PHOTO PROJECTS UPDATE DARKROOMS, Page 55

PROJECTS

ELECTRONICS HOBBYIST

$1.50

FALL-WINTER 1978 CC 02396

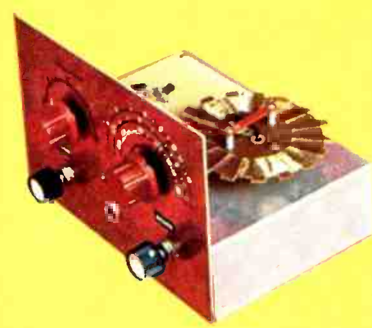
by the EDITORS of ELEMENTARY ELECTRONICS

UP-TO-THE-MINUTE HOBBY PROJECTS TO FIT ANY WALLET AND WORKBENCH

KNOW the full picture about your weather, what it really is now, what it's going to be, how fast it'll get here. MEASURE THE WIND with ELECTRONIC HOBBYIST'S digital anemometer. Uses latest IC circuitry to measure relative wind velocity. Remote sensor lets you read wind speed in the comfort of your own living room, rain or shine.

POUND OUT your rhythm with MIGHTY MET, the midget metronome that will measure out nearly any tempo and accent you want. Uses ICs, too, for real reliability.

SAVE on IC service—use simple, easy, quick 555 IC TESTER. Pinpoints that balky 555 and cuts circuit searching time to virtually nothing.



PULL IN those distant stations just like grandpa did it with the SPIDERWEB receiver. Covers a lot of bands, too, with plug-in flat-wound coils.

BEEF-UP your beat-up old shortwave rig. SHORTWAVE PRESELECTOR peaks frequencies you want and cuts the rest. Sharp and clear signals where there used to be static.

ALWAYS get that call when RING-A-THING's on the job. Simple, safe circuit adds as many bells to your phone as you like, easily.

SOCK IT to your buddies with a disco beat—build SIMPLE SYN, the music synthesizer. It'll solve all of your sound problems, and much more.

SERVICING your car's electrical system is a snap when you use our ALTERNATOR TESTER. Spots potential trouble—keeps you charging.

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A DAVIS PUBLICATION

ELECTRONICS HOBBYIST

PROJECTS **FALL—WINTER 1978**

CONSTRUCTION PROJECTS THAT PACK A PUNCH

PHOTO PROJECTS THAT KEEP YOU CLICKING

DEPARTMENTS AND FEATURETTES

ELECTRONIC HOBBYIST is published semi-annually by Davis Publications, Inc. Editorial and business offices: 380 Lexington Avenue, New York, New York 10017. Advertising offices: New York, 380 Lexington Ave., New York, New York 10017. 212-949-9190; Chicago, 520 N. Michigan Ave., 312-527-0330; Los Angeles: J. E. Publishers' Rep. Co., 8732 Sunset Blvd. 213-659-3810. EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care: however, publisher assumes no responsibility for return or safety of manuscripts, artwork, or photographs. All contributions should be addressed to the Editor-in-Chief, ELECTRONICS HOBBYIST, 380 Lexington Avenue, New York, New York 10017. Copyright 1978 by Davis Publications, Inc.

New Products

Digital Multimeter

A low-cost accurate digital multimeter by EICO, the EICO Model 272, is factory-assembled to sell for $69.95. The Model 272 reads out up to 1000 Volts DC, up to 600 Volts AC, up to 1000 milli-Amperes DC and AC, and up to 1 Megohm resistance on three 0.3-in. bright LED digits. Overrange is indicated by a flashing display. The zero setting is automatic and the polarity reading is also automatic. The Model 272 is fully protected against overload and has 10-Megohm input impedance. Battery supply consists of four penlite cells (supplied) and there is a convenient built-in test point for checking the batteries. For further details contact EICO Electronic Instrument Co., Inc., 108 New South Road, Hicksville, NY 11801.

CIRCLE 59 ON READER SERVICE COUPON

Mini Frequency Counter

Designed for 115V to 12V operation, the Davis 7208 UHF/VHF frequency counter is available factory-assembled or in kit form for even greater savings, and incorporates latest LSI technology. Features of the Davis 7208 include large 8-digit LED display, push-button switches, built-in prescaler, gate light, crystal time base and automatic decimal point placement. Available low-cost options are crystal oven, a Ni-Cad rechargeable battery feature for total portability, and built-in VHF-UHF preamp for direct measurement of low level RF signals in RF generators, receivers, etc. The Davis 7208 has a frequency range from 10 Hz to 600 MHz, with 0.1 and 1.0 sec. gate time; resolution is 1 Hz with 1.0 sec. gate, and sensitivity is from 10 mV at 60 MHz and 100 mV at 600 MHz. Input impedance is 1 Megohm/20 pf to 60 MHz, 50 Ohm above 60 MHz, and maximum safe input is 120V RMS to 10 MHz, 2V RMS above 60 MHz. The 600 MHz kit, (7208K), costs $149.95, complete with all parts, drilled and plated thru glass P.C. boards, cabinet, parts, hardware, plus assembly manual and calibrating instructions. A factory-assembled 600 MHz unit (7208A) costs $199.95 (plus $2.00 shipping), and is calibrated to specifications and guaranteed for one year. For further information, contact Davis Electronics, 636 Sheridan Drive, Dept. 803, Tonawanda, NY 14150.

CIRCLE 63 ON READER SERVICE COUPON

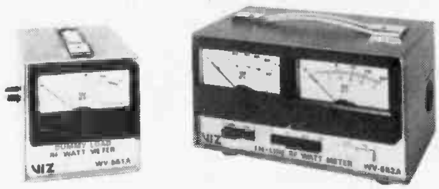
Auto Biamplified AM/FM/ Cassette Unit

An in-dash AM/FM cassette player with biamplification, said to bring to the car and van the same quality music reproduction associated with fine home audio equipment, has been introduced by Sanyo. The unit, model FT 1490A, carries the Sanyo "Audio Spec" label, and is spec'd with a super-sensitive FM tuner; wide frequency response; Dolby noise reduction for tape and FM; a loudness contour control; tape transport with virtually negligible wow and flutter. Biamplification provides separate amplifiers for bass and treble frequencies, a system professional sound engineers have favored for years in some of the most costly home stereo systems, and in discotheques and concert halls, to produce maximum sound power and minimum distortion. The FT 1490A has a total output of 28 watts RMS, 12 watts per channel on woofer amp and 2 watts per channel tweeter amp. The FM tuner, Sanyo's finest, features dual gate MOSFET front end and PLL MPX decoder, producing a sensitivity of 1 microvolt. Frequency response is 30-16 kHz. Installation in most domestic autos and some imports is greatly simplified with Sanyo's "E-Z Install" system which includes mounting accessories and instructions. Suggested retail price is $199.95. Get more facts by writing to Sanyo Electric Inc., Consumer Electronics Division, 1200 West Artesia Blvd., Compton, CA 90220.

CIRCLE 65 ON READER SERVICE COUPON

Pair of Wattmeters

VIZ has introduced two new easy-to-use wattmeters that are ideal for testing CB and ham, VHF, FM, and even UHF transmitters. The WV-551A dummy-load RF wattmeter has a broad frequency range from 1.9 to 512 MHz. Its power range is 0.5 to 15 W with full-scale accuracy better than 5%. Input impedance is 50 ohm ±2%, and VSWR is less than 1.15 at 500 MHz. Simple to use—the transmitter output line is connected directly to the unit and readings are taken from a taut-band meter. The user price is $60.00. The WV-552A inline RF wattmeter is a dual taut-band meter unit used to measure forward and reflected power. It especially is useful in matching and adjusting ("tuning") transmitters to antennas for optimum power output. Measurements are possible over three selectable frequency ranges: 20-40 MHz, to 40-100 MHz, and 100-230 MHz. The



CIRCLE 74 ON READER SERVICE COUPON

meter's power ranges are 0-20W and 5-100W (forward) and 0-5W and 1-20W (reflected); full-scale accuracy is said to be better than 5%; VSWR less than 1.15 over the entire frequency range, and input impedance 50 ohm ±2%. The user price is $150.00. For further information and data sheets, write to VIZ Test Instruments Group, VIZ Mfg. Co., 335 E. Price Street, Philadelphia, PA 19144.

Carbon Monoxide Sentry for Car

GC Electronics' newest security product is the Deluxe Gas Sentry (15-200), a carbon monoxide detector for motor vehicle installation. The Gas Sentry also detects gasoline vapors, propane, butane and other hydrocarbon gases. The Deluxe Gas Sentry operates from a 12 VDC motor vehicle battery. An integrated circuit responds to 425-ppm carbon monoxide level (factory preset) with a 7-dB solid-state buzzer. It features an automatic reset and a delay feature to suppress warm-up buzzing. It installs easliy in passenger compartments with

CIRCLE 68 ON READER SERVICE COUPON

self-adhesive backing or hardware, both supplied. The back of the product card contains information on "Effects of Carbon Monoxide on the Human Body." For instance, when CO concentration in the air reaches .04% (425 ppm) a stationary person would develop a frontal headache within 1-2 hours. The headache would become widespread in 2½-3½ hours. Priced to sell at $24.95. Get all the facts direct from GC Electronics, 400 South Wyman, Rockford, IL 61101.

Stereo Tuner

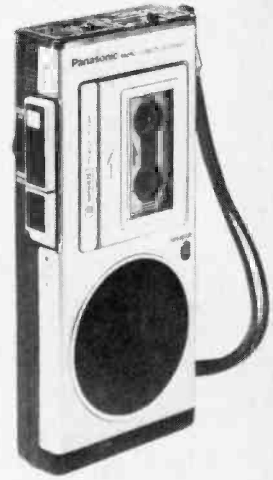
The ST-1122 FM/AM stereo tuner made by Sharp comes in a black cabinet and has such professional features as an air check button. This is a special, built-in, 400 Hz tone generator which provides a signal to set the optimum levels when recording FM broadcasts. The unit also has a Field Effect Transistor front end for increased FM sensitivity and low distortion. Other features include a signal strength meter to indicate FM broadcast quality, which also doubles as an AM tuning meter. ST-1122 has a center channel FM tuning

CIRCLE 55 ON READER SERVICE COUPON

meter, linear slide rule tuning with smooth flywheel action, push button selector switches for AM, FM mono and FM muting and LED stereo and power-on indicators. Suggested retail price is $109.95. Get all the facts direct from Sharp Electronics Corp., 10 Keystone Place, Paramus, NJ 07652.

Two-Speed Micro Cassette

Panasonic unveiled its new Model RQ-180 two-speed Micro Cassette Recorder with capstan drive—less than 1-in. thick and weighing approximately 12 ounces.



CIRCLE 72 ON READER SERVICE COUPON

The new unit's 2-speed tape selector provides up to 2 hours recording and playback with one micro cassette and is equipped with a built-in condenser microphone. A silent, full Auto-Stop automatically shuts the unit off when the tape comes to an end. Model RQ-180's

CIRCLE 9 ON READER SERVICE COUPON

New Products

other features include: an LED record/battery indicator which glows green when in playback and red when in record mode; one-touch recording; cue and review controls; lockable pause control; Easy-Matic circuitry; digital tape counter; model RP-36 AC adaptor/recharger. With optional rechargeable battery pack, RP-095 ($9.95), you can recharge in only 5 hours. The unit operates on 2 AA-size batteries. Sells for $209.95. Get the facts direct from Panasonic, One Panasonic Way, Secaucus, NJ 07094.

