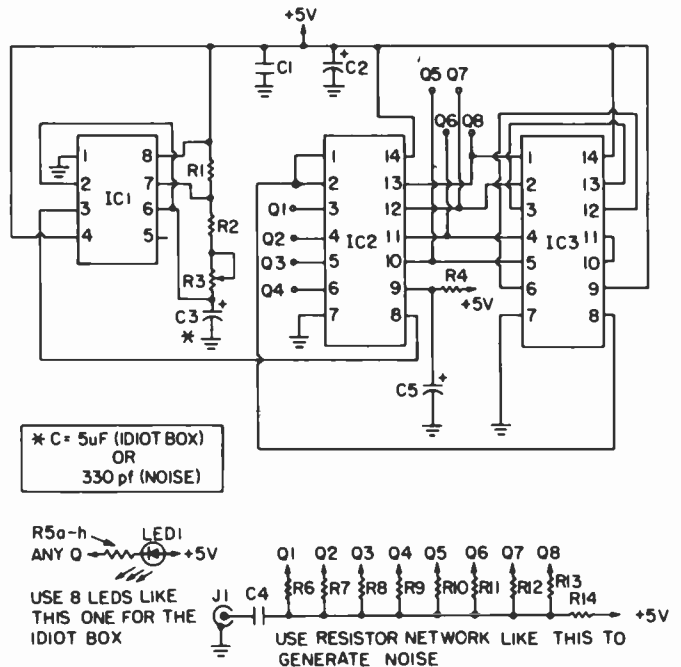
First, you might hook up an LED and a 330-ohm resistor to each output as illustrated. Use a 5- $\mu$ F electro-

lytic capacitor for C3, and you'll have a dandy idiot box, which will blink impressively on your desk, but do nothing.

Or, you could hook up the resistor network diagrammed, and use a 330 pF polystyrene capacitor for C3. You'll get a 1-volt peak-to-peak noise voltage at J1 which can be used to generate interesting percussive sounds in conjunction with the Musical Modulator presented elsewhere in this issue.

### PARTS LIST FOR PSEUDO-RANDOM SEQUENCE GENERATOR

- C1—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C2, C5—100- $\mu$ F electrolytic capacitor, 10 VDC
- C3—5- $\mu$ F, 10V electrolytic or 330-pF polystyrene capacitor (see text)
- C4—1.0- $\mu$ F mylar capacitor (non-polarized), 35 VDC
- IC1—555 timer
- IC2—74164 shift register
- IC3—7486 quad EX-OR gate
- J1—phono jack
- LED1 through LED8—light-emitting diode
- R1, R2—6800-ohms
- R3—100K linear-taper potentiometer
- R4, R6—1000-ohms
- R5a through R5h—330-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R7—2200-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R8—3900-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R9—8200-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R10—15K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R11—33K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R12—62K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R13—120K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R14—120-ohm  $\frac{1}{2}$ -watt resistor, 10%

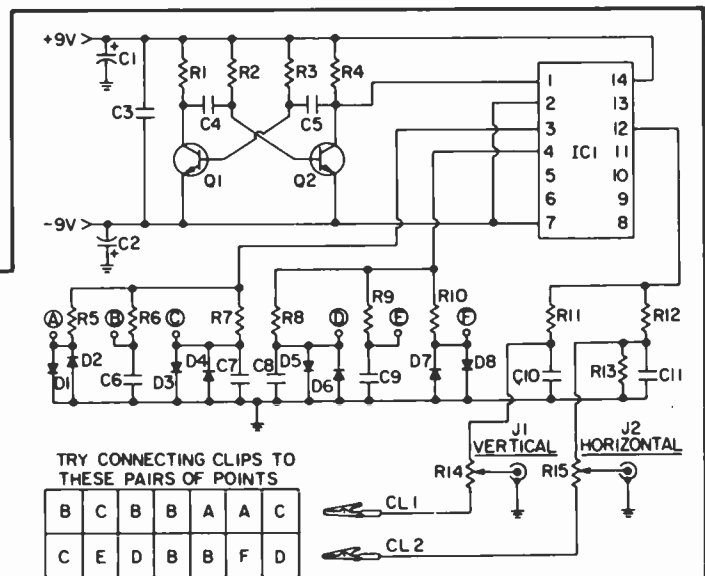


## 14. Video Pattern Generator

Those of you with oscilloscopes might enjoy breadboarding this pattern generator. Feed the signal at J1 to your scope's vertical input, and connect the horizontal input to J2. Attach the clips to the selected pairs of test points, then adjust potentiometers R14 and R15 to create complex images. Output signals are about 1-volt, peak-to-peak.

### PARTS LIST FOR VIDEO PATTERN GENERATOR

- C1, C2—250- $\mu$ F electrolytic capacitor, 25 VDC
- C3—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C4, C5—100-pF polystyrene capacitor, 35 VDC
- C6, C7—1.0- $\mu$ F mylar capacitor (non-polarized), 35 VDC
- C8, C9—0.5- $\mu$ F mylar capacitor, 35 VDC
- C10—0.022- $\mu$ F mylar capacitor, 35 VDC
- C11—0.001- $\mu$ F mylar capacitor, 35 VDC
- CL1, CL2—alligator clip
- D1 through D8—1N914 diode
- IC1—4024BE CMOS ripple divider
- J1, J2—phono jack
- Q1, Q2—2N3904 NPN transistor
- R1, R4, R5, R10—100K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R2, R3—1.5-Megohm  $\frac{1}{2}$ -watt resistor, 10%
- R6, R9—68K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R7, R8—33K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R11, R12—47K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R13—3300-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R14, R15—250K linear-taper potentiometer



## 15. Featherweight Foghorn

Despite its small size, this circuit generates an authentic-sounding foghorn blast. Couple the output signal

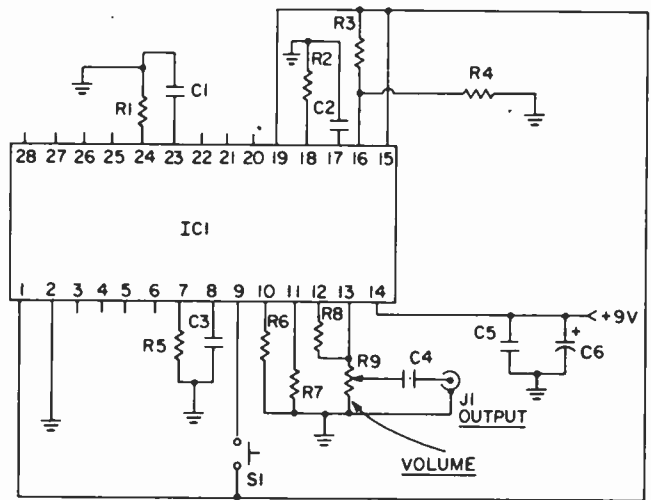
to a good amp and loudspeaker, press switch S1, and you'll unleash a blast that will untie the shoelaces of

anyone within hearing distance. The output signal has a 1-volt peak-to-peak maximum amplitude, which is just right for driving the AUX or TUNER inputs of most hi-fi or PA amplifiers. You can change the pitch to suit your

own taste by substituting a different value of resistance for R2; larger resistances lower the pitch while smaller ones raise it. Be sure to use a socket with the IC.

#### PARTS LIST FOR FEATHERWEIGHT FOGHORN

- C1, C3—0.47- $\mu$ F mylar capacitor, 35 VDC
- C2—0.01- $\mu$ F mylar capacitor, 35 VDC
- C4—1.0- $\mu$ F mylar capacitor, 35 VDC
- C5—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C6—100- $\mu$ F electrolytic capacitor, 16 VDC
- IC1—SN76477 sound generator
- J1—phono jack
- R1—1-Megohm  $\frac{1}{2}$ -watt resistor, 10%
- R2—470K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R3—15K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R4—10K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R5—1.5-Megohm  $\frac{1}{2}$ -watt resistor, 10%
- R6—180K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R7—150K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R8—47K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R9—5K audio-taper potentiometer
- S1—SPST normally open pushbutton switch

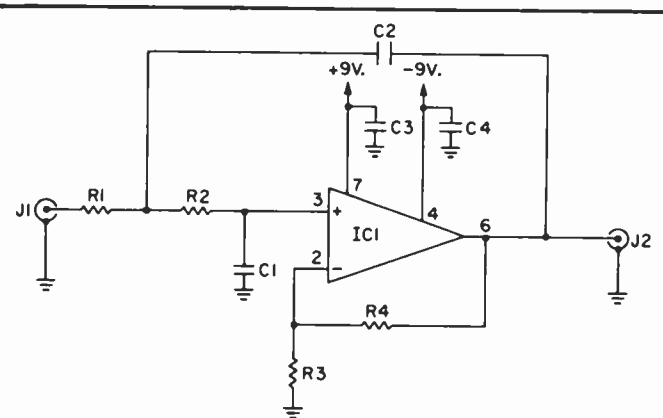


## 16. Active Low Pass Filter

As its name suggests, a low-pass filter passes signals with frequencies lower than some specific value, called the *cut-off frequency*, but blocks passage of frequencies above the cut-off. Illustrated here is an active low-pass filter having a 1000 Hz cut-off frequency. You can shift the cut-off by changing C1 and C2 together. To multiply the cut-off by a factor of N, multiply the capacitances of C1 and C2 by a factor of 1/N. For example, a 2000 Hz cut-off would require 0.005  $\mu$ F capacitors, while a 500 Hz cut-off calls for 0.02  $\mu$ F capacitors for C1 and C2. Drive the filter directly from the output of a preceding op-amp stage for best results.

#### PARTS LIST FOR ACTIVE LOW PASS FILTER

- C1, C2—0.01- $\mu$ F polystyrene or mylar capacitor, 35 VDC
- C3, C4—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- IC1—741 op amp
- J1, J2—phono jack
- R1—12K-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R2—22K-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R3, R4—68K-ohm  $\frac{1}{2}$ -watt resistor, 5%



- R2—22K-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R3, R4—68K-ohm  $\frac{1}{2}$ -watt resistor, 5%

## 17. Alternator Monitor

This circuit will monitor the output of the alternator of any car with a 12 volt electrical system and indicate if the charging system is either undercharging or overcharging. This is accomplished by using 2 sections of a quad voltage comparator IC and connecting the outputs in an "OR" configuration so that the LED will become lit if section A or section B of the comparator detects an improper voltage level. The circuit is connected into any

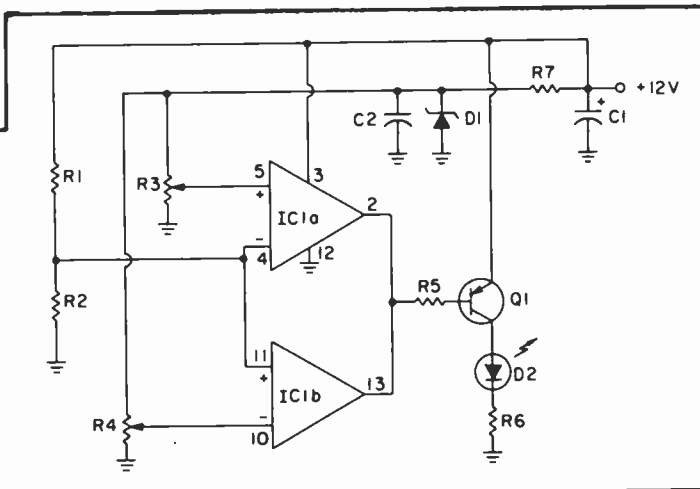
circuit which is active when the car is in operation, such as the ignition or radio circuit. This prevents drain on the battery when the car is not in use. To calibrate the circuit, connect an adjustable DC power supply to the + and - inputs of the circuit. Set the power supply to 13.4 volts and adjust R3 so that the voltage at pin 5 of IC1A is maximum. Then adjust R4 so that the LED just goes out. Set the power supply to 15.1 volts and adjust R3 so



that the LED just goes out. The LED will now become lit if the voltage is outside the permissible range of 13.5 to 15.0 volts when the engine is running.

#### PARTS LIST FOR ALTERNATOR MONITOR

- C1—10- $\mu$ F electrolytic capacitor, 15 VDC
- C2—0.1- $\mu$ F ceramic capacitor, 15 VDC
- D1—9 VDC zener diode
- D2—large LED
- IC1—339 quad comparator
- Q1—2N4403
- R1, R2, R5—10,000-ohm,  $\frac{1}{2}$ -watt resistor
- R3, R4—50,000-ohm linear-taper potentiometer
- R6—470-ohm,  $\frac{1}{2}$ -watt resistor
- R7—220-ohm,  $\frac{1}{2}$ -watt resistor

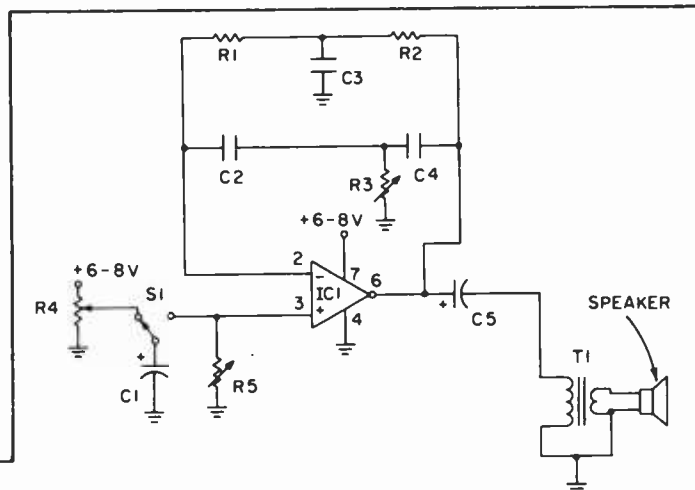


## 18. The Whistler

At the push of a button, this circuit lets forth with an attention-getting whistle, which can be tailored to meet a variety of formats. The circuitry is built around a Twin-T oscillator, which is triggered into action by a varying positive potential placed on the non-inverting op amp input. Resistors R1, R2, and R3, together with capacitors C1, C2, and C3, determine the fundamental pitch, with R3 providing a useful variation. When S1 is pushed, the potential stored in C4 is placed on the non-inverting input, causing the oscillator to function. The duration is determined by R5. The format of the whistle is modified by the setting of R4. At full potential, the effect is a sharply rising tone, followed by a more gradual decline. At about half setting, the effect is more bell-like.

#### PARTS LIST FOR THE WHISTLER

- C1—100 to 200- $\mu$ F electrolytic capacitor, 15 VDC
- C2, C4—0.001- $\mu$ F ceramic capacitor, 1 VDC
- C3—0.002- $\mu$ F ceramic capacitor, 15 VDC
- C5—100- $\mu$ F electrolytic capacitor, 15 VDC
- IC1—741 op amp



- R1, R2—100,000-ohm,  $\frac{1}{2}$ -watt resistor
- R3, R4, R5—10,000-ohm linear-taper potentiometer
- SPKR—8-ohm PM type speaker
- T1—audio output transformer 500-ohm primary/8-ohm secondary

## 19. One or Two-Way Reflex Tester

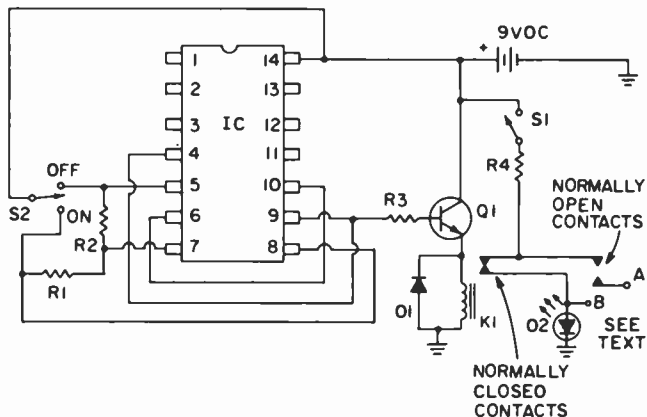
Two people are required to play this circuit: one, the "tester," and the other, the "testee" (sic). By building two of these circuits (as discussed below), one "referee" can test two players against each other. In the "tester-testee" version, the tester operates S1 out of sight of the testee. This causes D1 to light, which the testee must extinguish as fast as possible by operating S2. The flip-flop circuit of the CD4001 assures that testee begins with his switch in the full "off" position, not somewhere in the middle, as D1 will not extinguish unless this condition is met. Also, the relay assures that there is enough of a

time delay to see how long D1 is on and compare, visually, that "on" time with that of a competitor. S2 is then opened and closed to restart the game.

In the dual-circuit (competitive) version, two identical circuits are built and S1 becomes a DPST switch. The two circuits are interconnected by using a second set of normally open contacts on the relay. Point "A" of one competitor's circuit is connected to point "B" on the other's. When this is done, the winning competitor not only extinguishes his own LED, but "locks" the other competitor's "ON." So the slow one gets the "glow."

### PARTS LIST FOR REFLEX TESTER

- D1—1N4001 diode
- D2—small LED
- IC1—4001 quad NOR gate
- Q1—2N4401 transistor
- R1, R2—870,000-ohm, ½-watt resistor
- R3—2,000-ohm, ½-watt resistor
- R4—510-ohm, ½-watt resistor
- RL1—relay w/9 VDC coil; one set normally open contacts, and one set normally closed contacts
- S1—SPST toggle switch
- S2—SPDT toggle switch



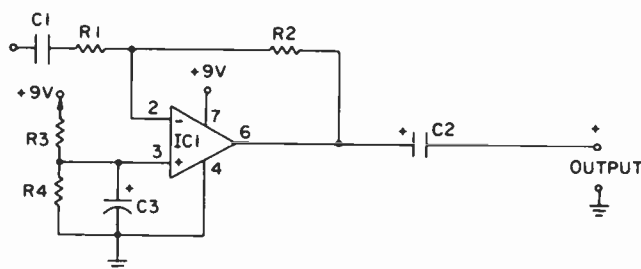
## 20. Single Supply Signal Shifter

□ Op amps, like the popular 741, are usually operated with matching plus and minus power supplies. However, for simple signal amplification applications, the single positive supply shown below has been found to work quite nicely. Resistors R3 and R4 may be fixed at about 5000 ohms each, or replaced with a 5K or 10K potentiometer,

if it is desired to adjust the no-signal output level so that high-amplitude signals will not be clipped. Sometimes, intentional clipping is desired, so this feature may be retained for general experimental applications. Note: If a potentiometer is used for R3, R4, connect center terminals of pots to pin #3 of IC1.

### PARTS LIST FOR SINGLE SUPPLY SIGNAL SHIFTER

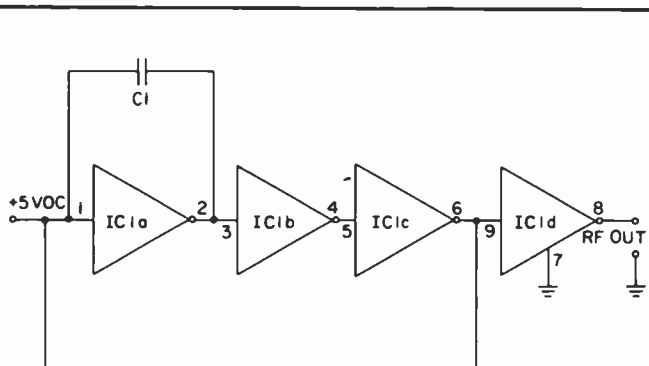
- C1—0.01- $\mu$ F ceramic capacitor, 15 VDC (gain=10)
- 0.10- $\mu$ F ceramic capacitor, 15 VDC (gain=100)
- C2—1 to 100- $\mu$ F electrolytic capacitor, 15 VDC (increase value with frequency)
- C3—100- $\mu$ F electrolytic capacitor, 15 VDC
- IC1—741 op amp
- R1—10,000-ohm, ½ watt resistor
- R2—100,000-ohm, ½ watt resistor (gain=10)
- 1,000,000-ohm, ½ watt resistor (gain=100)
- R3, R4—5,000-ohm, ½ watt resistor or 5,000-10,000 ohm linear taper potentiometer



## 21. Simple RF Generator

□ A single capacitor can turn a TTL hex-inverter into an RF generator with good solid waveform output. The circuit was checked out on both a 7404 standard TTL chip and the low power Schottky 74LS04 with about equal results, though slight departures in frequencies must be expected. One or more buffer stages from unused inverters on the chip may also be utilized.

- C1—0.01- $\mu$ F ceramic disc capacitor, 15 VDC
- IC1—7404 hex inverter



## 22. Pennypincher's Frequency Meter

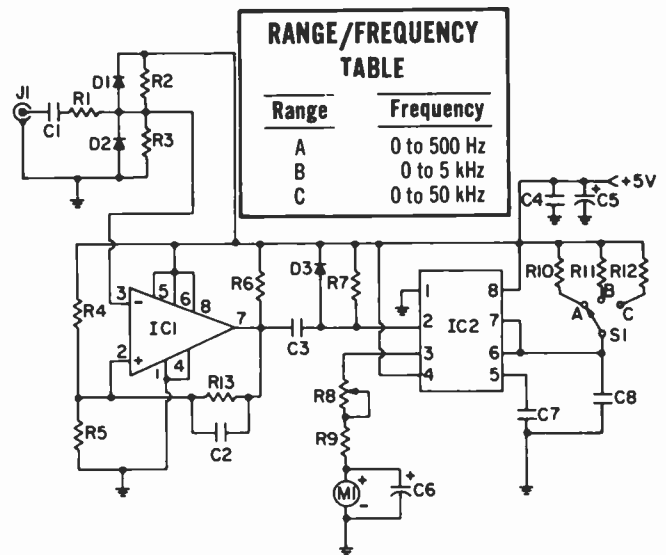


□ One of the handiest instruments you can own is the digital frequency counter, but unless you do an awful lot of experimenting, the expense is usually hard to justify. However, if you can spare \$15, consider building this *analog* frequency meter. Input impedance is 100,000-ohms, and frequencies up to 50 kHz can be measured,

which makes the instrument ideal for the audio experimenter. After construction, calibrate the instrument by first selecting the middle range (Range B, 0-5 kHz) with S1. Feed a 5-kHz signal of known accuracy to J1, and adjust potentiometer R8 for a full-scale deflection on meter M1. That's it.

### PARTS LIST FOR PENNY PINCHER'S FREQUENCY METER

- C1, C4, C7—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C2—5-pF polystyrene capacitor, 35 VDC
- C3—100-pF polystyrene capacitor, 35 VDC
- C5, C6—100- $\mu$ F electrolytic capacitor, 10 VDC
- C8—3000-pF polystyrene capacitor, 35 VDC
- D1, D2, D3—1N4001 diode
- IC1—LM311 comparator
- IC2—555 timer
- J1—phono jack
- M1—0-50 microAmp DC meter
- R1—4700-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R2, R3, R4, R5—18K-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R6—1000-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R7—10K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R8—10K trimmer potentiometer
- R9, R11—30K-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R10—300K-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R12—3000-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R13—10 Megohm  $\frac{1}{2}$ -watt resistor, 10%
- S1—single pole, 3-position rotary switch



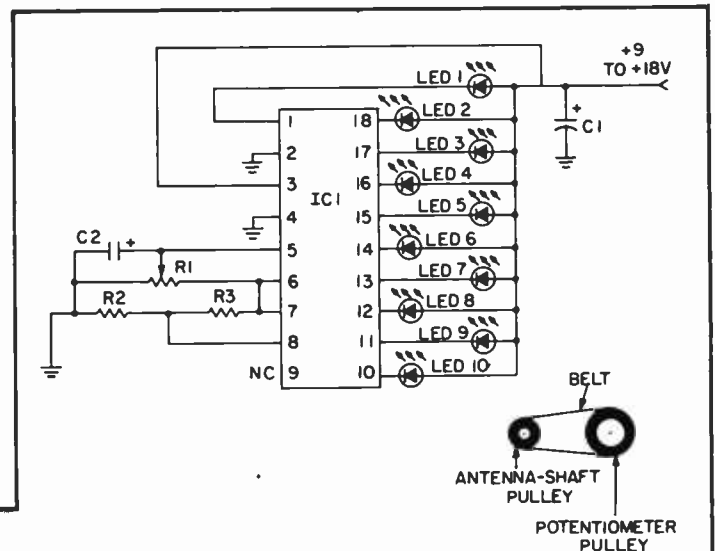
### RANGE/FREQUENCY TABLE

Range	Frequency
A	0 to 500 Hz
B	0 to 5 kHz
C	0 to 50 kHz

## 23. Antenna Bearing Indicator



□ Using an economy-type rotator with your TV, FM or ham beam-type antenna? Then you probably have a direction indicator that's hard-to-read, inaccurate, or in the case of homebrew rotators, probably non-existent. However, it's easy to add on a direction indicator using LEDs for readout. Referring to the schematic, note direction-sensing potentiometer R1. As its wiper moves away from ground potential, first LED 1 will light, then LED 2 will come on as LED 1 extinguishes; this process continues in numerical succession until finally LED 10 is the only lit LED. Coupling the pot to your rotating antenna's shaft with pulleys and a belt allows the display of LEDs to respond to antenna position. The potentiometer's pulley should have a larger diameter than that of the antenna shaft because most potentiometers cannot rotate through a full 360°.



### PARTS LIST FOR ANTENNA-BEARING INDICATOR

- C1—100- $\mu$ F electrolytic capacitor, 35 VDC
- C2—5- $\mu$ F electrolytic capacitor, 10 VDC
- IC1—LM3914 LED display driver
- LED1 through LED10—light-emitting diode

- R1—25K linear-taper potentiometer
- R2—3900-ohm  $\frac{1}{2}$ -watt resistor, 5%
- R3—1200-ohm  $\frac{1}{2}$ -watt resistor, 5%

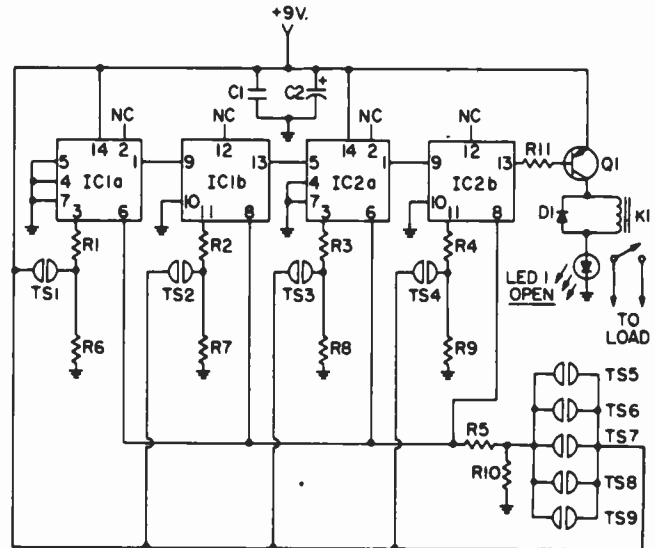
# 24. Touch-Activated Combination Lock

□ Here's an electronic combination lock that's tough to crack. To open the lock, thereby causing relay K1 to pull in and LED 1 to light, you must touch TS1, TS2, TS3 and TS4 in sequence. Should one of the dummy switches, TS5 through TS9, be touched, the lock immediately resets and the complete 4-digit combination must be re-entered to open it. Since there are five dummies, chances

of ever opening the lock accidentally are slim indeed. Once you've opened the lock, just touch one of the dummies to lock it again. The touch switches consist of two small pieces of aluminum or copper separated by a 1/16-inch gap. Bridging the gap with a fingertip closes the switch. If you like, conventional normally open push-buttons could be substituted for the touch switches.

### PARTS LIST FOR TOUCH-ACTIVATED COMBINATION LOCK

- C1—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C2—220- $\mu$ F electrolytic capacitor, 16 VDC
- D1—1N914 diode
- IC1, IC2—4013 CMOS dual D-type flip-flop
- K1—6V, 500-ohm relay with SPST contacts
- LED1—light-emitting diode
- Q1—2N3904 NPN transistor
- R1 through R5—100K-ohm 1/2-watt resistor, 10%
- R6 through R10—4.7 Megohm 1/2-watt resistor, 10%
- R11—18K-ohm 1/2-watt resistor, 10%
- TS1 through TS9—touch switches made of 2 pieces metal separated by a 1/16-inch gap.

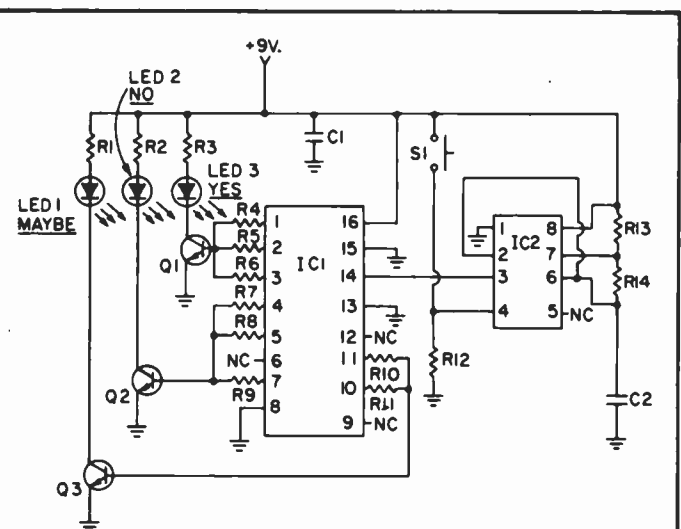


# 25. The Optical Oracle

□ In ancient times, if you needed help with a tough decision you went to the neighborhood oracle who, for a small fee, supplied you with advice straight from the gods. Those days are gone, unfortunately, but if you're really desperate for advice, maybe this circuit will help. Ask the Optical Oracle a question, press and release S1, and read your answer—YES, NO or MAYBE—on the lit LED. You'll get a MAYBE 25% of the time and a definitive YES or NO the rest of the time. If your horse comes in a winner, simply send 10% of the purse to us.

