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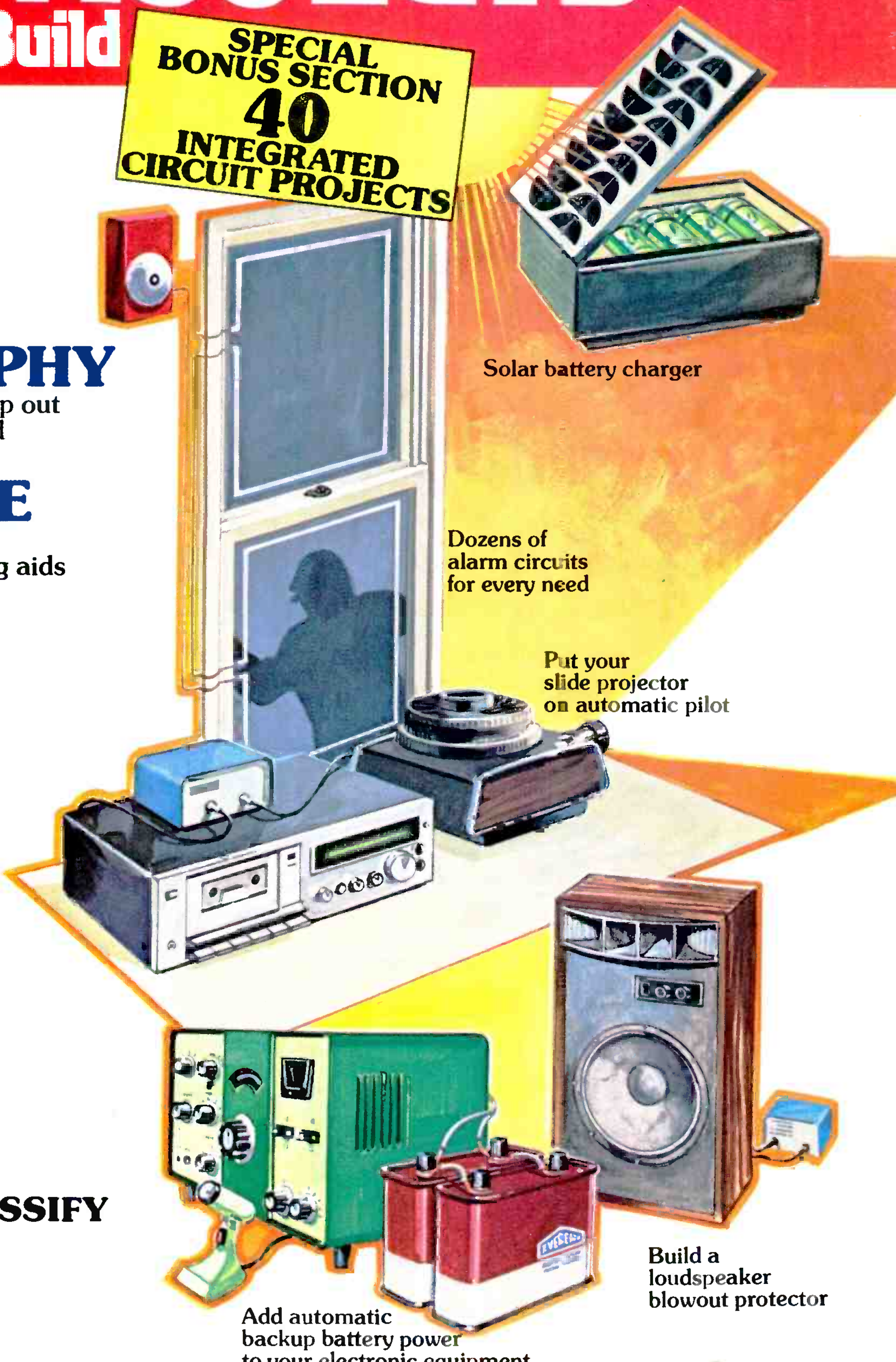

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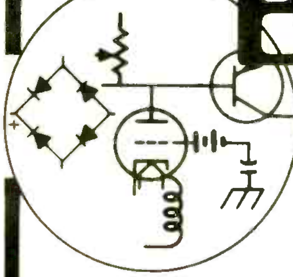

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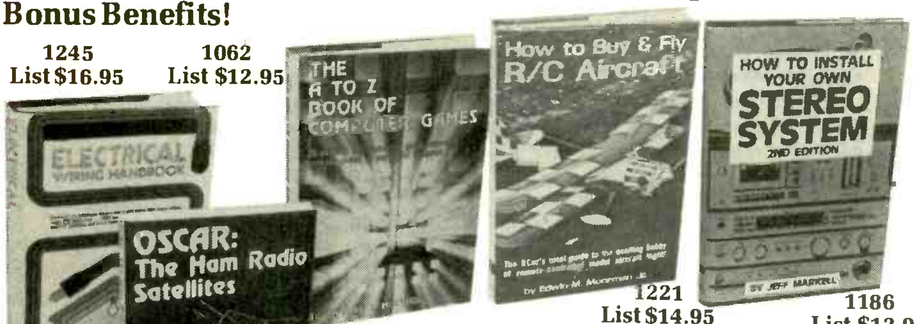

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New Products

Electronic Games

O.K. Machine and Tool Corporation has introduced a line of hobby construction kits that will make it easier for would-be electronics hobbyists to get started. These kits provide an enjoyable means of learning the basics of electronics construction. Each kit comes in a compact plastic package that becomes the project cabinet. Included are all parts, a printed circuit board and complete instructions. All you need are a few simple tools, solder, soldering iron and batteries. There are five kits now available: Quick Reaction (EK-1) tells which of two players responds first to a flashing LED

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—$9.90; Electronic Organ (EK-2) makes music at the touch of a probe—$11.89; Digital Roulette (EK-3) counts so fast that you have no way of knowing which number it will stop on—$14.90; Electronic Dice (EK-4) replaces rolling ivory with flashing LEDs—$13.80; and last but not least Morse Code Practice (EK-5) lets you build a handy code practice oscillator for would-be hams—$6.51. Available at many electronics retailers or directly from O.K. Machine and Tool Corporation, 3455 Conner Street, Bronx, NY 10475, or telephone 212/994-6400 for more information.

Roof Top CB Antenna

Combining the best characteristics of base loading, vehicle roof installation and fiber glass whip technology, Antenna Specialists has provided owners of fiber glass bodied RV's and other vehicles with non-metallic roof or deck surfaces a unique solution to the ground plane problem with its MR480 roof top CB antenna. The antenna is only 53 inches high, reducing overhead obstruction clearance to a minimum consistance with excellent performance. The MR480 combines a base loading coil encased in high impact white plastic with a white fiber glass whip thus requiring no metal ground plane. The antenna also employs a slim heavy-duty stainless steel shock spring. The mounting base is a standard roof-type requiring a ⅜-in. diameter hole. It is

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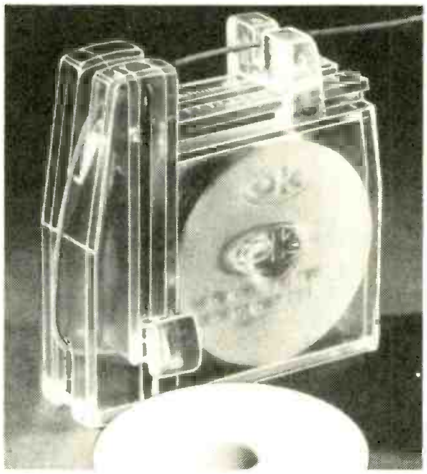
designed to mount on fiber glass roofs up to ⅜ inches thick and is provided with 24 feet of coax cable complete with connector. Suggested list price is $45.50. For further information contact The Antenna Specialists Co., Consumer Products Division, 12435 Euclid Avenue, Cleveland, OH 44106, or telephone 216/791-7878.

Wire Dispenser

The new "AD" series is the latest in the unique line of cutting and stripping wire dispensers from O.K. Machine and Tool. This heavy duty dispenser features precision ground steel cutters



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and die stamped stripping blade for easy and accurate cutting and stripping. Particularly notable is that the strip length is easily adjusted anywhere

New Products

from ⅜-in. to 2-in. simply by loosening the locking cam and sliding the stripping blade to the desired location. The second unusual feature of the AD series is interchangeability of stripping blades for 24 AWG or 30 AWG wire. The dispenser is available in either 24 AWG or 30 AWG version complete with blue or yellow Kynar insulated wire. The 24 AWG version includes 50 ft. of wire; the 30 AWG version contains 100 ft. The transparent housing allows easy monitoring of wire supply, and refill rolls are easily installed when needed. Each AD dispenser, complete with wire, is only $11.95; refills are $3.98; replacement blades cost $1.98. Available from local electronics retailers or directly from O.K. Machine and Tool Corporation, 3455 Conner Street, Bronx, NY 10475, or telephone 212/994-6600 for more information.

Microcomputer Autoranging DMM

B&K-Precision's new microcomputer-controlled, hand-held, autoranging DMM, the Model 2845, offers controlled autoranging at a price comparable to conventional DMMs. The microcomputer of the 2845 automatically selects the proper range without the slow "hunting" action. The new meter is actually a highly accurate full-function 3½ digit DMM combined with a complete microcomputer. The new B&K-Precision 2845 autoranging portable DMM is now available at local distributors at a user price of $175. The unit is supplied complete with safety-designed test leads, built-in tilt stand, detailed operating manual and spare fuse. For additional information, write to B&K-Precision, Sales Department, 6460 W. Cortland St., Chicago, IL 60635 or telephone 312/889-9087.

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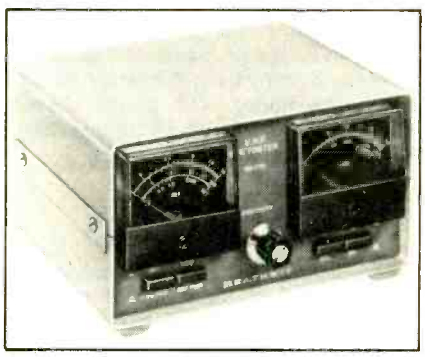
Dual Meter VHF Wattmeter

The Dual Meter VHF Amateur Wattmeter Model HM-2141, monitors both forward and reflected power simultaneously between 50 and 175 MHz. Offered in kit form by Heath, the HM-2141 measures forward and reflected average power, forward and reflected peak envelope power (PEP), and standing wave ratio (SWR). The dual range meter gives simultaneous readings of transmitted output up to 30/300 watts forward, and 10/100 watts reflected power for complete ease of antenna tuning. Mail order priced at $74.95, F.O.B. Benton Harbor, MI, the HM-2141 is featured, along with other Amateur gear and nearly 400 kits you can build yourself, in the latest Heathkit catalog. For a free copy write: Heath Company, Department 350-130, Benton Harbor, MI 49022, or telephone 616/982-3417.



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Indoor Scanner Antenna

Antenna, Inc. is offering a new antenna for monitors and scanner receiving radios. The All-Band Persuader Scanner Indoor Base Station Antenna approaches the high performance of an outdoor scanner ~~antenna~~ with a unit that can be installed inside a home or apartment. The All Band Persuader consists of a 7-ft. wire which is attached vertically to an inside wall, a small black box on the baseboard (a self-adhesive pad is provided), a short 2-ft. wire is connected to a convenient ground and a 10-ft. interconnect cable with pin plug is connected to the antenna receptical of the scanner. The entire installation takes only 1 minute and a screw driver is the only tool required. The All Band Persuader Antenna operates on all frequencies between 25-900 MHz. The suggested resale price of model 60502 is $11.95 and is available from most electronic dealers. For further information, contact Antenna Incorporated, 26301 Richmond Road, Cleveland, OH 44146, or telephone 216/464-7075.

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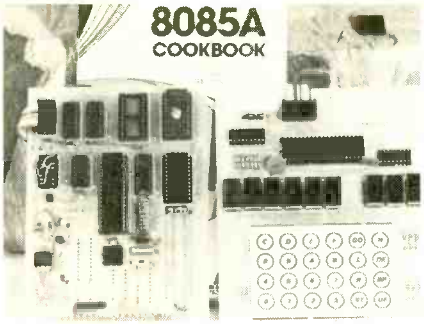
Computer Training

Paccom has a new Microprocessor Training Unit, called the 8085AAT. The 8085AAT MTU hardware includes a fully tested and assembled 8085A microcomputer with 1K RAM, 1K PROM, and 1K EPROM memory, programmable I/O, keyboard unit, CPR card, display and operatory system, 44 pin edge connector that allows configuration to any bus structure, area on the CPU card for custom wire-wrap design or user defined interface circuitry, completely expandable, and a 20 mA asynchronous port. The 8085AAT MTU software includes a complete step-by-step instruction manual, a complete User's Manual with programs included, a 352 page 8085A Cookbook which takes the user from basic microprocessor concepts to actual design of an 8085A Microcomputer, and a 334 page 8080/8085A Software Design Book 1 with over 190 executable program examples, plus detailed examination of all 244 Instructions and typical assembly language for the 8080/8085A Microprocessor. The complete Microprocessor Training Unit is $299.95. A kit version is also available for $249.95. Write to Paccom, 14905 N.E. 40th Street, Redmond, WA 98052, or telephone 206/883-9200.



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Acoustic Modem

The new 300 baud acoustically coupled LEX-11 modem from Lexicon has originate or answer capability, full and half duplex modes, and a self test feature, all switch selectable. LED indicators display power and ready status. All switches and indicators are highly visible and accessible allowing operating ease and assurance. The modem can communicate with Bell System 103A models as well as other LEX-11 modems. The RS-232 interface of the LEX-11 makes the modem compatible with most terminals, and small and personal computers. The LEX-11, with its battery option, can be used with battery powered handheld terminals to allow data interchange anywhere a telephone exists, even from a phone booth. In the self test mode the output of the modem is looped back into its receiver. This test feature allows the terminal operation as well as the modem operation to be tested locally. The LEX-11 is in molded plastic case and is priced at $175. Write to Lexicon Corporation of Miami, 8355 Executive Center Drive, Miami, FL 33166.

CIRCLE 49 ON READER SERVICE COUPON

Clamp-On Goes VOM

The hand-size Model 30 Clamp-on AC Voltmeter/Ammeter from Triplett Corporation, Bluffton, Ohio, now has extended versatility with the new Model 32 Ohms probe accessory. The plug-in probe permits fast-in-the-field or lab continuity checks on fuses, switches, circuit wiring, indicators, motor windings, checking open and shorted junctions of many semiconductor devices and a myriad of resistance checks on electronic/electrical components or circuits. The Model 30 probe features handy thumbwheel zeroing and measures from 0-1000 ohms with 10 ohm center. It's overload protected up to 600 volts with a ¾ Amp/600V fuse. Price of the probe is $14.00 and the Model 30 is $65.00. For further information on this versatile addition for Model 30 capability, write to Triplett Corporation, One Triplett Drive, Bluffton, OH 45817, or telephone 419/358-5015 for more information.

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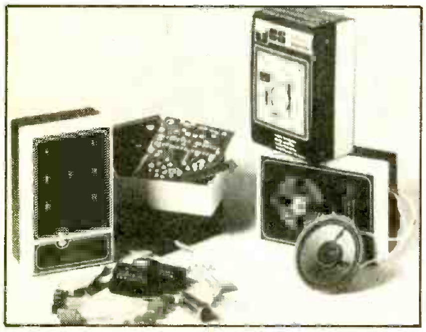
Micro Kits

Edmund Scientific is the exclusive domestic distributor of Josty Kit electronic kits of Denmark. Offered for the first time through the Edmund Scientific Fall/Winter 1980 catalog, Josty Kits are ideal for use in classroom demonstrations, science fair projects, home study projects, or for anyone interested in building useful instruments with electronics. Electronic projects by Josty Kit are available for building Electronic Dice, Portable Alarm, a McCloud-

New Products

Sound Siren and an FM Tuner and Amplifier. Each kit includes a schematic diagram, printed right on the circuit board. All parts are included and enclosed in a handy 3 x 1½ x 2-in. container which later becomes the housing



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for your project. All that is needed are wire cutters, drill and soldering gun. Each unit operates on a 9V battery (not included). Josty Kits ave available by mail from Edmund Scientific, 7082 Edscorp Building, Barrington, New Jersey 08007. The Electronic Dice Kit, no. 42,949, is $16.95; Alarm Kit, no. 42,950, is $12.95; McCloud Siren Kit, no. 42,951, is $14.95, and the FM Tuner & Amplifier Kit, no. 42,952, is $29,95; each kit F.O.B. Barrington, New Jersey. For information on a complete line of educational aids and kits, write for the free Edmund Scientific catalog at the address listed above.

Concealable CB

The new 40-channel citizens' band two-way mobile transceiver introduced by RCA can be installed in a concealed location to deter theft and conserve space. In Model 14T280, all controls, along with LED digital readout, are

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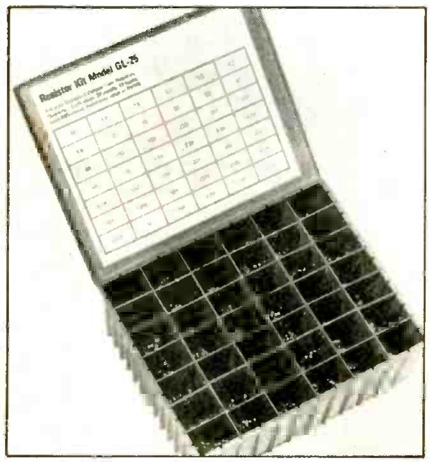
located on the microphone, which can be disconnected and removed or hidden when not in use. The main chassis can be installed in a concealed location, such as firewall, side panel or under the seat, since it contains no switches or other controls that require access. A built-in speaker relay permits use of existing radio speakers with the RCA CB, or separate speaker (not supplied) may be used through external speaker jack. The CB radio is designed with "channel memory" that gives you the last channel used when you turn it on; electronic channel selector for convenience in changing channels up or down; channel 9 switch to select that emergency channel fast for receiving or transmitting; and channel lock switch that prevents accidental channel change. Suggested list price for RCA Model 14T280 citizens' band radio is $199.95. Further information on these new units is available through RCA Custom AutoSound Distributors or RCA Distributor and Special Products Division, Deptford, NJ 08096.

Resistor Organizer

Century Electronics offers a wide assortment of fixed resistors in an attractive and convenient storage case. The GL-25 Econo-Pak Organizer contains 840 top quality ¼-watt resistors in 42 of the most commonly used resistance values for the home hobbiest



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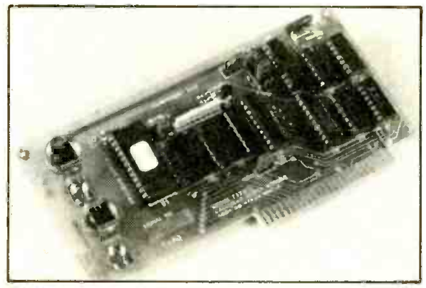
as well as for the shop and laboratory repairman. Each resistor value is prepackaged in its individual compartment thus assuring fast and accurate selection of any desired value. The compact Econo-Pak Resistor Organizer measures only 7½-in. x 6⅛-in. x 3-in. and is priced at only $29.95, FOB: Factory. Order directly from: Century Electronics Corporation, 3511 N. Cicero Avenue, Chicago, IL 60641, or telephone 312/777-9700.

Calendar/Clock Module for Apple II

The Model 7424 Calendar/Clock Module provides Apple II users with accurate real time counting for a broad range of applications. The module, featuring a crystal-controlled MSM5832 clock chip, counts seconds, minutes, hours, days of the week and month, months, and years. A battery may be installed to maintain uninterrupted



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time counting during power-down or power outages. The 7424 includes three separate, jumper-selectable CCS driver programs, plus space for user-written drivers, on-board in 1K of EPROM. One driver transfers data and time in the Mountain Hardware format to the Apple's input buffer. Another driver uses interrupts to write the correct time into an Applesoft string, from which it may be called by software. A third driver uses interrupts to maintain the correct time in the corner of the CRT screen. The Model 7424 is available completely assembled and tested for the list price of $125.00 (battery not included). For more information, contact California Computer Systems, 250 Caribbean Drive, Sunnyvale, CA 94086, or telephone 408/734-5811.

Tutor Micropro

The TM990/189-1 Microcomputer by Texas Instruments is a singleboard microcomputer that can be used as an aid in learning highlevel languages, 16-bit microprocessor fundamentals

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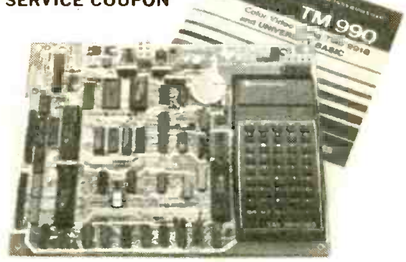
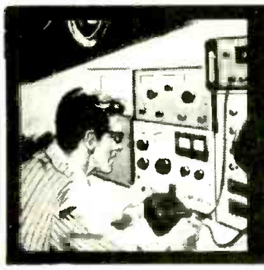


and interfacing techniques, as well as demonstrating TMS9900 family memory-to-memory architecture. It comes with the University Basic ROM Kit. The packaged University Board is available now from TI distributors at a suggested retail price of $399. For more information, write to Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265. ■



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

Big Amp

Recently I purchased an old Radio Engineering Labs Inc. Model 518-B-DL 1000 watt FM broadcast transmitter with Model 710 10,000 watt amplifier and power supply. All for personal, nonbusiness use. I need the schematic diagram and manuals for the Model 710 amplifier and power supply. Can anyone help me? Also, I'd like to get in touch with Radio Engineering Labs, or anyone who has ever serviced the 710 or 518-B-DL rigs.

—Jerry Kautz, KWNB-TV
Box 37
Hayes Center, NE 69032
Tel: 308/286-3664

Sounds like you have the makings of a hot-dog amateur station. Good luck, Jerry.

On the Level

Hank, I was all set to buy a TRS-80 Level I, when I heard disturbing news that Radio Shack was going to drop the Level I from its line of hobby computers. Is this true?

—W.N., Syracuse, NY

My two local Radio Shack stores (within a short drive) both claim they sell only personal and small business microcomputers. It seems that the word "hobby" does not exist for them even though the TRS-80 is probably used more in hobby applications than any other computer type sold. As for the Level I model, both stores did not have the Level I in stock, and suggested I buy the Level II, since "everybody who owns a Level I steps up to the II." My view is that the TRS-80 Level I will soon take its honored spot next to the Model T and the Wright airplane in the Smithsonian.

Wrap Up

Is wire wrapping all it is cracked up to be?

—J.N., Huntsville, AL

It sure is, if you are an experimenter or fool with circuit designing. Wire wrapping is a method of making electrical connections by winding the bare end of a wire around the connecting pins of an electronic part or its socket pin. These pins are square posts that bite into the copper wire forming tiny spotwelds at each contact forming an excellent mechanical connection without heat and a perfect electrical connection. I find that wiring mistakes and modifications can be made quickly and 100% of the parts salvaged, when the circuit or project is junked. I use an OK Machine and Tool wire wrapper that holds a spool of wire. You know, I've yet to make a cold solder joint with it!

Modification

I would like to use the Digital Voltmeter that appears in the March/April 1980 issue of ELEMENTARY ELECTRONICS *(now changed to* SCIENCE & ELECTRONICS*) to indicate voltage output from my 0-40 VDC variable power supply. Can it do the job?*

—A.W., Columbia, SC

Modifications are necessary. First, disconnect diode D1 and connect the top of C1 where it connects to U1 to a 12-13.8 VDC source. This way when the voltage drops to zero, or very low, the unit will be powered. Now power up the circuit and align it as the text instructs with a 15 VDC input. Then slowly increase the test voltage input until you reach 40 VDC. If the meter circuit functions correctly by supplying the correct indication—O.K. If not, you may have to increase R1 to 150,000 ohms.

Manual Supplier

Hank, if any of your readers have questions concerning military electronic communication equipment, we have thousands of technical manuals covering just about all military equipment.

—Col. Wayne D. Russell
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You can get a quote on any manual you need by sending a stamped self-addressed envelope to the Colonel. He specializes in military gear—not consumer goods.

DX Club Forming

If you're a teen-aged DXer, and are looking for a DX club especially designed for young listeners, one is being formed right now—TEENDX. If you are interested in helping to form it, or just being a casual member, write to:

—Josh Cherry
3217 Wynsum Avenue
Merrick, NY 11566

Good luck!

Ask Hank, He Knows!

It's a Cannon

What is an XL-type connector?

—D.M., Boston, MA

It's any of several varieties of audio connectors having 3 or more conductors plus an outer metal shell which shields the mating pieces and locks them in place. The most common type is the 3-pin XL-type connector used to make balanced mic and line level connections on professional audio systems. It is not uncommon for XL-type connectors to be connected to unbalanced lines. Very often the XL-type connector is called a "Cannon connector," so named for the original manufacturer. Presently, many companies now manufacture compatible 3-pin connectors.

Bond It

My serviceman suggested I "bond my chassis." He meant that the engine compartment leaked RF which interfered with my radio reception. How do I do it?

—W.N., Oceanside, NY

Check your auto parts supply outlet for bonding straps. If you can't get any, use the wire braid from an RG-8/U cable. Take off the outer jacket and inner insulation and center wire. It's easy to do, and you'll need strips of about one foot in length. Now, connect the hood to the firewall with one strap. Connect each fender to the firewall. (The firewall is the metal between the engine compartment and the passenger section.) Check to see that the cable from the battery ground to the engine makes a good connection and is not damaged. That should do it.

Disc—oh!

What is the difference between a "direct disc" and a "digital disc?"

—C.E., Reno, NV

A "direct-to-disc" recording is a technique whereby live performances by artists are recorded directly on to the master disc. No tape recording is utilized. The entire performance must be recorded continuously. It is impossible to over dub on errors. "Digital-to-disc" recording process uses a digital master tape on which the sound is broken down into its digital counterparts greatly reducing the effect tape has on a recorded performance like reduced dynamic range and increased noise level. Overdubbing is possible, and second, third and higher generation tapes are indistinguishable from each other with respect to effect in performance and increasing noise level.

An Upsidedown World

What is meant by "susceptance"?

—W.Y., Redmond, WA

Impedance (Z) consists of a real part called resistance (R) and an imaginary part called reactance (X). Admittance (Y) is the reciprocal of impedance. Conductance (G) is the real part of admittance and is the reciprocal of resistance. Susceptance is the imaginary part of Admittance (B) and is the reciprocal of reactance. This detailed terminology is seldom used. We usually talk about impedance and its two parts, and the reciprocals of all three. (Now I know some high school science teacher will write saying that I'm working against him.)

Tough to Hear

I have a Bearcat Scanner. My outside antenna is 30 feet above the ground. Base stations come in well but mobile transmissions are weak. I live in a mountainous area. Will a preamplifier be the answer?

—J.H., Blaireville, GA

I doubt it! We're talking about signal loss due to terrain. If the signal can't get to you, there's nothing to amplify.

Help Wanted

Lend a Hand. Here is a super long list of readers asking for help. Some requests come from readers of SCIENCE & ELECTRONICS, and others from electronics handbooks like BUDGET ELECTRONICS, 99 IC PROJECTS, and ELECTRONICS THEORY HANDBOOK—to name a few. All these magazines are prepared by the SCIENCE & ELECTRONICS editors, and I assist with the question and answer columns. So lend a hand, if you can. And, if you need assistance, let me know, and maybe one of our readers will drop you a note.

Hallicrafters HT-17 transmitter; requires oscillator and power amp output coils; Larry Jessip, 1112 Whitcher, Sioux City, IA 51109.

Computer Gans Programs—any language; Andy Herman, 115 Federal St., Belchertown, MA 01007.

Philco radio with 307459 on bottom of cabinet; needs schematic diagram and owner's manual (11 years old); James Wildman, 34 Raymond Ave., Shelby, OH 44875.

Hickok Model 534 dynamic mutual conductance tube tester and analyzer; operating manual needed; A. V. Everett, Rt. #1, Box 48, Ramer, TN 38367.

General Radio Telephone Model M. C. 3 CB (vacuum tube) transceiver; needs schematic diagram; E. J. Weselek, Sr., 71 So. Main St., Middleport, NY 14105.

RME-84 (Radio Mfg. Engineers, Inc.); requires tube layout, info—anything!; Robert Rasussen, 9 Whitehall Way, RD#1, Coatsville, PA 19320.

Hallicrafters S-38 Shortwave Receiver; require owner's manual and schematic diagram to put in tip-top shape; S. Merr, Box 303, Yonkers, NY 10710.

Bruiser 100-watt Linear Amplifier, 2-30 MHz; needs schematic diagram to wire up remote jack plus any other info available; Peter Garde, 21 Leicester Ave., Timperley, Altrincham, Cheshire WA15-6HR, England, Tel: 061-973-8006.

Atwater Kent Model 206 Receiver; urgently request schematic diagram and alignment information; Robert Payne, 806 California Blvd., Ridgecrest, CA 93555.

Hallicrafters Model 5R10A radio; needs glass dial to restore; Harry E. Smith, 2254 Dora St., Fort Myers, FL 33901.

Atwater Kent Model 20 receiver; needs all the data he can get to restore 100%; Edwin Phelps, Box 553, Mandan, ND 58554.

Allen B. Dumont Type 208B oscilloscope; instruction book and schematic diagram urgently needed; Allan Madsen, 4608-38th Ave., NE, Salem, OR 97303.

Hallicrafters S-210 Shortwave Receiver; needs schematic diagram, alignment information and manual; Roy Patterson, P.O. Box 2085, Spring Valley, CA 92077.

Video Brain Computer, Model 101A made by Umtech; needs info on CPU 3850, and associated IC's; Donald Crumly, P.O. Box 2732, Kailua Kona, Hawaii, 96740.

Tempo One SSB Transceiver; needs schematic diagram and operating manual; Lewis Horn, 13 Spinning Wheel Lane, Tamarac, FL 33319.

RCA Oscilloscope Model W056A; Service manual and schematic diagram urgently requested; M. Wahl, W4NRF, 2250 Bay Drive, Miami Beach, FL 33141.

Hoffman Color TV, Model W7340A, Chasis 913-000617; needs service data and schematic diagram; Wm C. LeDuc, SC112, 3 House Ave., Troy, NY 12180.

J. C. Penny Model 680-1901 AM/FM/TV Receiver; need schematic diagram and service data; Shawn Harrison, 11 Edgett St., Bath, ME 04530.

Sanyo Model RD4550 Stereo Cassette Deck; needs specs and schematic diagram; Andy Yero, Rt. 1 Box 127, Highland, WI 53543.

Dynoptimum Test (Radio City Products) Model 309 Tube Tester; needs wiring diagram, schematic diagram, and manual; Hervy Glover, Rt. 1, Box 37, Bokehito, OK 74726.

Freed-Eisemann Serial 37862 table radio with six tubes—80, 42, 77, 77, 78 plus one unknown; need identification schematic diagram, and anything else; Fred Paul III, 138 E. Bacon Street, Plainville, MA 02762.

DeVry Instrument Model 34 Oscilloscope made for Bell & Howell Schools; need schematic diagram; Walter M. Thode, 903 Benton Street 5, Allentown, PA 18103.

Radio Shack Science Fair Globe Patrol 4-band Shortwave Receiver; urgently needs schematic diagram and manual for operation; Stanley R. Garcia, 415 Akers Rd. #81, Visalia, CA 93277.

Webcor Model WFX-239 Stereo; needs schematic diagram for necessary repair; Howard A. Rosine, 1401 Ashland Ave., Claremont, CA 91711.

Hickok Model 670 Oscilloscope; schematic diagram urgently needed; Woodie De Byle, 4129 Dundee Rd., Apt. C, Columbus, OH 43227. ■

There are many ways to go about building an electronic project—some of them good, and some of them downright awful. Before you start building any of the projects in this handbook, please take a few moments to read this introduction. We have compiled a small but worthy collection of project-building tips that should benefit both the novice builder and the old hand, too.

Planning. The first stage of construction, one that is usually overlooked by the inexperienced builder, should involve careful planning of what's to be done, and how to do it. Be certain that you understand your project's schematic completely. If you know what to expect in terms of circuit performance, voltages, and component characteristics, inadvertent damage and mistakes during construction are less likely to occur. Furthermore, final testing and troubleshooting will be impossible without adequate prior knowledge of your circuit's electrical characteristics.

Next, decide on whether permanent or temporary construction is desired. Temporary construction, usually on a solderless breadboard, is fine when you just want to try out a circuit to see how well it works. For those projects you wish to keep and use, more permanent construction methods involving printed-circuit or wire-wrap techniques are warranted.

Another important step in the planning process is to review all anticipated construction steps and set up a plan of attack. Naturally, this becomes easier after you've built several previous projects, since experience is still the best teacher. However, there is no need to plan every step of construction; a rough outline will do nicely. Too many people waste time trying to set up the quickest and most efficient procedure when, in fact, there are probably few significant differences between the various possible alternatives. Just plan the high points—the rest will fall in place.

Finally, before beginning the actual construction, make sure that you have collected all the parts required by the project. It makes little sense to have drilled and punched a cabinet only to find that some crucial part is either unavailable or so expensive that you cannot afford it. (Let's note right here that all the projects in this book use inexpensive, readily available components. In fact, most of the components you purchase can be used in four or five different projects.)

Construction Methods. The method employed to build a project will depend to a certain extent on how you intend to use the finished device. Projects will generally fall into one of two categories: temporary or permanent. Temporary projects should be wired up on one of the new, solderless breadboards. These consist of ceramic plates with numerous, recessed contact points, into which component leads and wires may be inserted. If solderless breadboards are unfamiliar to you, take a walk to your local electronics supply store, or consult a catalog from one of the mailorder electronics firms. Breadboards of this type are both inexpensive and easy-to-use. We highly recommend them to those of you who wish to quickly evaluate a wide variety of circuits.

Permanent projects, which will not be dismantled after experimentation, can be constructed by a number of methods. Perfboard is the oldest and cheapest mode of construction. It requires that contact pins be staked into a perforated phenolic sheet, and that component leads and wires then be soldered to these contact pins. This method works, but it requires quite a bit of manual dexterity.

Wire-wrapping is a newer method of construction that is faster and neater than perfboarding. Actually, wire-wrapping is probably best suited to integrated-circuit projects, where the large number of closely spaced IC pins

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makes it especially attractive. The wire-wrap process requires either a manual or battery-powered tool that wraps thin-gauge wire around contact posts having square cross-sections. Wrapped joints need not be soldered, yet they are every bit as reliable as conventional soldered joints. Wire-wrap kits are available from many electronic suppliers.

Perhaps the most professional and neatest way to build a project is to use a printed circuit. Unfortunately, fabrication of the printed circuit itself can be time-consuming, but many constructors feel that the professional-looking results and compact size of the finished product justify the extra effort. Printed-circuit kits are readily available for those so inclined. The rest of us, who may not be as talented or ambitious, can take advantage of printed-circuit construction by purchasing printed circuit boards that have been etched in a pattern similar to a solderless breadboard so you can easily convert a breadboard design to a permanent PC board with soldered connections.

Tools. There are a lot of tools that could be employed in the construction of a project, so rather than tackle the whole boring list, we'll simply highlight some of the more indispensable ones. Of course, a soldering iron is mandatory most of the time—with the possible exception of breadboarding and wire-wrapping. Even here, a soldering iron is sometimes handy. For the majority of electronic projects, a light iron drawing between 15 and 25 watts is ideal. A soldering gun (100-250 watts) might be useful when soldering heavy wires and terminals, but for general-purpose electronic construction, it's a white elephant. By all means, use only rosin-core solder, since acid-core solders leave residues of HC1 and other activators that will corrode wires and contacts.

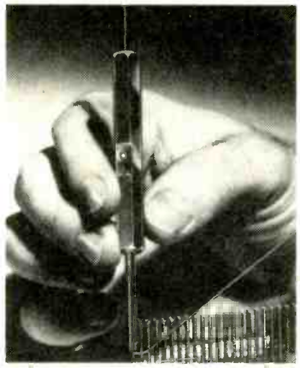
You will also be needing plier/grabber tools, such as diagonal cutters, needle-nose pliers, wire strippers and tweezers. Devices designed for the electrician won't do, because they are too large and clumsy. Miniature tools are what you need. If you cannot find them locally, request a catalog from Jensen Tools Inc. (1230 S. Priest Dr., Tempe, AZ 85281).

Another handy device to have around is the nibbler, which can be used to make burr-free cuts in aluminum, light-gauge steel or printed-circuit stock. While shearing would curl sheet metal into the shape of a potato chip, nibbling will leave it flat. Furthermore, a nibbler allows you to execute more intricate cuts than would be possible with any other tool.

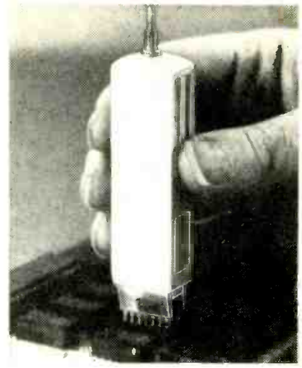
An electric drill is always welcome. You can use it to drive the usual drill bits and special hole-cutting devices, too. One such hole-borer, with the appearance of a tooth-laden ice-cream cone, is capable of cutting a wide variety of hole sizes in light-gauge sheet metal. Cutting heads of this sort are fairly expensive (about $30), but for speed and convenience, they can't be beat.

Testing and Troubleshooting. Once you've accomplished the mechanical fabrication (if any) and wiring of your project, it's testing time. If the project does not perform as intended, troubleshooting will be necessary to find the cause of the problem and correct it. The most valuable tool of the troubleshooter is knowledge. You may possess $1,000 worth of test equipment, but without a clear understanding of how the circuit operates, your chances of locating a fault are slim indeed.

Each circuit will require its own unique testing and troubleshooting procedures; there is no single prescription



Wire wrapping is one of the fastest and easiest ways to wire up a circuit board.



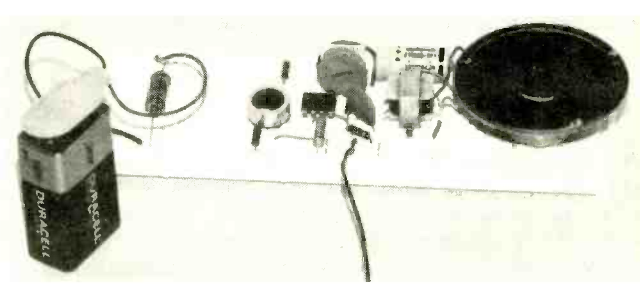
Mishandling ICs often results in bent pins. An IC insertion tool is safer.

that works for every ailing circuit. However, a thorough understanding of proper circuit operation plus a little deductive logic will often effect a cure. For example, let's consider a simple circuit consisting of an oscillator, a counter IC, and a 7-segment display. Suppose that when the circuit is turned on, we see the number 2 and no other activity. Since we expect to see a sequence of number flashing (0, 1, 2 . . .), something must be wrong.

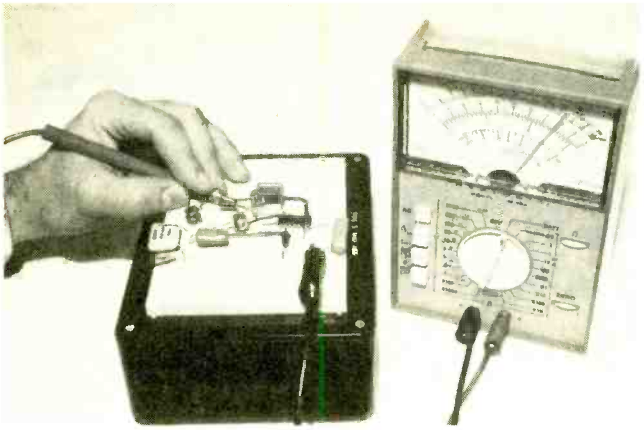
From our knowledge of the circuit, we conclude that either the oscillator is not working, or the counter is stuck at 2. If we now check the oscillator and find a healthy output signal, the logical deduction is that the counter is stuck. Maybe the integrated circuit is defective, or perhaps it was wired incorrectly. In any event, further checking will isolate the fault, either directly or by the process of elimination. Similar reasoning can be applied whenever a circuit misbehaves, but let us stress one more time that in order to troubleshoot a circuit, you must understand it thoroughly. To that end, you will find fairly complete descriptions attached to the projects in this book. Read them carefully *before* you reach for a soldering iron.

Test Instruments. Obviously, in order to do any meaningful testing and troubleshooting, you are going to need some form of electronic instrumentation. The first acquisition of most experimentors, and rightfully so, is the multimeter or VOM (Volt-Ohm-Milliameter). As its name implies, this device measures voltage, resistance and current. An important consideration in the purchase of such an instrument is its input impedance. In short, to get an accurate reading the input impedance of the instrument must be significantly greater than that of the circuit being tested. For that reason, electronic multimeters with field-effect transistor (FET) inputs are extremely popular.

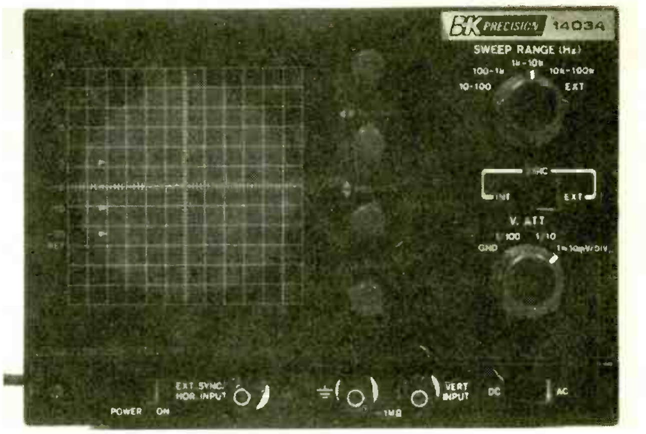
These FETVOMs have typical input resistances of 10-megohms and, unlike the less sophisticated VOM, they



The easiest way to prototype a circuit is with a solderless breadboard. They are made by dozens of companies.



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.



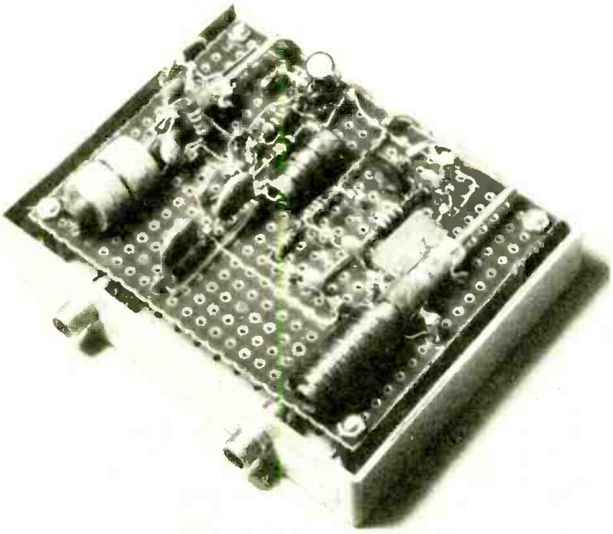
The most versatile troubleshooting aid available is an oscilliscope such as the one shown here. With a 'scope you can measure AC and DC voltage levels or combinations of both. For signal tracing they are unbeatable; you see the wave form. A dual-trace 'scope shows two signals simultaneously.

exhibit the same high input impedance on all measurement ranges. Electronic multimeters are available with either digital or analog (i.e., needle-on-a-scale) readouts. Digital types are more rugged, potentially more accurate, and easier to read. On the other hand, analog meters follow up-and-down voltage trends more readily.

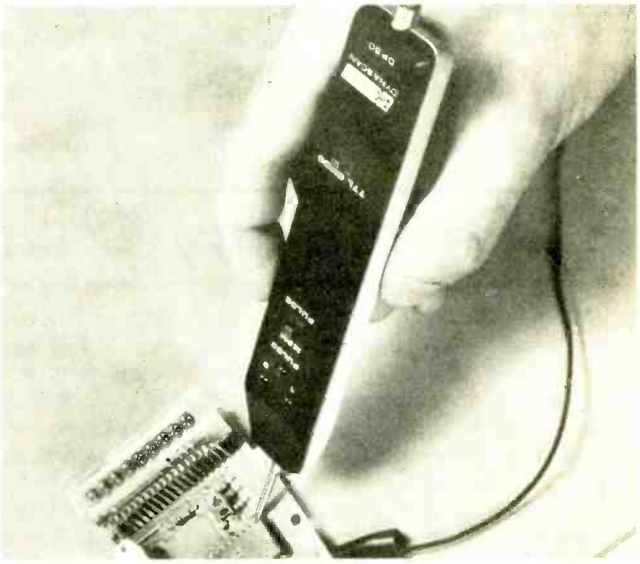
Without a doubt, the most important instrument you can own besides a multimeter is an oscilloscope. This instrument provides graphic display of AC waveforms on the face of a small cathode-ray tube. With a 'scope, you can see the shape of a waveform and measure its instantaneous amplitude or time duration.

If your interest in electronics is serious, but your cash flow is merely a trickle, you might consider buying a 'scope in kit form. The Heath Co. (Benton Harbor, MI 49022) offers a variety of kits starting at $200. It would be wise, however, to have some previous kit-building experience before tackling an oscilloscope. For the beginner, an oscilloscope with a 5-MHz bandwidth should fill the bill nicely, although the advanced experimenter with an interest in digital circuits should probably opt for a minimum bandwidth of 10- to 15-MHz. The higher the bandwidth, the more faithful the reproduction of high-frequency signals and, naturally, the higher the cost of the instrument.

The more experienced hobbyist could eventually add a frequency counter, a capacitance meter, a signal generator, and maybe even a logic probe to his arsenal of equipment. However, to build and test the projects in this volume, you can fare quite well with only a multimeter. If you have access to a 'scope, so much the better, because it will afford you the chance to see what's really going on in these circuits. But remember, your most important piece of equipment is between your ears. If you follow the advice offered here, and temper it with a little common sense, you should have little difficulty with any of the projects in this book. ■



Perfboard 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.



If you do a lot of digital troubleshooting but can't afford a oscilliscope then a logic probe is the next best thing. It will indicate whether a point has a high, low, off or pulsing logic state. You'll find plans for a simple logic probe in this issue; commercially manufactured probes usually work better.

101 ELECTRONIC PROJECTS

1. Solar Battery Charger

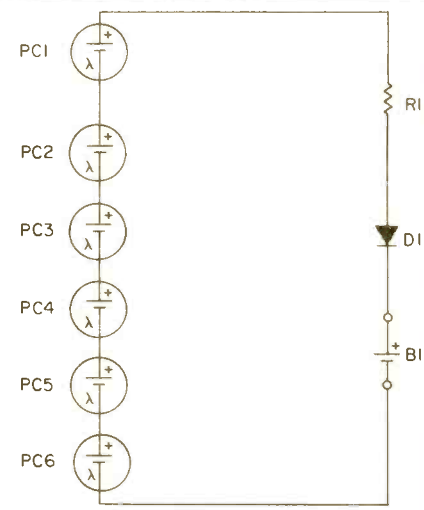
☐ Tired of charging your NiCd cells? Then let Old Sol do the work for you free-of-charge. In this circuit, photovoltaic cells supply the charging current, which is limited to a safe level by R1. Diode D1 prevents the battery from discharging through the solar cells during periods of darkness.

NiCd cells of different sizes require different maximum charging currents for best results. Currents in excess of the recommended values result in rapid evolution of oxygen gas within the cell. When this happens, oxygen-gas pressure is relieved through vents, and a significant portion of the cell's chemical contents may be lost in the process. The net effect is reduced cell life; therefore, resistor R1 should be selected to limit the charging current to a safe level.

To do this, break the circuit and insert a DC milliameter in series with B1. (Watch those polarities!) Expose the solar cells to the brightest sunshine they can expect to receive, and make note of the charging current. The recommended charging rates for various NiCd cells are: 50 mA for AA cells, and 100 mA for C or D cells. To obtain these currents, the suggested values of R1 are approximately 18 ohms (for AA cells) and 9.1 ohms (for C or D cells). With your milliameter, measure the actual charging current produced by your circuit with the resistor appropriate to your chosen cell size. If the current exceeds the safe level, replace R1 with a larger resistance. As a final note, be sure to select solar cells capable of supplying the desired charging current.

PARTS LIST FOR SOLAR BATTERY CHARGER

B1—1.25V rechargeable NiCd battery
D1—1N4001 rectifier diode
PC1 thru PC6—.5-volt silicon photovoltaic cell (see text)
R1—current-limiting resistor (see text)



2. Frequency Divider

☐ Mention the topic of frequency division, and immediately most of us start thinking in terms of TTL, CMOS or some similar family of digital integrated circuits. In fact, surprising though it may seem, frequency division can be readily accomplished without ICs using common discrete semiconductors—in this case, a unijunction transistor.

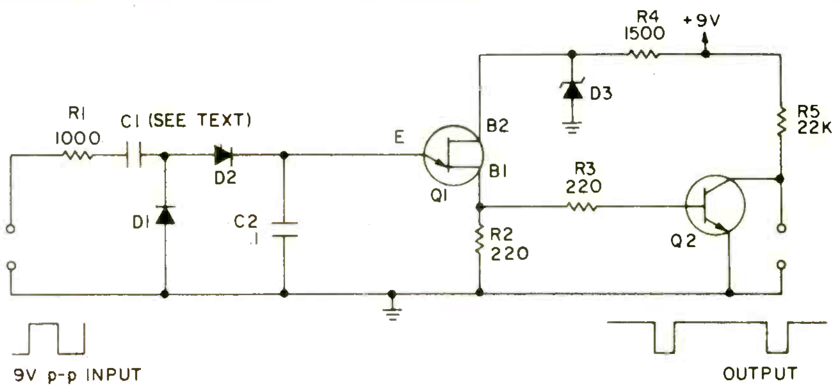
Capacitors C1 and C2 together with diodes D1 and D2 constitute a simple *charge pump*, which feeds the emitter of UJT Q1. Normally, C1 is chosen to be smaller than C2, and in this circuit values of C1 between .02 and .1 mf should be satisfactory. With each positive-going transition of the digital input signal, C1 transfers a small amount of charge to C2, which acts as a reservoir. This accumulated electronic charge is prevented from leaking away by D2. As successive input pulses transfer more and more charge to C2, the voltage across C2 naturally rises.

Eventually, the voltage on C2 will become high enough to cause Q1's emitter to break down and discharge C2 through R2. When this happens, Q2 amplifies and inverts the voltage pulse appearing across R2. This amplified pulse may then be used to clock a subsequent circuit. Q1's emitter reverts to a high-impedance state once again after C2 has been discharged. Thus, the whole process can repeat itself.

The ratio of C2 to C1 will determine the number of positive-going input pulses needed to accumulate the necessary threshold potential on C2. With C2 equal to C1, the frequency will be divided by a factor of 1. The higher the C2:C1 ratio, the more input pulses needed and, as a result, the greater the frequency division obtained. This circuit is sensitive to the magnitude of its input pulses, so keep the input amplitude at 9 volts, or thereabouts. Satisfactory performance with input signals as high as 10 kHz will be obtained with the parts listed.

PARTS LIST FOR FREQUENCY DIVIDER

C1—mylar capacitor, .02-.1 uF (see text)
C2—.1 uF mylar capacitor
D1, D2—1N914 silicon diode
D3—1N751A 5.1V, ½W zener diode
Q1—2N2646 unijunction transistor
Q2—2N3904 NPN transistor
R1—1,000-ohm, ½-watt resistor, 10%
R2, R3—220-ohm, ½-watt resistor, 10%
R4—1,500-ohm, ½-watt resistor, 10%
R5—22,000-ohm, ½-watt resistor, 10%



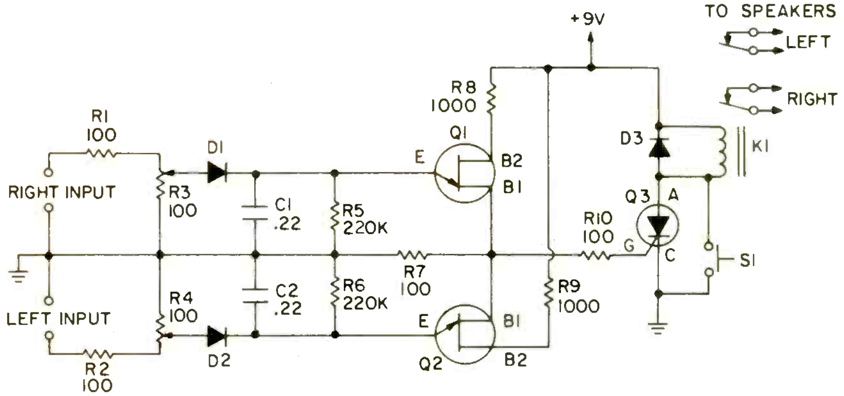
3. Stereo Speaker Protector

☐ The advent of the superamplifier, capable of supplying 100 to 200 watts per channel on a continuous basis, has been both a blessing and a curse to the audiophile. The blessing is that a recording's dynamic range can now be more faithfully reproduced, even with inefficient loudspeakers. Unfortunately, these amps are so powerful that loudspeakers can often be overdriven, and eventually destroyed, if sufficient care is not exercised. If your amp lacks provisions for speaker protection, you may want to build the speaker protector diagrammed here.

The contacts of relay K1 are hooked in series with your right- and left-hand speakers in such a way that, when K1 is unenergized, its contacts close and complete the circuit to each loudspeaker.

Inputs to the protection circuit come from your amp's outputs (the same outputs that drive the speakers). If the signal feeding the 'right' input is sufficiently large to charge C1 to a potential greater than the breakdown voltage of Q1's emitter, a voltage pulse will appear across R7. Similarly, excessive inputs to the 'left' channel will also produce a pulse across R7, this time due to the discharge of C2 by Q2. The pulse across R7 triggers SCR Q3, which latches in a conducting state and energizes K1. This interrupts both speaker circuits, and the resulting silence should alert you to a problem. Cut back on your amp's volume; then, press and release S1 to reset the circuit and restore normal operation.

The circuit can be adjusted to trip at lower levels from 15 to 150 watts rms. To calibrate, feed a deliberately excessive signal to the 'right' input, and raise R3's wiper up from ground until K1 pulls in. Disconnect the signal from the 'right' input, and apply



PARTS LIST FOR STEREO SPEAKER PROTECTOR

C1, C2—.22 uF mylar capacitor
D1, D2, D3—1N914 silicon diode
K1—6-volt relay, DPDT contacts (see text)
Q1, Q2—2N2646 unijunction transistor (Radio Shack RS2029)
Q3—2N5060 sensitive-gate SCR
R1, R2—100-ohm, ½-watt resistor, 10%
R3, R4—100-ohm linear-taper potentiometer
R5, R6—220K-ohm, ½-watt resistor, 10%
R7, R10—100-ohm, ½-watt resistor, 10%
R8, R9—1,000-ohm, ½-watt resistor, 10%
S1—N.O. pushbutton switch

it to the 'left' input. Press S1 to reset the circuit, and raise R4's wiper up from ground until K1 pulls in again. The circuit is now calibrated. Your calibration signal should preferably be a continuous tone, but a musical passage of fairly constant loudness will probably suffice. K1's contacts should be rated to carry a 3- to 5-amp load.

4. Neon Audio Oscillator

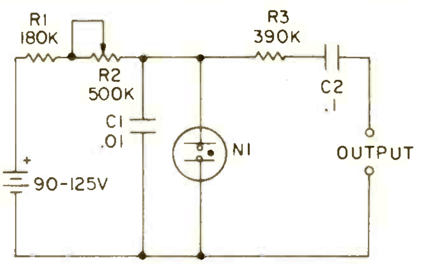
☐ Here is a circuit that may be somewhat surprising to newcomers, though old-timers should recognize it right away. This is an audio oscillator that exploits the unique characteristics of the neon lamp. Basically, a neon bulb consists of two electrodes surrounded by neon gas plus, if the lamp is intended for use in total darkness, a small quantity of radioactive material. (Radiation serves to partially ionize the neon gas. Bulbs designed to operate in room light will have their neon gas partially ionized by ambient electromagnetic radiation; therefore, no radioactive material need be added.)

So little of the neon gas is ionized initially that, for all practical purposes, the neon lamp behaves electrically like a very high resistance. However, if the voltage between its electrodes is raised sufficiently high, the neon gas within the lamp will ionize completely. This causes the lamp to revert to a low-resistance state and glow with a bright orange color. To turn the lamp off, the voltage across its electrodes must drop several volts below the potential that originally triggered the lamp.

In the relaxation-oscillator circuit shown here, C1 charges through R1 and R2 to a potential of roughly 65 volts. At this point, the neon lamp fires and discharges C1. After firing, the neon lamp reverts to a high impedance, which allows C1 to charge once again. The frequency of the sawtooth-shaped oscillation developed across C1 can be adjusted by means of R1. As a final note, beware of the high voltages present in this circuit.

PARTS LIST FOR NEON AUDIO OSCILLATOR

C1—.01 uF, 250V mylar capacitor
C2—.1 uF, 250V mylar capacitor
N1—NE-2 neon lamp
R1—180K-ohm, ½-watt resistor, 10%
R2—500K linear-taper pot
R3—390K-ohm, ½-watt resistor, 10%

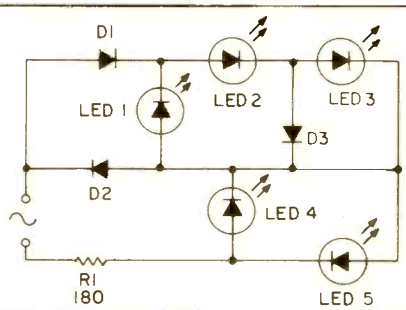


5. Diode Puzzle

☐ This innocuous-looking little circuit will provide a good indication of how well you really understand the rectifier diode and the light-emitting diode. Your task is to determine which of the five LEDs will light up when 6.3 volts AC is applied to the circuit. We won't give you the answer; to find that out, just breadboard the circuit. However, we will supply you with a couple of hints. First, the forward voltage drop of a rectifier diode is approximately .8 volt, while that of an LED is about 2 volts. Naturally, rectifiers conduct current in one direction only. LEDs will light up only when their anodes (arrows) are 2-volts more positive than their cathodes (bars). Finally, you can expect to find 3 LEDs lit and 2 LEDs dark. Pencils sharpened? OK, begin.