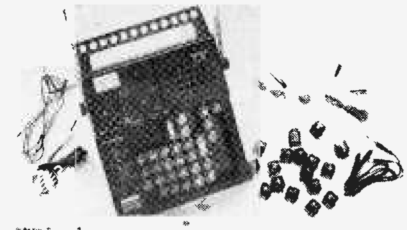
Portable Compressed-Air System

Chemtronics Inc. recently introduced Micro-Duster, a new product that permits compressed-gas dusting of delicate instruments and assemblies. The product contains pure, moisture-free, nonflammable and non-toxic filtered gas, providing controlled removal of dust, lint, oxide particles, etc., without depositing harmful contaminants. A single, 15 oz. can of Micro-Duster produces over 1800 one-second compressed-gas bursts, or 25 to 30 minutes of continuous dusting. Spraying in short bursts until contaminants are dislodged is recommended for most efficient utilization. The product comes with a 6-in. extension tube for pin-point applications. Micro-Duster sells for $2.50 through Chemtronics Distributors. For more information, including the location of local distributors, contact Chemtronics, Inc., 45 Hoffman Avenue, Hauppauge, NY 11787.

CIRCLE 60 ON READER SERVICE COUPON

150 Circuits Without Wiring or Soldering

Utilizing small electronic blocks, you can make a radio, wireless microphone, electronic organ, various meters, light-sensitive circuits, and AND/OR/NOT/NAND/NOR circuits. You can assemble up to 150 fascinating projects. No wiring is required, no soldering or mechanical connections. A 158-page manual leads you step-by-step through each project. Blocks are heat-stamped to indicate the wiring and electronic parts welded in them. You graphically learn while having the fun of assembling working projects.



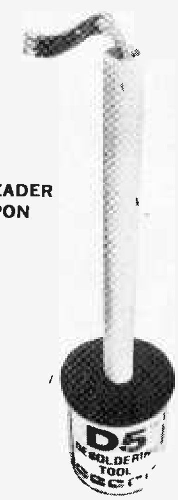
CIRCLE 49 ON READER SERVICE COUPON

Included are 46 component blocks; 2 transistors, 2 diodes; headset and microphone; built-in amplifier, speaker, antenna, variable condensor, meter, volume control and photocell. Batteries included. $73.95 postpaid. Illinois residents add 5% sales tax. Order from Paxton/Patterson, 5719 W. 65th Street, Chicago, IL 60638.

Pocket-Sized Desoldering Tool

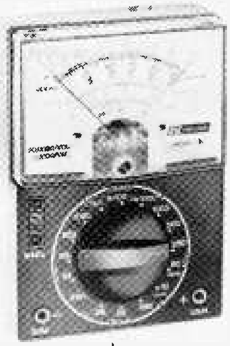
The D5 Desoldering Tool is a highly effective desoldering wick in a specially engineered, refillable dispenser tool. The D5 Desoldering Tool consists of a 1-in. long, clear plastic cylinder which contains a visible supply of 5 feet of desoldering wick. Braid is fed to the work through a 2½-in. Teflon probe that extends from one end of the wick supply. The heat-resistant Teflon probe allows users to desolder with pin-point accuracy and without burnt fingers, even in high-density circuitry. Sells for $2.29. More information is available at Chemtronics distributors or directly from Chemtronics Inc., Solder Products Division, 45 Hoffman Avenue, Hauppauge, NY 11787.

CIRCLE 60 ON READER SERVICE COUPON



Experimenter's VOM

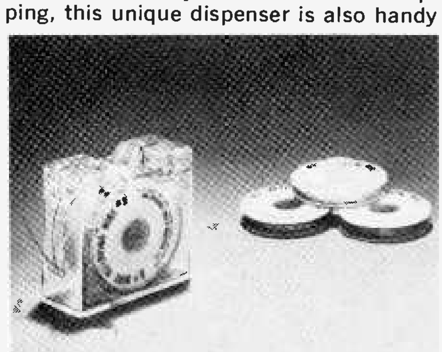
The 20,000 ohm/volt compact model 110 VOM introduced by B&K-Precision is a 16-range fuse-protected multimeter. For checking the low resistance of coil, transformer and motor windings, a 10-ohm mid-scale range is featured. This range offers better than one-ohm resolution. Resistance ranges cover 0-1KΩ, 100KΩ and 1 megΩ. Three DC current ranges (0.05mA, 25mA and 250mA) and five DC voltage ranges (0-2.5V, 10V, 50V, 250V and 1000V) are featured. DC accuracy is ±3% at full scale. Five AC ranges (0-10V, 50V, 250V, 500V and 1000V) provide "easy-reading" measurements. The 110 is compact enough to fit into most tool kits. Test leads and instructions are included; a carrying case is optional. The ohm meter requires a common "AA" battery. The B&K-Precision Model 110 is user priced at only $24.50 and is available for immediate delivery at local distributors. Get all the facts direct from B&K-Precision, 6460 W. Cortland Ave., Chicago, IL 60635.



CIRCLE 70 ON READER SERVICE COUPON

3-Color Wire Dispenser

Remarkable new WD-30-TRI dispenser from OK Machine and Tool holds 3 colors of wire and features a built-in cutting and stripping mechanism. The refillable dispenser holds 50 feet each of red, white and blue insulated, silver-plated, solid copper wire. To operate the cut/strip mechanism, the wire is first drawn out to the desired length. Then a built-in plunger cuts the length free from the roll while a gentle pull through the stripping blade removes the insulation. Ideally suited for wire-wrapping, this unique dispenser is also handy for many other wiring jobs. WD-30-TRI is priced at $5.95, R-30-TRI 3-color refill is $3.95. Available from your local electronics distributor or O.K. Machine and Tool Corporation, 3455 Conner Street, Bronx, NY 10475.



CIRCLE 56 ON READER SERVICE COUPON

Universal Magnet

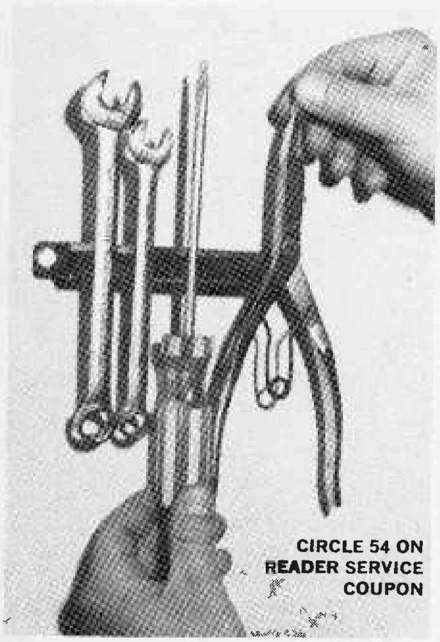
Magnets having many uses and super strength are now available to consumers. The Universal Magnet is designed for use as a retrieving magnet for boaters and fishermen or as a tool and knife holder for mechanics and housewives. Other

(Continued on page 8)

New Products

(Continued from page 6)

uses include removing nails from driveways or lawns, holding a trouble light or drop light in position, and holding parts for welding or repairs. The Universal Magnet is reported to have a lifting power of more than 125 pounds on a flat steel plate through air, much greater under water. It is guaranteed to never lose the powerful magnetic grasp. Six inches long and packed with power.

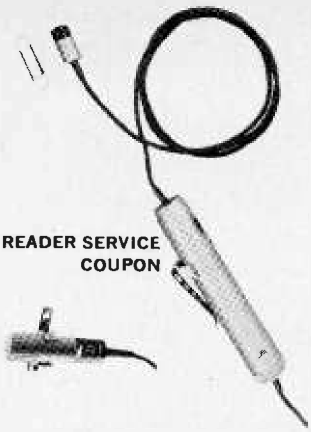


CIRCLE 54 ON READER SERVICE COUPON

The most common use of this magnet is for retrieving metal items containing iron, such as tools, fishing poles, cotter pins, motor parts, and tackle boxes, from deep water and holes. Another popular use is for holding a trouble light or drop light in position while working on cars, trucks or other machinery. Sells for $6.95 plus 75¢ for postage. Comes with eyebolt included from Ten Gam Corp., P.O. Box 156, Castle Rock, CO 80104.

Miniature Microphones

Audio-Technica is offering miniature microphones, made to be worn on the clothing when the situation demands faithful but unobtrusive sound pickup. The new microphones, designated the AT803S and AT805S, are electret condenser models with omnidirectional pickup patterns. Accessories furnished with each include windscreen, battery, protective carrying case, lavalier neck cord, belt clip and tie clasp for fastening the mic to a necktie or shirt lapel. The AT803S is just 0.4 inches (-0.2 mm) in diameter and 0.78 inches (19.8 mm) long. Specifications include a frequency response of 50-20,000 Hz; —57 decibels sensitivity; —151 decibels EIA sensitivity; and 600-ohm impedance. The maximum input sound level is 130 decibels, and the signal-to-noise ratio is greater than 50 decibels. Suggested resale price is $80. A bit larger, the AT805S is merely

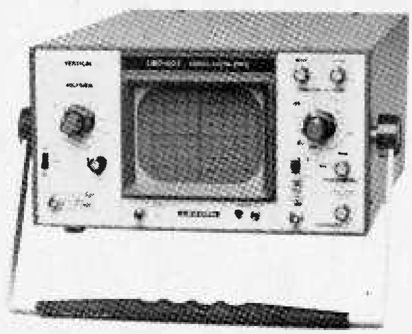


CIRCLE 57 ON READER SERVICE COUPON

0.59 inches (15 mm) in diameter and two inches (52 mm) long. Specifications include frequency response of 50-15,000 Hz; —57 decibels sensitivity; —151 decibels EIA sensitivity; and 600-ohm impedance. The maximum input sound level is 130 decibels, and the signal-to-noise ratio is greater than 50 decibels. Suggested resale price is $50. Get all the facts complete from Audio-Technica, 33 Shiawassee Avenue, Fairlawn, OH 44313 or call (313) 644-8600.