### PARTS LIST FOR THE OPTICAL ORACLE

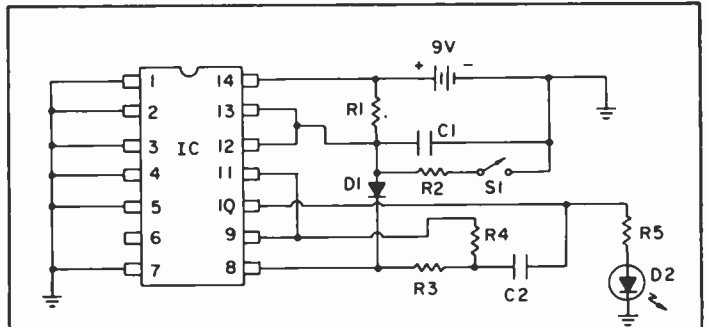
- C1—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C2—330-pF polystyrene capacitor, 35 VDC
- IC1—4022 CMOS octal counter
- IC2—555 timer
- LED1, 2, 3—light-emitting diode
- Q1, Q2, Q3—2N3904 NPN transistor
- R1, R2, R3—680-ohm 1/2-watt resistor, 10%
- R4 through R11—47K-ohm 1/2-watt resistor, 10%



- R12—2200-ohm 1/2-watt resistor, 10%
- R13, R14—18K-ohm 1/2-watt resistor, 10%
- S1—normally open SPST pushbutton switch

## 26. LED Black Jack

□ The object is to see who can get closest to 21 LED flashes without going over. Any number of people can play. Press S1 until D2 starts flashing (1 second on, 1 second off). Then count the number of pulses *after* S1 is released. You may get 5 the first time. That is like being dealt a 5 in Black Jack. Do it again and add the second count to the first, etcetera, until you are as close as you can get to 21 without going over. If you go over, you are out of the game. A fun game and easy to build. The 9 volt battery will last for months.



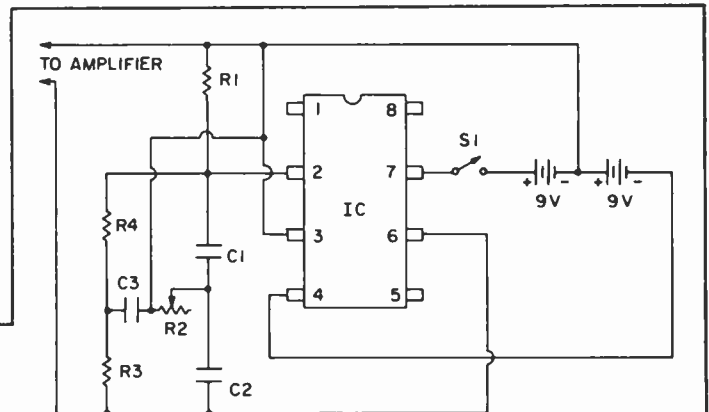
### PARTS LIST FOR LED BLACKJACK

C1—4.7- $\mu$ F tantalum capacitor, 15 VDC  
 C2—0.1- $\mu$ F ceramic disc capacitor, 15 VDC  
 D1—1N4001 diode  
 D2—small LED  
 IC1—4000 NOR gate

R1—5,000,000-ohm, ½-watt resistor  
 R2—30,000-ohm, ½-watt resistor  
 R3, R4—10,000,000-ohm, ½-watt resistor  
 R5—1,000-ohm, ½-watt resistor  
 S1—SPST pushbutton (doorbell) switch

## 27. The Howler

□ This howler will produce a loud dog-like howl that starts strong and slowly grows weaker and weaker until it stops. To start it again, just press S1. Useful for alarms, bicycle horns, a different type doorbell, or as a Halloween trick. Changing R4 will change the frequency, or pitch of the howl, but the main purpose of R4 is to set the filter circuit into oscillation with the op amp. Adjust R4 until oscillations begin. The output should go to an amplifier rather than just to a speaker directly because the effect is better.



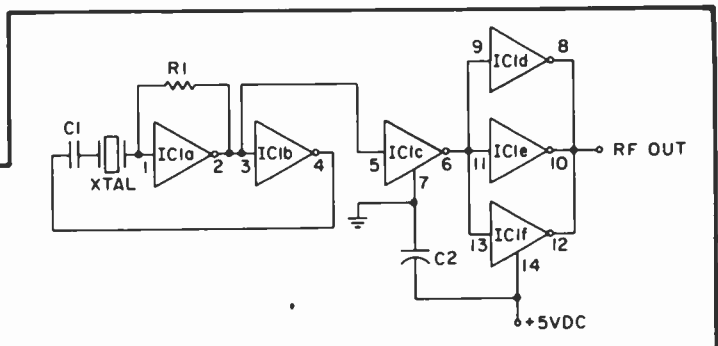
### PARTS LIST FOR THE HOWLER

C1, C2—0.001- $\mu$ F ceramic disc capacitor, 15 VDC  
 C3—0.005- $\mu$ F ceramic disc capacitor, 15 VDC  
 IC1—741 op amp  
 R1—10,000-ohm, ½-watt resistor  
 R2—1,000,000-ohm, linear-taper potentiometer

R3, R4—220,000-ohm, ½-watt resistor  
 S1—SPST momentary-contact switch

## 28. Crystal-Controlled TTL

□ This inexpensive color-TV crystal of approximately 3.58 MHz can readily be persuaded to oscillate in the following 7404 circuit. The resultant waveform can be divided down, via other popular IC chips, such as the 4017 CMOS type.



### PARTS LIST FOR CRYSTAL-CONTROLLED TTL

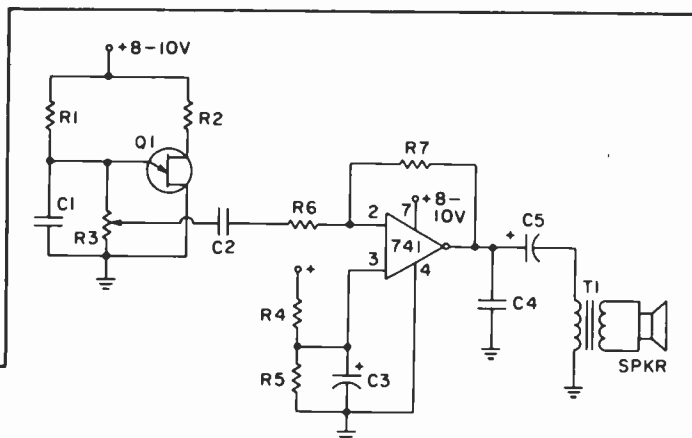
C1—75-pF mica capacitor, 15 VDC  
 C2—0.01- $\mu$ F ceramic capacitor, 15 VDC  
 IC1—7404 hex inverter  
 R1—1,000-ohm, ½-watt resistor  
 XTAL—3.58 MHz crystal (color TV carrier type)

## 29. Sawtooth Sounds

□ The Micro-Mini-PA described earlier can put the sound of the unijunction transistor oscillator in the air and demonstrate its operation via the charge and discharge of its timing capacitor. The tone, about 300 Hz with the components shown below is roughly musical and can be shaped with filtering. The waveform of the inverting op amp is the reverse of the charge on the capacitor before the unijunction fires. This is the same as when a *charged* capacitor is discharged through a resistance to a certain level, whereupon it is recharged through negligible resistance to full potential.

### PARTS LIST FOR SAW-TOOTH SOUNDS

C1—0.47- $\mu$ F ceramic capacitor, 15 VDC  
 C2—0.1- $\mu$ F ceramic capacitor, 15 VDC  
 C3—6 to 8- $\mu$ F electrolytic capacitor, 25 VDC  
 C4—0.01- $\mu$ F ceramic capacitor, 15 VDC  
 C5—50- $\mu$ F electrolytic capacitor, 25 VDC  
 IC1—741 op amp  
 Q1—2N2646 unijunction transistor  
 R1, R4, R5—4,700-ohm, ½-watt resistor



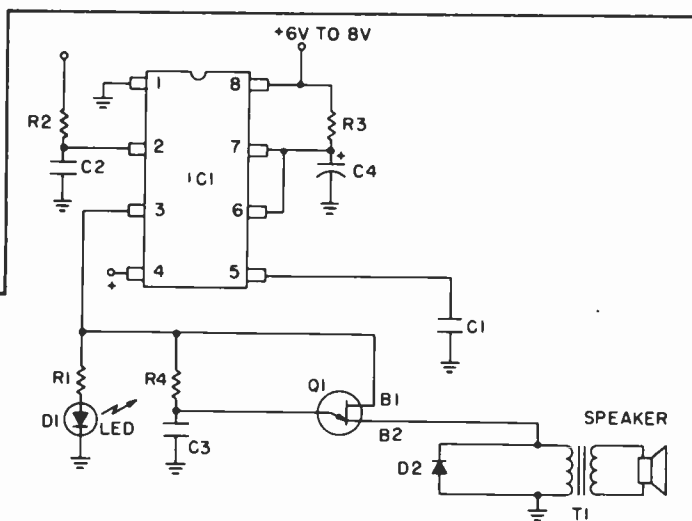
R2—100-ohm, ½-watt resistor  
 R3—50,000-ohm linear-taper potentiometer  
 R6—10,000-ohm, ½-watt resistor  
 R7—100,000-ohm, ½-watt resistor  
 T1—audio output transformer 500-ohm primary/8-ohm secondary

## 30. Hands Off!

□ This circuit finds the 555 timer as a watchdog ready to cry out if an inquisitive finger comes too close. The trigger input is terminated with a one megohm resistor, attached to a coin or some other small metallic object. Hand capacity is sufficient to initiate the timer for about five seconds. The output is fed not only to a warning LED, but to a unijunction type oscillator, whose tiny two-inch speaker can make itself heard throughout the room.

### PARTS LIST FOR HANDS OFF

C1—0.1- $\mu$ F ceramic capacitor, 15 VDC  
 C2—0.01- $\mu$ F ceramic capacitor, 15 VDC  
 C3—0.1- $\mu$ F ceramic capacitor, 15 VDC  
 C4—1- $\mu$ F electrolytic capacitor, 15 VDC  
 D1—small LED  
 D2—1N4148 diode  
 IC1—555 timer  
 Q1—2N2646  
 R1—470-ohm, ½-watt resistor  
 R2—1,000,000-ohm, ½-watt resistor  
 R3—220,000-ohm, ½-watt resistor



R4—15,000-ohm, ½-watt resistor  
 SPKR—8-ohm PM type speaker  
 T1—audio output transformer 500-ohm primary/8-ohm secondary

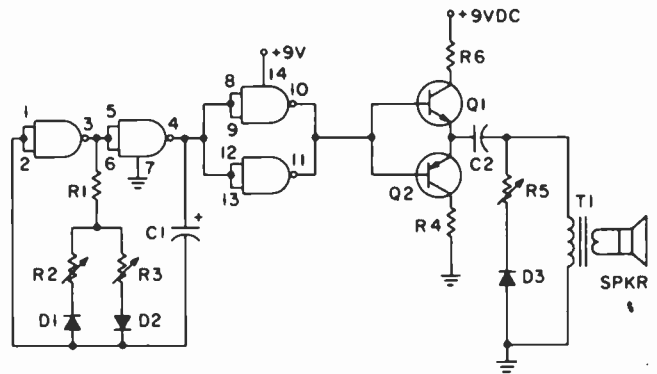
## 31. Mini-Micro Metronome

□ Transforming IC pulses into sound, this tiny ticker goes both tick *and* tock, at a rate of about 2 seconds per tick to 6 tocks per second. The timing capacitor, C1, should be a low leakage mylar type of about 2- $\mu$ F or else a quality tantalum of about 4.7- $\mu$ F. Although the

reversed flow of current through the transformer's primary winding causes a different sound in the speaker from the positive-going inrush, diode D3 and potentiometer R5 can be added to make the "tock" more definitive in its sound quality.

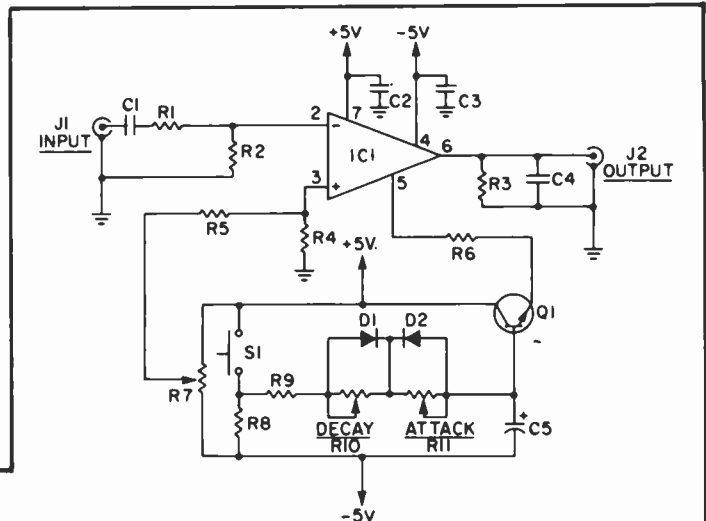
### PARTS LIST FOR MINI-MICRO METRONOME

- C1—2 to 5- $\mu$ F low-leakage mylar or tantalum capacitor, 15 VDC
- C2—2.2 to 10- $\mu$ F electrolytic capacitor, 15 VDC
- D1, D2, D3—1N4148 diode
- IC1—4011A quad NAND gate
- Q1—2N4401 transistor
- Q2—2N4403 transistor
- R1—47,000-ohm,  $\frac{1}{2}$ -watt resistor
- R2, R3—500,000-ohm linear-taper potentiometer
- R4, R6—10-ohm,  $\frac{1}{2}$ -watt resistor
- R5—1,000-ohm linear-taper potentiometer
- T1—audio output transformer 500-ohm primary/8-ohm secondary



## 32. Musical Modulator

□ Feed this circuit a simple audio tone, and it gives you back a musical note with selectable attack, sustain and decay. Input impedance is 10,000-ohms, output impedance is 1000-ohms, and the gain is unity. Best results will be obtained with signal inputs having amplitudes of 1-volt peak-to-peak or less. When S1 is pressed, the output volume rises at a rate determined by attack control R11. As long as S1 is pressed, the sound will be sustained. Releasing S1 causes the note to decay at a rate determined by decay control R10. Try sine, square or triangular wave inputs for musical notes. With a noise input you can imitate such things as gunshots and explosions. Trimmer R7 can be adjusted to cancel out any audible "thumping" (noticeable with very rapid attack or decay).



### PARTS LIST FOR MUSICAL MODULATOR

- C1—0.33- $\mu$ F mylar capacitor, 35 VDC
- C2, C3—0.1- $\mu$ F ceramic disc capacitor, 35 VDC
- C4—0.005- $\mu$ F mylar capacitor, 35 VDC
- C5—2.2- $\mu$ F electrolytic capacitor, 16 VDC
- D1, D2—1N914 diode
- IC1—RCA CA3080 transconductance amp
- J1, J2—phono jack
- Q1—2N3904 NPN transistor
- R1—9100-ohm  $\frac{1}{2}$ -watt resistor, 10%

- R2, R3, R4—1000-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R5—2.2 Megohm  $\frac{1}{2}$ -watt resistor, 10%
- R6—15K-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R7—1 Megohm trimmer potentiometer
- R8, R9—5600-ohm  $\frac{1}{2}$ -watt resistor, 10%
- R10, R11—250K linear-taper potentiometer
- S1—normally open SPST pushbutton switch

## 33. Dividing It All Up

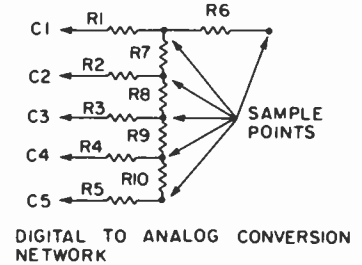
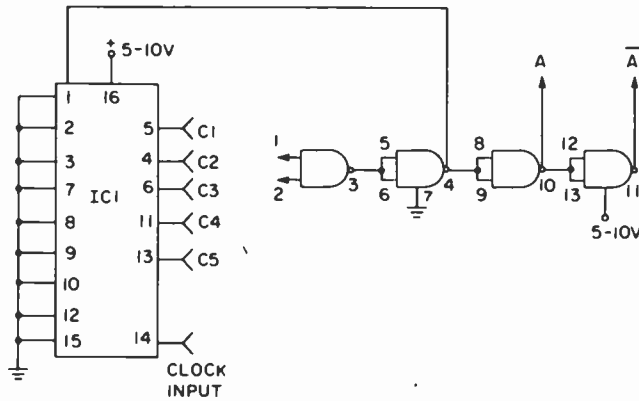
□ The type 4018 programmable counter is a useful digital tool, especially where a basic clock frequency must be divided down for various timing operations. With proper connections, divisors of from 2 through 10 may be configured. The table shown below gives the connections. The odd divisors do not give symmetrical outputs, but close ratios, such as four-high, three-low for a divide-by-seven setup. Digital-to-Analog Conversion may also be studied by connecting the outputs as shown. Interesting waveforms may be obtained by trying out the various dividing connections, while tying an oscilloscope into

the different resistor network junctions. With the circuit set for a divide-by-ten function, a *digital sine wave* may be discovered at certain points along the network. With clock frequencies above 1 KHz, this output may be heard on an audio amplifier. Computer Music, anyone?

### PARTS LIST FOR DIVIDING IT ALL UP

- IC1—4018 dividing counter
- IC2—4011A quad NAND gate
- R1 through R6—100,000-ohm,  $\frac{1}{2}$ -watt resistor
- R7 through R10—47,000-ohm,  $\frac{1}{2}$ -watt resistor

To Divide By	Connect Pin 1	Connect Pin 2
2	C1	C1
3	C2	C1
4	C2	C2
5	C2	C3
6	C3	C3
7	C3	C4
8	C4	C4
9	C4	C5
10	C5	C5

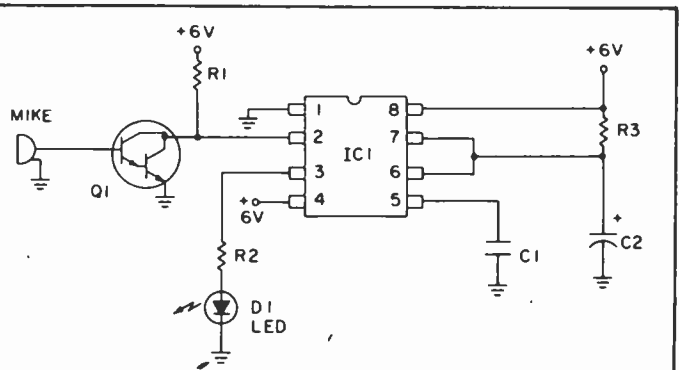


## 34. The TTL Robot Ear

□ The type 555 timer can not only see, but hear, as this sound pick-up circuit shows. It is most apt in picking up sudden sharp sounds. A type MPS A13 Darlington transistor provides gain to cause triggering action. With RC time constants of 4.7 or 5- $\mu$ F and 220,000 ohms, the warning indicator LED will remain on for about two seconds.

### PARTS LIST FOR THE TTL ROBOT EAR

- C1—0.1- $\mu$ F ceramic capacitor, 15 VDC
- C2—5- $\mu$ F electrolytic capacitor, 15 VDC
- D1—small LED
- IC1—555 timer
- Q1—Motorola MPS-A13 transistor
- R1—47,000 to 100,000-ohm, 1/2-watt resistor



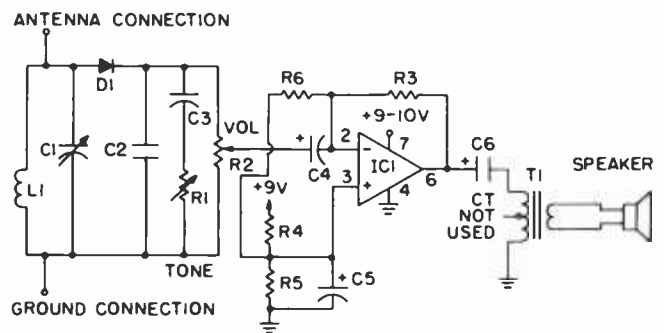
- R2—470-ohm, 1/2-watt resistor
- R3—220,000-ohm, 1/2-watt resistor

## 35. Mini-Modern Crystal Receiver

□ A 741 mini-power-amplifier can update those 1N34 "cat's whiskers" crystal receivers right into the Space Age. Depending on antenna and ground facilities, good reception is possible with clear volume from the tiny speaker. A 9-volt transistor battery provides portable radio convenience for escaping the frustrations of the IC experimental test bench, for one thing!

### PARTS LIST FOR MINI-MODERN CRYSTAL SET

- C1—365-pF variable capacitor
- C2—0.01- $\mu$ F ceramic capacitor, 15 VDC
- C3—0.1- $\mu$ F ceramic capacitor, 15 VDC
- C4, C5—100- $\mu$ F electrolytic capacitor, 15 VDC
- C6—50-100- $\mu$ F electrolytic capacitor, 15 VDC
- D1—1N34 diode
- IC1—741 op amp
- L1—loopstick coil
- R1—25,000-ohm linear-taper potentiometer
- R2—25K to 50,000-ohm audio taper potentiometer



- R3—1,000,000-ohm, 1/2-watt resistor
- R4, R5—4,700-ohm, 1/2-watt resistor
- R6—10,000-ohm, 1/2-watt resistor
- T1—500/8-ohm audio output transformer
- MISC.—8-ohm 2 in. PM type speaker; snap type 9 V battery clip

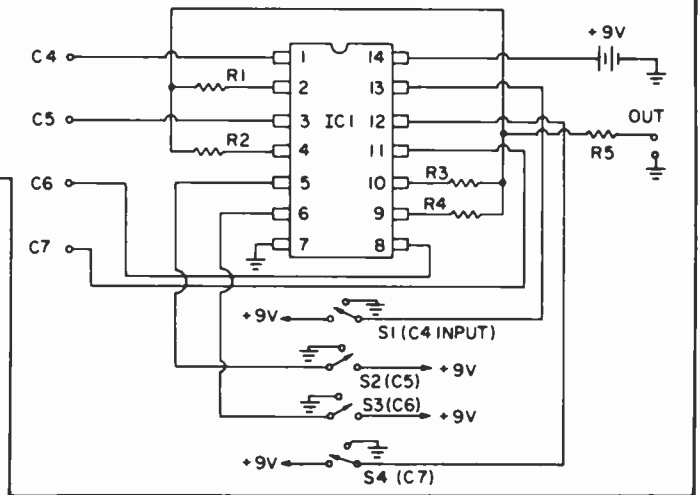


# 36. Multi-Input Music Synthesizer



**PARTS LIST FOR MULTI-INPUT MUSIC SYNTHESIZER**  
**IC1**—4016 quad bilateral switch  
**R1 through R5**—1,000-ohm, ½-watt resistor  
**S1 through S4**—SPDT slide switch

□ The inputs to this synthesizer can be from any musical instruments. C4 can be from an electric guitar, C5 from an electronic organ, etc. Or the inputs can be from the outputs of the "Octave Music Maker" project. The voltage should not exceed 9 volts at these inputs. The output will be a combination of the inputs, where you control the combining via the switches. The switch marked "S1" will put the C4 input through to the output when it is switched to the down position.

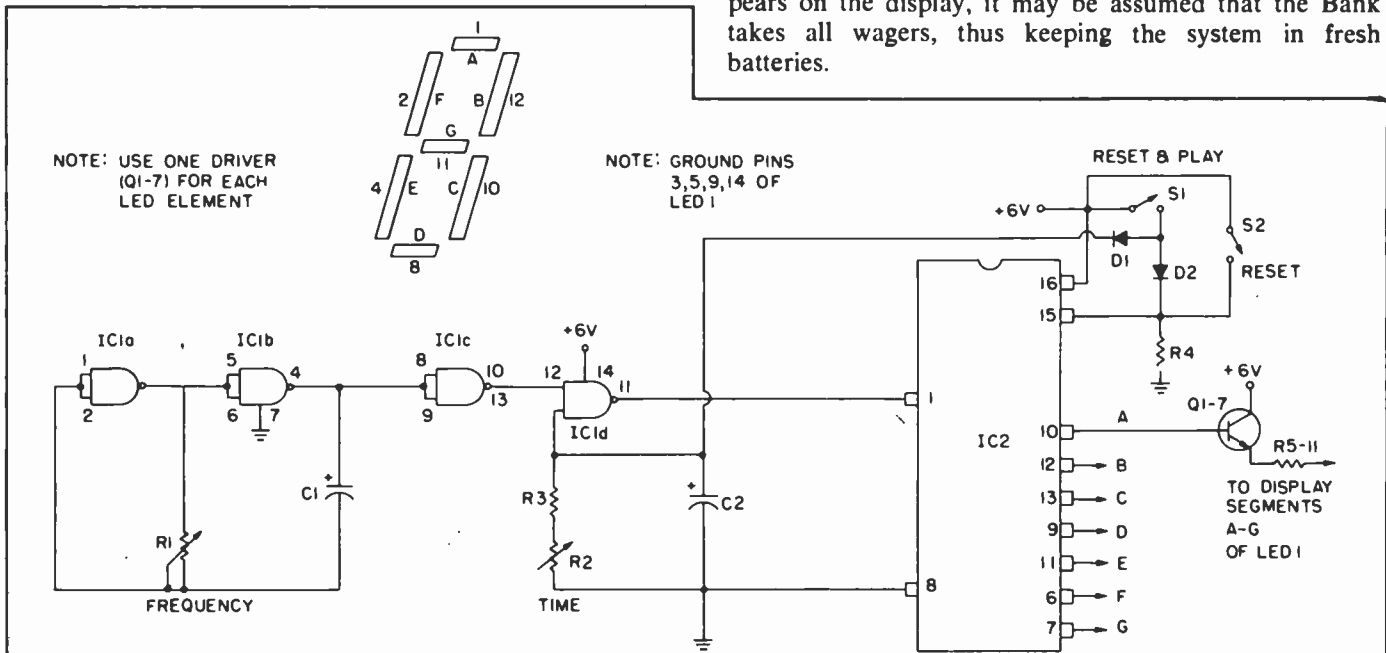


# 37. Mini-Digital Roulette



□ A more adult form of entertainment can be obtained from the 4026 counter and display previously described. The clock input terminal is connected via a pushbutton switch to the "Basic Pulse Maker" and two to nine players select a number. Then, press the button. The input fre-

quency should be 10-Hz or higher and the Reset may zero the display first, although there is statistically little or no effect upon subsequent outcomes. When the switch is released, the counter holds on one number, which is displayed until reset or new counts arrive. If a Zero appears on the display, it may be assumed that the Bank takes all wagers, thus keeping the system in fresh batteries.



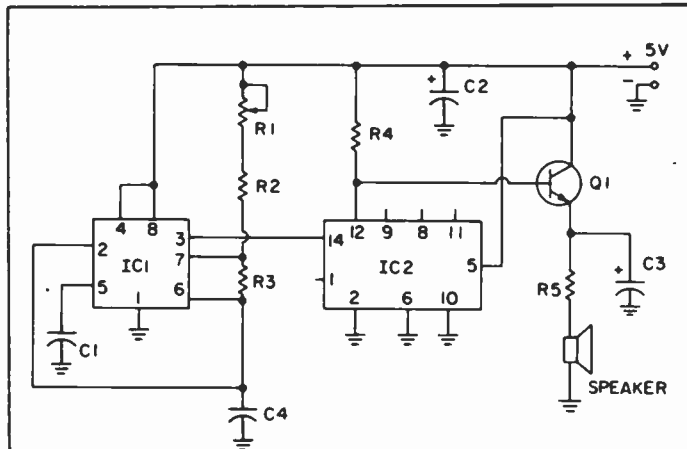
**PARTS LIST FOR MINI-DIGITAL ROULETTE**

**C1**—0.47 to 2.2- $\mu$ F electrolytic capacitor, 15 VDC  
**C2**—100- $\mu$ F electrolytic capacitor, 15 VDC  
**D1, D2**—1N4148 or 1N914 diode  
**IC1**—4011 quad NAND gate  
**IC2**—4026 decade counter  
**LED 1**—DL-750 7-segment display

**Q1 through Q7**—2N4401 transistor  
**R1**—500,000-ohm linear-taper potentiometer  
**R2**—100,000-ohm linear-taper potentiometer  
**R3**—10,000-ohm, ½-watt resistor  
**R4 through R11**—1,000-ohm, ½-watt resistor  
**S1, S2**—SPST momentary-contact switch

## 38. Guitar Tuning Aid

By taking advantage of the frequency stability of the 555 timer IC operating in an astable mode, an oscillator can be constructed which can be used as a tuning aid for the guitar. The first string of the guitar, E, produces a note with a frequency of 82.4 Hertz. The frequency of the oscillator is set to twice this value, 164.8 Hertz, and then followed by a divide-by-two stage to produce the desired frequency. The purpose of the divide-by-two stage is to guarantee that the waveform produced has a duty cycle of exactly 50%. This produces a note with no second harmonic distortion. The frequency of oscillation of the circuit is set by adjustment of R1, R2, and C2 also determine the frequency of oscillation but these components are fixed values and need no adjustment. The output of IC2 is fed to an emitter follower to provide current gain to drive a loudspeaker. C3 acts as a low-pass filter to attenuate harmonics and produce a more natural sounding note. The circuit is powered by a 5 volt supply, and this voltage *must* fall within the range of 4.75 to 5.25 volts for IC2 to operate properly.