PARTS LIST FOR DIODE PUZZLE

D1, D2, D3—1N4001 rectifier diode
LED1 thru LED5—red light-emitting diodes
R1—180-ohm, ½-watt resistor, 10%



6. Photoelectronic Annunciator

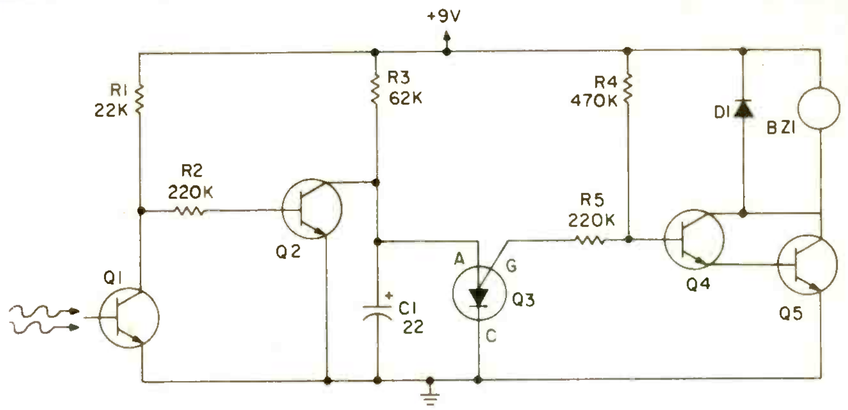
☐ Momentarily interrupt the beam of light shining on Q1, and you get a one-second "beep" from this circuit. Most likely you've encountered circuits of a similar nature in retail stores, where the buzzing sound signals your entrance and alerts salesmen to their prey. Obviously, a great many other applications are possible as well.

With light shining on Q1's sensitive face, the phototransistor conducts heavily and shunts current away from the base of Q2. But when the beam of light is interrupted, Q1 ceases to conduct—thus allowing current to flow through R1 and R2 into Q2's base. The collector of Q2 then conducts current and rapidly discharges capacitor C1. This allows Q3's gate lead (G) to swing high, thereby turning on Q4, Q5 and the buzzer.

Assuming that the interuption of the beam was only temporary, Q2's collector will now have ceased to conduct current. This allows C1 to charge until it reaches a level sufficient to trigger Q3, a programmable unijunction transistor (PUT). When that happens (in about 1 second), Q3's gate potential drops, which turns off Q4, Q5 and the buzzer. Another interruption will repeat the whole process and yield one more "beep."

PARTS LIST FOR PHOTOELECTRONIC ANNUNCIATOR

- **BZ1**—piezoelctronic buzzer, 6-9 VDC
- **C1**—22 uF, 16V electrolytic capacitor
- **D1**—1N914 silicon diode
- **Q1**—FPT-100 NPN phototransistor
- **Q2, Q4, Q5**—2N3904 NPN transistor
- **Q3**—2N6027 programmable unijunction transistor
- **R1**—22,000-ohm, ½-watt resistor, 10%
- **R2 R5**—220K-ohm, ½-watt resistor, 10%
- **R3**—62,000-ohm, ½-watt resistor, 10%
- **R4**—470K-ohm, ½-watt resistor, 10%



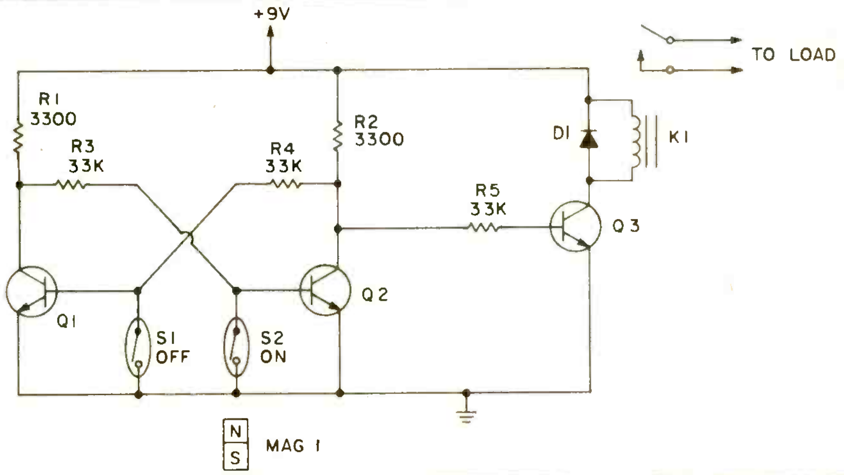
7. Magnetic Latch

☐ Here is a circuit that enables you to turn a device ON and OFF using a small, permanent magnet. Bring your magnet close to S2, and the reed switch will close. This shunts all current away from Q2's base and sends its collector potential high. As a result, base drive is available for Q1 and Q3. Transistor Q3 obliges by conducting and thereby causing relay K1's contacts to close. Q1 conducts too, and this sends Q1's collector to ground potential. Therefore, when you remove your magnet from S2, Q2 remains latched in a non-conducting state, since Q1's collector is low.

Now, suppose you approach S1 with your magnet. Once the reed switch closes, it shunts base current from Q1, thus causing Q1's collector potential to go high. As a result, Q2 receives base current that causes it to conduct, which sends its collector to ground potential. This removes base drive from Q3, so K1 is no longer energized. When you remove your magnet, the circuit remains latched in this OFF condition, since Q2's grounded collector cannot supply base current to transistor Q1.

PARTS LIST FOR MAGNETIC LATCH

- **D1**—1N914 silicon diode
- **K1**—6-volt, 500-ohm relay
- **Mag1**—small permanent magnet
- **Q1, Q2, Q3**—2N3904 NPN transistors
- **R1, R2**—3300-ohm, ½-watt resistor, 10%
- **R3, R4, R5**—33,000-ohm, ½-watt resistor, 10%.
- **S1, S2**—magnetic reed switches

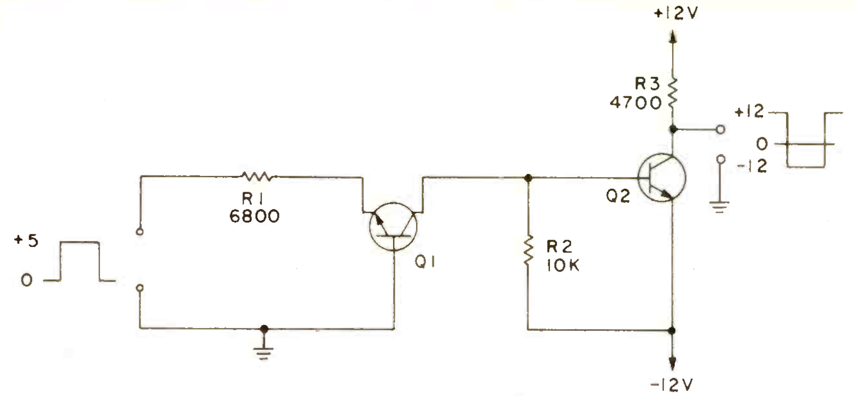


8. TTL-to-RS232C Converter

☐ If you happen to be a computer hobbyist, no doubt you are familiar with the EIA's RS-232C standard, which governs certain aspects of the communication between a computer and its peripherals. By peripherals, of course, we mean things like a CRT terminal, a printer, a modem or whatever else you could dream up. By convention, a high signal is defined by RS-232C as being greater than +3 volts, but no greater than +15 volts. Low signals, on the other hand, must be less than −3 volts, but no less than −15 volts. The region from −3 volts to +3 volts is a limbo area, and signals within this range do not qualify as valid input/output (I/O).

The problem that confronts many an experimenter is one of interfacing a project to his computer. In most instances, digital devices will be based on TTL circuitry, the maximum signal excursion of which is from ground to +5 volts. However, a more typical TTL signal would swing from +.4 volt to +3.5 volts. How do you convert such a signal to levels acceptable to the RS-232C convention?

It's easy, and requires just two transistors. Common-base stage Q1 acts as a level-shifter that couples the TTL signal to Q2, a saturating switch. Q2's output swings between −12 volts and +12 volts, levels compatible with RS-232C. Note that this is an inverting circuit: High inputs yield low outputs, and vice-versa. Since computer-to-peripheral communication usually requires several I/O lines, you will need to build one converter for each line in use. Also, see the companion converter that follows.

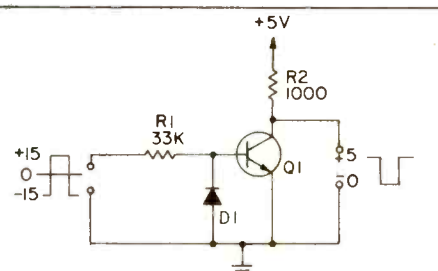


PARTS LIST FOR TTL-TO-RS232C CONVERTER

Q1, Q2—2N3904 NPN transistors
R1—6800-ohm, ½-watt resistor, 10%
R2—10,000-ohm, ½-watt resistor, 10%.
R3—4700-ohm, ½-watt resistor 10%

9. RS232C to TTL Converter

☐ There are two sides to the interfacing problem introduced by the previous project. Not only must TTL signals be converted to RS-232C levels, but RS-232C signals may have to be converted to TTL, too. Fortunately, the latter problem is even simpler to solve than the former. All that's needed is a simple saturating switch, Q1, with its base protected by a diode. (This prevents the negative excursion of the RS-232C signal from breaking down the emitter/base junction of Q1.) As was the case in the previous project, you must build one converter for each signal line to be interfaced.



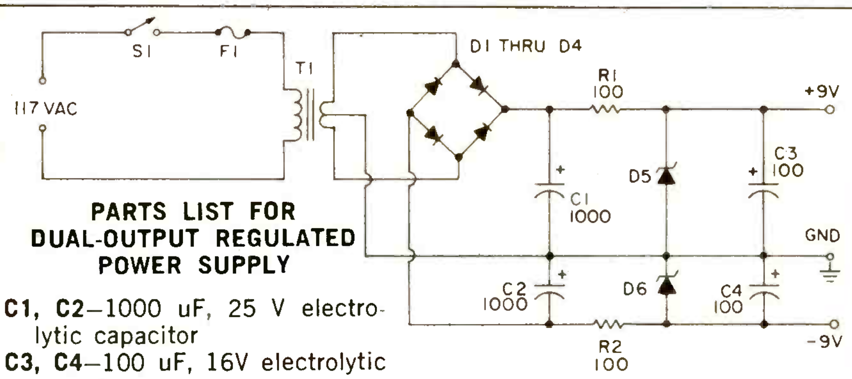
PARTS LIST FOR RS232C-TO-TTL CONVERTER

D1—1N914 silicon diode
Q1—2N3904 NPN transistor
R1—33,000-ohm, ½-watt resistor, 10%
R2—1000-ohm, ½-watt resistor, 10%

10. Dual-Output Regulated Control

☐ Those of you who experiment with op amps know that them little critters demand a split power supply in most instances. If you've been making do with batteries, you might like to step up in class with the simple, dual-output, regulated power supply diagrammed here. Not only will you be able to experiment with op amps, but you can also use either the positive or negative half of the supply by itself when dual outputs are not needed.

Center-tapped transformer T1 feeds four rectifier diodes arranged in the familiar full-wave-bridge configuration. Opposing taps on the bridge furnish positive and negative rectified current to filter capacitors C1 and C2. Conventional shunt-type zener-



PARTS LIST FOR DUAL-OUTPUT REGULATED POWER SUPPLY

C1, C2—1000 uF, 25 V electrolytic capacitor
C3, C4—100 uF, 16V electrolytic capacitor
D1 thru D4—1N4002 rectifier diodes
D5, D6—9-volt, 1-watt zener diodes
F1—⅛ A, slow-blow fuse
R1, R2—100-ohm, 1-watt resistor, 10%
S1—SPST switch
T1—24 VCT, 300 mA transformer

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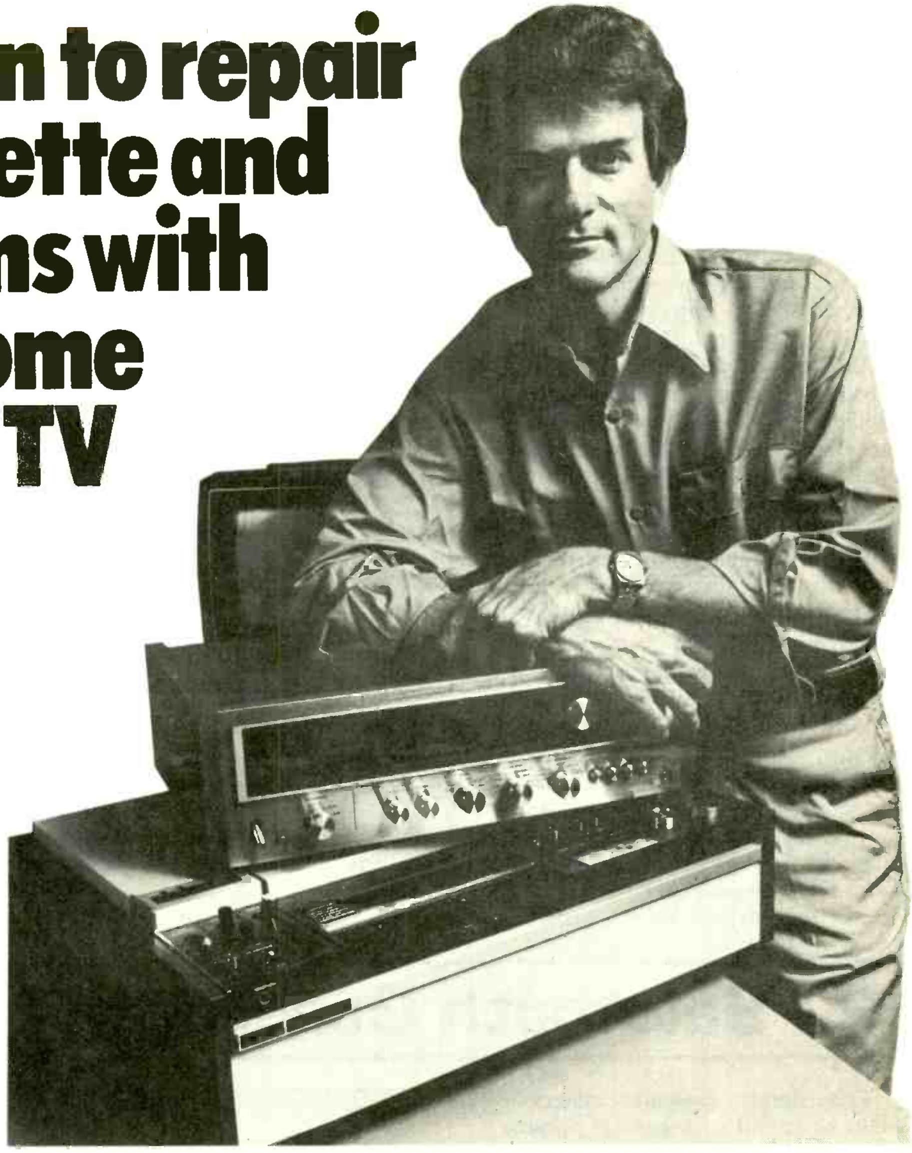

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diode voltage regulators (D5 and D6), fed by current-limiting resistors R1 and R2, provide output voltages of +9V and −9V. You can draw between zero and 40 mA from either half of this supply with no ill effect.

11. UJT Tester

☐ Having read this far in the book, you must certainly have noticed that a number of our projects feature unijunction transistors. The unijunction, or UJT to you abbreviators, cannot be used in linear circuits (such as amplifiers) in the same way that a conventional bipolar transistor can. Instead, you will find the UJT in timing and oscillating circuits for the most part. In order to test a UJT, therefore, it appears logical that a representative timing circuit should be used to do the job.

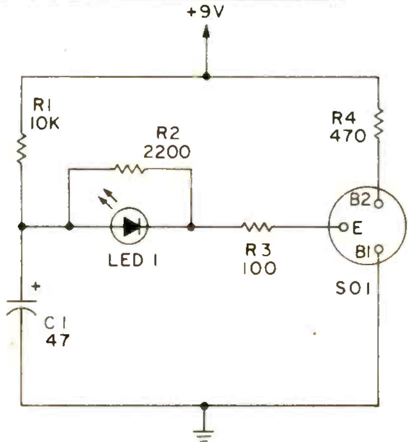
To operate the UJT tester presented here, begin by plugging your unijunction into SO1. This circuit is similar to the classical UJT relaxation oscillator, except that an LED and current-limiting resistor (R3) have been inserted in series with the emitter lead. Initially, capacitor C1 will charge up through R1, and the voltage on C1 will gradually rise.

Once the potential on C1 becomes large enough to force the UJT's emitter to break down, C1 gets discharged through LED1, R3 and the UJT's emitter. After discharge, the emitter terminal returns to a high-impedance state, and the capacitor charges once more.

Each time the capacitor discharges through the LED, a flash of light is produced. This serves as a simple GO/NO GO indication of the UJT's ability to oscillate. Resistor R2 is used to swamp the LED's high impedance in the OFF state, thus enabling the UJT to break down more readily.

PARTS LIST FOR UJT TESTER

C1—47 uF, 16V electrolytic capacitor
LED1—red light-emitting diode
R1—10,000-ohm, ½-watt resistor, 10%
R2—2200-ohm, ½-watt resistor, 10%
R3—100-ohm, ½-watt resistor, 10%
R4—470-ohm, ½-watt resistor, 10%
SO1—transistor socket

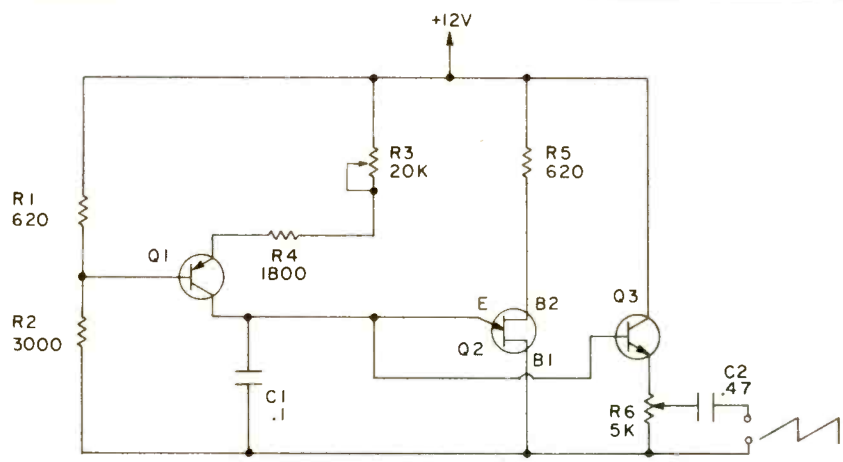


12. Sawtooth Generator

☐ This simple sawtooth generator should be useful as a general-purpose source of audio test signals. Here we have a basic UJT oscillator, but instead of using a resistor to charge the timing capacitor, a transistor constant-current source (Q1) is employed instead. This results in a sawtooth that rises linearly as a function of time, since the capacitor's charging rate is constant. When a simple resistor is used to charge a capacitor, the waveform produced is curved like a shark fin, since the charging current falls off as the voltage on the capacitor increases.

The charging current available from constant-current source Q1 is adjustable by means of R3. The higher the current, the quicker C1 gets charged, and the higher the frequency of the resultant sawtooth voltage developed across the capacitor. Therefore, decreasing R3 increases the frequency. With the values shown, the generator's output frequency can be varied from roughly 100 to 1000 Hz.

Since unijunction Q2 breaks down and discharges capacitor C1 very



PARTS LIST FOR SAWTOOTH GENERATOR

C1—.1 uF mylar capacitor
C2—.47 uF mylar capacitor
Q1—2N3906 PNP transistor
Q2—2N2646 unijunction transistor
Q3—2N3904 NPN transistor
R1, R5—620-ohm, ½-watt resistor, 10%
R2—3000-ohm, ½-watt resistor, 10%
R3—20,000-ohm trimmer
R4—1800-ohm, ½-watt resistor, 10%
R6—5K audio-taper pot

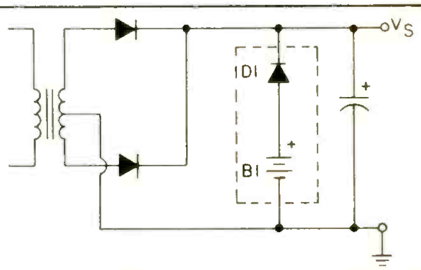
quickly, we get a near-perfect sawtooth shape: slow, linear ascent, and rapid, vertical decline. Emitter follower Q3 acts as a buffer between C1 and whatever load you connect. Maximum peak-to-peak amplitude is roughly 6 volts, which level control R6 allows to be cut down to any convenient voltage level needed.

13. Battery Back-Up

☐ Sometimes, it is advantageous to supplement a conventional AC power supply with battery back-up. In case of a power failure, the battery cuts in so that the circuit in question can function without interruption. Burglar alarms, computer memory boards, and timing or control systems are a few of the circuits that can benefit from battery back-up.

PARTS LIST FOR BATTERY BACK-UP

B1—Battery of appropriate size (see text)
D1—1N4001 silicon rectifier diode



The accompanying schematic shows how easy it is to add battery back-up to an existing AC supply. Under normal conditions with AC power intact, voltage Vs on the supply's filter capacitor exceeds the voltage of battery B1. As a result, diode D1 is reverse-biased, and it prevents supply current from flowing into battery B1.

When the line voltage fails, Vs starts to drop. Once it reaches a level about 1-volt less than the battery voltage, it stops dropping. At this point, battery B1 is powering the circuit through D1.

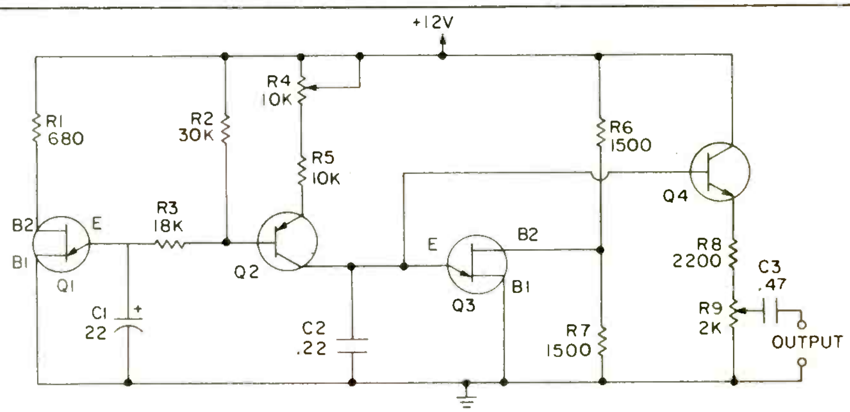
Let's suppose Vs equals 11 volts. We could choose a battery voltage somewhat less than this—for example, 9 volts. Once the power fails, our circuit will be running on about 8 volts (9V minus 1V for the diode drop). Many circuits can tolerate a diminished supply potential with no ill effect. Make sure your choice of battery can supply all the current demand.

14. The Obnoxillator

☐ This little audio oscillator emits a sound that's obnoxious to both man and beast, which is why we call it an obnoxillator. The tone starts out at a relatively high pitch which, over a period of about one second, swoops downward in frequency. Then, the signal jumps abruptly to its initial pitch and commences its downward plunge once more. The effect is approximately as pleasant as running your nails over a blackboard, and as such it will get people's attention—if not their admiration.

Q1 together with R1, R2, R3 and C1 comprise a conventional UJT relaxation oscillator with a period of approximately one second. The roughly sawtoothed voltage developed across C1 drives current source Q2, the output of which charges capacitor C2. Adjustment of R4 affects the magnitude of the current and, hence, the rate at which capacitor C2 charges. Unijunction transistor Q3 discharges C2 when the voltage on the capacitor reaches 4.2 volts, or so. The rate at which the voltage on C2 oscillates is in the audio range and is much faster than that of the waveform developed across C1.

After C2's discharge, the capacitor once again gets charged up by current from Q2. Since Q2's charging current is a function of the voltage across C1, the rate at which C2 charges will vary (in fact, diminish) over the 1-second interval it takes for C1 to charge. Once Q1 discharges C1,



PARTS LIST FOR OBNOXILLATOR

C1—22 uF, 25V electrolytic capacitor
C2—.22 uF mylar capacitor
C3—.47 uF mylar capacitor
Q1, Q3—2N2646 unijunction transistor
Q2—2N3906 PNP transistor
Q4—2N3904 NPN transistor
R1—680-ohm, ½-watt resistor, 10%
R2—30,000-ohm, ½-watt resistor, 10%
R3—18,000-ohm, ½-watt resistor, 10%
R4—10,000 trimmer
R5—10,000-ohm, ½-watt resistor, 10%
R6, R7—1,500-ohm, ½-watt resistor, 10%
R8—2,200-ohm, ½-watt resistor, 10%
R9—2,000-ohm audio-taper pot

Q2's charging current returns to a high value, and the frequency of the sawtooth waveform across C2 jumps back to its initial high value.

Emitter follower Q4 reads the signal developed on C2 and provides a buffered audio output with a maximum peak-to-peak amplitude of about 1-volt. Volume control R9 can be used to vary the magnitude of the output, which should drive an audio amplifier through its high-level input.

15. Electrolytic Capacitor Tester

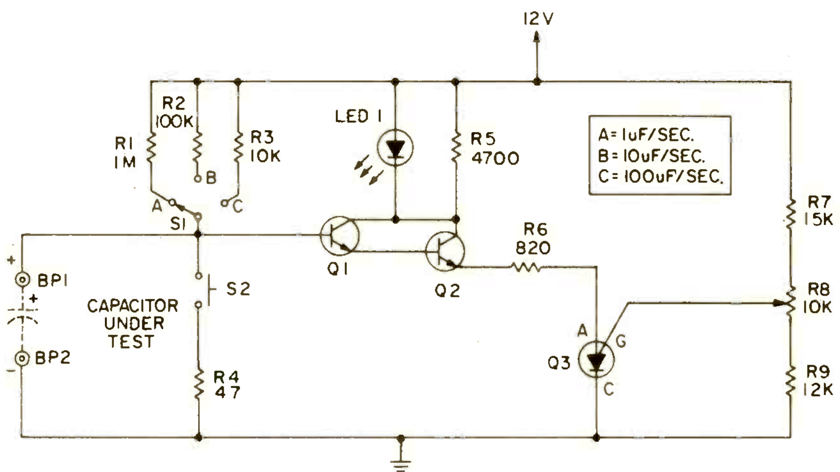
☐ In conjunction with a watch or clock capable of resolving seconds, this simple circuit can be used to measure the value of any electrolytic capacitor. With the capacitor in question connected to the binding posts (watch polarities), press and release S2; then, time how long it takes for LED1 to come on.

Multiply the time by the appropriate scale factor, and you have the capacitance. For example, suppose S1 is in position B, and that 19 seconds have elapsed before the lighting of LED1. The capacitance is then equal to:

19 sec × 10 uF/sec = 190 uF.

Circuit theory is quite simple. As the capacitor charges (through R1, R2 or R3), the voltage on the capacitor rises. Darlington pair Q1-Q2 buffers the capacitor voltage and feeds it to the anode terminal of Q3. When the capacitor voltage reaches a certain threshold level, determined by the setting of R8, the anode of programmable unijunction transistor Q3 breaks down and allows current to flow through R6, which lights LED1. The amount of time necessary for the voltage on a capacitor to rise to a specified level through a given reasistance is directly proportional to the size of the capacitor. So, by measuring the charging interval, we also measure the capacitance. To reset the circuit and discharge the capacitor, just press and release S2.

To calibrate the circuit, you will need a 22-uF tantalum electrolytic capacitor. Set S1 to position A (1 uF/sec), and set R8 to its midpoint. Connect the capacitor to the binding posts, then press and release S2. Time how long it takes before LED1 lights. If it takes longer than 22 seconds, move R8's wiper downward slightly. If less than 22 seconds elapse, move R8's wiper upward slightly. Repeat the process until it takes exactly 22 seconds for LED1 to light. Calibration is now complete.



PARTS LIST FOR ELECTROLYTIC CAPACITOR TESTER

BP1, BP2—binding posts
LED1—light-emitting diode
Q1, Q2—2N3904 NPN transistor
Q3—2N6027 programmable uni junction transistor
R1—1 Megohm, ½-watt resistor 5%
R2—100K-ohm, ½-watt resistor, 5%
R3—10,000-ohm, ½-watt resistor, 5%
R4—47-ohm, ½-watt resistor, 10%
R5—4700-ohm, ½-watt resistor, 10%
R6—820-ohm, ½-watt resistor, 10%
R7—15,000-ohm, ½-watt resistor, 10%
R8—10,000-ohm trim pot
R9—12,000-ohm, ½-watt resistor, 10%
S1—SP3T rotary switch
S2—N.O. pushbutton switch

16. Audio Power Meter

☐ This tiny power meter will enable you to measure the output of any audio amplifier over the range from 1 to 100 watts rms. Resistor R1 acts as a dummy load for the amp being tested. If you cannot locate the 8-ohm, 100-watt resistor specified in the parts list, a series-parallel combination of smaller resistors could be lashed together as a substitute. However, the 100-watt resistor in question is available from several mailorder electronics distributors and from a number of surplus dealers as well.

The audio voltage impressed across R1 is rectified by D1 and stored as a DC potential on capacitor C1. Meter M1's deflection will be directly proportional to this voltage. Note that two power ranges, 0-10 and 0-100 watts, are available.

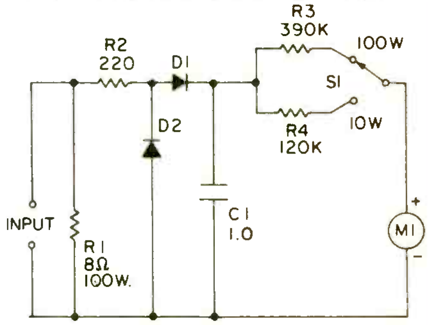
Because M1's deflection is directly proportional to voltage, readings will not be a linear function of power. Instead, M1's deflection will be proportional to the square root of the power, so a conversion scale must be used to transform the reading on M1 into watts. For example, from the accompanying chart it can be seen that a meter reading of 71 corresponds to a power level of 50 watts rms. The only point where the meter reading is identical with the power is at the 100-watt mark.

When the 0-10 watt scale is being used, simply divide the wattage figures in our conversion table by 10. For example, a reading of 90 on the 0-10 watt range corresponds to an audio power of 8 watts rms. Readings on the 0-10 watt range will not be as accurate as those on the 0-100 watt range because the .8-volt diode drop across D1 will assume greater significance. For most purposes, however, this small error (10% worst case) can be ignored, since relative power levels are usually of greater interest than absolute levels.

WATTS	READING
10	31
20	44
30	54
40	63
50	71
60	78
70	84
80	90
90	96
100	100

PARTS LIST FOR AUDIO POWER METER

C1—1.0 uF, 100V mylar capacitor
D1, D2—1N914 silicon diode
R1—8-ohms, 100-watt (see text) resistor
R2—220-ohm, ½-watt resistor, 10%
R3—390,000-ohm, ½-watt resistor, 10%
R4—120,000-ohm, ½-watt resistor, 10%



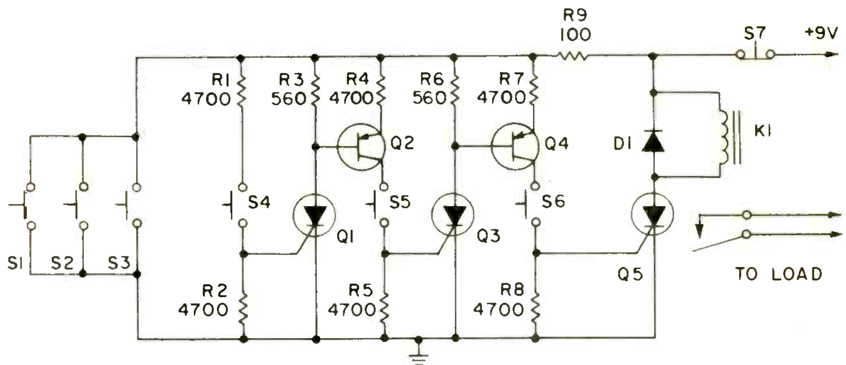
M1—0-100 uA DC microameter
S1—SPDT switch

17. Sneaky Combination Lock

☐ Now you can lock up your valuable electronic equipment and prevent tampering with this handy electronic combination lock. Press S4, S5 and S6 in sequential order (the switches can be mounted in any physical order), and you latch K1 in the ON state, thus turning on your load in the process. Hitting S7 momentarily will reset the circuit.

When S4 is pressed, gate current is supplied to Q1, which causes this SCR to latch in a conducting state. This pulls current through R3 and turns on current source Q2. Consequently, when S5 is later pressed, Q2 is able to supply a pulse of gate current to Q3, thereby latching this SCR. At the same time, current source Q4 is activated by the latching of SCR Q3. Thus, when S6 is pressed, Q4 supplies a pulse of gate current that latches Q5 in a conducting state. As a result, relay K1 pulls in.

Whenever one of the dummy switches—S1, S2, S3—is pressed, Q1 and Q3 are reset to their non-conducting states. Therefore, whenever a potential intruder hits one of these dummies, he defeats his own attempt at picking your lock. Pressing S7 removes power from the circuit and unlatches all the SCRs—Q5 included. Relay K1 therefore gets de-energized, and your circuit is locked up tight.



PARTS LIST FOR SNEAKY COMBINATION LOCK

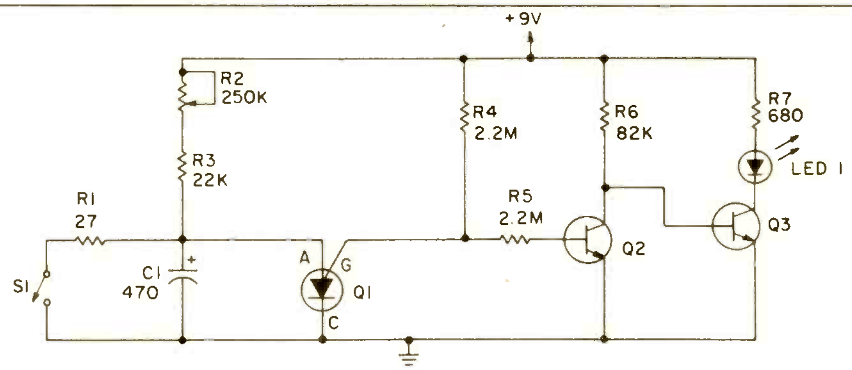
D1—1N914 silicon diode
K1—6-volt, 500-ohm relay
Q1, Q3, Q5—2N5060 sensitive-gate SCR
Q2, Q4—2N3906 PNP transistor
R1, R2, R4, R5, R7, R8—4700-ohm, ½-watt resistor, 10%
R3, R6—560-ohm, ½-watt resistor, 10%
R9—100-ohm, ½-watt resistor, 10%
S1 thru S6—normally open pushbutton switch
S7—normally closed pushbutton switch

18. Timer

☐ Need an inexpensive means of timing events from 10 seconds to 2 minutes in duration? If so, then this circuit is for you. With switch S1 closed, capacitor C1 is completely discharged, and the gate potential of programmable unijunction transistor Q1 is high. Thus, Q2 is turned on, Q3 is turned off, and LED1 is extinguished.

Once S1 is opened, capacitor C1 begins to charge through R2 and R3. The larger the resistance of R2, the more slowly C1 charges. As the voltage on C1 climbs, it eventually exceeds the threshold potential of Q1's anode: about 5.3 volts. When this happens, Q1's gate drops low—thereby turning Q2 off and Q3 on. LED1 then lights up to indicate the end of the timed interval. (Sharp-eyed readers may note that Q1's configuration is similar to that of a relaxation oscillator. Although this is true, Q1 does not oscillate; it merely latches, since the resistance of R2 and R3 is so low as to preclude oscillation.)

To reset the circuit, you must discharge C1 by closing S1. With the aid of a clock equipped with a second hand, it is possible to calibrate a dial scale for R2 using increments of 10 seconds, or so.



PARTS LIST FOR TIMER

C1—470 uF, 25V electrolytic cap.
LED1—red light-emitting diode
Q1—2N6027 programmable unijunction transistor
Q2, Q3—2N3904 NPN transistor
R1—27-ohm, ½-watt resistor, 10%
R2—250,000 linear-taper potentiometer
R3—22,000-ohm, ½-watt resistor, 10%
R4, R5—2.2-megohm, ½-watt resistor, 10%
R6—82,000-ohm, ½-watt resistor, 10%
R7—680-ohm, ½-watt resistor, 10%
S1—SPST toggle switch

19. Simple AND Gate

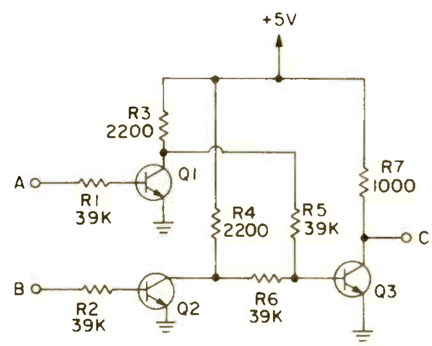
☐ If you want to build an AND gate without resorting to ICs, here is the way to do it. As can be seen from the schematic, all that's necessary is a handful of resistors and transistors. Although we would not recommend that you forsake ICs entirely, it's nice to know how to make do when integrated logic is unavailable.

The accompany truth table concisely describes the AND gate's operation. The 1s denote a high voltage level, while the 0s denote a low level (i.e., ground potential). Note that the only way to obtain a high output from an AND gate is to send both inputs high simultaneously.

PARTS LIST FOR SIMPLE AND GATE

Q1, Q2, Q3—2N3904 NPN transistor
R1, R2, R5, R6—39,000-ohm, ½-watt resistor, 10%
R3, R4—2,200-ohm, ½-watt resistor, 10%
R7—1,000-ohm, ½-watt resistor, 10%

A	B	C
0	1	0
1	0	0
0	0	0
1	1	1



20. Differential Thermometer

☐ In some instances, we are more interested in the temperature difference between two points than in the absolute value of the temperature at either point. Making such relative temperature measurements calls for a differential thermometer like the one diagrammed here.

To zero this instrument, place the two thermistors in close proximity, and allow a minute or two for them to reach thermal equilibrium. With R2 set for minimum resistance, adjust R3 to obtain a zero (center-scale) indication on meter M1. Now, leave the reference thermistor, RT2, right where it is, but move RT1 to a point at a different temperature.

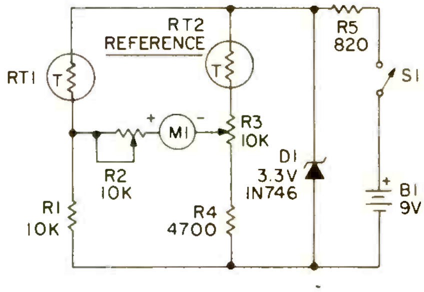
If RT1's new environment is warmer than the environment of RT2, RT1's resistance will decrease, and M1 will deflect upscale. Conversely, if RT1 is now colder than RT2, M1 will deflect downscale from zero. R2 may be used to vary the meter's sensitivity.

A note about components: Just about any negative-temperature-coefficient thermistor having a resistance of 10K ohms at 25° C. will do. Note that meter M1 should have its zero position at center scale, thus allowing for temperatures greater or less than the reference. Always re-zero the instrument when changing the reference temperature.

A possible application for this thermometer lies in estimating the effectiveness of forced-air cooling within a piece of equipment. Since the flow of cooling air within a computer or other piece of equipment is drastically altered once the cover is removed, an electronic differential thermometer of the sort described here is really the only practical way of identifying hot spots with the cover in place.

PARTS LIST FOR DIFFERENTIAL THERMOMETER

B1—9-volt transistor battery
D1—1N746, 3.3V, ½-watt zener diode
M1—50-0-50 uA DC microameter
R1—10,000-ohm, ½-watt resistor, 10%
R2, R3—10,000 linear-taper pot.
R4—4,700-ohm, ½-watt resistor, 10%
R5—820-ohm, ½-watt resistor, 10%
RT1, RT2—negative-temperature-coefficient thermistor, 10,000-ohms @ 25°C. (Fenwal UUT-41J1 or equivalent)
S1—SPST switch



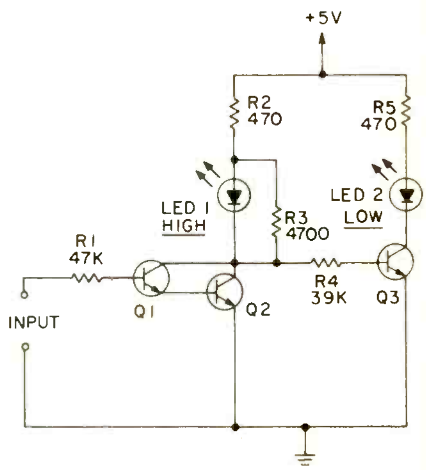
21. Logic Probe

☐ As most digital experimenters are aware, a logic probe is nothing more than a convenient tool to indicate whether the voltage at a circuit node is high or low. The simple probe presented here will do just that using two LEDs for output. If the input voltage exceeds approximately 1.5 volts, the Q1-Q2 Darlington pair is biased into conduction, and LED1 is illuminated.

On the other hand, if the input voltage is below Q1-Q2's switching threshold, Q1 and Q2 stop conducting. As a consequence, LED1 extinguishes, Q3 gets turned on, and LED2 lights. If you find that both LED1 and LED2 light during a test, it means that the input signal is oscillating between high and low levels. The 1.5-volt switching threshold of Q1-Q2 is a good match for TTL circuits.

PARTS LIST FOR LOGIC PROBE

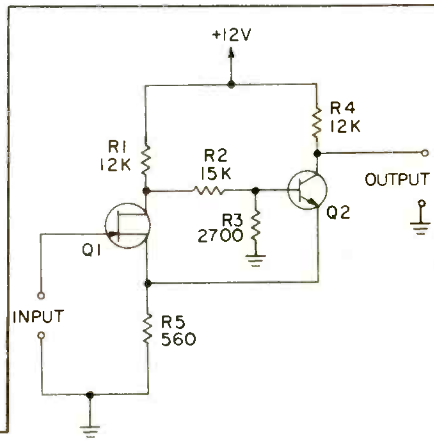
LED1—green light-emitting diode
LED2—red light-emitting diode
Q1, Q2, Q3—2N3904 NPN transistor
R1—47,000-ohm, ½-watt resistor, 10%
R2, R5—470-ohm, ½-watt resistor, 10%
R3—4,700-ohm, ½-watt resistor, 10%
R4—39,000-ohm, ½-watt resistor, 10%



22. Schmitt Trigger

☐ A Schmitt trigger is an interesting switching circuit with a wide variety of applications. Because of positive feedback—in this case, through R5—a Schmitt trigger exhibits switching hysteresis: The input signal must exceed some upper threshold voltage before the output goes high. Subsequently, in order to send the output low, the input signal must drop below some lower threshold value.

The difference between the lower and upper threshold potentials is called the hysteresis voltage. The higher the hysteresis, the larger the voltage swing needed at the input to make the output change state. This property makes the Schmitt trigger useful in digital systems as a sort of noise filter. If the magnitude of the interfering noise voltage appearing at the input is less than the hysteresis voltage, no false triggering due to noise will be possible. Play around with this circuit by feeding it potentials between ground and +12 volts (using a pot, for example), and see if you can identify the upper and lower switching thresholds.



PARTS LIST FOR SCHMITT TRIGGER

Q1—2N5950 n-channel JFET
Q2—2N3904 NPN transistor
R1, R4—12,000-ohm, ½-watt resistor, 10%
R2—15,000-ohm, ½-watt resistor, 10%
R3—2,700-ohm, ½-watt resistor, 10%
R5—560-ohm, ½-watt resistor

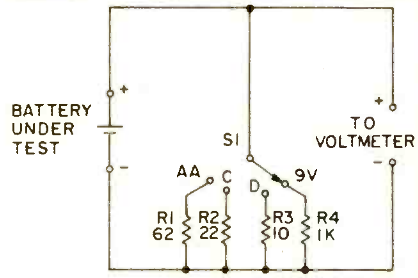
23. Battery Tester

☐ Perhaps you have seen the advertisements for battery testers and had a good chuckle at the ridiculously inflated prices being demanded. If you had the opportunity to disassmble one of these electronic marvels, all you would find would be a very cheap meter and a couple of resistors. In just a few minutes' time, you can lash together a battery tester yourself.

Resistors R1 through R4 provide suitable loads for the various battteries to be tested, while a VOM or an electronic multimeter is used to read the cell voltage. If the indicated voltage is much below the nominal battery potential, give your battery the heave-ho, and buy another. Resistors R1, R2 and R3 have been selected as loads for ordinary 1.5-volt, zinc-carbon AA, C and D cells, respectively, while R4 is appropriate for the standard 9-volt, zinc-carbon, transistor-radio battery. When a 1.5-volt cell registers 1.2 volts, it is relatively weak. By the time it reaches 1.0-volt, it's done for.

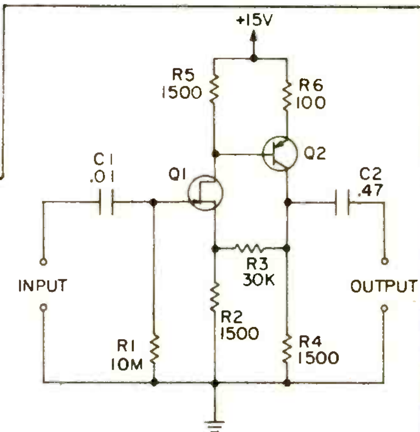
PARTS LIST FOR BATTERY TESTER

R1—62-ohm, ½-watt resistor, 10%
R2—22-ohm, ½-watt resistor, 10%
R3—10-ohm, ½-watt resistor, 10%
R4—1,000-ohm, ½-watt resistor, 10%
S1—SP 4-position rotary switch



24. High-Input-Impedance Amp

☐ If you need a really high-impedance amplifier, you can't do better than this little circuit. Its input impedance is essentially 10 Megohms in the audio range, and the voltage gain is approximately 20. For best results, keep the input signal small—50 millivolts or less. You can vary the gain to some extent by changing the value of resistor R3. Higher values increase the gain, while lower values diminish it.



PARTS LIST FOR HIGH-INPUT-IMPEDANCE AMP

C1—.01 uF mylar capacitor
C2—.47 uF mylar capacitor
Q1—2N5950 n-channel JFET
Q2—2N3906 PNP transistor
R1—10 Megohm, ½-watt resistor, 10%
R2, R4, R5—1,500-ohm, ½-watt resistor, 10%
R3—30,000-ohm, ½-watt resistor, 10%
R6—100-ohm, ½-watt resistor, 10%

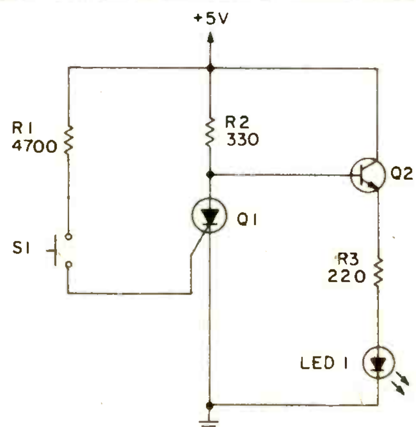
25. Power Failure Indicator

☐ The purpose of this little device may seem a little obscure. After all, when the lights go out, there must have been a power failure, so who needs a special circuit to detect the obvious? It just so happens, however, that many failures are either momentary or incomplete, so we are never aware of them. To certain types of electronic circuits, unfortunately, even a brief power outage can be disasterous. Control systems, computer systems, even your AC-powered digital clock can all go awry when the juice is cut off.

To the rescue comes our little power-failure indicator. It will alert

PARTS LIST FOR POWER FAILURE INDICATOR

LED1—red light-emitting diode
Q1—2N5060 sensitive-gate SCR
Q2—2N3904 NPN transistor
R1—4,700-ohm, ½-watt resistor, 10%
R2—330-ohm, ½-watt resistor, 10%
R3—220-ohm, ½-watt resistor, 10%
S1—normally open pushbutton switch

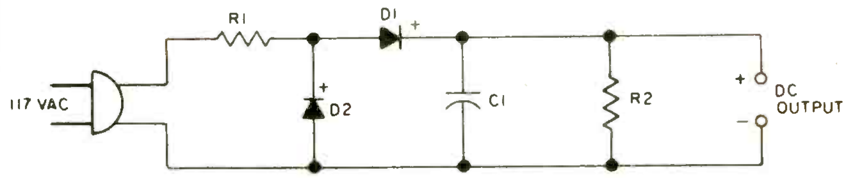


you to even the briefest power failure so that you can take whatever corrective action is necessary. The indicator is set by pressing S1, which injects gate current into SCR Q1. Consequently, Q1 latches in a conducting state with its anode potential low. If the power is interrupted, then Q1 will be in an unlatched state once normal power is restored. Since Q1 is not conducting, base current flows into Q2, and LED1 lights up. This alerts you to the fact that power was off. To reset the circuit, just press S1 again. LED1 will be off until the next power interuption.

26. 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

D1, D2—Silicon rectifiers rated 200 PIV minimum

Output V	I max*	R1	C1	R2
12	1 mA	43,000-ohm, ½-watt	250-uF, 15-VDC	180,000-ohm, ½-watt
12	2 mA	22,000-ohm, ½-watt	250-uF, 15-VDC	100,000-ohm, ½-watt
25	2 mA	18,000-ohm, ½-watt	250-uF, 30-VDC	180,000-ohm, ½-watt

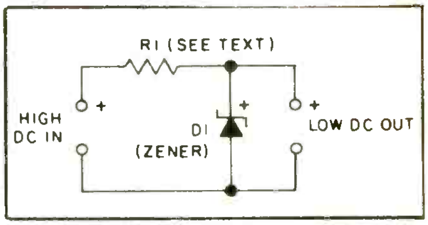
*For lower current, decrease value of R2

27. 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.



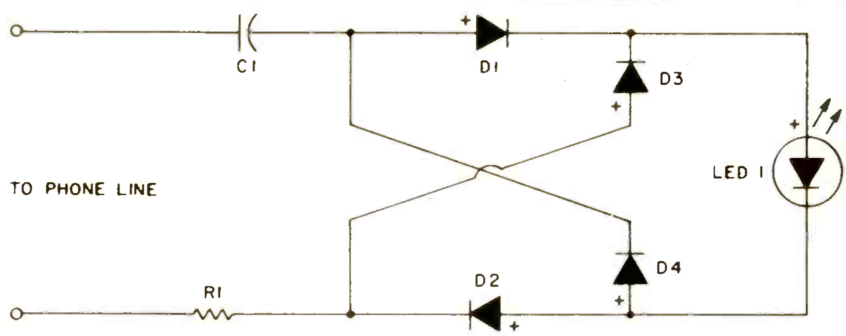
28. LED Telephone Ring Indicator

☐ 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-uF capacitor
D1, D2, D3, D4—Diode, 1N914 or equiv.
LED1—Light emitting diode
R1—82,000-ohm resistor, ½-watt



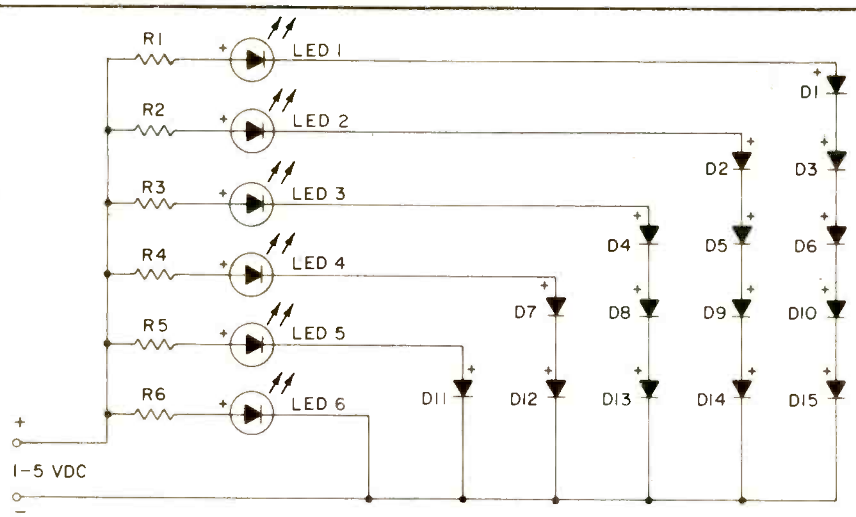
29. LED Bar Graph Display

☐ 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 germanium, 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 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:

$$Ein = Em \times \frac{Rin}{Rsum}$$



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

30. Stereo Beat Filter

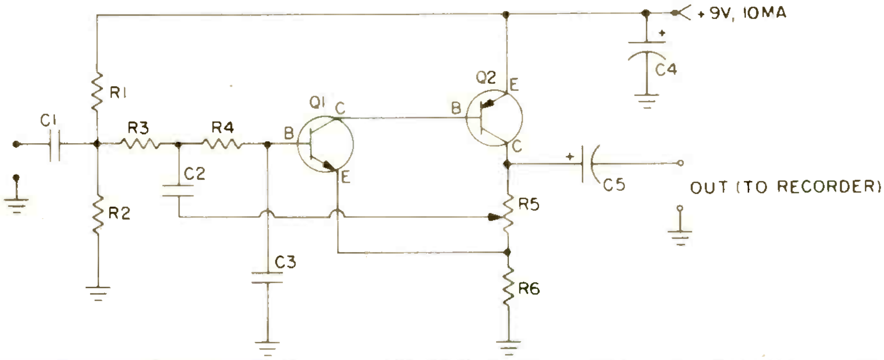
☐ Many early stereo tuners, and quite a number of modern budget priced stereo tuners, have considerable output at 19 kHz and 38 kHz from the stereo pilot system. While these frequencies aren't heard, they can raise havoc if they leak through to a Dolby noise reduction encoder, or if the frequencies beat 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-uF
C2, C3—220-pF, 2% silver mica or equiv.
C4—25-uF
C5—1-uF
Q1—Transistor, Radio Shack 276-2009
Q2—Transistor, Radio Shack 276-2021

31. 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.

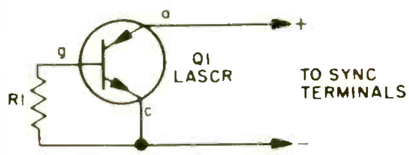
To operate, provide a 6-in. length of stiff wire for the anode and cathode connections and terminate the wires in a polarized power plug that matches the sync terminals on your electronic flashgun (strobelight). Make certain the anode lead connects to the *positive* sync terminal.

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, ½-watt resistor

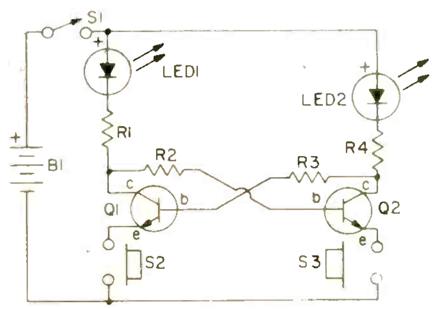


32. Quick Draw Game

☐ 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, ½-watt
R2, R3—22,000-56,000-ohm resistors, ½-watt
S1—SPST switch (see text)
S2, S3—Normally open momentary, or micro, switches

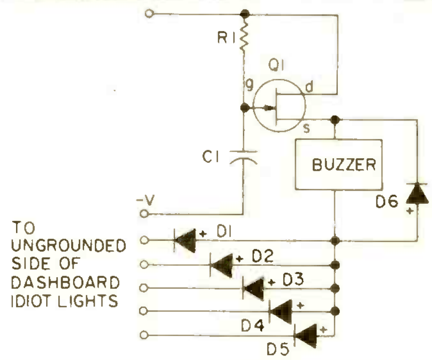
33. Idiot's Delight

☐ Sometimes the dashboard idiot lights aren't warning enough that something's gone awry. Bright sunlight, a burned-out lamp or simply a lack of attention can obviate Detroit's brilliant efforts. But this simple 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-uF capacitor
D1, D2, D3, D4, D5, D6—Diode, 1N914 or equiv.
Q1—FET (Field Effect Transistor), 2N5458 or equiv.
R1—470,000-ohm resistor, ½-watt



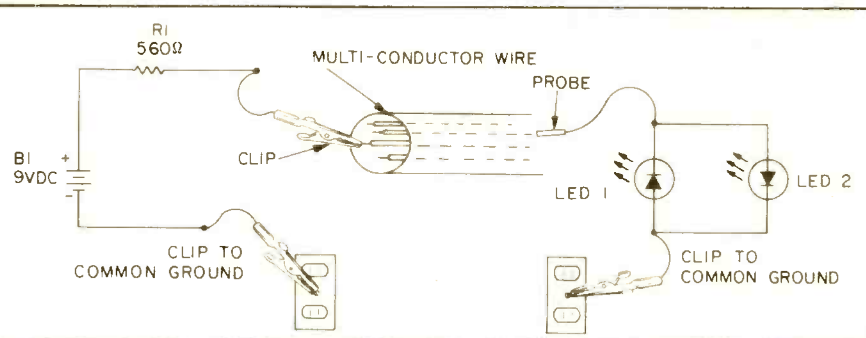
34. Wire Tracer

☐ 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, ¼-watt resistor
Misc.—3 alligator clips, 1 test probe



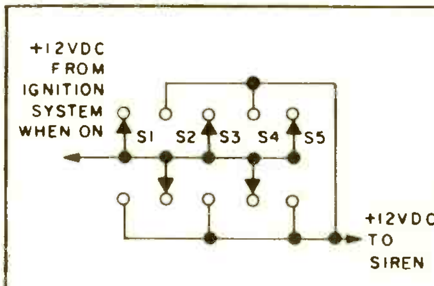
35. Automobile Ignition Maze

☐ 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.

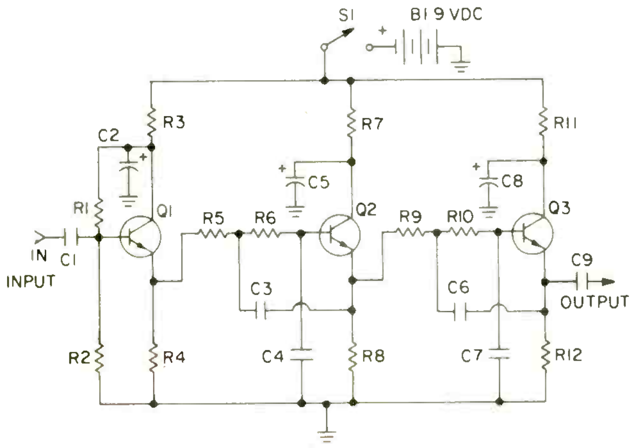
The switches can be "sporty" auto accessory switches sold individually or in switch banks such as G.C. 35-916. Provide labels such as "Carburetor Heater," "Window Washer," etc. and no one will know the car is wired for "sound."



36. 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.