20 MHz Triggered Scope

The Leader LBO-507, a 20 MHz triggered scope is designed for broad use in industry, hobby, laboratory and service. The LBO-507 offers automatic triggered circuitry to assure maximum display stability with minimal adjustments as well as a trigger sensitivity over the entire operational range. It provides convenience of pushbutton switch selection for every functional demand; 10 mV/cm vertical sensitivity calibrated in 11 steps—in a 1-2-5 sequence up to 50 V/cm with variance control; and a 17.5 nanosecond rise time. Bandwidth is DC to 20 MHz. Sweep

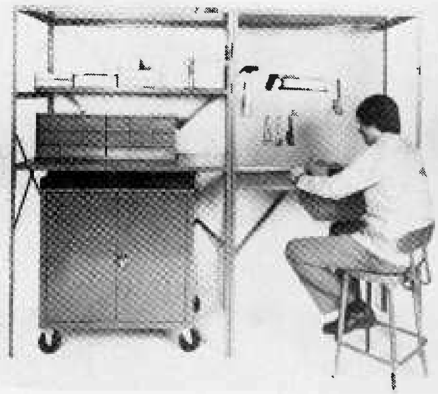


CIRCLE 64 ON READER SERVICE COUPON

speed for the LBO-507 is 0.5 uSec/cm, 18 steps in a 1-2-5 sequence up to 500 mS/cm with variable control. The LBO-complete with low capacitance probe and terminal adapter. Get the complete specs 507 is priced at less than $500 and is direct from Leader by writing to Leader Instruments Corp., 151 Dupont St., Plainview, NY 11803.

Mini-Shop

A new self-contained mini-shop that affords organization and easy access to tools is now available from Penco Products. Called "Shopcrafter," the mini-shop can be used by home craftsmen, servicemen, and do-it-yourselfers. The mini-shop is composed of two sections, one section includes a work bench with drawer and a peg board back for hanging tcols; another section includes standard accessories—rollable machine cabinet, drawer case with 18-drawer insert, work stool and an extra shelf. The two sections are attached side-by-side so that all tools can be stored easily within arms' reach. Machine cabinet and drawer case allow organization of tools

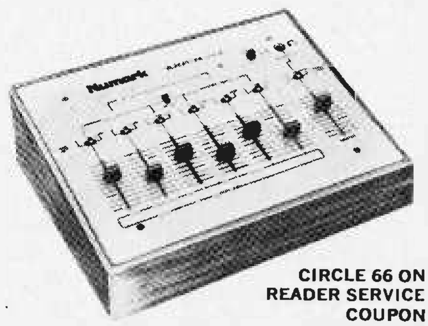


CIRCLE 73 ON READER SERVICE COUPON

and other equipment, to avoid time-consuming searches over the odd-sized tables, drawers and shelves that comprise most homeowners' tool storage facilities. The two work units are each 75-in. high, 48-in. across, and 24-in. deep. The shelves and workbenches can easily be adjusted vertically on 2-in. increments. The mini-shop lists for $413.00 with individual parts sold separately. Consult factory for price list. For further information, contact Penco Products, Inc., Oaks, PA 19456.

Six Mike Mixer

The Numark Microphone Mixer (Model MX3000) is a sound studio control unit capable of handling any high power amplifier without the use of an external preamplifier. It has six mike inputs; two line

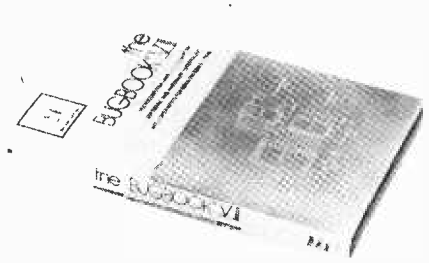


CIRCLE 66 ON READER SERVICE COUPON

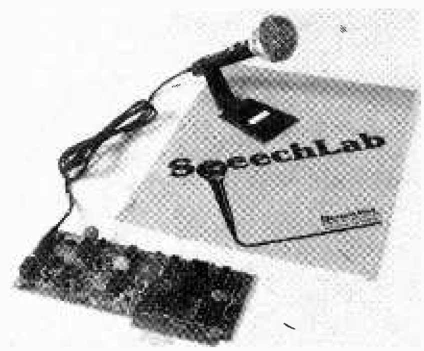
inputs for stereo; individual mike attenuator control switches. Stereo/Mono switches for outputs. Master volume control; Headphone monitor with level control switch. The MX3000 can handle mike inputs from 20 to 18,000 Hz with distortion levels of 0.1% or less and —52 dB hum and noise level. Headphone jack for monitoring unit's output. Powered by 117 VAC, 50/60 line. Sells for $149.95. For more details write to Numark Electronics Corp., 503 Raritan Center, Edison, NJ 08817. ■

COMPUTER NEW PRODUCTS

Here in one place ELECTRONICS HOBBYIST presents the latest in home and hobby computers and computer accessories.

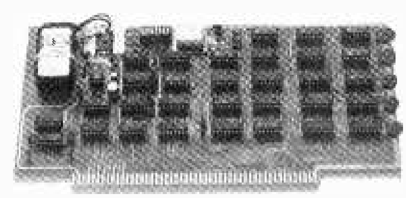


Interfacing Bugbook—An in-depth treatment of how 8080 family microcomputers are interfaced to real world analog devices for measurement, control, and display applications is contained in Bugbook VII, Microcomputer—Analog Converter Software and Hardware Interfacing from E&L Instruments. The 284-page, 6 x 9 inch soft cover volume is priced at $8.50. It combines practical examples of hardware and software analog converter interfacing techniques with a series of experiments in waveform generation, data acquisition, and CRT display control. Bugbook VII begins with microcomputer interfacing to D/A converters, then proceeds to software control of ramp, successive approximation, and dual slope A/D converters. The sample-and-hold amplifiers and analog multiplexers used in many practical data acquisition systems are treated in a full chapter. Consideration is given to factors in selecting and interfacing packaged A/D and D/A data acquisition modules. Nine experiments are configured for the E&L Instruments MMD-1®, an 8080A-based educational and development microcomputer. They include program controlled waveform generators, data acquisition and display systems, a precision voltage measuring system, and CRT display generators. Circle 53 on Reader Coupon.

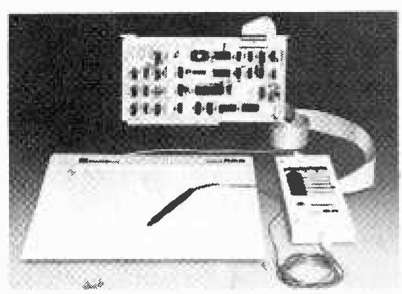


Apple 2 Voice Input—A new voice data input for the Apple II computer is available from Heuristics, a California speech research firm. Speechlab Model 20A is priced at $189, assembled and tested. Included in the price is a high-fidelity microphone and a user manual having six demonstration programs written in Apple Basic to illustrate the use and capabilities of the unit. The programs include Mastermind, Blackjack and Shooting Stars. The voice input complies with Apple II "smart" peripheral conventions and interfaces directly with user-written Basic programs as easily as with keyboard input. The program to run the unit is contained on an on-board PROM which is automatically enabled and executed by the Apple II monitor program when speech input is desired, allowing speech input to be easily incorporated into the user's present and future programs. Speechlab Model 20A features a 32-word vocabulary, fast real time response, and the capability of multiple training samples for high accuracy. An optional headset-mounted noise-cancelling close-speaking microphone for use in high-noise environments, or for applications requiring free use of both hands, is available for $85. Circle 58 on Reader Service

Computer Chess—Microchess 1.5, for use with the TRS-80 microcomputer, is offered by Micro-Ware Limited of Canada. Microchess is a 4K Z-80 machine language program utilizing every available byte of user RAM in the TRS-80. The program is designed to load using the CLOAD command. Standard algebraic notation describes the moves to the computer, and every move is verified for legality to prevent user error. A simple command allows temporary numbering of the squares to assist in move entry. The chess board is displayed using the graphics mode of the TRS-80. The moving pieces flash before they move to simulate the gradual narrowing of attention on the moving piece as found in human chess play. There are three separate levels of play to challenge all players from beginners to experienced players. Michochess 1.5 is an expanded version of Microchess 1.0 which has been available for the 8080 and 6502 microprocessors. Price: $19.95, postage prepaid. Circle 67 on Reader Coupon.



100,000 Day Clock—Expand your timekeeping capabilities with Mountain Hardware's new 100,000 Day Clock for S-100 computers. The clock is crystal controlled for accuracy and an on-board, 9-volt rechargeable battery keeps the clock ticking away during computer down times, intentional and otherwise. The versatile board keeps time in 100us increments for periods as long as 100,000 days—or 273 years. An interrupt feature can be programmed for any change in a clock digit to help make efficient use of computer time. The clock is easily set by entering BCD digits at each time port, and it stops the moment you enter the first digit and starts again on the first "read" command. A "write protect" switch prevents the clock from being accidentally stopped or changed. The clock can be used with most BASICs, and especially the company's Introl BASIC, to provide a powerful set of commands which makes it simple to set, compare, check, display and print time. Prices: $219 assembled and tested, and $179 in kit form. Circle 69 on Reader Service Coupon.



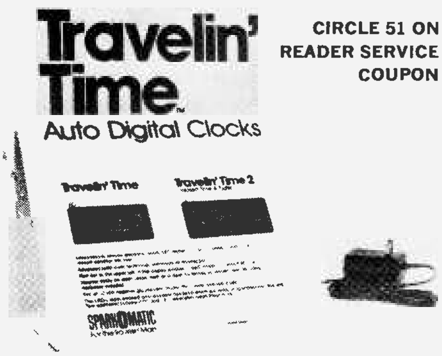
Low-Cost Bit Pad—Summagraphics has come out with a new version of its low-cost Bit Pad, a digitizer for small computer systems. The pad configuration is Intel Multibus™ compatible, and it can be plugged into the Multibus along with Single Board Computers (SBC), memory and I/O boards, peripherals and controllers. All electronics are located on one SBC card. Operational control and status indication is provided from a small, hand-held console. The system also includes an 11" x 11" Bit Pad tablet and a data input stylus. The basic Multibus Bit Pad configuration carries a retail price of $625. Circle 80 on Reader Service Coupon for more information. ■

CB NEW PRODUCTS

Electronics Hobbyist looks over some of the newest transceivers, antennas and accessories for you to use in CB contacts this year!

For Watch Watchers

Listening to Channel 9 one can hear frequent requests for the time. Your four wheleer can be customized to be equipped with Sparkomatic's Travelin' Time 2 (Model LED 2) auto digital clock with date and elapsed time

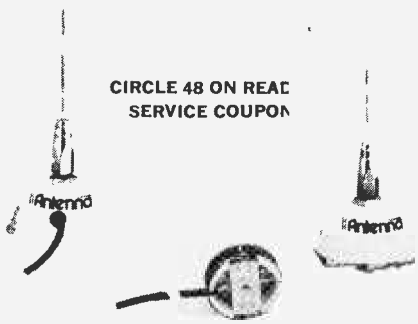


CIRCLE 51 ON READER SERVICE COUPON

indicator so that you'll not need to transmit to know what the time is, or how long you've been driving. Elapsed time ("E") and date ("D") replace time of day on LED display when their respective buttons are depressed. Time automatically returns to display after button is released and date or elapsed time readout is completed. Hour ("H") and minute ("M") buttons set the time. Unit is 3⅛-in. by 1-1/16-in. by 2⅝-in. (WHD) and is quartz operated for time accuracy. Unit sells for $30.00. Get all the facts on LED 2 and other Sparkomatic electronic auto products by writing to Sparkomatic Corp., Milford, PA 18337.