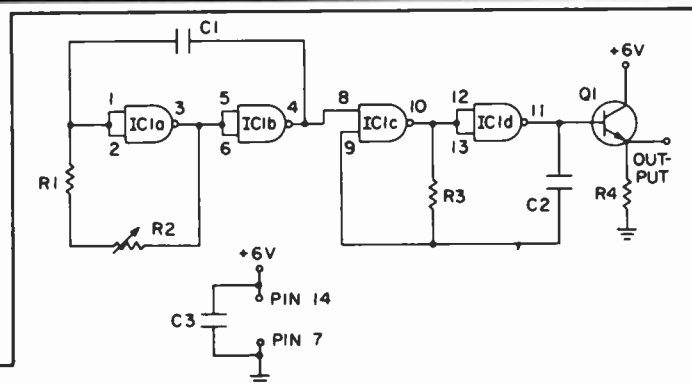
- C3—100- $\mu$ F electrolytic capacitor, 15 VDC  
 IC1—555 timer  
 IC2—7490 decade counter  
 Q1—2N4401  
 R1—50,000-ohm linear-taper potentiometer  
 R2, R4—4,700-ohm, 1/2-watt resistor  
 R3—33,000-ohm, 1/2-watt resistor  
 R5—33-ohm, 1/2-watt resistor  
 SPKR—8-ohm PM type speaker

### PARTS LIST FOR GUITAR TUNER

- C1, C4—0.1- $\mu$ F ceramic capacitor, 15 VDC  
 C2—15- $\mu$ F electrolytic capacitor, 15 VDC

## 39. Digital Modulator

When a high-frequency oscillator is gated by a much lower frequency, modulation is accomplished. The following circuit provides a 1 MHz oscillator modulated or gated by a variable frequency in the audio range. A transistor-buffer is used for the output. The resulting signal can be employed for a variety of AM radio testing and each signal may be individually be taken off, increasing the versatility of this little circuit. *Note:* Do not use an antenna longer than 3 ft., or RF emission may exceed allowable FCC standards and cause illegal RF interference.



- PARTS LIST FOR DIGITAL MODULATOR  
 C1—0.01- $\mu$ F ceramic capacitor, 15 VDC  
 C2—100-pF mica capacitor, 15 VDC  
 C3—0.1- $\mu$ F to 0.22- $\mu$ F ceramic capacitor, 15 VDC  
 IC1—4011A quad NAND gate

- Q1—2N4401 transistor  
 R1—10,000-ohm, 1/2-watt resistor  
 R2—100,000-ohm, 1/2-watt resistor  
 R3—2,200-ohm, 1/2-watt resistor  
 R4—150-ohm, 1/2-watt resistor

## 40. TTL Logic Probe

This circuit can be used as an indicator of the logic conditions at any point in a TTL digital circuit. It will

indicate the presence of a continuous logic 1 or logic 0  
 (Continued on page 113)

# WIRE WRAP BREADBOARDING

New construction technique unites the best features of printed circuit and solderless breadboard construction

by Lee Lensky

FOR THE LAST FEW YEARS, there have been two major methods of circuit board construction dominating the hobbyist field: etched printed circuit boards, and solderless breadboards. Both have their respective advantages and disadvantages. The printed circuit offers compactness and ease of actual assembly of components onto the board. However, the initial startup cost for the hobbyist can be expensive, when the cost of materials necessary for the production of a printed circuit board is added up. Additionally, there is the time involved in the design of a printed circuit, where component shapes and sizes often dictate departures from simply transferring the flow of the schematic onto the board.

However, the finished product is rugged and, if designed with care, usually compact in size.

**To Solder or Not.** Solderless breadboards, on the other hand, offer the hobbyist the opportunity to literally transfer a schematic on paper to a physical working circuit by utilizing point-to-point construction. Spring-

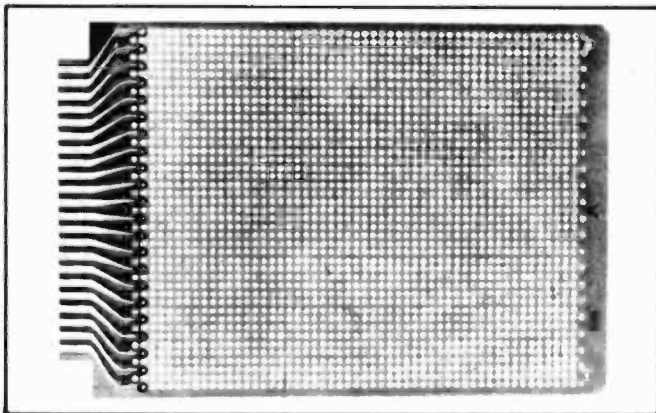
loaded terminals allow the insertion of component leads without trimming, thereby extending their value in that they remain completely reusable in other circuits at a later time. However, the drawback with solderless breadboards is that they lack permanency in the sense that components can become dislodged from their terminals due to careless handling and through exposure to the elements, if not used in a controlled environmental setting (meaning that you'll require a heavy degree of weather-proofing if the circuit is to be used anywhere outside the home).

**The Best of Both.** This brings us to the relative newcomer in the hobbyist construction field, the wire-wrapped breadboard. We use the term "relative newcomer," because in fact wire-wrapping as a method of connecting

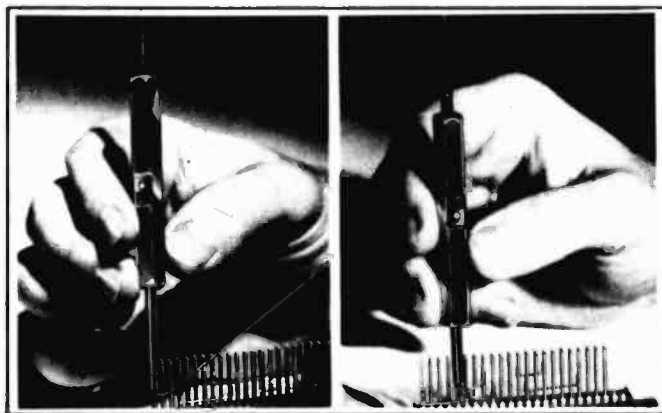
components together on a circuit board has been around for close to twenty years, but was mainly used only in industrial applications before printed circuitry came into widespread acceptance, bringing with it miniaturized components. Many of you will recall the advertisements of the Zenith Television Corporation in the early 1960's, extolling the virtues of their completely hand-wired television receivers. If you still have one about the house, a quick gander at the chassis will reveal the presence of wire-wrapped connections, running from point to point between tube sockets and tie points for such components as capacitors and larger resistors. And those sets really did last.

Through the good offices of the OK Machine and Tool Company, and Vector Electronics, we've illustrated a fair cross section of the tools and accessories necessary and available to the hobbyist for wire-wrap construction.

**Made for You.** Perhaps the primary reason for the emergence of wire wrapping on the hobbyist level has been the increase in complexity of the pro-



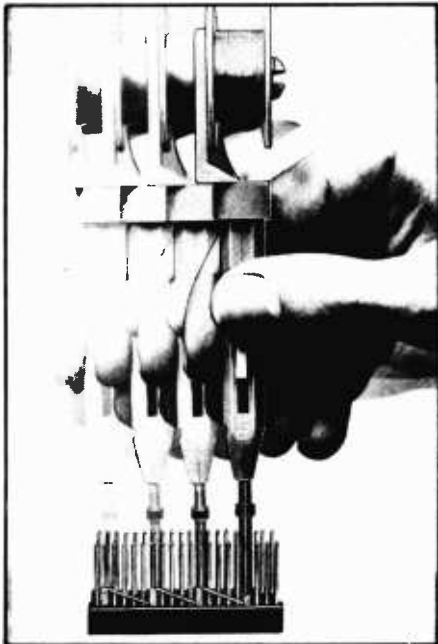
An excellent example of a "basic" matrix board is this model 3662 Plugboard™ from Vector. In addition to the edge-pin terminals, this model has hole spacing which accommodates that of DIP ICs.



A basic wrap tool, such as OK's WSU-30 allows the user to wrap and unwrap connections with ease. The built-in wire stripper is seen in the middle of the tool in both photographs above.

# WIRE-WRAP

jects available for the hobbyist to build. One can literally build her or his own microcomputer from scratch these days, and the complexity of the circuitry involved dictates that the medium upon which the circuit is constructed be flexible enough to allow rearrangement of components and connections as modifications (and yes, sometimes mistakes) are made, yet it must be rigid enough to allow the circuit to be put to practical use. Let's face it—the days of the electronics project as a conversation piece are almost gone. Today's hobbyist builds for more pragmatic reasons, and



If you're willing to spend a few more dollars for convenience, OK's "Just Wrap" tool has a built-in wire dispenser, allowing for one-handed operation. Circle number 40 on the reader service coupon for more info.

it has become necessary to apply the latest technology to keep up with the demands of the hobbyist builder. Therein lie the advantages of wire-wrapping.

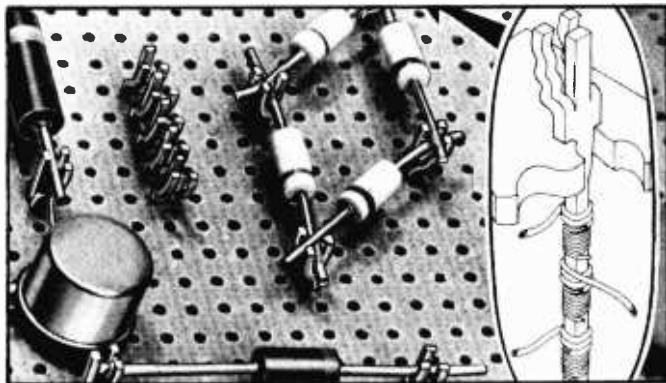
**What You'll Need.** The basics you'll require for wire-wrapping are: the wrapping tool, wire (usually the wrapping tools can accommodate anything



A good starter kit is OK's WK-4B, which contains all you'll need to begin to execute your projects in wire-wrapped formats. Make sure the terminals you buy are the correct diameter for your boards' holes.

from #22 to #30 gauge insulated wire), a perforated matrix board, and the terminal posts upon which to wrap both component leads and interconnecting leads (meaning jumpers).

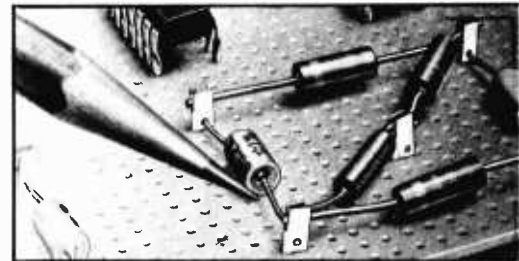
A basic wrapping tool, such as OK's WSU-30, allows the user to strip insulation from the wire, wrap connections with one end, and unwrap connections (just as quickly) with the other end. As you can see from the photos, connections between terminals are made by



A further improvement upon the basic terminal is the "Klip-wrap"™ type, which can accommodate up to three component leads on top of the board, the wrapped wire connection underneath the board. These are used on the larger, unetched perforated matrix boards.

stopping the wrap on one terminal, stretching the unbroken wire to another terminal, and then wrapping again. As your proficiency increases, you'll find that this process can take less than a second, and that you'll be producing the kind of tight mechanical connection that can stand by itself or take solder just as easily. (Everyone who has ever read about or been instructed on proper solder techniques has heard about the necessity for a "good mechanical connection" underlying the solder joint. There is no better example of that connection than a wire-wrapped junction.)

The base for your wire-wrapped circuitry can be as simple as a regular, perforated phenolic board, or something as esoteric as an epoxy/glass copper-clad board. The simpler perforated boards require that you merely insert wire-wrap terminals at the points where component leads meet on the board, and then simply wire up the junctions. Some of the more expensive boards available (and there are none in the hobbyist category that would be considered prohibitively expensive even for the most budget-minded builder)



Vector offers push-in flea clips which are extremely suitable for pre-wrap circuit testing. They can be crimped and soldered for permanent use as well. Circle number 79 on the reader service coupon for more info.

have staggered hole spacing which can accommodate the DIP (dual in-line package) pin spacing required for integrated circuits (or IC sockets) at certain areas on the boards.

**Some Nice Touches.** Additionally, there are many specialized board designs available for computer-type circuitry, with special end terminal accessories for mating with standard ribbon connectors and/or PC card 44-pin edge connectors. For breadboarding peripheral circuitry for home computers, wire-wrap construction offers the unique advantage of having all junctions exposed and accessible for signal tracing and logic testing with probes. Any of you who have ever attempted to force a

probe tip into a standard solderless breadboard hole in order to trace a pulse will no doubt appreciate this.

The more complex copper-clad boards which we referred to earlier also allow the builder to create "hybrid" circuit boards, utilizing the copper traces for standard printed circuit assembly of some components, while still being able to insert terminals through



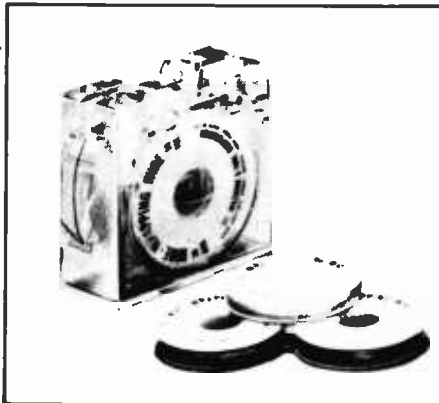
The high-voltage circuit board of this mid-1960's TV shows the use of wire-wrapped terminals combined with printed circuits. This type of hybrid can be built using the type of matrix boards seen on this page.

the same holes or busses for the flexibility of rapid changeover of certain other components. This allows for much experimentation with differing component values without having to rip up an entire board, (something of a nuisance if the circuit is a functional, in-use item already installed in a cabinet or another piece equipment) while still maintaining the physical integrity of the circuit's other connections.

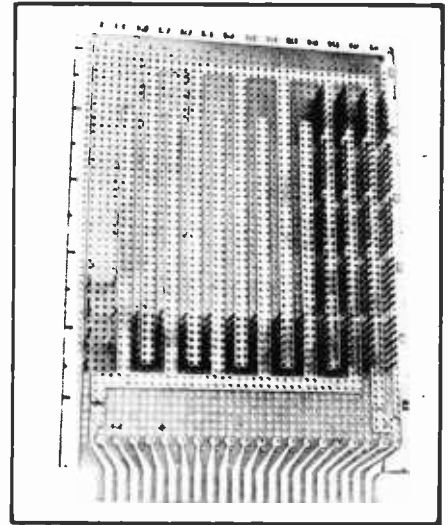
**Where to Get Them.** If the possibilities we've presented here appeal to you, then by all means do some further investigating on your own, either at your local electronics supplier, or by contacting the manufacturers directly. OK Machine and Tool Company, one of the largest hobby supplier of wire-wrapping tools and accessories, has a free catalog available, which can be had by writing them at: 3455 Conner St., Brooklyn, NY 10475, or by circling number 40 on the reader service coupon. A listing of one of the widest assortments of matrix boards available to the hobbyist can be obtained by writing to: Vector Electronics Company, 12460 Gladstone Avenue, Sylmar, CA 91342, or by circling number 79 on the reader service card. ■



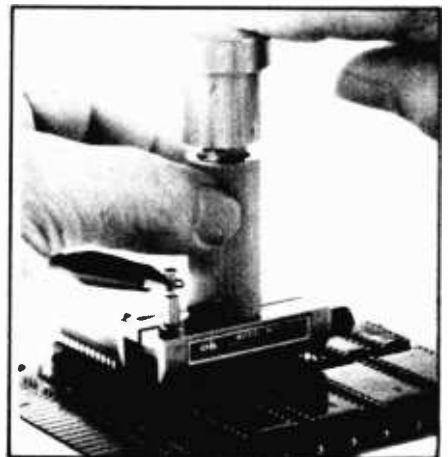
If you decide to go into wire-wrapping in a big way, a battery-operated wrapping tool can be a real time and work-saver. Interchangeable bits accommodate all wire sizes commonly used for wire-wrap construction.



Buying your wire in a dispenser will keep it handy and always ready for use. Some dispensers have built-in cut/strip mechanisms, which make them all the more useful. Most types of dispensers are refillable.

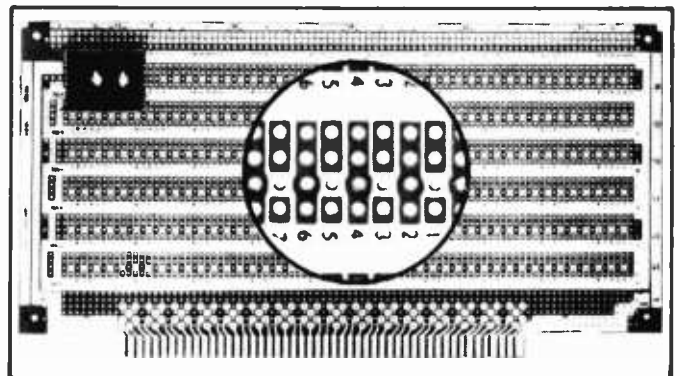


This Plugboard™ (model 3682-4) has etched copper bus strips for soldering as well as holes for wire-wrap terminals. This allows you to build rugged, yet flexible circuitry for virtually any electronic application.



For safe and sure removal of delicate CMOS (as well as other types) ICs, an insertion tool is recommended. OK's MOS-40 has a lug for grounding the tool, this prevents damage caused by static electrical charges.

Vector's "Any DIP"™ Plugboard is designed specifically for S-100 microcomputer accessory circuitry. It comes complete with a built-on heatsink for power supply voltage regulator chips.



# DESIGNING REGULATED POWER SUPPLIES



You don't have to have a degree to design the power supply you need

by Walter Sikonowiz

**U**P UNTIL A FEW YEARS AGO, the task of designing a regulated power supply was both complicated and time-consuming. As a result, the average experimenter either made do without regulation or copied someone else's circuit. Things have changed a lot since then. Now, even a beginner can design his own regulated supply using one of the integrated-circuit voltage regulators. No fancy oscilloscope is necessary; in fact, you don't even need a calculator. Simply by consulting the tables and graphs in this article, you can custom-design your own regulated supply in a matter of minutes.

The supplies to be covered here range in output from 5 to 18-volts at currents up to one-ampere. Both positive and negative outputs are possible. Let's start by examining the basic positive-regulator circuit shown in Figure 1. Voltage from transformer T1 is full-wave rectified by diodes D1 and D2, and smoothed by filter capacitor C1. Voltage regulator VR+ converts the unregulated DC across C1 into a regulated potential of the desired size at its output, pin 2. Capacitor C2 bypasses this output and thereby stabilizes the circuit and improves transient response.

On the primary side of T1, fuse F1 protects the circuit should a malfunction cause excessive current to be drawn from the AC line.

**Similar, But Not Equal.** The similarity between the positive-supply circuit and the negative-supply circuit (Figure 2) is apparent. Note, however, that D1, D2, C1 and C2 are reversed in the negative circuit. Furthermore, the pin designations of negative regulator VR- are different from those of positive regulator VR+. For the positive regulator, pin 1 is the input, while pin 2 is the output, and pin 3 is ground. On the negative regulator, however, pin 1 is the ground connection. Pin 3 is now the input, and pin 2 remains as the output of the voltage regulator.

Both the positive and negative regulators are available in two case styles, a "T" package and a "K" package; see the base pin diagram.

Regardless whether a regulator is positive or negative, the same pin-numbering scheme applies. Remember, however, that the numbers have different meanings for positive and negative regulators. For example, on the "T" package, pin 3 is always the middle pin. If the regulator is positive, the middle pin

is ground. But if the regulator is negative, then the middle pin is its input.

In the design procedure to follow, the same tables and rules will be used to specify F1, T1, D1, D2, C1 and C2, whether a positive or negative supply is being built. This is certainly reasonable since the two circuits are so similar. However, the positive and negative supplies must use different types of regulator ICs, and these may not be interchanged. With all the preliminaries out of the way, let's get down to the basics of this easy seven-step method for designing the supplies.

#### Determine the Required Voltage.

You have your choice of seven positive voltages and seven negative voltages, as shown in the middle column of Figure 6. Note that +10V has no negative counterpart. Be sure that you know the *maximum* current that your load can draw; it must be no more than one ampere. If you are powering a construction project or a kit, you should find a supply-current specification somewhere in the literature. If you have no idea as to how much current your intended load will draw, you can measure it directly. Connect the device you intend to power to a variable bench

supply set to the desired voltage. Measure the current drain with an ammeter in series with one of the power leads.

**Select a Transformer.** Refer to Figure 6, and locate the desired output voltage in the middle column. For a positive supply, you will find the necessary transformer listed in the high-hand column, and in the same row as your selected voltage. The proper transformer for a negative supply will be found in this same row, but in the column furthest to the left. The transformers are specified according to the RMS voltage from one end of the secondary to the other. Note that all secondaries must be center-tapped (CT). The transformers listed are standard, although they may not seem so if you are accustomed to the usual 6, 12, and 24-volt transformers that flood the hobby market. Finding a source is not hard; check the catalogs of any of the large electronics retailers. At least one transformer company, Signal, will sell you these transformers by direct mail-order. Before ordering, request a catalog and price list (Signal Transformer Co., 500 Bayview Ave., Inwood, N.Y. 11696).

You do have a little bit of leeway in the selection of a transformer, particularly at the higher voltages. If a 34-VCT transformer is called for, and you have on hand one that measures 32-VCT, go ahead and use it. Also, you could hook up the secondaries of two 12-volt transformers in series (and in the proper phase) to obtain the equivalent of a 24-VCT transformer.

In addition to the voltage, you must also specify your transformer's current rating. A convenient rule-of-thumb is to pick a transformer whose secondary-current rating is about 1.2 times the maximum current that is to be drawn from the supply. If you use a transformer whose current rating is too small, it will overheat. On the other hand, if you choose a transformer that can supply much more current than is necessary, it will be bulkier and more expensive than a transformer of the proper size.

**Pick a Regulator.** Here again, you should use Figure 6. Positive regulators can be found in the column just to the right of the "Output Voltage" column, and negative regulators are just to the left. As you can see, a positive regulator may be chosen from either of two IC families: The 7800 series, or the 340 series. Furthermore, each family comes in either the "T" package or the "K" package. Thus, when selecting a 6-volt positive regulator, you can pick from any of the following: 7806K, 7806T, 340K-6 or

340T-6. If you were looking for a negative 6-volt regulator, the 7900 and 320 families would offer the following candidates: 7906K, 7906T, 320K-6 or 320T-6. Actually, there is no significant distinction between the 7800 and 340 families, nor between the 7900 and 320 families. The "K" package, however, can facilitate high power more readily, so it might be preferred at the higher supply-current levels. On the other hand, the "T" package is probably preferable if you intend to build your supply on a PC board.

At all but the smallest load currents, these voltage regulators will have to be heat-sunk. This will be covered in more detail later. When you buy a regulator, try to get a specification sheet, too. It will provide you with more complete information on your particular IC.

**Choose Your Rectifier Diodes.** The factors to be considered here are the diodes' voltage rating, average-current rating, and surge-current rating. Since the supply's load current is restricted to a maximum of one ampere, each diode must see an average current of less than half an ampere. Therefore, a rectifier diode with an average-current rating of one-ampere should suffice. A voltage rating of 100-PIV would be adequate, but it is even safer to use diodes with a 200-PIV rating. These will survive most power-line transients. The surge-current rating becomes an important consideration at the instant when the supply is turned on. At that moment, filter capacitor C1 is uncharged. Transformer T1 charges the capacitor with a current through one of the rectifier diodes. Since this current is limited primarily by the small resistance of the transformer's secondary, it is very large. When all of the above factors are taken into account, the 1N4003 emerges as a good rectifier with transformers of 28-VCT or

less. Its higher-voltage cousins, the 1N4004 and 1N4005, also will work well. For transformers of 34-VCT to 48-VCT, use a 1N5402 rectifier or a higher-voltage relative (1N5403), etc.). The 1N5402 is a 3-ampere diode that will handle higher surges than the 1N4003. Both rectifier types are readily available from many suppliers, including Radio Shack.

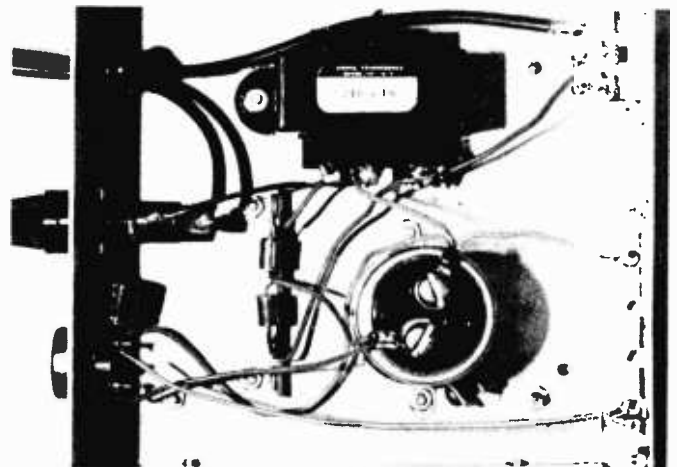
**Specifying Capacitor C2.** This is easy, since anything greater than 25- $\mu$ F will be fine. The capacitor's voltage rating should be from 1.5 to 2-times the output voltage of the supply you are building. If a capacitor with too small a working voltage is used, it will not last long. Conversely, using a capacitor with a working voltage greater than twice the supply voltage is wasteful of space and money.

**Selecting Filter Capacitor C1.** First, determine this component's working-voltage rating from the chart. A range of satisfactory working voltages will be found opposite the transformer voltage that you selected in step 2. Use a filter capacitor with a voltage rating as high as possible within the recommended range of working voltages.

The minimum capacitance of C1, in microfarads, can be found from the graph. Locate your supply's maximum current drain (see step 1) on the x-axis of the graph. Project a line upward to strike the one line (out of the three in the graph) that is appropriate to the transformer voltage being used. The y-value at the point of intersection is the minimum capacitance necessary. Use a standard electrolytic capacitor that is greater than or equal to the value determined from the graph.

In most cases, you can afford to be generous with capacitance. A larger capacitor will have less ripple voltage across it. As a result, it will heat less and last longer. So, when a low-current supply demands only 200- $\mu$ F, you can

Here's the interior of our "typical" 5-volt power supply. Unless you're the type who likes to dress up all of your projects, these types of power supplies can be assembled in any handy chassis. There's almost never any cause to worry about ventilation, as many of the regulator chips can handle their full-rated loads without even heatsinking!



# DESIGNING SUPPLIES

use 500- $\mu$ F if you like. But when the capacitor must have a high working voltage (50 to 75-volts), extra microfarads come in a bigger package and at a higher price. Therefore, you may not wish to be so generous.

In order to locate a suitable electrolytic capacitor, consult the catalog of a large mail-order supplier, such as Allied or Burstein-Applebee. You will find some electrolytics listed as "computer-grade." These cost a little more, but they last longer in heavy-duty service. Whether or not the extra cost is warranted is a decision that is up to you.

**Finding the Right Fuse.** The fuse rating table will be of assistance here. Locate the row corresponding to the transformer being used, and the column appropriate to the maximum expected load current. Check the zone in which the row/column intersection lies for the proper fuse rating. Be certain to buy a slow-blow (3AG) fuse, since this type is less prone to blow on the current surge at turn-on.

Now, let's consider a practical design example. Suppose that a 15-volt, 350-milliamp, positive supply is required. The table indicates that a 40-VCT transformer will be needed. Estimate the transformer's current rating:  $350 \times 1.2 = 420$ . A look through a transformer catalog reveals the nearest commercially available unit to be 40-VCT @ 500 milliamps.

Referring once more to the table, let's choose a 7815K regulator IC.

Since a 40-VCT transformer is being used, 1N5402 rectifier-diodes are a good choice.

For capacitor C2, let's use a 100- $\mu$ F unit with a standard working voltage of 35-volts. Because the voltage rating is about twice the supply's output voltage, this is a safe selection.

Figure 4 reveals that filter capacitor C1's working voltage should lie between 40 and 60-volts. Turning to Figure 5, and using line "B," we find the minimum capacitance to be about 750- $\mu$ F. The nearest commercial unit turns out to be 1000- $\mu$ F @ 50 volts. You can use more capacitance if desired.

Finally, Figure 3 indicates that a  $\frac{1}{4}$ -amp. slow-blow fuse is appropriate for this particular combination of transformer voltage and maximum load current.

Now that you know how to design your supply, let's talk about how to

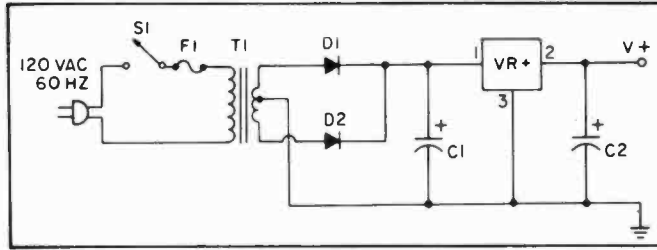


Fig. 1. Here is the schematic for the typical positive-regulated supply. Note the pin connections on the voltage regulator chip.

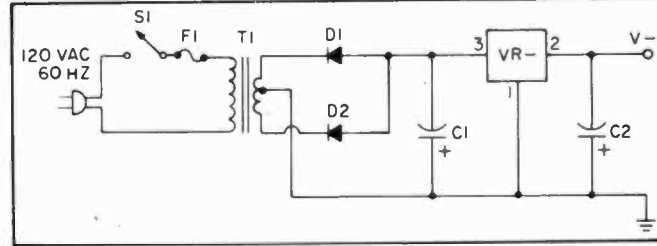
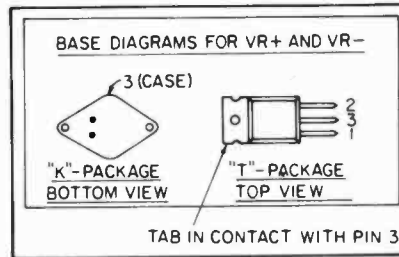


Fig. 2. The negative supply is almost identical to positive, with the exception of the reversals of the diodes and the pinouts of the regulator.