PARTS LIST FOR LOW PASS AUDIO FILTER

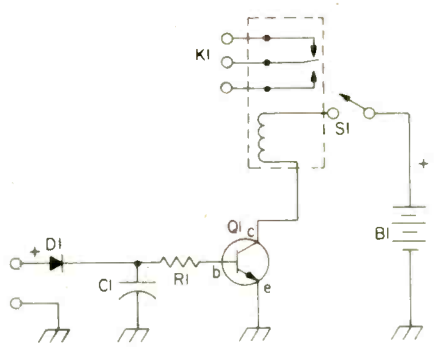
B1—6 to 12-volt battery
C1, C3, C6—0.1-uF, 25-VDC mylar capacitor
C2, C5, C8—22-uF, 20-VDC tantalum capacitor
C4, C7—0.02-uF, 25-VDC mylar capacitor
C9—1.0-uF, 25-VDC non-polarized mylar capacitor
Q1, Q2, Q3—2N3391 NPN transistor
Note: All resistors rated ½-watt, 5% tolerance unless otherwise noted.
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

37. 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 earphone 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 discharges 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).



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

38. Slide Show Stopper

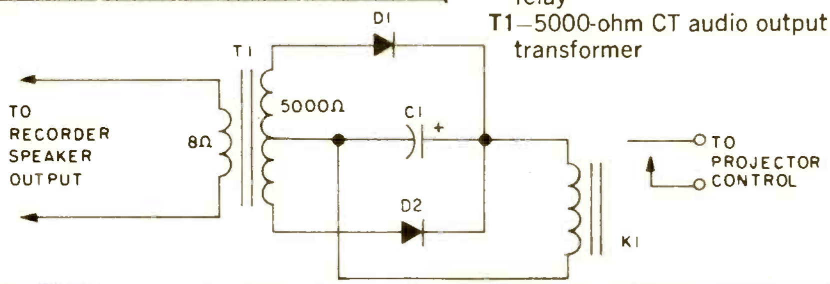
☐ Soundless slide shows are dull, dull, dull! But a stereo recorder can automate the whole show so slides change automatically in step with the commentary.

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-uF, 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



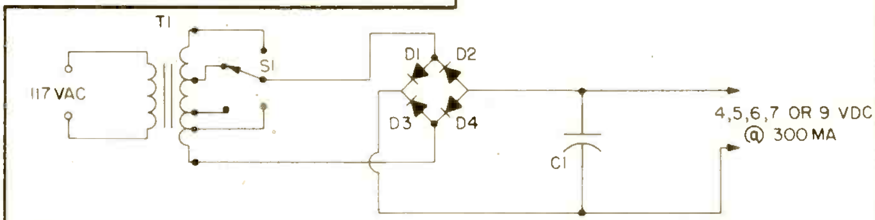
39. AC Adaptor

☐ 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

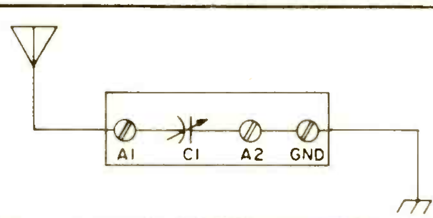
T1—Adaptor transformer, Calectro D1-743
D1-D4—Any silicon rectifier rated at least 25 PIV at 0.5 A.
C1—2000-uF, 15 VDC capacitor
S1—Any switch that can provide 4PST.



40. Add An Antenna Trimmer

☐ One part? That's all, but it can make a big difference in your shortwave listening. The American Radio Relay League's *ARRL Handbook*, the ham operator's "bible," can help you understand the complex nature of radio waves and how this circuit (is one part a circuit?) helps your antenna match your receiver at any given frequency.

But for right now, all you need to know is that when you add this trimmer (or connect it to these leads through coax, but only a very short length), you can adjust it to make your receiver really hot wherever it's tuned. It works by helping your receiver take advantage of all the signal your antenna can pick up. Try it and see.



PARTS LIST FOR ADD AN ANTENNA TRIMMER

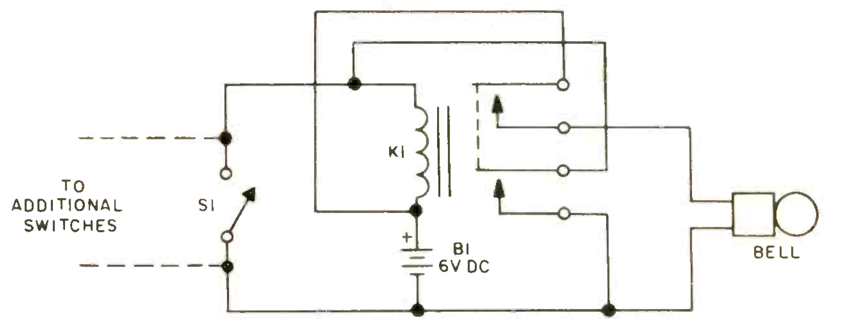
C1—60-pf trimmer

41. 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.



PARTS LIST FOR LATCHING BURGLAR ALARM

B1—6-V lantern battery
BELL—6-VDC alarm bell
K1—6-VDC dpst relay
S1—Spst n.o. switch

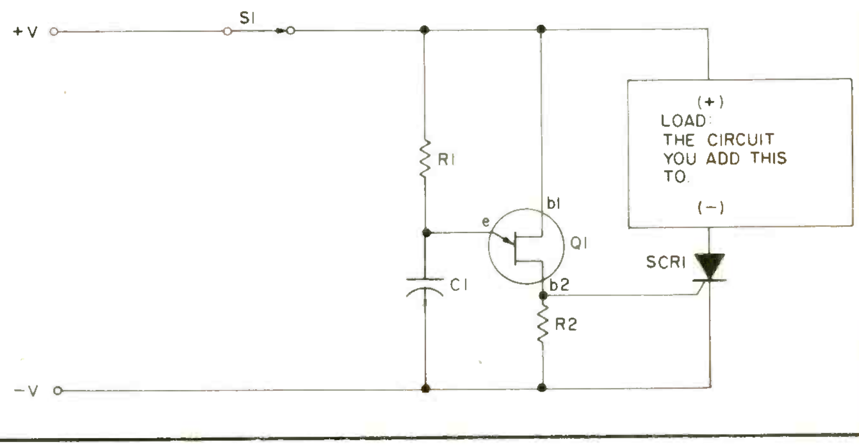
42. Turn-on Delay

☐ 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.

PARTS LIST FOR TURN-ON DELAY

C1—220-uF capacitor
Q1—UJT (Unijunction Transistor), 2N2646 or equiv.
R1—47,000-ohm resistor, ½-watt
R2—22-ohm resistor, ½-watt
SCR1—See text
S1—SPST



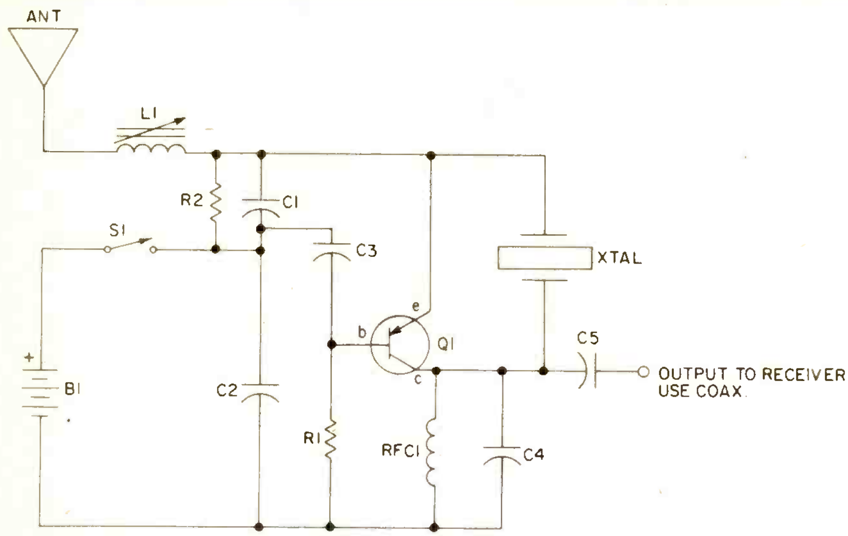
43. SWL's Low Band Converter

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

L1 is a standard broadcast loop-stick 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-uF capacitor
C3—.001-uF capacitor
C5—50-pf capacitor
L1—Loopstick coil
Q1—PNP transistor, 2N3906 or equiv.
R1—470,000-ohm resistor, ½-watt
R2—330-ohm resistor, ½-watt
RFC—2.5 mH choke
S1—SPST switch
XTAL—3.5 MHz crystal

44. Wide Range Voltage Pilot

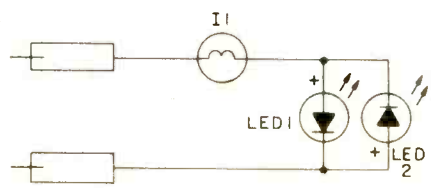
☐ Believe it or not, this simple tester will verify voltages between 2 and 120 Volts, AC or DC—and tell you which!

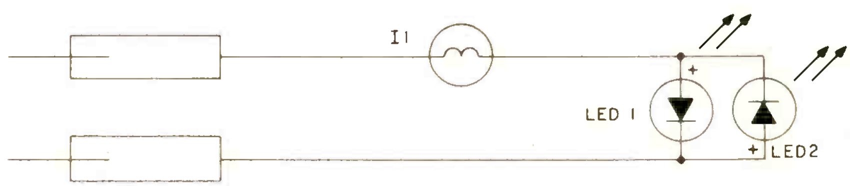
It's easy to understand if you can think of the filament of a small night-light bulb as being a wirewound resistor. It provides the current limiting that LED 1 and LED 2 need to operate safely. And, of course, when the voltage at the probe tips is high enough, I1 lights as well.

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.

PARTS LIST FOR WIDE RANGE VOLTAGE PILOT

I1—Bulb, 7½ watts at 120-volts
LED1, LED2—Light emitting diode





45. Stereo Balance Meter

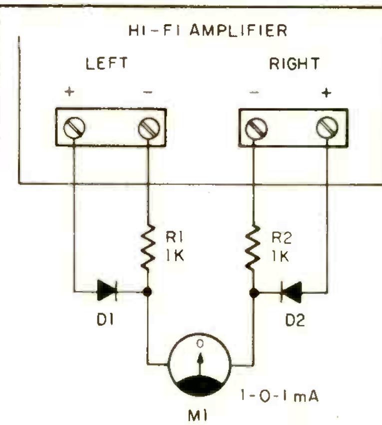
☐ One sure way to be certain your sound system is in perfect electrical balance is to use a power amplifier stereo balance meter to substitute for guesswork.

Meter M1 can be a zero-center DC milliammeter rated 1-0-1 mA or less. Alternately, you could use a standard meter but the pointer might be driven off-scale to the left while making adjustments, though the meter won't be damaged—it will just be an inconvenience.

Play any stereo disc or tape and then set the amplifier to *mono*. Adjust the left and right channel balance until meter M1 indicates zero; meaning the left and right output level are identical—that's balance.

PARTS LIST FOR STEREO BALANCE METER

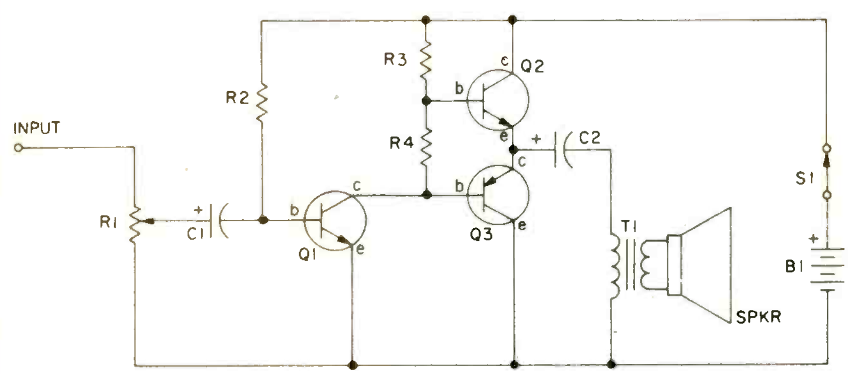
D1, D2—Silicon rectifier rated 100 PIV at any low current
M1—Zero-center DC mA meter (see text)
R1, R2—1000-ohm, ½-watt resistor, 5% or 1%



46. 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-uF electrolytic capacitor, 15 VDC (or greater than needed)
C2—100-uF 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, ½-watt
R3—1200-ohm resistor, ½-watt
R4—100-ohm resistor, ½-watt
S1—SPST switch
T1—500:8-ohm matching transformer
SPKR—8-ohm speaker

47. High Performance Transistor Radio

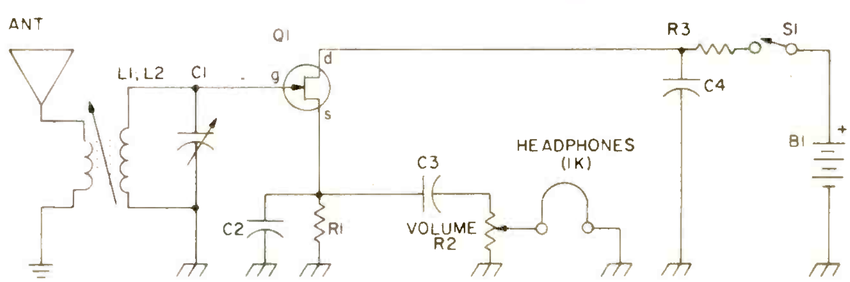
☐ Here's a neat way to update your crystal set, assuming you can still find it. Or use these few inexpensive parts to build from scratch. Instead of using a cat's whisker or a diode, this radio uses the very sensitive junction of a junction FET as its detector. This makes it a very "hot," very sensitive high impedance detector. Then the JFET does double duty by converting 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 bedspring, a windowscreen, 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, ½-watt
R2—20,000-100,00-ohm potentiometer
R3—4700-10,000-ohm resistor, ½-watt

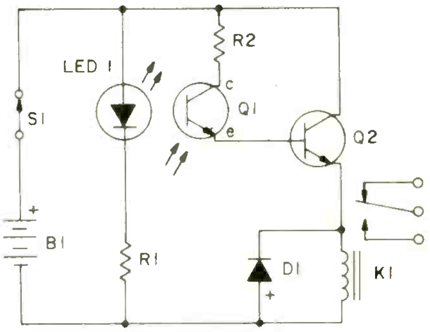
48. Photoelectric Tattletale

☐ 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 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.

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, ½-watt
R2—2700-ohm resistor, ½-watt
S1—SPST switch

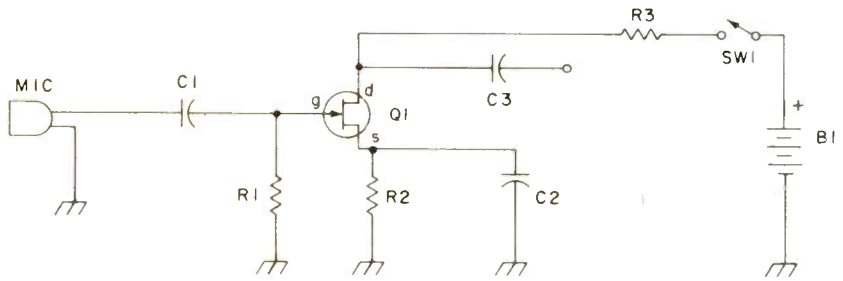


49. High Impedance Mike Amplifier

☐ 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-uF capacitors
C2—25-100-uF
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)

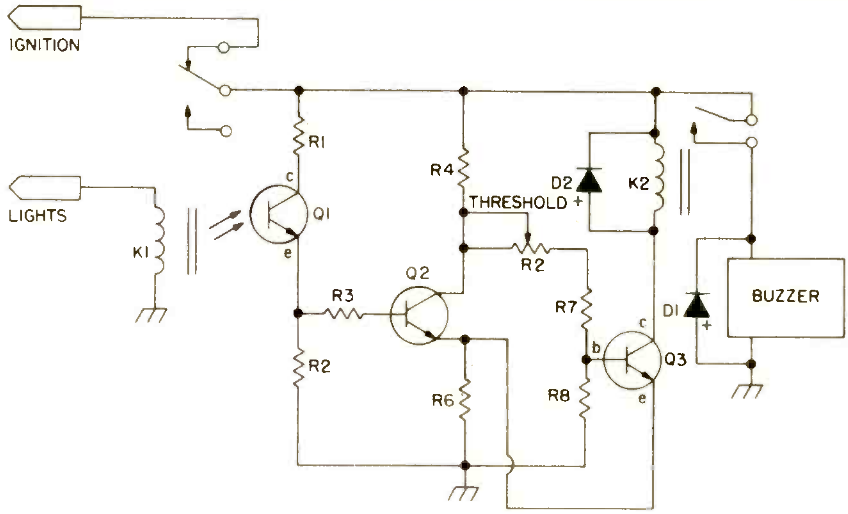
50. Highway Nightfall Alert

☐ 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
Q2—NPN transistor, 2N3904
Q3—NPN transistor, 2N2222
R1, R4, R7—4700-ohm resistor, ½-watt
R2—560-ohm resistor, ½-watt
R3, R8—10,000-ohm resistor, ½-watt
R5—10,000-ohm trimmer potentiometer
R6—220-ohm resistor, ½-watt

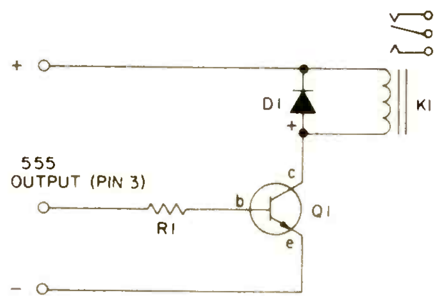


51. 555 Switch Hitter

☐ 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.

PARTS LIST FOR "555" SWITCH HITTER

D1—Diode, 1N914 or equiv.
Q1—NPN transistor, 2N2222 or equiv.
R1—1000-ohm resistor, ½-watt
K1—Relay, (rated at least equal to system voltage)

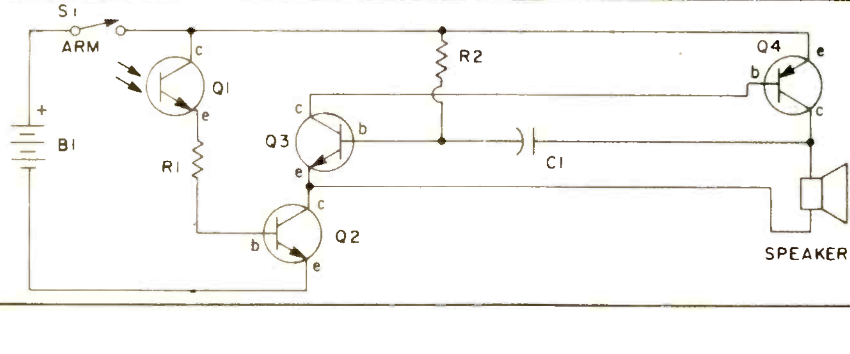


52. Attache Alarm

☐ 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. 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-uF capacitor
Q1—Photoelectric transistor, FPT 100 or equiv.
Q2—NPN transistor, 2N2222 or equiv.
Q3—NPN transistor, 2N3904 or equiv.
Q4—PNP transistor, 2N39Q06 or equiv.
R1—2200-ohm resistor, ½-watt
R2—100,000-ohm resistor, ½-watt
S1—SPST switch
SPKR—8-ohm speaker



53. 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).

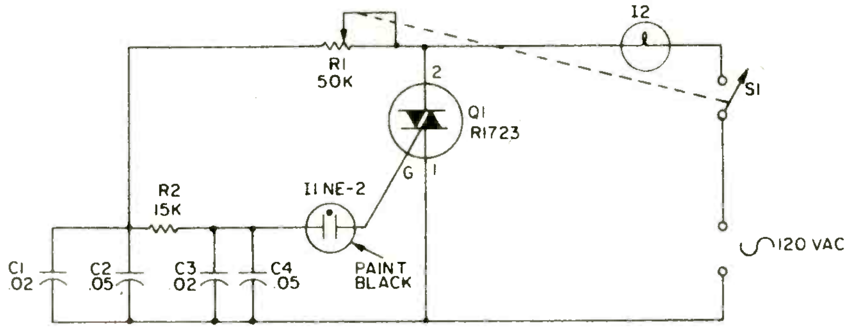
Triac Q1 can handle up to 75-watts without a heat sink. Over 75 watts, sink Q1 to the metal enclosure, or a small heat sink insulated from the socket (if you build the dimmer into a socket). If you mount Q1 on the enclosure, make certain none of the Triac's leads "short" to the enclosure. Use silicon 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.

PARTS LIST FOR BUDGET LAMP DIMMER

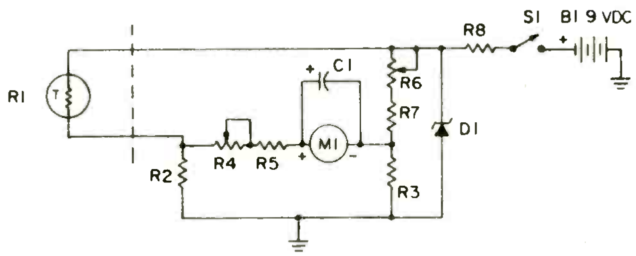
- **C1, C3**—0.02-uF, 50-VDC ceramic disc capacitor
- **C2, C4**—0.05-uF, 50-VDC ceramic disc capacitor
- **I1**—NE-2 neon lamp
- **I2**—75-watt or smaller standard lighting fixture
- **Q1**—HEP-R1723 Triac
- **R1**—50,000-ohm, linear taper potentiometer
- **R2**—15,000-ohm, ½-watt resistor
- **S1**—SPST switch (part of R1)



54. 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

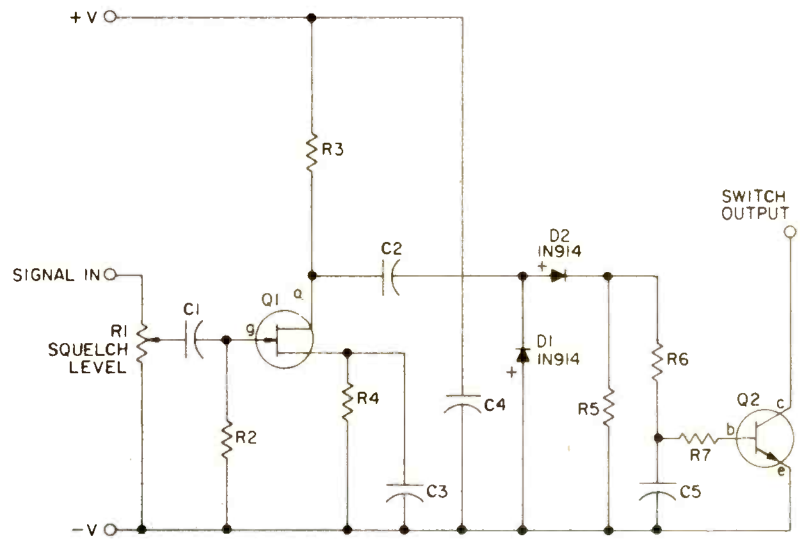
55. Sensitive Squelch

☐ 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, ½-watt
R3—12,000-ohm resistor, ½-watt
R4—3300-ohm resistor, ½-watt
R5—3.3-Megohm resistor, ½-watt
R6, R7—1000-ohm resistor, ½-watt



56. 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.

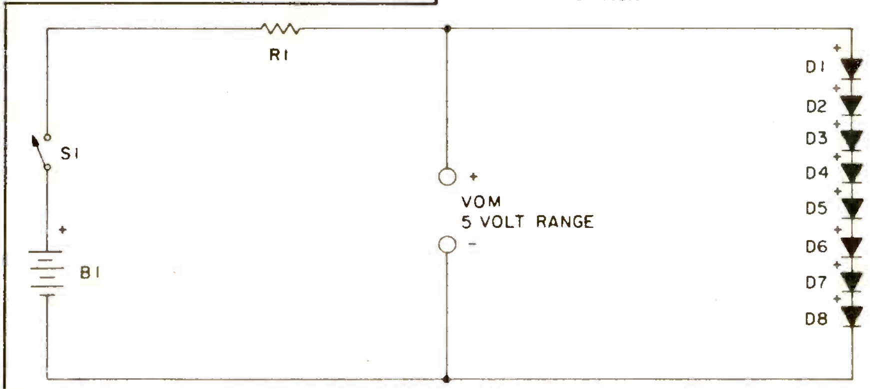
Almost every semiconductor device shows a junction voltage drop of about ½ Volt when forward biased, as the diodes here are.

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.

PARTS LIST FOR A VOM THERMOMETER

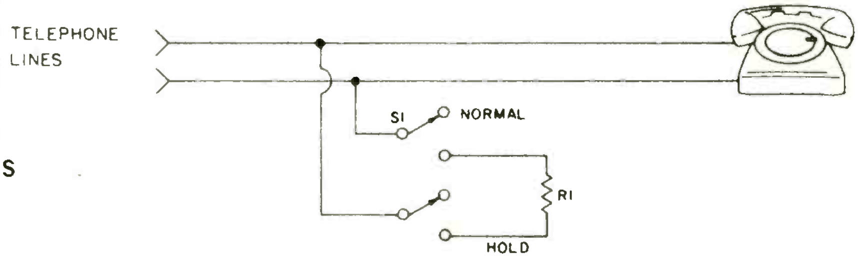
B1—9 VDC battery
D1, D2, D3, D4, D5, D6, D7, D8, D9—Diode, 1N914 or equiv.
R1—4700-ohm resistor, ½-watt
S1—SPST switch



57. 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, ½-watt
S1—DPDT switch

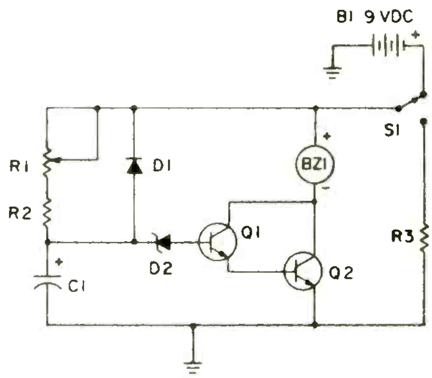
58. Tom Thumb's Timer

☐ We're 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

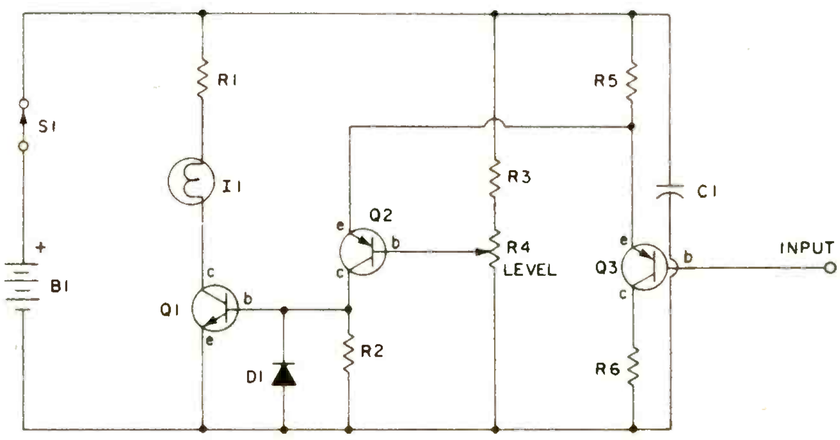
B1—9-volt transistor battery
BZ1—9-VDC buzzer (Radio Shack #273-052)
C1—470-uF, 25-VDC electrolytic capacitor
D1—1N4002 diode
D2—1N748A, 3.9-volt, ½-watt zener diode
Q1, Q2—2N3904 NPN transistor
R1—200,000-ohm trimmer potentiometer
R2—62,000-ohm, ½-watt, 5% resistor
R3—330-ohm, ½-watt, 5% resistor
S1—SPDT slide switch



59. 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 voltage (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 voltage 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.



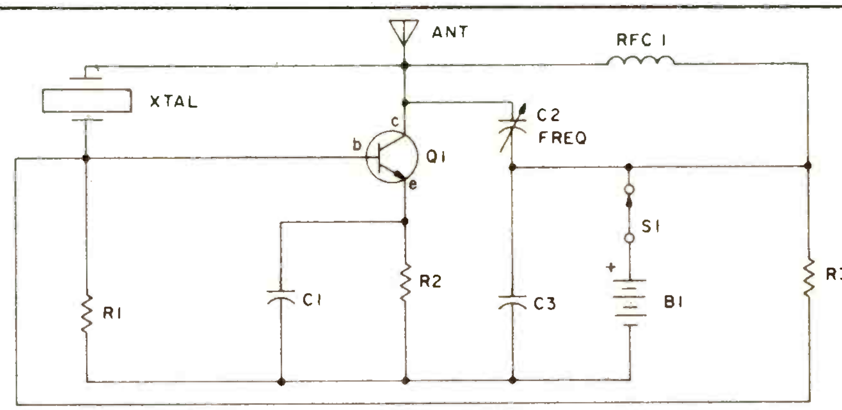
PARTS LIST FOR LEVEL DETECTOR

B1—9VDC battery
C1—.1-uF 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, ½-watt
R2—5600-ohm resistor, ½-watt
R3—100,000-ohm resistor, ½-watt
R4—1-Megohm potentiometer
R5—3300-ohm resistor, ½-watt
R6—1000-ohm resistor, ½-watt
S1—SPST switch

60. Fox Hunt Transmitter

PARTS LIST FOR FOX HUNT TRANSMITTER

B1—9 VDC battery
C1, C3—.001-uF capacitor
C2—90-pF variable capacitor
Q1—NPN transistor, 2N2222 or equiv.
R1—10,000-ohm resistor, ½-watt
R2—470-ohm resistor, ½-watt
R3—47,000-ohm resistor, ½-watt
RFC1—2.5 mH radio frequency choke
S1—SPST switch
XTAL—crystal cut for the 49 MHz band



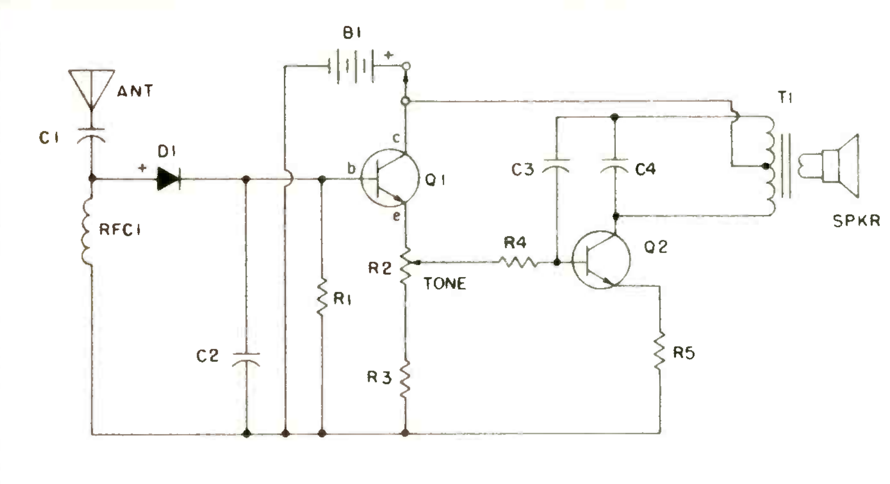
☐ Ever been to a radio foxhunt? Everyone brings a portable radio and a very directional antenna and tries to find where a small transmitter has been hidden. First one to find it wins. And here's just the transmitter to bring this old ham radio game to the rest of us. Transistor Q1 acts as a crystal oscillator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

61. 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-uF 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

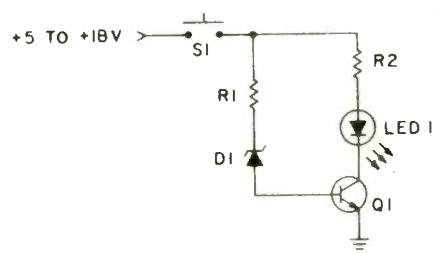
62. Battery Monitor

☐ 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-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

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, ½-watt resistor, 5%
R2—680-ohm, ½-watt resistor, 5%
S1—normally open SPST push-button switch

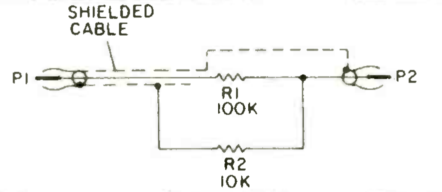


63. Computer Recording Attenuator

☐ 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 impossible.

If you have trouble recording your programs, try installing this attenuator cable between the computer's "output to recorder" and the recorder's *auxillary* 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

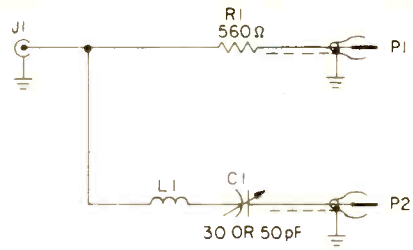
P1, P2—plugs to match existing equipment
R1—100,000-ohm, ¼-watt resistor
R2—10,000-ohm, ¼-watt resistor

64. 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.



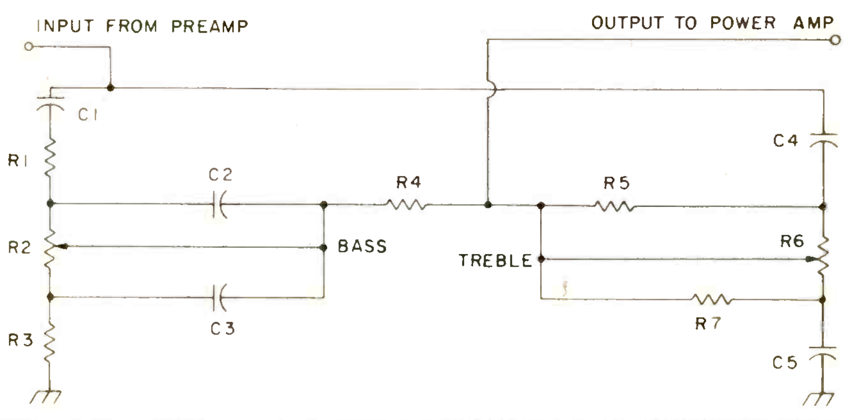
PARTS LIST FOR DISGUISED CB ANTENNA MATCHER

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

65. 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 experimenting 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 components 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

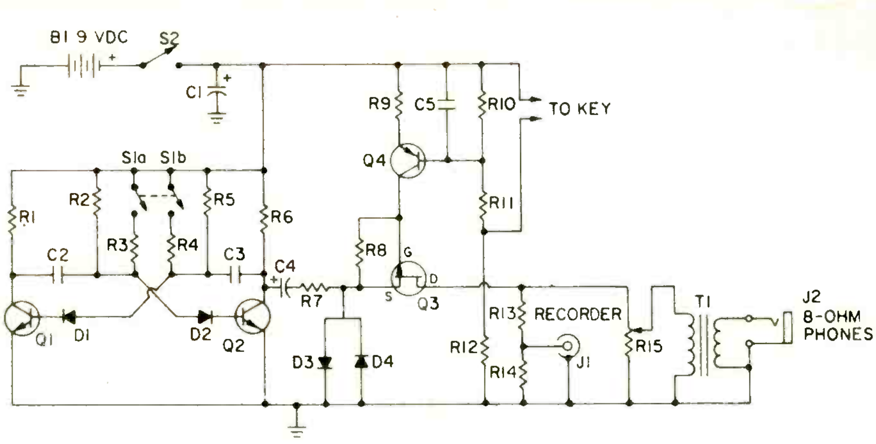
C1, C5—.068-.2-uF capacitors
C2—.033-.068-uF capacitor
C3—.33-.68-uF capacitor
C4—.005-.02-uF capacitor
R1, R4, R5—1500-ohm resistors, ½-watt
R2, R6—50,000-200,000-ohm potentiometer, logarithmic or audio taper
R3, R7—820-1500-ohm resistors, ½-watt

66. Shaped Output Code Oscillator

☐ Most code-practice oscillators are keyed by switching the oscillator transsistor'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 mellower 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-uF, 25-VDC electrolytic
C2, C3—0.22-uF, 25-VDC mylar capacitor
C4—2.2-uF, 10-VDC tantalum capacitor
C5—0.22-uF, 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 ½-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

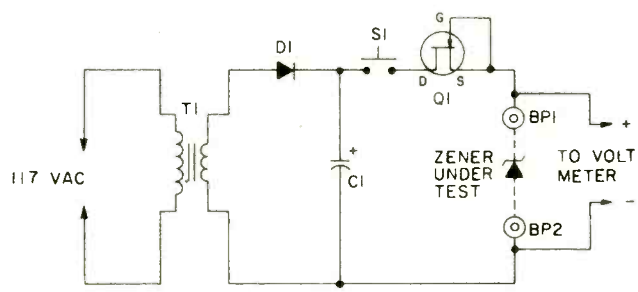
67. Zener Diode Tester

☐ 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.

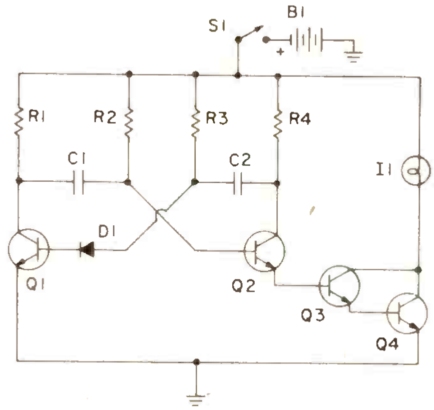
PARTS LIST FOR ZENER DIODE TESTER

BP1, BP2—binding posts
C1—500-uF, 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



68. 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

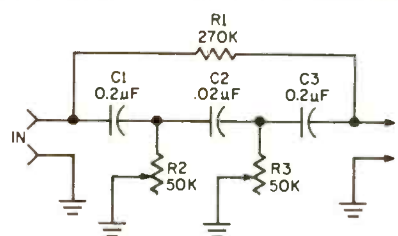
B1—6-volt lantern (heavy-duty) battery
C1, C2—1.0-uF, 25-VDC non-polarized mylar capacitor
D1—1N4002 diode
I1—#82 lamp rated 6.5-VDC @ 1-amp
Q1, Q2, Q3—2N3904 NPN transistor
Q4—2N3724A NPN transistor
R1, R4—10,000-ohm, ½-watt resistor, 5%
R2, R3—390,000-ohm, ½-watt resistor, 5%
S1—SPST toggle switch

69. 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.

PARTS LIST FOR RECORD RESTORER

C1, C3—0.25-uF mylar capacitor
C2—0.02-uF mylar capacitor
R1—270,000-ohm, ½-watt resistor
R2, R3—50,000-ohm potentiometer, linear taper



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

70. General Purpose Pulser

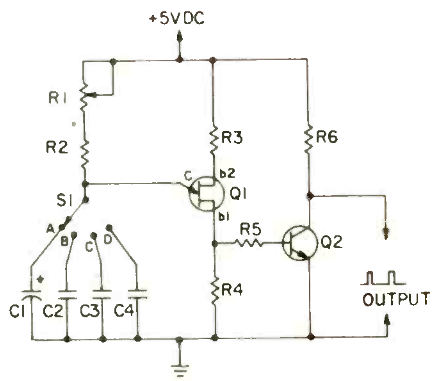
☐ Here is a simple pulse generator that can be useful in a variety of applications, from audio to logic. The heart of the circuit is the familiar UJT (unijunction transistor) relaxation oscillator, Q1. Potentiometer R1 adjusts the repetition rate over a range of one decade, while range switch S1 allows 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-μF capacitor).

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

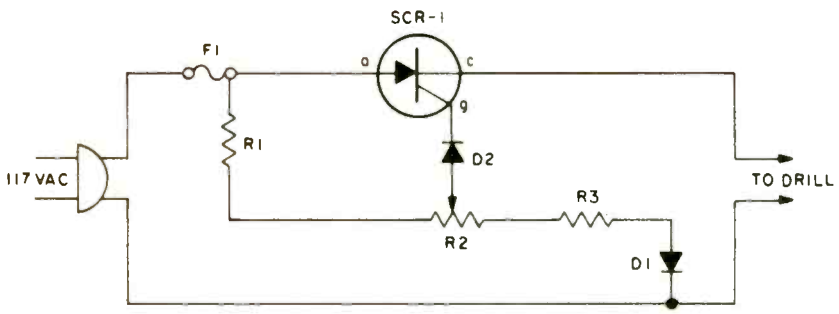
PARTS LIST FOR GENERAL PURPOSE PULSER

C1—15-uF, 10-VDC tantalum capacitor
C2—1.5-uF, 25-VDC non-polarized mylar capacitor
C3—0.15-uF, 25-VDC mylar capacitor
C4—0.015-uF, 25-VDC mylar capacitor
Q1—2N2646 unijunction transistor
Q2—2N3904 NPN transistor
Note: All resistors rated ½-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



71. Power Tool Torque Control



PARTS LIST FOR POWER TOOL TORQUE CONTROL

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

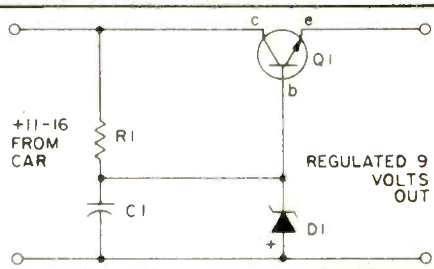
The only construction precaution is an extra-heavy heat sink for the SCR. The SCR should be mounted in a ¼-in. thick block of aluminum or copper at least 1-in. square; 2-in. if you drill for extended periods.

72. 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-uF capacitor
D1—Zener diode, 9.1 V at ¼-watt
Q1—NPN transistor, 2N2222 or equiv.
R1—560-ohm resistor, ½-watt



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

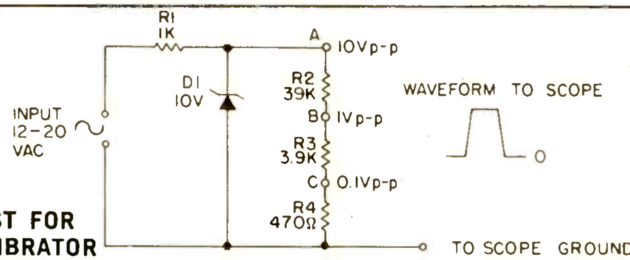
There are two easy ways to determine how much current your transistor radio or whatever draws (more to the point, whether or not the amount of current it draws will necessitate heat sinking). One is to connect your VOM in series between one of the battery posts and its associated clip connector. You 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 ½ amp).

73. 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 adjust the variable attentuator 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.



PARTS LIST FOR SCOPE CALIBRATOR

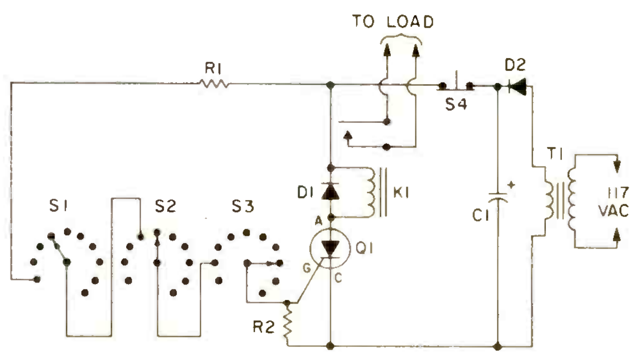
D1—10-volt, 0.25 to 1-watt Zener diode
R1—1,000-ohm, ½-watt resistor
R2—39,000-ohm, ½-watt resistor, 5% tolerance
R3—3900-ohm, ½-watt resistor, 5% tolerance
R4—470-ohm, ½-watt resistor, 5% tolerance

74. 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, curent 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-uF, 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, ½-watt resistor, 5%
S1, S2, S3—single pole, 10-position rotary or thumbwheel switches
S4—normally closed SPST pushbutton switch
T1—120-VAC to 6.3-VAC @ 300mA power transformer

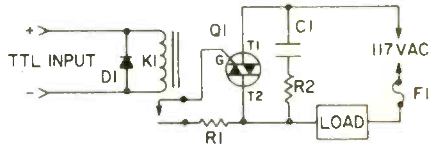


75. Microcomputer/AC Interface

☐ 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-uF, 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 ½ 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

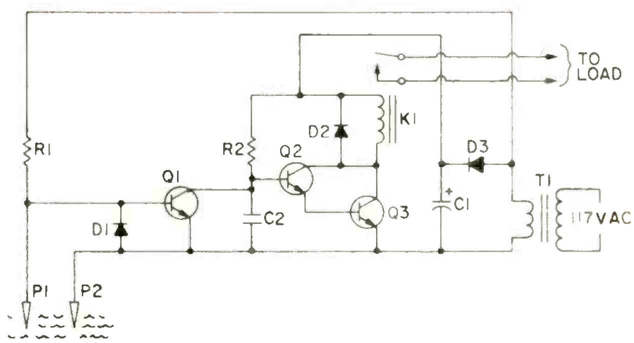
76. Fluid Detector

☐ 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-uF, 25-VDC electrolytic capacitor
C2—0.5-uF, 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, ½-watt, 5% resistor



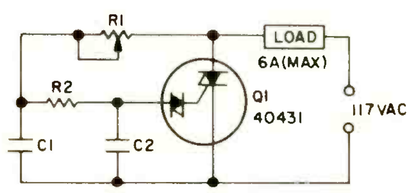
R2—470,000-ohm, ½-watt, 5% resistor
T1—120-VAC to 6.3-VAC @ 300-mA power transformer

77. 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, variable 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 device, 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.



PARTS LIST FOR VARI-REV MOTOR CONTROL

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

With the component values shown on the parts list, the Triac controls motor speed from full *off* to full *on*.

78. Photoflood Dimmer #1

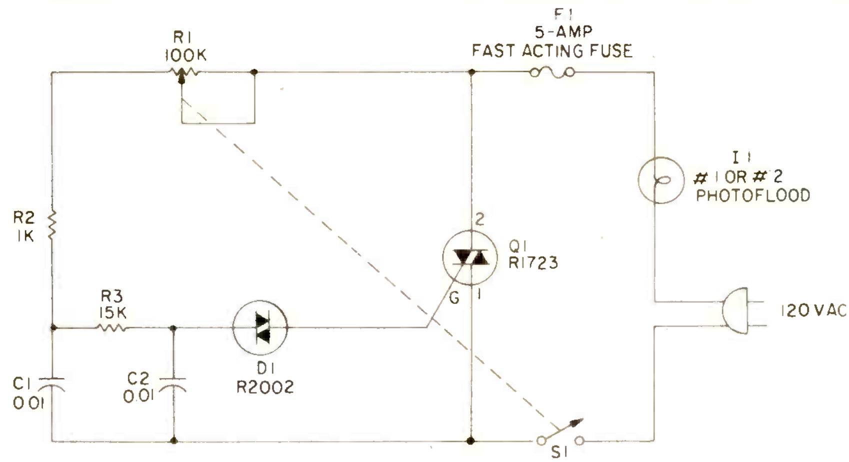
☐ Professional quality photographic lighting requires complete control of the studio lights, and that's just what you'll get with the pro-type, full-range 500-watt dimmer. Each one can handle one 500-watt #2, or two 100-watt #1 photoflood lamps, and the lighting range can be adjusted from full off to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

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



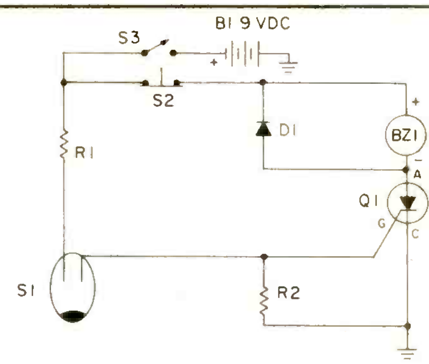
79. Equipment Theft Alarm

☐ 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.

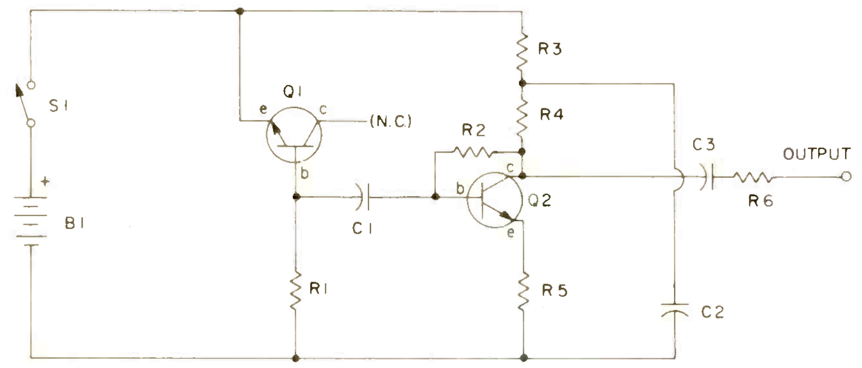
In the schematic, mercury switch S1 is normally open. However, should the equipment in which the alarm has been installed be picked up and tilted, S1 closes and thereby supplies gate current to the SCR. Q1 then latches in a conducting state, causing current to flow through buzzer BZ1. The buzzer will sound until pushbutton S2 is pushed to reset the circuit. For best results, use an electromechanical, rather than piezoelectronic buzzer, since it will emit more noise.

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, ½-watt resistor
S1—normally open SPST mercury switch
S2—normally closed pushbutton switch
S3—SPST toggle switch



80. Noise Generator



PARTS LIST FOR NOISE GENERATOR

B1—9 VDC battery
C1—.05-uF capacitor
C2—220-uF capacitor
C3—.005-uF capacitor
R1—1-Megohm resistor, ½-watt
R2—1.8-Megohm resistor, ½-watt
R3, R5—150-ohm resistor, ½-watt
R4—120,000-ohm resistor, ½-watt
R6—56,000-ohm resistor, ½-watt
Q1, Q2—NPN transistor, 2N3904 or equiv.
S1—SPST switch

☐ 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 shound 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-to-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 your hear.

81. Photo Print Meter

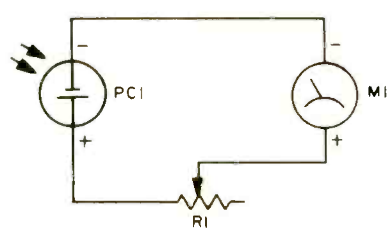
☐ Every print a good print! That's what you get with the photo print meter.

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 *u*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 negative. 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

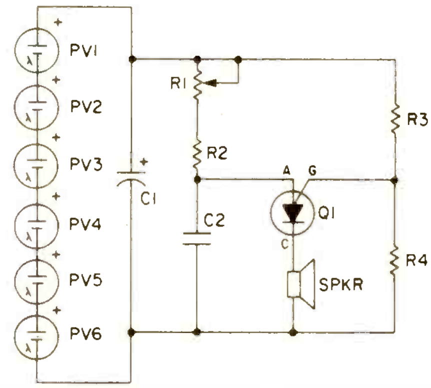
M1—100, 250, or 500-uA DC meter
PC1—Solar cell (Calectro J4-801)
R1—5000-ohm potentiometer linear taper

82. 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 lamplight 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

C1—220-uF, 25-VDC electrolytic capacitor
C2—0.39-uF, 25-VDC mylar capacitor
PV1 thru PV6—0.5-VDC silicon solar cells (Radio Shack #276-120 or equiv.)
Q1—2N6027 programmable unijunction transistor
R1—2,000,000-ohm linear-taper potentiometer
R2—470,000-ohm, ½-watt resistor, 5%
R3—1,500,000-ohm, ½-watt resistor, 5%
R4—2,400,000-ohm, ½-watt resistor, 5%
SPKR—8-ohm PM miniature speaker



83. Phototachometer Adapter

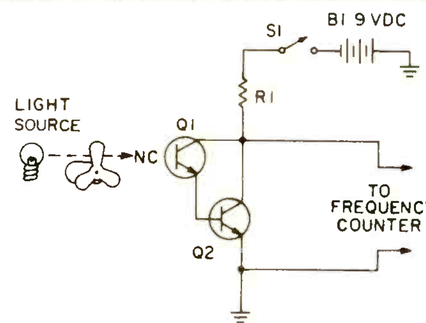
☐ If you own a frequency counter, you can use this nifty little circuit to measure the rate of rotation of motors, fans and anything else that revolves and can break a beam of light. In the accompanying schematic, you can see that light from the bulb is chopped by the rotating fan blades. This chopped light beam then falls on the light-sensitive face of phototransistor Q1. Transistor Q2 amplifies the photo-current 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.

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

Suppose we obtain a frequncy 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.

PARTS LIST FOR PHOTOTACHOMETER ADAPTER

B1—9-volt transistor battery
Q1—FPT-100 phototransistor (or equiv.)
Q2—2N3904 NPN transistor
R1—10,000-ohm, ½-watt resistor, 5%
S1—SPST toggle switch



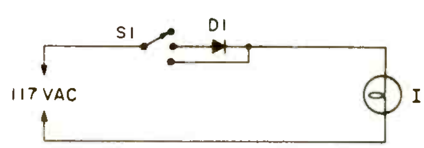
84. Photoflood Dimmer #2

☐ 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 photoflood 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.

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



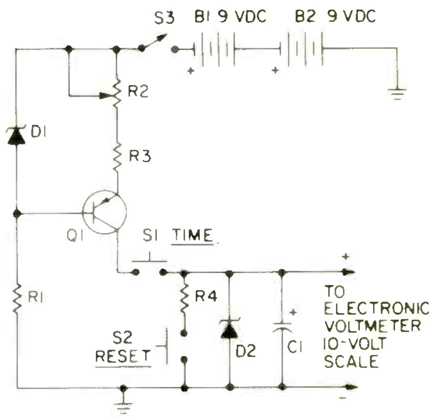
85. EVM Timing Adapter

☐ 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 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.

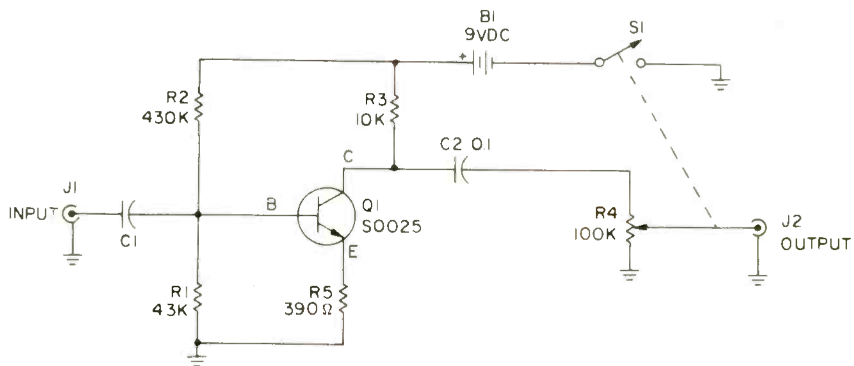
PARTS LIST FOR EVM TIMING ADAPTER

B1, B2—9-volt transistor battery
C1—10-uF, 20-VDC tantalum capacitor
D1—1N748A 3.9-volt, ½-watt zener diode
D2—1N759A 12-volt, ½-watt zener diode
Q1—2N3906 PNP transistor
R1—2,700-ohm, ½-watt resistor, 5%
R2—10,000-ohm trimmer potentiometer
R3—27,000-ohm, ½-watt resistor, 5%
R4—100-ohm, ½-watt resistor, 5%
S1, S2—normally open SPST push-button switch
S3—SPST toggle switch



86. Rocker'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 ROCKER'S MIKE BOOSTER

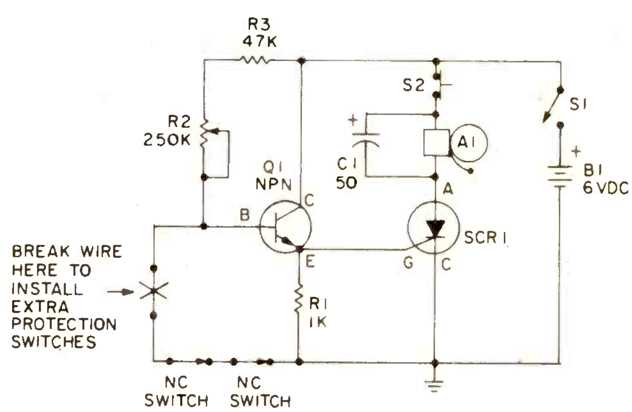
B1—9-volt transistor radio battery,
C1—10-uF capacitor
C2—0.1-uF, 10-VDC mylar capacitor
J1, J2—jacks to match existing cables
Q1—HEP-S0025 NPN transistor
R1—43,000-ohm, ½-watt resistor
R2—430,000-ohm, ½-watt resistor
R3—10,000-ohm, ½-watt resistor
R4—100,000-ohm, audio taper potentiometer w/SPST switch
R5—390-ohm, ½-watt resistor
S1—SPST switch, part of R4

87. 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 because the continuous current drain is only about 100 μA. 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 circuit. 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. It 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

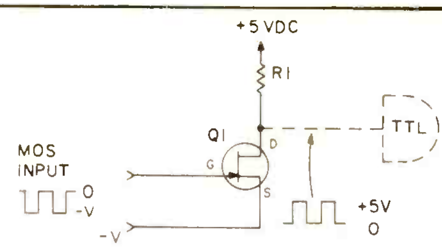
- **A1**—6-VDC alarm bell or siren
- **B1**—6-volt lantern battery
- **C1**—50-uF, 6-VDC electrolytic capacitor
- **Q1**—2N2222A NPN transistor or equivalent
- **R1**—1,000-ohm, ½-watt resistor
- **R2**—250,000-ohm linear taper potentiometer
- **R3**—47,000-ohm, ½-watt resistor
- **SCR1**—GEMR-5 silicon controlled rectifier
- **S1**—SPST switch
- **S2**—normally-closed SPST pushbutton switch

88. 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, ½-watt resistor, 5%



89. 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 regulated 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.

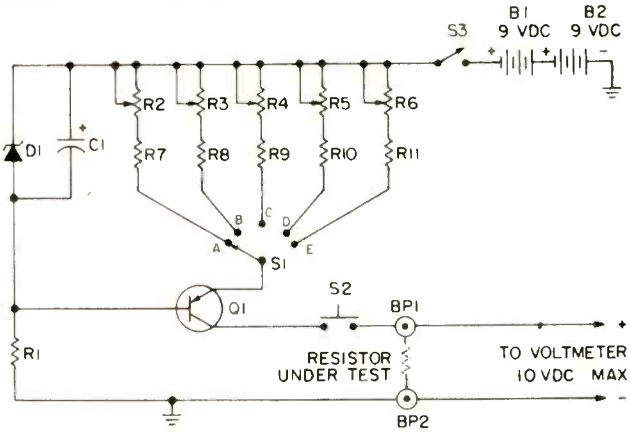
When measuring resistance, use the following conversion formula:

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

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 accuracy, 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-uF, 20-VDC tantalum capacitor
D1—1N748A, 3.9-volt, ½-watt zener diode
Q1—2N3676 PNP transistor
Note: All resistors rated ½-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

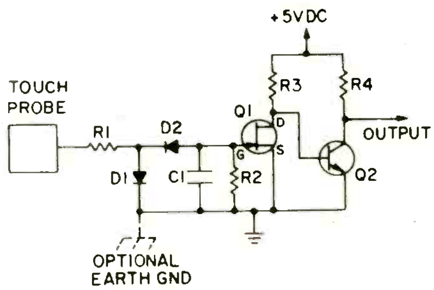
90. Simple Touch Switch

☐ 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 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.