Low-Cost Coil-in-Cup Antennas

Two new Antenna Incorporated coil-in-cup antennas feature handwound, hand-tuned loading coils in the mounting cup. The two



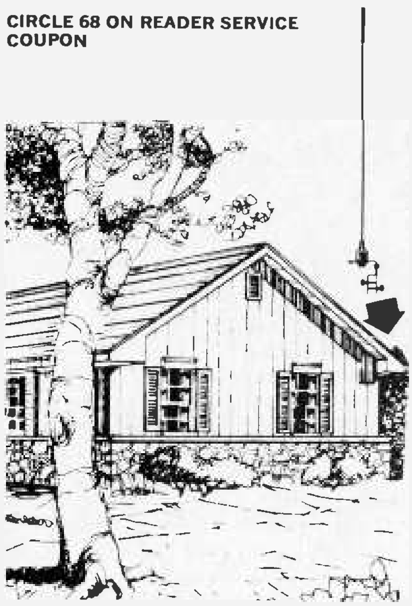
CIRCLE 48 ON READER SERVICE COUPON

antennas, the "Power Grip" magnetic mount antenna (Model 13504) holds at speeds up to 100 mph on metal roofs and up to 70 mph on vinyl roofs, and the "White Max" trunk mount antenna (Model 17604) is designed for quick and easy installation on the auto's rear deck lid or on the front hood of rear-engine vehicles. The prices are all right at $15.94 for the Model 13503 and $14.96 for the Model 17604. Both antennas feature high impact, plastic mounting cups with soft rubber gaskets to protect vehicle finish, impact resistant 34-in. stainless steel whips for maximum flexural strength, and RG-58/U coaxial cable with PL-259-type connector. For further information on the new coil-in-cup antennas, and the company's complete line of American-made antennas and accessories, write to Antenna Incorporated, 26301 Richmond Road, Cleveland, OH 44146.

Two-Minute Mount

GC Electronics has introduced a Gutter Mounting Base Station Antenna (18-3000) which can be easily installed in two minutes and requires only a medium-size screwdriver.

CIRCLE 68 ON READER SERVICE COUPON



Apartment dwellers, in particular, will appreciate the easy mounting features. The patent-pending gutter mount attaches securely to eave trough and gutters, with a simple twist of the thumb screw. The rain gutter itself acts as a ground plane. Thirty-feet of pre-assembled coax cable and complete, illustrated instructions are provided. The antenna is the popular GC "Readywhip" antenna, a 48-in. top-loaded, factory pre-tuned fiberglass model. Sells for $24.05. GC Electronics manufactures a complete selection of CB antennas, microphones, test meters and related CB accessories. For more information, write to GC Electronics, 400 South Wyman Street, Rockford, IL 60001.

Spare the Strap

Valor Enterprises have made bulky strap and chain bumper mount assemblies obsolete by creating the new Model 219 Strapless Bumper Mount. This simple but rugged mount fastens to the inside of any steel or aluminum bumper and is held in place by two ¼-in. stainless steel set screws. The

CIRCLE 62 ON READER SERVICE COUPON

Model 219 can handle any ⅜-in.-24 threaded base CB antenna up to 8-ft. long which makes it ideal for cars, trucks and recreational vehicles of all types. It is constructed of corrosion resistant, heavy chrome plated steel, and comes complete with Valor's patented "Wafer" termination system. Sells for $8.00. For more information on the 219 Strapless Bumper Mount or any Valor communication product, write to Valor Enterprises, Inc., 185 West Hamilton Street, West Milton, OH 45383.

Wattmeter for Everyone

The Transel Wattmeter IIA for CB test application offers a headphone output for modulation monitoring of CB transmissions. All three power ranges (20, 200 and 2000) appear on a single meter scale. Frequency range is 3.5 to 30 MHz, and accuracy ±5% of full scale. Amateur and commercial radios can be tested. Sloping cabinet has cover with rugged black crackle finish and recessed light gray front panel. The back is open to allow removal of R.F. connector box

CIRCLE 77 ON READER SERVICE COUPON

for remote reading of wattmeter. Mark IIA is sold through electronics distributors. Suggested retail is $79.95. Get all the facts direct from Transel Corp., 2898 N. Catherwood, Indianapolis, IN 46219. ■

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
BUDGET ELECTRONICS
380 Lexington Avenue
New York, N.Y. 10017

Color Blind

What is the difference between black-and-white and color TV antennas?

—*J.K., Panorama City, CA*

Either antenna cannot tell the difference between the black-and-white or color TV signals they receive, so either work equally as well if designed alike. The truth is that TV antenna manufacturers discovered the "color" TV antenna when they wanted an excuse to hike prices. Pay for only expected results and not for fancy labels.

Surplus Coax

Can I use ordinary coax cable as a long wire antenna?

—*D.J., Milford, Utah*

Sure you can, but use your head! RG-58/U and RG-59/U coax can be strung for 20 to 40 feet with no problem except for icy conditions. Be sure to connect the outside braid to the inner conductor. Remember, the weight of the coax will cause stretching, hence sagging. For longer runs go the traditional way.

Direct is Best

What are these new direct LPs that play at 45 RPM? The reason I ask is that they sound so much better than ordinary LPs.

—*S.T., Butte, MT*

Direct-to-disc recordings are actually live recordings from the entertainer through an electronic amplifier system direct to the recording disc. There is no time delay or tape used. What you hear, is what you get. Results are better than using a tape system to record the performance and then later cutting a disc. The hokus-pokus of compression-expansion, noise reduction circuits, limited headroom, etc., no longer add restrictions to the recording process. Unfortunately, should a performer blow a note, the entire performance must be redone from scratch. Some of those funky singers of today will be wiped out.

Turn It Off

Your "Telephone Trigger" construction project in the March/April 1978 issue of Elementary Electronics *is great. I get the coffee pot going by turning on the hotplate before I leave for work. My question is, how do I turn it off? The coffee is over-perked before I get to work.*

—*D.M., Alamosa, CO*

The editors use a new automatic drip coffee pot as the article's first photo shows. You must be using an old perk-type that keeps boiling until dry. I suggest you either switch over to the new type or use a timer that turns the hotplate off after a short use.

Maybe the Muffler

I used a bumper-mount with a half-wave stainless steel whip for the first time and the results were terrific—when the motor was off. With the motor on, I hear engine noises. This never happened when I used a trunk-mounted coil-loaded antenna! Why?

—*J.S., Canby, OR*

An automobile engine is a source of radio noise! The noise is radiated by the rods and pipes connected to the engine block, and the exhaust pipe is normally electrically insulated at the bumper end by a flexible hanger and thus becomes an ideal "antenna" for noise radiation. If the antenna is mounted directly above the exhaust pipe you have force fed a high level of static into the transceiver. One cure is to by-pass the exhaust hanger with electrically conducting braid to ground the end of the exhaust system. Also make sure that the bumper itself has a good ground.

Gain is Getting

I've been into shortwave listening a little over a year. At the present I'm using a Realistic DX-160 and two longwire antennas, one is 75-ft. and the other 240-ft. I also have an antenna switch. With the present antenna I pick up a station at maybe 5/S9 on the meter (on the 75-ft. antenna) and then when I switch to the 240-ft antenna, the signal is 10 or 15/S9. Does this mean the longer antenna has gain?

—*G.H., Ft. Smith, Ark.*

Yes, when you compare one antenna array to another in signal gathering ability, one would pull more signal than another exhibiting something we call gain. I suggest you try the RAK Listener 3 double dipole antenna. The results are surprising.

So Sorry

Hank, I love you. Can we get married? Enclosed is a stamped, self-addressed envelope.

—*Ms T.W., Columbia, SC*

I sure would like to answer your letter, but the rules are simple. Ol' Hank does not reply directly by mail even when an envelope is supplied. Next time I'm in Columbia, I'll wear a pink carnation in my lapel. Watch for me!!

What the Hertz?

How can I use a frequency counter to indicate the frequency of the signal I am tuned to on my shortwave receiver?

—*W.B., Minneapolis, MN*

First, determine the frequency of your IF stages. Pass a CW signal through it and zero beat to a null on the audio. You'll find that it's almost 455 KHz or whatever. Next, couple the signal from the local oscillator via a gimmick capacitor to the connector and tune to a station. Zero beat the station to a null with the BFO on and read the frequency counter. Subtract the IF reading made earlier, and that is the frequency to which your receiver is tuned. I suspect it would be easy to develop an offset circuit that would subtract the IF amount internally so that the counter would be indicating the frequency of the received signal.

Scanner Fan

I'm an active scanner listener and I'd like you to know about one of my favorite dispatchers who is a dispatcher operating out of Police Headquarters in downtown Chicago. The frequency is 460.225 MHz, Zone 3, Districts 13 and 14. The sergeant usually works weeknights and he tries to make long evenings go a little faster; at times he can be serious or be filled with humor. One night there was a break in the action so he humorously commented on what the radio officers would say. I remember that an officer called in for a canine unit, so the sergeant replied, "O.K., we'll send in the puppy dogs to help you out." The next minute he was serious. The sergeant received an urgent call saying an officer was in trouble. One could hear the tension in his voice. Listening to this type of action makes my Pro-2001 scanner more exciting.

—*S.L., Clarendon Hills, IL*

Okay, that's a good report. I'd like to hear from other scanner listeners about their favorite stations.

Traveling Radio

Can I take my Patrolman 3 AM/VHF/UHF portable radio in the aircraft when I go to Fort Worth, Texas?

—*M.B., Phoenix, AZ*

Yes, If you pack it in the luggage. Air lines forbid the use of radio and electronic devices on aircraft. They have the Federal Marshals backing them up, so forget it. However, you can use the receiver in the terminal and gate areas.

Frequency Asked

What frequency is used to determine the impedance of AC devices such as speakers, and audio and RF impedance matching transformers?

—*M.H., Colorado City, AZ*

The frequency used is the frequency they're intended to be used at. You wouldn't use an audio signal to check out IF transformers. Audio devices are usually averaged over the human voice range 300 to 3000 Hz.

Lightning Struck

Last night there was a thunderstorm in my area. During the storm I was fooling around with antenna wires, hooking them up various ways, when a bolt of lightning hit the ground nearby. A strange thing happened—my VHF-HI police monitor was tuned to 154.83 MHz. For a few seconds

ASK HANK, HE KNOWS

(Continued from preceding page)

the radio pulled in a strong shortwave signal, (I know it was shortwave because it was a time signal) and then it faded out. I left the wire hooked up and it happened a couple more times. After the storm, I checked the radio and it was undamaged. Could you explain what happened?
—D.L., Ellington, CT

Yes, you were trying to kill yourself! Aside from that, I really don't know. Can any of our readers help out?

Screw Blues

I would like to buy an electronic siren, but everything I hear is not loud enough. Do you know where I can get one rated for 2 to 4 watts output?
—J.S., West Palm Beach, FL

Ramsey Electronics, Box 4072L, Rochester, NY 14610 (telephone: 716/271-6487) sells a siren kit rated at five watts to drive an 8-45 ohm loudspeaker. Cost is only $2.95. Circuit works on 3 to 9 VDC. Give it a try.