LOAD CURRENT (AMPS)	XFMR RATING (VOLTS RMS)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
16										
20										
24										
28										
34										
40										
44										
48										

Fig. 3. To calculate what size fuse is needed for your supply, find your transformer's output rating in the vertical column, and your regulator's rating at top. Draw a line out to the center of the chart from each box. Where they meet is the fuse rating in amps.



Above are the pin diagrams for both the "T" and "K" package regulators. Note difference between pos. and neg.

TRANSFORMER RATING (RMS VOLTS)	WORKING VOLTAGE OF C1 (VOLTS DC)
16	16-25
20	25-35
24	25-35
28	30-40
34	35-50
40	40-60
44	50-75
48	50-75

Fig. 4. Simply look across from left to right in order to determine what the working voltage of C1 will need to be.

build it. Most manufacturers recommend that a voltage regulator be mounted fairly close to C1. This means 3-inches or less of interconnecting wire. Likewise, C2 should be mounted close by—right on the pins of the regulator, if possible.

Rectifiers D1 and D2 are cooled by heat conduction through the two mounting leads. To assist conduction, mount these rectifiers with short leads. If the rectifier is mounted on a terminal strip, then the lugs of the strip will act

to sink some heat. Printed-circuit mounting requires the use of large pads and thick connecting traces to draw heat away from the rectifier's leads.

Be sure that there is adequate air flow around the components of the supply in order to prevent overheating. This applies particularly to the higher-current supplies.

Short, heavy wires should be used for interconnecting components. Again, this is most important for high-current



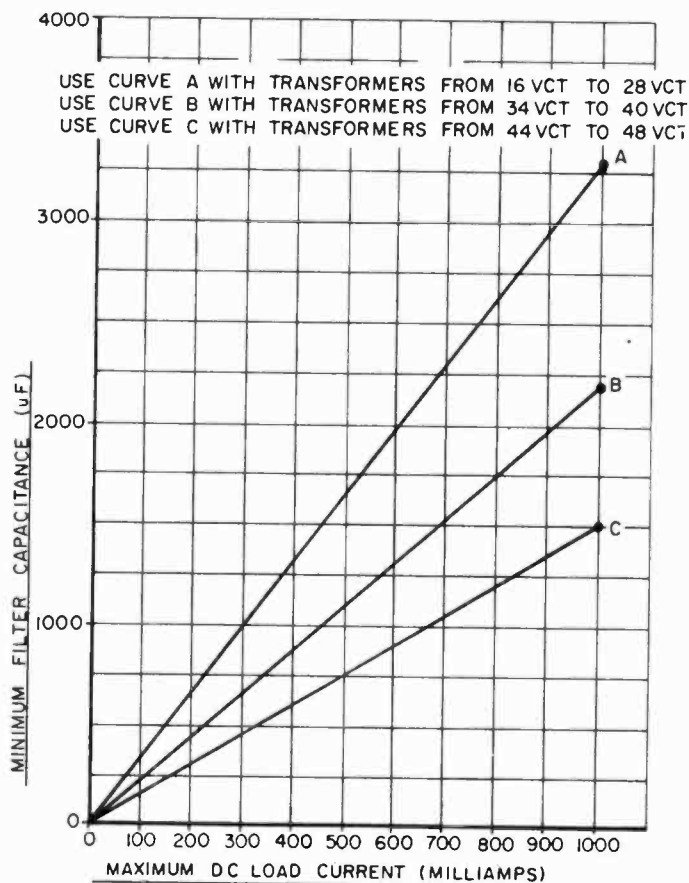


Fig. 5. After consulting fig. 4 for the voltage rating, use this graph to determine the correct capacitance for capacitor C1.

NEGATIVE SUPPLIES			POSITIVE SUPPLIES		
TRANSFORMER (RMS VOLTS)	REGULATOR	OUTPUT VOLTAGE	REGULATOR	TRANSFORMER (RMS VOLTS)	
16 ct	7905/320-5	5	7805/340-5	20ct	
20 ct	7906/320-6	6	7806/340-6	20 ct	
24 ct	7908/320-8	8	7808/340-8	24 ct	
24 ct	7909/320-9	9	NOT AVAILABLE		
NOT AVAILABLE		10	7810/340-10	28 ct	
34 ct	7912/320-12	12	7812/340-12	34 ct	
40 ct	7915/320-15	15	7815/340-15	40 ct	
44 ct	7918/320-18	18	7818/340-18	48 ct	

Fig. 6. Here's a listing of the most commonly used transformer and regulator combinations for both positive and negative.

supplies, which should be wired with #16 or #18 stranded wire. Those wires connecting the load to the supply should be as short as possible for the best regulation.

In most instances, voltage-regulator ICs will need to be heat-sinked. There just fine. However, there is an even better, cheaper way to heat-sink a regulator IC: Assuming that the supply will be mounted in an aluminum case, simply attach the regulator to the case. Remove all paint from the

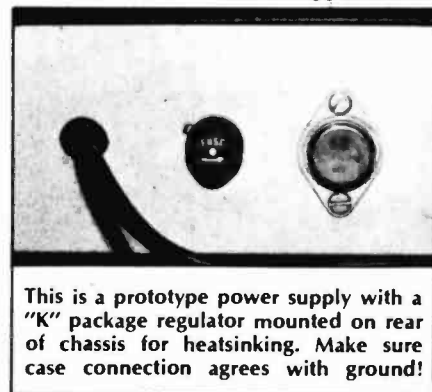
area where the IC is to be mounted, and then bolt the regulator to the chassis. Silicone grease between the chassis and the regulator will improve the heat transfer.

If, as is generally the case, the chassis is to be at ground potential, then positive regulators may be mounted directly to the chassis with no difficulty. Negative regulators, however, pose a problem because the mounting flange on both the "T" and "K" packages is connected to the in-

If, as is generally the case, the chassis is to be at ground potential, then positive regulators may be mounted directly to the chassis with no difficulty. Negative regulators, however, pose a problem because the mounting flange on both the "T" and "K" packages is connected to the input, not ground. The solution here is to use mica insulating wafers, coated with silicone grease, between the IC and the chassis. Heat will still be effectively transferred, but the mounting flange will be electrically insulated from the chassis.

Once your supply is finished, check it out before permanently wiring it to a load. You will need a dummy resistor to test the supply. Its resistance should be equal to the supply's output voltage divided by the maximum expected output current, in amperes. For the supply that was designed in this article, that amounts to 15/35, or about 43-ohms. The resistance should have a power rating of about two-times the product of output voltage and maximum current. Again, for the supply that was designed here, this comes to 2 x 15 x .35, or about ten-watts. Usually, you can build up such a dummy resistance from series and parallel combinations of lower-wattage resistors.

Connect the dummy resistance across the supply's output terminals, and then connect a voltmeter across the dummy resistance. Turn on the supply. Your



meter should indicate the desired output voltage. After a few minutes, carefully feel the regulator IC's flange. It should be no hotter than hot tap water. If touching the regulator case is painful, use a larger heat-sink to cool it down.

If, at the end of ten minutes, your supply is still putting out full voltage, and the regulator is not uncomfortably warm, you can turn the supply off. Disconnect the dummy resistance and voltmeter, wire the supply up to its load, and start pumping out those happy amps. ■

Here's the universal digital clocking source you always needed but couldn't afford

# ★ PULSTAR

IF YOU HAVE BEEN INVOLVED in designing and building digital circuits, you have undoubtedly found a constant need for a handy clock signal source of some kind. There are several ways of satisfying this need. One way is to build a simple R/C oscillator whenever you need one. Another way is to build a fixed-frequency crystal oscillator, and divide the output frequency down to whatever frequency you want. Any of these methods will do the job in most cases, but it invariably involves building something special for each particular case, and tearing it down again when it is no longer needed. Of course, you could also buy one of the commercially available pulse generators if your budget can stand the price tag of \$150.00 and up.

We have another solution for you—a simple pulse generator based on two CMOS ICs. It covers a frequency range of 1 Hz to 1 MHz, and has a pulse-width variable between 0.5-seconds and 0.5-microseconds. It features three modes of operation: Free running, Gated oscillator, and Single Shot, with either external or internal triggering.

The unique thing about this design is that it is powered from the same power supply as the circuit it is driving. This means that you can use the pulse generator to drive both CMOS and TTL circuits, as the drive level will always match the circuit you are testing. It also saves you the cost of a separate power supply for the pulse generator.

**The Circuit.** Referring to the schematic diagram, it can be seen that the basic pulse generator consists of U2 and U3, which are both 4047s, a low-power CMOS Astable/Monostable multivibrator.

U2 and associated circuitry form an oscillator circuit with a 50% duty-cycle in the free running mode. In the monostable mode, it is a one-shot oscillator which may be triggered either from an external source or from the internal pushbutton.

S4 controls the mode of operation. In the free running mode, it grounds pin 8 and pin 9 of U1, thereby keeping pin 6 of U2 high, and pin 8 of U2 low. This enables the astable mode of U2. Neither the trigger input or the push-button have an effect on the circuit

operation in this mode, because pin 5 of U1 is held high.

When S4 is in the free running position, pin 5 of U2 may be pulled low by a low input on GATE IN. This allows U2 to operate as a gated oscillator. When GATE IN is pulled low, the operation of U2 is inhibited.

With S4 in the one-shot position, U2 operates as a one-shot oscillator. In this mode, U2 is triggered by a low-going signal at pin 6 of U1. This low-going signal may originate from an external source (if S3 is in the EXT TRIG mode) or from the de-bounced pushbutton switch, if S3 is in the INT TRIG mode. Two sections of U1 are used to de-bounce the push button switch.

The components which determine the operating frequency of U2 are capacitors C1 through C6, and resistors R6 and R8. S1 allows frequency adjustment in decade steps while R8 is a vernier control allowing adjustment of the output to the exact frequency required.

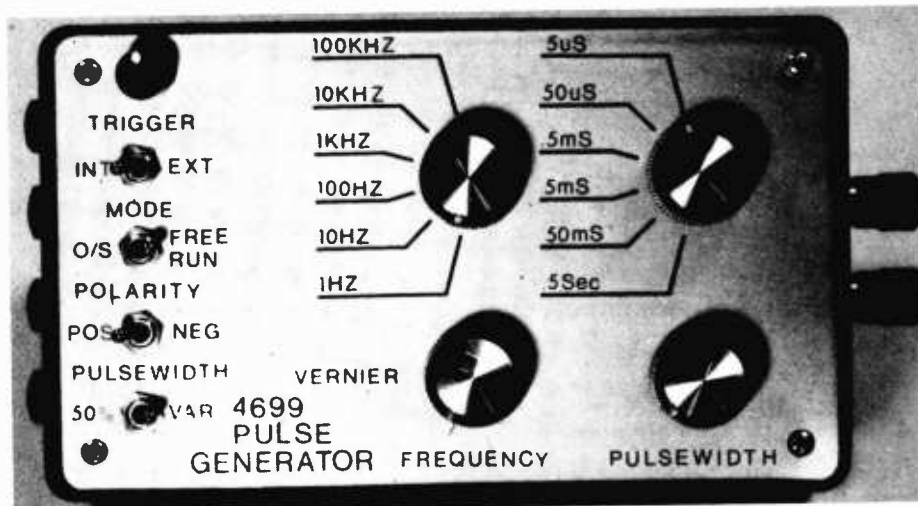
U3 operates continuously in the astable mode. It is used to generate an

by  
**John Rasmussen**

output signal with a variable pulse-width, and is triggered on the rising edge of the waveform output of U2. The components which determine U3's pulsewidth are C7 through C12, and R7 and R9.

S5 allows a choice of either a positive or negative-going output pulse. S6 allows a choice between an output signal with a 50% duty-cycle, or one with a variable pulsewidth (adjusted by R9).

The output signal is buffered by U4. Only one section of the six buffers contained in the chip is shown on the schematic, although all the buffer sections can be driven in parallel to provide as many as 12 (each buffer can drive 2 TTL or DTL circuits) outputs. Check the wiring diagram provided

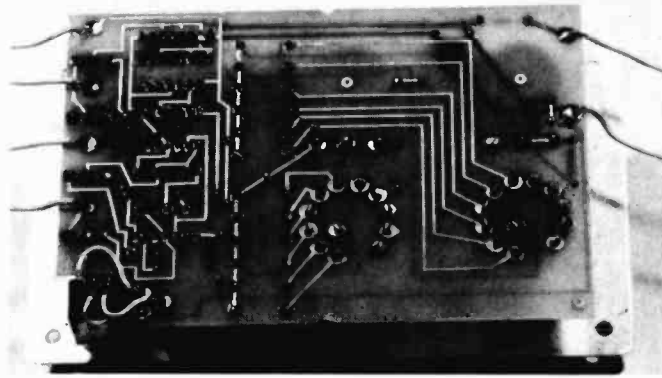


This professional-looking finished product was completed with the aid of a dry lettering transfer kit, which is available in most art supply stores for a usually very low price.

with the chip for the pin numbers of the additional buffers.

**Construction.** Assuming that you will utilize a PC board for assembly of the pulse generator's circuitry (and we suggest that you do), take note of the fact that the PC board that must be used for this project is a double-sided one, with copper foil on both sides of the board. We have provided two templates for this purpose. Template "A" is to be used to create the foil pattern on the underside of the board (the side opposite the component side). Template "B" is to be used to create the foil pattern on the component side of the board. Depending upon what etching method you use, you may have to etch one side, and then repeat the process for the other side, or you may be able to etch both sides in one single process. Check the directions with your etching kit before proceeding with the etching process.

Once the board is completed (and after you have visually inspected it for accuracy and compliance with the original template) solder all of the components (except the ICs) to the "B" side, following the component layout diagram we have provided. We strongly



This photograph shows the foil pattern of the PC board. Use the template on the next page to obtain similar results in building your own PULSTAR.

suggest that you utilize IC sockets, especially for CMOS chips, since they are susceptible to damage from static charges emanating from your body, as well as stray AC from a soldering iron.

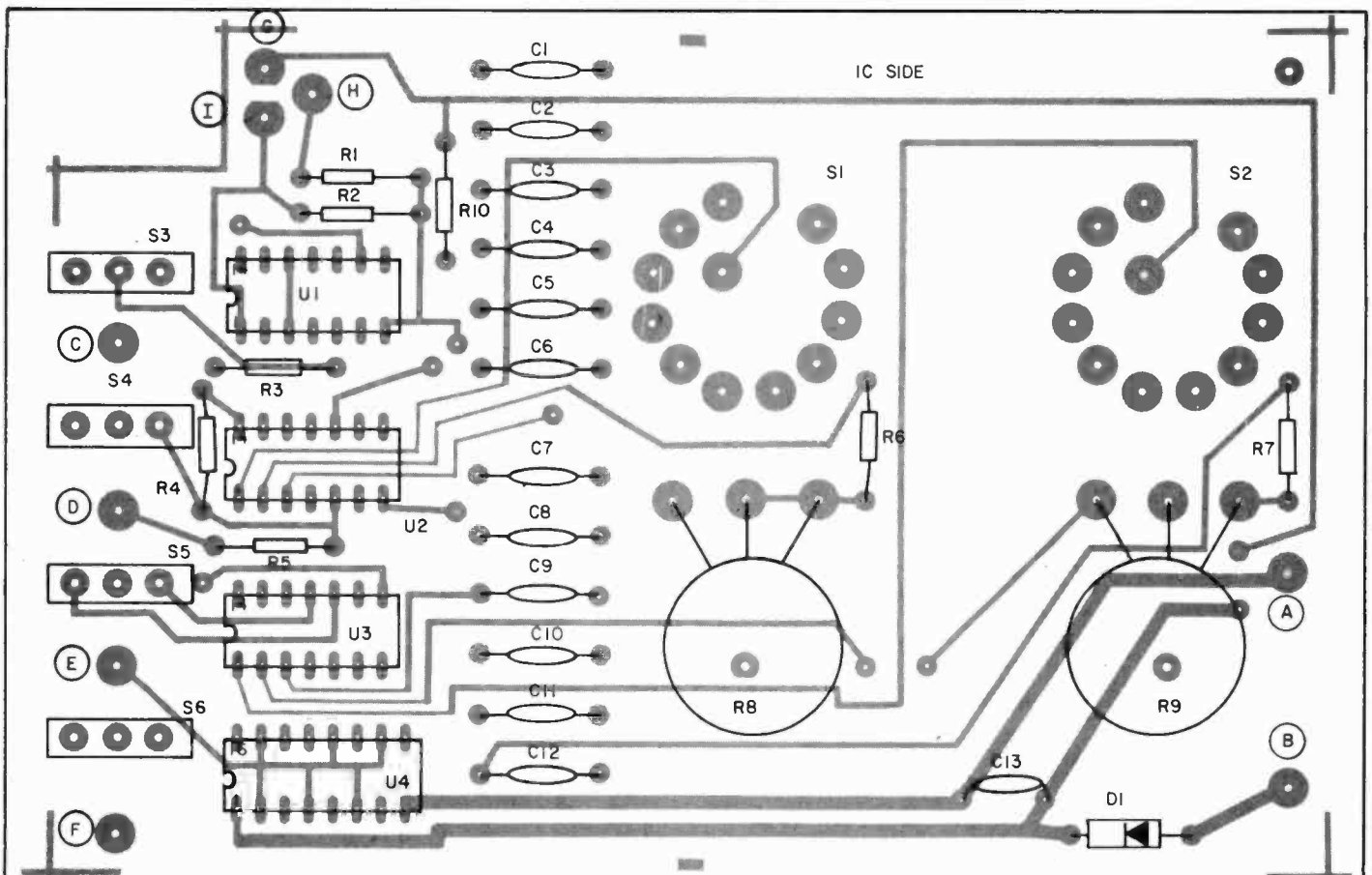
The only component which is not mounted on the board is switch S7. As you can see in the photograph, S7 is connected to the board by three jumper wires to points G, H and I.

In order to mount switches S1 and S2 on the PC board, the wiper and the topmost terminal of the unused second sections must be cut away. In addition, the wiper of the section that is to be used must be bent down slightly to

accommodate the holes drilled in the PC board.

**Applications.** This pulse generator may be used to check out all kinds of digital circuits. Its wide frequency range and operating voltage make it very adaptable. The variable pulse-width feature enables you to check a circuit for sensitivity to variation in clock pulse width.

Let's say a circuit using CMOS ICs with long counting chains, and both positive and negative edge-triggered flip-flops was to be tested. Such a circuit, due to the relatively high propagation delays in the CMOS ICs, may



This is the component placement guide for the printed circuit board. Be certain that you observe correct pin orientation when installing the integrated circuit sockets. Switches S1 and S2 can be mounted directly on the PC board. Refer to the text for mounting instructions.

# PULSTAR

be sensitive to clock pulsewidth variations. With this pulse generator, you will be able to check the operating margins of such a circuit.

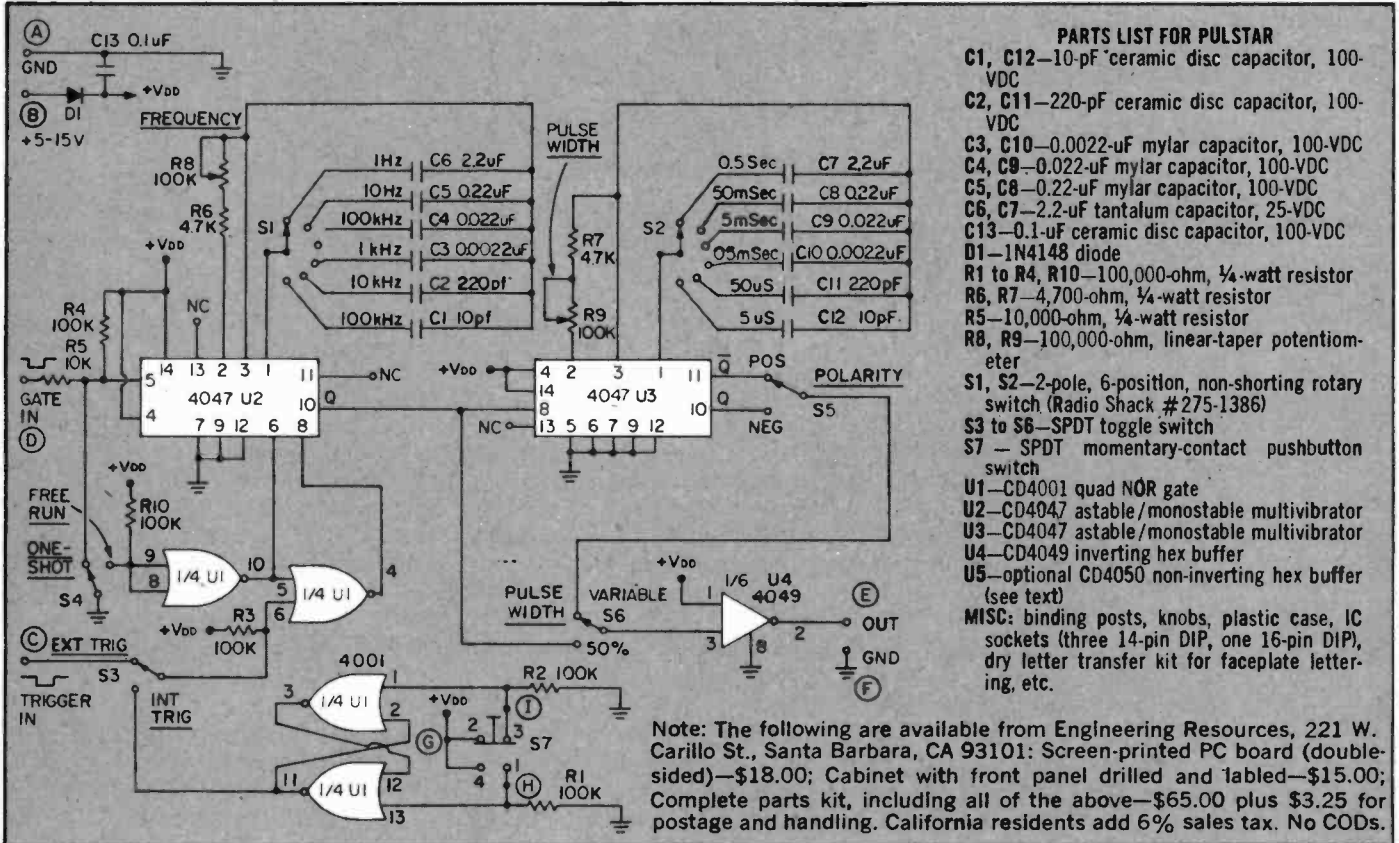
If you wish to drive a TTL circuit

at 1MHz with this pulse generator, it may be done by operating the pulse generator from a voltage source between 10-volts and 15-volts and by using an external type 4050 IC to level-shift the output pulse to the TTL level. The 4050 would be powered from a 5-volt source.

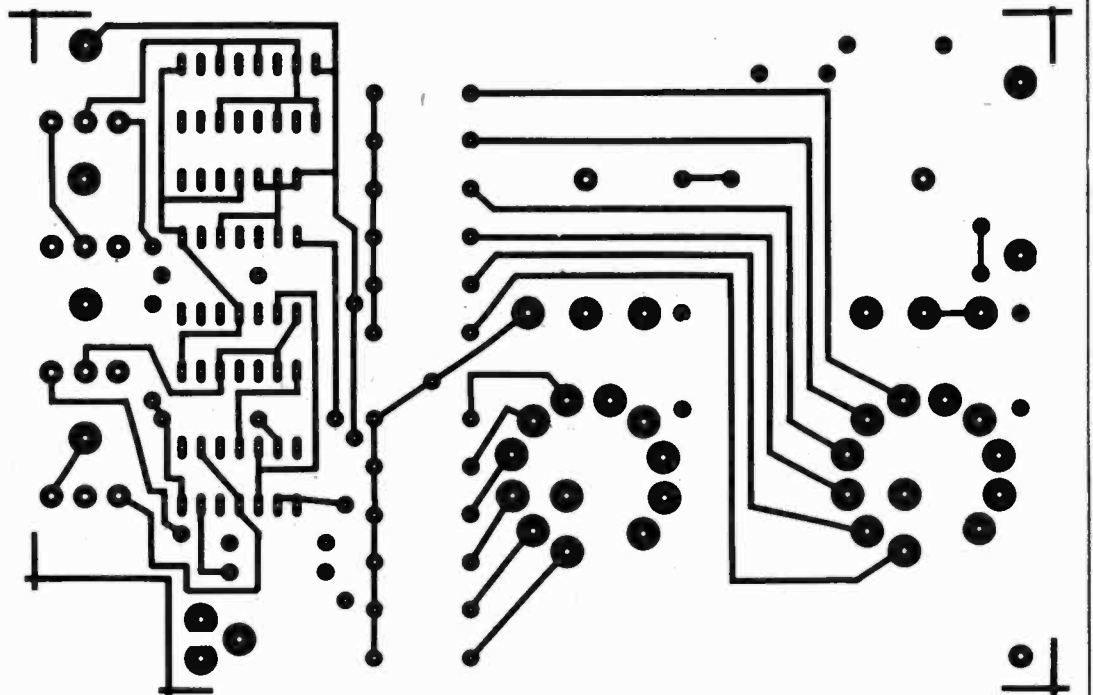
The pulse generator is not calibrated

per se. The component values are chosen so that the ranges are overlapping on both ends of the vernier control. It was designed so, in order to accommodate the changes in the operating frequency and pulsewidth associated with different supply voltages. It is suggested that either a scope or a

(Continued on page 114)



This is the full-scale circuit board template for PULSTAR. Check your finished board for unwanted foil bridges and continuity of the long foil paths before attempting to assemble the project. This precaution can save a lot of headaches later on.



# COUNT CAPACITA



## Bring Your Junk Box Capacitors Back From The Dead!

by Walter Sikonowiz

**M**AYBE YOUR JUNK BOX looks like a haunted mansion? Full of mystery and intrigue? Do you sometimes wonder just what values all those surplus or unlabeled capacitors really are? All the VOMs, frequency meters, power meters, FETVOMs and tachometers in the world aren't going to help you here. What you need is a visit from the Count—*Count Capacita*—our own toothsome capacitance meter.

You can use this capacitance meter to separate good capacitors from bad ones in your junk box. In addition, if you ever have to repair a television or radio, *Count Capacita* will quickly put the bite on a defective capacitor, thus saving you the expense of a repair bill in the process. Last, but certainly not least, the Count will enable you to purchase surplus capacitors, and this is where you can really save money.

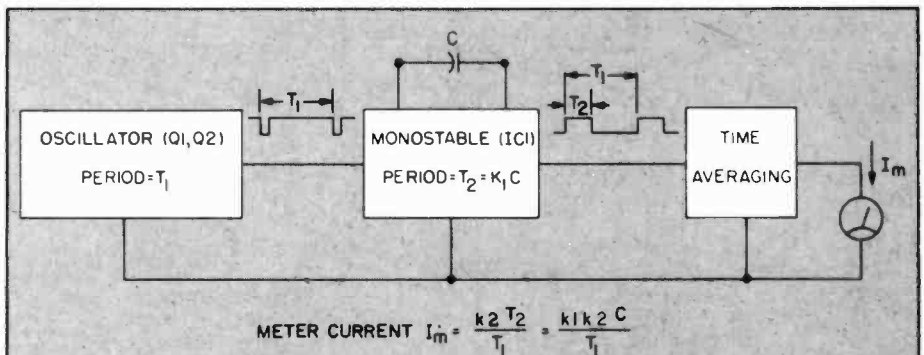
Surplus capacitors are sold at discount rates, usually by mail-order dealers and for several reasons. First, suppose an audio manufacturer decides to completely phase-out his old capacitively coupled amps in favor of direct-coupled designs. His inventory of new and perfectly good capacitors is now useless to him, so he disposes of the lot on the surplus market. Second, sometimes a capacitor manufacturer wants to get rid of old, mislabelled or out-of-tolerance units; he can do this on the surplus market. You can take advantage of the savings—often more than 75%—if you know the Count.

With our meter, you can spot the mislabelled or out-of-tolerance units, identify unmarked devices, and eliminate the occasional defective unit. If you do much experimenting, your savings may soon pay for your capacitance meter.

**Transylvanian Circuitry.** Let's begin discussion of this particular circuit with the block diagram. The circuit is driven by a free-running oscillator that generates short-duration, negative-going pulses. These pulses are spaced by a time interval  $T_1$ . Now,  $T_2$  is controlled by the capacitor under test. Specifically,  $T_2$  is equal to  $k_1 C$ , where  $k_1$  is just a constant of proportionality. At the monostable's output, there is a rectangular waveform that is high for a time  $T_2$ , and low for a

time equal to  $(1 - T_2)$ . This waveform is then time-averaged to yield a meter current equal to  $(k_2 T_2) / T_1$ , where  $k_2$  is another constant of proportionality. Since  $T_2$  is equal to  $k_1 C$ , it follows that meter current  $I_m$  must also equal  $(k_1 k_2 C) / T_1$ . Therefore, there is a direct relationship between meter deflection and capacitance; by choosing the right values for  $k_1$ ,  $k_2$  and  $T_1$ , you get a capacitance readout.

The Count's various constants have been chosen to allow a useful measurement range that spans from less than 100 picofarads to 5000 nanofarads (5 microfarads). In case you are unfamiliar with the above nomenclature, one microfarad is one-millionth of a farad, the standard unit



**Count Capacita's circuit is driven by a free-running oscillator that generates short-duration, negative-going pulses. The pulses are spaced by a time interval  $T_2$  controlled by the capacitor being tested. The waveform is averaged to yield a meter current that changes with varying capacitance moving the meter's pointer to the value.**

# CAPACITA

of capacitance. It takes a thousand picofarads to equal one nanofarad, and a thousand nanofarads to equal one microfarad. The scales on this meter measure capacitance in terms of picofarads and nanofarads; with the above information, you should be able to easily convert between units when necessary.