PARTS LIST FOR SIMPLE TOUCH SWITCH

C1—0.1-uF, 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 ½-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

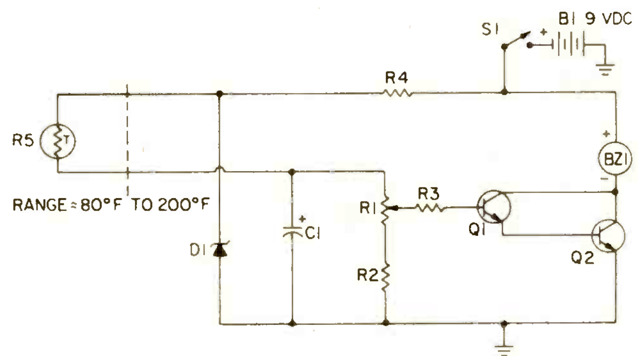
91. Hi-Temp Alarm

☐ 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 substited for the buzzer, you get a thermostat capable of turning on a fan or turning off a small electric heater.

PARTS LIST FOR HI-TEMP ALARM

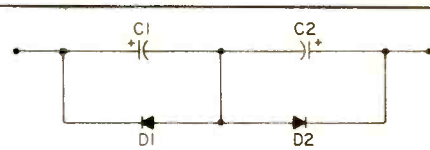
B1—9-volt transistor battery
BZ1—9-VDC buzzer (Radio Shack #273-052)
C1—220-uF, 10-VDC electrolytic capacitor
D1—1N752A, 5.6-volt, ½-watt zener diode
Q1, Q2—2N3904 NPN transistor
R1—2,000-ohm trimmer potentiometer
R2, R3—1,000-ohm, ½-watt, 5% resistor
R4—820-ohm, ½-watt, 5% resistor
R5—thermistor rated 10,000-ohms @ 25°C (Fenwal part #RB41L1)
S1—SPST toggle switch



92. 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-μf 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 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.



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.

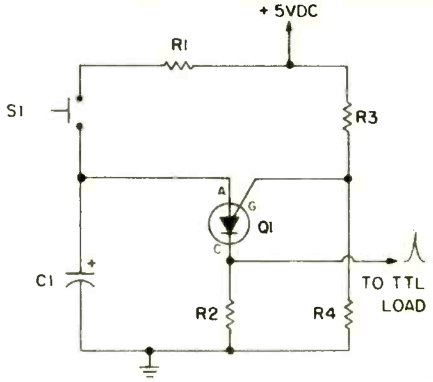
93. Bounce-less Digital Switch

☐ 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 any TTL circuit.

PARTS LIST FOR
BOUNCE-LESS DIGITAL SWITCH

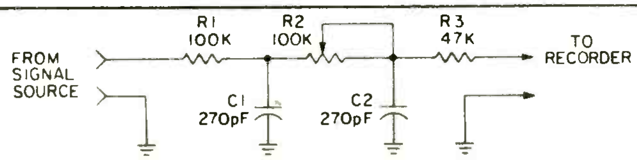
C1—2.2-uF, 10-VDC tantalum capacitor
Q1—2N6027 programmable unijunction transistor
Note: All resistors rated ½-watt, 5% tolerance unless otherwise noted.
R1—10,000-ohms
R2—47-ohms
R3—390,000-ohms
R4—1,200,000-ohms
S1—normally open SPST pushbutton switch



94. 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 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.



PARTS LIST FOR SCRATCH FILTER

C1, C2—260-pF silver mica capacitor, 5% or better tolerance
R1—100,000-ohm, ½-watt resistor
R2—100,000-ohm, linear taper potentiometer
R3—47,000-ohm, ½-watt resistor

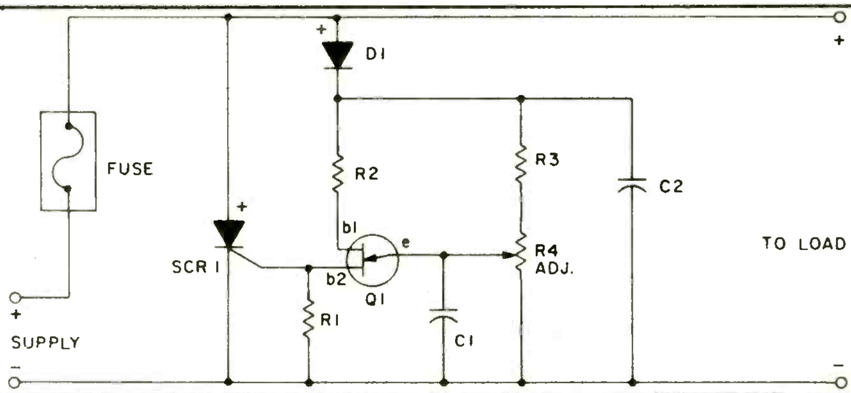
95. Adjustable Crowbar

☐ This crowbar circuit takes advantage of the electrically well-defined switching point of UJT (unijunction transistor) Q1. Q1's actual trip point voltage is set by trimmer R4. The Q1 circuit is isolated from the load by D1. When Q1 conducts, it triggers SCR1, shorting the supply and blowing the fuse. Choose SCR1 to handle more than the rated fuse current at the maximum supply voltage.

To test for your trip point (when setting it, for example), disconnect the LOAD. Substitute a lamp of the proper voltage (the supply voltage or a little more) for the fuse. Set the voltage at the supply voltage terminals for the trip point you desire, then adjust R4 until the test lamp just lights.

PARTS LIST FOR
ADJUSTABLE CROWBAR

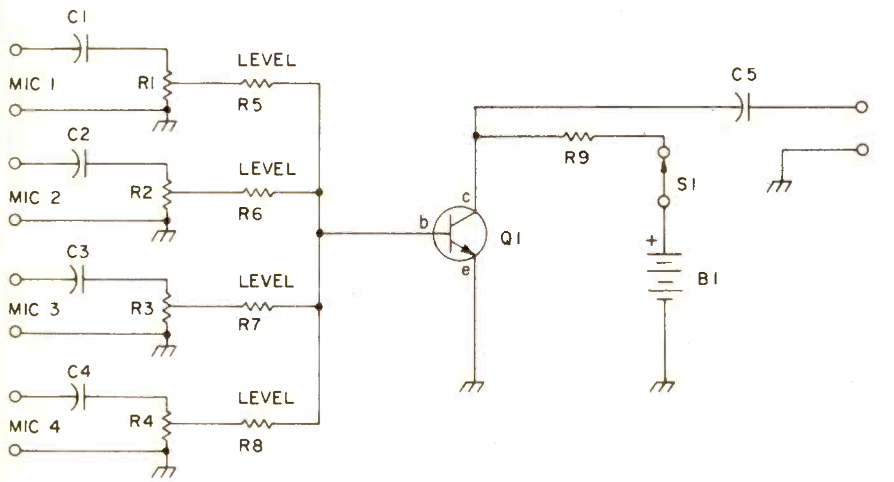
C1—.02-uF capacitor
C2—2.2-uF capacitor
D1—Diode, 1N914 or equiv.
R1—47-ohm resistor, ½-watt
R2—330-ohm resistor, ½-watt
R3—3300-ohm resistor, ½-watt
R4—10,000-ohm trimmer potentiometer
Q1—UJT (Unijunction Transistor), 2N2646 or equiv.
SCR1—See text



96. Low Impedance Mike Mixer

☐ There's no reason to limit yourself to using just one mike at a time when you have this circuit to help you with your recording—or any other purpose. You can set up a small microphone mixing console. For pizzazz, you could use slide-style controls for R1-4; for miniaturization, you could use tiny trimmer resistors.

Each control adjusts the level of its associated microphone as they are mixed together. This gives you the versatility of making one mike louder or softer without upsetting the level of any of the others. Transistor Q1 provides a bit of amplification to compensate for losses in mixing, and to assure good level at the input.



PARTS LIST FOR LOW IMPEDANCE MIKE MIXER

B1—9 VDC battery
C1, C2, C3, C4—.1-uF capacitor
C5—10-uF capacitor
Q1—PNP transistor, 2N3904 or equiv.
R1, R2, R3, R4—1-Megohm potentiometer, audio taper
R5, R6, R7, R8—100,000-ohm resistor, ½-watt
R9—15,000-ohm resistor, ½-watt
S1—SPST switch

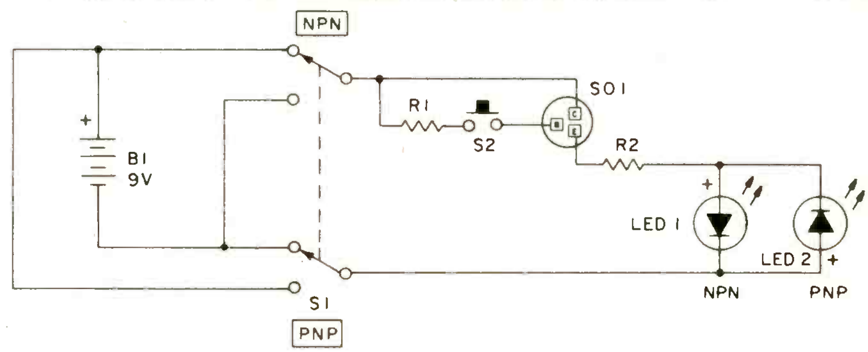
97. Transistor Checker

☐ 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.

PARTS LIST FOR TRANSISTOR CHECKER

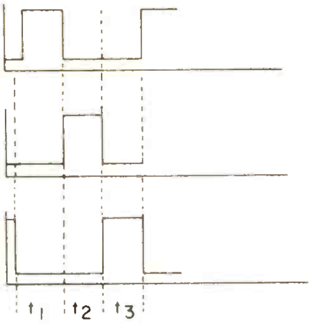
B1—9 VDC battery
LED1, LED2—Light emitting diode
R1—1000-ohm resistor, ½-watt
R2—470-ohm resistor, ½-watt
S1—DPDT switch
S2—Momentary push button switch
SO1—Transistor socket

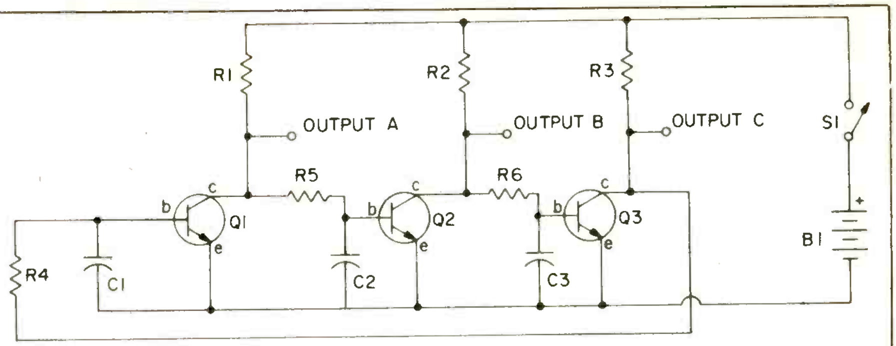


98. Square Wave Generator

☐ 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 ouput is rich in harmonics. If you use a 5-volt power supply, this circuit can trigger TTL.





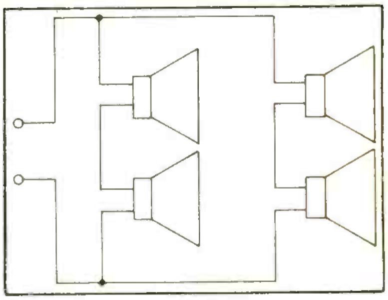
$t_1 = t_2 = t_3$ WHEN R1 = R2 = R3
C1 = C2 = C3 AND R4 = R5 = R6

PARTS LIST FOR SQUARE WAVE GENERATOR

B1—6-15 VDC battery
C1, C2, C3—.5-uF capacitor
Q1, Q2, Q3—NPN general purpose transistor (2N2222, 2N3904 or equiv.)
R1, R2, R3—500-2700-ohm resistors, ½-watt
R4, R5, R6—10,000-47,000-ohm resistor, ½-watt
S1—SPST switch

99. Speaker System Expander

☐ This neat arrangement lets you connect multiple speakers to your system's speaker terminals without upsetting the impedance match. This series-parallel arrangement of speakers exhibits the same impedance as a single speaker, assuming all speakers are of equal impedance and individually match the rating of the system. And inasmuch as the bass response of arrayed speakers is somewhat additive, you will find more bottom to your sound than any one of the speakers could have delivered alone. Of course, it takes more power to drive an array than a single speaker, but most modern music systems have plenty to spare.

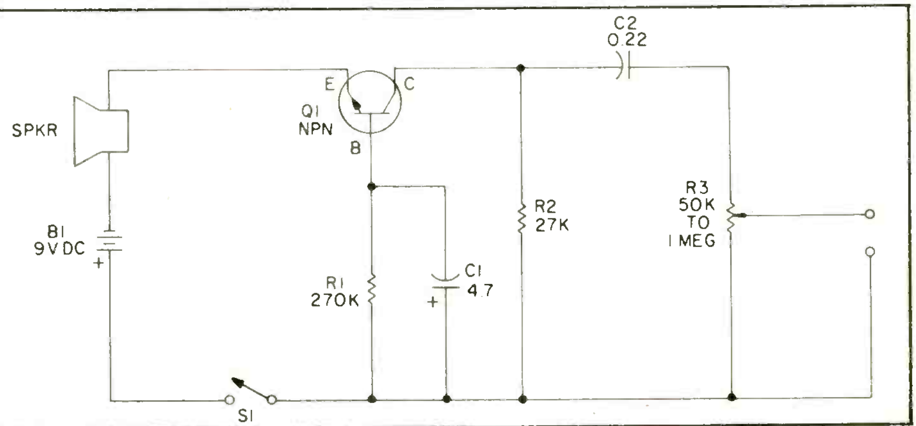


100. Speaker-Mic

101 ELECTRONIC PROJECTS
(Continued on page 114)

PARTS LIST FOR SPEAKER-MIC

B1—9-volt transistor radio battery
C1—4.7-uF, 10-VDC electrolytic capacitor
C2—0.22-uF, 10-VDC mylar capacitor
Q1—general purpose NPN transistor, see text
R1—270,000-ohm, ½-watt resistor
R2—27,000-ohm, ½-watt resistor
R3—audio taper potentiometer, see text
S1—SPST switch



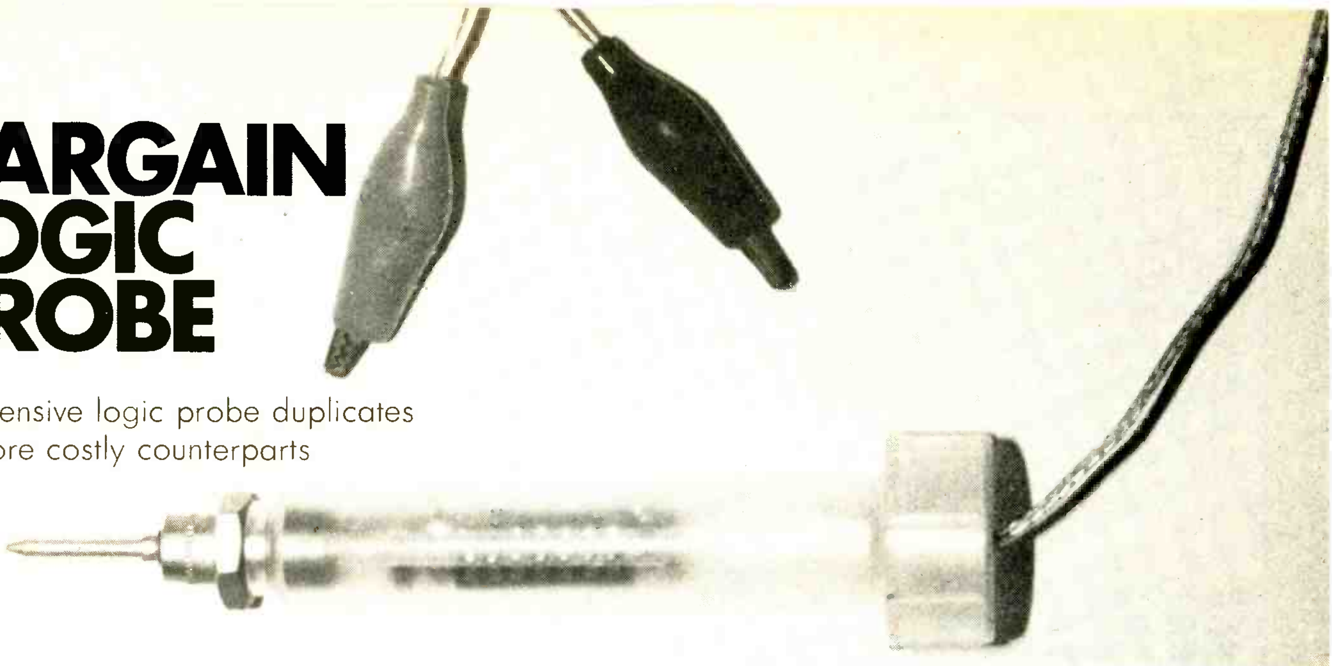
☐ A "junk box" speaker and a general purpose transistor, plus a few other "general purpose" components are all that are required for a high-output microphone substitute. While not hi-fi quality by any stretch of the imagination, the Speaker-Mic handles voice frequency signals very well.

Transistor Q1 can be just about any general-purpose NPN wtih 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.

BARGAIN LOGIC PROBE

Inexpensive logic probe duplicates its more costly counterparts



When we are dealing with varying voltages, that is called analog data. In the digital world we do not find a variable signal. It is either on or off, just as a switch would be either on or off. Another way of saying this is high or low, or 1 or 0. Each high or low bit is put together to make up a basic character or Byte. Sometimes these Bytes are called words.

If we have 1001, then we can call that a 4 bit Byte. That is the smallest Byte ever to be encountered in the computer world. It can be used where the data accuracy is not critical and the amount of data is small. To illustrate this, if 1001 were sent and interference generated a pulse at the moment of the third bit, then we have been left with false data of 1011. Its meaning would be completely different. To increase accuracy and handle more data, we could go to 8 bit Bytes. Such as 10101010. A logic probe allows us to look at a particular point in the circuit to determine if a low (0) or high (1) is present.

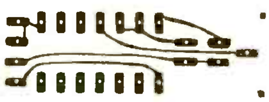
For most of our electronic experiments, we don't need expensive logic probes costing upwards of $40. Here is a cheap unit which can signal high level (1), low level (0), and oscillation. No pulse detection feature was included thus keeping the size small and the price low, around $2. The probe is designed for TTL signal levels and can be used for 5 volt CMOS circuits although loading may occur.

Theory of operation: Bargain Logic Probe uses only one IC, a 74L04 hex inverter shown in the schematic. The input to inverter A normally floats high, making its output low so as to light L1. The output of inverter B is high so L2 is off. If you now make the input of inverter A zero volts, L1 will turn off and L2 will illuminate. When oscillation is present at the input, both L1 and L2 will light at some intermediate brightness depending on the duty cycle of the signal being observed.

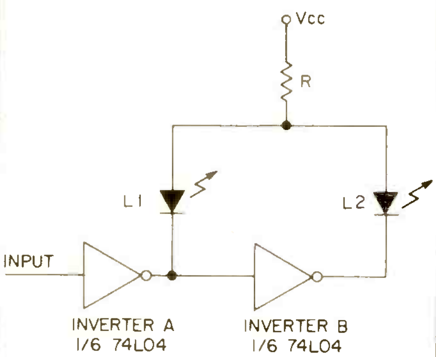
Using a 74L04 is important, the "L" series only requires the driving signal to sink 180 μA max, much below the 7400 series 1.6 mA max or even the 74LS00 series 400 μA requirement.

Construction: A full scale PC board layout is shown in addition to the parts layout on the component side. I slid the entire PC board inside a used syringe cover (available at hospitals for free), and attached a readily available test probe tip. Using different color L.E.D.s to signal high or low will help to quickly distinguish the signal level. Power is supplied by the circuit under test, and runs around 10 mA. Note, voltage requirements for the "L" series are 5 ±.25 V nominal.

So far, Bargain Logic Probe works great. It fits in my pocket and gives me a quick handle on circuit performance. It can also be used to show oscillator output in low power transmitter stages, SW converters & receiver local oscillators. ■

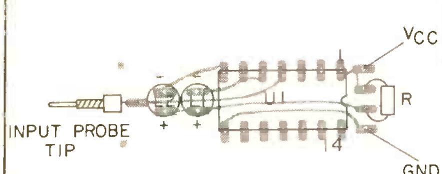


Here's the extra-small printed circuit board template for Bargain Logic Probe.

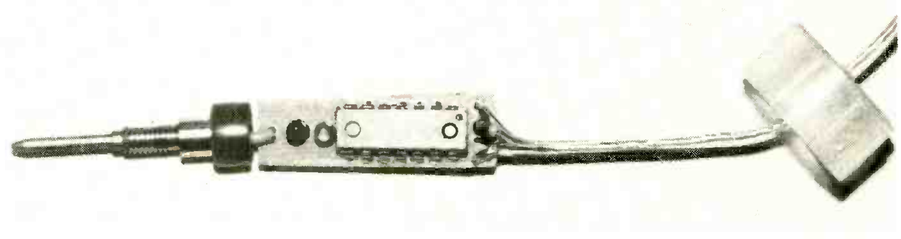


PARTS LIST

- **L1**—light emitting diode, red
- **L2**—light emitting diode, yellow
- **R**—1,000 ohm, ¼-watt resistor, 5%
- **U1**—74L04 hex inverter
- **Misc.**—probe tip, syringe cover, pc board, alligator clips, wire.



This will give you a good idea of parts layout on PC board. There are few parts.

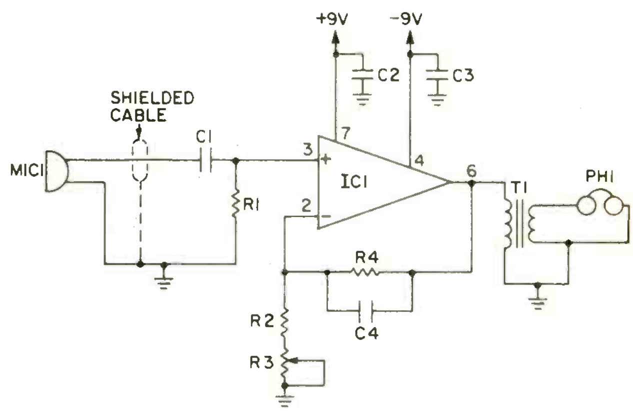


This photo of the Bargain Logic Probe will give you some idea of the simplicity of the unit. It's small, but there aren't very many components. When done, just cap it up.

40 INTEGRATED CIRCUIT PROJECTS

1. 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.

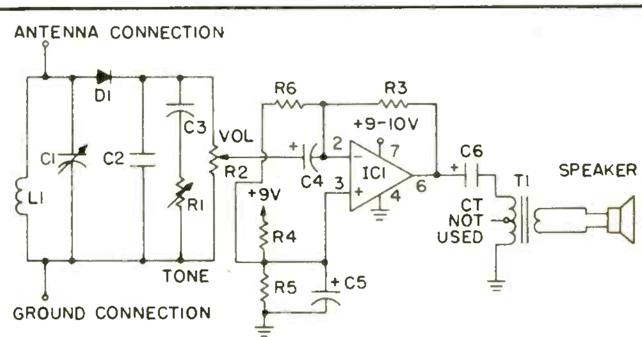


PARTS LIST FOR SUPER STETHOSCOPE

C1—0.01-uF mylar capacitor, 35 VDC
C2, C3—0.1-uF 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, ½-watt resistor, 10%
R2—1000-ohm, ½-watt resistor, 10%
R3—10K linear-taper potentiometer
T1—miniature audio output transformer—1,00-ohm primary/8-ohm secondary

2. 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.

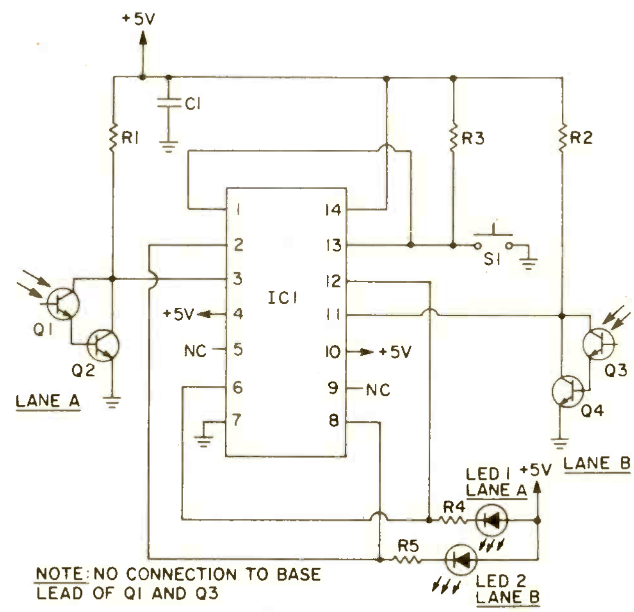


PARTS LIST FOR MINI-MODERN CRYSTAL SET

C1—365-pF variable capacitor
C2—0.01-uF ceramic capacitor, 15 VDC
C3—0.1-uF ceramic capacitor, 15 VDC
C4, C5—100-uF electrolytic capacitor, 15 VDC
C6—50-100-uF 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, ½-watt resistor
R4, R5—4,700-ohm, ½-watt resistor
R6—10,000-ohm, ½-watt resistor
T1—500/8-ohm audio output transformer
MISC.—8-ohm 2 in. PM type speaker; snap type 9 V battery clip

3. 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 desklamp 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.

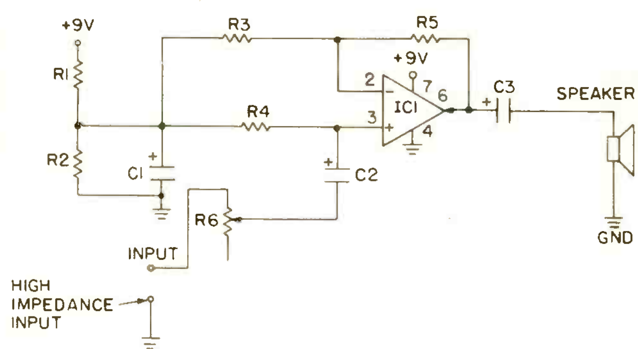


PARTS LIST FOR SLOT CAR RACE REFEREE

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 tranistor
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

4. Micro-Mini PA

☐ Designed for *very* private listening, this little amplifier sports a tiny loudspeaker of 1½ to 2 inches diameter. The gain may be varied through the feedback resistor from about 1 to 100. Only a single power supply, which may be a nine volt transistor radio battery, is required.

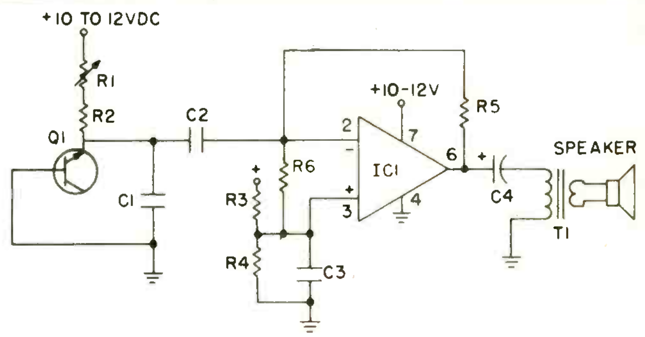


PARTS LIST FOR MICRO-MINI PA

C1—100-uF electrolytic capacitor, 100 VDC
C2—100-uF electrolytic capacitor, 6 VDC
C3—100-uF electrolytic capacitor, 10 VDC
IC1—741 op amp
R1, R2—5,600-ohm ½-watt resistor
R3—1,000-ohm ½-watt resistor
R4—50,000-ohm ½-watt resistor
R5—100,000-ohm ½-watt resistor
R6—100,000-ohm audio taper potentiometer
SPKR—8 ohm, 2-in. PM type

5. Useful Noise

☐ Noise, more or less "pure white" from some source of uncertainty, can be filtered and shaped for various purposes, ranging from radio alignment, to music, or the simulated sounds of rain on the roof. There are various naturally random impulse sources available to the experimenter, including the plasma from gaseous discharges occurring in neon lamps. On the semi-conductor level, there are diodes and transistors purposely configured and biased into noisiness. But under certain conditions, many semiconductor junctions develop wide band RF noise. When amplified by a type 741 op amp, which has internal frequency roll-off elements, the result is a continuous hiss in the output speaker, simulating rain. The signal can also be used in the development of "electronic music" and the testing of hi-fi filters and systems.

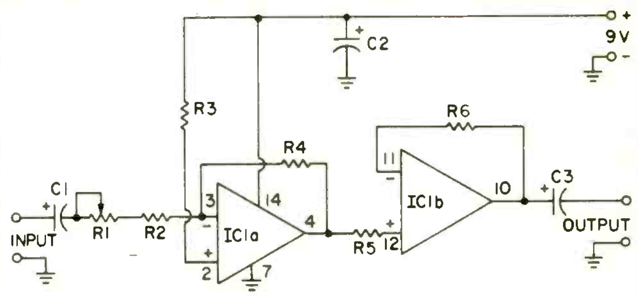


PARTS LIST FOR USEFUL NOISE

C1—.005-uF ceramic capacitor, 15 VDC
C2, C3—10-uF electrolytic capacitor, 15 VDC
C4—75-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
Q1—2N4401
R1—100,000-ohm linear-taper potentiometer
R2, R6—10,000-ohm, ½-watt resistor
R3, R4—4,700-ohm, ½-watt resistor
R5—1,000,000-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker
T1—audio output transformer with 500-ohm primary/8-ohm secondary

6. Power Mike Amplifier

☐ A popular accessory to a CB radio is a power microphone. This circuit provides an adjustable gain of 1 to 10 which will increase the output of a dynamic microphone for higher modulation levels without shouting. The circuit has very low output impedance and will drive the microphone input circuit of any CB radio. IC1A provides voltage amplification and is adjustable by potentiometer R1. IC1B is a buffer amplifier which provides isolation between the amplifier and output terminal. The circuit draws about 7 milliamperes from a 9 volt supply and can be powered by an ordinary 9 volt transistor battery.

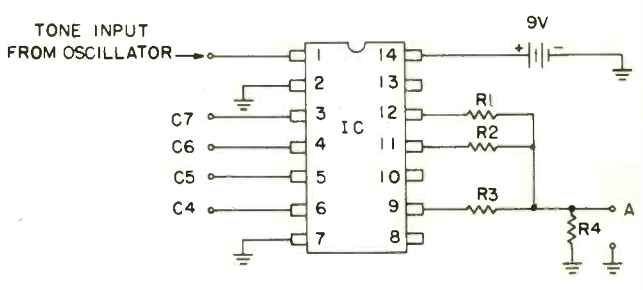


PARTS LIST FOR POWER MIKE AMPLIFIER

C1, C2, C3—10-uF electrolytic capacitor, 10 VDC
IC1—3900 quad amplifier
R1—100,000-ohm audio taper potentiometer
R2—10,000-ohm, ½-watt resistor
R3—220,000-ohm, ½-watt resistor
R4—100,000-ohm, ½-watt resistor
R5, R6—1,000,000-ohm, ½-watt resistor

7. Octave Music Maker

☐ This circuit will provide you with musical octaves that are very well reproduced from the top octave that you feed as an input. Putting in any tone, like the tone from an electric guitar, or from an organ, or from a CMOS oscillator, will cause C4 to be four octaves lower, C5 to be five octaves lower, and so on. Output A is a special waveform that is a saw-tooth made up of octaves that are one, two, and three times lower than the input. The sounds of these outputs can be changed with resistor and capacitor circuits before feeding into your hi-fi.

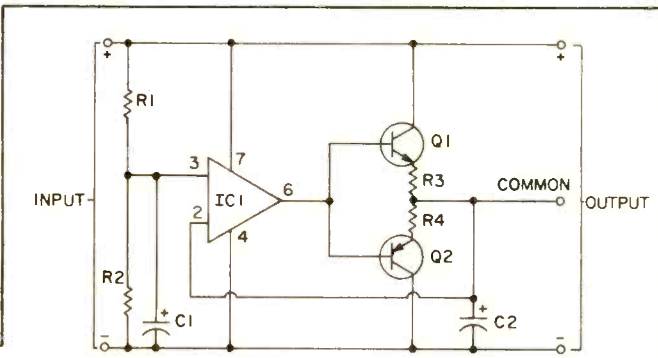


PARTS LIST FOR OCTAVE MUSIC MAKER

IC1—4024 binary counter
R1—12,000-ohm, ½-watt resistor
R2—22,000-ohm, ½-watt resistor
R3—47,000-ohm, ½-watt resistor
R4—1,000-ohm, ½-watt resistor

8. Dual Polarity Power Supply

☐ Many operational amplifiers require both positive and negative supplies for proper operation. With this simple circuit you can take a floating power supply and convert it into a dual polarity supply. To provide ±15 volts as most op amps require, you will need a 30 volt supply to drive the circuit. The output voltages of this circuit are set by the voltage divider action of R1 and R2 and are well regulated. Current output is limited only by the unbalance between the loads on the positive and negative outputs, and should not exceed the rating of the transistors, 200 milliamperes.

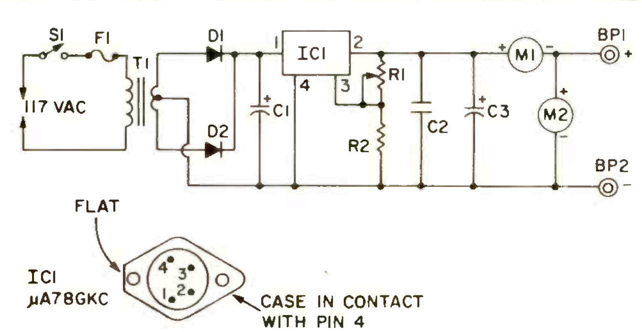


PARTS LIST FOR DUAL POLARITY POWER SUPPLY

C1, C2—15-uF electrolytic capacitor, 30 VDC
IC1—741 op amp
Q1—2N4401
Q2—2N4403
R1, R2—100,000-ohm, ½-watt resistor
R3, R4—10-ohm, ½-watt resistor

9. 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 μA78GKC 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.

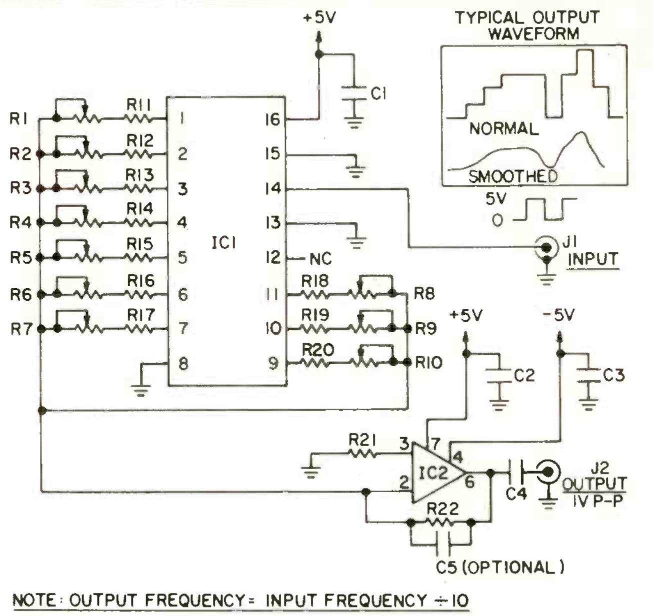


PARTS LIST FOR VARIABLE REGULATED POWER SUPPLY

BP1, BP2—binding post
C1—2200-uF electrolytic capacitor, 40 VDC
C2—0.1-uF ceramic disc capacitor, 35 VDC
C3—100-uF electrolytic capacitor, 25 VDC
D1, D2—1N4003 (1A, 200 PIV) rectifier diode
F1—0.5-Ampere slow-blow fuse
IC1—μA78GKC 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, ½-watt resistor, 5%
S1—SPST toggle switch
T1—28VCT, 1.2-Amp power transformer (see text)

10. 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 μF 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.

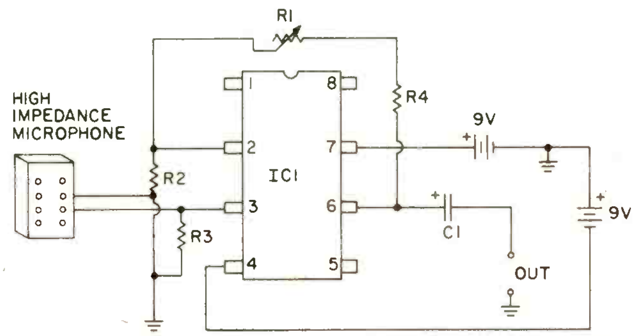


PARTS LIST FOR THE WAVESHAPER

C1, C2, C3—0.01-uF ceramic disc capacitor, 35 VDC
C4—0.5-uF 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 ½-watt resistor, 10%
R21, R22—15K-ohm ½-watt resistor, 10%

11. High Impedance Mike Amplifier

☐ A high impedance microphone will drive this circuit nicely. The output can drive a 1000 ohm earphone directly, or it can drive a transistor to, in turn, run a speaker. The gain is determined by the ratio of R1 to R2 and, in practice, can get up to about 50 dB.

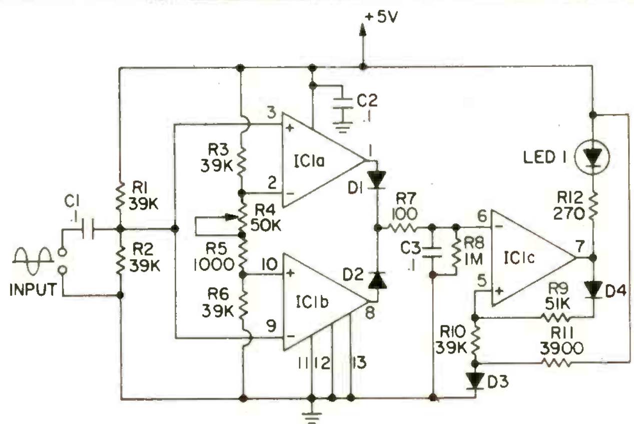


PARTS LIST FOR HI-IMPEDANCE MIKE AMP

C1—68-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
R1—500,000-ohm linear-taper potentiometer
R2, R4—1,000-ohm, ½-watt resistor
R3—910,000-ohm, ½-watt resistor

12. Peak-Level Detector

☐ In many situations, particularly in recording, it is more important to know a signal's peak level than its average level. While VU meters are customarily employed for such



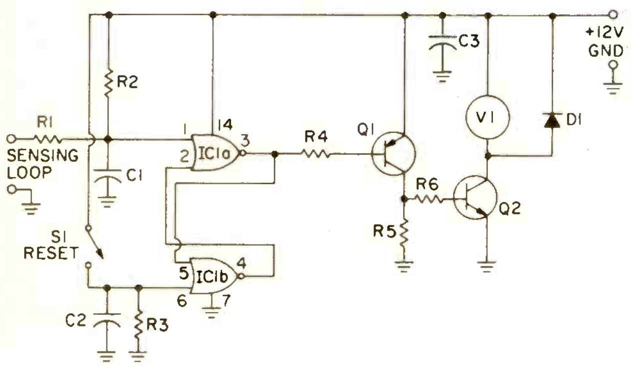
PARTS LIST FOR PEAK-LEVEL DETECTOR

C1, C2, C3—0.1-uF ceramic disc capacitor
D1-D4—1N914 diode
IC1—LM324 quad op amp integrated circuit
LED1—light emitting diode
R1, R2, R3, R6, R10—39,000-ohm, ½-watt resistor (all resistors 5%)
R4—50,000-ohm, ½-watt trim-potentiometer
R5—1,000-ohm, ½-watt resistor
R7—100-ohm, ½-watt resistor
R8—1,000,000-ohm, ½-watt resistor
R9—51,000-ohm, ½-watt resistor
R11—3,900-ohm, ½-watt resistor
R12—270-ohm, ½-watt resistor

purposes, you'll find this circuit's LED output easier to interpret and, as a result, more accurate. IC1a gauges the positive peaks, while IC1b does the same for the negative peaks. Both the positive and negative signal thresholds are determined by pot R4's setting. You can choose any threshold from ±20 mV to ±1 V. Whenever the input exceeds either the positive or negative threshold, LED1 flashes on for approximately one-tenth of a second. That's long enough to attract your attention and warn you to cut back on the volume.

13. Burglar Alarm

☐ This burglar alarm circuit uses one integrated circuit and operates from a 6 volt battery. It is activated upon the breaking of a circuit. Since the sensing loop operates in a high impedance circuit, there is virtually no limit to the length of wire you can use. You can protect every window and door in your house. Practical operation by using four D cells for power is accomplished through the use of a four-section CMOS integrated circuit which draws only a few microamperes from the battery. Thus, battery life will be equivalent to its shelf life unless the alarm is activated. The heart of the circuit is a pair of NOR gates connected in a bistable configuration called a flip-flop or latch circuit. When the circuit is in standby, pin 1 of IC1 is held to almost zero volts by the continuous loop of sensing wire. This causes pin 3 to assume a voltage of 6 volts, cutting off Q1 and Q2. When the sensing circuit is broken, C1 charges to battery voltage through R2. This causes the latch circuit to change state and pin 3 goes to zero volts. B1 becomes forward-biased through R4 and turns on Q2 which operates the buzzer. The circuit will remain in an activated state once the alarm is set off, even though the broken circuit is restored. A reset switch has been provided to return the latch circuit to its original state and shut off the alarm.

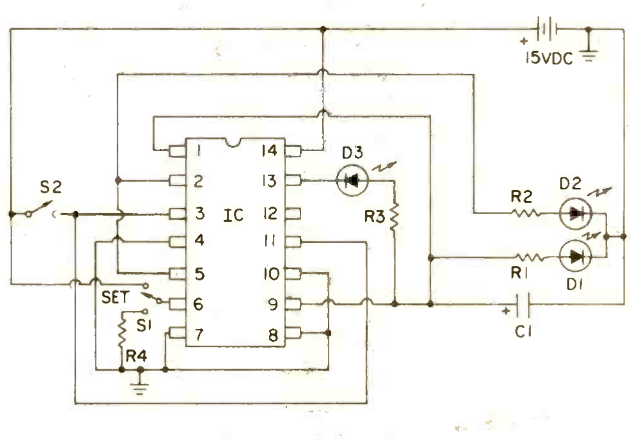


PARTS LIST FOR HOME BURGLAR ALARM

C1—0.1-uF ceramic capacitor, 15 VDC
C2—0.1-uF ceramic capacitor, 15 VDC
C3—0.47-uF ceramic capacitor, 15 VDC
D1—1N4148 diode
IC1—4001 quad NOR gate
Q1—2N4403
Q2—2N4401
R1, R3—100,000-ohm, ½-watt resistor
R2—4,700,000-ohm, ½-watt resistor
R4, R5—10,000-ohm, ½-watt resistor
R6—100-ohm, ½-watt resistor
S1—SPST momentary-contact pushbutton switch
V1—6 VDC buzzer

14. Lightning Speed Reaction Tester

☐ This circuit uses the two flip-flops of the CD 4013 integrated circuit to test your eyesight. Start by moving S1 from ground to "set" and back to ground. This will light D1 and D3. Now press S2. D1 and D3 will go off and D2 will go on, but D3 must go off slightly later than D3 due to built-in delays in the circuit. Can you see the difference in the two LED's? This makes a great experiment for kids to take to school.



PARTS LIST FOR LIGHTNING REACTION TESTER

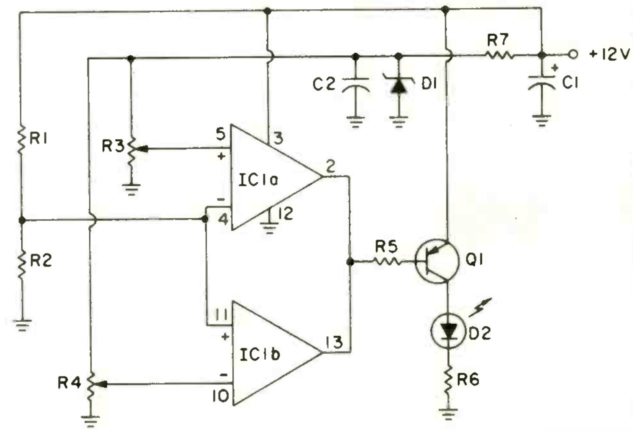
C1—1-uF electrolytic capacitor, 15 VDC
D1, D2, D3—small LED
IC1—4013 dual flip-flop
R1, R2, R3—2,000-ohm, ½-watt resistor
R4—500,000-ohm, ½-watt resistor
S1—SPDT slide switch
S2—SPST momentary contact pushbutton switch

15. 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 permissable range of 13.5 to 15.0 volts when the engine is running.

PARTS LIST FOR ALTERNATOR MONITOR

C1—10-uF electrolytic capacitor, 15 VDC
C2—0.1-uF ceramic capacitor, 15 VDC
D1—9 VDC zener diode
D2—large LED
IC1—339 quad comparator
Q1—2N4403
R1, R2, R5—10,000-ohm, ½-watt resistor
R3, R4—50,000-ohm linear-taper potentiometer
R6—470-ohm, ½-watt resistor
R7—220-ohm, ½-watt resistor

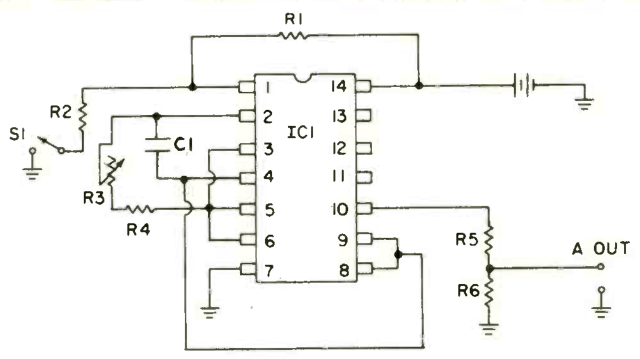


16. Code Practice Oscillator

☐ Boning up for your Amateur code exam? Pushbutton S1 makes a very inexpensive Morse code key. The tone out of the circuit, at point A, can drive an amplifier or a pair of high-impedance headphones.

PARTS LIST FOR CODE PRACTICE OSCILLATOR

C1—0 1-uF ceramic capacitor, 15 VDC
IC1—4001 quad NOR gate
R1—91,000-ohm, ½-watt resistor
R2—220-ohm, ½-watt resistor
R3—500,000-ohm, linear-taper potentiometer
R4—50,000-ohm, ½-watt resistor
R5, R6—2,200-ohm, ½-watt resistor
S1—SPST momentary-contact pushbutton switch



17. Cassette-Based Control System

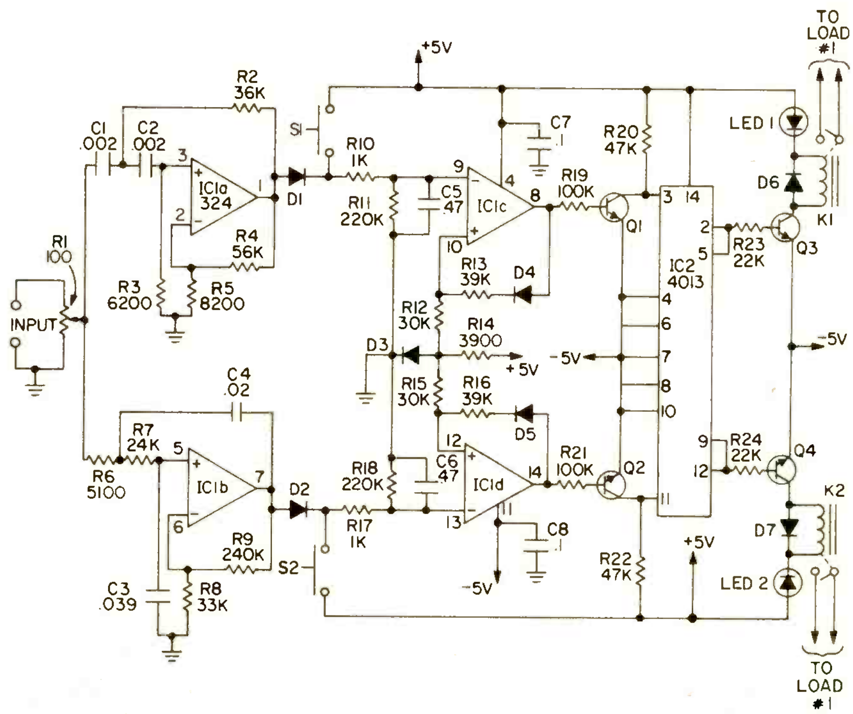
☐ Let's say that you need a programmable control system that can perform a timed sequence of operations. This sounds like a job for a high-priced computer, doesn't it? In many instances, however, just a cheap cassette recorder can do a respectable job—provided, of course, that you build this 2-channel controller.

High-frequency signals (above 5000 Hz) at the controller's input are amplified by high-pass filter U1a, then detected and used to clock one half of a dual flip-flop (U2). Each tone burst toggles the flip-flop, causing relay K1 to alternately open and close. These high-frequency audio signals have no effect on low-pass filter U1b, but frequencies below 500 Hz will produce the same effect in the lower channel as high frequencies in the upper channel, with the result that K2 alternately opens and closes on successive bursts of low frequency audio.

Feed the signal from your recorder's speaker output jack to the controller's input. Record a short sequence of tones—about 300 Hz for the low channel, and 7500 Hz for the high channel. Play back the tape-recorded sequence, and adjust R1 somewhat past the point where toggling of the relays starts. The LED go on and off with the relays and serve as convenient indicators of channel activity. Pushbuttons S1 and S2 can be used to change the status of a channel independently of the audio input. Whistles, tuning forks and electronic oscillators can all be used as tone sources. Whichever you use, strive to keep the level of the recorded signal constant.

PARTS LIST FOR CASSETTE-BASED CONTROL SYSTEM

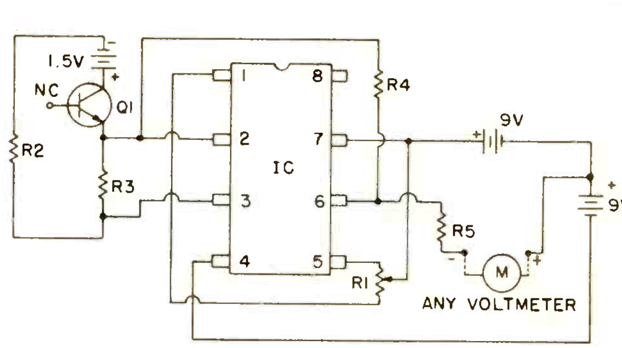
C1, C2—.002-uF polystyrene capacitor
C3—.039-uF polystyrene capacitor
C4—.02-uF polystyrene capacitor
C5, C6—0.47-uF mylar capacitor
C7, C8—0.1-uF ceramic disc capacitor
D1-D7—1N914 diode
IC1—LM324 quad op amp integrated circuit
IC2—4013 CMOS dual flip-flop integrated circuit
K1, K2—6-VDC, 500-ohm relay
LED1, LED2—light-emitting diode
Q1-Q4—2N3904 NPN transistor
R1—100-ohm trimpot (all resistors 10% unless otherwise noted.)
R2—36,000-ohm, ½-watt resistor 5%
R3—6,800-ohm, ½-watt resistor, 5%
R4—56,000-ohm, ½-watt resistor 5%
R5—8,200-ohm, ½-watt resistor 5%
R6—5,100-ohm, ½-watt resistor 5%
R7—24,000-ohm, ½-watt resistor 5%
R8—33,000-ohm, ½-watt resistor, 5%
R9—240,000-ohm, ½-watt resistor, 5%
R10, R17—1,000-ohm, ½-watt resistor
R11, R18—220,000-ohm ½-watt resistor
R12, R15—30,000-ohm, ½-watt resistor
R13, R16—39,000-ohm, ½-watt resistor
R14—3,900-ohm, ½-watt resistor
R19, R21—100,000-ohm, ½-watt resistor



R20, R22—47,000-ohm, ½-watt resistor
R23, R24—22,000-ohm, ½-watt resistor
S1, S2—pushbutton switch, normally open

18. VOM Light Meter

☐ The beauty of this light meter is that it is almost perfectly linear over a wide range of light inputs. It provides you with the basic operation of a camera light meter and can be made to read directly in f-stops and shutter speed. Phototransistor Q1 senses the light level and passes that on to the 741 op amp where the small voltage is amplified. Meter M is any you currently have around the house, or any inexpensive meter you can buy. If you do not have a meter, see the meter eliminator circuit in this book. R1 provides a zero adjustment for the meter.



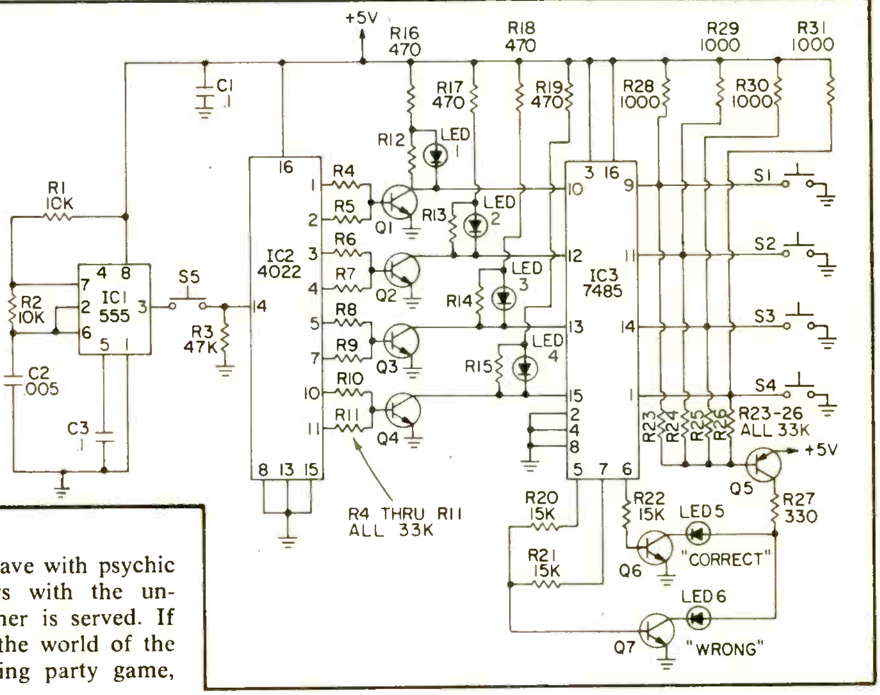
PARTS LIST FOR VOM LIGHT METER

IC1—741 op amp
Q1—FPT100 phototransistor
R1—10,000-ohm, linear-taper potentiometer
R2—10,000-ohm, ½-watt resistor
R3—30,000-ohm, ½-watt resistor
R4—100,000-ohm, ½-watt resistor
R5—2,000-ohm, ½-watt resistor

19. ESP Tester

PARTS LIST FOR ESP TESTER

C1, C3—0.1-uF ceramic disc capacitor
C2—.005-uF mylar capacitor
IC1—555 timer integrated circuit
IC2—4022 CMOS octal counter integrated circuit
IC3—7485 4-bit magnitude comparator
LED1-LED6—light emitting diodes
Q1-Q4, Q6, Q7—2N3904 NPN transistor
Q5—2N3906 PNP transistor
R1, R2—10,000-ohm, ½-watt resistor (all resistors 10%)
R3—47,000-ohm, ½-watt resistor
R4-R11, R23-R26—33,000-ohm, ½-watt resistor
R12-R15—4,700-ohm, ½-watt resistor
R16-R19—470-ohm, ½-watt resistor
R20-R22—15,000-ohm, ½-watt resistor
R27—330-ohm, ½-watt resistor
R28-R31—1,000-ohm, ½-watt resistor



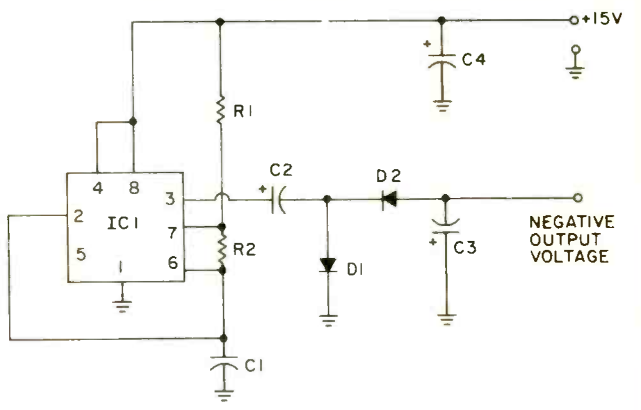
☐ The closest encounter most of us ever have with psychic phenomena probably comes from in-laws with the uncanny knack for dropping by just as dinner is served. If you'd like to delve somewhat deeper into the world of the unknown, or if you just want an intriguing party game, give this ESP tester a try.

Testing requires three persons—a Tester, a Sender and a Receiver—each one of whom has access only to a part of the circuitry. The Tester has S5, LED5 and LED6. By pressing and releasing S5, he causes the random lighting of one LED out of the set consisting of LEDs 1, 2, 3, and 4. Each LED of this set is identified in some way—usually by a geometric symbol like a star or triangle alongside it. The Sender, who views only these four LEDs, seeks to telepathically transmit the identity of the lit LED by mentally "broadcasting" a picture of the symbol linked with the LED.

The Receiver, whom we hope is monitoring the correct channel, indicates his response by pushing one of the four switches (S1 through S4) at his disposal. S1 corresponds to LED1 and is marked with the same geometric symbol. Likewise, S2 corresponds to LED2, and so forth. If the Receiver makes the correct choice, the Tester sees LED5 light up. On the other hand, if the Receiver's choice is wrong, or if he gets cute and pushes several buttons simultaneously, the Tester is notified of an error by the lighting of LED6.

20. Negative Power Supply

☐ Many operational amplifiers operate from a dual-polarity power supply. For low current applications, it may be easier to construct this negative power supply using one IC, rather than rectifying from the power line or transformer. IC1 operates in an astable mode with essentially square wave output at pin 3. C2, C3, D1 and D2 form a full-wave voltage doubler circuit which produces approximately minus 14 volts with no load at the negative output terminal. The circuit will deliver 12 volts into a load of 1000 ohms.