Racing With the Amp

I see a lot of raceways in buildings that add wiring on the internal wall. Is this a good practice?
—A.M., Silver Springs, MD

You bet it is! It may not look good in your living room, but in the office, garage, shop, and maybe the kitchen, it's alright. The raceway is a metal conduit that is secured to the wall. It is an inexpensive way to add outlets without breaking up walls and floors. Raceways can also be used to cheaply interconnect air conditioners to the main fuse panel.

One Score and Four Years Ago

Hank, what happened to the good old days? My old Dual turntable bit the dust after 12 years of faithful service, and while looking for a new one I must have seen over 100 different models. How can a guy chose?
—L.S., Elmwood Park, NJ

My dad had a 1927 Ford that lasted up until World War II, when he sold it because he couldn't get gas. You know what he bought after the war? That's right, a Ford. Once you like a brand, and its products are still very competitive and high in quality, why gamble and change.

Meters Lie

On my hi-fi receiver, when tuning FM, the signal strength is not at maximum position when the tuning indicator is centered. For maximum signal, the tuning indicator is about 1/32-in. to the left of zero. What should I do?
—W.D., Chatsworth, CA

You didn't say a thing about how the unit sounds! Tune for minimum distortion. I think you'll discover this occurs when the tuning meter is centered. If the sound is poor, then alignment is necessary. I know this should not happen, but it is fairly common.

Blinky Bow Tie

Hank, can the editors run a short story on how to wire up a bow tie to blink neon lamps? If they do, please have them give complete parts list and where to buy. Thanks.
—H. A. Chatsworth, CA

Neon lamps are out and LEDs are in. I suggest you obtain the "LED Blinky Kit" from Ramsey Electronics, Box 4072L, Rochester, NY 14610. You can phone in the order: (716) 271-6487. Two jumbo LEDs are used in the kit and comes complete less batteries and bow tie.

Looking for Help

Schematic diagrams and service information on specific radio and TV sets are available at a nominal charge. Supreme Publications is offering to mail promptly service material on almost any television, radio, or stereo. It is able to supply such information from its own service manuals, from its extensive files of factory data going back to the 1920's, and from manuals of other publishers. The charge is $1.50 and up, and the usual charge is $2.50.

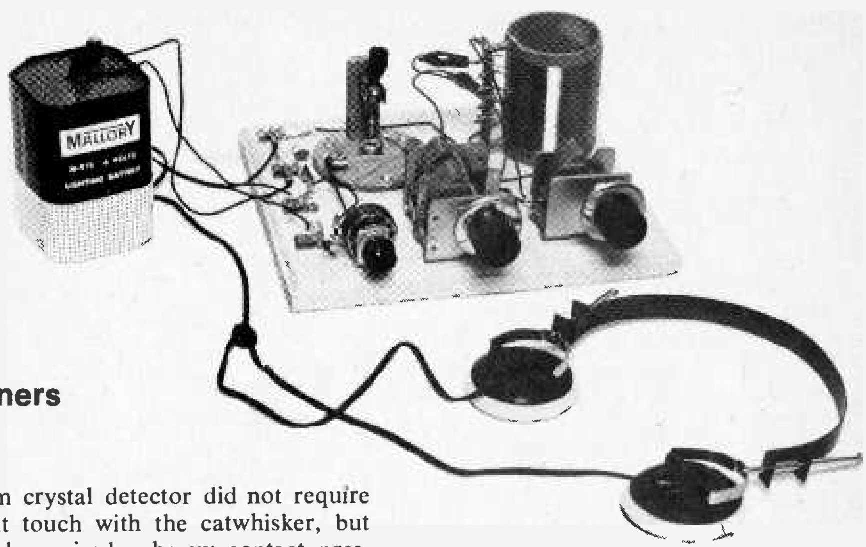
Lend A Hand

Here's our list guys—hope you will be able to assist! If anyone out there needs help, write to me, Hank Scott, and I'll try to do my best to give you coverage. Keep your question limited to one item (or piece of equipment).

Δ Sylvania TV Lab Scope type 404, service manual and/or schematic diagram urgently needed; Clyde N. Smith, 11 Brown Street, Reynoldsville, PA 15851.

Δ Decca Model TT-33 AM/LW battery operated receiver, schematic diagram needed; Bruce L. Werner, 206508 Ross Parkway, Big Rapids, MI 49307. ■

GRANDPA'S WHISKER



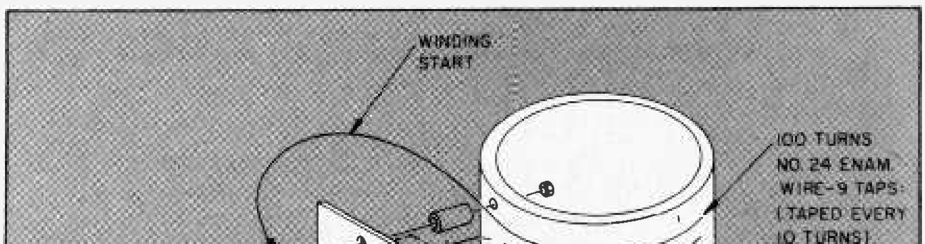
Build a carborundum detector from the days of the not-so-ancient mariners

by Charles Green

IN THE BEGINNING OF this century, when radio was still called "wireless," the crystal set was used by most of the early radio pioneers. The simple "catwhisker" touching a piece of galena or silicon crystal, and a coil wound on an oatmeal box, formed a primitive yet effective radio receiver that stayed popular for many years. Even the later development of the vacuum tube could not entirely bury the crystal set; it still remained popular as a first set for many radio experimenters who later went on to more complicated electronic developments. Even today, the simple crystal set is still being built using modern germanium or silicon diodes in place of the moveable catwhisker and crystal.

Back in the old days, the popular galena and silicon crystals had a rival for the more specialized ship-to-shore communication work. It was the carborundum crystal detector. The carborundum crystal detector did not require a light touch with the catwhisker, but instead required a heavy contact pressure. This heavy catwhisker pressure was more suitable for the early radio stations on ships. The lesser sensitivity of the carborundum detector was compensated by the crystal's ability to take stronger radio signal energy (such as leakage from nearby spark transmitters) without burning out, then the galena and silicon crystals could. What is *really* different about the carborundum detector, is the requirement for a bias battery. This bias battery is normally not used with galena and silicon crystals.

You can experiment with the carborundum detector by building our *Grandpa's Whisker*, which is patterned after the early crystal sets. The receiver uses a tapped coil and two variable capacitors (one capacitor tunes the antenna) to allow coverage of the entire broadcast band and for maximum signal coupling to the detector. A separate assembly is provided for the carborundum detector and a control is mounted for convenient adjustment of bias battery voltage for maximum detector sensitivity. The receiver is built "breadboard style" on a 8½-inch by 7¼-inch by ¾-inch wood base which is similar to the style of construction used by early radio experimenters.



The tuning coil is wound on a cardboard mailing tube section for 100 turns of #24 enameled wire, tapped every ten turns. The taps should be stripped bare with sandppaer before soldering to the clips which are mounted on a section of perfboard. See the text.

The Receiver Circuit. Signals from the antenna are fed through J1 and coupled through C1A-C1B to the parallel tuned circuit of L1-C2. C1A-C1B is in a series tuned circuit with L1, and serves to tune the antenna for maximum RF current flow. The resultant tuned signals are detected by D1 and the audio is fed through the R1 bypass C3 to J5-J6 and external headphones. R1 adjusts the D1 bias voltage from B1 and C4 is the RF bypass for the headphones.

Carborundum. Not a natural mineral like galena or silicon, carborundum is the name given to a compound of silicon carbide by its American inventor Edward Goodrich Acheson (a former assistant of Thomas Edison), Acheson was experimenting with a primitive electric furnace in 1891, when he fused a mixture of clay and powdered carbon. He found that the resultant crystals would cut glass similarly to a diamond (silicon carbide is next to a diamond in hardness), and he called his discovery Carborundum; thinking it was a substance composed of carbon and corundum (a crystalized form of alumina). Scientific analysis later showed it to be silicon carbide, but the designation Carborundum was kept as a trade name. Industrial usage of carborundum is primarily grinding compounds and grinding wheels.

Its use as a detector was discovered by experimenters around the beginning

WHISKER

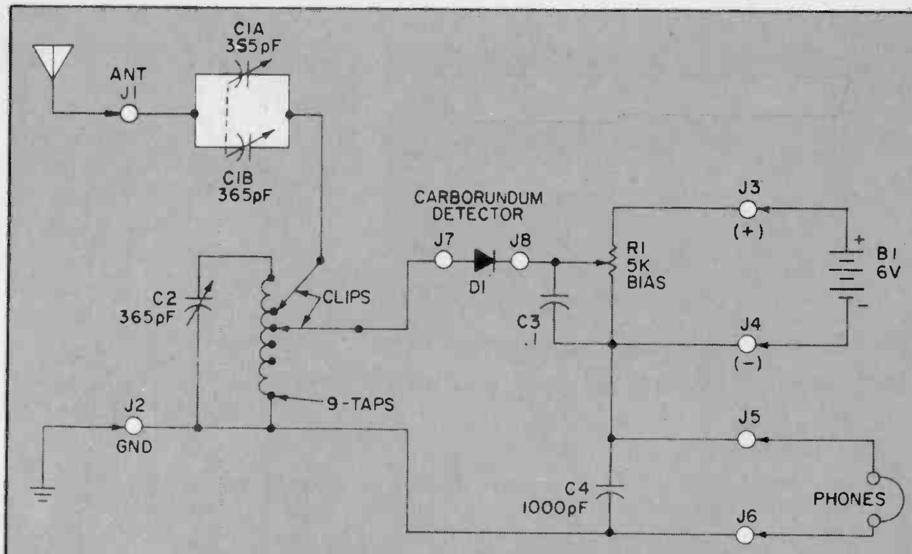
of this century who tried various minerals and substances in their search for better types of radio wave detectors; much as Edison tested many materials in his search for the proper material for his incandescent lamp filament.

A crystal diode has a high current flow with voltage applied so that it conducts in the forward direction (catwhisker to crystal), and a very low current flow in the reverse direction. The amount of current flow in the forward direction depends upon the characteristics of the crystal material and the applied forward voltage. As shown in the Crystal Forward Conduction Curves graph, Germanium minimum voltage is approximately 0.3 V, Silicon is 0.6 V, and Carborundum is 3 V. (The high Carborundum voltage is the reason why a bias battery is necessary to move the threshold down so that the weak RF signal voltages can be detected.)

Tuning Coil (L1) Construction. Look at the drawing of the L1 construction details. The tuning coil is wound on a cardboard mailing tube section 2-inches in diameter and 2¾-inches long. Start winding approximately ¼-inch from the form edge with #24 enameled copper wire. Punch a small hole to feed the wire into the cardboard before you start winding, then wrap the wire around the edge of the form to hold it in place while winding; or, a section of plastic tape can be used to keep the wire from moving.