Let's now consider the schematic diagram. Assume that switch S2 is in its *battery* position and that S3 is pressed down. Battery current will flow into meter M1 through resistor R2, and M1's deflection will indicate whether or not the batteries are good. Fresh batteries will provide a meter indication of about "45"; batteries should be changed when the indication drops below "33", or thereabouts. Now, flip S2 mentally back to its *capacitance* position, and let's proceed with the rest of the circuit.

Battery current flows through resistor R1 to yield a regulated 6.2-volt supply potential across zener diode D1. Capacitors C1 and C2 bypass the supply and stabilize the circuit. The free-running oscillator is composed of uni-junction transistor Q1 plus associated components. Timing capacitor C5 is charged through R13 and R14, or R15 and R16, depending on the setting of range switch S1. When the voltage on C5 reaches a specific level, Q1's emitter breaks down to a low impedance, thus discharging C5 through resistor R11. When the capacitor has been discharged to a sufficiently low level, Q1 ceases to conduct, and C5 once again

begins to charge. This charging and discharging of C5 proceeds alternately, causing a voltage spike to appear across R11 each time C5 discharges. Transistor Q2 inverts and amplifies the pulse, which is applied to the inputs (pins 2 and 4) of monostable IC1.

The monostable's period is determined by the capacitor under test in conjunction with a resistor—either R5, R6, R7 or R8—selected by range switch S1. In operation, the capacitor being tested first gets connected across a pair of binding posts, and then S3 is pressed to take a reading. You will note that these binding posts are polarized, with BP1 being positive and BP2 (which connects to ground) being negative. This is an important consideration with polarized capacitors such as aluminum and tantalum electrolytics; the capacitor's positive terminal must connect to BP1. Reverse connection is harmful to such capacitors, so be careful. The standard non-polarized capacitors—mica, paper, mylar, polystyrene, ceramic and glass—may be connected across the binding posts in either direction.

Diode D2 functions to provide a quick discharge of the capacitor under test when S3 is released. Monostable IC1's output, pin 3, drives meter M1 through R3. Averaging of the pulses is accomplished by capacitor C3 across M1. Finally, diode D3 ensures that no current is emitted from IC1's output when it drops low (to about a tenth of a volt).

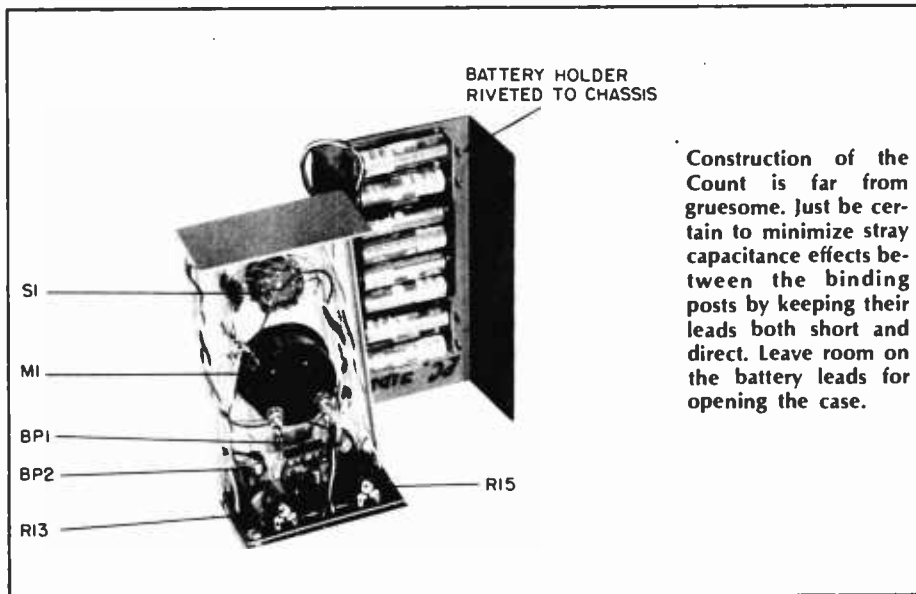
Since this is not a temperamental circuit, though the Count is a bit batty you should have few problems with its construction. One point that you should bear in mind, however, is that the binding posts must connect to

the rest of the circuitry via short and direct wires spaced at least an inch apart. This minimizes stray capacitance between the binding posts and maintains good accuracy on the lowest range (pf. X 10).

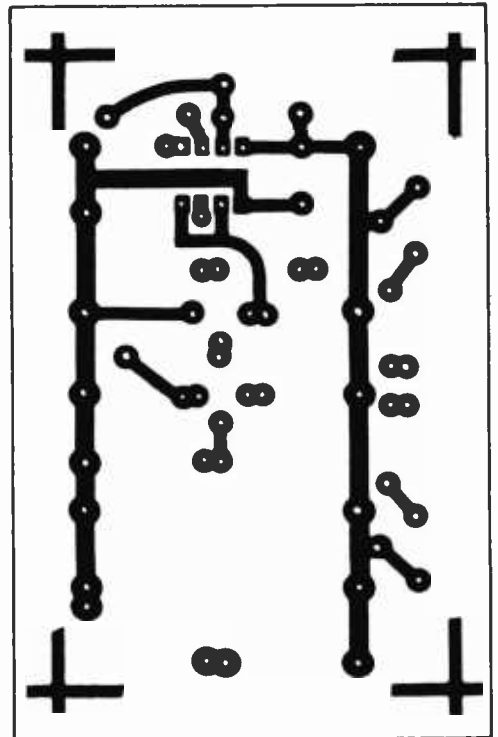
As specified in the parts list, resistors R2 and R3 must have 5% tolerances. Likewise, the tolerances of R5, R6, R7 and R8 must be at least 5 percent. If you desire, 1% precision resistors could be used for R5 through R8. This will improve accuracy somewhat on the four lowest ranges, but it will also be more expensive. You won't be needing hair-splitting precision, so 5%-tolerance resistors should be quite adequate here.

Although it might seem more difficult at first, printed-circuit construction is far and away the most convenient method of assembly. For your convenience, a PC foil pattern is provided elsewhere in this article, and it may be used in conjunction with a printed-circuit kit from any of the electronics retailers. An equally effective construction method involves the use of perf-board. Either technique is capable of turning out a small, neat circuit board.

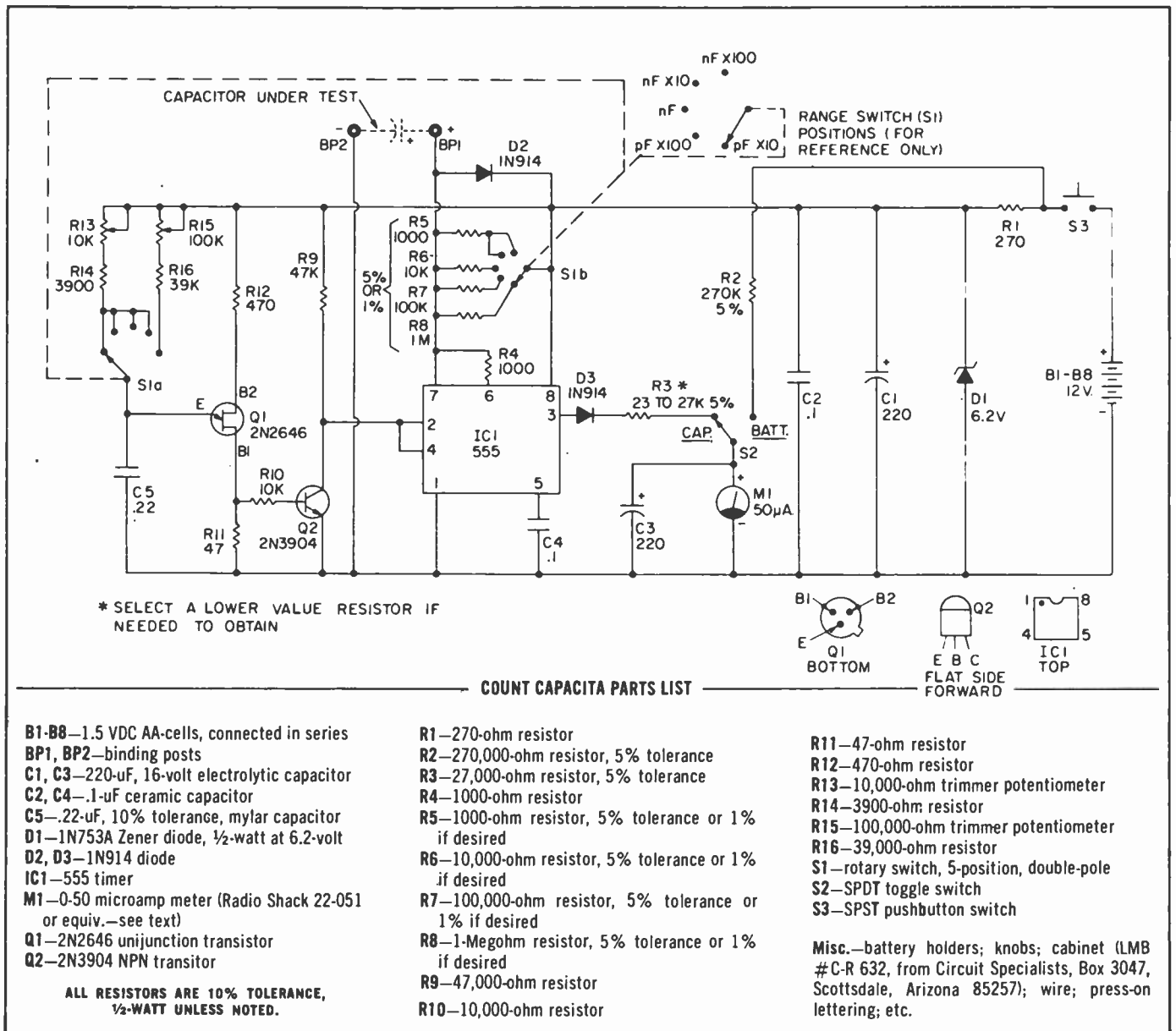
When wiring the circuit, be careful to install all polarized devices in the correct orientation. This applies to all the semiconductors, meter M1, the batteries, and electrolytic capacitors C1 and C3. Basing diagrams for all the semiconductors may be found elsewhere in the article. Lead identification



Construction of the Count is far from gruesome. Just be certain to minimize stray capacitance effects between the binding posts by keeping their leads both short and direct. Leave room on the battery leads for opening the case.



Here's your PC board template to bring the Count home to roost. Use either photo-etch materials or just use a resist marking pen.



for transistor Q1 applies specifically to a 2N2646. If you use a Radio Shack RS2029 for Q1, note that it uses a different lead orientation, which is clearly illustrated on the package in which it is sold. Though their lead orientations are different, these two transistors are electrically equivalent and interchangeable.

Although it is not absolutely necessary, the use of a socket is advisable for IC1, especially if you haven't had much experience soldering integrated circuits. The socket, as well as most of the other components in the parts list, is available at Radio Shack. Two of the components, S1 and the case, may be purchased by mail from Circuit Specialists (see the parts list for their address). Circuit Specialists carry a tremendous assortment of electronic devices, and they cater to the experi-

menter by not imposing a large handling charge on small orders. You can obtain their catalog by writing to the address in the parts list.

**Under the Lid.** During construction, do not substitute for meter M1 unless the device you intend to use has a full-scale sensitivity of 50 microamps and an internal resistance of about 1500 ohms. As usual, you should make all connections with a 25-watt iron and resin-core solder. When wiring S1, make sure that the rotor of S1b engages R8 in the fully CCW position, and R5 in the CW position. Also, S1a's rotor must contact R16 when fully clockwise, and R14 in all other positions. You may then label S1 according to the diagrams provided here, with the lowest range in the extreme CCW position. Finally, be certain to label BP1 with a "+" and BP2

with a "-".

When construction is complete, there are two calibration adjustments that must be made. In order to make these adjustments, you will need two accurate reference capacitors. The first, which will be used to calibrate the highest range, should have a value between 2 and 5 microfarads—the higher the better. Commonly available capacitors in this range are generally mylar or electrolytic. The mylar is your best choice; pick a unit with the tightest tolerance you can find. In this capacitance range, that means about  $\pm 10\%$ —sometimes better. If you must go with an electrolytic, choose a tantalum device and avoid the aluminum electrolytics, which tend to be leaky and have poor tolerances. Common tolerances for tantalums run about  $\pm 20\%$ , so you can see why the mylar is the better

# CAPACITA

choice.

For calibration of the lower four ranges you will need another reference capacitor; since calibration can take place on any of the four ranges, you have some leeway in your choice of a calibration capacitor for these lower ranges. One especially good choice is a 5000 picofarad polystyrene capacitor, available from just about all of the large electronics retailers. This particular capacitor is cheap but precise ( $\pm 5\%$  tolerance). The steps that follow will use this capacitor, but remember that you can use any capacitor as long as it is accurate and its nominal capacitance falls at the high end of one of the scales.

Begin calibration of the lower ranges by connecting the 5000 picofarad polystyrene capacitor to BP1 and BP2. Set trimmer R13 to the midpoint of its range of adjustment. Make sure that S2 is in its *capacitance* position, and that *range* switch S1 is set to PF. X 100. Press S3 and adjust trimmer R13 for a full-scale indication of "50" on M1. This completes calibration of all four lower ranges.

Calibration of the top range is similar to the above. Hook up your capacitor, and set R15 to its midpoint. Make sure that S2 is set to *capacitance*, and that S1 is fully clockwise. Press S3 and adjust trimmer R15 until your meter indication corresponds to your capacitor's marking. This finishes the cali-

bration.

Use of Count Capacita is fairly obvious; nevertheless, here are a few odds and ends that you might find helpful: The maximum voltage appearing across any capacitor under test is about 4.2 volts, which is well below the rated working voltage of almost any capacitor that you are likely to encounter. Because battery current drain is intermittent and moderate, the cells will last a long time—possibly for years. However, it might be a good idea to replace batteries once a year, even if they indicate more than "33", in order to prevent the possibility of a battery leak inside your meter.

Whenever you make a measurement, start on a range high enough to accommodate the capacitor being tested. If you have no idea of the capacitor's approximate value, always start on the highest range. Should a capacitor be opened up internally, it will provide a reading of zero on all scales.

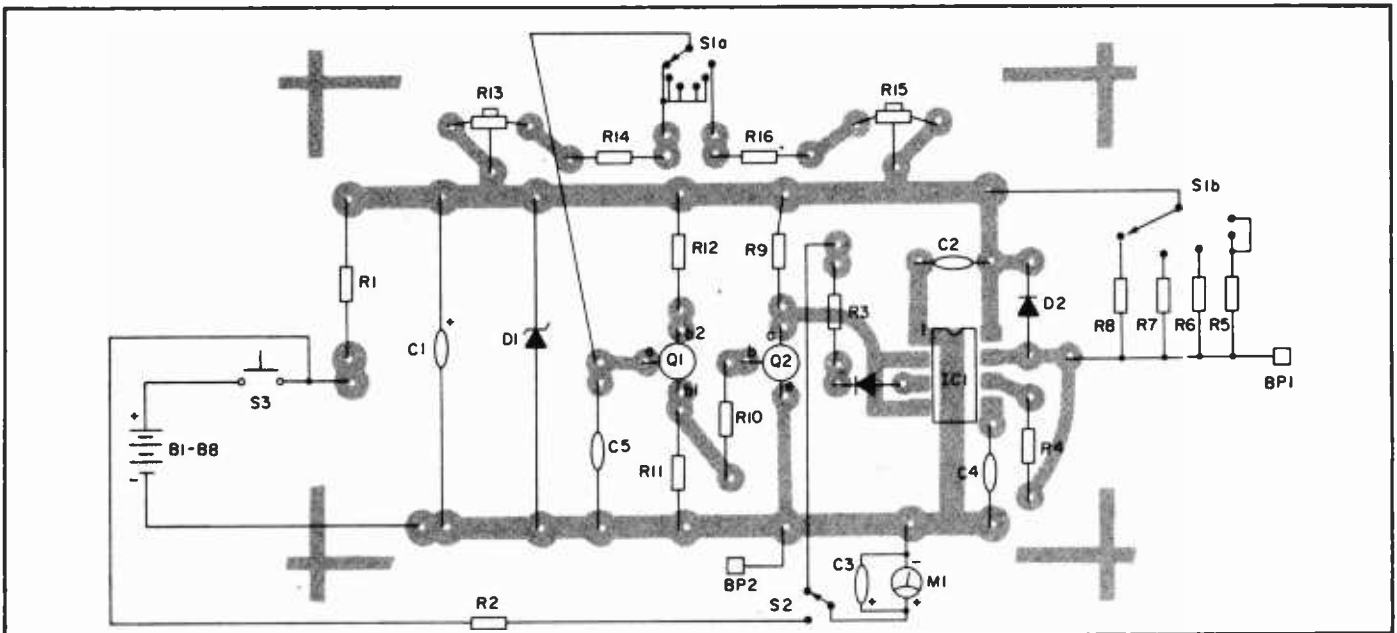
If the capacitor is leaky, its measured capacitance will be considerably larger than the value stamped on its case. This is because capacitor leakage is equivalent to having a resistor in parallel with the capacitor. This leakage resistance siphons off capacitor current, so the capacitor takes longer to charge, and monostable IC1's output stays high for a longer time. The result is an erroneously high capacitance reading. By the same token, you can expect an internally shorted capacitor to pin the meter's needle on all scales, since a short is, in effect, just a case of complete leakage.

Now, let's return to an important

topic that was introduced earlier; stray capacitance between the binding posts. The construction details already presented should help to keep strays at a minimum; however, you can never completely eliminate stray capacitance or the errors it may cause. Fortunately, it is very simple to compensate for such errors.

After your meter is calibrated, turn to the most sensitive range: Picofarads x 10. This is where the effects of stray capacitance will show up. Without any external capacitor between the binding posts, press the pushbutton and note meter M1's indication. On the prototype, a reading of 30 picofarads was obtained. This represents the value of the stray capacitance in parallel with any capacitor under test. It also represents the amount by which any capacitance reading will be in error. To compensate, simply subtract the residual capacitance from any given meter reading. For example, a reading of 480 pf. on the prototype meter would be corrected to 450 pf. (480 pf. minus 30 pf.). Such corrections are significant and necessary only on the most sensitive scale. Finally, since stray capacitance can obviously affect accuracy on the most sensitive scale, it is preferable that you *not* calibrate there, but on one of the higher scales, as outlined previously.

So, on the next dark night, why not sit yourself down and, to the strains of some Transylvanian music, acquaint yourself with the inner workings of our Count Capacita? You have nothing to lose but your fear—fear of choosing the wrong capacitor! ■



Take your mind off those eerie noises from off the moors by building our sanguine Count. Here's where the components lie. The Count will bring back to life all of those once-useless, unmarked capacitors once doomed to a junkbox graveyard!



**W**hen working with various electronic projects, it's easy to get carried away with too many current-eating components, which can overload a power supply. Our Smart Power Supply solves this problem with its built-in LED ammeter, which always tells you what the current draw is.

The supply delivers a regulated 5 and 8-volt output at up to 1-amp, and you'll never be in the dark as to how much current is being drawn. 4 LEDs display the amount of current being utilized by the load. Each LED lights respectively to show the level of current being drawn. For example, if  $\frac{3}{4}$  of an amp (.75) is being used, the first three LEDs (".25", ".50", and ".75") will all glow to show that a current of at least  $\frac{3}{4}$  of an amp is flowing. Best of all, the current measuring resistance is an unprecedented 0.1-ohm! What's more, the cost for the ammeter portion of the circuit is only about \$5. That's way less than you'd pay for a good mechanical meter.

The 5-volt output is ideal for all of your TTL IC projects, while the 8-volt output may be selected for CMOS circuits, and other, higher-power requirements. The total cost for the whole supply, including the bargraph ammeter, is about \$15-20, depending on your buying habits, and choice of parts suppliers.

**How it Works.** IC4 is supplied by an accurate reference voltage of 5-volts by IC3. IC4 is a quad op amp used in a quad comparator configuration.

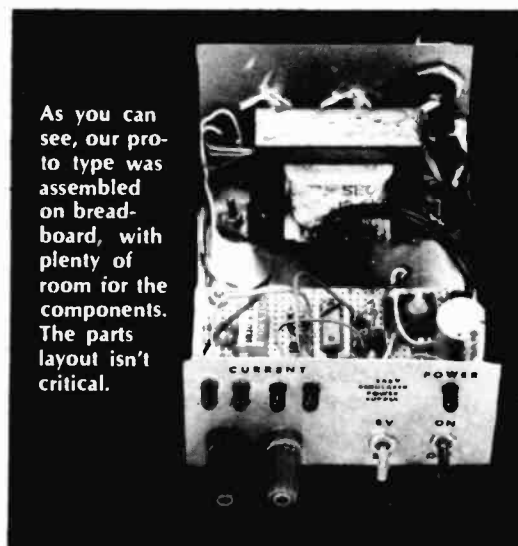
The 4 op amps (comparators) in IC4 are each fed a separate reference voltage by the divider network made up of R1-R4 and R5-R8. These comparators in IC 4 are very sensitive, and they can detect extremely small voltage differences and compare them.

Let's take the first op amp comparator as an example. Its inputs are pins 2 and 3, and its output is pin 1. The reference voltage appearing at pin 3 is compared to the voltage coming into the first comparator at pin 2. When  $\frac{1}{4}$  of an amp or more is flowing thru R10, .025-volts or more (0.1-ohms times  $0.25A = .025V$ ) appears across R10, which is enough voltage to equal pin 3's reference voltage, thus turning on the first op amp. The output of this op amp is at pin 1, so LED1 turns on to signify that at least  $\frac{1}{4}$  of an amp is being drawn. In a like manner, the other LEDs turn on or off with the changing current. The rest of the circuitry makes up a basic voltage-regulated power supply.

**Construction.** All of the circuitry, except ICs 1 and 2, can be mounted on a small piece of perfboard. These two ICs must be mounted to the cabinet. In operation, IC1 and IC2 will get hot

when the supply is run at higher currents, and they may shut down if the heat is not carried away. The back of the cabinet is the best place to mount ICs 1 and 2, for it allows a large heat dissipating area, while keeping the rest of the cabinet cool to the touch. When mounting ICs 1 and 2, smear heatsink grease between the IC cases and the cabinet, then bolt the ICs down tightly. Connect three long wires to IC1 and 2. These will be connected to the main circuit board later.

If the transformer that you wish to use has a center tap, cut it off or tuck it away. You won't need it. Bolt T1 down to the cabinet. Use heavy gauge (#16) wire for all line voltage connections, and carefully wrap all AC line connections with electrical tape. Use a



As you can see, our pro-to type was assembled on bread-board, with plenty of room for the components. The parts layout isn't critical.

# The Smart Power Supply

by Bob Powers

Keeps tabs automatically on current and voltage levels



# Smart Power

grommet around the line cord exit hole in the chassis to protect the cord from the heat that will be there due to ICs 1 and 2. Tie a knot in the line cord just inside the cabinet hole to prevent it from being pulled out.

IC3, unlike ICs 1 and 2, can be mounted on the perf-board because it will not get hot in operation. You should use a 14-pin socket for IC4. In-

stall IC4 only after all of your wiring to the socket is complete.

Be careful not to make any solder "bridges" between socket pins, as they are close together. When you install IC 4 in its socket, make sure that you observe the correct orientation with regard to pin 1.

After you've installed the circuit board, attach the wires from ICs 1 and 2 to their proper places on the board. Connect the wires to the display LEDs last, and make sure that you observe polarity on each LED. Be careful not

to let the LED leads short against the metal cabinet.

**Operation.** Carefully inspect your wiring on the circuit board, especially the wiring to IC4's pins. This is a very important step, as one misplaced wire here can produce some real odd-ball systems. If everything appears to be in order, turn the unit on. The "power" LED (LED5) should glow.

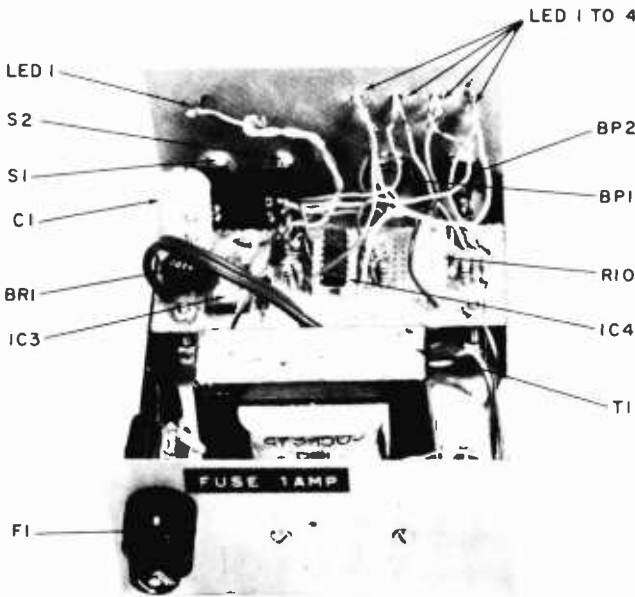
Connect a voltmeter to the output jacks. Depending on what position switch S2 is in, the voltmeter will read 5 or 8 volts. Throwing S2 to its other position should cause the voltmeter to read the other of the two voltages that the supply delivers.

To test the ammeter section, connect a circuit to the output jacks. With the supply set for 5-volts, a TTL IC circuit would be good for this test.

If the circuit that you hooked up draws more than ¼ amp, then one or more of the display LEDs will go on to show you how much current is being drawn.

**Conclusion.** You shouldn't worry about overloading the power supply, as fuse F1 will limit current draw to a peak of about 1.3-amps momentarily, before acting, and we deliberately overloaded several times in a row, with no damage occurring to the circuitry.

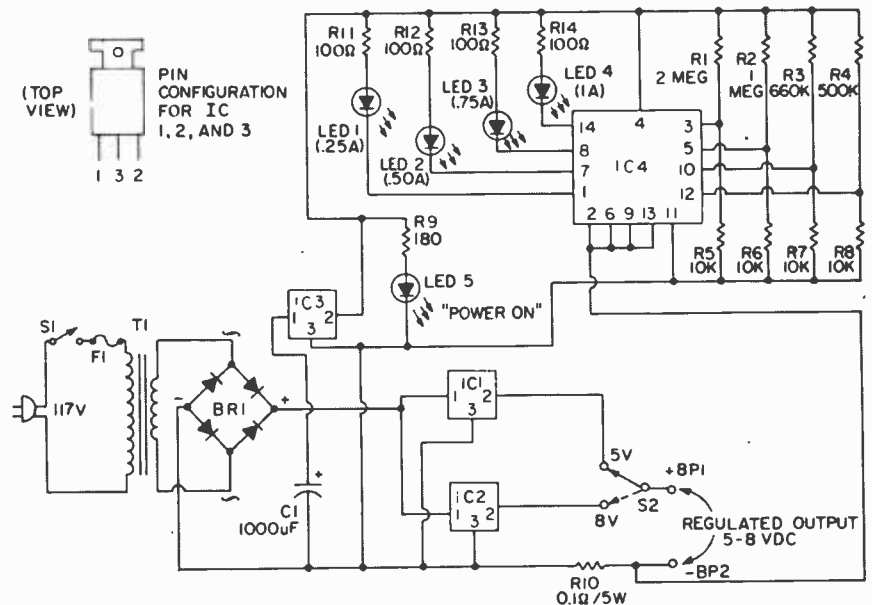
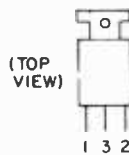
You might wish to attach a solderless breadboard to the top of the cabinet, to act as a permanently-powered breadboard for your experiments, or to construct an output voltage switcher for powering several projects alternately. ■



Again, parts layout is not critical in this power supply, but feel free to use our idea of where things should go. It's always a good general design idea to keep the power transformer as far away from the rest of the circuitry as cabinet size or practicality permits. Suspend the board above chassis.

## PARTS LIST FOR THE SMART POWER SUPPLY

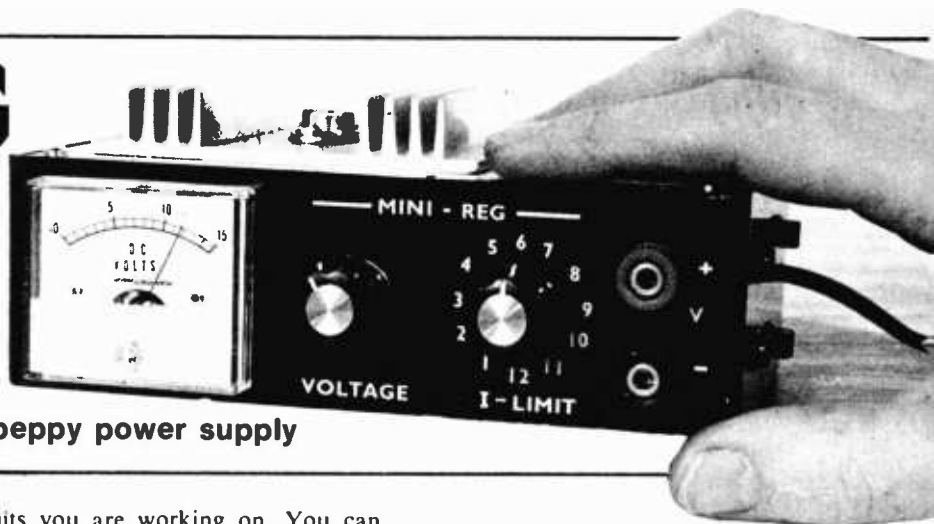
- BP1, BP2—5-way insulated binding post
- BR1—bridge rectifier rated @ 50 PIV 2-Amperes
- C1—1,000- $\mu$ F, 24-VDC electrolytic capacitor
- F1—3AG 1-Amp fuse
- IC1, IC3—7805 linear voltage regulator
- IC2—7808 linear voltage regulator
- IC4—LM324N quad op amp
- LED1 through LED5—large, red LED rated @ 20 mA.
- R1—2,000,000-ohm, ¼-watt resistor
- R2—1,000,000-ohm, ¼-watt resistor
- R3—660,000-ohm, ¼-watt resistor
- R4—500,000-ohm, ¼-watt resistor
- R5, R6, R7, R8—10,000-ohm ¼-watt resistor
- R9—180-ohm, ¼-watt resistor
- R10—0.1-ohm, 5-watt resistor (Radio Shack #271-128)
- R11, R12, R13, R14—100-ohm, ¼-watt resistor
- S1—SPST switch
- S2—SPDT switch
- T1—transformer with primary rated @ 120-VAC/secondary @ 12.6-VAC, 2-Amperes



# MINI-REG

## the regulated IC Power Supply

Keep your projects cool,  
calm and under control with this peppy power supply



**H**ERE'S A LOW-COST precision regulated DC power supply which is sure to be a welcome addition to any workbench—provided some family member doesn't appropriate the power supply for use as a universal AC adaptor! Compactly assembled in an eye-catching low profile, the Mini-Reg is continuously adjustable from 3.4 volts to 15 volts DC and delivers up to 500 milliamperes, enough for just about any job. Using the HEP C6049R precision monolithic IC regulator, the Mini-Reg effects 0.01% regulation with line voltage variations, 0.05% regulation for load variations, and its output impedance is a mere 35 milliohms. Short-circuit proofed, the Mini-Reg also features adjustable current limiting which greatly reduces the chances of damaging valuable components in the

circuits you are working on. You can also use the Mini-Reg as a constant-current source and recharge nicad batteries.