PARTS LIST FOR NEGATIVE POWER SUPPLY

C1—.01-uF ceramic capacitor, 15 VDC
C2, C3, C4—15-uF electrolytic capacitor, 25 VDC
D1, D2—1N4148 diode
IC1—555 timer
R1—1,000-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor

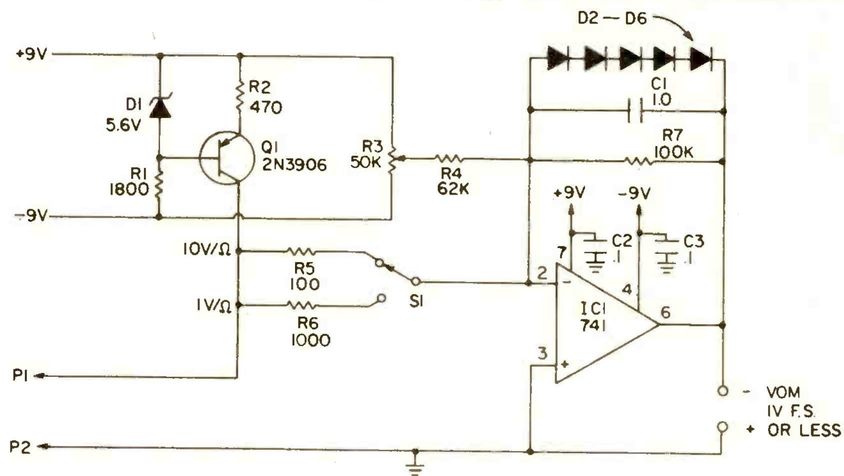
21. Milliohms Adapter

☐ Few experimenters have the equipment to measure resistances of less than one ohm, and even fewer of them could care to do so. But the ability to measure resistance in the milliohm range can be very handy. For insance, motor manufacturers routinely check their coils with milliohmmeter. Since the net resistance is proportional to the length of wire on the coil form, measuring the resistance provides a simple, non-destructive method for checking the number of turns on a coil. With a milliohmmeter you can even check the relative quality of switch contacts and solder joints.

Current source Q1 drives a constant 10-milliamp current through whatever resistance lies between probes P1 and P2. U1 amplifies the voltage generated across the resistance by the current flowing through it. You read the voltage at U1's output on your VOM and multiply by the appropriate scale factor—10V/ohm with S1 up, 1V/ohm with S1 down—to get the resistance. Before reading, short the probes together, and adjust R4 for zero output. Use needle-type probes, since they easily pierce surface oxide films (which can introduce significant resistance of their own). Keep the output voltage below one volt; in other words, the *maximum* resistance you can measure is one ohm.

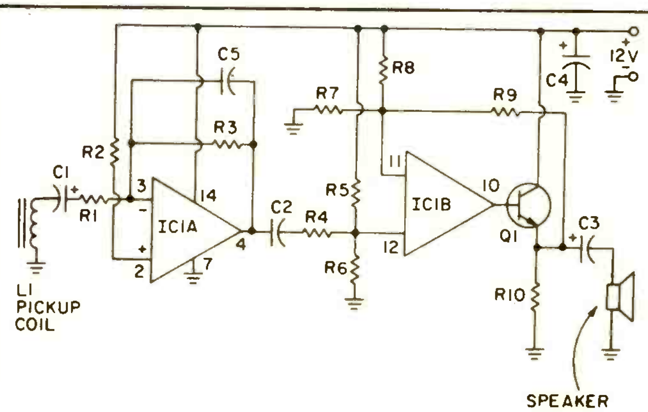
PARTS LIST FOR MILLIOHMS ADAPTER

C1—1.0-uF mylar capacitor
C2, C3—0.1-uF ceramic disc capacitor
D1—5.6-VDC, ½-watt zener diode
D2-D6—1N914 silicon diode
IC1—741 op amp
P1, P2—test probes
Q1—2N3906 PNP transistor
R1—1,800-ohm, ¼-watt resistor (all resistors 5%, unless otherwise noted.)
R2—470-ohm, ¼-watt resistor
R3—50,000-ohm linear taper potentiometer
R4—62,000-ohm, ¼-watt resistor
R5—100-ohm, ¼-watt resistor
R6—1,000-ohm, ¼-watt resistor
R7—100,000-ohm, ¼-watt resistor
S1—SPDT toggle switch



22. Telephone Pickup

☐ You can pick up and amplify the voice signals from your telephone by using this simple IC circuit and a small pickup coil. The circuit has sufficient output to drive a loudspeaker. One section of a quad op amp is used as a high-gain voltage amplifier. This increases the relatively low output of the pickup coil (a few millivolts) to a sufficient level to drive the loudspeaker. The circuit draws about 60 milliamperes from a 12 volt power source. You can purchase a ready made pickup coil or construct one yourself using about 200 turns of fine enamel wire wound around an iron core. Place the pickup coil near the telephone receiver for best results.



PARTS LIST FOR TELEPHONE PICKUP

C1—10-uF electrolytic capacitor, 25 VDC
C2—.01-uF ceramic disc capacitor, 15 VDC
C3, C4—15-uF electrolytic capacitor, 15 VDC
C5—.001-uF ceramic disc capacitor, 15 VDC
IC1—3900 quad amplifier
L1—inductance pickup coil (see text)
Q1—2N4401
R1—1,000-ohm, ½-watt resistor
R2, R4—1,000,000-ohm, ½-watt resistor
R3—470,000-ohm, ½-watt resistor
R5, R6, R7, R8, R9—10,000,00-ohm, ½-watt resistor
R10—100-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker

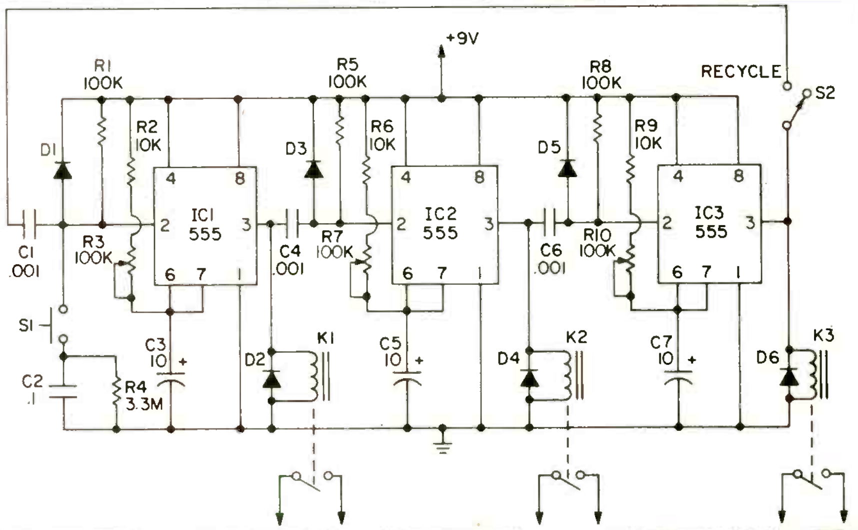
23. Re-Cycling Sequential Timer

☐ Press S1, and relay K1 pulls in for a time interval determined by the setting of R3. When IC1 times out and K1 opens once again, IC2 gets triggered. This causes K2 to pull in for an interval determined by R7's setting. Finally IC2 will time out and trigger IC3, thereby causing K3 now to pull in. Once IC3 times out and K3's contacts open, action ceases if S2 is flipped to the right. However, if S2 had been flipped to the left, IC1 would have once again been triggered as IC3 timed out, thus starting the whole cycle over again.

With the values shown, each timer can be adjusted for times from .1 to 1 second. If your application demands longer timing intervals, simply increase the size of the timing capacitors (C3, C5 and C7) and/or the timing resistors (R2-R3, R6-R7, and R9-R10). One application of the circuit that comes to mind is in flash photography. Let each relay fire a separate, cheap flash unit. With the timers adjusted for rapid fire, you'll be able to take stroboscope-like pictures that you couldn't take with a single conventional flash unit because re-cycle times (.3-.5 second) are too long. With three units, each flash has ample time to re-cycle while the others are firing. You might also try using color film and putting a separate colored filter over each flash tube.

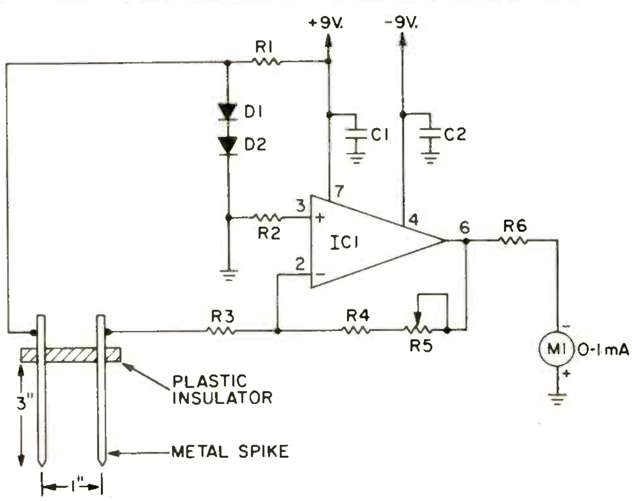
PARTS LIST FOR RE-CYCLING SEQUENTIAL TIMER

C1, C4, C6—.001-uF mylar capacitor
C2—0.1-uF ceramic disc capacitor
C3, C5, C7—10-uF, 25-VDC electrolytic capacitor
D1-D6—1N914 diode
IC1, IC2, IC3—555 timer integrated circuit
K1, K2, K3—6-VDC, 500-ohm relay
R1, R5, R8—100,000-ohm, ½-watt resistor (all resistors 10% unless otherwise noted.)
R2, R6, R9—10,000-ohm, ½-watt resistor
R3, R7, R10—100,000-ohm, linear-taper potentiometer
R4—3,300,000-ohm, ½-watt resistor
S1—pushbutton switch, normally open
S2—SPDT switch



24. 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-uF ceramic disc capacitor, 35 VDC
D1, D2—1N914 diode
IC1—741 op amp
M1—0-1 mA DC meter
R1—6800-ohm ½-watt resistor, 10%
R2—15K-ohm ½-watt resistor, 10%
R3—1000-ohm ½-watt resistor, 10%
R4—10K-ohm ½-watt resistor, 10%
R5—100K trimmer potentiometer
R6—3300-ohms ½-watt resistor, 10%

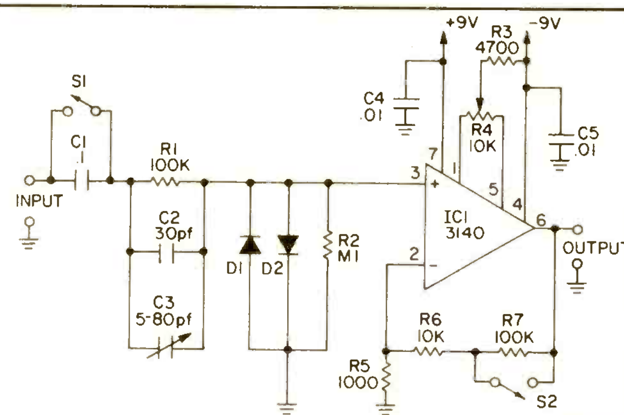
25. Instrument Sensitivity Booster

☐ This tiny, high-impedance amplifier will boost the sensitivity of your oscilloscope or voltmeter by a factor of 10 or 100. So, if your oscilloscope's maximum sensitivity at present is 10mV/div, you can boost it to 1mV/div or .1mV/div. Signals you previously could not measure, such as the output of your magnetic phono cartridge, will now be visible. Note also that if all you own is a 20K-ohms-per-volt VOM, the sensitivity booster will not only let you measure smaller voltages, it will give you a 1-megohm input impedance besides.

Switch S2 selects the gain—10 if closed and 100 is open. When you need direct coupling to measure DC voltages, close S1. Otherwise, leave it open for AC coupling. If the booster is to be used with a scope, feed a 20-kHz square wave to its input, and adjust C3 for the best-looking square wave at the output. For use with just a VOM, C2 and C3 will have little effect; therefore, you can leave them out. The amp can be nulled by grounding its input and adjusting R4 for zero output. Sinewave response extends to 400 kHz at a gain of 10, and 40 kHz at a gain of 100. Limit input signals to less than ± 100 mV.

PARTS LIST FOR INSTRUMENT SENSITIVITY BOOSTER

C1—0.1-uF mylar capacitor
C2—30-pF polystyrene capacitor
C3—5-80-pF trimmer capacitor (Arco 462 or equivalent)
C4, C5—0.01-uF ceramic disc capacitor
D1, D2—1N914 diode
IC1—3140 FET-input op amp (RCA or equivalent)
R1, R7—100,000-ohm, ½-watt resistor (all resistors 5% unless noted.)
R2—1,000,000-ohm, ½-watt resistor
R3—4,700-ohm, ½-watt resistor
R4—10,000-ohm, linear-taper potentiometer
R5—1,000-ohm, ½-watt resistor
R6—10,000-ohm, ½-watt resistor
S1, S2—SPST switch

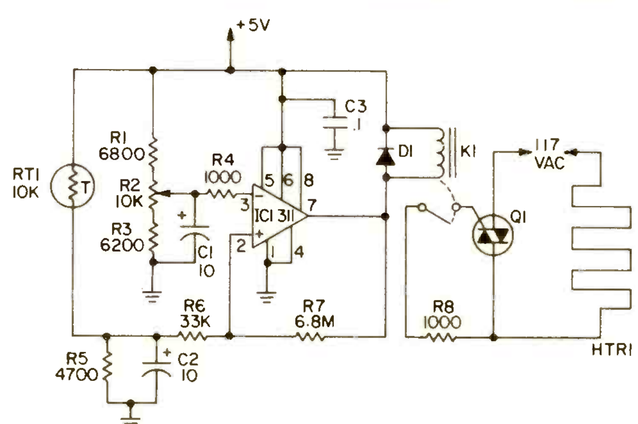


26. Thermostatic Bath

☐ Maintaining a volume of solution at constant temperature is easy if you do it electronically. Photographic processing is the obvious application for a thermostatic bath, but if you etch your own printed circuits, you can also use it to keep your etchant hot. Thermistor RT1 comes packaged as a small glass probe. Waterproof it with several coats of epoxy, and mount it below the surface of the fluid in your tank. The heating element, HTR1, must also be submerged—preferably close to the bottom of the tank and away from RT1. (CAUTION: Do not operate an immersion heater in open air.) Heater wattage depends upon the volume of solution you wish to heat. A 500-watt heater will raise two gallons of water from 70° to 120° F. in half an hour or so. Conventional brass or stainless steel heaters are perfect for a simple water bath, but if you plan to heat an etchant like ferric chloride, get a quartz immersion heater. Pot R2 sets the bath temperature at any point between 70° and 160° F. A temperature of 115° gives safe and fast etching with ferric chloride. Do not use this bath with flammable liquids, and always wear goggles.

PARTS LIST FOR THERMOSTATIC BATH

C1, C2—10-uF, 10-VDC tantalum capacitor
C3—0.1-uF ceramic disc capacitor
D1—1N914 diode
HTR1—200 to 500-Watt immersion heater (see text)
IC1—LM311 comparator
K1—6-VDC, 500-ohm relay
Q1—200-VDC, 10-A triac
R1—6,800-ohm ½-watt resistor (all resistors 5% unless otherwise noted.)
R2—10,000-ohm linear-taper potentiometer
R3—6,200-ohm, ½-watt resistor
R4—1,000-ohm, ½-watt resistor
R5—4,700-ohm, ½-watt resistor
R6—33,000-ohm, ½-watt resistor
R7—6,800,000-ohm, ½-watt resistor
R8—1,000-ohm, 1-watt resistor
RT1—10,000-ohm, @ 25° Thermistor (Fenwal 6B41P12 or equivalent)

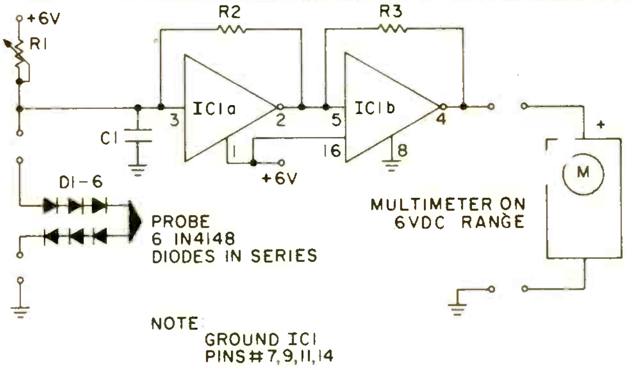


27. Diode Thermometer

☐ In another project, it was shown how a package of silicon diodes could be developed into a solid-state thermostat. Here is an analog version, which can be interfaced with a voltage-to-frequency converter for use with a frequency counter, or can be directly read by a 10 to 20 thousand-ohms-per-volt multimeter. The circuit utilizes a pair of 4009 inverter sections, biased into the linear region to amplify the temperature effects upon the diode probe. In this application, the adjustment potentiometer, R1, is set to give a mid-scale reading at room temperature on a typical multimeter set on the 6 volts DC scale. If a separate 0-1 DC miliampere meter is available, it could be calibrated directly in degrees F or C, with a suitable resistance in series with the amplifier output.

PARTS LIST FOR DIODE THERMOMETER

C1—0.1-uF ceramic capacitor, 15 VDC
D1 through D6—1N4148 diode
IC1—4009A hex buffer
R1—100,000-ohm linear-taper potentiometer
R2, R3—1,000,000-ohm, ½-watt resistor



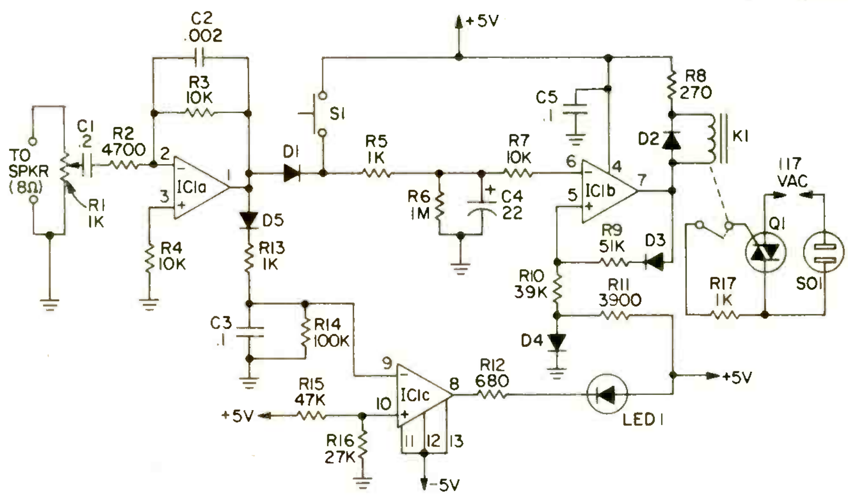
28. Automatic Stereo Shut-Off

☐ It's ironic, isn't it? Almost every cheap stereo system shuts itself off after the last record has been played, but just try to find a sophisticated, multi-component system that can do the same. Well, here's a circuit that may solve the problem for you. Plug all of your equipment into SO1. Touch S1 and K1 closes, thereby energizing your system. If no audio is fed from your amp's output (4-16 ohms) to R1, the system shuts down in approximately thirty seconds. However, if music is being fed into the shut-off circuit's input, C4 is consantly re-charged, and the power remains on until 30 seconds after the last record goes silent.

To set the circuit up, select the quietest passage to which you expect to listen. Press S1; put the tonearm in the groove, and adjust R1 until LED1 begins to flicker on and off with the music. Now relax, knowing that you finally have all the advantages of a cheap stereo.

PARTS LIST FOR AUTOMATIC STEREO SHUT-OFF

C1—0.2-uF mylar capacitor
C2—.002-uF mylar capacitor
C3—0.1-uF mylar capacitor
C4—22-uF, 10-VDC tantalum capacitor
C5—0.1-uF ceramic disc capacitor
D1-D5—1N914 diode
IC1—LM324 quad op amp integrated circuit
K1—6-VDC, 500-ohm relay
LED1—light emitting diode
Q1—200-VDC, 10A triac
R1—1,000-ohm linear taper potentiometer
R2—4.700-ohm, ½-watt resistor (all resistors 5% unless otherwise noted.)
R3, R4, R7—10,000-ohm, ½-watt resistor
R5, R13—1,000-ohm, ½-watt resistor
R6—1,000,000-ohm, ½-watt resistor
R8—270-ohm, ½-watt resistor
R9—51,000-ohm, ½-watt resistor
R10—39,000-ohm, ½-watt resistor



R11—3,900-ohm, ½-watt resistor
R12—680-ohm, ½-watt resistor
R14—100,000-ohm, ½-watt resistor
R15—47,000-ohm, ½-watt resistor
R16—27,000-ohm, ½-watt resistor
R17—1,000-ohm, 1-watt resistor
S1—pushbutton switch, normally open
SO1—AC power socket

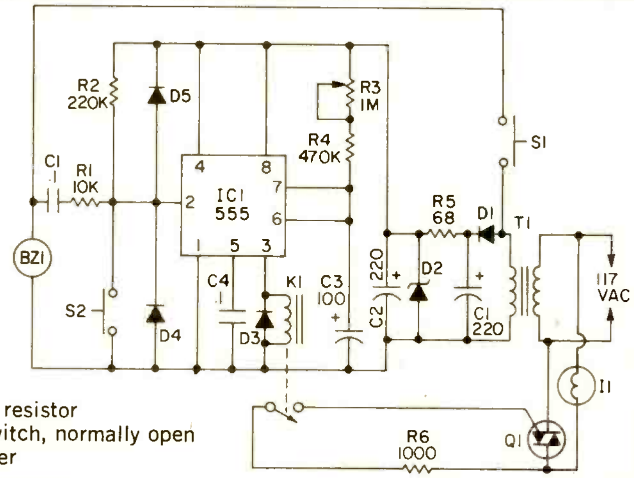
29. Smart Porch Light

☐ For convenience and security, you can't beat this smart porch light. Whenever someone rings your door buzzer with S1, on comes the front porch light. One to three minutes later, depending on the setting of R3, it goes off. If a burglar rings the doorbell while you're away (trying to ascertain whether or not the house is empty), the light will fool him. But even if he's smart enough not to be fooled, he'll think twice about breaking in. After all, there are likely to be more electronic booby traps and alarms waiting for him inside.

You can activate the light timer without ringing the buzzer by pressing S2. Do this as you leave the house at night, and you'll never stumble over a skateboard again.

PARTS LIST FOR SMART PORCH LIGHT

BZ1—6-VAC buzzer
C1, C2—220-uF, 25-VDC electrolytic capacitor
C3—100-uF 25-VDC electrolytic capacitor
C4, C5—0.1-uF ceramic disc capacitor
D1—1N4003 rectifier diode
D2—15-VDC, ½-watt Zener diode
D3-D5—1N914 diode
IC1—555 timer integrated circuit
I1—incandescent porch light
K1—6-VDC, 500-ohm relay
Q1—200-VDC, 6-A triac
R1—10,000-ohm, ½-watt resistor (all resistors 10% unless otherwise noted.)
R2—220,000-ohm, ½-watt resistor
R3—1,000,000-ohm trim potentiometer
R4—470,000-ohm, ½-watt resistor
R5—68-ohn, 1-watt resistor
R6—1,000-ohm, 1-watt resistor
S1, S2—pushbutton switch, normally open
T1—6.3-VAC transformer



30. Penny Pincher Frequency Meter

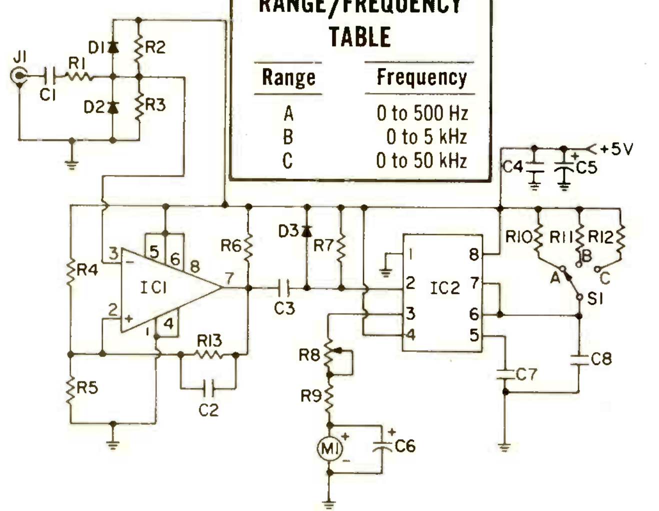
☐ One of the handiest instruments you can own is the digital frequency counter, but unless you do an awful lot of experimenting, the expense is usually hard to justify. However, if you can spare $15, consider building this *analog* frequency meter. Input impedance is 100,000-ohms, and frequencies up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

C1, C4, C7—0.1-uF ceramic disc capacitor, 35 VDC
C2—5-pF polystyrene capacitor, 35 VDC
C3—100-pF polystyrene capacitor, 35 VDC
C5, C6—100-uF 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 ½-watt resistor, 10%
R2, R3, R4, R5—18K-ohm ½-watt resistor, 5%
R6—1000-ohm ½-watt resistor, 10%
R7—10K-ohm ½-watt resistor, 10%
R8—10K trimmer potentiometer
R9, R11—30K-ohm ½-watt resistor, 5%
R10—300K-ohm ½-watt resistor, 5%
R12—3000-ohm ½-watt resistor, 5%
R13—10 Megohm ½-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

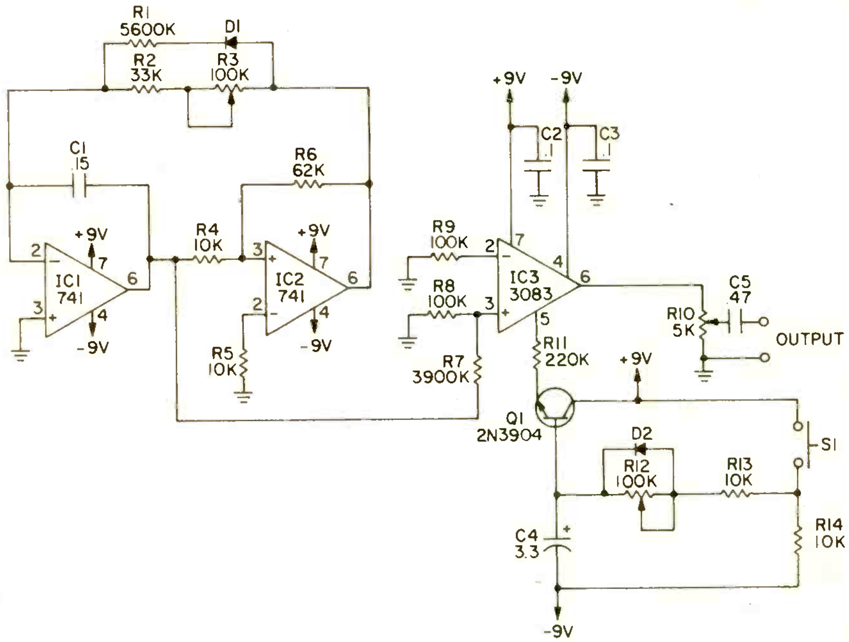


31. Slide Trombone

☐ This is a novel little instrument that can be played through your stereo system. IC1 and IC2 comprise a ramp generator, the frequency of which is adjusted by R3. The range of adjustment spans two octaves from 150 to 600 Hz. The ramp signal is fed to modulator IC3, which imparts a natural-sounding attack and decay to the note the sounds when S1 is pressed. R12 allows adjustment of the note's decay interval, and R10 controls the volume. Maximum signal amplitude at the output is 500 mV peak to-peak (sufficient to drive an amp's high-level input). To play, adjust R3 for a particular note; press S1; slide R3; then release S1. You can make things easy by calibrating R3 in terms of musical notes. Either a slide or rotating pot can be used for R3, depending on your playing preferences.

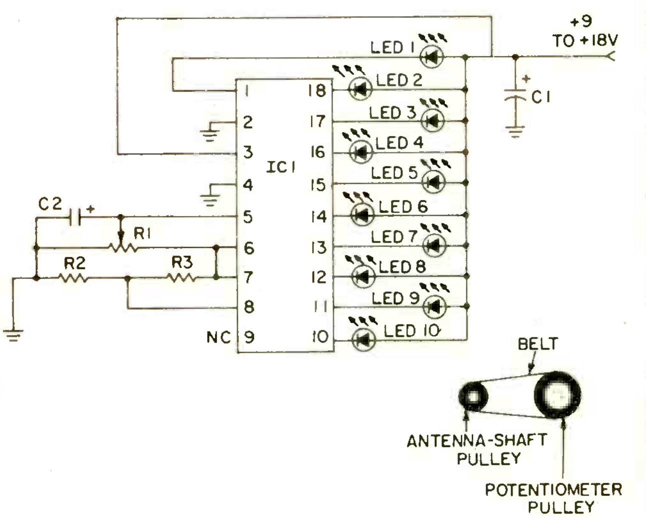
PARTS LIST FOR SLIDE TROMBONE

C1—0.15-uF mylar capacitor
C2, C3—0.1-uF ceramic disc capacitor
C4—3.3-uF, 25VDC electrolytic capacitor
C5—0.47-uF mylar capacitor
D1, D2—1N914 diode
IC1, IC2—741 op amp integrated circuit
IC3—3080 transconductance amp integrated circuit (RCA)
Q1—2N3904 NPN transistor
R1—5,600-ohm, ½-watt resistor (all resistors 10%)
R2—33,000-ohm, ½-watt resistor
R3, R12—100,000-ohm linear-taper potentiometer
R4, R5, R13, R14—10,000-ohm, ½-watt resistor
R6—62,000-ohm, ½-watt resistor
R7—3,900-ohm, ½-watt resistor
R8, R9—100-ohm, ½-watt resistor
R10—5,000-ohm audio-taper potentiometer
R11—220,000-ohm, ½-watt resistor
S1—pushbutton switch, normally open



32. 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

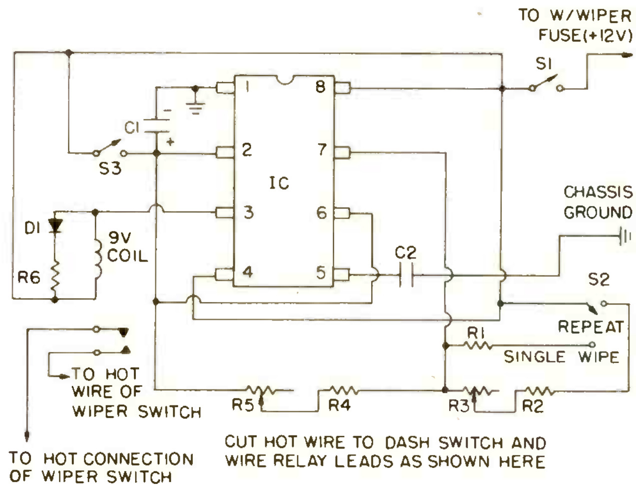
C1—100-uF electrolytic capacitor, 35 VDC
C2—5-uF electrolytic capacitor, 10 VDC
IC1—LM3914 LED display driver
LED1 through LED10—light-emitting diode
R1—25K linear-taper potentiometer
R2—3900-ohm, ½-watt resistor, 5%
R3—1200-ohm, ½-watt resistor, 5%

33. Go-Slo Wiper Control

☐ Ever have the problem of not being able to make your car wipers go slow enough? And sometimes, would you like to just press a button to make wipers flip one time? This circuit does both. Set S2 to the mode you want. If you pick "repeat", then R3 will determine the time between wipes (up to several minutes), so put R3 on a knob you can turn while sitting in the driver's seat. R5 will control the length of the wipe; you just set it once for your car. If S2 is set to "single wipe", then pressing S3 will kick the wipers up once. A very handy circuit.

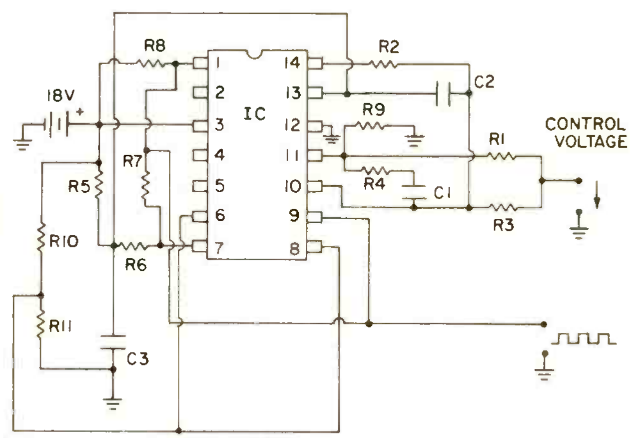
PARTS LIST FOR SELECT-DELAY WINDSHIELD WIPER CONTROL

C1—100-uF electrolytic capacitor, 15 VDC
C2—0.1-uF ceramic disc capacitor, 15 VDC
D1—1N4001 diode
IC1—555 timer
R1—10,000,000-ohm, ½-watt resistor
R2—20,000-ohm, ½-watt resistor
R3—500,000-ohm linear-taper potentiometer
R4—18,000-ohm, ½-watt resistor
R5—50,000-ohm linear-taper potentiometer
R6—100-ohm, ½-watt resistor
S1—SPST toggle switch
S2—SPDT toggle switch
S3—SPST momentary-contact (pusbutton) switch
RELAY—9 VDC coil with normally open SPST switch contacts rated at 15 VDC/25 amps



34. High Frequency VCO

☐ By varying the control voltage (a separate battery) between 1 and 25 volts, the output frequency of this oscillator will vary between about 500 Hz and 50,000 Hz. There are a host of experimental applications, such as putting a microphone in series with the control voltage and having the output frequency go into an amplifier and speaker. Voice-like singing sounds can be made. Or run the output of an electric guitar into the control voltage input and listen to the music!



PARTS LIST FOR HIGH-FREQUENCY VOLTAGE CONTROLLED OSCILLATOR

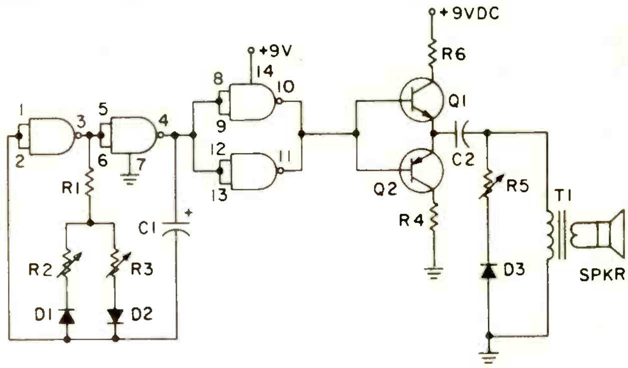
C1—0.1-pF ceramic disc capacitor, 15 VDC
C2—500-pF mica capacitor, 15 VDC
C3—0.01-uF ceramic capacitor, 15 VDC
IC1—LM339 quad comparator
R1, R7—100,000-ohm, ½-watt resistor
R2—50,000-ohm, ½-watt resistor
R3—20,000-ohm, ½-watt resistor
R4—10,000-ohm, ½-watt resistor
R5, R8—3,000-ohm, ½-watt resistor
R6—5,100-ohm, ½-watt resistor
R9, R10, R11—30,000-ohm, ½-watt resistor

35. Mini Micro Metronome

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

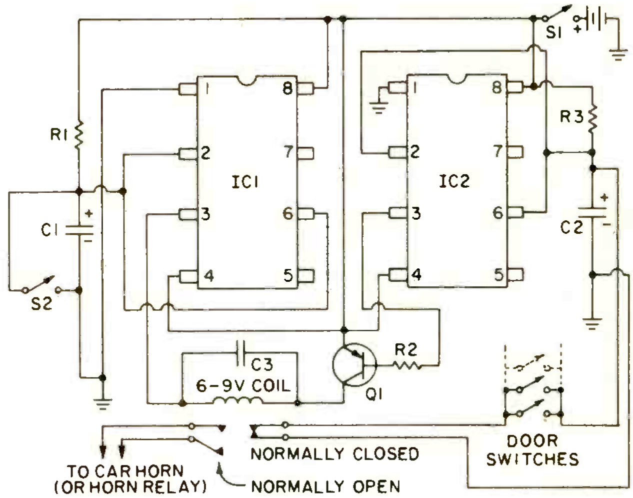
PARTS LIST FOR MINI-MICRO METRONOME

- **C1**—2 to 5-uF low-leakage mylar or tantalum capacitor, 15 VDC
- **C2**—2.2 to 10-uF electrolytic capacitor, 15 VDC
- **D1, D2, D3**—1N4148 diode
- **IC1**—4011A quad NAND gate
- **Q1**—2N4401 transistor
- **Q2**—2N4403 transistor
- **R1**—47,000-ohm, ½-watt resistor
- **R2, R3**—500,000-ohm linear-taper potentiometer
- **R4, R6**—10-ohm,½-watt resistor
- **R5**—1,000-ohm linear-taper potentiometer
- **T1**—audio output transformer 500-ohm primary/8-ohm secondary



36. Auto Burglar Alarm

☐ This burglar alarm will sound your car horn if anyone opens your car door. The timers allow you to leave and enter the car without the horn sounding. To set, or arm, the alarm circuit, open S2. This will give you five seconds (R1, C1) to get out and shut the door behind you. If anyone opens a door for two seconds (R3, C2), the horn will sound and will stay locked on until S1 is opened. If you open the door to enter, you have two seconds to close S2, which is plenty of time if S2 is conveniently located.



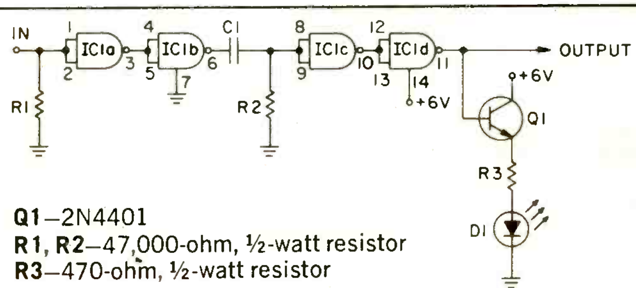
PARTS LIST FOR AUTO BURGLAR ALARM

- **C1**—10-uF electrolytic capacitor, 15 VDC
- **C2**—1-uF electrolytic capacitor, 15 VDC
- **C3**—0.1-uF ceramic disc capacitor, 15 VDC
- **IC1, IC2**—555 timer
- **Q1**—2N4403
- **R1**—500,000-ohm, ½-watt resistor
- **R2**—270-ohm, ½-watt resistor
- **R3**—2,000,000-ohm, ½-watt resistor
- **RELAY**—6 to 9 VDC coil with switch contacts rated at 15 VDC/30 amps; 1 set SPST normally open, 1 set SPST normally closed

37. Improvised Monostable

☐ Like the preceeding projects, this one is also dedicated to the art of improvisation. While TTL and CMOS prepackaged monostable multivibrators are available, one may not be at hand when such a useful device is called for. Once again, two very common gates, the 4001 quad NOR and the 4011 quad NAND will equally fill the bill.

In operation, when the input is made high, the output of the first inverter goes low, forcing the output of the



PARTS LIST FOR IMPROVISED MONOSTABLE

- **C1**—0.1-uF ceramic capacitor, 15 VDC
- **D1**—small LED
- **IC1**—4001A or 4011A quad NAND gate
- **Q1**—2N4401
- **R1, R2**—47,000-ohm, ½-watt resistor
- **R3**—470-ohm, ½-watt resistor

second high, charging the capacitor C through resistor R2. For a while, the output of the third gate is driven low, causing the output stage to go high, activating the LED indicator. In this elementary circuit, it is only necessary that the turn-on signal remain high for at least the duration of the timed interval.

38. Computer-Controlled Keyer

□ This is a good companion to the computer-controlled note generator. Your computer should have available an 8-bit parallel port with which to control the keyer's gain. Feed the desired audio tone to the keyer's input, and hook an amplifier to its output.

A binary zero on the 8 lines from your computer yields zero output, while a binary 255 (11111111) provides maximum output. (D7 is the most-sinificant bit, and D0 is the least significant.) During a note's attack interval, count upwards from 0 to 255. Conversely, count down from 255 to 0 to make the note decay. Take tiny steps for best results. Large steps generate thumping sounds in the output.

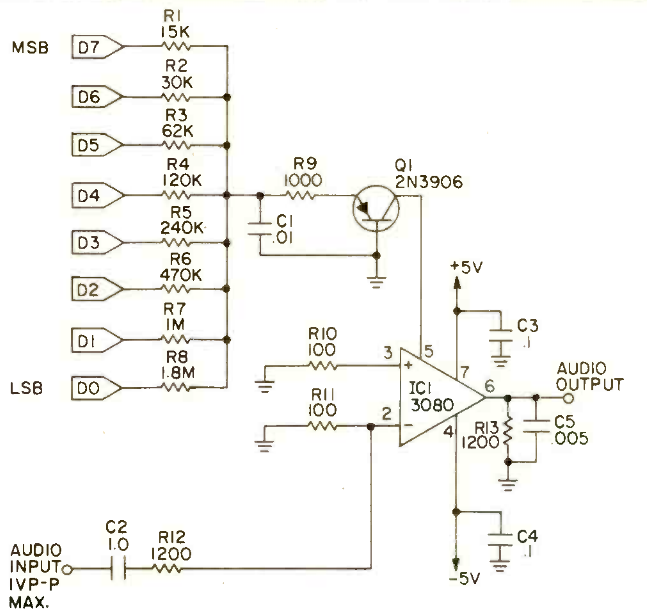
Let's say we want a fast attack time of 10 milliseconds. Using all available codes, it will take 255 steps to climb from zero to full output. For simplicity's sake, we'll let the note's amplitude rise linearly during attack, which means that the code will be incremented at regular, fixed time intervals. Since we wish to take 255 steps in 10 milliseconds (10,000 microseconds), it will be necessary to increment the code by 1 every 40 microseconds or so.

Linear attacks and decays are easy to figure, but not very realistic—especially for decay. The notes from most musical instruments attack and decay exponentially. This circuit gives you unlimited potential in the specification of a note's envelope, and it lets you change the envelope from note to note.

The audio input should be in the neighborhood of 1 volt peak-to-peak. When using the 12-volt signal from the computer-controlled note generaor, raise R12 to 15K ohms to accommodate the increased input amplitude.

PARTS LIST FOR COMPUTER-CONTROLLED KEYER

C1—.01-uF ceramic disc capacitor
C2—1.0-uF mylar capacitor
C3, C4—0.1-uF ceramic disc capacitor
C5—.005-uF mylar capacitor
IC1—3080 transconductance integrated circuit amplifier (RCA)
Q1—2N3906 PNP transistor
R1—15,000-ohm, ½-watt resistor (all resistors 5%)
R2—30,000-ohm, ½-watt resistor
R3—62,000-ohm, ½-watt resistor
R4—120,000-ohm, ½-watt resistor
R5—240,000-ohm, ½-watt resistor
R6—470,000-ohm, ½-watt resistor
R7—1,000,000-ohm, ½-watt resistor
R8—1,800,000-ohm, ½-watt resistor
R9—1,000-ohm, ½-watt resistor
R10, R11—100-ohm, ½-watt resistor
R12, R13—1,200-ohm, ½-watt resistor



39. Computer-Controlled Note Generator

□ Computer music can be created in many different ways. One method is to specify all of a note's parameters—frequency, harmonic structure, amplitude, and attack/sustain/decay times—as well as special effects by means of software. Naturally, this gobbles up a lot of memory, thus making such an approach impossible for the owner of a very small computer. All is not lost, however. By augmenting your system with some inexpensive hardware, the software burden is diminished.

This computer-controlled note generator produces 5 octaves of the equally tempered chromatic scale under the control of one of your computer's 8-bit parallel ports (only 7 bits of which are used). Lines D6 through D4 select the octave, while lines D3 through D0 select one of the twelve notes within that octave.

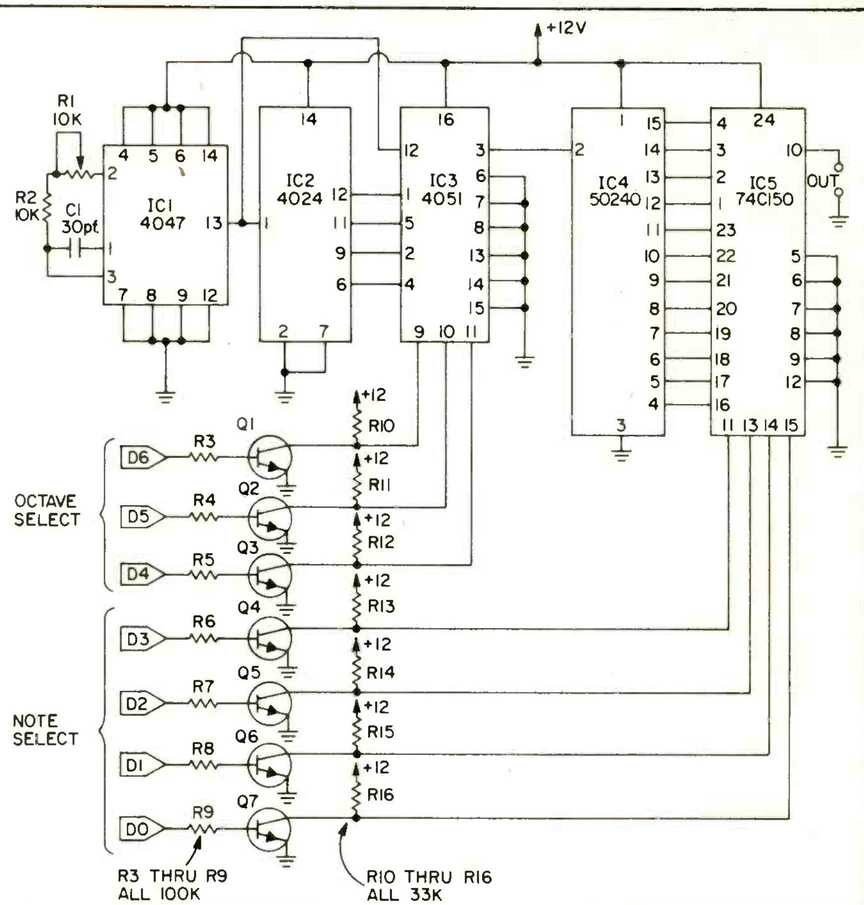
The lowest octave is selected by a binary 0 on lines D6 through D4. A binary 1 selects the next higher octave, and so on until you reach the highest octave, coded by a binary 4 (100). (Note: D6 is the most significant bit; D4 is the least significant.) Codes higher than 4 yield no output.

The note-selection lines behave similarly, except that 12 codes are used. (Here D3 is the most significant bit, and D0 is the least significant.) Binary 0 gives you a C#. D is produced by a binary 1, and binary 2 yields D#. This continues on up the scale until you reach binary 11, which gives the twelfth note, C. Codes above binary 11 give no output.

Tuning can be accomplished by adjusting R1 to produce a 1,000,120 Hz signal at pin 13 of IC1, or you can tune by ear against some pitch reference. The output at pin 12 of IC5 is a square wave that can be filtered and/or shaped (see the computer-controlled keyer circuit). The software we'll leave to you. In general, your programming burden has been reduced to the generation of a rhythmic sequence of 7-bit binary codes.

PARTS LIST FOR COMPUTER-CONTROLLED NOTE GENERATOR

C1—30-pF polystyrene capacitor
IC1—4047 CMOS multivibrator integrated circuit
IC2—4024 CMOS binary divider integrated circuit
IC3—4051 CMOS 8:1 multiplexer integrated circuit
IC4—50240 Mostek top-octave generator integrated circuit
IC5—74C150 16:1 CMOS multiplexer integrated circuit (National)
Q1-Q7—2N3904 NPN transistor
R1—10,000-ohm trim potentiometer (all resistors 10% unless otherwise noted.)
R2—10,000-ohm, ½-watt resistor
R3-R9—100,000-ohm, ½-watt resistor
R10-R16—33,000-ohm, ½-watt resistor

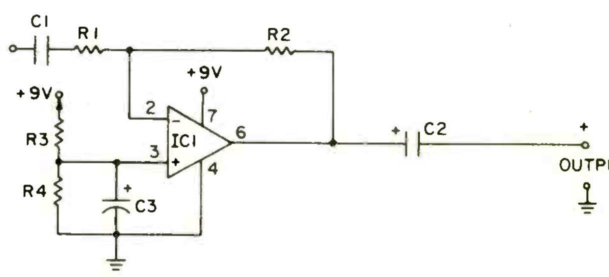


40. Single Supply Signal Shifter

☐ 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.

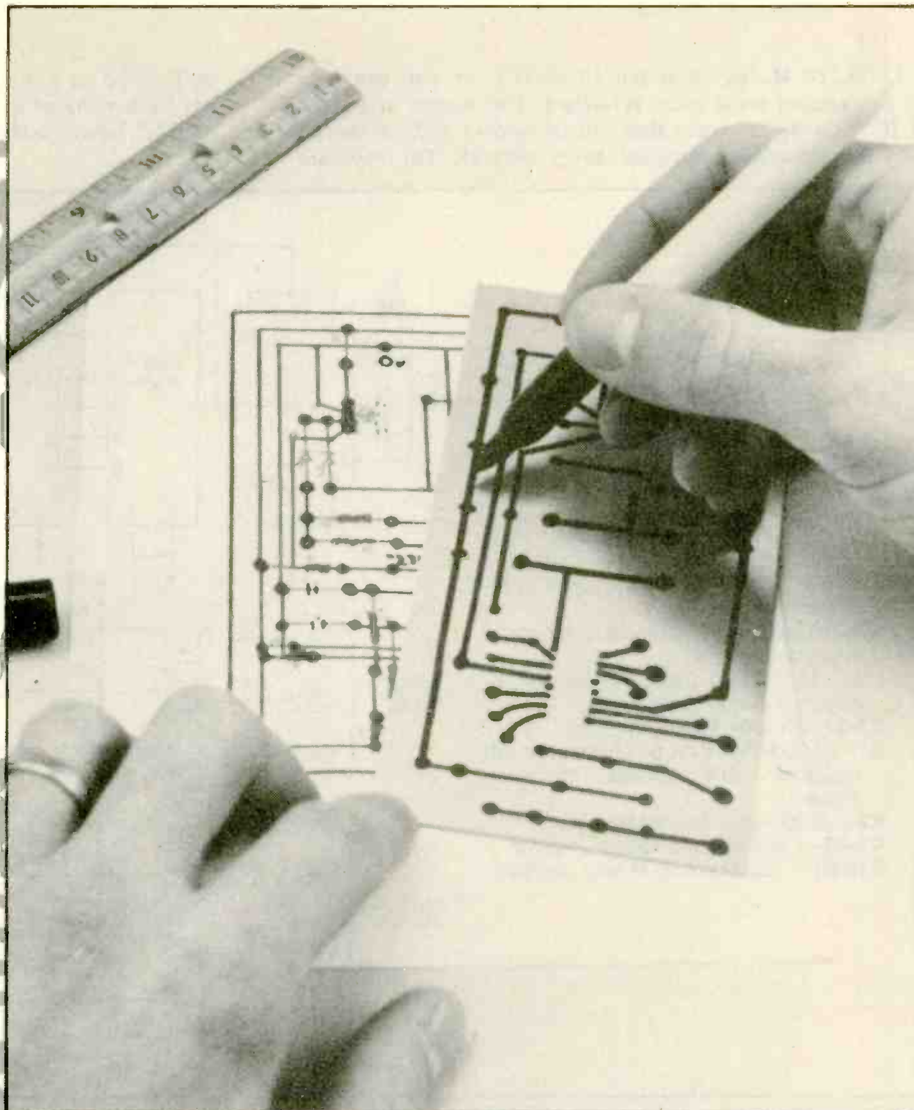
PARTS LIST FOR SINGLE SUPPLY SIGNAL SHIFTER

C1—0.01-uF ceramic capacitor, 15 VDC (gain=10)
—0.10-uF ceramic capacitor, 15 VDC (gain=100)
C2—1 to 100-uF electrolytic capacitor, 15 VDC (increase value with frequency)
C3—100-uF 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



CIRCUIT BOARD ETCHING

A step-by-step guide to making project boards



WHILE PERFORATED PROJECT BOARDS, or perf boards, are relatively cheap and easily obtained, a circuit board etched for its particular usage will provide neater, more professional results. Projects with the circuitry foundation of an etched board will be less prone to vibration damages as well as have greater impact resistance—in all, an etched board provides sturdier construction and greater safeguards.

In addition to the quality of construction, in contrast to perf boards, etching lessens the chances of undesirable oscillations caused by crossed or jumpered output signal wires producing feedback in sensitive component elements. Also, electrical noise interference caused by spurious radiations in the circuit's environment are more easily suppressed as a result of the close proximity of ground and voltage supply leads. Decoupling capacitors can easily span supply and ground distribution lines with correct board layout.

Only the etching process will be discussed in this article. The actual circuit board layout should be considered carefully and fully in advance.

Materials. The materials required for board etching can be found in nearby electronic retail stores, and the supplies, once purchased, should last through a number of etchings. A list of the materials needed includes:

1. Copper Clad Board.
2. Etchant Solution.
3. Resist Pen.
4. Shallow Pan.
5. Heat Source.
6. Template.
7. Drill Bits.

1. Copper-Clad Board. For good results on initial etchings, use boards with copper coating on one side only. A little experience is best before attempting double-sided boards. As for board dimensions, any convenient thickness or size will do depending upon the individual project. Copper-clad boards can easily be cut to fit exact measurements with a fine-toothed saw such as a hacksaw.

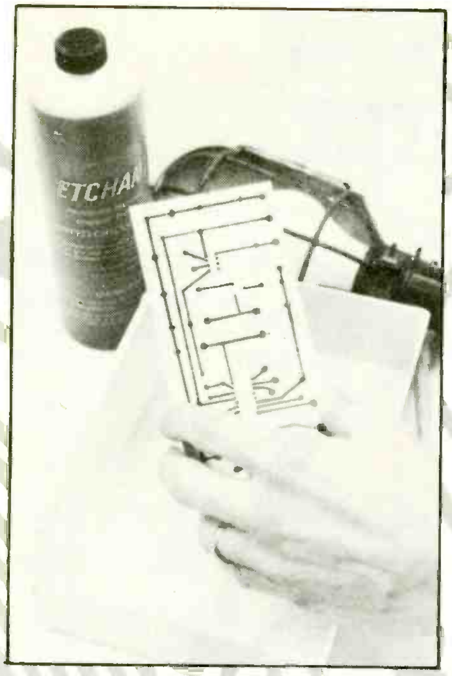
2. Etchant Solution. There is a variety of etchant solutions currently on the market, both in crystal form and already mixed. An inexpensive, pre-mixed solution of ferric chloride is good for a starter; it conveniently provides a uniform end product. Although the solution used during an etching (several boards may be etched at once) cannot be reused, the bottles of solution commercially available contain enough fluid for a number of board projects.

3. Resist Pen. Most electronic retail outlets have on stock pens specially designed for circuit board etching. However, most discount or five-and-dime stores sell the Sanfords Sharpie pen, or one like it, guaranteed to write on metal, plastic, etc. for one-quarter to one-half the price of the special resist pens. Both types give good service.

4. Shallow Pan. Do not use metal pans to etch in, because the etchant will act on the pan metal. Instead, use a glass or plastic pan close to board size to conserve the etchant solution. An inexpensive set of plastic photographic developing trays would be a good investment for etching projects. Photographic trays are available in a variety of sizes.

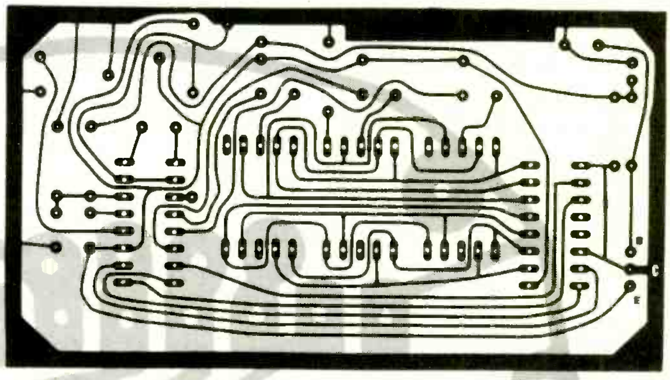
5. Heat Source. A thermostatically controlled heat lamp would be the ideal heat source to be used during the etching process. However, an ordinary 60-watt light bulb suspended near the solution pan will accomplish the same thing for less expense. A droplight with a 60-watt bulb works well. Use a plastic photographic darkroom thermometer for temperature checking. In fact, with warm (60°F or above) air temperature, simply placing the plastic tray in warm water will provide the needed heat during the etching process.

6. Template. A template, or exact board layout, can be hand drawn. Often



This photo shows all of the vital items needed to etch custom-made circuit boards.

Some practice is needed to etch involved circuit boards like this one, but even a board of this complexity is within reach of hobbyist who is willing to learn etching.



it is provided in electronic project plans.

7. Drill Bits. For board projects, get drill bits size 1/16-inch and 1/32-inch. Bits in these sizes can be found in most hardware or hobby stores.

Marking The Board. A board layout, or template, provided with an electronic project may already be drawn in reverse. This is necessary, since circuit designs are drawn from the component side of the board, leaving the copper clad rear of the board an exact reverse.

If the design to be etched onto the circuit board is an original hand drawn layout, though, a reversed drawing can be easily accomplished by placing a carbon ink side up beneath the drawing and retracing the lines of the layout topside. When the carbon is removed, an exact reverse remains on the back of the original drawing. This carbon reverse is the template for etching. Before transferring the template drawing to the copper clad board, *lightly* rub the copper with a steel wool pad, then rinse and dry. Cleaning the board in this way permits the resist ink to adhere better.

Taking the template, punch small holes in the paper at each connection point. Place the template over the copper and use the resist pen to mark each connection point through the holes. Remove the template. If the circuit is simple, draw the rest of the template drawing onto the board. If lines are complicated, use a ruler as straightedge.

To get the most accurate results using the resist pen, store the pen with its tip down for several hours prior to use. When drawing on the copper, use long smooth lines and stop marking only at connecting points, otherwise there will be fine lines in the resist ink that will cause hairline cracks in the finished product. Do not back-up while marking or retrace lines for best results. Wide lines can be drawn by using the side of the pen point. Two lines drawn side by side can produce a wide area, but generally the end product is better using one mark. When mistakes occur, erase with a pencil eraser. Store the resist pen point down to prevent the point from drying between usages.

Etching. The etchant itself is an acid and therefore handle the solution with care. Take the same precautions necessary when handling any acid. Do not store the fluid where it is accessible to children. If during the etching process the solution splashes into the eyes, flush the affected area with water immediately and see a physician. Avoid body contact with the fluid and wash well if the etchant touches skin.