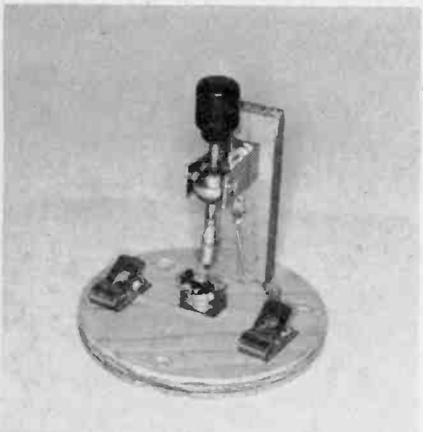
As shown in the drawing, the tuning coil is wound with 100 turns and is tapped every 10 turns. An easy way to make the taps is to twist the wire together for a half-inch and position the free end out. Then, when all of the taps have been made, used sandpaper to take the enamel off the tap-wire ends. At the end of the winding, punch another hole in the coil form and after cutting a three inch lead, thread the free end of the coil wire through the hole and wrap it one turn around the coil form edge (or tape it in place).

Mount 9 push-in clips in a ½-inch by 2¼-inch perf board section and mount it on the coil form with machine screws and nuts and two ½-inch long spacers (as shown in the drawing). Then solder the coil taps to the push-in clubs. Connect the coil start and end wire leads to solder lugs mounted on the perf-board screws. Punch two holes

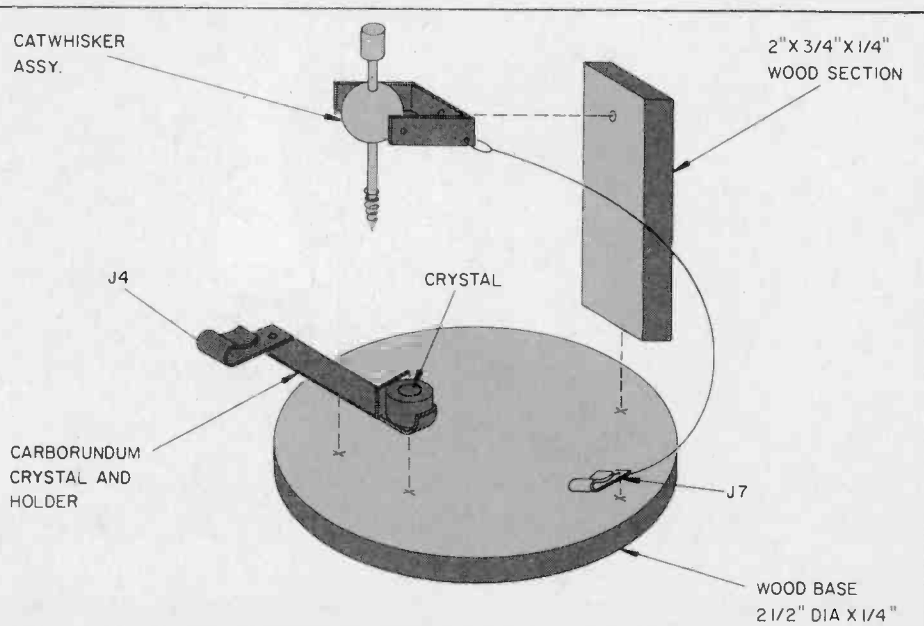


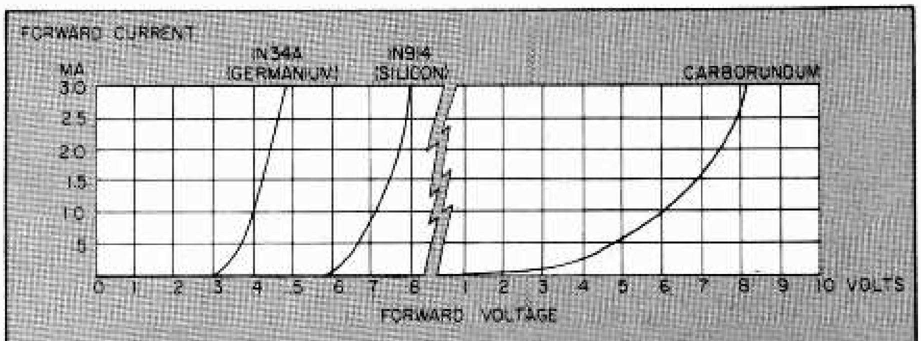
PARTS LIST FOR GRANDPA'S WHISKER

B1—6 V battery
C1A-C1B—Dual 365-pF tuning capacitor (dual gang)
C2—365-pF tuning capacitor (single gang)
C3—0.1-uF capacitor
C4—1000-pF capacitor
D1—Carborundum Crystal (Modern Radio Labs, P.O. Box 1477, Garden Grove, CA 92642), and Crystal Detector Assembly (Philmore #7003 open type detector, or equiv.)
J1-J8—Fahnestock Clips
L1—See drawing and text
R1—5,000-ohm potentiometer. (linear taper)
MISC: 2000-ohm earphones, 2¾-in. x 2-in. dia. coil form, clips, #24 enam. wire, ½-in. long spacers, perfboard strip, push-in clips, solder lugs, mtg. brackets, wood sections for detector assembly, knobs, 8½-in. x 7¼-in. x ¾-in. wood base, hook-up wire, wood screws, headphones (2000-ohms), and a 1N34A germanium diode (or equiv.) for initial adjustment of the receiver.



Most of the crystal detector assemblies you can turn up will be of the horizontal type. You will need a heavier pressure for the carborundum crystal, so convert the assemblage to a vertical format. None of the dimensions shown are all that critical.





As you can see, the minimum forward voltage for carborundum to forward conduct is very nearly ten times that for germanium. This is the reason that our Grandpa's Whisker requires a bias battery. Moving the threshold down allows weak RF signals to be detected.

on opposite sides of the base of the coil form, mount two brackets, and the tuning coil is completed.

Detector Assembly Construction. Most of the crystal detector assemblies available nowadays are of a horizontal type; designed for fine adjustment of a galena crystal. The carborundum crystal requires a heavier catwhisker pressure than the galena crystal, so the detector assembly (as shown in the drawing) is constructed in a vertical configuration.

Begin construction by cutting a 2-inch x ¾-inch x ¼-inch wood section, and then gluing or using wood screws to fasten it to a 2½-inch diameter x ¼-inch high wood base. This wood base is readily available from art, or hobby, supply stores that stock wood plaques. Or, a suitable base can be cut out of a section of plywood. The dimensions of the detector assembly are not critical and should be modified as necessary to fit your particular crystal mount and catwhisker configuration. If necessary, the rivets holding the catwhisker mount to a metal strip can be drilled or ground out, and then reassembled with a solder lug as shown in the drawing.

Mount the crystal holder on the base of the detector as shown in the drawing and photos, and then mount the catwhisker assembly on the vertical section with small wood screws, or machine screws and nuts. Make sure that the crystal holder screws do not protrude below the base bottom. Connect a lead between a solder lug on the catwhisker assembly and a terminal clip mounted on the base. If the crystal cup does not have an attached metal strip and terminal clip as in our model, it will be necessary to mount a solder lug with the cup and connect a lead to a terminal clip mounted on the base.

Receiver Construction. Most of the receiver components are mounted on a 8½-in. x 7¼-in. x ¾-in. wood base. The base dimensions are not critical and any size wood base can be used that will be large enough to mount the components as shown in the photos. The model wood base shown was obtained from an art supply store and was originally intended for use as a wood plaque. Small wood screws were used to hold most of the components on the base, except the variable capacitors C1A-C1B and C2 are mounted with machine screws in countersunk holes drilled through the base bottom. If the particular capacitors in your model do not have tapped bottom holes, metal brackets must be fabricated to fit either front or back capacitor mounting holes. The Bias Adjustment Control R1 is also mounted on the wood base with a metal bracket.

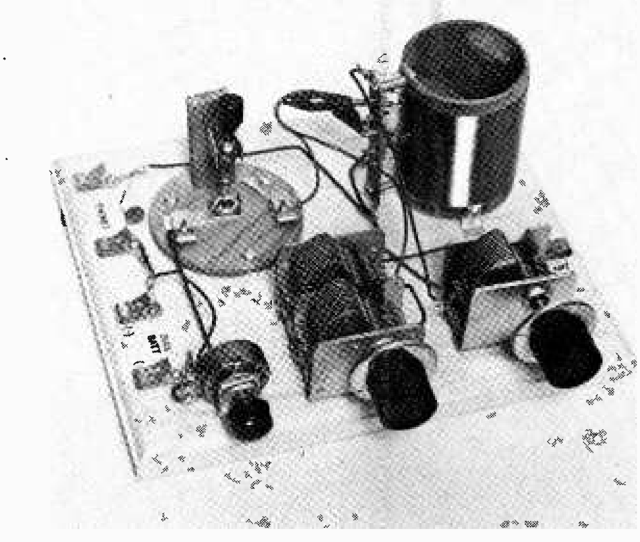
Begin construction by locating the component mounting holes on the wood base, and then mounting the parts as shown in the photos. Install solder lugs on all of the terminals J1 to J6 and also on the metal frames (rotors) of the variable capacitors C1A-C1B and C2. Install the detector assembly with three wood screws to the wood base and then install L1 positioned as shown in the photos (with the taps facing the detector assembly).

Wire the components as shown in the schematic diagram and position the wiring for short, direct connections. Install a clip on the lead to C1A-C1B and also on a lead to J7 of the Detector Assembly (the connection to the catwhisker). These clips will be connected to the coil taps during operation of the receiver. Install knobs on the variable capacitors and also on the Bias Adjustment Control, then mark the terminals with rub-on lettering or with small slips of typed, paper designations cemented on to the board.

Operation. All types of crystal set receivers require a good, outside antenna and a good ground for best results. If you are located near a high-power radio station, an inside antenna and a waterpipe ground will probably work. For distant stations, an outside antenna, 50 to 100 feet long will be necessary. Check the mail order houses for supplies and antenna kits.

The taps on L1 are provided to compensate for antenna loading as well as for the loading effect of the carborundum detector. The position of the clip leads on the coil taps must be determined by experiment as they will vary according to the length (loading) of your antenna and the frequency of the radio station being received. Inasmuch as the carborundum detector also requires adjustment (both in determining a sensitive crystal point and in the proper bias voltage adjustment), a saving in initial L1 tap set-up time can be achieved with the use of a fixed crystal diode (1N34A, or equivalent germanium type).

(Continued on page 117)



Grandpa's Whisker is a nostalgic look back at the days when a ship's radio lifeline to shore was dependent on no more than a coil, a battery, a catwhisker, and carborundum.