**Circuit Operation.** The HEP C6049R is actually a DC regulator within a regulator which accounts for its high performance. As shown in the block diagram, a very stable reference voltage ( $V_r$ ) is applied to the non-inverting or voltage follower input of an op-amp which serves as the first regulator and DC level shift amplifier. The output voltage of this stage can be varied from 3.4 volts to 15 volts by varying pot R11. This voltage is applied to the non-inverting input of the second op-amp which is capable of supplying up to 5000 milliamperes current to the load. This stage has unity voltage gain wherein V-out follows the input voltage to this stage. This double regulator arrangement fully isolates the DC level shift amplifier and results in very close regulation. Capacitor C4 provides frequency compensation and precludes possible circuit oscillation.

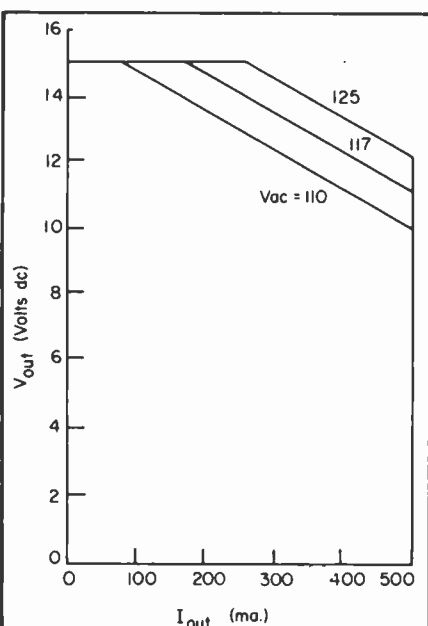
External components consisting of transistor Q1 and selectable resistor  $R_{sc}$  provide constant-current limiting should the supply be short-circuited. When the load current passing through  $R_{sc}$  becomes sufficiently high, the base of Q1 becomes forward biased causing Q1 to

conduct. When Q1 conducts, the voltage regulator delivers an essentially constant current to the load at a level depending on the value of  $R_{sc}$ . In the schematic diagram, resistor R3 places a minimum load on the regulator. Switch S3 selects the desired current limit. Jacks J1 and J2 permit insertion of a milliammeter to read load current but without impairing regulation. Diode D2 provides meter protection and diode D1 provides reverse voltage protection.

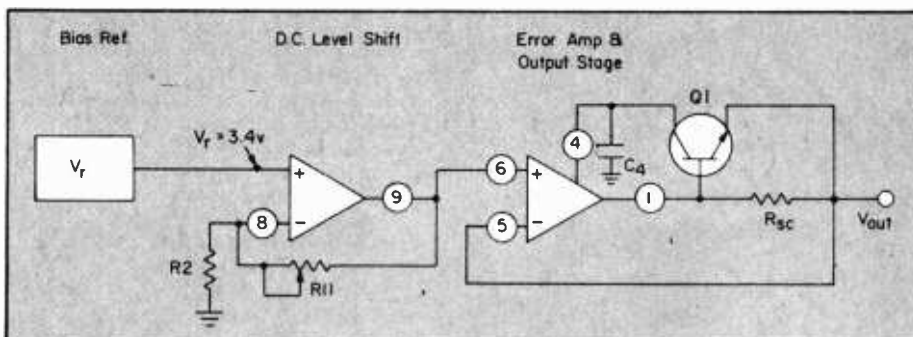
**Construction.** Assemble the Mini-Reg in an aluminum case or in a plastic case with aluminum cover plate. Select a case which will accommodate the particular meter and transformer you plan to use. Plan the layout allowing room for the PC board assembly when the cover plate is secured.

Begin by laying out and drilling mounting holes for IC1 in the heatsink. Drill a 7/16-inch-diameter hole in the heatsink to pass the lead wires of IC1. File off drill burrs and ridges so that IC1 mates perfectly on the heatsink. Drill matching holes in the cover plate. For ventilation, drill a number of holes in the cover plate and on the bottom of the case.

Make the PC board using the circuit pattern shown, taking care to locate



This chart shows the operating range of the Mini-Reg at various line voltages. The full 15 VDC is only available at lower currents, but few IC projects ever require that much voltage or current supply.



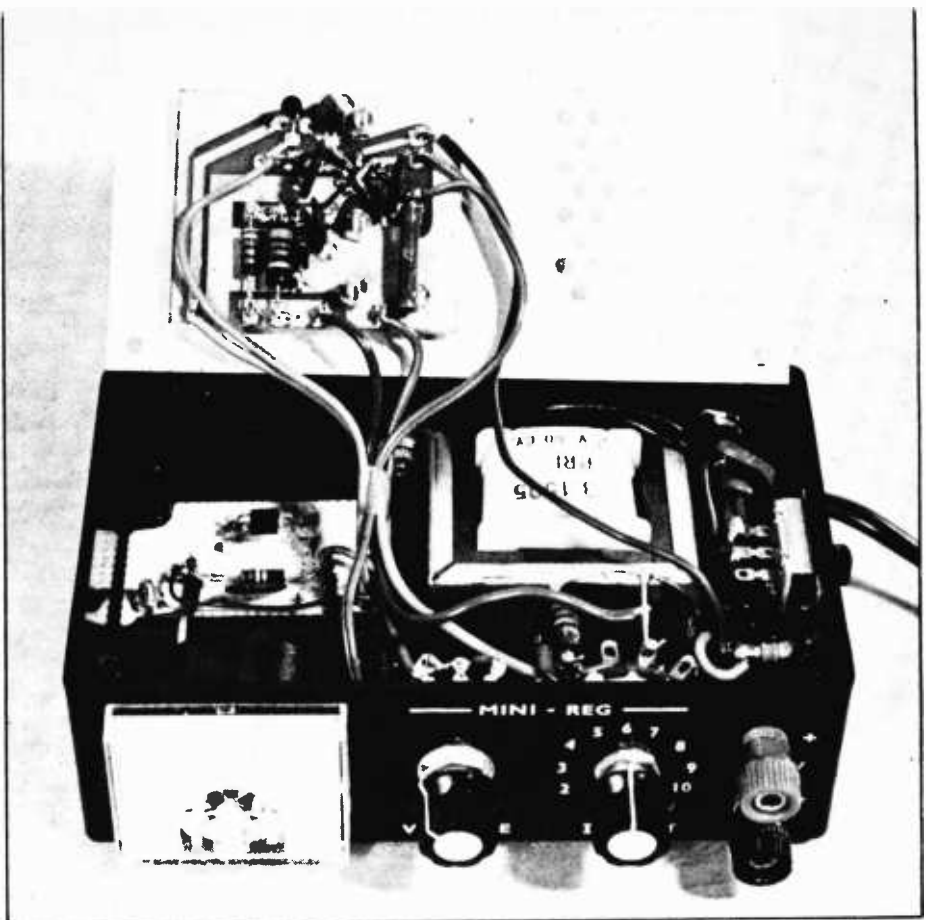
This is a simplified block diagram of the C6049R regulator chip—the heart of the Mini-Reg power supply. Thanks to such ICs construction projects are easy to build.

# MINI-REG

pads for IC1 just right. Push IC1 into the drilled board and mark and drill the mounting holes. For easier mating, countersink the lead holes for IC1 on the insulation side of the board by twirling a small drill bit.

Install and solder the jumper on the insulation side of the board and install and solder T42-1 micro-clips (Vector) on the copper side at all resistor and board take-off terminals. Clip a small heatsink (Radio Shack 276-001) on the leads of Q1 when soldering. Install remaining circuit board components excepting trim resistor R5. Using 6-32 machine screws, bolt IC1 and the heatsink to the cover plate. Place a lock washer and two 6-32 nuts on each mounting bolt. *Omit the mica washer between IC1 and the heatsink* and apply a bit of silicone heatsink grease between IC1 and the heatsink. Coil a ¼-by 1½-inch strip of fishpaper insulation and slip it down into the hole in the cover plate around the IC lead wires. Push the PC board assembly down on the mounting screws and mate with the protruding IC leads and secure. If you can't install the assembly, look for bent pins or reversed installation of IC1.

Install switches S1 and S2 along with jacks J1 and J2 on the left side of the case. Install diode D2 and capacitor C7 on switches S2. Secure two solder lugs on each binding post and install diode D1 and capacitor C6 on the binding posts. Pass the AC line cord through the left side of the case and knot the cord for strain relief. Install resistors R6 thru R10 on switch S1. Depending on the base-emitter characteristics of Q1, the specified values of current limit resistors R6 through R10 may differ somewhat in your power supply. This is why trim resistor R5 was included to properly trim the 500 mA current



Internal view of the Mini-Reg. The circuit board is positioned so that it doesn't come in contact with the meter and transformer. The case is perforated for ventilation. You can see the tiny, square HEP 176 rectifier on the small circuit board in the bottom of the case.

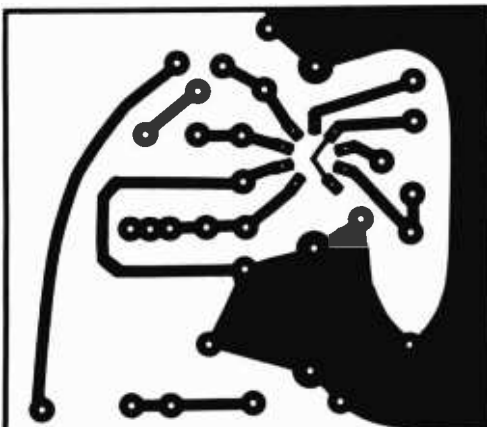
limit. For this reason, you may defer installation of resistors R6 thru R9 but *do* install resistor R10.

Place RECT-1, R1, C5, and C8 on a small piece of perfboard and situate this sub-assembly behind the meter. Connect meter M1 directly to binding posts BP1 and BP2. Use #20 stranded wire for connections to the PC board. Connect a wire from board pin G to BP2. Run a wire from board pin E to the rotor lug of S3. Connect a wire from board pin D to resistors on S3. Run a wire from board pin F directly to BP1. Run a pair of wires from pot R11 to board pins B and C. Connect a wire from *V-in minus* directly to BP2. Do not make the connection from *V-in*

*plus* to board pin A at this time. You may omit the double-fused plug and provide but one fuse in the primary side of transformer T1. Carefully check all wiring and solder connections.

**Checking It Out.** We intentionally deferred installation of several components and some wiring, so that you can perform a few simple tests which preclude damage to circuit components. Connect a voltmeter across R1 and verify that *V-in plus* is nineteen volts DC. Connect a milliammeter and 100-ohm resistor in series from *V-in plus* to board pin A. Set S3 to pick up R10 and set R11 to minimum resistance. Turn S1 on and observe about five milliamperes current on the milliammeter and 3.4 volts on meter M1. Advance R11 and observe a voltage increase up to fifteen volts DC. If the output voltage is less than fifteen volts, the value of R11 may be too small or R2 may be too large. Having verified the above, you may now install the wire from *V-in plus* to PC board pin A.

Plug the milliammeter into jacks J1 and J2 and open S2 (Meter In). Adjust R11 for ten volts output and set S3 to ten milliamperes current limit. Then, connect a 500-ohm ½-watt resistor across the output terminals. If current limiting action is taking place, the milliammeter should indicate roughly ten milliamperes and the output voltage

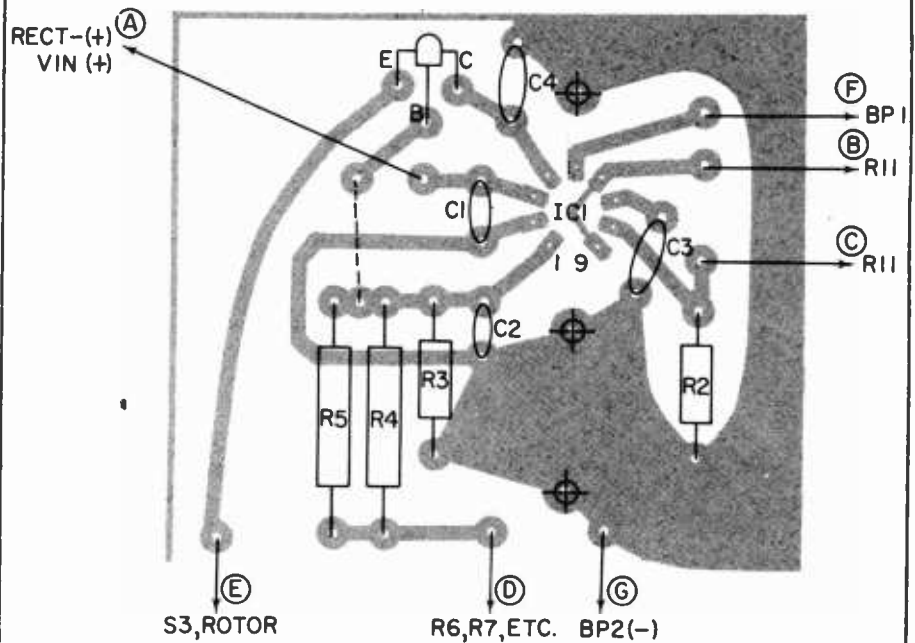


This is an exact-scale printed circuit board pattern showing the foil side of the board. This side contrary to normal, is, where the components are to be mounted. Only the jumper and the IC chip are mounted on the other side. Be careful to keep the foil-side component bodies off the metal surface to avoid shorts. Be especially careful with resistors R4 and R5 and capacitor C3.

should drop to about five volts. If much higher values are observed, current limiting is not taking place. Look for a defective or improperly installed Q1. If your current limit is, say, seven milliamperes, you can bring it up to ten by using a smaller value for R10 or by connecting a suitably larger value resistor across R10.

Only after you have verified current limiting action at low current, set S3 to pick up R4 (500 ma setting) and set the VOM accordingly. You will need either a 50-ohm 10-watt rheostat or adjustable power resistor to gradually load the supply. Or, you can use a number of small-valued power resistors. Set the rheostat to maximum resistance and connect it across the output terminals. Gradually reduce load resistance while observing output voltage and current. Current limiting should occur at below 500 ma. To increase the limit to 500 milliamperes, select and install a suitable resistor for R5. Proceed similarly to size or trim resistors R6 thru R10. You can easily include other current limits in the spare positions on S3 to match the charging currents of your nicad batteries. Do not exceed 500 milliamperes or IC1 will be damaged.

**Application.** The operating range of

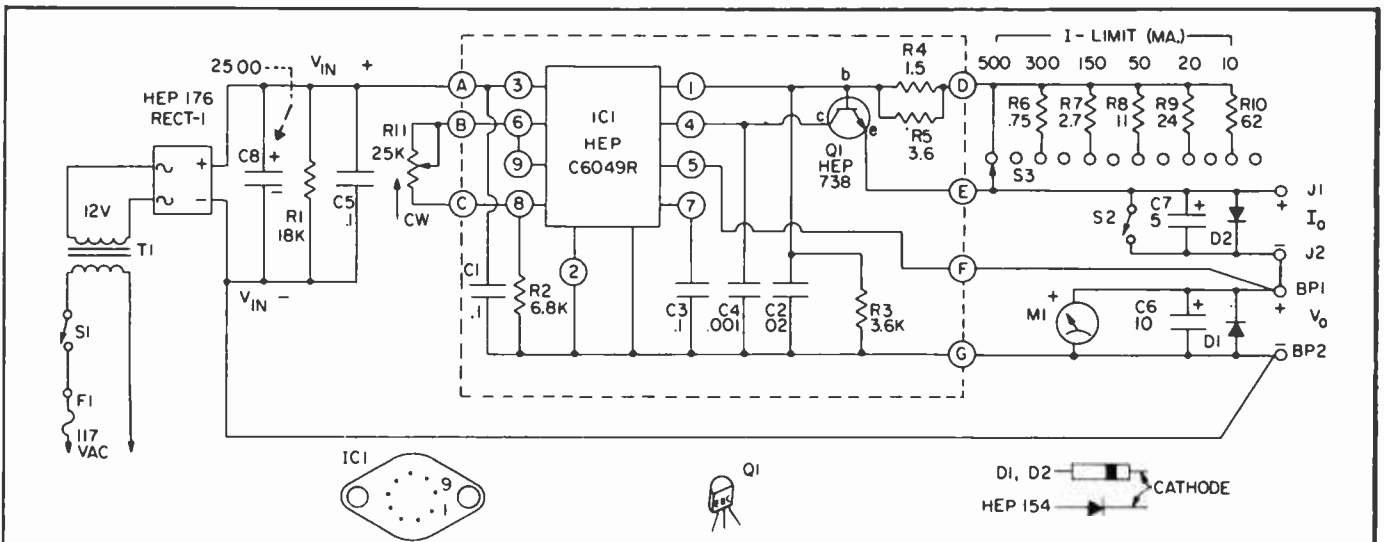


The parts should be placed according to this diagram. Note the location of the three drill holes for securing the IC and the board to the chassis. Locate the IC mounting holes very carefully so that everything mates snugly. This will help keep the chip cool.

the Mini-Reg for several line voltages is shown. The supply "drop-out" shown in the upper right hand corner of this chart is due to an insufficient difference between V-in plus and V-out which in turn depends on transformer T1 volt-

age. When you are not using a meter at jacks J1 and J2, close S2.

The adjustable current limiting feature of the Mini-Reg greatly reduces the chances of damaging circuit components of the circuit powered by the supply.



#### PARTS LIST FOR MINI-REG

BP1, BP2—binding posts, red, black  
 C1, C3, C5—0.1-µF 25-VDC capacitor, ceramic  
 C2—0.02-µF 25-VDC capacitor, ceramic  
 C4—0.001-µF 25-VDC capacitor, ceramic  
 C6—10-µF 25-VDC electrolytic capacitor  
 C7—5-µF 25-VDC electrolytic capacitor  
 C8—2500-µF 25-VDC electrolytic capacitor  
 D1, D2—1-Amp 50 PIV silicon rectifier diode, HEP 154  
 F1—½-Amp fuse  
 IC1—HEP C6049R voltage regulator  
 J1, J2—insulated phone tip jacks, red, black  
 M1—0-15 VDC miniature DC voltmeter  
 Q1—HEP 738 transistor

R1—18,000-ohm, ½-watt resistor  
 R2—6800-ohm, ½-watt resistor  
 R3—3600-ohm, ½-watt resistor  
 R4—1.5-ohm, 2-watt wire-wound resistor, IRC type BWH  
 R5—3.6-ohm, ½-watt resistor  
 R6—0.75-ohm, 2-watt wire-wound resistor, IRC type BWH  
 R7—2.7-ohm, 2-watt wire-wound resistor, IRC type BWH  
 R8—11-ohm, 1-watt resistor  
 R9—24-ohm, 1-watt resistor  
 R10—62-ohm, 1-watt resistor  
 R11—25,000-ohm linear taper potentiometer

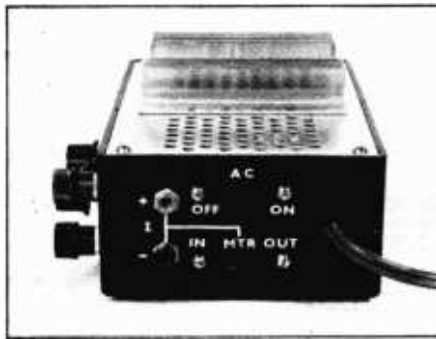
RECT-1—HEP 176 1-amp, 200-PIV bridge rectifier.  
 S1, S2—SPST slide switch  
 S3—1-pole, 12-position switch, non-shorting (Mallory 32112J or equiv.)  
 T1—12-volt, 1.2-ampere filament transformer  
 Misc.—Plastic case with aluminum top, 6¼ x 3¼ x 2 inches; heat sink, 3 x 3½ inches, (Allied Electronics 957-2840 or equiv.); T42-1 micro-clips (Vector); AC line cord; fused cord plug or fuseholder; perforated board; copper clad board; rubber feet (4); hardware, etc.

# MINI-REG

Suppose you are experimenting with a transistorized circuit drawing five milliamperes at five volts. You would then set S2 to ten milliamperes. At these settings, the maximum power the supply can deliver is but a mere fifty milliwatts.

If you plug a transistor in backwards, the most it can draw is fifty milliwatts, probably much less; hence, the device will survive the error. However, certain semiconductors can be damaged with but microwatts of power. Nevertheless, you are far better off using current limiting supplies. If your experimental circuit draws 400 milliamperes at five volts, set S3 to 500 milliamperes limiting the power to 2.5 watts. This power level is more than enough to zap many devices if you make an error. If you have another five volt supply, split the circuit supply lines and protect those devices you cannot spare with the Mini-Reg.

Almost any circuit operating off three volts can safely operate at 3.4 volts. The output voltage can be further reduced by connecting a low-voltage zener diode in series with the plus lead to the



The AC line switch, current jacks and current meter switch are on the end of the case.

load and monitoring the load voltage with a voltmeter. In this case, load voltage regulation now depends on zener diode characteristics.

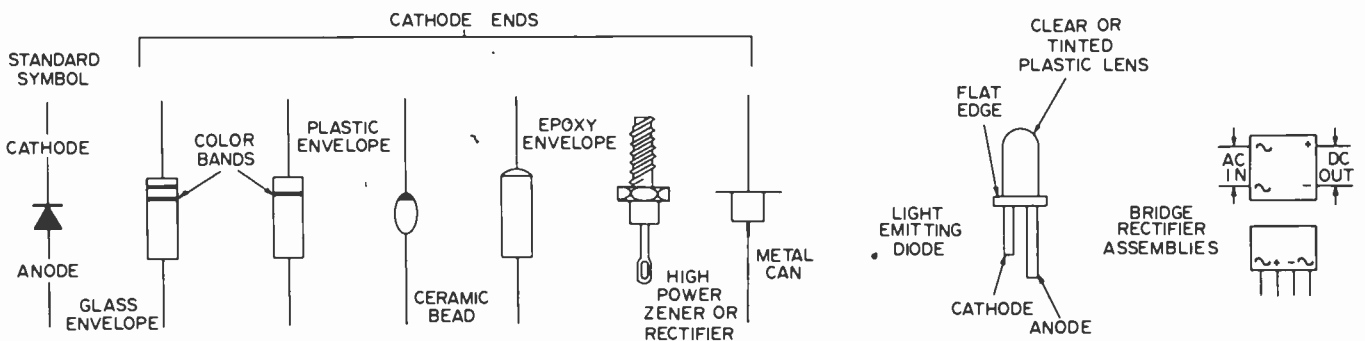
When recharging batteries with the Mini-Reg, connect a silicon rectifier diode in series with the plus lead going to the battery. This eliminates "back-leak" when the supply is turned off with battery yet connected. Observe battery polarity when making connections. Circuits using op-amps usually require a dual or split supply. To provide a dual six-volt supply, set the output voltage to fifteen volts, set S3 to 100 milliamperes, and connect two six-volt zener diodes in series across the output terminals. Then, connect a 100

uF 25V electrolytic capacitor across each zener diode.

The Mini-Reg handily checks and sorts zener diodes of fifteen volts or less. Set R11 for fifteen volts output and set S3 to ten milliamperes. Connect the diode across the output terminals with plus lead wire to BP1. Observe zener diode voltage on M1. Advance S3 to high currents but do not exceed rated current of the diode. The better the quality of the diode, the less increase in voltage observed on M1.

When you operate radio or audio equipment from the Mini-Reg, set S3 to a current level which supplies peak currents on audio peaks. Otherwise, you will notice audio distortion on audio peaks. With some radio and audio equipment, operations off an AC adaptor or the Mini-Reg may introduce an AC hum. Reversing the AC plug usually remedies the problem. If not, connect a ground wire to either the plus or minus terminal of the Mini-Reg, whichever proves most effective. In addition to its use as a universal AC adaptor, the Mini-Reg serves as an excellent power supply when servicing battery operated transistorized equipment. You'll wonder how you ever solved your power supply problems before you discovered Mini-Reg! ■

# DIODE DIGEST



IT MAY SOUND SILLY, but it seems that a lot of people still don't know which end of a diode is up. A letter we received recently from O.M.S. of Guilford, Connecticut illustrates this point. He writes:

*"I have been trying for the last three months to purchase a power supply that I can use to power a walky-talky from house current. I've finally given up and decided to build my own. I have a transformer that converts 110 VAC to 12.6 VAC, some large filter capacitors salvaged from an old television, and some 'bargain bag' diodes I purchased from a discount store. The diodes are black, unmarked, and have one rounded end. Can I use them,*

*or will I have to shell out for ones with known values?"*

Of course, we couldn't be sure of just exactly what he had in hand, but from the description, and basing our guess on the chart, we were pretty sure that these were epoxy-encapsulated rectifiers, with probably about a 100 to 200-PIV rating. These would fill his needs if our guess was right. Although we haven't heard any more from that gentleman, we assume he didn't blow himself up. By tearing out the chart and pasting it up inside the cover of your spare parts box, you can have a handy reference guide for identifying the leads and types of whatever diodes happen to find their way into your hands. ■



# The Fine Art of Buying Electronic Parts

by Walter Sikonowiz

**An inflation fighter's guide to buying components**

**A**SK A GROUP of electronics enthusiasts what the single most difficult part of project building is, and more often than not the reply will be, "Buying the #\$\$%&\* parts." Such an attitude is not unwarranted because, try as you may, you will never find one distributor capable of supplying all the parts you need. Even so, there is no reason for the incredible amount of difficulty experienced by some people.

If you're planning to build a particular group of projects at once or in a series, then it may be of help to plan in advance, and only have to make one or two parts orders by mail, or the same number of trips to the local parts stores. Buying in larger groups can also cut costs, because some houses give discounts for purchases of the same part in excess of five pieces. Your savings can

really add up if you exercise some prudence in shopping.

**The Big Four.** You start by collecting catalogs; the more the better. Ten will get you by, but twenty is not too large a figure. Begin with the Big 4: Burstein-Applebee (3199 Mercier St., Kansas City, Missouri, 64111), Radio Shack (everywhere), Allied (401 E. 8th St., Fort Worth, Texas, 76102), and Lafayette Electronics (PO Box 428, Syosset, New York, 11791). These are the general practitioners of electronics; they dispense a little of everything.

**The Specialists.** Once Ohm's Syndrome takes hold, however, and your sales resistance rises in the face of inflation (and limited selection), it's time to see a specialist. This might be any one of several firms selling certain

products, such as integrated circuits, and little else. Because of specialization, these companies can afford to have very complete inventories of selected merchandise. Furthermore, although you might expect a specialist to slap you with a fat fee, in most cases just the opposite will happen; you'll save money.

Who are these specialists? They are the mail-order businesses that advertise in the back pages of *ELEMENTARY ELECTRONICS* (as well as other publications). Some of these companies restrict themselves to new merchandise, which they sell at very agreeable rates because of low overhead. Others sell only surplus, that is, unused components obtained from manufacturers willing to sacrifice some inventory for ready cash. A component's appearance on the surplus market can be caused by a multitude of economic factors which are unfortunate for the manufacturer, but a windfall for you, the buyer.

**New or Surplus?** How can you tell whether merchandise is brand new or unused surplus? In many instances, the catalog will tell you. If not, there is one sure indication: If the merchandise is being sold for a fraction of the retail price you would expect to pay, it's surplus. Three firms that deal exclusively in surplus are Delta Electronics (PO Box 2, 7 Oakland St., Amesbury, Massachusetts, 01913), B&F Enterprises (119 Foster St., Peabody, Massachusetts, 01960), and John Meshna

# Parts

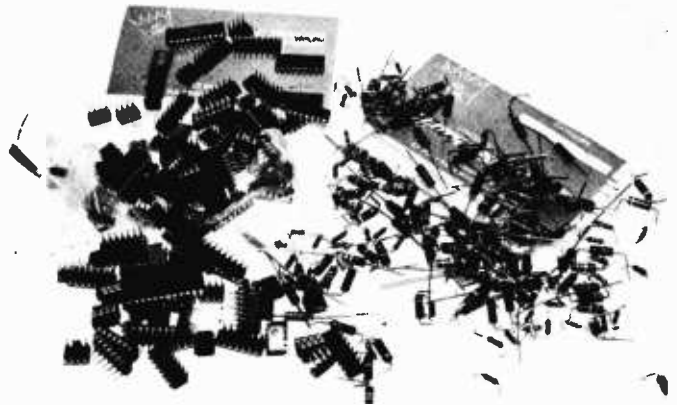
Inc. (PO Box 62, E. Lynn, Massachusetts, 01904). Others, like Poly Paks (PO Box 942, South Lynnfield, Mass., 01940), or Herbach & Rademan (401 E. Erie Ave., Philadelphia, Penn., 19134), offer a mixture of surplus and brand new stock. Regardless of whether the merchandise is new or surplus, all firms offer some guarantee of satisfaction.