Pour only enough etchant needed to cover the resist marked board to a depth of ⅛-inch or slightly greater into the shallow tray. Use the etchant solution in a well ventilated room, and avoid breathing the fumes. Place the heatlamp or light bulb near the solution to raise the fluid temperature to approximately 100°F—the exact degree of temperature is not critical. Carefully slide the board into the etchant, copper side up. Gently agitate the solution every few minutes. By using the proper temperature of near 100°F, the etching should be completed within 15 minutes or so. Keep a close eye on the board and remove immediately upon completion of the etching. Tilt the pan carefully to one side to determine if all unwanted copper is gone.

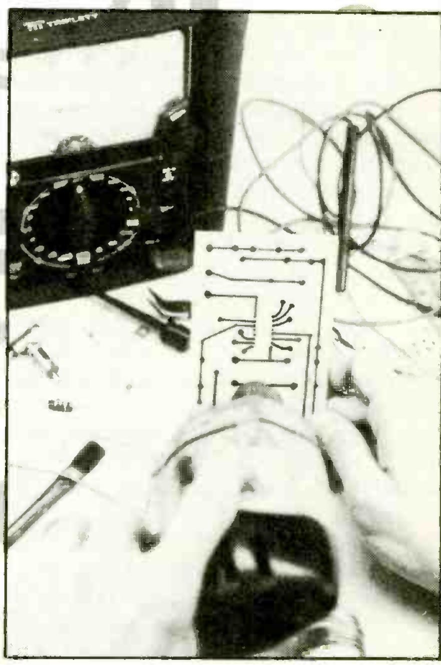
The etching process can be undertaken with success using no heat source if the etchant solution temperature is above 60°F. The process takes approximately one hour with no applied heat, but the results are not as certain.

Finishing The Board. After the etching process has been completed, pour off the solution and rinse the board well under running water. Do not pour the used solution back into the solution bottle with unused etchant—this contaminates the entire contents of the bottle. To remove the resist ink, *gently* rub with a steel wool pad. Rinse, then dry the etched board.

Drill holes for connection wires with a 1/16-inch drill bit. For transistor or other component leads, use a bit size of 1/32-inch. To use these tiny bits in an ordinary hand drill, wrap the bit shank with masking tape before inserting it into the drill.

During etching, hairline cracks may form in critical paths on the board. Repair these cracks with solder before attaching components to the board.

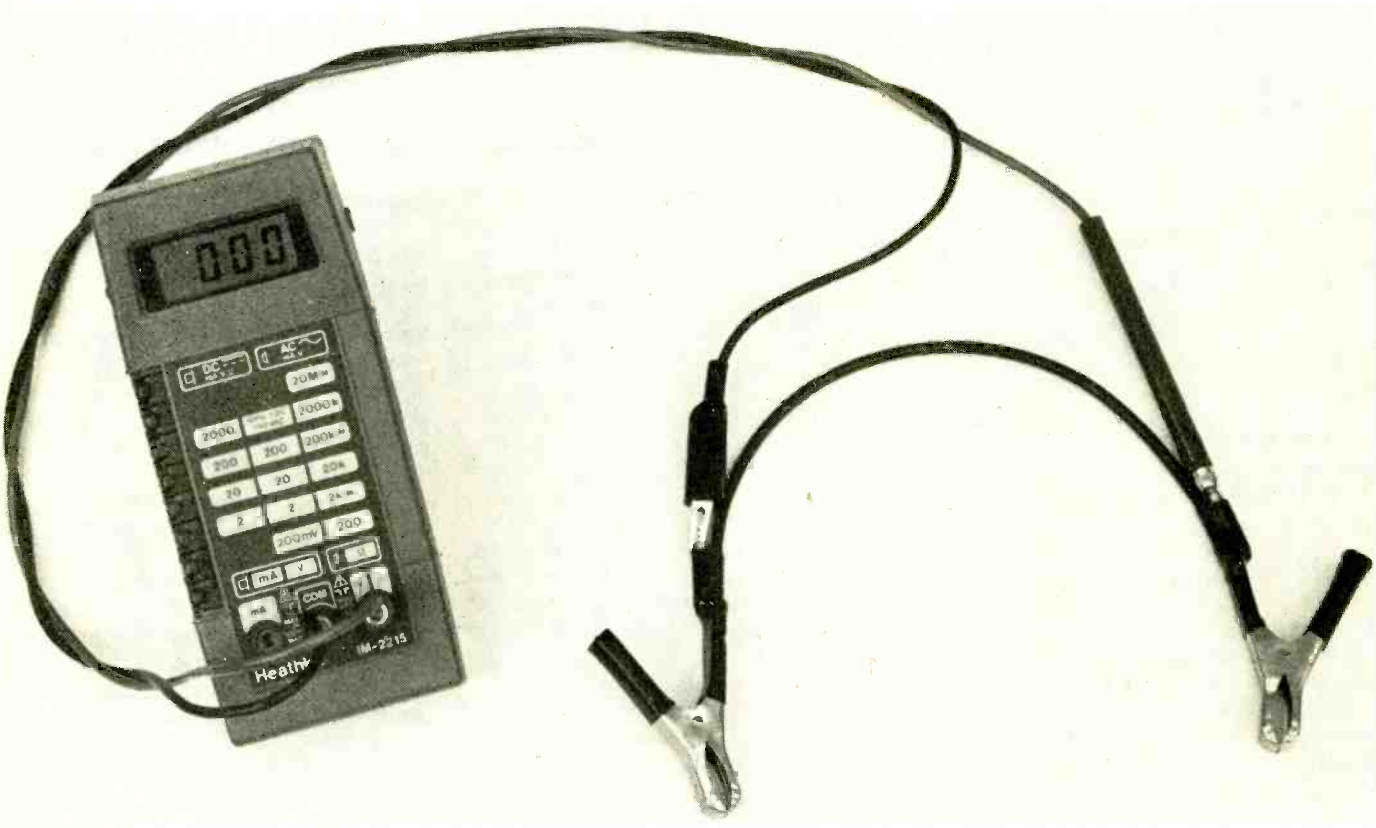
The etched circuit board is now ready for whatever project you have in mind. ■



The final step is drilling holes to mount components. Use a 1/16- or 1/32-inch bit.

TROUBLESHOOTING WITH A DIGITAL MULTIMETER

Check out your ignition system for fun and profit



IF YOU WANT to measure the large current from your car's alternator or starter, here are a few tricks on how to do it with your digital multimeter.

Digital multimeters (DMM) are sensitive and accurate devices. They have a much greater range than common analog multimeters; with a little help, they can measure very large currents. The help is from a low resistance shunt.

A Small Resistance. A one milliohm shunt is a very small resistance, but it still behaves as a resistor and every ampere through it causes a one millivolt drop. Digital voltmeters can read millivolts and most will read and display tenths of millivolts. This extreme voltage sensitivity allows them to work as ammeters when connected across a one milliohm shunt.

A DMM connected across the ground cable thus becomes a high-current ammeter. Similarly, a charging current of 40 amps into the battery produces a voltage drop of .040 volts across the cable.

The key is to calibrate your battery cable. It's easy. Most car low beams, including the running lights, use about 12 amperes. With the headlights on, measure the voltage drop across the ground cable. Suppose this turns out to be .020 volts.

Therefore, a starter draw of .192 volts across the cable means that 12÷20 or .6 of 192 amperes are flowing: about 120 amperes. Approximately .6 of the millivolts read on a DMM are the amperes through it.

If the 12 ampere headlight had caused a .005 volt drop across the cable, 12÷5 or 2.2 times the DMM reading of millivolts across the cable represents the amperes through it.

Needs A Strong Battery. This calibration is best done with a strong battery. Check the cable on the positive terminal, running to the solenoid. It might be more convenient to use.

If you do not like the mental arithmetic involved in converting millivolts into amperes, connect taps to the battery cable to produce a 12 millivolt drop when the low beams are on.

Puncture the cable insulation with a sharp pin. Place the tap in the middle of the region of the cable where the voltmeter reads 12 millivolts.

The taps are combination jacks accepting probe tips, banana plugs, or alligator clips (GC F2-883 or Allied 920-0222). Make the electrical connection with a small sheet metal screw, #4, ¼" long. It will separate the strands of wire in the cable and be held snug to the taps.

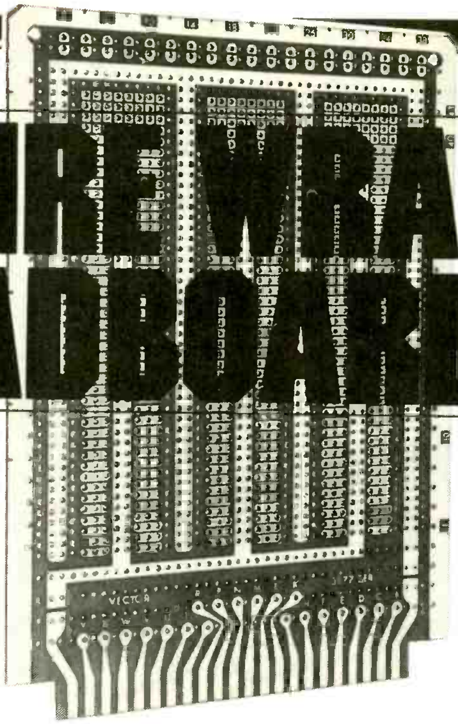
Tape it securely. This is a more satisfactory way to measure all currents in the car, even down to tenths of amperes for small lights or electronic systems, provided your DMM reads to tenths of millivolts.

Even a 20% error is acceptable when looking for trouble and will tell the difference between a shorted starter motor and a solenoid that isn't closing.

A third way to read currents in your car with a DMM is to build or buy a one milliohm shunt that can be clamped in between the battery ground cable and the negative terminal.

With this value of shunt the millivolts on the DMM connected to the shunt read accurately as amperes. ■

WIRE-WRAP BREADBOARDING



A survey of this method and its special tools

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.

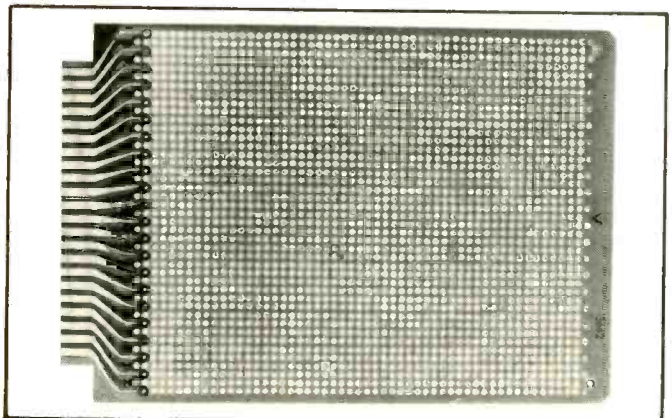
However, the finished product is rugged and, if designed with care, usually compact in size.

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 reuseable 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).

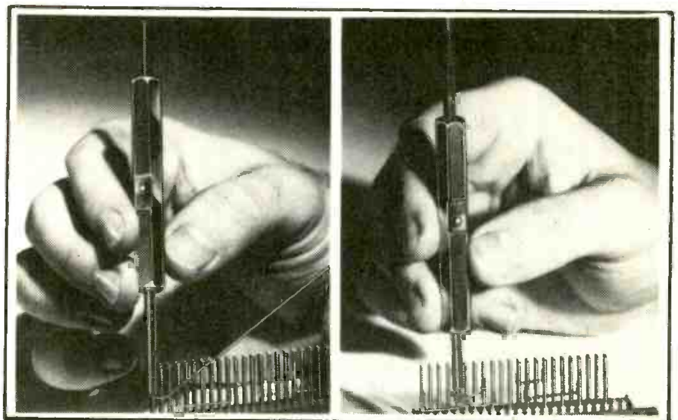
The Best of Both. This brings us to the relative newcomer in the hobbyist construction field, the wire-wrapped breadboard. We use the term "relative newcomer," because in fact wire-wrapping as a method of connecting components together on a circuit board has been around for close to twenty years, but 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-



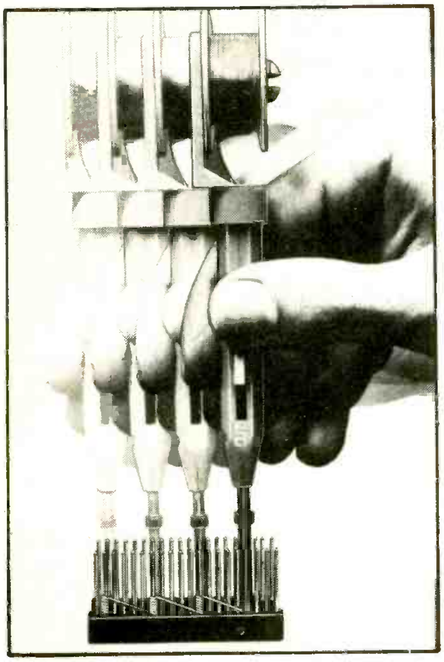
An excellent example of a "basic" matrix board is this model 3662 Plugboard™ from Vector. In addition to the edge-pin terminals, this model has hole spacing which accomodates that of DIP ICs.



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

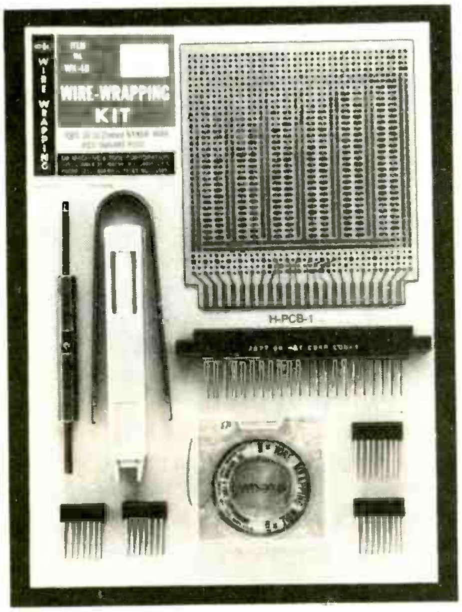
jects available for the hobbyist to build. One can literally build her or his own microcomputer from scratch these days, and the complexity of the circuitry involved dictates that the medium upon which the circuit is constructed be flexible enough to allow rearrangement of components and connections 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

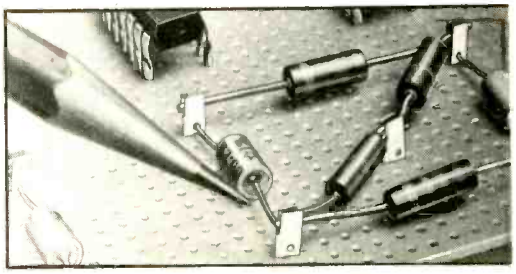


A good starter kit is OK's WK-4B, which contains all you'll need to begin to execute your projects in wire-wrapped formats. Make sure the terminals you buy are the correct diameter for your boards' holes.

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 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.)

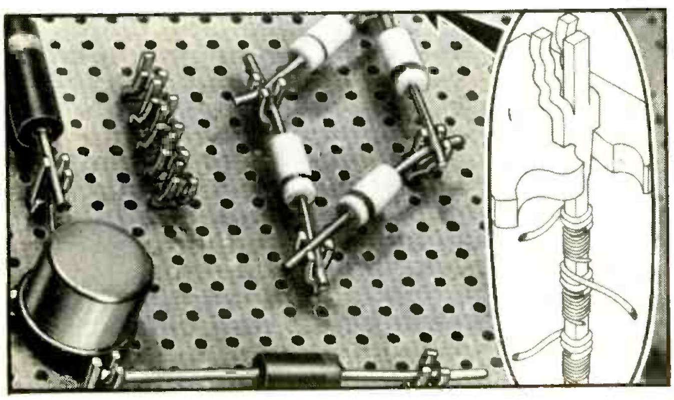
The base for your wire-wrapped circuitry can be as simple as a regular, perforated phenolic board, or something as esoteric as an epoxy/glass copper-clad board. The simpler perforated boards require that you merely insert wire-wrap terminals at the points where component leads meet on the board, and 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.

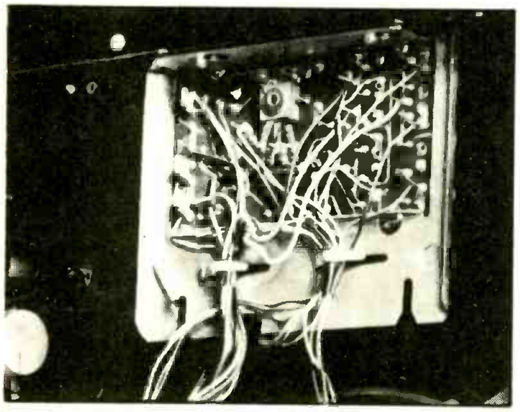
Some Nice Touches. Additionally, there are many specialized board designs available for computer-type circuitry, with special end terminal accessories for mating with standard ribbon connectors and/or PC card 44-pin edge connectors. For breadboarding peripheral circuitry for home computers, wire-wrap 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



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.

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

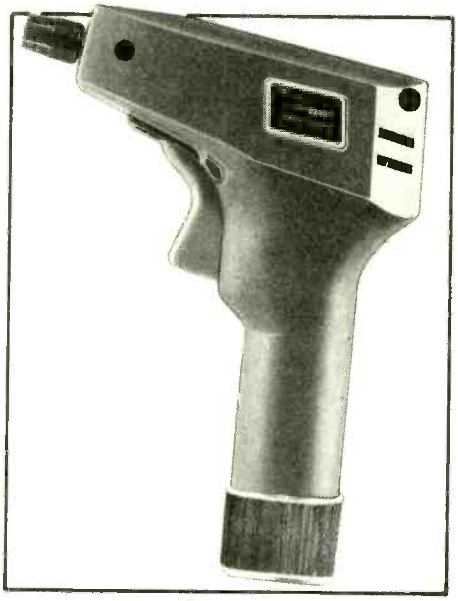
The more complex copper-clad boards which we referred to earlier also allow the builder to create "hybrid" circuit boards, utilizing the copper traces for standard printed circuit assembly of some components, while still being able to insert terminals through



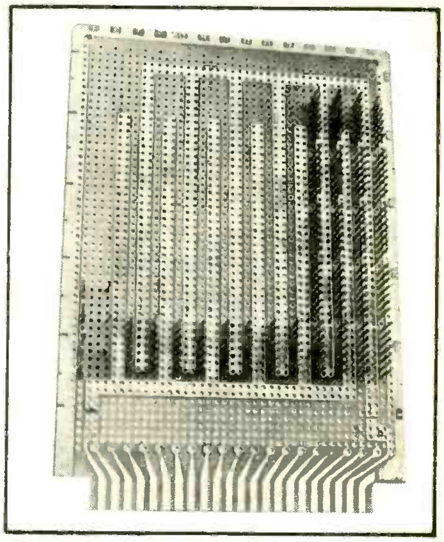
The high-voltage circuit board of this mid-1960's TV shows the use of wire-wrapped terminals combined with printed circuits. This type of hybrid can be built using the type of matrix boards seen on this page.

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.

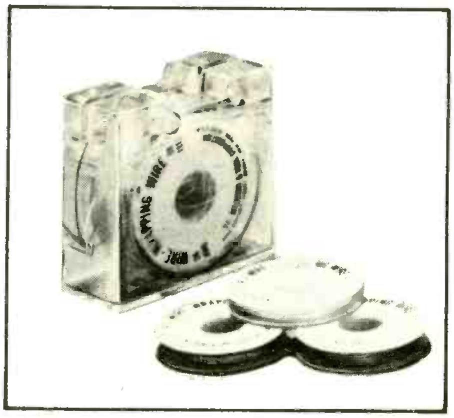
Where to Get Them. If the possibilities we've presented here appeal to you, then by all means do some further investigating on your own, either at your local electronics supplier, or by contacting the manufacturers directly. OK Machine and Tool Company, one of the largest hobby supplier of wire-wrapping 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. ■



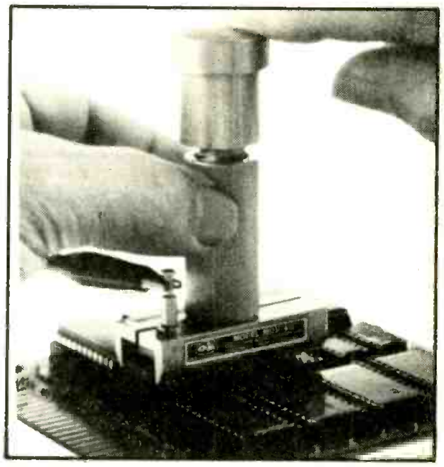
If you decide to go into wire-wrapping in a big way, a battery-operated wrapping tool can be a real time and work-saver. Interchangeable bits accommodate all wire sizes commonly used for wire-wrap construction.



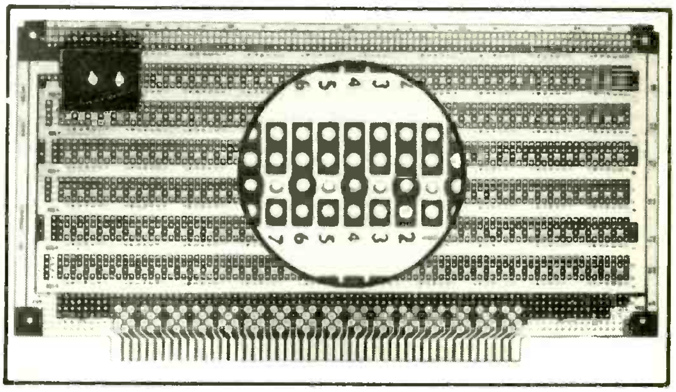
This Plugboard™ (model 3682-4) has etched copper bus strips for soldering as well as holes for wire-wrap terminals. This allows you to build rugged, yet flexible circuitry for virtually any electronic application.



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.

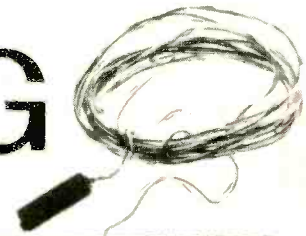


For safe and sure removal of delicate CMOS (as well as other types) ICs, an insertion tool is recommended. OK's MOS-40 has a lug for grounding the tool, this prevents damage caused by static electrical charges.

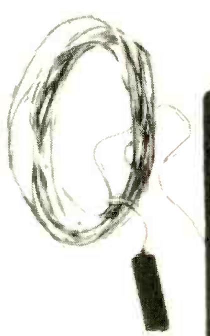
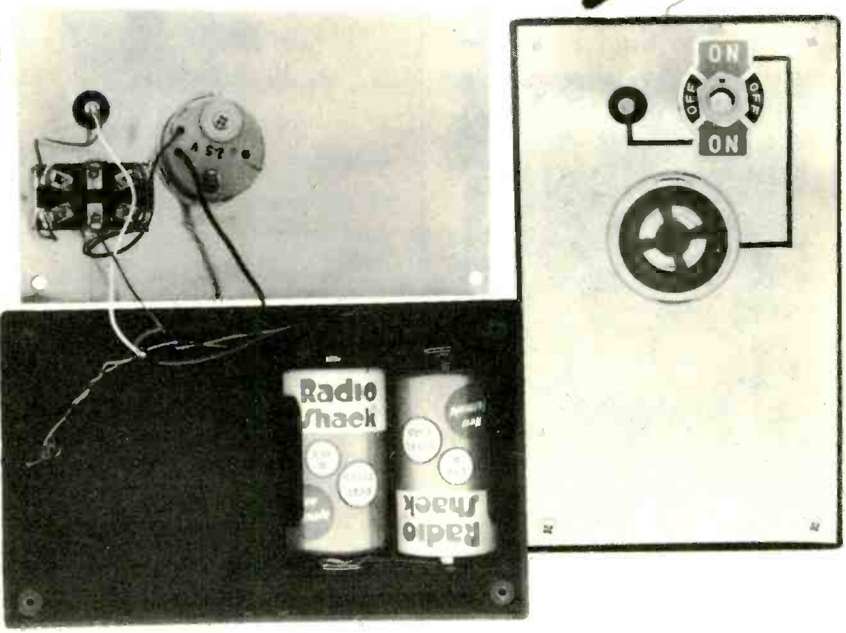


Vector's "Any DIP"™ Plugboard is designed specifically for S-100 microcomputer accessory circuitry. It comes complete with a built-on heatsink for power supply voltage regulator chips.

SIMPLEX-A-THING



Remote telephone signaling helps avoid missing those important phone calls

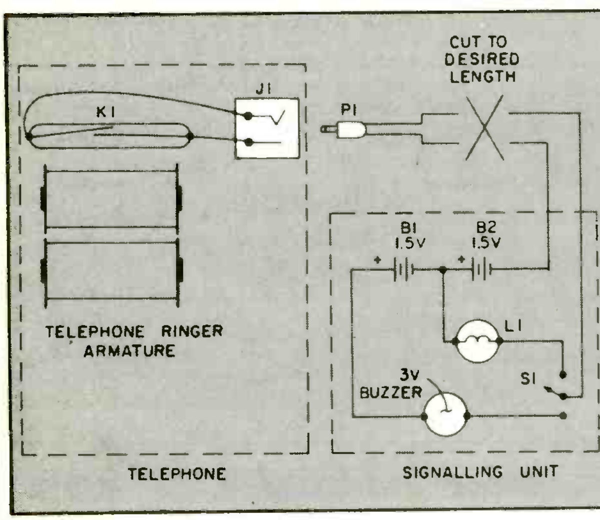
YOU WON'T MISS any more phone calls when out of hearing range of your telephone, if you add this simple remote signalling unit which alerts you to incoming calls by means of either a buzzer or blinker light. The unit is self powered for easy placement in any room in your home, or even outdoors where there are no AC outlets.

Now that you are permitted to own your own phone, you don't have to worry about the legality of add-on convenience devices, so long as you don't upset the phone company's circuits. This unit won't bother Ma Bell one bit because it is *not* electrically hard-wired to the telephone lines, and therefore cannot possibly cause voltage drops that could be detected at the phone company switching station. This gadget simply senses the normal ringing of the telephone with a magnetic reed switch placed near the telephone ringer armature. When the phone rings, the armature generates a strong electro-magnetic field, which trips the reed switch. The switch is triggered even if you turn the regular telephone bell off to provide completely silent signalling by means of a blinker light.

Construction. Solder a 14-inch-long insulated wire to each end of the reed switch and terminate these leads with a phone jack. Insulate the switch body before installation in the telephone, by means of a plastic sleeve or with electrical tape.

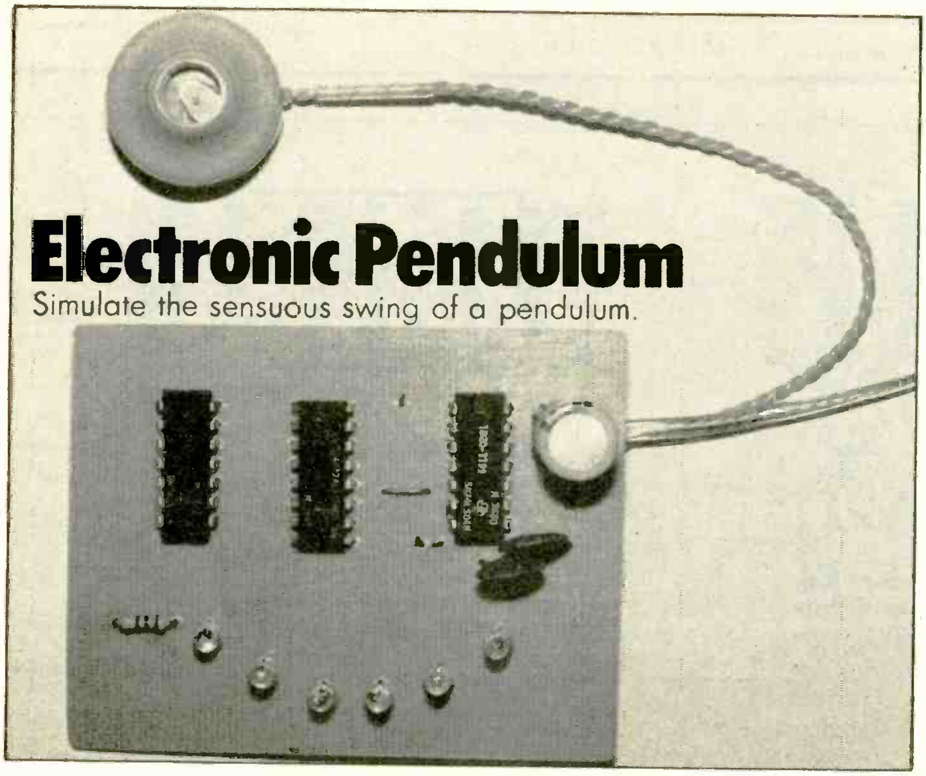
Open the telephone and remove the bell-clapper arm back to where it joins the armature-coil assembly.

Have someone call you on another dialer mechanism by gently lifting it off its mount. Find the ringer armature located just behind the dialer. You can recognize the armatur by following the telephone so that the regular bell rings. With the reed switch plugged into the signalling unit, and the selector switch thrown to the buzzer position, gradually move the reed switch close to the ringer armature. When the buzzer beeps in time with the telephone bell, the reed switch is correctly placed. If the buzzer sounds continuously, even when the phone stops ringing, back the reed switch off a little. In the telephone shown here, mounting was achieved easily by simply taping the reed switch to a large capacitor. ■



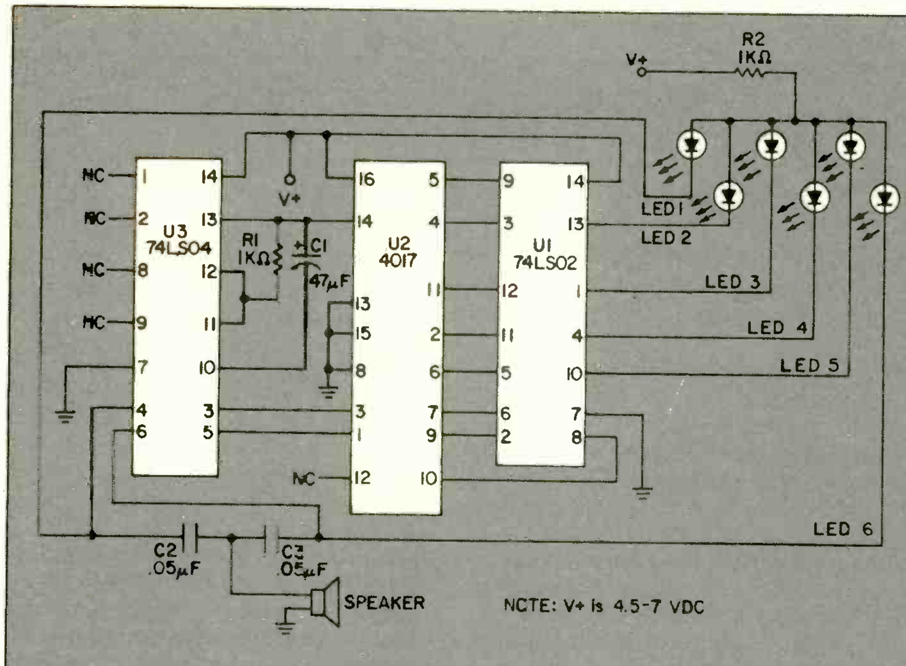
PARTS LIST FOR SIMPLEX-A-THING

- B1, B2—1.5-volt "D"-cell battery
- J1—subminiature phone jack, 2-conductor
- K1—miniature reed switch, SPST
- L1—1.5-volt flashlight lamp
- P1—subminiature phone plug, 2-conductor
- S1—SPDT toggle switch
- MISC: suitable mounting cabinet, 3-volt buzzer or screamer module, length of 2-conductor wire for extension, hookup wire, solder, tape, etc.



Electronic Pendulum

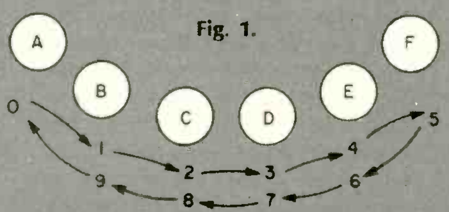
Simulate the sensuous swing of a pendulum.



PARTS LIST FOR ELECTRONIC PENDULUM

LED 1–6—light emitting diode red
R1, 2—resistor, 1,000 ohms, 1/4 watt, 10%
S—crystal earphone
U1—74LS02, quad NOR gate
U2—4017, CMOS counter
U3—74LS04, hex inverter
Misc.—jumper wire, PC board, solder

Fig. 1.



As you see, Electronic Pendulum's circuit is simple and straightforward. Just beware of solder bridges. Note the sequence of firing for the six light emitting diodes.

EVERYONE LIKES THE GRACEFUL SWING of a grandfather clock's pendulum. The motion and tick-tock sound are pleasing to the senses and reinforce the idea that the clock is working. Here is a quick and easy project which duplicates the motion of a pendulum electronically and if desired, the sound as well. Parts cost should run about $4-5 and if you use the PC layout in this article construction time will be a couple of hours.

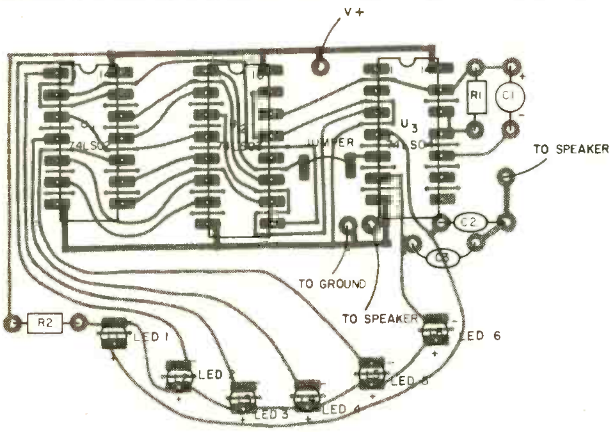
The Circuit. The pendulum operates by having an LSTTL oscillator drive a CMOS 4017 decade counter with decoded outputs. The CMOS chip has ten output lines, 0 through 9, each in turn going "high" after a clock pulse appears on pin 14. Now if you took those outputs and used them directly to light LEDs the result would be a series of bulbs illuminating in sequence 0 to 9 and then going back to 0. But a pendulum doesn't work like that, it swings to the right then to the left. Its electronic counterpart would retrace its path something like 0, 1, 2, 3, 4, 5, then 5, 4, 3, 2, 1, 0, 1, . . . One could use an up-down counter, changing its direction at each end of the count to achieve the above pattern, but there is a simpler way to approximate a pendulum's motion for the hobbyist.

Let's use six bulbs, labelling them A to F. Remember, the counter chip has ten output lines. If we allow some of the lamps to be lit by two outputs instead of just one, we can get oscillatory motion for free, so to speak. Let's see how. Look at Fig. 1. If we let bulb A be turned on by output line 0, bulb B by output 1 or 9, C by 2 or 8, D by 3 or 7, E by 4 or 6, and F by output line 5, the desired result is produced. You can see this easily if you count from 0 to 9 and repeat this modulo ten (base ten) sequence over and over using Fig. 1 for your guide.

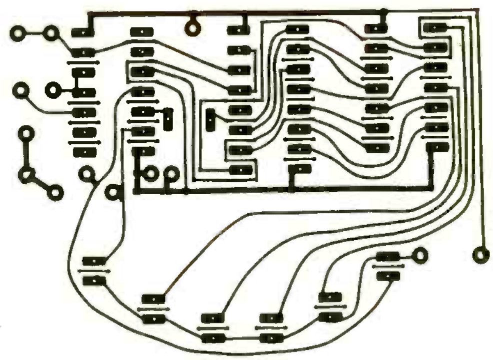
Be sure to notice that L1 is inserted in its PC board holes the reverse of the since the LEDs are activated by a "low" or ground signal. Also note that pins 15 and 13 of the 4017 must be at 0 volts for the CMOS chip to count.

Construction: The two boards on the other page show the respective orientation of the parts. C2, C3 and S are optional, depending on an audible click with the pendulum swing. This circuit can also easily be wire-wrapped, beginners may wish to do this since the PC layout is somewhat tight and could be difficult for you to reproduce easily.

The schematic shows how this is done. Note the use of the circuit's NOR gates other LEDs. Failure to invert it will not harm anything, but it won't light. Sound output for the unit is provided

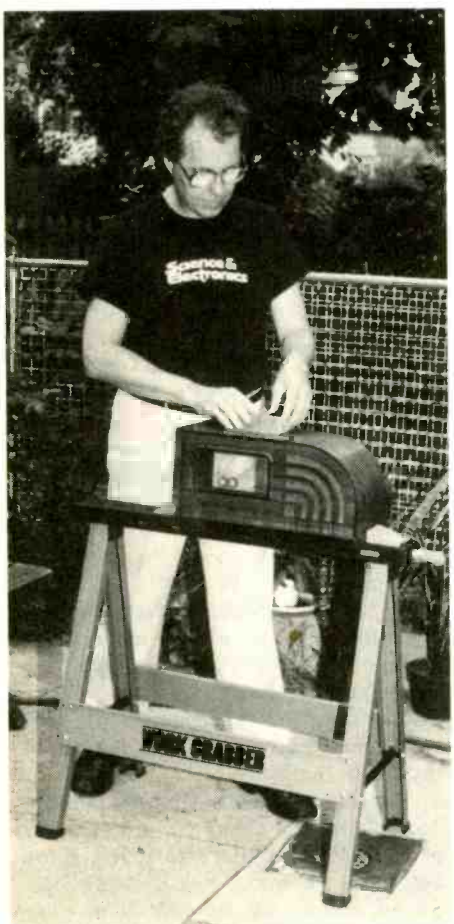


Six LEDs are the center of the Electronic Pendulum. Watch polarity when you install them otherwise you could ruin hours of hard work.


A small printed circuit board, such as the one given for Electronic Pendulum requires good soldering skills. Try to be careful.

by a crystal earphone fed by LED1 and LED6. This arrangement gives plenty of noise in a quiet room, but if desired, more volume can be obtained using an audio amp like the LM386. You will have to experiment with the circuit components to get the proper loudness.

Operation: Simply connect power and ground and Electronic Pendulum should start up. It should be easy to add this project to an existing clock or incorporate it into a new design. Voltage to the board should not exceed 7 V, as the 74LS chips will fail, but V+ can dip to about 4.5 V if you don't mind dim lamps. The circuit draws less than 10 mA so drain from existing supplies will be minimal. Adding a red plastic filter in front of the lamps will improve the illusion of oscillatory pendulum motion. ■



Bench Testing The Work Grabber

CIRCLE 101 ON READER SERVICE COUPON

TRYING TO REFINISH antique radios in an apartment can be fun provided you don't mind sawdust in your salad, varnish stains on your rug, and tool scratches on the furniture. The Editors saw an easy solution to the house polution problem in Work Grabber, a unique all-metal saw horse with a swivel-jaw vise on a crank assembly that holds the project as you work on it. It can be set up anywhere and stored flat in a closet.

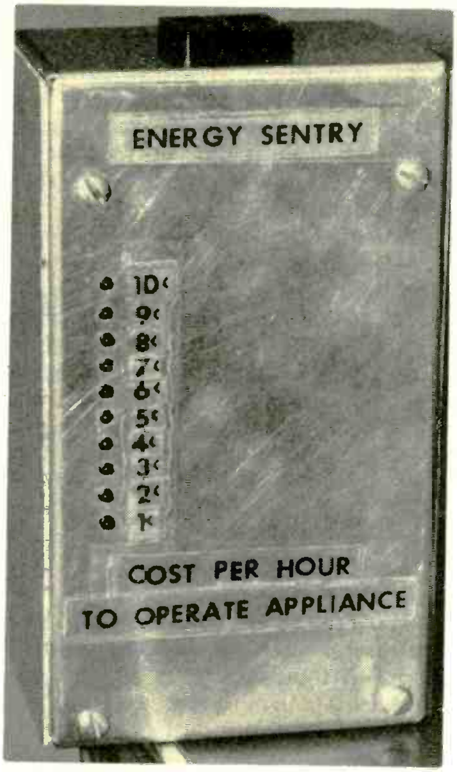
Work Grabber is an ideal portable clamping vise and saw horse for antique radio buffs, and project builders who can safely use both hands to control hand tools and paint brush. The swivel jaws of the vise are removable, or can be installed on top or side of the Work Grabber's load bar. Just set the swivel jaws to fit the work piece, radio, speaker cabinet, whatever, and tighten the hand crank securely. Work up to 24-inches wide can be clamped.

Checking Dimensions. The portable, fold-away Work Grabber is 30-in. high, 32-in. long and has an open leg spread of 19 inches. It's all solid-steel constuction except for plastic floor guards, swivel-jaws, crank and jaw carrier. Like lawn furniture, junior's bike and other consumer products, the Work Grabber comes knocked down for you to assemble. The owner's manual surpasses in clarity and illustrations the kit builder's dream step-by-step instruction booklet. We put the Work Grabber together in 20 minutes. All assembled it weighed about 16 pounds and held two editors' combined weight of 345 pounds.

Work Grabber sells for $39.95 postpaid from Distributor-Sales, P.O. Box 363, Woodstock, IL 60098. We see Work Grabber as an excellent multipurpose saw horse for our readers. Get more information direct from Distributor-Sales by circling number 101 on the Reader Service card. ■

ENERGY SENTRY

Monitor your power consumption to save energy and reduce your electric bill



IF YOU PAY the electric bill, you know only too well what has happened to that bill over the past few years. In addition, you have been bombarded through radio, television, newspapers, and magazines on how important it is to conserve energy, wherever possible. Part of energy conservation includes the electricity used in your home. With the help of Energy Sentry you can determine just how much it is costing you to operate that appliance or T.V. set. This will help you to minimize your electric bill, while saving precious fuel.

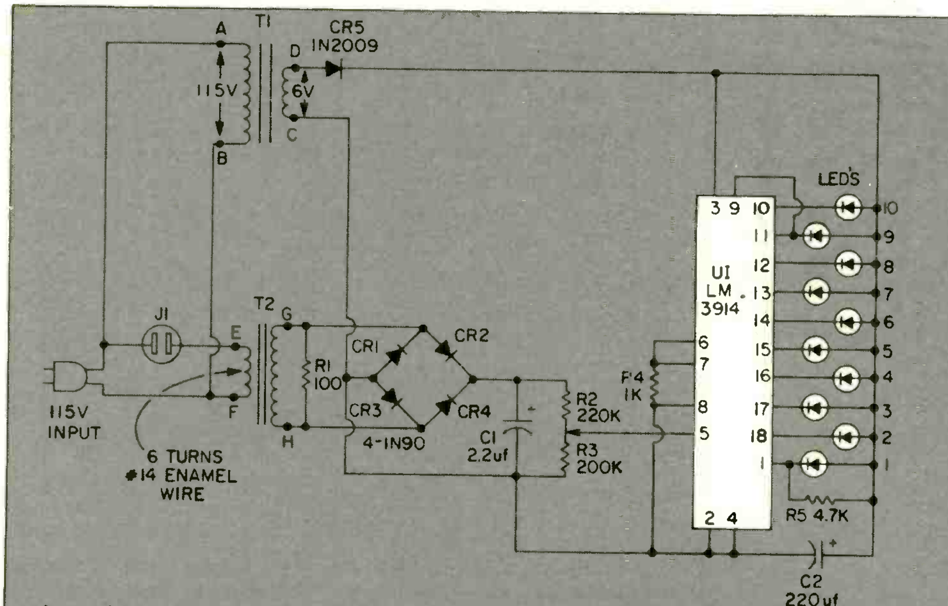
Energy Sentry is an easy to construct circuit; built in a small enclosure, with a built-in receptacle into which the appliance is plugged. Ten separate LED's provides an indication of the power consumption of the appliance. Energy Sentry is calibrated in "cents per hour" over a range of 1 to 10 cents. Depending upon your electric rate, this will provide a useable power range of up to 1500 watts. This is near the maximum power which can be delivered by an ordinary 115 volt power receptacle. A simple calibration procedure is provided at the end of this article allowing you to compute the average cost of a kilowatt hour of electrical power in your home or office.

About The Circuit. The heart of Energy Sentry is current transformer, T2, which produces an output voltage across its secondary winding corresponding to the magnitude of current flowing in the AC line. A current transformer follows the same turns ratio relationship as does the more common voltage transformer, except that secondary current, not voltage is determined by the number of turns of both primary and secondary. In the case of Energy Sentry, the primary of the current transformer consists of just 6 turns of wire wound by yourself around the core. The secondary is the existing 115 volt winding of the transformer, resulting in a turns ratio of perhaps 100. The existing 12 volt winding of the transformer is not used.

The primary of the transformer is connected in series with the power line and the appliance under test. The current drawn by the appliance induces a proportional current in the secondary. Since a current transformer must operate into a load to provide a path for secondary current, a voltage across R1 is produced which is proportional to the magnitude of the current (and power) drawn by the appliance. This voltage varies linearly with primary current and therefore linearly with power. This is true since the voltage fed to the appliance under test is a fixed power line voltage that is well regulated by the power company.

A bridge rectifier circuit converts the secondary voltage of T2 to pulsating DC which is filtered by C1. The resulting DC voltage is fed to input terminal 5 of U1 through calibrating potentiometer R3. It can be seen that the drive voltage to U1 will be determined by the current drawn by the appliance you are checking out.

U1 is a LED driver chip which has been designed to drive a series of 10 LED's in response to the voltage applied to its input terminal, pin 5. When the voltage applied to the input is zero,



A complete parts kit including PC board, all components and cabinet is available from Niccum Electronics, Rte. 3, Box 271B, Stroud OK, 74079. Price is $26.50; pre-etched and labeled PC board only is $6.50. Include $1.50 for postage and handling and allow 3 to 4 weeks for delivery.

PARTS LIST FOR ENERGY SENTRY

C1—2.2 ufd 10 volt electrolytic capacitor
C2—220 ufd 10 volt electrolytic capacitor
CR1, CR2, CR3, CR4—Germainium diode 1N90 or similar
CR5—Silicon diode 1N2069 or similar
J1—Power receptacle Radio Shack 270-642 or similar
LED 1 through LED 10—Radio Shack 276-026 or similar
R1—100-ohm, ¼-watt composition resistor 10%
R2—220,000 ohm, ¼-watt composition resistor 10%
R3—200,000 ohm miniature potentiometer, PC mount
R4—1,000 ohm, ¼-watt composition resistor 10%
R5—4,700 ohm, ¼-watt composition resistor 10%
T1—6-volt transformer (Radio Shack 273-1384)
T2—6 or 12-volt transformer (Radio Shack 273-1505 or similar)
U1—National LM3914N Radio Shack 276-1707
Misc.—Cabinet, line cord, plug, wire, solder, etc.

no LED will be illuminated. As the voltage is raised each succeeding LED will light, one at a time, until the 10th LED is illuminated. Thus, it can be seen that the circuit will provide a visual indication of the current drawn by the appliance under test.

A fascinating display can be seen when a light bulb load is being observed. As soon as the light bulb is flicked off, LEDs representing full current to no current, will light in rapid succession in an interesting display.

Power to operate the circuit is provided by T1, which feeds a half wave rectifier and capacitive filter composed of CR 5 and C2. The resulting DC voltage, about 8 volts, is sufficient to operate U1. Since U1 has a built-in regulator, the circuit will hold calibration regardless of changes or fluctuations in power line voltage.

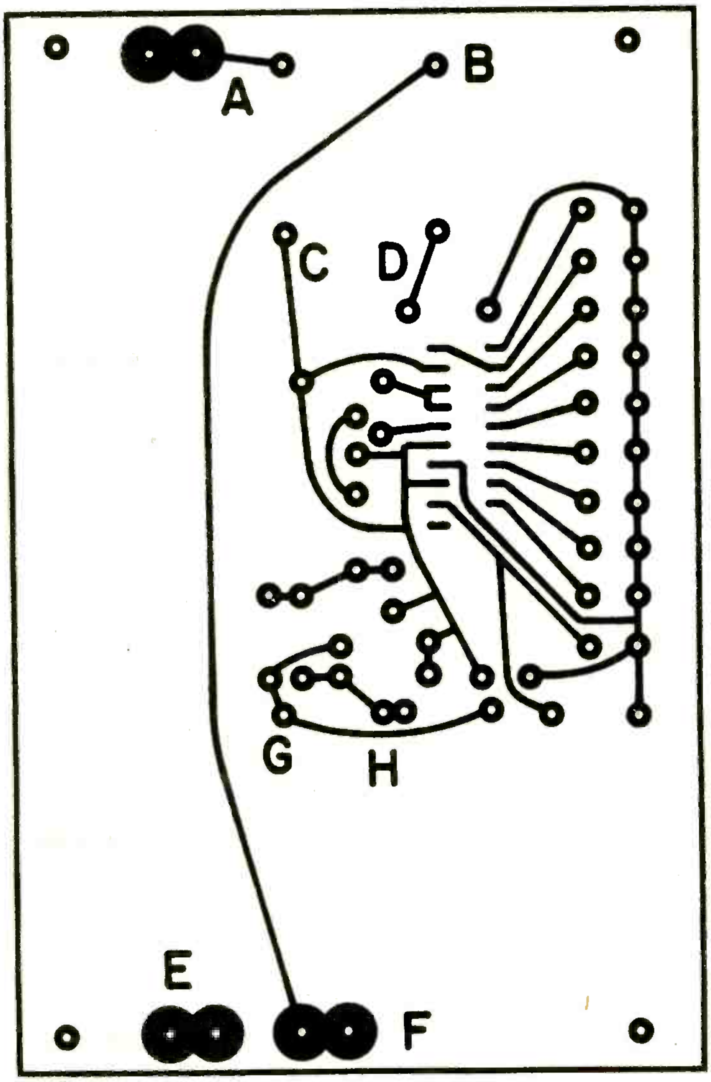
Construction. Most of the circuitry of Energy Sentry is contained on a printed circuit board. At lower left is a full scale layout of the foil layout as seen from the copper side of the board. At right is the parts layout as seen from the component side.

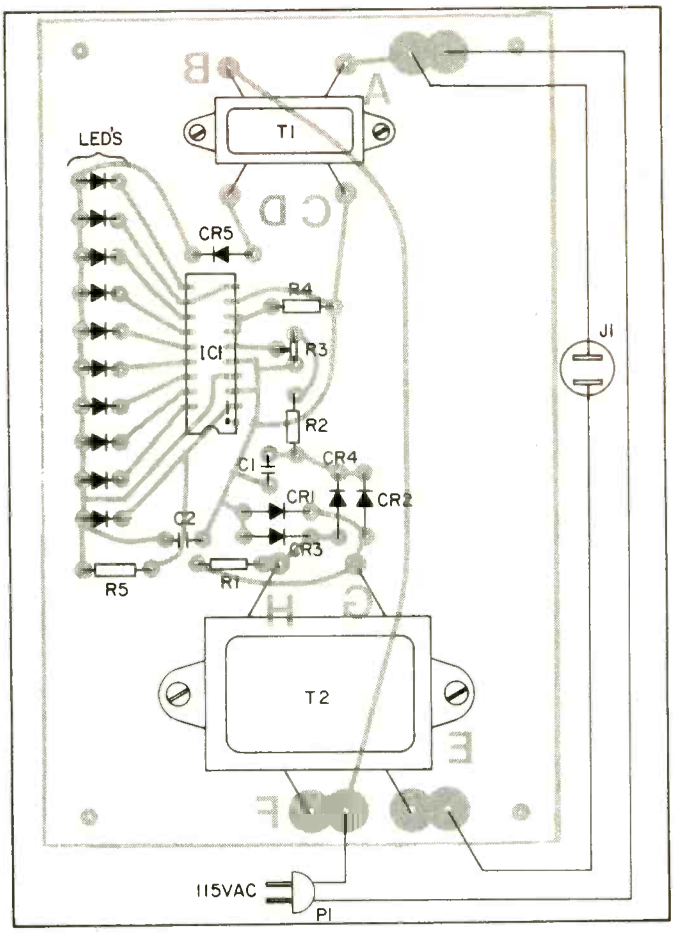
Note that the set of 10 LED's is placed on the copper side of the board. This will permit the printed circuit board to be assembled into a cabinet with the LED's protruding through a set of 10 holes drilled in the cabinet. A drilling template for the cabinet front can easily be obtained by making a photocopy of the printed circuit layout and placing it on the front of the cabinet. The printed circuit board can be mounted in the cabinet with a set of four 3/8" long spaces used for clearance and #6 machine screws.

Transformer T2 has been selected for ease of adding the additional winding. This transformer has ample room between the laminations and winding to easily fit 6 turns of #14 enamel wire. Do not use wire of smaller gauge. *Place sufficient insulating tape around the laminations to prevent a short circuit between the enamel wire and core.* If you substitute another transformer for T2 it may be necessary to remove the existing low voltage winding to provide sufficient room for the new primary. The additional winding placed on the transformer is connected to pads E and F of the printed circuit board. In a similar manner, use pads marked A, E, F, G and H for the 115 volt and transformer connections as shown in the schematic diagram. Except for pads G and H, use #14 gauge wire.

It is recommended to use a socket for U1. This will prevent damage to the IC or printed circuit board in the event U1 has to be removed for service. Double check the polarity of the LED's, diodes, and electrolytic capacitors before soldering them in place. These

(Continued on page 117)





Seen above is the component side of the Energy Sentry PC board. T2 provides power coupling, and T1 provides power for circuit.

To the left is the PC board, with the etched side up. The row of LED connection terminals can be seen on the right.

Convert your AM/FM pocket radio into an aircraft scanner

Monitor the skies with this simple receiver conversion

DELTA FLIGHT 759 TO KNOXVILLE TOWER . . . what is your local weather? We're experiencing a lot of turbulence."

"Cessna 616 to Miami Center . . . we've spotted what looks like a boat in trouble. Would you notify the Coast Guard?"

The VHF band is filled with intriguing listening. Private aircraft, commercial airliners, military and government flights fill the skies 24 hours a day, seven days a week. Many scanner listeners are discovering the fun and excitement of tuning in on aircraft in flight.

But aircraft scanners are expensive; even pocket aircraft radios command premium prices. There is another way.

Any inexpensive pocket AM/FM portable radio may be converted into an effective aircraft band monitor. The receiver's AM band will remain untouched, so that you will still be able to listen to your favorite local broadcast stations. While the changes to the FM band will allow aircraft band reception, the procedure may be easily reversed to restore the set to FM band reception if desired.

Absolutely any AM/FM portable, even the larger multiband radios, may be converted. Our illustrations happen to use the Radio Shack 12-609. You may wish to check local discount houses for advertised specials on similar radios; flea markets and garage sales are also excellent sources of pocketable AM/FM radios. These are frequently found for $5 to $10.

The Conversion. Before beginning the changeover process, it is a good idea to check the radio completely to determine that it is in good working order. Use a fresh battery and tune it through its FM range to be sure that it is functional, sensitive, and that its audio is loud and clear.

Next, remove the back carefully and locate the IF transformers, as shown in Fig. 1. Some of the IF transformers are used for AM and some for FM. It is virtually impossible to predict accurately which are which without a diagram. Fortunately, only one of them is of interest to us for this conversion project: the FM discriminator transformer; and it is easily located.

If you examine the parts layout of your radio carefully, you will note that one of the IF transformers, probably the one farthest removed from the tuning capacitor, will have two or three glass diodes alongside it (see Fig. 2). That is the discriminator transformer; the diodes are the detectors which extract audio from the IF circuitry. Switch the radio on and adjust it to receive the background hiss between FM stations.

Using an appropriate non-metallic fiber, wood or plastic tool, adjust the slug slightly until the background hiss peaks to a maximum. You have now converted the radio to receive AM! This step was necessary because *all* VHF aircraft transmissions are AM.

The next step is to increase the tuning range to receive the 108-136 MHz aircraft band. Since the receiver already tunes 88-108 MHz, we are nearly there!

Changing Frequency. Inspect the circuit board and locate two open-wound coils each consisting of four or so turns and positioned next to the tuning capacitor shown in Fig 3. Tune in an FM broadcast station (it will probably sound distorted now) and touch each coil lightly with your finger. When you touch one of them, the station will be detuned off-frequency; this is the oscillator coil. The remaining coil is in the RF amplifier circuit. Both coils will be altered to change the receiver's tuning range. To raise the frequency of the circuit we need to decrease the inductance of the associated coils.

There are several ways to decrease the inductance of a coil: spread the turns father apart; pinch each turn to flatten it slightly; twist the turns at right angles to each other; insert a brass slug inside the windings; remove one or more of the turns; short-circuit two adjacent turns with solder.

The first step in changing the tuning range of your radio will be to spread the turns of the oscillator coil widely apart with a small screwdriver. Be sure to spread them evenly and do not allow the coil to touch any adjacent metal part or wiring. Spread the turns of the RF coil similarly.

Now attempt to tune through the range of the dial, noting the locations of the FM broadcast signals. Chances are you'll find them cutting off below

(Continued on page 118)

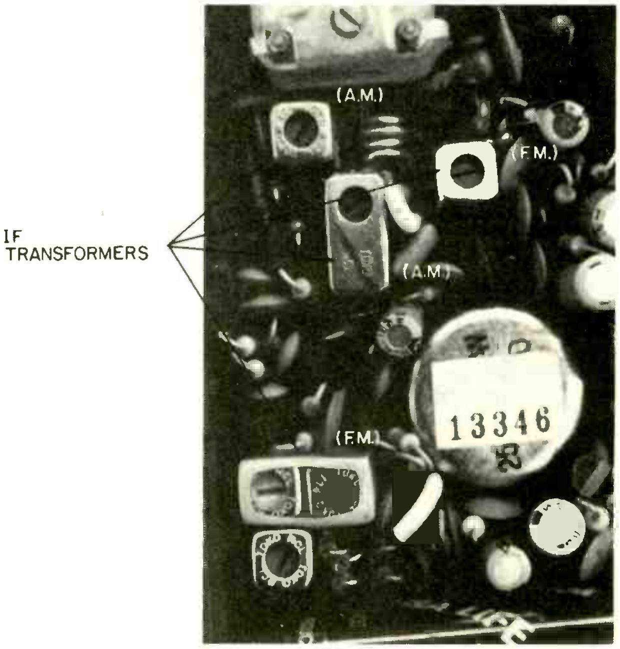


Fig. 1. The IF transformers are shown in this photo. Since it is virtually impossible to tell which are for AM and which are for FM, a process of trial and error will be employed in retuning the frequency.

The open radio gives an idea of the overall parts placement. It is important to work methodically, going from one area of the conversion to the next in the right order. You will find most layouts similar.