SOME BIG CHANGES are on the way for the SWL, especially in the upper shortwave bands from the 25-meter band on up to 30 MHz and beyond. The Sun is now entering one of its periods of increased sunspot activity after a 20-year period of relative calm. This will make short range communications unreliable and long range DX an everyday affair. Signals from stations just down the road will be, literally, lost in outer space, and wishy washy signals from outer nowhere will come booming

SHORTWAVE SUPERCHARGER

Turn your old SW clunker into a high-band hot-rod.

by Cass Lewart

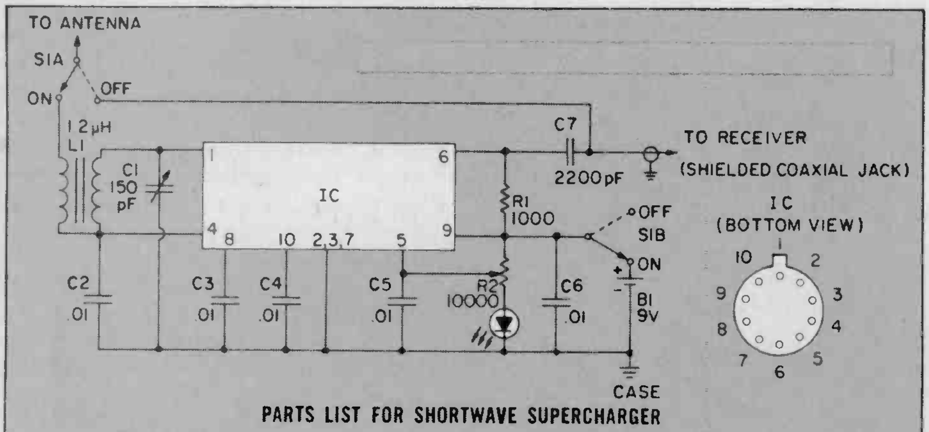
into your listening post like they were right next door.

Under these conditions many old and some not-so-old shortwave receivers will need a bit of help when they try to work the high bands. Their circuits tend to get a little frazzled. As a matter of fact, almost any SWL would appreciate a bit of a signal boost now and then. It might just make the difference between a very good DX catch and a record breaking DX discovery.

If you decide you want a DX boost or you need to increase the versatility of your old set then you should build this Shortwave Supercharger.

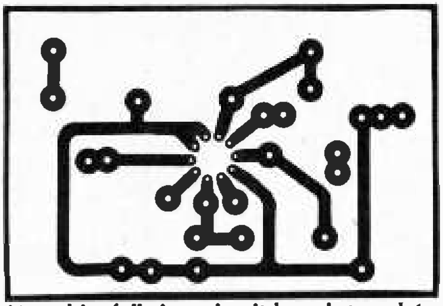
This unit will boost selectively the RF signal by 20-30 dB and it will compensate for many deficiencies of your set. It will not only improve the gain of the shortwave receiver but will also improve its selectivity and the image frequency rejection. Simple, single conversion superhet SW sets have the annoying tendency of receiving spurious signals separated by twice the IF frequency from the desired signal. For example if you tune to 20 MHz you may also receive 20 + (2 × 0.455) = 20.910 MHz (image frequency) signal which will interfere with the 20 MHz signal. In addition you will be able to pull in many SW stations you didn't even know existed. With 10- to 15-feet of wire behind your sofa as an antenna you may receive stations as distant as Australia or mainland China.

How does it work. The circuit is based on an inexpensive integrated circuit manufactured by Motorola and its HEP subsidiary. Its innards consist of three transistors, a diode and four resistors which together form an excellent automatic gain controlled (AGC) radio frequency amplifier. To build the circuit with separate discrete components would cost a bundle and the result would not be as good. The incoming RF signal is coupled with a few turns of wire to the coil L1. The tuned parallel-resonant circuit consisting of L1 and C1 selects the wanted signal by rejecting adjacent frequencies and feeds the sig-

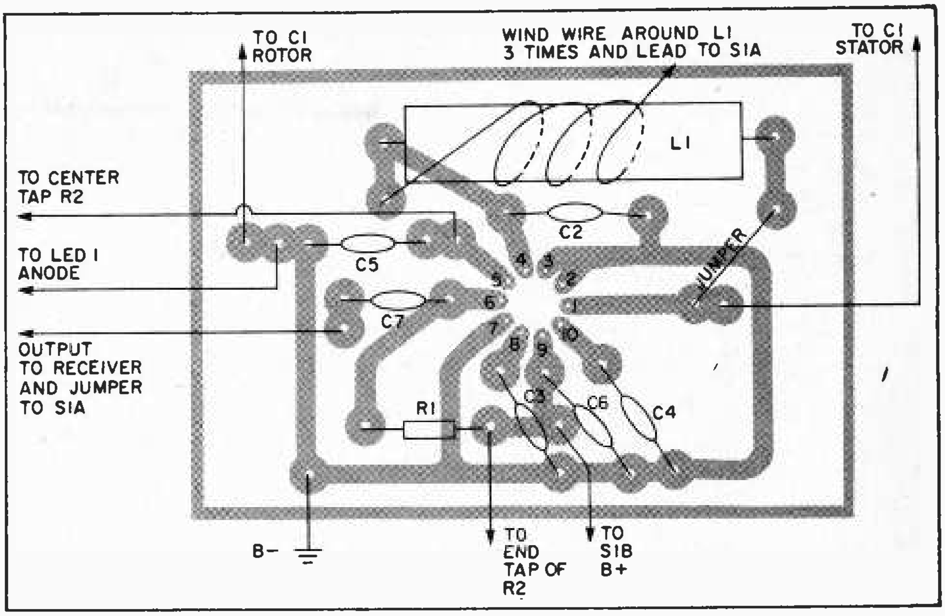


PARTS LIST FOR SHORTWAVE SUPERCHARGER

B1—9V transistor radio battery
C1—150-pF variable capacitor
C2, C3, C4, C5, C6—0.01 uF capacitor
C7—2200-pF capacitor
R1—1000-ohm ¼-watt resistor
R2—10,000-ohm variable resistor
IC—Motorola MC1550, HEP 590 or HEP C6091
LED—Red LED indicator
L1—Miller 4502, 1.1-1.5-microhenry coil (for winding your own, see text), for antenna connection use 3 turns of wire wound tightly around the coil.
S1—DPDT switch
Misc.—case, knobs, jacks for shielded cable



Use this full-size circuit-board template to build your Shortwave Supercharger. You can find etching materials at a radio shop.



This part's location overlay is twice the actual size in order to make the positioning clearer. If you use a loop different than specified in the parts list you may want to modify the appropriate spacing on the printed circuit board. Don't forget to wrap the L1-to-antenna wire around the loop stick three times. You might install an integrated circuit socket on the printed circuit board to simplify installation and repair.

nal to pin 1 of the integrated circuit. The amplified signal leaves the IC on pin 6. The AGC input on pin 5 is used to control the gain of the amplifier when you turn potentiometer R2. The light emitting diode indicates that the circuit is on and that the battery is still alive. The DPDT switch S1 selects between straight-through connection, booster off and booster on.

Construction. This is a radio frequency project which requires a neat soldering job and short connections. However, if you do a half-decent job the supercharger should fulfill your expectations. The author used point-to-point wiring on a perf board. If you have some experience with PC boards you might use the layout shown here. The Supercharger with the indicated component values will cover approximately 10-30 MHz. Using different values for L1 or C1 will change this range, though the ratio of minimum to maximum frequency will remain 1:3. Doubling the capacitor *or* inductance value lowers the frequency by 1.41 and lowering either value increases the frequency by the same factor. If you want to substitute some parts, or wind your own coil or use a different capacitor, the circuit is quite flexible in this respect. For example you may want to replace the 150 pF capacitor C1 used by the author since this is often difficult to find. Use instead the oscillator half of the standard AM tuning capacitor from any pocket transistor radio. Instead of the coil mentioned in the parts list you might try to wind 15-20 turns of insulated copper wire on a pencil.

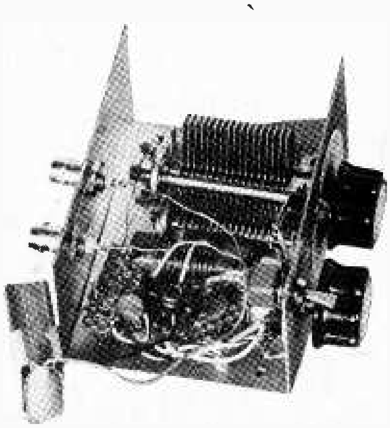
Mount the Shortwave Supercharger inside a metal case which you can find in most electronic supply stores. Use shielded cable between the supercharger and your receiver otherwise the connecting wire will behave like an antenna and some of the features of your supercharger will be lost. The final job is to make a dial. You can calibrate it with your shortwave receiver by tuning C1 to optimum reception.

If you find that the circuit "whistles" at certain frequencies (this may easily happen if you do not use a PC board or your connections are too long), the simplest cure is to thread a few small ferrite cores through pins 1 and 4 of the IC. Such cores can be purchased from many electronic surplus dealers.

Operation. Tune your receiver to the desired frequency and then tune C1 till you can hear maximum signal or noise, if no station is present. Returning your receiver with the fine tuning knob should require no readjustment of the supercharger. You can use R2 as your volume control or leave it in some intermediate position and use the volume control of the receiver. For strong signals you may want to turn R2 back to prevent overloading the receiver with the corresponding increase in the background noise.

Once you get it working, start digging deeper into the higher shortwave frequencies. There is a lot going on out there and with the increased sunspot activity and a Shortwave Supercharger you can't go wrong. ■

The author's prototype, shown here, used perfboard and point-to-point construction. You may build your Shortwave Supercharger using this technique or by making a printed circuit board and soldering on all the parts. The author added a small LED power indicator to prevent dead batteries if left on.



CUSTOM SWITCHES ...THAT YOU COULDN'T AFFORD TO BUY.

By Jorma Hyypia

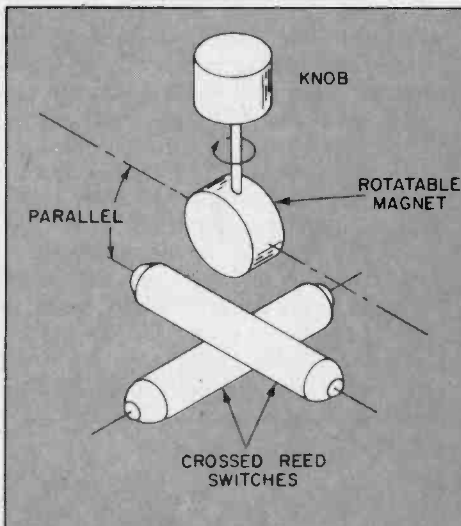
HOW OFTEN HAVE YOU searched fruitlessly for a special switch? Probably dozens of times—if you're at all an active builder. The next time this happens, consider custom-building your own complex switches using inexpensive magnetic reed switches and small ceramic magnets. Such do-it-yourself switches offer several advantages. They are relatively inexpensive, silent, and long lasting, as there are no rubbing contacts and the reed contacts are sealed in glass, away from corrosive atmospheric gases.

You can purchase two sizes of magnetic reed switches and the ceramic magnets from Radio Shack. The larger switch (Cat. No. 275-034; 1¾" overall length) comes in a 4-for-79¢ blister package. The smaller "Micro Mini" switch (275-035; 1⅛" long) comes 10 to a package, for $2.99. The magnets cost 10 cents each, regardless of size. The smallest, ½" diam. disc ("button") magnet is the most useful, but you may need the larger 1⅛" disc or 1" x ¾" rectangular magnets to build really large, complex switches.