In order to get better acquainted with the various suppliers, let's survey the market item-by-item. In the following paragraphs, whenever a specific company is mentioned in connection with a component, it is only because that firm is particularly strong in a certain area. Some degree of overlapping does exist among all firms, however, so don't assume that any one supplier is being recommended to the exclusion of all others.

**Integrated Circuits.** Although human life is based on the chemistry of carbon, it is the chemistry of silicon that now forms the basis for our business and industry, thanks to the integrated circuit. Because of their tremendous importance, integrated circuits are sold by almost every electronics supplier, big or small. You'll find that the Big 4 have quite respectable IC inventories, but prices are relatively high, and selection is not complete. Jameco Electronics (1021 Howard St., San Carlos, Calif., 94070), and Ancrona Corp. (PO Box 2208, Culver City, Calif., 90230) feature perhaps the widest selections of ICs; linear, TTL, CMOS, DTL, ECL, LSI and so forth. Jade Computer Products also offers a good selection of ICs in their catalog.

Circuit Specialists (PO Box 3047, Scottsdale, Ariz., 85257) is a nice company to do business with, since they require no minimum-size order. In addition to a wide range of the standard ICs, Circuit Specialists carries special numbers from RCA, Motorola, and

You can buy bulk components at next-to-nothing prices if you buy untested, surplus parts. Poly Paks is a popular bulk supplier and two of their packs are shown here. Most of the parts are useable.



Mostek. Digi-Key (PO Box 677, Thief River Falls, Minn., 56701) also features a wide assortment, including some circuits difficult to find elsewhere. Last, but not least, there is Solid State Sales (PO Box 74A, Somerville, Mass., 02143). Although this company's selection may be a trifle smaller than some, its service is like the fabled "greased lightning."

Occasionally, you are going to receive a dud. When this happens, it's best not to go berserk. A calm request for a replacement is usually accommodated very quickly. After all, these companies want your continued business in the future. As a precautionary measure, you might consider ordering two of each IC. The chances of getting one dud are so small that the probability of receiving two duds simultaneously is infinitesimal. You can use the extra IC, if it is good, in a future project.

Occasionally, the inevitable happens, and you will find yourself with an inoperative circuit. If you have any reason to suspect the IC as the culprit, either from poor handling technique, or from having eliminated any other possible causes, a spare IC will cure many late-night headaches caused by projects that have no good reason *not* to work. Try the new IC before you burn the schematic!

**Discrete Semiconductors.** This category is an exceptionally broad one. Included are: bipolar transistors, FETs,

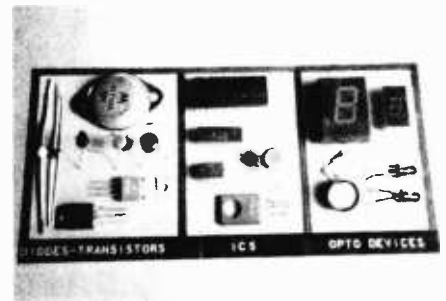
SCRs, diodes, UJTs and so on. As in the case of ICs, almost everyone sells some discrete semiconductors, but few vendors stock each part number. Before giving up an elusive part, try either Hanifin Electronics Corp. (P.O. Box 188, Bridgeport, PA 19405), or the Ancrona Corp. These two firms have perhaps the most extensive listings of discretes.

Most suppliers offer special discounts to encourage volume buying of parts. This appeals directly to the squirrelish instincts of the electronics hobbyist, but be careful. Just like that greedy little tree-dweller, you will probably hoard more than you can ever use. If you must stockpile parts, do it sensibly. Choose those discrete components that are most frequently used: 2N3906 PNP's, 2N3904 NPN's, 1N914 switching diodes, 1N4003 rectifiers and so forth. Avoid the high-wattage zener diodes now appearing in surplus. Today, integrated circuits have supplanted zeners as regulators at all but the lowest power levels.

**Resistors.** Buying from one of the larger retailers, you can expect to pay around 10 cents a piece for carbon-composition resistors. Compare that with the typical 4-cent selling price from the specialist firms, and the choice of a supplier is obvious. Resistors are one class of component that can be sensibly stockpiled. Buy half-watters with a 5% tolerance. They cost only a bit more than 10% resistors



Since a great many people have trouble remembering the color code, a useful aid to sorting surplus resistors is an old tie box with the color code marked inside the lid.



Try to build up a supply of transistors, diodes, ICs and electro-optical devices.



## ADDRESSES OF PARTS SUPPLIERS:

Ace Electronics, 5400 Mitchelldale  
Houston, TX 77092

Active Electronics Sales Corp.  
12 Merser Rd., Natick, MA 01701

ALdelco, 228 E. Babylon Tpk.  
Merrick, N.Y. 11566

Allied Electronics, 401 E. 8th St.  
Forth Worth, TX 76102

Ancrona Corp., P.O. Box 2208  
Culver City, CA 90230

B&F Enterprises, 119 Foster St.  
Peabody, MA 01960

Bullet Electronics, P.O. Box 1944  
Dallas, TX 75219

Burstein-Applebee, 3199 Merceir St.  
Kansas City, MO 64111

Calectro Products of GC Electronics  
Rockford, IL 61101

Chaney Electronics, P.O. Box 27038  
Denver, CO 80227

Circuit Specialists, P.O. Box 3047  
Scottsdale, AZ 85257

Delta Electronics, P.O. Box 2  
7 Oakland St., Amesbury, MA 01913

Diamondback Electronics Co.  
P.O. Box 194, Spring Valley, IL 61362

Digi-Key, P.O. Box 677  
Thief River Falls, MN 56701

Digital Research Corp.  
P.O. Box 401247B, Garland, TX 75010

Electronics Distributors, Inc.  
4900 N. Elston  
Chicago, IL 60630

ETCO Electronics, 521 Fifth Ave.  
New York, NY 10017

Formula International, Inc.  
12603 Crenshaw Blvd.  
Hawthorne, CA 90250

Fuji-Svea, P.O. Box 3375  
Torrance, CA 90510

Hanifin Electronics, P.O. Box 188  
Bridgeport, PA 19405

Herbach and Rademan, 401 E. Erie Ave.  
Philadelphia, PA 19134

HobbyWorld, 19355 Business  
Center Dr., Northridge, CA 19324

Integrated Electronics  
540 Weddell Dr., Sunnyvale, CA 94086

International Electronics Unlimited  
Village Square P.O. Box 449  
Carmel Valley, CA 93924

Jade Computer Products  
5351 W. 144th St.  
Lawndale, CA 90260

Jameco Electronics, 1021 Howard St.  
San Carlos, CA 94070

John Meshna, Inc., P.O. Box 62  
East Lynn, MA 01904

Lafayette Electronics, P.O. Box 428  
Syosset, NY 11791

Mouser Electronics,  
11511 Woodside Ave.  
Lakeside, CA 92040

New Tone Electronics, P.O. Box 1738  
Bloomfield, NJ 07003

Olson Electronics, 260 S. Forge St.  
Akron, OH 44327

Optoelectronics  
5821 N.E. 14th Avenue  
Fort Lauderdale, FL 33334

Poly Paks, P.O. Box 942  
South Lynnfield, MA 01904

Quest, P.O. Box 4430  
Santa Clara, CA 95054

Radio Hut, P.O. Box 401247  
Dallas, TX 75238

Radio Shack Consult your local  
phone book

Ramsey Electronics, P.O. Box 4072  
Rochester, NY 14610

Signal Transformer Co.,  
500 Bayview Ave.  
Inwood, NY 11696

Solid State Sales, P.O. Box 74A  
Somerville, MA 02143

Steven Products, P.O. Box 698  
Melville, NY 11746

Surplus Electronics Corp.  
7294 N.W. 54th St., Miami, FL 33166

and save you the trouble of stocking two tolerances.

Most construction projects are designed to utilize resistors with a tolerance of 10%, unless specified otherwise in the parts list.

Power resistors, with ratings from 5 to 100 watts, are available from the surplus dealers at incredible prices. Buy a small assortment. Power supplies and audio amps often need dummy loads during checkout, and for such purposes these high-power resistors are ideal. If you do not have exactly the right resistance at hand, use serial and parallel combinations whose net resistance is the desired value.

Don't forget those high-class resistors, the metal-film precision units with tolerances of 1% or better. You can get these from the larger retailers, but at 60 cents to one dollar apiece (often with a ten-piece minimum order) who needs them? Actually, for certain ultra-stable or low-noise circuits, precision resistors are mandatory. Active filters, accurate voltage dividers, and analog-computer circuits are but a few examples. When you really need precision resistors, Hanifin Electronics can sup-

ply them at about 15 cents each. But because Hanifin is an industrial supplier, do not send in a 75¢ order; fifteen dollars worth is a realistic minimum. Since Hanifin offers lots of goodies besides resistors, you should have no trouble putting together a good-sized order.

**Capacitors.** The best all-around capacitor that money can buy is the polystyrene type. It also happens to be one of the cheapest, a fortunate coincidence. Polystyrenes are available in the range from 5 pF to 0.5-uF, but above .01-uF, they begin to get bulky and expensive. Your best and most complete sources for these capacitors are Burstein-Applebee and Allied (addresses supplied previously). Standard tolerances are 5% (super for a capacitor), with 2.5% and 1% available at higher prices.

In the range from 0.01-uF to 1-uF, you are best off with mylar (polyester) capacitors. (Mylars are available outside this range, too.) Standard tolerances are 20% and 10%. A great many firms carry mylar capacitors.

Above 1-uF, most capacitors are aluminum electrolytics, which are polar-

ized devices. One of their most important functions is filtering, particularly in AC power supplies. Tolerances tend to be relatively loose since applications rarely call for very precise electrolytic capacitors. Capacitances as high as 40,000-uF and beyond are available.

The aluminum electrolytic has a more sophisticated cousin, the tantalum capacitor, which is commonly available in capacitances as high as several hundred microfarads. Relative to the aluminum electrolytic, the tantalum features tighter tolerances (10% typically), lower leakage, and smaller size for equivalent capacitance. As a result, tantalums are preferred over aluminum electrolytics in timing applications. Both electrolytic types are stocked by many distributors.

Surplus capacitors are available, with perhaps the best source being Poly Paks (see above), at least in terms of variety. If you do buy surplus capacitors, play it safe and check each one on a capacitance meter. Ceramic bypass capacitors for digital logic are available very cheaply as surplus, and so too are mylars. On the other hand,

# Parts

be very cautious when buying surplus aluminum electrolytic capacitors. They have a limited shelf life, and once they dry out, they are useless. Most dealers are scrupulous enough not to do this to you, but you can end up with a relic of the 1950's that looks more like an artillery shell than a capacitor. Choose carefully.

**Potentiometers.** New pots cost about the same no matter where you buy them. Imported units may sell for less, but cheap materials yield an inferior device, one that is often difficult to turn because of high-friction bearings. While imports are excellent for experimenting, it always pays in the long run to use top-quality pots in your projects.

Surplus pots can save you a lot of money, but read the fine print closely. Pay attention to shaft length. Some units are intended for screwdriver adjustment and have short, slotted shafts which cannot accept a knob. In addition, watch out for strange tapers, such as "reverse logarithmic." Pots specified as having either "linear" or "audio" tapers are the ones most usually called for in projects.

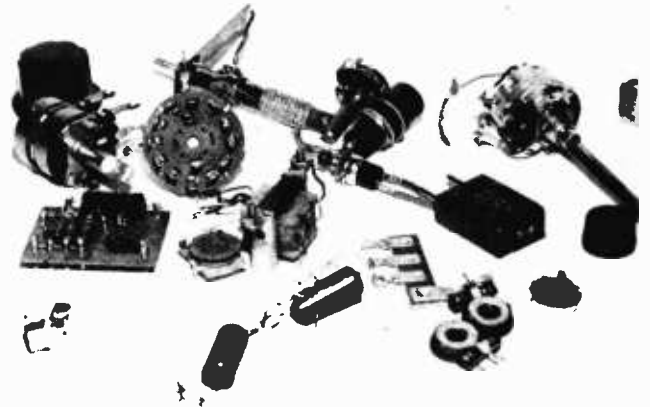
You will find that only linear and audio taper potentiometers are called for in the circuits described in 101 Electronics Projects.

For some reason, wirewound pots seem to abound in surplus. These are fine for low-frequency work, often at high power. But wirewounds have poor resolution and should never be used in a circuit where very precise adjustments must be made. For the bulk of your experimenting, standard carbon-composition pots are your best choice.

Slide pots are a great convenience in audio work, especially if you are building a mixer or music synthesizer. Many outlets carry them, but most units have too short a path of travel (1¼ inches) to be really useful. Slide pots with twice the adjustment range are preferable, and they can be purchased at reasonable cost from Mouser Electronics (11511 Woodside Ave., Lakeside, Calif., 92040).

**Relays.** These may well share the fate of the dodo, thanks to fast and reliable solid-state switchers like triacs, SCRs and transistors. Industrial control systems that once bristled with relays and cam-actuated microswitches now rely on digital logic and thyristors. Even Ma Bell, at one time the patron saint of relay manufacturers, now uses electronic switching to route calls. The result of all this phasing-out is a sur-

The best way to build up your parts inventory is to salvage useable components from junked pieces of electronics gear. Transformers, switches, potentiometers, crystals and coils are always handy to have.



plus market chock full of relays at bargain prices.

Despite the decline in its commercial popularity, the relay still possesses some admirable qualities, such as excellent driver/load isolation and minimal temperature sensitivity. Furthermore, it happens to be one of the easiest devices for the beginner to understand and use. All things considered, it makes sense to take advantage of the surplus bargains now, while they last.

**Power Transformers.** Here is another item carried by almost every supplier, but inventories are generally limited in scope. When your application demands just the right transformer, it pays to be able to order directly from the manufacturer. Signal Transformer Co. (500 Bayview Ave., Inwood, N.Y., 11696) offers a wide array of transformers, from tiny, PC-mount devices to mammoth, kilowatt isolation transformers. Other makers also offer diverse selections, but some may not encourage direct mail ordering.

Undoubtedly the most economical way of securing a transformer is through a surplus dealer like Delta. Many kinds of transformers end up as surplus, and with just a little luck you can find one to suit your purposes. Discounts greater than 75% off list are common, so the money you save may be substantial. This is especially true if you are planning to construct something big such as a high-powered audio amplifier. Transformers from some of the best amps ever to shake a loudspeaker end up as surplus, victims of design changes and competition.

**PC Supplies.** There is no surplus material worth mentioning in this category, so let's focus on new merchandise. The simplest PC methods involve placement of a pattern directly on copper-clad board. These are fine in the beginning, but for serious experimenters, photographic techniques are a must. Not only do photographic methods yield neater copper traces and a

greater density of components on your board, they also allow any number of boards to be produced from a single piece of artwork.

Photographic PC processing can best be learned from one of the kits offered by various manufacturers. You do not need expensive equipment like a camera or enlarger. All necessary materials and instructions come in the kit. These PC kits may employ either negative or positive photographic processes, which differ from one another principally in the method used to prepare a board's artwork. Positive methods are perhaps easier for a beginner to visualize, but negative kits seem to be equally popular. Most suppliers carry at least one brand of PC kit, if not more. Choose one that fits your needs and budget. You'll find the professional-looking results to be well worth the extra effort.

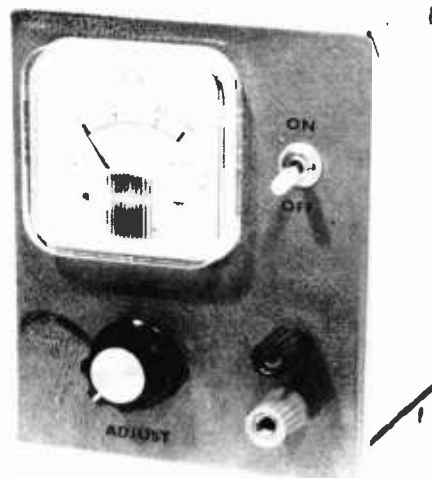
Although only the tip of the iceberg has been exposed here, you should have a pretty good idea of how to find supplies by now. To obtain copies of the catalogs you want, write directly to the companies mentioned in the text. Note that our coverage has been by no means exhaustive. Undoubtedly other worthwhile catalogs are available, so hunt carefully through the back pages, too. Remember, all companies stock much more merchandise than they can economically include in a single magazine advertisement.

Now that you have a pretty fair idea on how to purchase the parts you'll need for the projects you plan to build, sit down and compile a master parts list. As you do this, you'll probably start to see the same parts cropping up time and time again. To avoid unnecessary duplicity, only buy a part twice (or more) if the project it is being used for is one of a permanent nature. If you're going to tear it down, you can use its parts for another project at a later time. ■

# THE JUNK BOX SPECIAL

Power your projects, spend pennies for parts.

by Herb Friedman



Between 555 timers, TTL, CMOS, opamps and run of the mill transistor projects, the average experimenter is often faced with the need for a regulated power supply with a range of about 5 to 15 volts—just to try out a breadboard project. If you've priced any regulated supplies lately you know they don't come cheap. Maybe, just maybe, you might get one for \$30 or \$35.

With a little careful shopping, a reasonably stocked junk box and one or two "brand new" components you can throw together a regulated supply costing less than \$10 that will handle most of your experimenter power supply requirements. One of these Junk Box Specials is shown in the photographs and schematic. The range of this model is 5 to 15 volts DC at currents up to 1 ampere. One of the common, 3-terminal regulators which are now flooding the surplus market provides everything in the way of regulation. Depending on the source, the regulator will cost you from \$1 to \$2.50; the higher prices often include an insulated mounting kit (worth about 25-cents).

5 to 15 volts from one 3-terminal regulator? Correct. If regulator IC1's collector terminal is connected to a voltage divider across the output—R1 and R2—the output voltage will be that at the junction plus the voltage rating of the regulator, which in this instance is 5 volts. So, when potentiometer R2 is adjusted so its wiper is grounded the power supply's output is that of the regulator, 5 volts—perfect for TTL projects. As R2 is advanced, increasing the resistance from IC1's collector to ground, the voltage output increases.

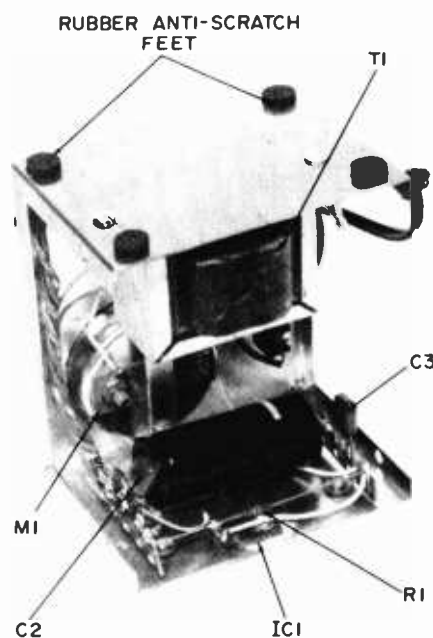
**Getting the parts.** There are plenty of parts around to build this supply for

under \$10. If you go out and round up "all new" components the cost is likely to go well over \$30, so forget about new parts. Power transformer T1 can be 18 volts at 1 ampere (or rated at higher current, though the supply's maximum output is 1 ampere), or 36 volts center-tapped at 1 ampere or more. Both the 18 volt and 36 volt transformers are glutting the surplus market. If you get an 18 volt transformer use the bridge rectifier shown in the schematic. If you get a 36 volt C.T. transformer use the full-wave recti-

fier shown below the schematic. The diode rectifiers SR1 through SR4, are type 1N4001, 1N4002, 1N4003, or 1N4004, which are also glutting the surplus market. Just to show you the savings possible, at the time this article is being prepared you can buy fifteen surplus 1N4001s for \$1. Just one single "general replacement" for the 1N4001 from a national supplier is selling for over 40-cents. Get the idea how to save costs on this project?

Capacitor C1 can be anything from 2000 to 4000 uF at 25 volts or higher. Look for an outfit selling surplus computer capacitors. If worse comes to worse you can get the value specified in the parts list in a Radio Shack store.

The 3-terminal, 5 volt regulator is another item easily found on the surplus market. With an adequate heat sink—such as the cabinet itself—the device can safely deliver 1 ampere. The unit shown in the photographs is a Motorola MC7805 (though you can substitute any similar type) obtained for \$2.50 from Circuit Specialists. We have seen similar devices from other manufacturers selling for \$1. The terminals B, C and E are indicated directly on the device or on the terminals—where they join the case. The collector (C) lead is connected to the IC's metal tab, and is normally grounded. Note that in this project, however, the collector terminal, and therefore the tab, is not grounded. You must use an insulated mounting kit consisting of a mica insulator and a shoulder washer. Place the insulator between the IC's body and the cabinet, or the tab and cabinet, and slip the shoulder washer into the opening (hole) in the body or tab. Pass the mounting screw from outside the cabinet through the mica washer, through the IC, and



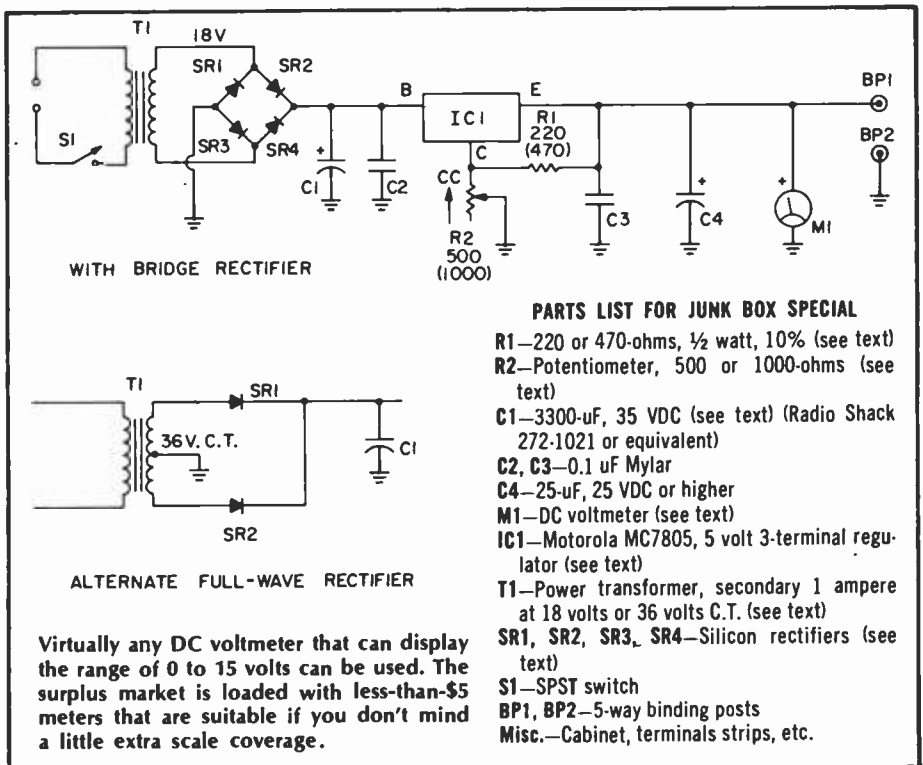
To prevent scratching your workbench apply rubber anti-scratch feet or bumpers on the bottom of the cabinet. They are available in most hardware and houseware stores.

# JUNK BOX

through the shoulder washer. Secure with a 1/4-inch (or smaller, not larger) nut hand-tightened against the shoulder washer. Before going any further check with an ohmmeter to be certain the collector terminal is insulated from the cabinet.

Connecting wires are soldered directly to IC1's terminal leads; use a heat sink such as an alligator clip on each terminal if you have a large (greater than 40 watts) iron. Since the layout is not important, we suggest the arrangement shown, with IC1 positioned between two mounting strips so R1 can span across the strips and be soldered to IC1's collector terminal.

Finally, we come to the meter, a device that has become slightly more expensive than a barrel of Arabian oil. Any meter that can indicate at least the range of 0 to 15 VDC is adequate. The EMICO 0-30 VDC meter shown in the photographs was selling in one local store for \$7.95, while we bought ours almost down the block as "surplus" for \$2.99. A good source for surplus meters is Fair Radio Sales. You might not end up with a meter case that looks



suitable for NASA, but the output voltage doesn't care two hoots whether the meter is a modern \$25 dollar model or a surplus-special for a buck ninety-nine.

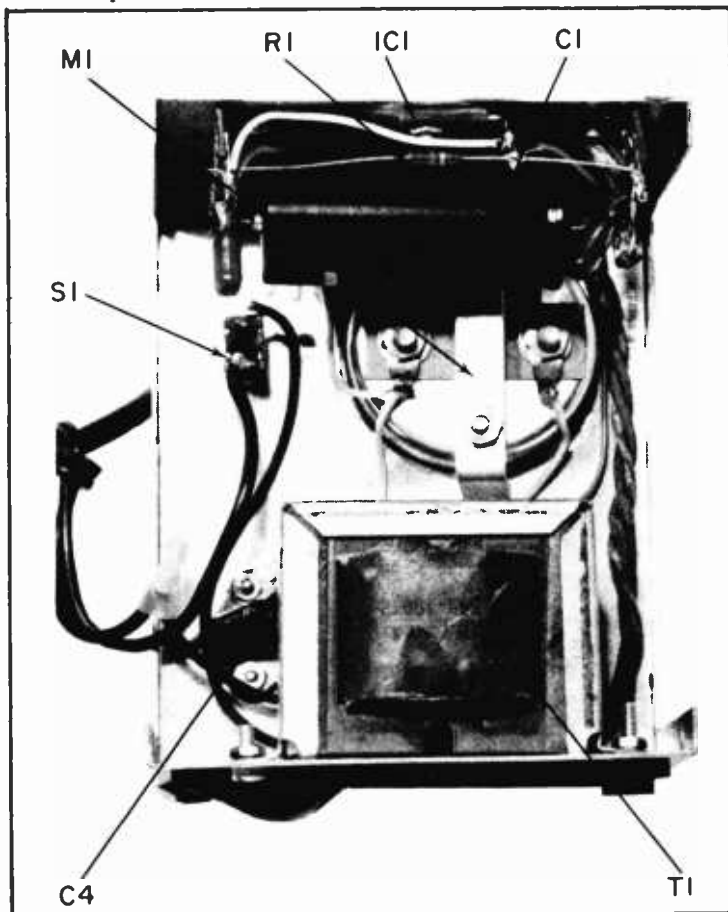
Power switch S1 can be a separate

SPST as shown in our project, or it can be part of R2. But keep in mind that a separate S1 allows you to turn the supply on and off without affecting voltage control R2's adjustment.

Finally, we come to R1 and R2. You will note that the schematic shows two values for each. One value for each resistor is in brackets (parenthesis). You can use either set of values as long as they are matched. If R2 is 500 ohms; if R2 is 1000 ohms R1 is 220 ohms; if R2 is 1000 ohms R1 is 470 ohms. The reason we show both sets of values is because 500 and 1000 ohm potentiometers appear on the surplus market from time to time, but usually not together. This way, you can use whatever is available at low cost.

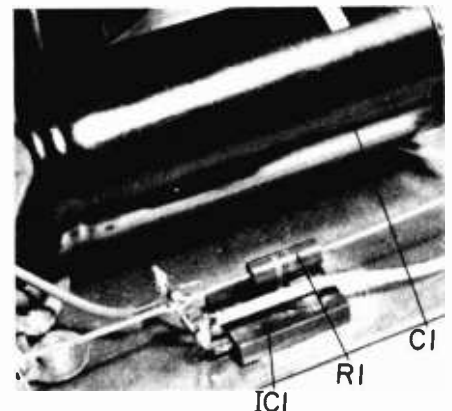
**CHECKOUT.** Set potentiometer R2 so the wiper shorts to the end connected to IC1's collector terminal, thereby connecting the collector directly to ground.

(Continued on page 114)



If you've had experience with assembly in tight quarters, you can shoe-horn the power supply into a standard 3 x 4 x 5-inch Mini-box. If your soldering iron is so big it burns adjacent wires when you make a connection, use a larger size cabinet.

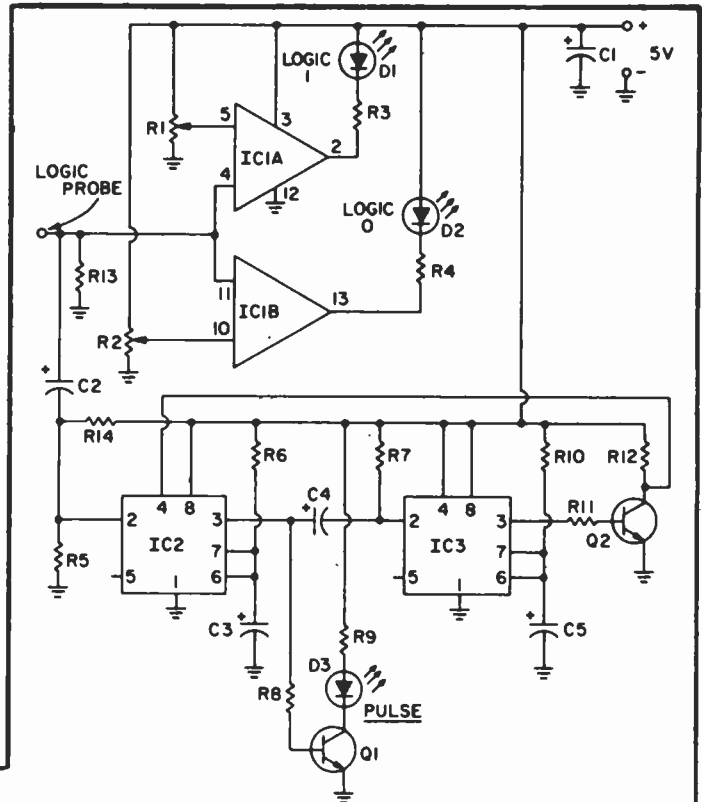
In order to handle a full ampere, the IC regulator must be heat sunk to the cabinet. Make certain the collector and its attached sink tab (the back of the package) is insulated from the cabinet. Use silicon grease to insure heat transfer from the IC to the cabinet.