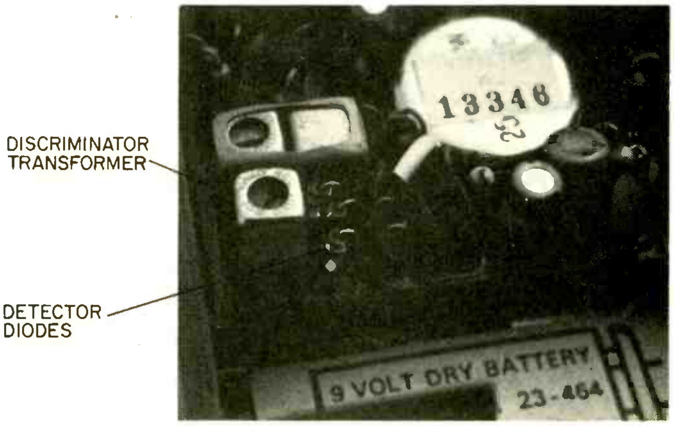


Fig. 2. The discriminator transformer, shown here, has several glass diodes beside it. These take audio from the IF stage.

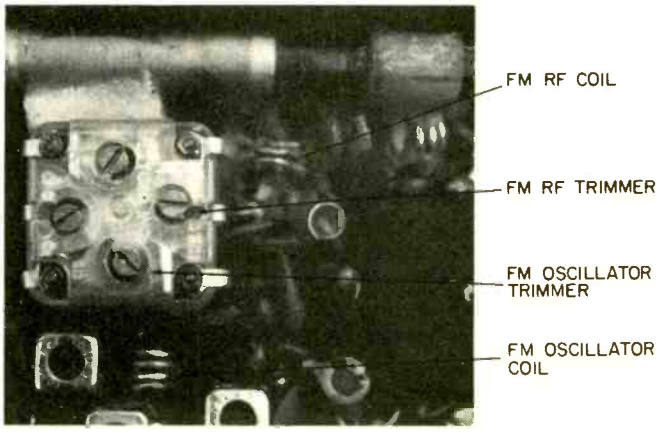


Fig. 3. The two open wound coils located next to the tuning capacitor must have their inductance raised to raise the frequency.

COMBO AMP

Equalizing levels is a snap with this quick project.

WHEN THE TAPE recorder or public address (P.A.) system is situated away from your microphone, it's inconvenient and a waste of time to go back and forth checking and adjusting volume levels. Unless there's an equipment operator, someone must scramble when the system's level is too high, too low, or if feedback occurs.

But with a Combo-Amp you eliminate all level problems by having a microphone level control and a volume level meter next to you.

If the audience yells for more volume, the gain is easily cranked up. If a P.A. system breaks into howling, the speaker simply turns down the volume.

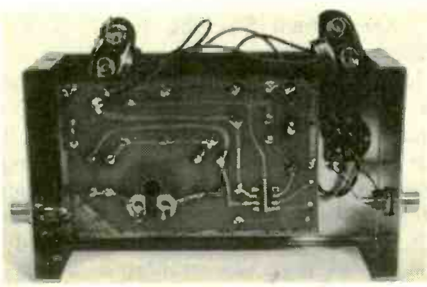
Quite A Combination. The Combo-Amp is a combination microphone preamplifier, line amplifier, and volume level meter. It takes mike level input and provides a line level output of 0.5 volts. An ordinary 0-1 DC mA meter within the feedback loop of the amplifier serves as a volume indicator; a cheaper method than using a VU meter.

A 741 operational amplifier integrated circuit (U1) provides all the gain (approximately 15 dB). U1 is an internally compensated op-amp that's free of self-oscillation. The internal compensation, however, results in a high end that's –3 dB at 12 kHz.

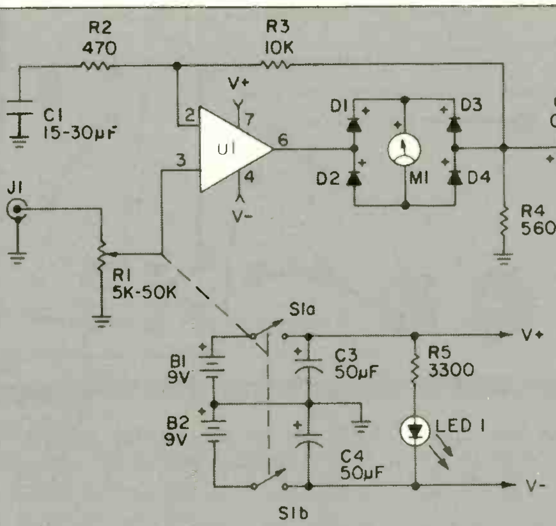
Flat Response. For a flat response to 20 kHz a wideband op-amp requiring compensation is necessary, but they are difficult to find; the 741 is universally available at low cost. The PC board and circuit have been specifically designed for the mini-dip (8-pin) version (available from Radio Shack).

The input impedance is determined by level control R1, which is itself determined by the type of microphone you will be using. For a low impedance (50-600 ohms) mike, a 5000-ohm value is suggested for R1. If you use a high impedance microphone (up to 50,000 ohms), R1 should be a 50,000 ohm resistor.

For a Combo-Amp capable of handling any microphone (other than crystal and/or ceramic), or a line level



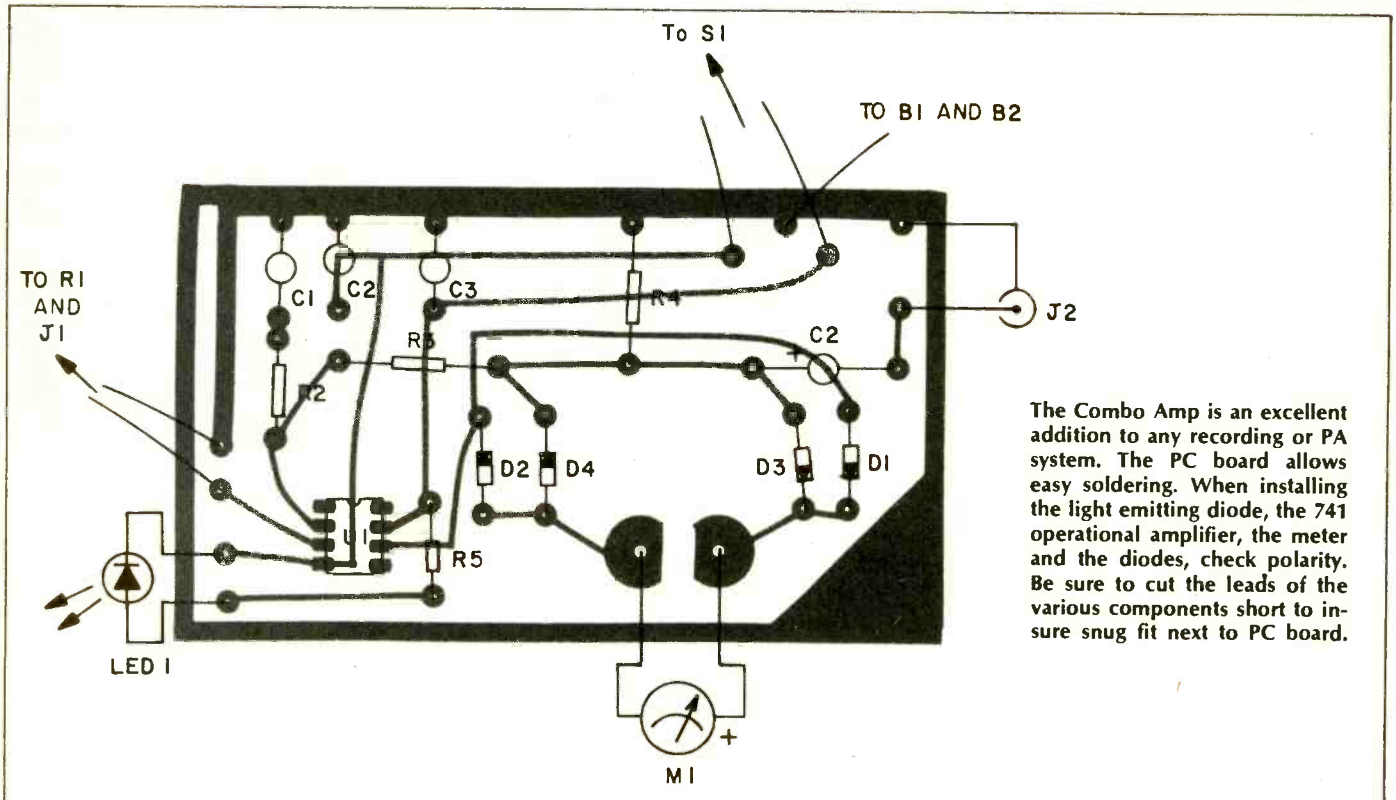
The PC board of the Combo Amp is quite simple. Be careful when soldering. Do not bridge connections with excess solder.



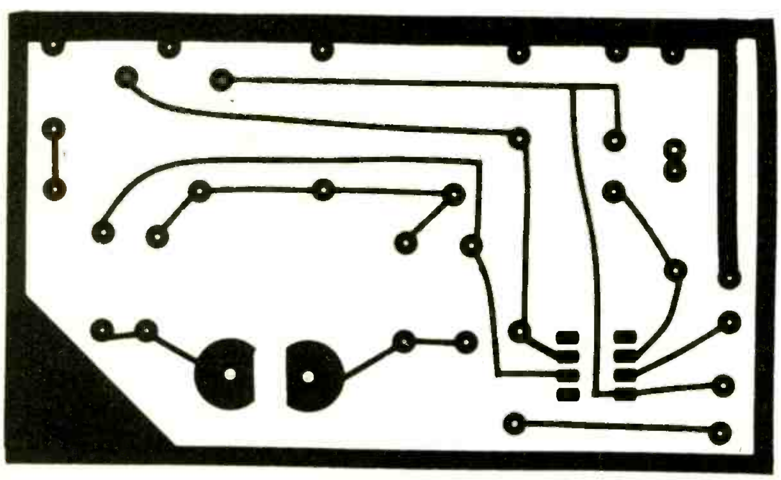
PARTS LIST FOR COMBO AMP

B1, B2—9-volt battery
C1—15 to 30 μF non-polarized capacitor, 10 VDC or higher, see text
C2—0.1 μF Mylar, 10 VDC or higher
C3, C4—100 μF electrolytic capacitor, 15 VDC or higher
D1, D2, D3, D4—Germanium diode, type 1N60
J1, J2—Jacks to match existing equipment
LED1—Light emitting diode
M1—Meter, 0-1 mA
R1—5,000 or 50,000-ohm audio tape potentiometer, see text
(Resistors, ¼ watt, 10% unless otherwise noted)
R2—470-ohm resistor
R3—10,000-ohm resistor
R4—470 or 560-ohm resistor
R5—3300-ohm resistor
S1—Switch, DPST, part of R1
U1—Operational amplifier type 741 integrated circuit

Misc.—Cabinet, battery terminals, wire, solder, hardware, etc.



The Combo Amp is an excellent addition to any recording or PA system. The PC board allows easy soldering. When installing the light emitting diode, the 741 operational amplifier, the meter and the diodes, check polarity. Be sure to cut the leads of the various components short to insure snug fit next to PC board.



If you don't have the tools or the ability to etch out the printed circuit board, you may want to try to wire wrap your project. It's easy to do.

device, use 50,000 ohms for R1. Using a lower value for R1 for low impedance mikes doesn't affect the sound quality all that much but it does reduce the possibility of noise and hum pickup on long microphone lines.

The output level is indicated by a 0-1 milliammeter. The PC board is designed to fit directly on the terminals of a Radio Shack meter. If your meter has different connections, you must modify the PC template accordingly or use the PC assembly external from the meter. One corner of the PC board has a triangular copper foil that can be drilled to secure a mounting foot.

Diodes Are Critical. The only critical parts of the circuit are diodes D1 through D4. They must be the germanium 1N60 type. Do not substitute silicon diodes as their higher breakover voltage will result in excessive distortion to the output signal.

The PC board is designed to fit an aluminum cabinet approximately 3 x 2⅛ x 5¼ inches. If you want to substitute a different meter or a larger cabinet modify the PC template.

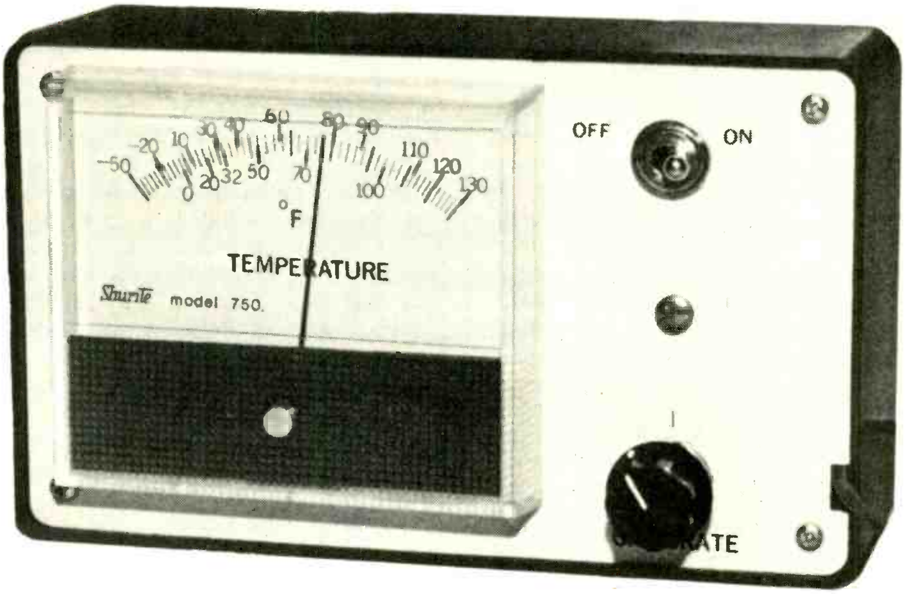
Provision is made on the PC board (R5) for an LED power indicator that draws little battery current (about 6 mA). Eliminate R5 if you don't want a power indicator.

Because the holes for the meter terminals must be 3⁄16 inches large, solder pads are used for the PC connections. Don't hope to use standard component circles and drill-thru with precision; it probably won't work. Make the pads at least ⅜ inch.

There is a boss on the back of the meter that will prevent the PC board from fitting flat on the back of the meter unless the board is drilled to accommodate the boss.

Keep Them Straight. Install all PC components except the meter connections before plugging in U1. If you use a mini-dip U1, just plug it in. If you get a can (T0-5) type 741 install it in the following manner: Using long nose pliers fold out leads one through four so they form a straight line. Cut the leads about ⅝ inch from the body of U1 so they are straight across the bottom. Do the same for leads four through eight.

(Continued on page 118)



SITRAT

Build this highly accurate electronic thermometer

SITRAT IS AN ELCTRONIC thermometer that requires six components and a battery. The parts are readily available. You may already have them in your junk box. All you need to build the SITRAT is one NPN silicon transistor a potentiometer, 2 resistors, a zener diode, a battery and a 0-1 milliampere panel meter. There's a good chance you can salvage the meter from some previous project. Maybe that neutrino monitor you designed that was to estimate the rate of energy conversion of a Quasar! If you purchase a brand new panel meter it should set you back between five and nine dollars. Other parts combined, if purchased new, should cost less than three bucks.

The author's prototype model of SITRAT is just as accurate with a weak battery as with a brand new one.

The Circuit. In the circuit diagram, the current flowing through the meter is the transistor's collector current. Collector current increases when the transistor's temperature does. This means that the meter's needle goes up when the temperature does. That's basically all the theory you need, to understand how SITRAT works!

For those who desire a little more insight into this thermometer, notice that the base current flows through R1. Since R1 is a potentiometer we can set the transistor's base current to some specific value by just turning R1's knob. By definition, a transistor's collector current is just its base current times its DC current gain, usually abbreviated β_{DC}. Collector current is equal to the DC current gain times the base current plus I_{CEO}, which is the collector cut off current with the base open. However, I_{CEO} is negligible in silicon transistors so we don't even mention it here. This means, if we squirt a tiny current into the transistor's base, out of the collector comes β_{DC} times the current we squirted into the base.

Let's suppose we have a transistor with a DC current gain, at room temperature of 100. We apply 10 microamperes to its base. We get 10 microamperes × 100 = 1000 microamperes = 1 milliamperes at the collector. Let's warm the transistor to 100°F. At this temperature, the current gain has risen to 110. Collector current is now 10 microamps × 110 = 1100 microamps = 1.1 milliamps. These calculations assume base current always remains the same. In real life, base current will increase due to a temperature increase, causing an even greater increase in collector current. The base current increases with temperature because the base-to-emitter voltage, V_{BE}, decreases with increasing temperature. The reason that a decrease in V_{BE} causes an increase in the base current is easy to visualize. R1 see 9 V_{BE}. As V_{BE} decreases, the voltage across R1 increases. As the R1 voltage increases, its current also increases. The current that flows through R1 is the same current that flows through the base. In fact, it is the base current.

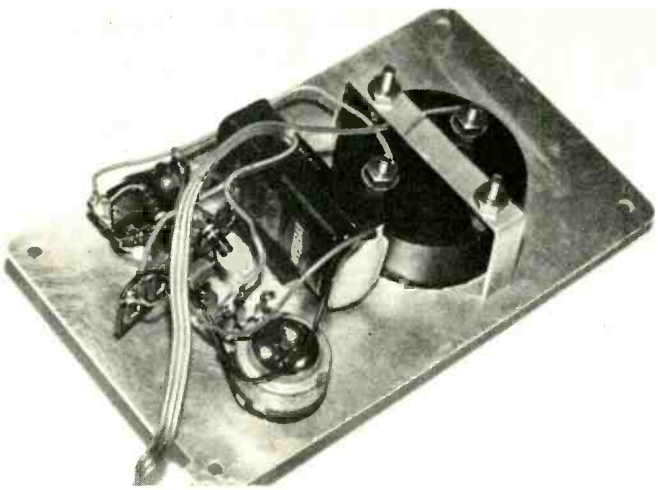
A simple voltage regulator circuit consists of R3 and zener diode D1. This voltage regulator provides a constant voltage source for Q1's base bias circuit. Voltage regulation insures that the battery's voltage won't affect I_B and thus the meter's current.

Picking The Transistor. You can use any NPN slicon transistor you find laying around in SITRAT—even that free one that came with that surplus company's "bonus pack." The author has determined the DC current gain at room temperature for 10 different transistors picked at random. The list below includes two unmarked surplus transistors.

You may have noticed that the author chose the transistor with the least DC current gain to use in his prototype.

TABLE ONE

Transistor	DC Current Gain
2N5088	710
HEPS002	110
2N5089	625
2N3860	200
2N2222A	153
RS2031	167
2N5129	47
2N2897	55
Surplus "A"	100
Surplus "B"	140



Inside view of SITRAT. Note component simplicity. There is no need for printed circuit board here! The ball-bearing potentiometer is very classy—but you can use a regular one meg pot in this circuit.

SITRAT

The reason he did this is that he found that when the transistors are placed in the circuit (see schematic), it appeared that the lower the current gain, the more sensitive the thermometer. Since the author was seeking a relatively sensitive thermometer he chose the lowest gain transistor he tested. However, you can use any transistor you have, although the author does not recommend those extremely high gain transistors, say with gains over 500. If the thermometer doesn't seem as sensitive as you would like, just plug a different transistor into the circuit. If you have a data sheet available, choose one with a relatively small β_{DC}, which is the DC current gain.

Construction. Because of its extreme simplicity, the actual construction is a no-sweat job. Use a 2 lug terminal strip to mount R2, R3 and D1 and use point-to-point wiring between them and R1, S1 and M1, which are all mounted on the front panel. See line drawing and the photo. In the parts list, R2 is listed as a 100K resistor. If you use a high gain transistor, R2 may have to be increased to 470K or even 680K.

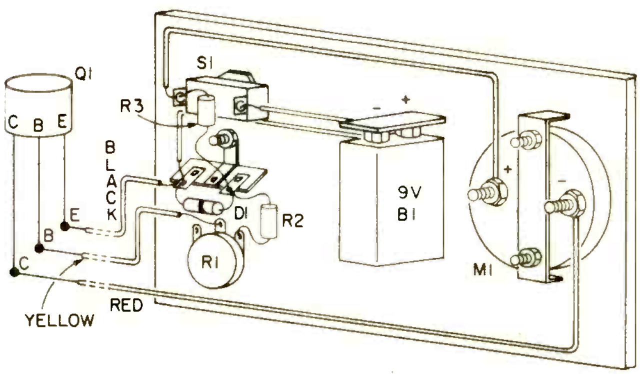
For details on making the transistor probe, see line drawings on this and the next page. First cut a 3-conductor cable, shown in drawing. Strip away the outer cable and push spaghetti sleeving up the three inner leads as shown. Next, using a heat sink such as an alligator clip, solder the cable's wires to the transistor leads, as in detail. Make sure you record on a sheet of paper which wire (usually color coded) is connected to each lead of the transistor (emitter, base, collector)—this is done to avoid any possibility of error when connecting the probe's cable to the rest of the circuit. Next, spray the bare leads, connections and transistor with acrylic plastic. After the acrylic dries, pull up the sleeving over the connections and leads as shown in the drawing. To completely waterproof the probe, take Epoxy Putty or E-POX-E RIBBON and encase the transistor assembly in it. Try to fashion a reasonable looking, pointed probe, by using your fingers. See Figure 8. For that final, semi-professional touch, wet your hands and roll the rough-looking probe between them like dough. You should be able to fashion a smooth, cylindrical probe out of the putty, as in drawing. This completes the actual construction

Data For Meter Dial. The first step here is to 'make like a scientist' and take a number of meter readings when the transistor probe is placed in different temperature water baths.

Obtain a small plastic container. You also will need a fairly accurate thermometer. This thermometer will be kept submerged in the pail. The pail itself will be about half filled with water. For good accuracy, you will have to take at least 10 different readings, each reading at a different temperature.

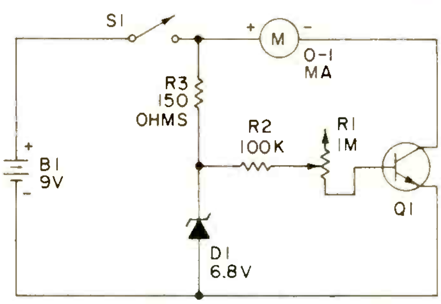
Start out with exactly 120°F water. This can be easily done by first filling the pail with hot water—say 125-135°F—and then waiting until it cools to exactly 120°. Be sure you have the probe in the water for at least a few minutes before you make any adjustments or take any readings. Once you have exactly 120° water, set R1 so that the meter reads exactly .9 milliamperes. If you wish, place a drop of Plastic Rubber or similar glue at the pot's shaft so it can't be turned by mistake or accident. Mark this point down as .9 ma at 120°F. Next, replace the 120° water with some slightly cooler water. Be sure you stir the water. After a minute or two, again take both SITRAT's and the thermometer's readings. Also mark the information down. Similarly, you should take at least six more readings at different temperatures. Make sure each of the six separate temperatures differ by at least 5°F. Another reading should be taken at the freezing point of water. To take this reading, empty the bucket and then half fill it with small ice cubes or compacted snow. Then, pour cold water into the bucket until it is about ⅔ full. Finally, place the probe in the middle of the bucket and stir the icy mixture frequently. Wait several minutes or until the meter's needle stops moving. Then mark down 32°F and next to it place the meter's reading—for example 32°F @ .3 ma. (Notice that in Table 2, which is the reading the author recorded, 32° corresponds to exactly .32 ma. This is entirely a coin-

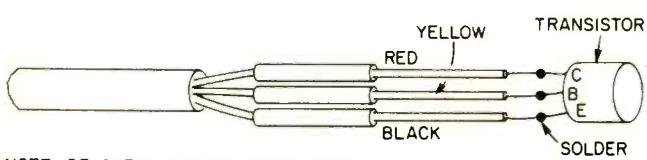
SITRAT line drawing shows simple placement of the few components. Cable to the probe can be almost any length; no electrical problems to worry about. A quick kit!



PARTS LIST FOR SITRAT

B1—9-VDC transistor radio battery
D1—6.8-volt zener diode, ½ watt
M—0 1-mA panel meter
Q1—any type NPN silicon transistor (see text)
R1—1,000,000-ohm potentiometer
R2—100,000-ohm, ¼ watt resistor, 10%
R3—150 ohm, ¼ watt resistor, 10%
S1—SPST switch
Misc.—2 lug terminal strip, an appropriate length of a 3 conductor cable, spaghetti sleeving, acrylic plastic spray, E-POX-E Ribbon or Epoxy Putty, Dry Transfer Lettering, graph paper, suitable case, small plastic pail, good quality thermometer, wire, solder, hardware, etc.





NOTE: BE SURE TO MARK DOWN WHICH WIRE IS CONNECTED TO EACH LEAD OF THE TRANSISTOR. FOR EXAMPLE; RED TO COLLECTOR, YELLOW TO BASE, BLACK TO EMITTER

This is the only tricky part of SITRAT. Follow the directions in the text carefully, and you will not have a single bit of trouble.

cidence!) You should also take at least one reading below freezing. To do this, make a mixture of salt and ice cubes and place both the probe and thermometer in it. Record both the thermometer's and SITRAT's reading and jot it down in the table.

Table 2 lists the readings from the author's prototype. While the general appearance of your table should be similar, your actual readings will differ, except for the .9 ma at 120°F reading which should be identical. (Quickie Quiz: Do you know why this reading is identical to the author's and will always to be the same for all transistors regardless of DC current gain? HINT: Read this section over.)

TABLE 2
MEASUREMENTS TAKEN WITH AUTHOR'S PROTOTYPE OF SITRAT

Temperature of Water Bath (°F)	Current (milliamperes)
120°	.9
108	.8
98	.735
91	.67
85	.63
77	.58
68	.52
61	.48
54	.445
40	.36
32	.32
9	.22

NOTE: This Table is to be used as a guide ONLY. Your readings will differ, perhaps substantially.

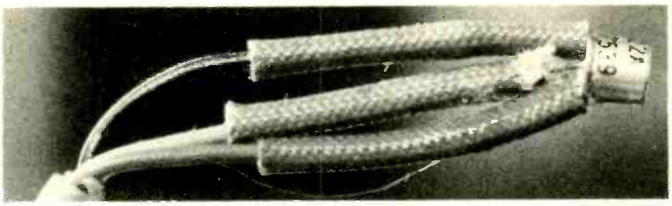


Photo of probe just before encapsulating in putty. Don't forget to use the insulator sleeves, and spray with acrylic, as the text directs you to.

We have the data. Now what? If we tried to label a meter's dial directly from our data we would have a funny looking thermometer indeed. Only the various temperatures measured would appear on the dial.

A far better way is to obtain a sheet of graph paper. Then mark the vertical axis with milliamperes (0, .1, .2 . . . . . 9, 1.0) and the horizontal axis with temperature measured in degrees Fahrenheit. See chart below. Now plot the data points you obtained (as in Table 2) on the graph paper, as in the chart. Then draw a SMOOTH curve through the points. To draw this smooth curve use a 'french curve' or if you are careful, you can draw it free hand. Refer to chart. Notice that this curve has been extended quite a bit above and below the known data points. This procedure enables you to use SITRAT over a greater range of temperatures than you actually measured. This procedure is known as extrapolation.

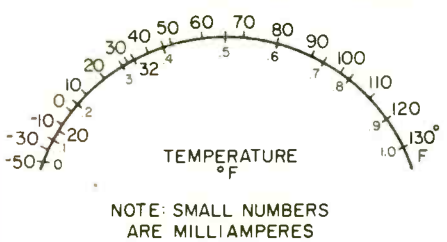
So now you have a beautiful curve. What now? If you are acquainted with curves on graph paper, simply read off the current readings that correspond to every temperature that is divisible by 10 (e.g. 120, 110, 100, 90 etc.) and mark the information down in a table. We assume, that you aren't acquainted with this technique. For this reason, we will describe it.

First you should determine the maximum temperature your SITRAT will measure. To find this 'maximum' temperature draw a horizontal line (this line is marked (a) in the chart) parallel to the temperature axis starting at the 1.0 ma marking on the current axis. Determine the point where this line intersects the curve, then draw a straight line directly down (parallel to the current axis). This line is labeled (b) in the chart. Mark down where this vertical line intersects the temperature axis —this will be the maximum temperature your SITRAT will measure. Note that the author's prototype can measure a maximum temperature of 130°F.

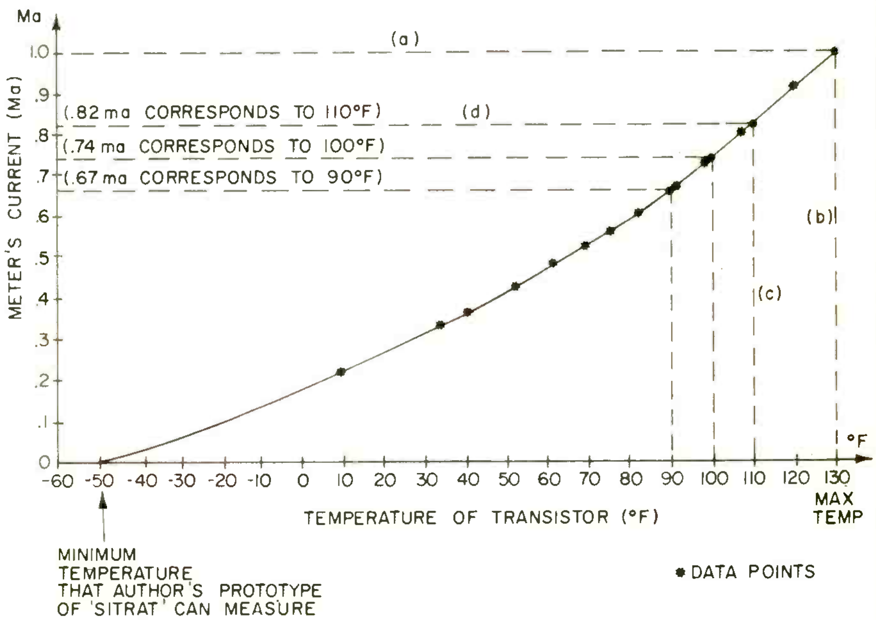
Now to find how low a temperature your SITRAT can measure. Finding the minimum temperature is a bit simpler. First, make sure you have continued extrapolating the smooth curve until it hits the horizontal axis (0 ma point). Mark down the temperature where this extrapolated curve hits the horizontal axis. In the chart, this point is −50°F. This is the lowest temperature your SITRAT can measure and

(Continued on page 114)

Drawing of the probe after is has been coated with the epoxy putty. The idea is to mold the putty until it is fairly smooth all around he transistor and leads. Make sure that there are no holes or openings.



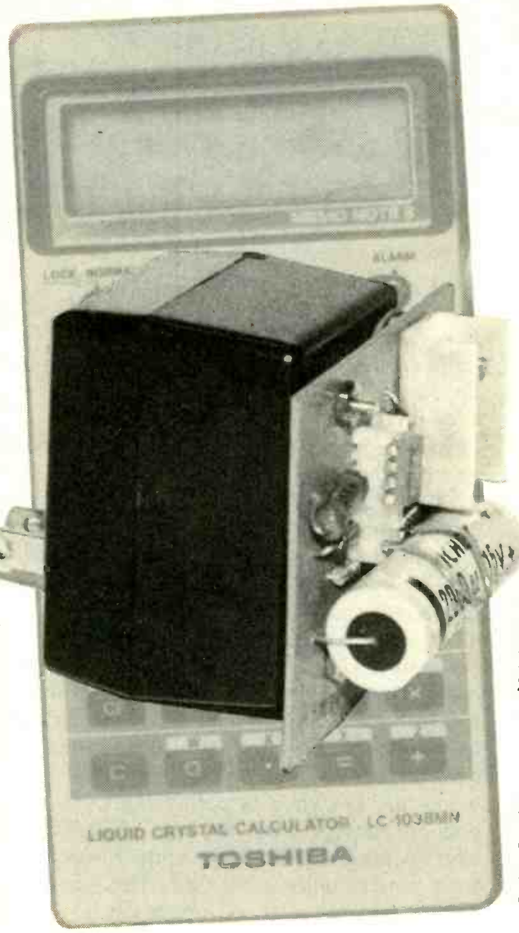
The dial plate of milliammeter, converted to degrees Fahrenheit. Of all the aspects of assembling SITRAT, this is the most time consuming, since you will have to calibrate dial according to your own specific components. Follow text with real care!



This is the graph that you will need to calibrate the temperature reading meter scale. Make a couple of trial runs on graph paper until you get the knack of drawing smoothly.

Calculator Power Supply

Build this handy, multi-voltage power source for your calculator



WHEN WAS THE LAST TIME the batteries in your calculator went dead? Perhaps the night before an important school assignment was due. Or when you were balancing your bank account and found out that you would have to do all of the calculations on paper-again! Such heartbreaking events can be frustrating, and take up much of your valuable time.

Of course, we can do arithmetic manually or in our heads, but it is faster and easier to use a calculator. As one can see, if the batteries are dead and no external power supply is available, the calculator is of no value. This is why the inexpensive power supply described here will be useful.

Batteries are not cheap. It costs roughly one dollar for two AA batteries, or for one 9 volt transistor battery. Supplying approximately 0.3 watts of power, a battery will last for about five hours. This amounts to about one third of a cent per minute to operate. What about cost per year? Here is an example: Say that someone uses his calculator five minutes per day on the average for an entire year. Calculating the battery cost over a year, we discover that we have spent over $6 for batteries. Six dollars could buy another calculator or pay for part (or all) of the power supply. The cost of batteries may seem trivial, but by eliminating the need for batteries, money is saved.

The power supply described in this article, will save money, and it can be used to power other devices. Cost of the power supply will run from five to fifteen dollars depending on cost and availability of parts. In fact, the calculator supply could be made completely from parts found in your junk box!

Ratings. The design of the power supply is flexible. You can change the design to fit your needs more fully; for example, different voltage outputs, current, regulation, etc. The prototype has the following ratings:

1. 3 volt regulated output
2. 9 volt regulated output (via Jumper 1)
3. Maximum current output of 150mA
4. Uses a transformer, from an adaptor, that has this approximate rating: 12 volt @ 200mA

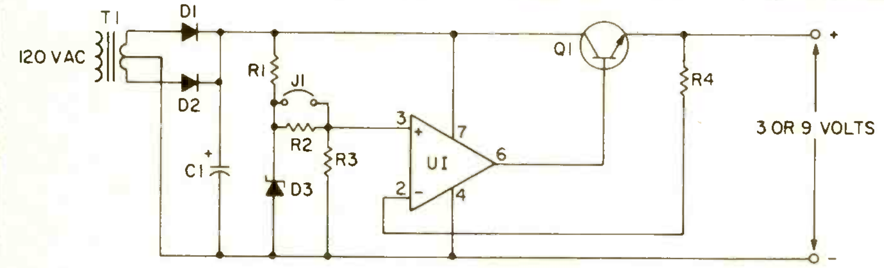
As mentioned before, you can alter these ratings to fit your needs. The phototype will regulate to at least ten percent or better. Its zener diode has a zener break down of about 9 volts.

Before building your power supply, define what it's going to be used for; i.e., the calculators voltage and ampere ratings. Another good question; is the transformer available, at reasonable cost. Once these questions are answered, it is time to proceed to the design and construction of your power supply.

Theory. Basically this power supply is a simple voltage regulator with a filtered and rectified input of about twelve volts. The block diagram in Fig. 1, gives a clear picture of how the circuits interact.

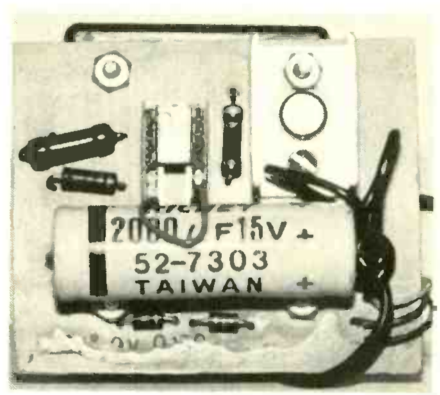
The transformer that will be used, should have a voltage rating of at least three to four volts higher than the regulated output voltage. The voltage output of the transformer is dependent on the load current. If the transformer has a high output current rating, the output voltage will be higher. Remember, ripple may play a part in how you choose your transformer. The current rating of the transformer should be at least fif-

(Continued on page 118)

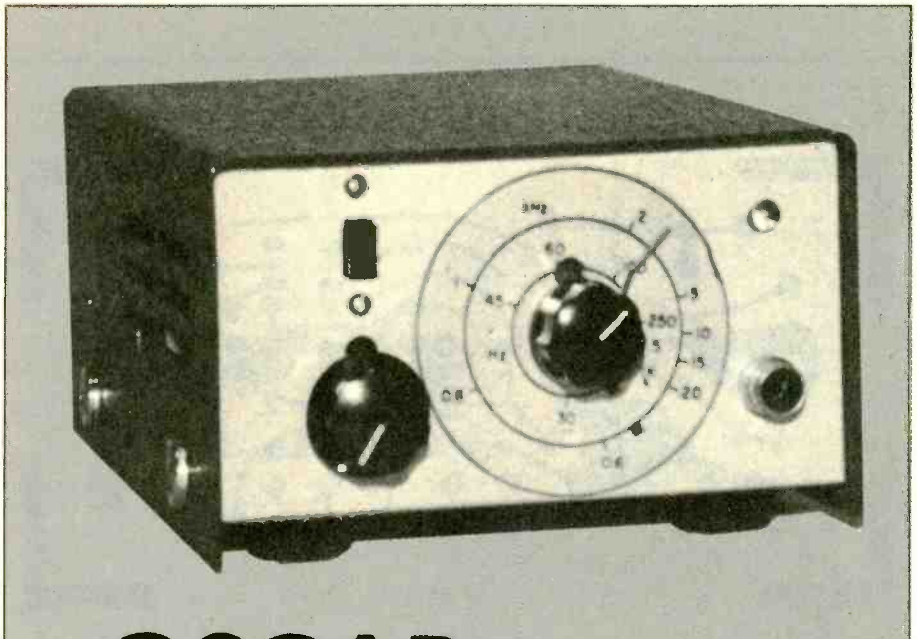


PARTS LIST FOR CALCULATOR POWER SUPPLY

C1—2,000uF capacitor
D1, D2—1N4001 diode rectifiers
D3—9-volt zener diode
Q1—NPN 2N1893 or similar
R1—200-ohm resistor
R2—43,000-ohm resistor
R3—25,000-ohm resistor
R4—10,000-ohm resistor
T1—12-volt center tapped transformer, 200mA
U1—741 Op Amp IC
Misc.—22-gauge wire, adaptor case, IC socket, 4-40 machine screws and nuts, heat sink and P.C. board.



The Calculator Power Supply is designed so that the circuitry can be mounted flexibly.



OSCAR, The Audio Freak

A handy audio oscillator for the electronics hobbyist

There's nothing quite as useful as an audio oscillator for testing defective audio or amplifier circuits. An audible signal, or the lack thereof, is proof positive as to whether or not a circuit is behaving as it should. Unfortunately, a good, stable variable oscillator can run into hundreds of dollars—far more than all but the wealthiest hobbyist can afford to spend.

Oscar is an inexpensive, easy-to-build oscillator with a frequency range from 30-Hz all the way up to 25-kHz and an almost flat response over the whole range. It uses a unique circuit: a Wien network with a photocell and 1.5-volt bulb coupled to maintain frequency stability. A compact unit (ours fits easily into a 5¾-inch by 4-inch by 2-inch box) Oscar will drive into a low impedance load, and is powered by a 9-volt transistor radio battery. Those parts that you don't have in your junk box can be found at the local Radio Shack or other well-stocked electronics supply house convenient to you.

Easy Assembly. Assembling Oscar is quite simple. All of the components—except for the variable potentiometers R2a, R2b and R3, the switch, LED and 9-volt battery—are mounted on an etched PC board. Our Oscar is rather fancy, mounted in a two-toned enameled aluminum box with vents and rubber feet, but any Bud or other box of approximately 6-inch by 4-inch by 2-inch dimensions will serve as a housing.

Oscar's heart is a Radio Shack LM386 low-voltage audio amplifier, an IC "bug" giving 20dB of gain without external components. Amplifier output feeds directly into a Wien network which determines the output frequency. From there the signal is fed back into the positive input of the amplifier.

The 150-kohm resistor (R6) is series with the input serves two purposes: it reduces the signal from the Wien network to the amplifier input to a satisfactory level. And, together with the input impedance to the amplifier, it provides an impedance which doesn't affect the audio frequency determined by the Wien network components. The oscillator's frequency is varied by changing the setting of the ganged potentiometers R2a, R2b.

The 5,000-ohm switched variable potentiometer serves as an ON-OFF switch in the circuit and volume adjustment control.

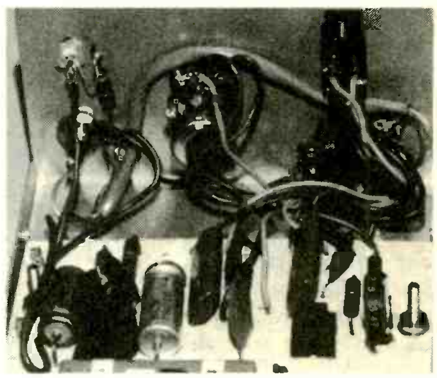
Thus far we have listed the components for a pretty straightforward amplifier circuit. The following components—a photocell (R4), 1.5-volt bulb (L1) and a 100,000-ohm preset linear potentiometer are what make for Oscar's uniqueness.

Circuit Theory. The photocell (R4) is a Radio Shack RS 276-116 or equivalent, with a 5-megohm to 100-ohm resistance range. It will be coupled to a Radio Shack 1.5-volt at 15ma. miniature bulb. The theory behind this circuit is that the light output of a bulb filament varies proportionately to applied voltage. The light output from this bulb is closely coupled to the photocell, the resistance of which varies in proportion to the light shining on it. This circuit ensures that, with proper setting of R1, the output of the oscillator is held constant over its entire frequency range, despite frequency gain variations in either the amplifier or Wien network.

The capacitor C5 blocks DC from getting to the photocell, and C6 blocks DC from the output. The LED lets you know that the oscillator is running.

The thermal time constant of the bulb filament is sufficient to prevent the light output from "following" the waveform output, except at the lowest frequencies. And, if R1 is carefully set, the circuit will be stable even at the lowest frequencies.

Make it Light-Tight. The only tricky spot in assembing Oscar is making the bulb/photocell unit. While the sketch should make this procedure clear, there are several points worth stressing. One—the most important—is that the unit must be absolutely light-tight when assembled. The fit between the bulb base and sealing grommet, and of the heat-shrinkable tubing over the entire assembly, is critical. Also, the tip of the bulb should just clear the surface of the photocell. The whole assembly then mounts on the PC board, supported on the photocell leads.



This photo shows the soldering connections at the rear of OSCAR's front cabinet panel.

OSCAR

While there are very few components on the PC board, it is necessary to pay close attention to the mounting and placement of these. Make sure that the polarities of the electrolytic capacitors are correct and that the amplifier IC "bug" is the right way around.

The PC board itself should be raised ½-inch or so above the bottom of the housing to prevent the soldered joints from shorting. This can be done by drilling two pieces of squared-off plastic to pass the shafts of the bolts attaching the PC board to the housing.

The frequency adjusting potentiometers R2a, R2b should be wired so that rotating the shafts clockwise REDUCES the resistance in the circuit. Reducing the resistance causes the oscillator frequency to rise in accordance with the formula:

$$f = \frac{1}{2\pi RC}$$

where R = R2+R3 and C = C1 or C2, as selected by the range switch S1.

Turning it on. At this point Oscar is just about ready to be buttoned up and turned on. The final step is turning the center rotor of R1 all the way to ground. Now connect the battery, put the top cover on, attach a pair of 1000-ohm or greater headphones and turn Oscar on.

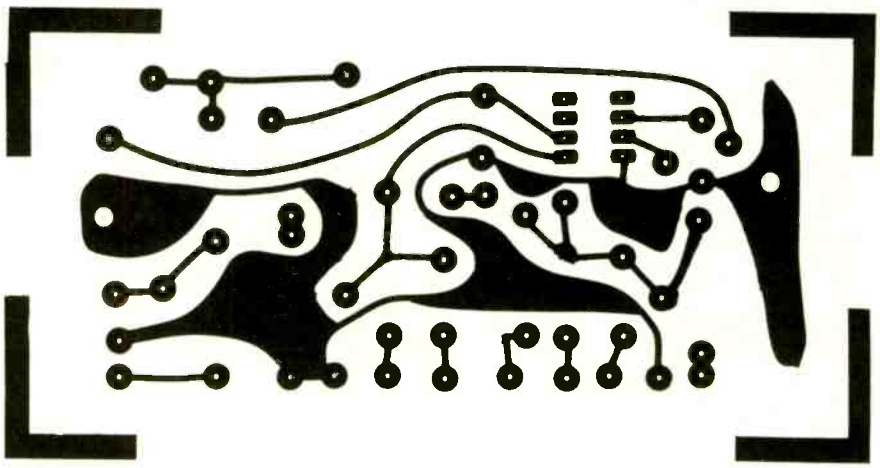
With S1 on the upper frequency range, turn the ganged pots R2a, R2b all the way counterclockwise for maximum resistance in the circuit. A sound—a distorted 600-Hz—should be heard in the headphones.

Let Oscar run for a minute or so to condition the photocell to the light. Now adjust R1 until the distortion just disappears. An oscilloscope makes this easier: adjust R1 for an output waveform that is just short of clipping.

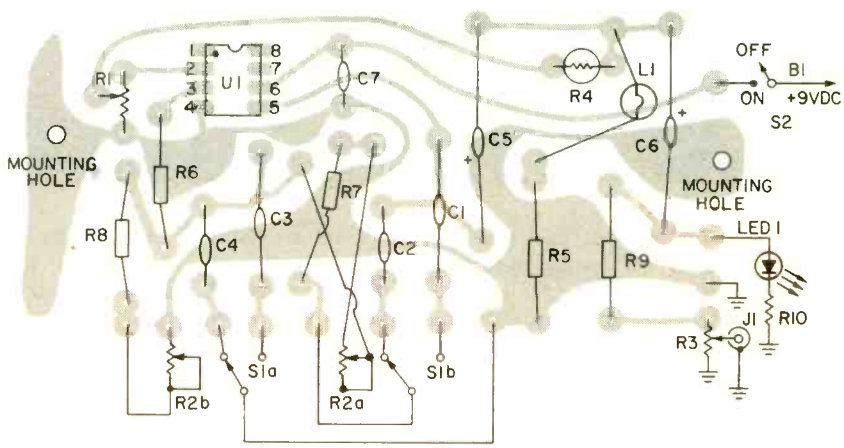
To make life easier for yourself, remember to drill a ¼-inch hole in the oscillator housing opposite the center rotor of R1 to allow a screwdriver blade access for adjustments.

Vary the output frequency by turning the ganged potentiometers R2a, R2b. Turn to the upper end of the frequency range—25-kHz, well beyond your hearing range—and allow a few seconds for the oscillator to stabilize there. Turn back to the audible signal range to make sure that the circuit is still oscillating. If it's not, turn R1 carefully towards ground until the oscillation starts up again.

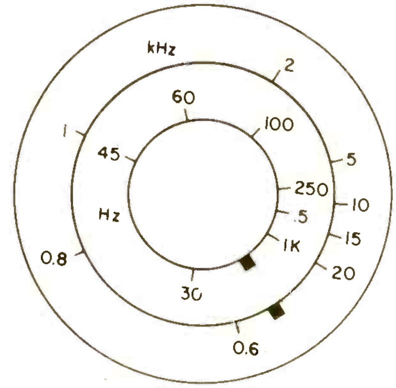
Now that the upper frequency range is adjusted, switch to the lower range.



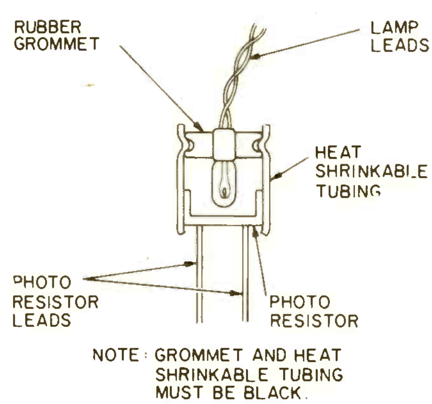
This is the circuit board template, appearing here in its exact size. For those who feel that their skills are not up to board etching, there is a complete kit listed below.



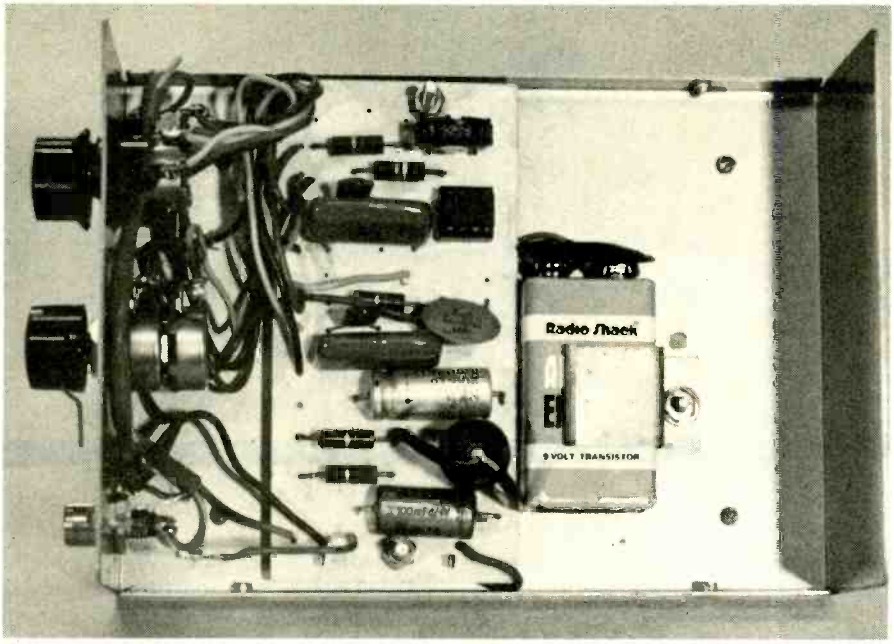
The parts placement is such that nearly any available cabinet which can easily hold the PC board is suitable for OSCAR. This cabinet leaves plenty of room for all components.



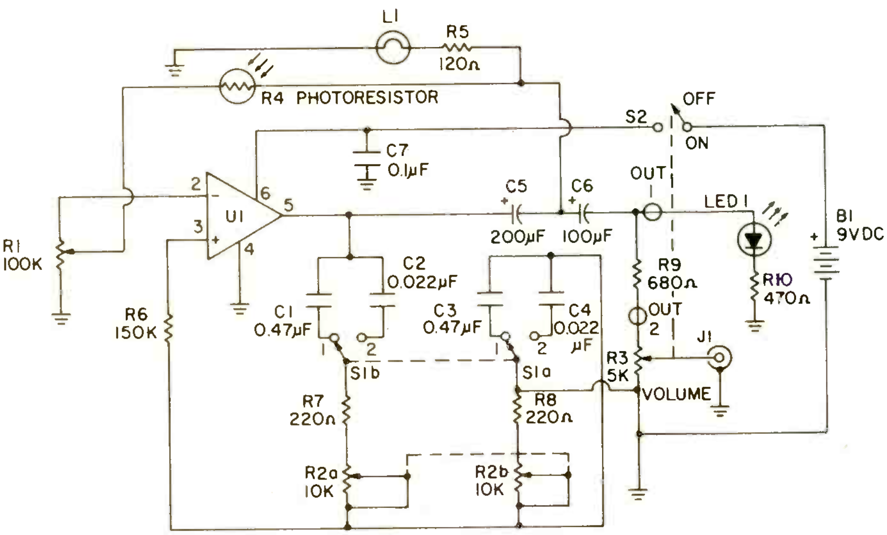
Trace this exact size oscillator range diagram or cut it out and use on the face of the oscillator. It is calibrated exactly for the dual frequency ranges available.



It is very important that the photocell and bulb tandem arrangement be light free.



This foil side down parts overlay shows the exact placement of all the components on the circuit board. Care is required in soldering and placing components with precision.



PARTS LIST FOR OSCAR

B1—9-volt transistor radio battery
C1, C3—0.47-uF, 50-VDC capacitor
C2, C4—0.022-uF, 50-VDC capacitor
C5—200-uF, 16-VDC electrolytic capacitor
C6—100-uF, 4-VDC electrolytic capacitor
C7—0.1-uF ceramic capacitor
J1—Shielded phono jack (Radio Shack 274-346 or equivalent)
L1—Miniature bulb, 1.5-volt 15-mA
LED1—Small red Light Emitting Diode
R1—100,000-ohm linear preset potentiometer for PC board mounting
R2a, R2b—10,000-ohm linear ganged potentiometers
R3/S2—5,000-ohm linear potentiometer with ON-OFF switch
R4—Photoresistor, 5-megohm to 100-ohm range (Radio Shack 276-116 or equiv.)
R5—120-ohm, ¼-watt resistor
R6—150,000-ohm ¼-watt resistor
R7, R8—220-ohm, ¼-watt resistor
R9—680-ohm, ¼-watt resistor
R10—470-ohm, ¼-watt resistor
S1—DPDT slide switch
U1—LM 386 Op amp Integrated Circuit (Radio Shack 276-1731 or equiv.)

MISC.—Box, PC board, 2 1-inch roundhead machine screws with nuts and washers, IC socket (8-pin), 9-volt battery clips, wire, knobs, sheet metal screws and assorted hardware as needed.

A complete parts kit (less case) is available from Niccum Electronics, Rte. 3 Box 271B, Stroud OK, 74079, for $18.50. For the pre-etched, drilled and labeled PC board alone send $5.50. A drilled and labeled case is available for $7.00. Please incude $1.50. for postage and handling

At the bottom end, about 30-Hz, the frequency amplitude may vary at a very slow rate. If that is the case, give the circuit a little more negative amplitude by turning R1 up slightly from ground. Some experimentation with R1 settings should yield a compromise position giving the best overall performance for both frequency ranges. When this is attained, the oscillator output should be constant within ±1dB over the whole frequency range.

Troubleshooting Oscar. If this output stability cannot be achieved, the ganged potentiometer R2a, R2b is probably at fault. The cheaper varieties track poorly; some may have worse than a 50% difference between the tracks in places. Before throwing out the old one and replacing it, try swapping the R2a and R2b leads around to see if this improves performance.

If the output frequency response is still unsatisfactory, change the 120,000-ohm resistor (R5) in series with the bulb one value up or down. Readjust R1 as before.

While you were making all those adjustments in the lower frequency range the LED should have been winking away at you. This indicates that the oscillator is running and that it has stabilized after a frequency change. You will notice that, in the upper range, the LED stays on steadily. This is because the human eye can't assimilate light oscillations above a certain frequency, so the high-speed flashings appear as a steady light.

Oscar is somewhat sensitive to variations in voltage, especially to low voltage. Serious clipping will result if the voltage drops below eight volts, but the oscillator will operate at up to 14 volts with only an adjustment of R1. If left with the power off for long periods of time, the R1 setting will probably have to be adjusted.

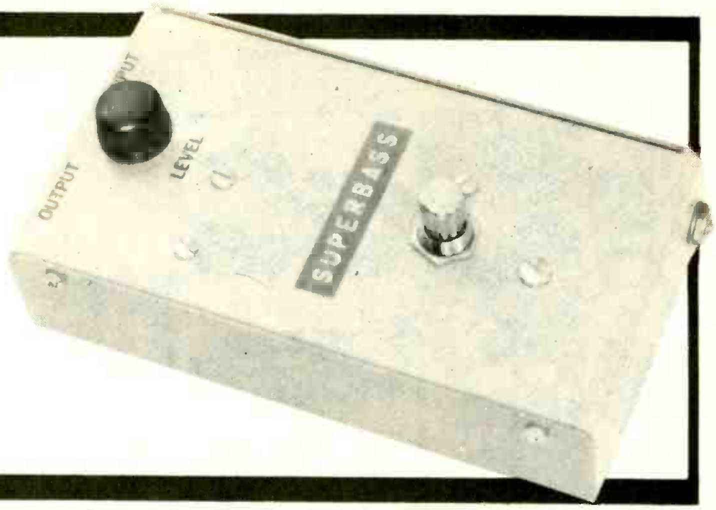
Oscar is a handy piece of test equipment well within the budget and building capabilities of any electronics hobbyist. It's a natural for shooting a signal into misbehaving audio or amplifier circuits: just attach a probe or even two leads to the output jack and you're ready to delve into the innards of recalcitrant circuits.

Other possible—and somewhat more farfetched—uses for Oscar are: as an audiometer, offering the bored hobbyist a hearing test at the bench; or, hooked to a high-powered amplifier and speaker, as a device to scare crows off the backyard garden patch.

Usefulness, low cost and ease of assembly makes Oscar both an interesting project and a welcome addition to any hobbyist's workbench. ■

SUPERBASS AMPLIFIER

Increase the bass output of your present instrument at modest cost!

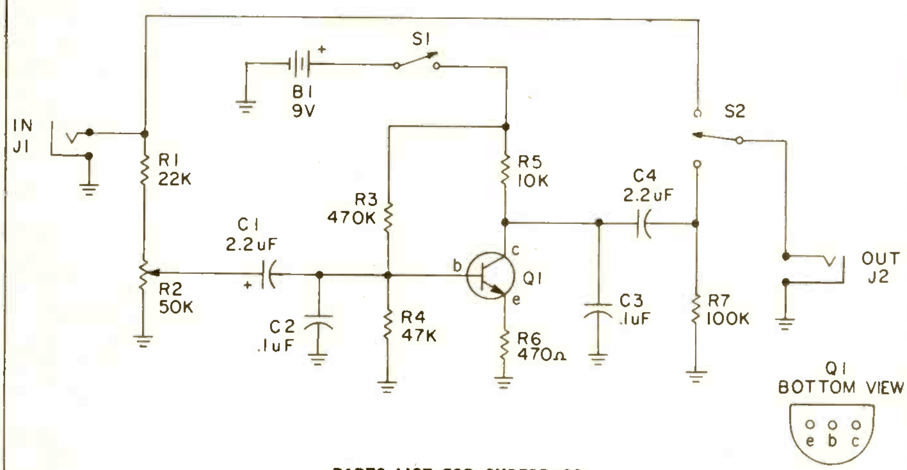


Superbass is today's sound . . . whether it's the driving, gut-vibrating pulsations of disco, or the solid bass line of soft, hard, or laid-back rock. One way to get the modern superbass sound without running out and buying an all-new expensive piece of equipment is to use a Superbass amplifier between your guitar, electronic organ or what-have-you, and the instrument amplifier.