## 40 Integrated Circuit Projects

(Continued from page 86)

zero, an illegal voltage level, or the presence of pulses at any frequency or duty cycle. The presence of a continuous logic level is detected by IC1A and IC1B, which are voltage comparators set to detect levels of 2.0 and 0.8 volts respectively. The presence of pulses is detected by a 555 timer connected as a one-shot multivibrator which illuminates an LED for about 0.5 second if pulses are present. A second 555 timer is used to disable IC2 for about 0.5 second each time it fires. This provides a flashing LED regardless of the frequency of the detected pulses. The circuit is powered by the 5 volt supply feeding the digital circuit under test. To calibrate the circuit, apply a voltage of 2.0 volts DC to the logic input terminal. Adjust R1 so that D1 is on the borderline between off and on. Apply 0.8 volts to the logic input terminal and adjust R2 so that D2 is on the borderline between off and on. When using the circuit either D1 or D2 or both must be lit to indicate a correct logic level. If both are out, the detected voltage is between 0.8 and 2.0 volts and is an illegal voltage level. D3 will flash only if there are pulses present on the line under test.



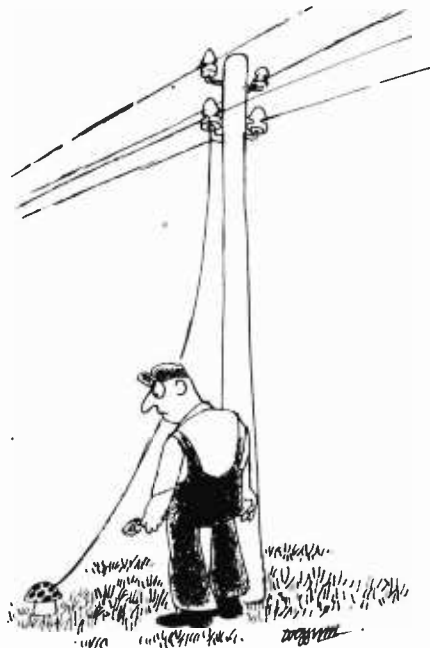
### PARTS LIST FOR TTL LOGIC PROBE

C1—10- $\mu$ F electrolytic capacitor, 25 VDC  
 C2—0.01- $\mu$ F ceramic capacitor, 15 VDC  
 C3—1- $\mu$ F electrolytic capacitor, 15 VDC  
 C4—0.01- $\mu$ F ceramic capacitor, 15 VDC  
 C5—1- $\mu$ F electrolytic capacitor, 15 VDC  
 D1, D2, D3—large LED  
 IC1—339 quad comparator  
 IC2, IC3—555 timer

Q1, Q2—2N4401  
 R1, R2—50,000-ohm linear-taper potentiometer  
 R3, R4—220-ohm,  $\frac{1}{2}$ -watt resistor  
 R5, R7, R14—100,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R6, R10—470,000-ohm,  $\frac{1}{2}$ -watt resistor  
 R8, R11, R12—4,700-ohm,  $\frac{1}{2}$ -watt resistor  
 R9—180-ohm,  $\frac{1}{2}$ -watt resistor  
 R13—10,000-ohm,  $\frac{1}{2}$ -watt resistor



"I assumed that when the salesman said that there were no tubes and no moving parts, he meant it was all solid state."



"Sorry bub, all I have on the truck are wall phones."



"Say, Frank, ever notice the catchy, hypnotic rhythm that data makes as it's processed... Frank... Frank... Hey, Frank..."

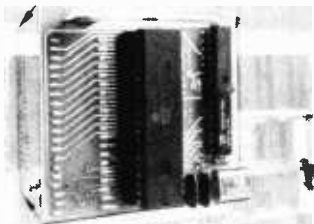
## New Products

(Continued from page 10)

trol of the reproduced sound to compensate for room acoustics, limitations of other components, characteristics of the music being listened to or personal taste. The SE-5 can be switched to apply equalization to a recording as it is made. This is useful when dubbing from old, noisy recordings, compensating for vocal or instrumental limitations or in preparing specially equalized tapes for use in cars, planes or boats with high ambient noise. For further information, write to Sansui Electronics Corporation, 1250 Valley Brook Avenue, Lyndhurst NJ 07071.

### Upgrade 6800 MPU to 6809

Percom Data Company is now offering a 6809 adapter for Southwest Technical Products' MP-A2 processor card. Although designed for the SWTP card, the Adapter may in fact be used to upgrade



#### CIRCLE 51 ON READER SERVICE COUPON

most other 6800 or 6802 MPUs to 6809 operation. The 6809 microprocessor chip offers several advantages over the 6800 chip, including more registers, expanded memory and register addressing capability, and a command/instruction set that includes the 6800 commands as a subset and faster throughput. The kit, which sells for \$69.96, is an inexpensive way for owners of 6800 or 6802 computers to upgrade to 6809 operation without changing any permanent wiring on the processor board, mother board or elsewhere. The original system may be restored by simply removing the Adapter, which plugs into the 6800 socket, and a wire-jumpered DIP header, which plugs into the clock generator IC socket, and rein-

serting the original components. The Adapter, which is supplied assembled and tested, includes the 6809 IC, a crystal, other essential parts and user instructions. The wire-jumpered DIP header is also included. An operating system—a version of PSYMON, Percom's operating system for the company's 6809 single board computer—is also available for users of the upgrade adapter. Orders may be placed by dialing

(Continued on page 117)

## Junk Box Special

(Continued from page 112)

If you wired R2 correctly it should be full counterclockwise. Then set S1 to on. The meter should rise instantly to 5 volts DC. As R2 is adjusted clockwise the output voltage should increase to 15 VDC or slightly higher. If R2 can adjust the output voltage only over the range of approximately 12 to 15 VDC, or 12 to 15+ VDC, IC1 is defective, or has been damaged. ■

## Pulstar

(Continued from page 96)

counter is used to monitor the output to determine operating frequency and pulsewidth, if accuracy is required.

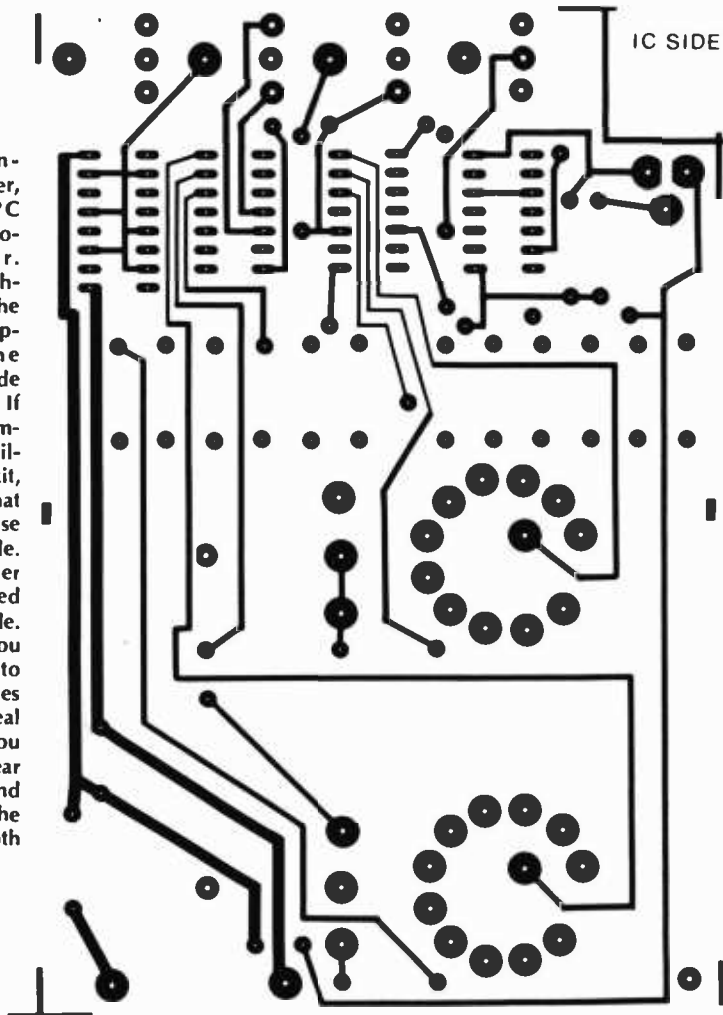
The output frequency and pulsewidth will vary with applied supply voltage, mostly on the high range. On that range, the maximum operating fre-

quency at 5-volts is about 600 kHz. At 10-volts and above, it is 1 MHz. This is due to limitations of the chip.

The gating feature allows you to generate pulse bursts containing a specific number of pulses.

The one-shot feature of the pulse generator may be used to manually, single-step counters, toggle flip-flops, and trigger one-shots. All in all, it's a great piece of test equipment for checking out your digital creations. ■

As we mentioned earlier, Pulstar's PC board is a two-sided affair. Here is the etching guide for the foil which appears on the component side of the board. If you use a commercially available etching kit, make sure that you can expose the second side, separately after you have etched the first side. Otherwise, you may have to etch both sides at once—no real headache if you have a clear etching tray and can observe the progress on both sides at once.



# LITERATURE LIBRARY

400. *Continental Specialties* provides new product info in its catalog of Testing and Design Instruments. A Digital Capacitance Meter and Tri-Mode Comparator are just some of the featured projects.

399. "Firestik" Antenna Company has introduced a new and informative product catalog on top-loaded, helically wire-wound antennas and mounts.

398. *Hamtronics, Inc.* has announced a new model R110 VHF AM Receiver Kit which employs an AM detector and a dual-loop agc system. A complete catalog is yours for the asking!

397. *Instant Software, Inc.* is offering a special holiday catalog for all kinds of year 'round software package gift-giving, as well as their regular microcomputer catalog.

396. *Creative Computing's* first software catalog of various education and recreation simulation programs as well as sophisticated technical application packages is available now.

395. *OK Machine and Tool Corporation* features the new PRB-1 Digital Logic Probe on the cover of its latest catalog of wire wrapping and other electronic assembly tools.

394. *KEF Electronics Ltd.* is offering two speaker systems in kit form at a significant cost-savings. The Model 104aB and the Cantata can be easily assembled and may be auditioned before purchasing.

389. You can't buy a bargain unless you know about it! *Fair Radio Sales'* latest electronics surplus catalog is packed with government and commercial buys.

388. SWLs need *Gilfer's* Shortwave Mail Order Catalog for economy one-stop armchair shopping. From top-notch rigs to reporting pads, Gilfer supplies all your hobby needs.

327. *Avanti's* new brochure compares the quality difference between an Avanti Racer 27 base loaded mobile antenna and a typical imported base loaded antenna.

362. A new catalog crunched full of military, commercial and industrial surplus electronics for every hobbyist is offered by *B&F Industries*. 44 pages of bargains you've got to see!

364. *B&K-Precision* has issued BK-10, a condensed catalog describing their oscilloscopes, semi-conductor testers as well as test instruments for CB, radio and TV repair.

310. *Compumart Corp.*, formerly NCE, has been selling computers by mail since '71, and is offering a 10-day return policy on many items featured in their latest catalog.

322. *Radio Shack's* latest full color catalog, "The Expanding World of TRS-80," is out now, packed with up to the date information on this microcomputer. Specifications for the new Model II as well as the Model I are included.

386. If you're looking for books on computers, calculators, and games, then get *BITS, Inc* catalog. It includes novel items.

335. The latest edition of the *TAB BOOKS* catalog describes over 450 books on CB, electronics, broadcasting, do-it-yourself, hobby, radio, TV, hi-fi, and CB and TV servicing.

338. "Break Break," a booklet which came into existence at the request of hundreds of CBers, contains real life stories of incidents taking place on America's highways and byways. Compiled by the *Shakespeare Company*, it is available on a first come, first serve basis.

345. For CBers from *Hy-Gain Electronics Corp.* there is a 50-page, 4-color catalog (base, mobile and marine transceivers, antennas, and accessories).

393. A brand new 60-page catalog listing *Simpson Electric Company's* complete line of stock analog and digital panel meters, meter relays, controllers and test instruments has just come out.

385. Amateur Radio buffs and beginners will want the latest *Ham Radio Communications Bookstore* catalog. It's packed with items for the Ham.

373. 48-page "Electronic Things and Ideas Book" from *ETCO* has the gadgets and goodies not found in stores and elsewhere.

382. Buys by the dozens in *Long's Electronics* super "Ham Radio Buyer's Guide." Good reading if you're in the market for a complete station or spare fuses.

383. If you're a radio communicator, either ham, SWL, scanner buff or CBER, you'll want a copy of *Harrison Radio's* "Communications Catalog 1979." Just what the shack book shelf needs.

380. If your projects call for transistors and FETS, linear and digital ICs, or special solid-state parts, then look into *Adva Electronics'* mini-catalog for rock bottom prices.

301. Get into the swing of microcomputer and microprocessor technology with *CREI's* new Program 680. New 56 page catalog describes all programs of electronics advancement.

305. A new 4-page directional beam CB antenna brochure is available from *Shakespeare*. Gives complete specs and polarization radiation patterns for their new fiberglass directional antennas.

371. Your computer system needn't cost a fortune. *Southwest Technical Products* offers their 6800 computer complete at \$395 with features that cost you extra with many other systems.

306. *Antenna Specialists* has a new 32-page CB and monitor antenna catalog, a new amateur antenna catalog, and a complete accessory catalog.

377. John J. Meshna, Jr., Inc. has a super saver catalog out (SP-16) featuring walky talkies and radar detectors.

330. There are nearly 400 electronics kits in *Heath's* new catalog. Virtually every do-it-yourself interest is included—TV, radios, stereo and 4-channel, hi-fi, hobby computers, etc.

392. The opening of the new Software of the Month Club has been announced by *Creative Discount Software*, which is giving out membership enrollment applications now. The Club plans to have separate branches for users of the Apple II, TRS-80, Ohio Scientific, Exity, Pet and CP/M based systems.

390. *Whitehouse & Co.*, your "hard to find parts specialist," offers over a dozen parts and kits in their latest catalogue, featuring an entire section on gunplexers for Amateur Radio buffs.

313. Get all the facts on *Progressive Edu-Kits* Home Radio Course. Build 20 radios and electronic circuits; parts, tools, and instructions included.

320. *Edmund Scientific's* catalog contains over 4500 products that embrace many sciences and fields.

328. If you are into audio, ham radio, project building, telephones, CB or any electronics hobby you'll want *McGee's* latest catalog of parts and gadgets.

333. Get the new free catalog from *Howard W. Sams*. It describes 100's of books for hobbyists and technicians—books on projects, basic electronics and related subjects.

354. A government FCC License can help you qualify for a career in electronics. Send for Information from *Cleveland Institute of Electronics*.

355. New for CBers from *Anixter-Mark* is a colorful 4-page brochure detailing their line of base station and mobile antennas, including 6 models of the famous Mark Heliwhip.

391. A new software products catalog for the Apple II Computer has just been issued by *Charles Mann & Associates*. The booklet contains business accounting, accounts receivable, inventory, BASIC teaching and other special purpose business applications.

359. *Electronics Book Club* has literature on how to get up to 3 electronics books (retailing at \$58.70) for only 99 cents each . . . plus a sample Club News package.

311. *Midland Communications'* line of base, mobile and hand-held CB equipment, marine transceivers, scanning monitors, plus a sampling of accessories are covered in a colorful 18-page brochure.

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SF by mail, Bem's Book Service, 2914 E. Southcross, San Antonio, TX 78223.

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CBer's! Personalized CB decal with a 1-year subscription to Elementary Electronics only \$3.97. E/E, the magazine that covers CB and all areas of radio communication. Send check: Elementary Electronics, Decal Dept., 380 Lexington Ave., New York, NY 10017.

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CB TUNEUP/MODIFICATION REPORTS! \$6 each, specify model. Free catalog. CB CITY, Box 1030D, Woodland Hills, CA 91365.

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RARE coins market. Send \$2.00 to Jefferson Press, P.O. Box 7055, Phoenix, AZ 85011.

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# PLACE

To be included in the next issue, please send order and remittance to R. S. Wayner,  
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**SAVE TO 90% WEEKLY** on groceries!! Guaranteed!! Information: Rush self addressed stamped envelope plus 25¢! Martens Ent., 1046 Greenwood Ct., Rm7DPG, Oshkosh, WI 54901.

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**\$300 WEEKLY SPARE TIME—**Mailing Salesletters. Details: Delta, Dept.-D, Box 2902-CRS, Rock Hill, SC 29730.

**MAKE \$100,000 YEARLY!** Guaranteed or \$1,000 refund! Executive type business. Free details! Success-669RR, Indian Hills, 80465.

**CASH ADVANCE \$500/Thousand** envelopes stuffed available. No limit! Information: Rexson 04-01, Box 1060, Orangepark, FL 32073.

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**MONEYMAKING OPPORTUNITIES—Cont'd**

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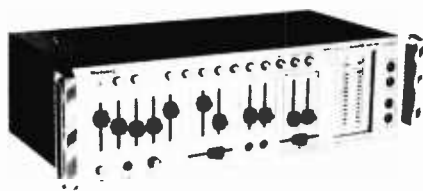
**New Products**

(Continued from page 114)

1-800-527-1592 (outside of Texas) or 214/272-3421 (within Texas), and may be paid by check or money order, COD or charged to a Visa or Master Charge accounts. When you call, tell Percom that **ELEMENTARY ELECTRONICS** sent you.

**Disco Delight**

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age for any disco application, portable or permanent. The amplifier section features 50 watts RMS per channel at less than 0.1% THD, from 20 Hz to 20,000 Hz,

along with 12 level LED display for accurate monitoring. The unit also features a five-band equalizer with a range of ±12 dB. The mixing section provides for two phono, two line and two mike inputs. Other features include fader and cue control, phone level adjustment and talk-over switch. The unit features a bridging circuit that allows any power amplifier to be tied into the MA4000 for unlimited versatility. Suggested retail price is \$580.00. Music lovers can get all the facts from Numark Electronics Corp., 503 Raritan Center, Edison, NJ 08817.

**Digital Thermometer**

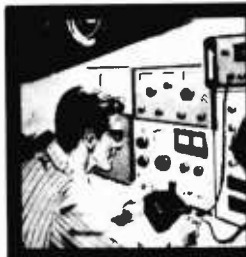
The EMS line of low-cost digital thermometers are excellent tools for calibration and testing of temperature-sensitive systems. The 2-inch or 6-inch stainless steel probes allow immersion in most corrosives and are remotable 2000-ft. with no performance degradation. The durable aluminum case is designed for rough field use. High accuracy (±.5°F over 0° to 150°F) and excellent repeatability (.1°F/1000 readings) insure

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CIRCLE 46 ON READER SERVICE COUPON

battery operated and sells for \$200. Model Th I-LED with power supply included sells for \$205. Both models supplied with 6-inch probe. Also available as panel meters. Send for free brochure by writing to Energy Monitoring Systems, Inc., 2444-L Old Middlefield Way, Mountain View, CA 94043. ■



**Ask Hank,  
He Knows!**

Got a question or a problem with a project—ask Hank! Please remember that Hank's column is limited to answering specific electronic project questions that you send to him. Personal replies cannot be made. Sorry, he isn't offering a circuit design service. Write to:

**Hank Scott, Workshop Editor**

**101 ELECTRONIC PROJECTS  
380 Lexington Avenue  
New York, NY 10017**

### Short Cut

*Can I switch VHF signals with an ordinary rotary switch?*

—J.L., Edison, NJ

I'd say no, even though it has been done. A "worst use" situation is an ordinary double-pole, double-throw knife power switch used to switch antennas on the back of TV sets. This was done for quite some time in the 1950s. Also, I have seen some MATV hookups using slide and rotary switches. Your best bet is to try it and see if it'll work for you. If the signal level is high and impedance matching not too critical, it may do the job!

### New Look at Sports

*Electronics has miniaturized its receivers and transmitters so much, I don't see why transceivers cannot be built into the headgear of football, baseball, and lacrosse players. What's your opinion, Hank?*

—B.R., Bloomington, IN

It can be done for all players with a computer tied-in providing electrical impulses for player guidance control which would be determined from a computer analysis of a video picture of the players in action. The engineer-in-charge could become the Player of the Year. We could give him the Ohms Law Memorial Award.

### Wayward Oscillator

*I built a 6-meter monitor receiver for my radio shack and it worked fine until I replaced the crystal controlled oscillator with a tuned circuit. Now I have a lot of drift. Any general hint I should know about when troubleshooting the circuit?*

—D.W., Kansas City, KN

The DC voltages usually cause the most problems. Be sure to use well filtered regulated DC power in the oscillator circuit. Be sure to include RF filtering in the DC supply. Temperature stable (zero drift) capacitors make a big difference. Also, shield the local oscillator by building a compartment around it and add a buffer stage to the output signal.

### Recording Bytes

*What is the difference between a "diskette" and a minifloppy? Aren't they both floppy discs?*

—J.N., Butte, MT

The IBM standard "Diskette" and copies of it are referred to as floppy discs, which are 7.8 inches in diameter. A small-

er version of the floppy disc is the "minifloppy" disc which is only 5.25 inches in diameter. Without getting too technical, here are some comparative data:

	5.25-inch Minifloppy	7.8-inch Standard
Unformatted Bytes	110K	400K
Tracks	37	77
Sectors	18	26
Ave. Access Time (Sec.)	0.566	0.286
Speed (RPM)	300	360
Drive Approx. Cost	\$350	\$600
Disc Approx. Cost	\$4.50	\$6.50

### What Time Is It

*Why do hams and SWLers use the 24-hour clock? The old 12-hour AM/PM technique is good enough. Give me one good reason!*

—D.N., Mississippi, MS

I never did dig that "1630 hours" talk much myself, and I'm ex-Army (draftee)! But when you are DXing the world, it's very useful to use the 24-hour clock along with reference to GMT (which is 24 hours). It's the hobby world you live in that makes it worthwhile. Sure, if you DX on two meters a state away, time reference can be local. CBers have no need for the 24-hour clock. As for me, my digital watch shows AM and PM—there's no changing me!

### Up the Volts

*I've always set my workbench DC power supply to 13.8 volts when fixing auto radios. Now a few car buffs are telling me it should be 14.4 volts. Have car batteries changed in the last year for this shift in typical auto voltage at running speed?*

—H.G., Addison, IL

No! But times are changing. You see, it has become important to lay guidelines for auto audio tests. And, like their big brother components that operate on 120 VAC, car audio components produce more speaker output in watts when the input voltage is increased. Sounds like someone is cheating, but not necessarily so. If everyone uses the same input voltage to power a rig, then all tests for power output can be compared. It's a shame that they couldn't stick to 13.8 VDC like most of the CB industry is doing.

### 50 kW Headache

*I have a shortwave 4-band receiver that covers the broadcast band right up to 30*

*kHz. I use a longwire antenna of approximately 75 feet in length. My problem is that CKHF at 1430 kHz (50 kW) distorts all reception up to 6,000 kHz. I use a ground wire tied to a grounding stake. Those frequencies are then totally unusable unless I happened to be a great fan of CKHF, (which I am not). If I cut the ground wire, I can use those frequencies very well. The use of the ground wire does, however, greatly improve all receptions between 12,000 and 30,000 kHz. What do I do, and, please, do not tell me to move!*

—M.C., Toronto, Ont.

You cut your ground line and my best line!! Your problem may be the ground circuit or the entire antenna system. I don't trust your ground rod which may be practically an insulator terminal in a very dry soil. The cold water pipe in your house is a better ground. Next, check every wire connection in your antenna system. Solder all joints to eliminate corroded joints acting as rectifiers. Also, your 75-foot antenna may be broadside to CKHF's antenna providing a huge signal that may swamp out your rig's front end. If I were you, I'd write a nice letter to the chief engineer of CKHF asking for technical help in designing a notch filter to kill the bulk of the 1430 kHz signal. Also, if your set does not have a built-in preselector, get one. And finally, your set may be due for a complete front end alignment.

### Stuck with 23

*My CB dealer refused to take my 23-channel CB rig as a trade-in. He tells me that it's against the law, and that I can't sell to a friend, either. Is he a liar, or is the FCC turning into the Gestapo?*

—J. M., Cleveland, OH

Easy now! I know you don't like the idea, but that's the law now until someone tests it in court. I had two 23-channel sets, both of which I loaned to friends with instructions to return them to me when they buy their own. Nothing wrong with that and what are friends for?

### Beer Bust

*I have a six-pack bet going that all CB rigs are made with built-in PLL. Am I right?*

—J. N., Knoxville, IL

You lose. There are a few hand portables still working on crystals. Burp!!

### Getting Started

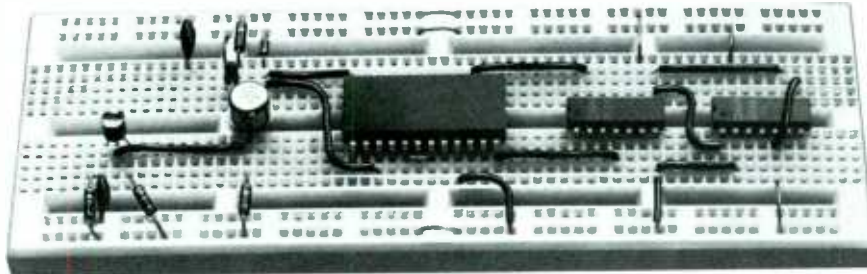
*It's time I learned something about CB repair. I'm no dummy. I can fix AM radios, read schematics, and once I held a 2nd Class Radio telephone license. Hank, can you suggest a school?*

—B. B., Honolulu, HI

Write to NRI Schools, McGraw-Hill Continuing Education Center, 3939 Wisconsin Ave., Washington, D.C. 20016 and tell them Hank sent you. ■

# Build Faster. Test Easier.

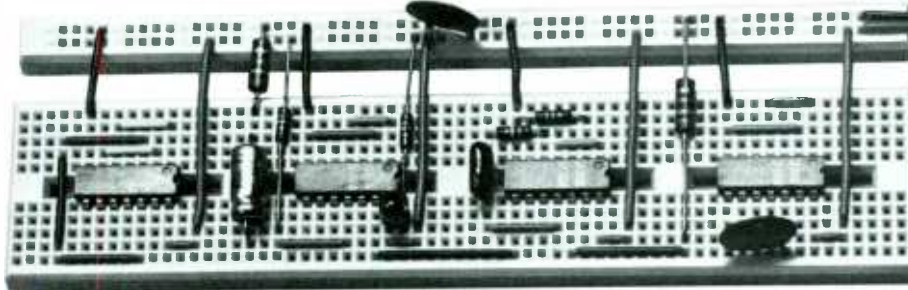
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You will receive training for the Novice, Technician and General Classes of F.C.C. Radio Amateur Licenses. You will build Receiver, Transmitter, Square Wave Generator, Code Oscillator, Signal Tracer and Signal Injector circuits, and learn how to operate them. You will receive an excellent background for television, Hi-Fi and Electronics.

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Included in the "Edu-Kit" course are Receiver, Transmitter, Code Oscillator, Signal Tracer, Square Wave Generator and Signal Injector Circuits. These are not unprofessional "breadboard" experiments, but genuine radio circuits, constructed by means of Professional wiring and soldering on metal chassis, plus the new method of radio construction known as "Printed Circuitry." These circuits operate on your regular AC or DC house current.

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In addition, you receive Printed Circuit materials, including Printed Circuit chassis, special tube sockets, hardware and instructions. You also receive a useful set of tools, a professional electric soldering iron, and a self-powered Dynamic Radio and Electronics Tester. The "Edu-Kit" also includes Code Instructions and the Progressive Code Oscillator, in addition to F.C.C. Radio Amateur License training. You will also receive lessons for servicing with the Progressive Signal Tracer and the Progressive Signal Injector, a High Fidelity Guide and a Quiz Book. You receive Membership in Radio-TV Club, Free Consultation Service, Certificate of Merit and Discount Privileges. You receive all parts, tools, instructions, etc. Everything is yours to keep.

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You will learn trouble-shooting and servicing in a progressive manner. You will practice repairs on the sets that you construct. You will learn symptoms and causes of trouble in home, portable and car radios. You will learn how to use the professional Signal Tracer, the unique Signal Injector and the dynamic Radio & Electronics Tester. While you are learning in this practical way, you will be able to do many a repair job for your friends and neighbors, and charge fees which will far exceed the price of the "Edu-Kit." Our Consultation Service will help you with any technical problems you may have.

### FROM OUR MAIL BAG

Ben Valerio, P. O. Box 21, Magna, Utah: "The Edu-Kits are wonderful. Here I am sending you the questions and also the answers for them. I have been in Radio for the last seven years, but like to work with Radio Kits, and like to build Radio Testing Equipment. I enjoyed every minute I worked with the different kits; the Signal Tracer works fine. Also like to let you know that I feel proud of becoming a member of your Radio-TV Club."

Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va.: "I thought I would drop you a few lines to say that I received my Edu-Kit, and was really amazed that such a bargain can be had at such a low price. I have already started repairing radios and phonographs. My friends were really surprised to see me get into the swing of it so quickly. The Trouble-shooting Tester that comes with the Kit is really swell, and finds the trouble, if there is any to be found."

### SOLID STATE

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