A Superbass strips the highs from the instrument's output signal and amplifies low frequencies, feeding on "all-bass" sound to the instrument amplifier. Naturally, the bigger the speakers used with the amp, the more powerful the bass: use 15-inchers with a Superbass and you can rattle the windows.

The Superbass is powered by an ordinary 9-volt transistor radio battery. It is keyed in and out–switching from superbass to standard instrument output–by a foot operated switch. A level control allows you to equalize the superbass sound level with that of the musical instrument, so your volume level remains relatively constant as you key the superbass sound in and out. Of course, if you want the superbass to be louder or softer than the unequalized sound, you can adjust the level control accordingly.

The superbass connects between your instrument and its amplifier through two standard phone jacks–you can use your regular "patch cords"



PARTS LIST FOR SUPERBASS

B1—9-volt battery, Burgess 2U6 or equivalent
C1, C4—2.2-4.7-uF, 10-VDC electrolytic capacitor (see text)
C2, C3—0.1-uF Mylar capacitor, rated 10-VDC or higher
J1, J2—3-conductor, ¼-inch phone jack
Q1—NPN transistor (Radio Shack RS-2010, or equiv.)
All resistors 1/10 or 1/4-watt, 10%
R1—22,000-ohm resistor
R2—100,000-ohm audio taper potentionmeter (see text)
R3—470,000-ohm resistor
R4—47,000-ohm resistor
R5—10,000-ohm resistor
R6—470-ohm resistor
R7—100,000-ohm resistor
S1—SPST switch (see text)
S2—SPDT push On-push Off switch

Misc.—9-volt battery clip, aluminum cabinet, screws and other hardware.

Construction. Since you're going to stomp down on a footswitch to key the superbass in and out, the project should be assembled in a sturdy metal cabinet. We suggest one of the flat "instrument-type" cabinets which are available from time to time. The project fits nicely into a 1¼-inch x 3-inch x 5½-inch cabinet such as the one shown in the photographs. The "instrument" cabinets are not always available; as a substitute we suggest an aluminum "handy" or "Minibox." Do not use a plastic cabinet with a metal cover because it will probably fall apart after a few stomps.

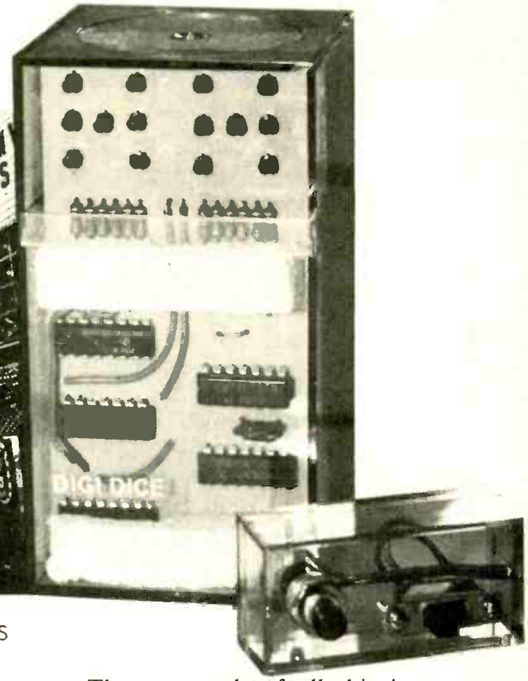
Plug-in Circuitry. The amplifier itself can be assembled on a small printed circuit board, or on a perf-board using point-to-point wiring. Perhaps the easiest construction is the one used for the model shown: it uses a combination of printed circuit and perf-board. The board is an "Op-Amp IC Experimental Breadboard," available from Radio Shack stores. It has factory-etched copper strips, ground loops and buses that are pre-drilled in a perf-board pattern. You simply plug the parts into the board so the leads stick out on the foil side and solder. When finished, you have a printed circuit without the bother of making the PC board itself. (Use a 1½-inch x 1⅞-inch piece for this project.)

While the overall layout isn't critical, try to follow the layout shown because it keeps cables and the level control away from the footswitch. To conserve space, level control R2 can be any type of miniature audio taper potentiometer.

The battery is held in place by a small L-bracket. To prevent the battery from sliding around, two small strips of cork or rubber are cemented to the bracket. The bracket should be positioned so the battery must be lightly forced into position—in this way the

(Continued on page 117)

DIGI DICE



An electronic dice game with infinite possibilities

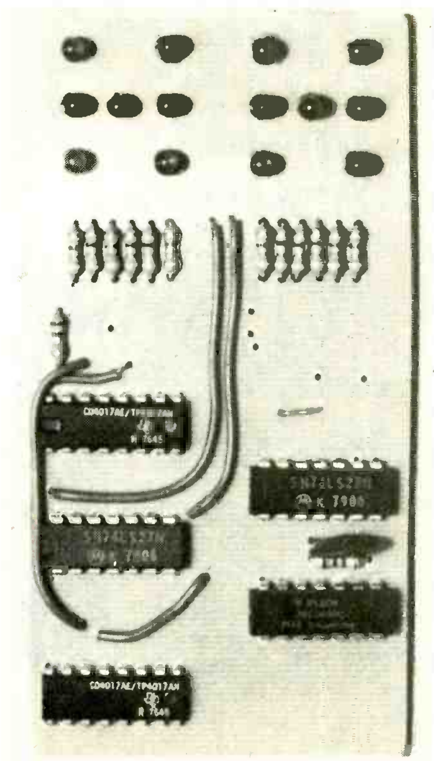
HERE IS A PROJECT for those of you tired of rolling old fashioned mechanical dice. *Digi Dice* can be used anywhere normal dice are used, and has been designed to be cheap, portable, and fun. And, since it is an electronic device, it is probably more random than any regular dice with their inherent mechanical imperfections. Construction time will vary, of course, but we built our dice in an afternoon and by evening were "rolling" in a game of craps. Total cost should run about $12 to $15, depending on how much spare junk you have lying about and where you buy the needed parts.

The Circuit. Refering to the block diagram, you can see that *Digi Dice* is composed of three main blocks. Block A, the oscillator, is made of two 74LS inverters connected as an oscillator, using a resistor and capacitor to regulate the frequency. The output of this oscillator is sent to block B, the counter. This consists of two CD 4017 decimal decoded counters, each wired to reset at a count of six, such that its sequence is 0, 1, 2, 3, 4, 5, 0, 1, etc. The first IC (U1) gets its input directly from the block A oscillator, while the second (U2) receives its pulses every time its partner resets itself to zero. Obviously, the second 4017 only counts one sixth as fast as the first.

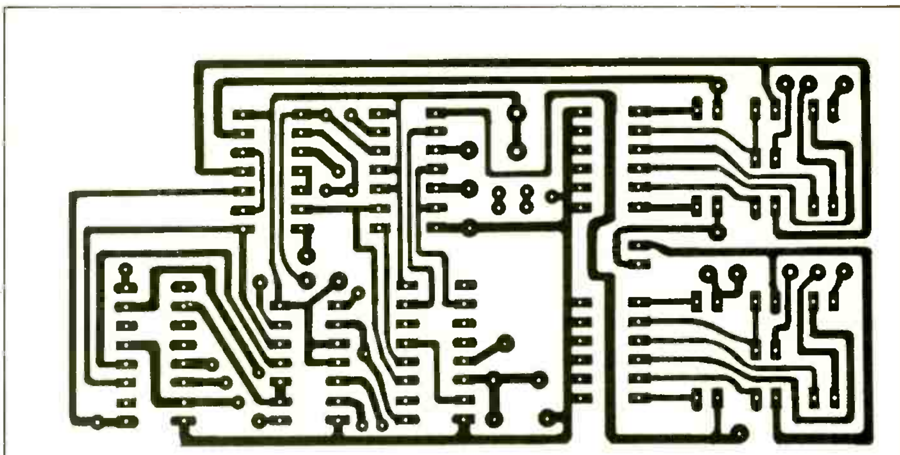
The net result of all this is a two-place base six (modulo six) counter. If we now interrupt the count at some point, each 4017 will contain a value of 0 through 5. If then, and this is the heart of the circuit, we run the counters so fast that we don't know where they are when we halt them, we have devised two independent and "random" six counters. But that is exactly what mechanical dice are, so now all that must be done is to display our results in some suitable way.

Block C, decoding and driving, does this by interpreting the values present in the CD 4017s and displaying them using red LEDs arranged to give the appearance of a pair of dice.

Now, look at the schematic diagram for a more complete idea of how the circuit operates. Switch S1 is power on-off. S2 is a normally closed momentary-contact pushbutton which inhibits



This front view of the PC board shows the arrangement of ICs and the LEDs that read out the score. "Snake eyes" lights up first.



This is the exact size of the PC board for Digi Dice, shown here with foil side up. If you do not care to etch the board yourself, order a pre-etched and labeled Niccum kit.

DIGI DICE

counting in both U1 and U2 by holding pin 14 at ground. Opening (pushing) S2 allows R14 to pull pin 14 to a high level, thereby allowing the counters to run. When this happens, the decoder/drivers will be displaying the contents of the U1 and U2 using the LEDs, but so quickly that the eye cannot follow. Releasing the pushbutton switch (closing S2) will freeze the count in each 4017, which can now be seen displayed by the LEDs.

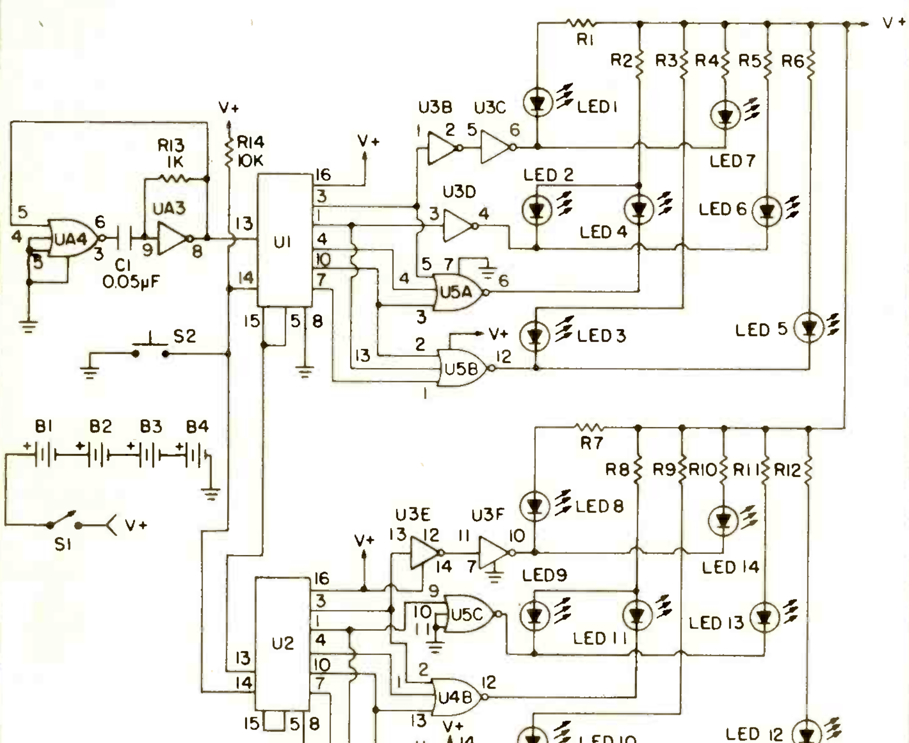
Construction. A full size PC board layout is shown for your use. As the pattern is very tight, we recommend that only advanced hobbyists attempt a reproduction. Wire wrapping is a bit more tedious and time consuming, but easier to correct. Anyway, if you do choose the PC route, carefully check for breaks and shorts in the foil with an ohmmeter, since they are easy to miss by visual inspection.

Follow the parts layout guide when assembling the PC board, and be sure you have the correct orientation of the chips; a small notch is preesnt at pin #1 of each chip. Also, don't arrange the LEDs backwards. The anode lead (+), which is usually longer than the cathode lead is always nearest to the ICs on the board. Reversing this won't hurt the LED but it won't light either.

The entire project fits neatly into a 2¼-inch by 2¼-inch by 4¹⁄₁₆-inch plastic box available in art supply stores. We ran four wires out of the main box to a smaller matching unit in which we mounted switches S1 and S2. Ribbon cable is perfect for this. The battery and circuit board are stabilized by styrofoam strips and blocks cut to the necessary shapes and either glued or press-fit into the large box. When the time comes to change batteries, the holder is easily unclipped and slid out of the case. Incidently, any 5-volt to 6-volt source can be used in place of the dry cells. The absolute maximum voltage the 74LS chips will tolerate is 7 VDC, so be careful.

Operation. Closing switch S1 activates the circuit. Don't be surprised if an unusual combination of lights appears when the unit is first turned on. Now press pushbutton switch S2. All of the LEDs will illuminate, some more brightly than others. Releasing the pushbutton will force *Digi Dice* to display two random values. Repeat the sequence for further play.

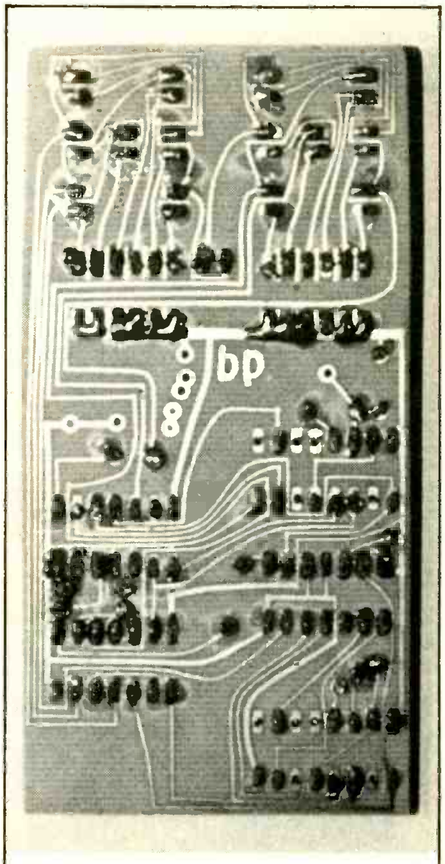
To test the theory of randomness, we "rolled" Digi Dice one hundred times. A summary of the results is shown. Although the tabulation was not checked using statistical analysis, you can see



PARTS LIST FOR DIGI DICE

B1 thru B4—1.5 VDC battery
C1—0.05-uF, 50 VDC ceramic disc capacitor
LED1 thru LED 14—light emitting diode rated 20 mA @ 1.7 VDC
R1 thru R12—470-ohm, ¼-watt resistor, 10%
R13—1,000-ohm, ¼-watt resistor, 10%
R14—10,000-ohm, ¼-watt resistor, 10%
S1—SPST subminiature slide switch
S2—SPST normally closed pushbutton switch
U1, U2—CD4017 decade counter integrated circuit
U3—74LS04 hex inverter integrated circuit
U4, U5—74LS27 three section, triple input NOR gate integrated circuit
Misc.—battery holder/clip, suitable enclosure, IC sockets, hookup wire, solder etc.

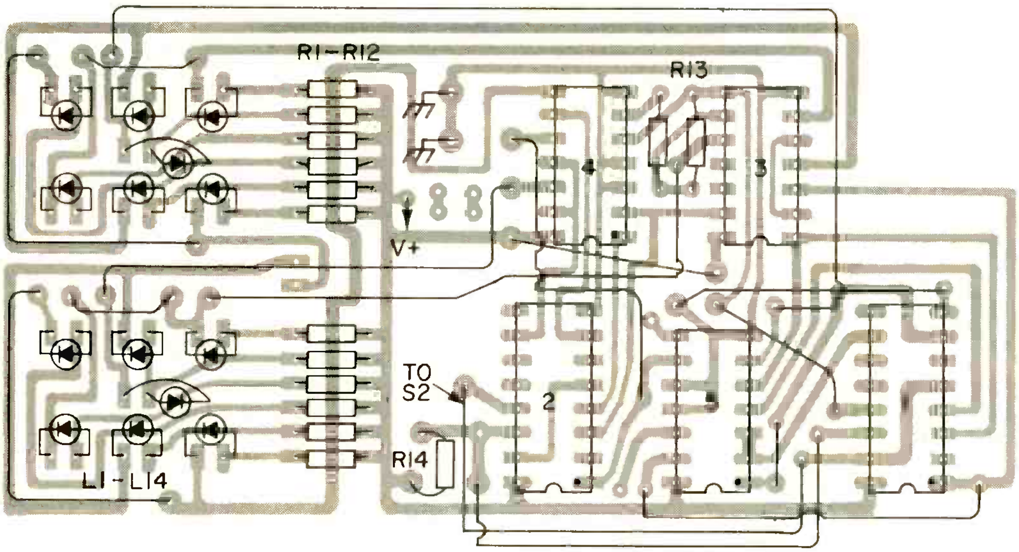
A complete parts kit including PC board and all components is available from Niccum Electronics, Rte. 3, Box 271B, Stroud, OK 74079. Price for the complete kit is $24.50; a pre-etched and labeled PC board only is $5.50. No CODs, please.



The foil side of the completed PC board is a gem of neat solder connections. The unit fits into a variety of handy plastic cases.

that the theoretical 16⅔ frequency for each level is closely approached—the small variations are just random fluctuations in this relatively few number of trials. *Digi Dice* draws about 20 to 60 mA from the supply, depending on how many LEDs are lit. Alkaline cells are best for long life, but regular carbon-zinc batteries will provide several hours of "rolling." Be sure to try this circuit in a game of backgammon. It runs much more quickly and a third person can get into the game as a dice roller.

Conclusion. We'll add the usual caution at this point about getting involved with "money" games. While *Digi Dice* has been designed to be as "random" as is possible for a project of this nature, we certainly do not wish to become referees in arguments between you and your friends (or your victims). *Digi Dice* is intended for entertainment only, and any other use of this project (either with a modified circuit or not), especially for gambling, is done against our strongest recommendation. If you're all that hot to *really* gamble, the Chamber of Commerce of Atlantic City would no doubt like you to visit the town's casinos instead! ■

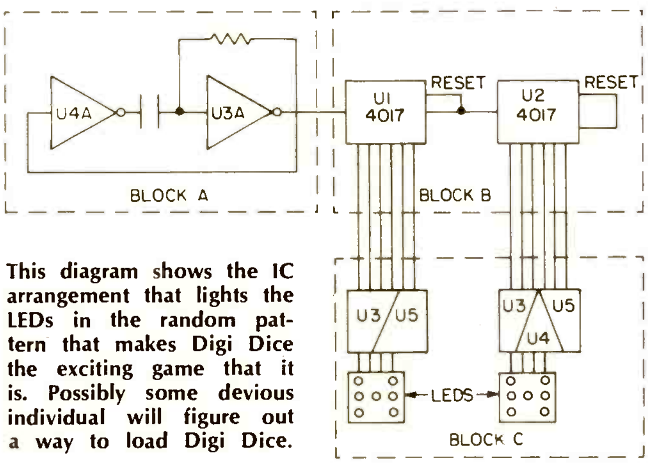


The parts overlay diagram shows the placement of components on the PC board. As in all projects using a number of delicate ICs care must be taken with the pins and with the use of soldering irons too near to the chips. Digi Dice is a project to gladden a gambler.

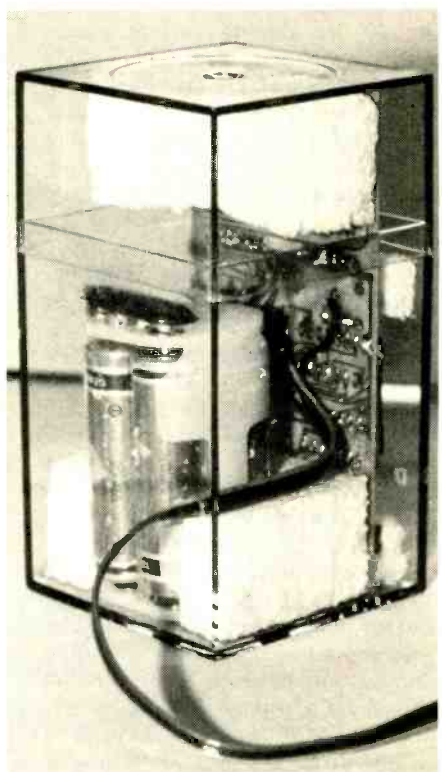
STATISTICAL BREAKDOWN OF 100 ROLLS

Face Value	Die #1/100 Rolls	Die #2/100 Rolls
1	18	16
2	14	18
3	18	14
4	15	17
5	18	16
6	17	19
Total	100	100

This chart shows how truly random Digi Dice is, much more so than old-fashioned "bones." While it may be possible, we know of no way to rig Digi Dice.



This diagram shows the IC arrangement that lights the LEDs in the random pattern that makes Digi Dice the exciting game that it is. Possibly some devious individual will figure out a way to load Digi Dice.



The battery pack holding the four 1.5 volt cells that power Digi Dice fits neatly into one of the common rectangular plastic boxes which can be found in a variety of shops. Styrofoam or a similar material can be used to take up room in the box, since the PC board and battery pack aren't likely to fill the entire box.

TELECHIRP

Make your home an aviary with this new telephone ringer.

An extra ringer in the bedroom or living room is always a good idea but the thought of waking up to a klaxon or having guests jolted out of their seats by a clanging bell is a bit too much for anyone.

However, if you would like a peaceful way to announce that your phone is ringing, use Telechirp. This device produces a low level chirp (or warble) instead of a clang or bong.

Easy To Build. The Telechirp is a simple device requiring few components and is easy to piece together. It is powered by the ringing signal of your telephone.

Electronic buzzer BU1 will produce a high frequency whistle (approximately 5 kHz) when 2-12 volts DC is applied to its wires. Normally, the output of the buzzer is a continuous tone because the applied voltage is continuous (DC). As used in the Telechirp, however, the buzzer chirps in step with the 20 Hz ringing current.

The 20 Hz ringing current passes through capacitor C1 to the diode bridge consisting of D1-D4. Partial filtering of the bridge's output is provided by C2. The resultant pulsating DC is applied to the buzzer, producing a high frequency chirp each time the phone rings.

All components are critical. Any change in values produces improper operation. Make only those changes or substitutions we specify. A silicon rectifier or full-wave bridge rated 200 PIV or higher can be substituted for D1-D4.

While the PIV can be lower, 200 PIV provides a good safety margin. For most applications C1 should be a .1 uF Mylar capacitor rated 500 VDC. (Again, a lower rated capacitor of 100 VDC could be used but 500 VDC provides greater protection.)

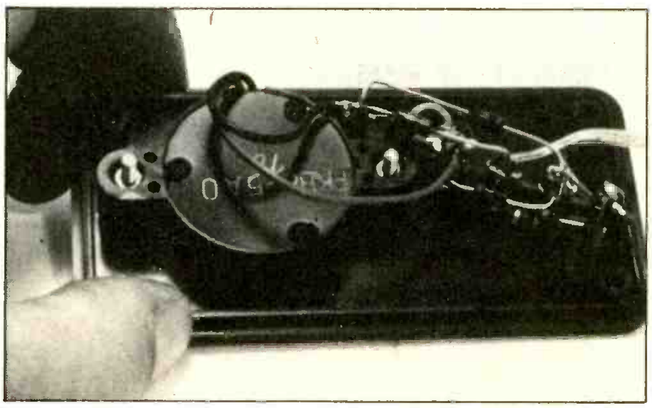
If C1 is made larger, say 0.47 uF, the output of the buzzer will be louder but you will also get kickback, meaning the buzzer will pulse in step with the telephone dial's pulses. If your phone has Touch-Tone® dialing, kickback is not a problem, but line static might cause the buzzer to tick.

Capacitor C2 is also critical. If made larger than 10 μF, it will produce a smooth, non-pulsating, DC and the output of the buzzer will be a continuous high frequency tone, which is not an attention-getter. If C2 is smaller than 10 mF there will be too much AC and the buzzer will tick instead of chirp; a nice sound but not loud enough for general use.

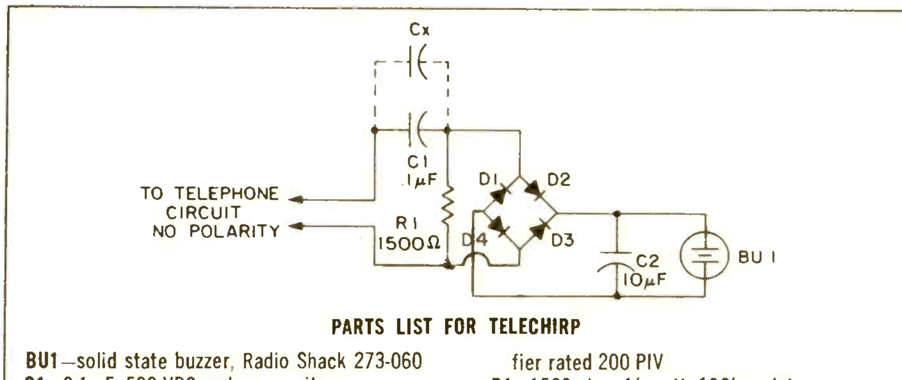
The Telechirp can be connected to your telephone circuit with ordinary zip-cord or speaker wire.

Telephone circuits do vary. Keep in mind that Telechirp is intended for a quiet location, but if the chirp produced by your telephone's ringing signal is too low, connect capacitor Cx, 0.05 uF disc, across C1.

The Telechirp can be used as a quiet warning that someone is dialing out on the phone circuit. If capacitor Cx is raised to 0.1 or 0.2 mF, the device will produce chirps in step with the dial pulsations each time someone dials out. (It works with rotary dial telephones.) The total value of capacitors C1 and Cx should never exceed 0.47 mF, nor should the value of R1 be changed by more than 10%. ■

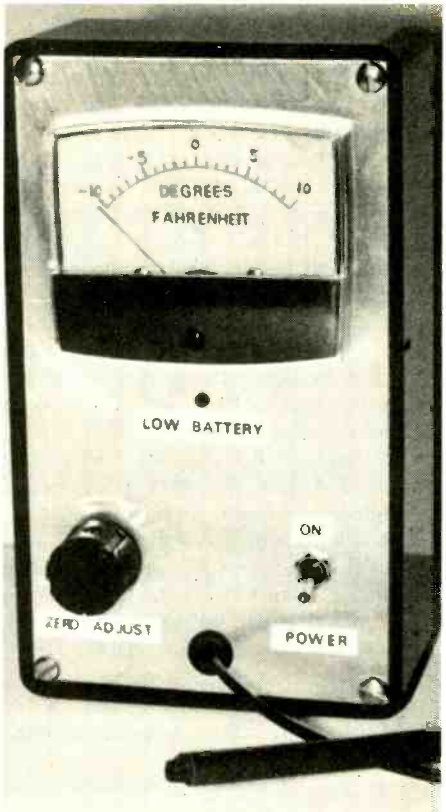


To make Telechirp, it doesn't take a lot of parts or a PC board. Just hook up the few parts with a terminal strip and Telechirp will sing away. Be very careful when you put together the diode bride. Make sure the diodes are properly polarized.



PARTS LIST FOR TELECHIRP

- **BU1**—solid state buzzer, Radio Shack 273-060
- **C1**—0.1-uF, 500 VDC mylar capacitor
- **C2**—10-uF, 25-VDC electrolytic capacitor
- **Cx**—see text
- **D1-D4**—silicon diodes on small silicon rectifier rated 200 PIV
- **R1**—1500-ohm, ½-watt, 10% resistor
- Misc.—cabinet, terminal strip, wire, solder, hardware, etc.



Heat Loss Sentry

Locate home heating losses and reduce your energy costs

THE MONEY spent on heating and cooling your home represents your largest energy expenditure. As you are well aware, this cost can easily amount to over $1000 a year at today's prices for energy. With the dramatic increase in energy costs, it behooves everyone to do everything possible to reduce his energy consumption. This will help reduce oil imports, while keeping your personal expenses as low as possible.

Many of our utility companies are instituting a program of energy surveys for homeowners to pinpoint the various sources of energy loss in our homes. One way this is done is to pressurize the home under test with an air blower and use smoke generators to detect the passage of air from within the home to the outside. These passageways represent points of heat loss (or gain) in winter and summer.

With the help of Heat Loss Sentry you can perform the same tests for heat loss, using not smoke as the detecting mechanism but temperature change. These tests can be made in winter or summer. All that is required is a temperature difference between the inside and outside of your home.

Heat Loss Sentry is a low cost quality instrument, sensitive enough to detect changes in temperature as low as one degree Fahrenheit. It is self contained in a small cabinet and powered by a readily available 9 volt transistor radio battery which provides many hours of operation. An easy to construct, probe contains a temperature sensing device used to locate sources of air leaks throughout the home. A built-in battery monitor circuit in the instrument alerts the user when the battery is near the end of its useful life. Although Heat Loss Sentry has been designed as a heat loss detector, it is accurate enough for use as a thermometer over its range of 20 degrees Fahrenheit.

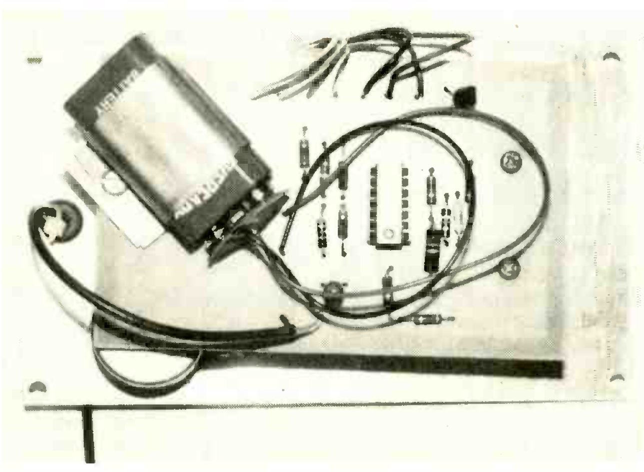
Circuit Theory. Heat Loss Sentry has been made possible by the development of an accurate low cost temperature sensor integrated circuit, LM335. This is a three terminal IC, designed to look like a 3 volt zener diode with an accurate temperature coefficient of 10 millivolts per degree Kelvin. (The Kelvin temperature scale is identical to the more familiar centigrade or Celsius scale with zero degrees Kelvin equal to −273° C, or absolute zero.) The IC can be accurately calibrated to any desired temperature. Typically, the LM335 will provide one degree C accuracy over its entire operating range when it's calibrated at any temperature.

Refer to the scematic diagram. U1 and U2 are each an LM 335 IC, connected in a differential amplifier circuit to detect a temperature difference between these two devices. U1 is mounted in a probe assembly, used to detect temperature changes, and U2 is contained in the instrument cabinet and acts as the reference. The adjustment lead of U2 is connected to a potentiometer (not panel mounted) so the meter reading can be set to center scale.

In energy leak detection, center scale becomes the nominal or average temperature being measured.

When Heat Loss Sentry is calibrated to center scale, the voltage across U2 is adjusted to be sufficiently below the voltage of U1 so that the output voltage of operational amplifier U3A drives the meter to center scale. Since U3A has an accurate gain of 18 determined by the ratio of resistors R6 and R5, the 10 millivolt per degree Kelvin sensitivity of U1 is amplified to 180 millivolts per degree Kelvin. This is equivalent to 100 millivolts per degree Fahrenheit. Resistors R7 and R8 are multiplier resistors which convert the one milliampere meter movement to a voltmeter of 2 volts full scale. This provides a total meter range of 20 degrees Fahrenheit, or a relative scale of ±10 degrees with zero at center scale. Once calibrated to center scale, placing the sensor probe in any environment with a different temperature, will produce an indication. A meter deflection downward occurs for colder temperatures, and an upward deflection occurs for warmer temperatures. If the total temperature change is 10 degrees or less, the actual differential can be read directly from the meter scale.

IC U3B is operated as a voltage comparator to constantly monitor battery voltage when the instrument is operating. This is accomplished by feeding a reference voltage across zener diode D1 to the positive input of U3B. A portion of the battery voltage is fed to the negative input of U3B. Voltage from a new battery is sufficient to develop a higher voltage at pin 9 of U3B than the D1 reference voltage. As a result, the U3B output is at zero potential and LED 1 is extinguished. As bat-



Looking inside a Heat Loss Sentry. There's plenty of room for the nine volt transistor battery, as well as for the components. Note series of wires coming from pads "A" to "I." The wiring is discussed in detail in the text.

tery voltage decreases a point is reached when voltage at pin 10 of U3B exceeds pin 9 voltage. This results in U3B output rising to battery potential, and illuminating LED 1. The user is thus alerted that the battery is near the end of its useful life and should be replaced.

Construction. The entire circuit, with the exception of the sensing probe and front panel components, is contained on a printed circuit board. On other page is a full size illustration of the foil layout as seen from the copper side of the board. On page also is the component side, showing the parts layout. The printed circuit board has been designed to mount directly on the back of the meter, using the meter screws for both mechanical and electrical assembly. Before constructing your printed circuit board, take into account the center to center distance of the studs of the meter, if you decide to use a different one milliampere movement than that specified in the parts list.

It is recommended that you use a socket for U3, rather than soldering it directly into the printed circuit board. This will permit ease of service should it ever be required. Be sure that the orientation of U3 is correct. Pin 1 of U3 is clearly marked on the parts layout and foil layout by a small dot. The same precautions hold for U2, the diodes, and electrolytic capacitor. These parts are polarized and must be placed into the circuit in the proper direction. A bottom view of U1 and U2 is seen on the schematic diagram.

Connections between the printed circuit board and external components are made through a series of pads marked with letters A through I. These connections are clearly shown on the schematic diagram. It is best to use wires of different colors to help prevent wrong connections. The sensing probe is connected to terminals A and B of the printed circuit board. Make this connection with a convenient length of flexible shielded wire. Maintain the correct polarity when connecting U1. The shield connection of the cable should be tied to the negative lead of U1, and to terminal B of the printed circuit board. Feed the probe cable through a front panel grommet.

Power to operate the circuit is obtained from a 9 volt transistor radio battery, mounted directly to the printed circuit board. Connect the battery to the circuit with a battery clip made for this purpose. The layout easily provides room on the board for this. The battery can be secured to the board with a homemade clamp constructed from a piece of sheet copper, or by any other means you care to use. The parts list specifies a normally open, spring return, power switch. This was chosen to prevent the unit from being left on when not in use, and depleting the battery.

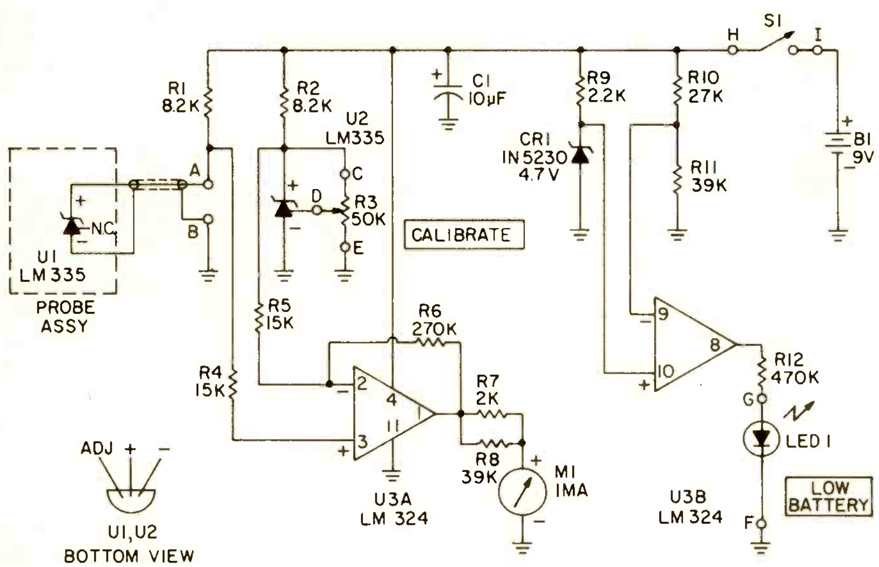
LED 1 is mounted on the front panel of the instrument using a small amount of epoxy. Use a pair of different colored wires to make the connections between the LED and printed circuit, and be careful not to bend the stiff leads of the LED where they enter the plastic body. This might render the LED defective.

Refer to the illustration of a typical probe assembly. If available, you may use a short piece of plastic or synthane tubing for the probe. You can even construct a probe from a piece of wood doweling. It is not recommended to use metal tubing for the probe, since the heat conduction from your hand may affect the temperature sensing performance of the sensor, U1.

Connect the shielded wire to U1, using the + and − terminals of the IC as shown on the schematic diagram. The adjustment terminal of U1 is not used. Insulate the connections carefully, and insert the IC and wire into the probe. Secure the IC and wire inside the probe with epoxy or silicon rubber compound. Allow part of the case of U1 to protrude outside the probe so that it is more sensitive to temperature change. Allow the assembly to harden before placing it in use.

For a professional looking instrument, you can use the meter scale shown which fits the meter specified in the parts list, as well as others. The existing meter scale can easily be removed by prying the plastic cover off the meter and removing two small screws. Be careful not to disturb the delicate needle. Paste the new scale on the back side of the meter scale, and reassemble it into the meter.

Checkout and Use. When the unit is



PARTS LIST FOR HEAT LOSS SENTRY

B1—9-VDC transistor alkaline battery
C1—10-µF, 15-VDC electrolytic capacitor
D1—4.7-volt zener diode, 1N5230 or similar
LED1—red LED
M1—0-1-mA, DC meter
R1—8,200-ohm, ¼-watt resistor (all resistors 10% unless otherwise noted)
R2—8,200-ohm, ¼-watt resistor
R3—50,000-ohm potentiometer, panel mounted
R4—15,000-ohm, ¼-watt resistor
R5—15,000-ohm, ¼-watt resistor
R6—270,000-ohm, ¼-watt resistor
R7—2,000-ohm, ¼-wat resistor, 5%
R8—39,000-ohm, ¼-watt resistor
R9—2,200-ohm, ¼-watt resistor
R10—27,000-ohm, ¼-watt resistor
R11—39,000-ohm, ¼-watt resistor
R12—470-ohm, ¼-watt resistor
S1—SPST toggle switch
U1, 2—LM335 temperature sensor, National Semiconductor or equivalent
U3—LM324 operational amplifier, National Semiconductor or equivalent

Misc.—Cabinet, GC Electronics H4-726 or similar, wire, solder, battery clip, etc.

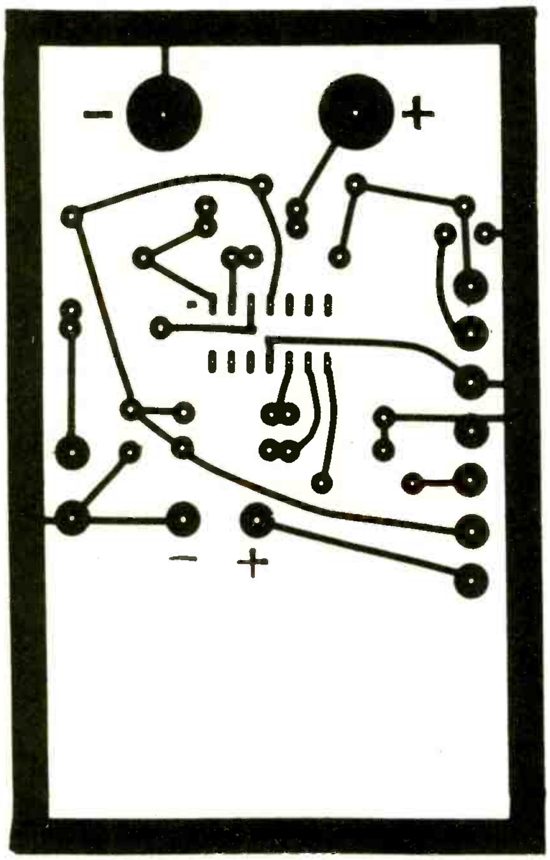
fully wired, check for wiring errors. Then, connect a 9 volt transistor battery to the power input terminals. Activate the power switch and rotate the zero adjust control over its full range. You should be able to adjust the meter reading from zero to full scale, with some extra range left in the potentiometer. Set the control so that the meter reads half scale. While holding the power control on, place your fingers over the sensing tip of the probe. The meter reading should increase to beyond full scale. If the unit performs as specified, it is operating properly.

You may wish to check the Low Battery indicator circuit to determine if it is operating properly. To do this, you must substitute a variable voltage DC supply for the battery. Set the supply to 9 volts and connect it to the power input terminals observing correct polarity. Turn the power switch of Heat Loss Sentry on, and observe the Low Battery indicator as the power supply voltage is reduced. The Low Battery indicator should become illuminated as the power supply voltage approaches approximately 6½ volts. Due to variations in zener diodes, you may wish to change the value of R11, if necessary, so that the LED lights at approximately 6.5 volts battery voltage. Once this is done, the checkout of the instrument is complete. Reconnect the battery to the instrument.

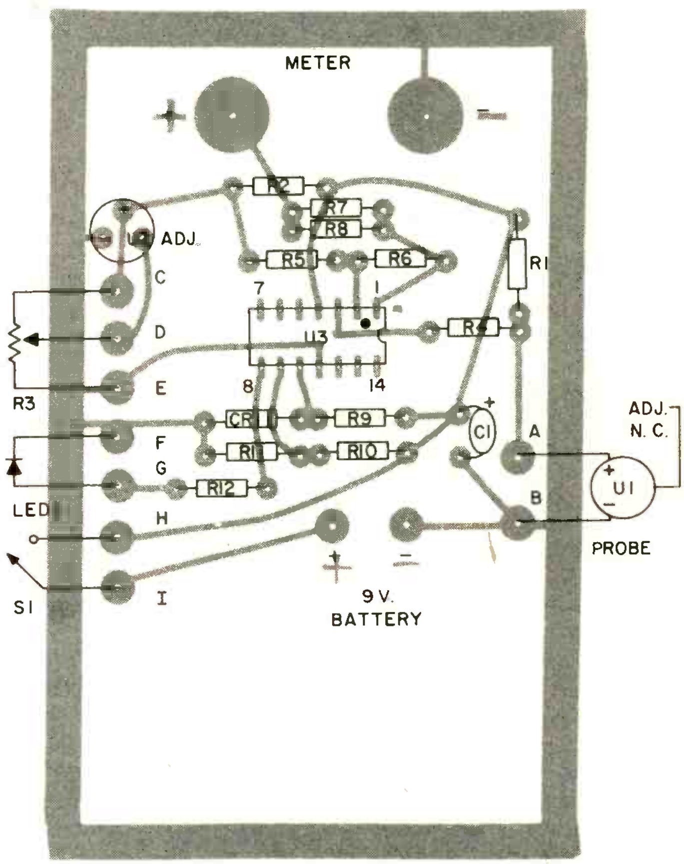
When Heat Loss Sentry is operated, you may notice that the Low Battery indicator blinks as the power is turned on and off. This is a normal reaction, which occurs as the circuit voltage passes from zero to battery voltage then back to zero.

To operate, hold the power switch on and adjust the meter to center scale. Holding the probe, search out any area where you suspect an air leak between inside and outside of your home. The meter will give an immediate indication if there is a change in temperature. In the case of very small leaks, allow sufficient time for the unit to react. This may take several seconds. Once a change of temperature has been detected, it is best to remove the probe from the leak and allow its temperature to stabilize to room temperature before searching out another leak. It takes a few minutes to familiarize yourself with this instrument.

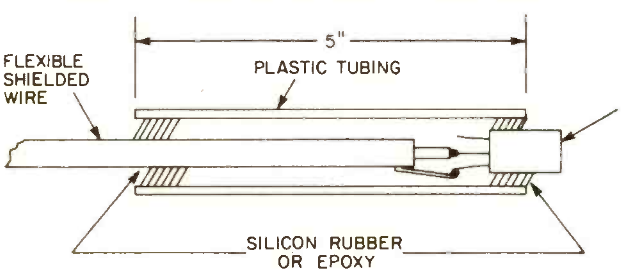
Another interesting use for this device is in troubleshooting defective electronic circuits. When the probe is held close to defective ICs, resistors, etc. a higher than normal temperature will be indicated. ■



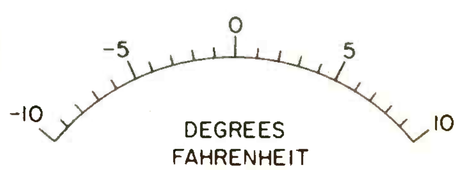
This is the foil side down view of Heat Loss Sentry's PC board. Care must be exercised in etching board.



The foil side up diagram illustrates parts placement on the top of the PC board. Heat Loss Sentry requires relatively few components.



To the left is a drawing of the heat sensing probe. Follow the set-up closely, and use the glue! At right is an exact size drawing of the meter face. Cut it out and paste it right on.



101. Add-A-Tweeter *(Continued from page 61)*

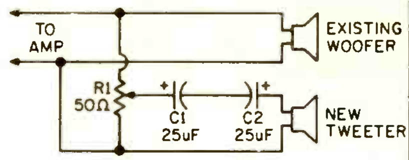
☐ Any single-voice coil speaker is hard pressed to handle both low and high frequencies simultaneously—and it's the highs that suffer most. A much cleaner sound can usually be obtained from speakers 6 inches or larger if the highs are pumped through a tweeter. It can be any small speaker rated 4 to 6 ohms of approximately 2 to 3 inches in diameter.

The back-to-back capacitors, C1 and C2, permit only the highs from about 1500 Hz up to pass into the tweeter. By keeping the lows out of the tweeter, the highs come out cleaner, and there's no chance of the greater low frequency power "blowing" the tweeter. Potentiometer R1 is used to match the tweeter's output level to that of the woofer—because small speakers are generally much more efficient than large speakers. If you eliminate R1, the highs will literally scream in your ears. ■

PARTS LIST FOR ADD-A-TWEETER

C1, C2—22-uF electrolytic capacitor, 50 VDC

R1—50-ohm wirebound potentiometer, 1 or 2 watts.



Misc.—Cone type tweeters are suitable for use with this circuit.

Sitrat
(Continued from page 101)

corresponds to 0 ma on your meter. When your SITRAT is complete, you will have labeled the 1.0 ma mark on the meter's dial with the maximum temperature and the 0 ma point with the minimum temperature.

Next, draw a vertical line directly up from the temperature axis at the 110° mark. This line is labeled (c) on the chart. Determine the point on the curve this line meets, then draw a horizontal line (labeled d) to the current axis and make a note of the current reading. The author marked this point as .82 ma at 110°F. He did the same for the following temperatures; 100, 90, 80, 70, 60, 50, 40, 30, 20, 10, 0, −10, −20, −30 and the minimum temperature (−50). All the information is given in Table 3. The reader should construct a table similar to Table 3. However, the exact numbers will differ (except for the 120°F, .9 ma point) from Table 3. This is due to the fact that no two transistors (even two 2N5129) have exactly the same characteristics.

Alternative Method. If graphs and curves aren't your bag, you can still build SITRAT. All you have to do is take measurements at *exactly* 10 degree intervals. While this isn't easy, it can be done. Your table should be similar to Table 3, although it probably won't go much below 10°F because of the difficulty of easily obtaining temperatures below this value.

Drawing The Meter's Dial. After you construct the final table (which should be similar to the author's Table 3), the final step is to label the meter's dial plate. Remove the meter's clear faceplate. For meter's with plastic faceplates, this is done by gently prying it off with your fingers. Better meters have two small screws holding it in place. Use a pencil eraser and remove the '*D.C. MILLIAMPERES*' label as well as all numbers.

TABLE 3

Temperature (°F)	Current (milliamperes)
130°F (Max.)	1.0 ma
120	.9
110	.82
100	.74
90	.67
80	.60
70	.54
60	.475
50	.42
40	.365
32	.32
30	.31
20	.265
10	.22
0	.18
−10	.145
−20	.11
−30	.07
−50 (Min.)	.00

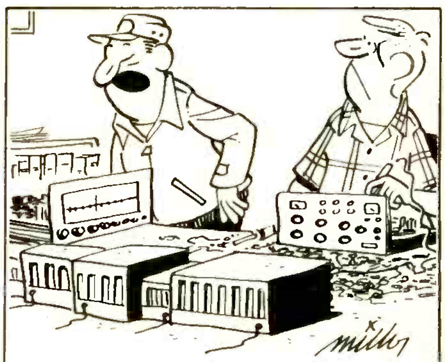
NOTE: Table 3 was derived by the author from measurements taken with his prototype of SITRAT. Your Table will be similar, although it will differ in actual readings as well as the minimum and maximum temperature.

Applications. This thermometer has many applications. Remote-reading outdoor thermometer and freezer thermometer are just a few of the possibilities. To catch lots of fish, find the species water temperature. Drop the probe to the water depth indicating that temperature. Then, drop your fishing line to the same depth. While the author hasn't tested SITRAT for cable's longer than 15 feet, the reader should experience no problem with very long cables.

Final Comments. Your SITRAT is unique. No one has another one exactly like it. The reason for this should be obvious now. The transistor you used is one of a kind. The higher the transistor gain, the less sensitive your SITRAT will be. However, this isn't necessarily bad. The less sensitive your SITRAT the greater the range of temperatures it will measure.

Your SITRAT's accuracy depends upon how carefully you labelled the meter's dial plate. The quality of panel meter you use is also a factor. SITRAT's accuracy is diminished at bitter cold temperatures; below about −20°F.

While SITRAT is about as cheap an electronic thermometer it is possible to build, you actually substitute your time for dollars. There is no such a thing as a free lunch. However, most of the time used in completing SITRAT is fun time. You will soon dream up applications that the author has never even thought of. ■



"You know, by the time you finish this thing, they probably won't make the tubes for it anymore."

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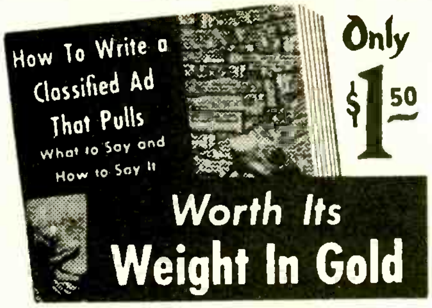

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Superbass

(Continued from page 106)

cork or rubber will retain the battery. You can use small cork "feet" such as sold in hardware stores for use on the bottom of bric-a-brac to prevent scratching of furniture. The cost is usually well under fifty cents and you can cut the "feet" to the needed size.

Take extra care to get S2's wiring right the first time. Note that S2 is SPDT, switching only the output connection. The input is permanently connected to the amplifier and switch S2.

Nothing about the entire project is really critical other than the values of C2 and C3. Resistors need be no better than 10% tolerance—why spend money for better tolerance when the project won't work any better?—and electrolytic capacitors C1 and C4 can be any value from 2.2-uF to 4.7-uF. Use whatever you can get at lowest cost. The same "lowest cost" rule applies to C2 and C3; they don't have to be precision tolerance as long as their rated value is 0.1-uF.

Using Superbass. Connect your electric guitar or other electronic instrument to input jack J1; connect output jack J2 to your instrument amplifier's normally-used input. With power switch S1 *off*, key S2 so the instrument feeds directly to the instrument amplifier. With R2 set full counter-clockwise (Off), turn power switch S1 on, key S2 once, and advance R2 for the desired superbass sound level. To cut back to natural sound just stomp down on S2 and key the superbass out.

Don't worry about leaving power switch S1 on for the several hours of a gig. The circuit pulls less than 1-mA from the battery, so the battery will last many, many months. ■

Energy Sentry

(Continued from page 94)

components are polarized and the circuit will not work if any of these are placed incorrectely on the board.

Before inserting U1 into its socket, apply power to the circuit and measure the DC voltage across C2 to ensure that the circuit is operating properly. Once this is done, disconnect line power before inserting U1. Be sure the IC is plugged in facing the correct direction. Pin 1 of the IC is indicated by a small dot on the foil layout.

Test And Calibration. For best accuracy, the circuit should be calibrated somewhere near the middle of its range. A set of six 100 watt incandescent lamps, connected in parallel, will provide an excellent 600 watt load to calibrate the unit.

Before the calibration can be performed, determine the actual cost of electricity in your area. The easiest and best way to do this is to obtain a recent electric bill which shows the number of kilowatt hours of electricity used, and the total cost during one billing period. Divide the electrical cost by the number of kilowatt hours. The resulting quotient will be the average cost of one kilowatt hour of electricity.

Once you have determined the cost per KWH, multiply this by the wattage of your test load. In this case it would be 8¢ times .6 KW (600 watts) for six 100 watt lamps connected in parallel. Thus, in our example:

8¢ per KWH × 0.6 KW = 4.8¢ per hour.

4.8¢ can be rounded off to 5¢ strictly for calibration purposes.

Connect the test load to the receptacle on Energy Sentry. Plug the line cord into a 115 volt receptacle and adjust R3 so that LED #5 (5¢) is illuminated. This completes calibration of your cost saving Energy Sentry.

Use of the Instrument. You may use Energy Sentry on any 115 volt appliance in your home. Although this unit will generally be accurate to within 1¢ per hour, it does not take into account the power factor of the load. In the case of appliances which generate heat, such as toasters, irons, and coffee makers, the power factor of these units is 1 and no correction factor is necessary. Other appliances which use inductive components, such as motors, have power factors of possibly 0.8 or 0.9. In this case Energy Sentry will indicate a cost per hour greater than true cost. A correction can be obtained by multiplying the indicated cost per hour by the power factor of the appliance or load being tested.

Note. Be sure to insulate the transformer case of T2 from the metal case. If not, an AC leakage current to the case will make the case hot, creating a shock hazard. ■

Combo Amp
(Continued from page 98)

Bend the groups of four leads so they correspond to the pin spacing of the socket. Plug U1 into the socket.

Install all the cabinet components, then place the completed PC assembly on the terminals of M1. Locate the position for LED1 on the cabinet directly under the PC board terminal holes and mark the cabinet.

If you want the LED at some other location make the change now, but keep in mind you must connect wires to the LED if its position is relocated.

Remove the PC board and the meter, drill the hole for LED1, replace the meter and the PC board and solder the meter's terminals to the foil pads. Then install LED 1.

The PC board has some give so you can work the wires into the PC board; push the LED against the panel and solder its leads to the PC foils.

Switch Both Leads. The positive and negative battery leads must be switched: S1 must be DPST. Twist the red wire from one battery connector with the black wire of another connector. This is the *common* or *ground* connection and is soldered to the PC board's ground foil. The remaining wires connect to switch S1.

Doublecheck the polarity; if it's reversed U1 gets instantly zapped.

The meter indicates one-half the output voltage. (We provide the information to avoid possible damage through unnecessary experimentation.)

Connect your mike to J1 and the line from your recorder to J2. Speak to the mike and advance level control R1 so meter M1 peaks at any convenient reference value: 0.8 is recommended. Adjust your recorder's control level so the 0-VU or 0-dB record level occurs when the Combo-Amp's meter peaks at the 0.8 reference value.

If you're using the device for a P.A. system, adjust the P.A. gain so the desired volume occurs when the meter indicates 0.8.

As long as the meter peaks at 0.8 you know the recorder or P.A. is getting the correct level. If the meter value rises above or below 0.8 simply adjust R1 for the optimum 0.8 value.

If you want to paint over the meter scale to show a 0-VU reference do so. The only reason we did not use a meter with a VU scale is that they are very expensive and difficult to obtain. Also a VU meter's internal diodes would have to be removed to work in this circuit, a somewhat difficult task. ■

Aircraft Scanner
(Continued from page 96)

the upper setting of the tuning dial. Ideally, you will adjust the oscillator coil so that the highest frequency FM station (near 108 MHz) will now be heard at the lowest dial setting (marked 88 MHz).

If the turns of the oscillator coil are fully spread and yet the tuning range is still not high enough to cover the aircraft band, carefully solder two adjacent turns together at one point. It is a good idea to scrape the wire at that point before soldering. Use a sharp blade or sandpaper cautiously.

Another way to increase the tuning frequency of the receiver slightly is to decrease the trimmer capacitance on the tuning capacitor (see Fig. 3). The four small adjustments are the oscillator and RF trimmers for the AM and FM band. Be sure to select the trimmers next to the FM coils! It would be wise to mark the original settings of all trimmers with a felt tip pen in case the wrong trimmers are turned.

A tiny screwdriver will be used to adjust the trimmer capacitors. Note as you turn the trimmer that there will be one setting where the two metallic surfaces of the trimmer will be fully visible. This is the minimum capacitance (highest frequency) setting.

Fine Tuning. Now for the final adjustment! Tune in a weak station near the low frequency (88MHz) portion of the dial and adjust the turns of the RF coil with a non-metallic tool for maximum signal strength. If your particular receiver has sufficient background hiss, you may use that sound for peaking the coil. Tune the receiver dial near its upper setting (108 MHz) and peak the RF trimmer capacitor for maximum background hiss.

By carefully repeating the last two steps (RF coil and RF trimmer capacitor), you will have completed the conversion of your AM/FM receiver into a useful aircraft band monitor. If you live near large airports, the radio will be extremely active. Even if you don't live near an airport, reception over long distances will be heard because of the altitude of the aircraft.

While the radio may not be as good as a receiver designed specifically for the aircraft band, it will give a good accounting of itself. And if you grow tired of aircraft band monitoring, you can always return the radio to its original state as an AM/FM set. ■

Calculator Power
(Continued from page 102)

teen hundredths of an ampere (150-mA), which will be adequate for most calculators. Try to get a transformer that has a higher current rating (in this case 200mA or greater) and at least three volts higher than the regulated output voltage.

One can apply this data to other power supply designs as well. It is very important to pick a transformer that has a current rating beyond what is necessary to supply a particular circuit. It is good practice to use a transformer with a current rating ten percent higher.

The block diagram shows in simple form how the inexpensive power supply works. As they say, a picture is worth a thousand words! The schematic shows how the circuit works in detail.

The pass regulator is an NPN transistor with a high current rating. This component should be able to easily handle the output current. The transistor should have a heat sink.

The 741 operational amplifier (U1), acting as the error detector/amp, has its negative input (pin 2) coming from the emitter of the transistor through a 10,000 ohm resistor. Its positive input (pin 3) comes from the reference voltage; either a 9 volt reference (via Jumper 1) or a 3 volt reference via a 43,000 ohm dropping resistor. The reference voltage originates across the zener diode.

Now, the output voltage regulation, or swing, for a variable load is approximately 10%. This is good enough for most calculators.

Construction. The printed circuit board layout is not included in this article because of design changes and other variations. It is a good project to practice printed circuit board designing, and to get the feel of fabricating PC boards. The prototype was designed so that the board could be piggybacked onto the adaptor's case. Thus, mounting schemes will dictate your PC board layout and design.

The board was mounted using 4-40 machine screws. These screws were placed through four holes that were drilled in the adaptor's plastic case and through the PC board.

The transformer was left inside the plastic case and the secondary wires were sent to the externally mounted PC board. In this way, the 120 VAC is isolated inside the plastic case and thus there is no chance of getting a shock. The rest of the construction is left up to the hobbyist. ■

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