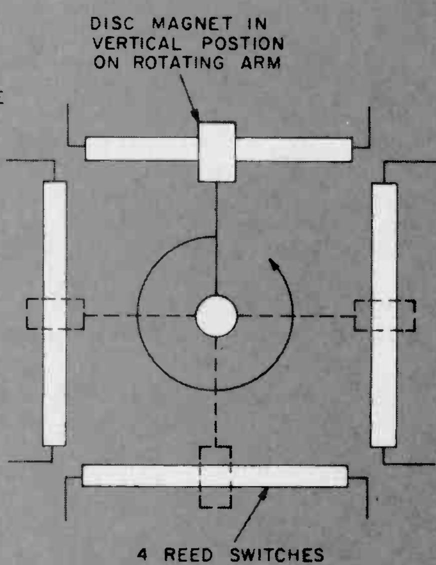
The several custom-built switches shown in this article only hint at the virtually limitless design combinations that are possible. Study the drawings to learn how magnet orientation and direction of travel past the reed switches affect switching action.

Carpetak Tape, a cloth tape with adhesive on both sides that is used to hold down carpets, is excellent for mounting the reed switches to panels. The switches adhere firmly, yet can be removed without damage. For greater permanence, you may wish to use epoxy cement for mounting once you know exactly where to locate the reed switches. Generally, it is best to locate the magnet and reed switches on the same side of the panel; however, it is also possible to put the switches on one side of a non-magnetic panel and orient the magnet on the other side. The ceramic magnets are of extremely hard material, and you may have poor success if you try to hacksaw them smaller. Try breaking the magnet by clamping in a vise and striking with a chisel; it may not break cleanly across, but grinding on an emery wheel may be practical. When possible, just use the magnets as they are. Mount them in aluminum holders as shown here, or glue to support arms with epoxy adhesive.

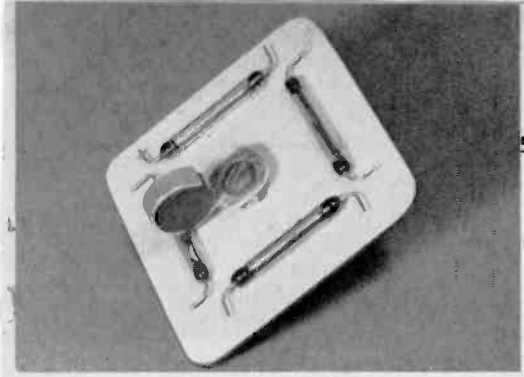
The following brief descriptions of various switch types should help clarify the principles of building switches.



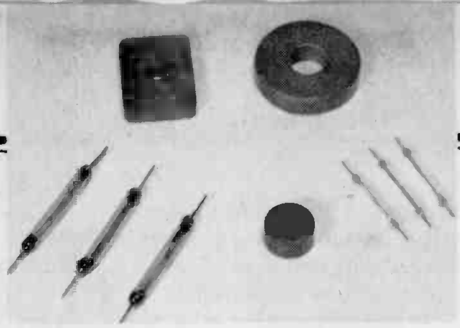
Make a single-pole, 2-position, on-before-off rotary switch with two crossed reed switches and a rotatable disc magnet positioned above them. When the magnet's axis is parallel with a switch's long dimension, that switch remains off; the other switch is simultaneously on. In the intermediate, 45° position; both switches are on. Use this arrangement when the second switch must come on before the first switch turns off.



A single-pole, 4-position switch is accomplished by a vertically-oriented disc magnet passing over four reed switches, which are arranged in a square.



A rotary switch with a 1/2" diam. ceramic magnet mounted vertically turns the switches on individually. The magnet arm is turned by a knob on the other side of the panel, or can be turned continuously with a small motor drive for constant scanning applications.



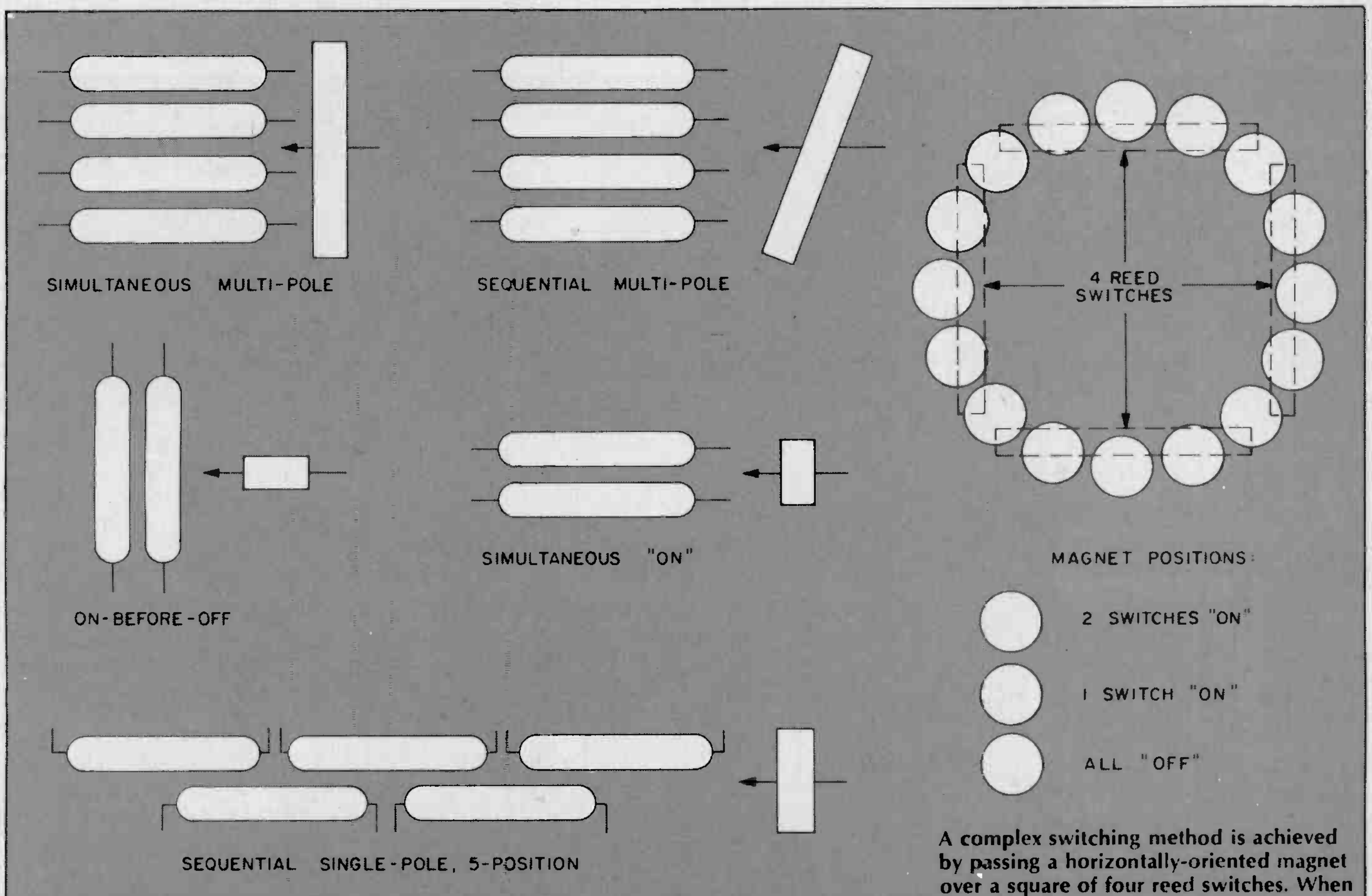
Magnetic reed switches, available from Radio Shack, come in two convenient sizes; the overall lengths, including leads, are 1 1/8" and 1 3/4". Both are rated at 0.56 amperes at 125 volts. The small, 1/2" diam. disc magnet is handiest, but the 1" diam. disc and 1" x 3/4" rectangular magnets may be desirable for building complex, multi-pole switches.

Single-throw, multi-pole. These can be constructed simply by mounting reed switches in parallel, and passing the *edge* of a vertically-mounted magnet over them to trip all switches simultaneously. If you need a sequential switching action, just angle the magnet about 30 degrees so that the parallel reed switches are tripped in 1, 2, 3, 4 order. If the magnet movement continues in the same direction, the switches will go off in the same 1, 2, 3, 4 sequence, on the other hand, if magnet movement is reversed when all switches are on, the switches will go off in the reverse 4, 3, 2, 1 order.

Multi-position, single-pole. Arrange the reed switches one after the other, like cars of a train. You can keep the switch smaller by using two lines of staggered switches, as shown. As the vertically-oriented disc or rectangular magnet passes over the switches, each "on" switch goes off before the next switch comes on.

A photograph shows a sliding switch of this general type, but one made to function as a double-pole, single-pole, double-pole sequencer. A simple locking device consisting of a lock washer under the knob on the other side of the panel permits locking the movement at any desired position. Note the "guide" strip near the slot; a square nut that holds the magnet support arm on the knob shaft bears against this guide to keep the magnet properly aligned over the reed switches.

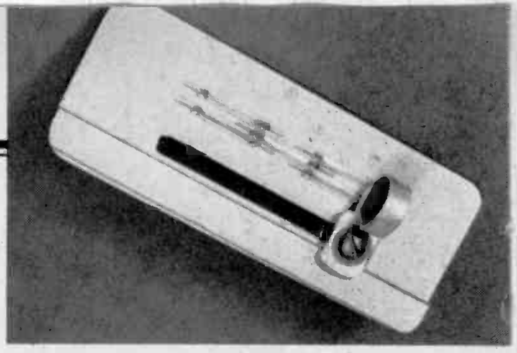
Rotary switches. These are easier to build than slide switches, and there are many ways to achieve special switching characteristics. Note that when the edge (diameter axis) of a disc magnet is aligned with the long axis of a reed switch there is no switching action.



Here are various magnet and reed switch orientations all of which achieve different switching actions. Position the magnets and reed switches exactly as shown, and as further discussed in the text, for best results.

A complex switching method is achieved by passing a horizontally-oriented magnet over a square of four reed switches. When the magnet is in a "corner" two adjacent switches are on; in other positions only one switch is on.

CUSTOM SWITCHES



The ceramic magnet of this sliding switch passes over five 1¹/₈" size reed switches to provide double-pole, single-pole sequencing. Separate diagram shows a simple mechanism which permits locking the magnet "on" or any "off" position.

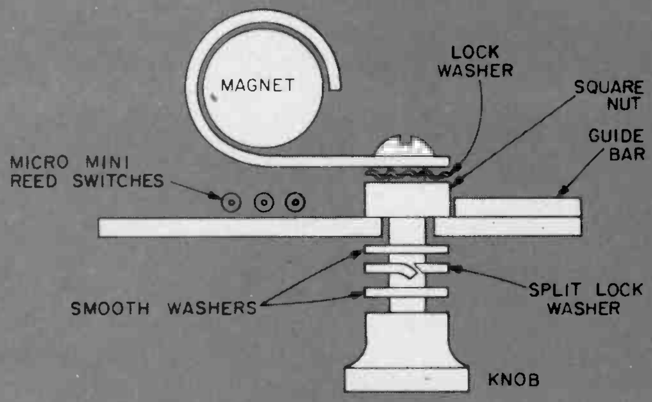
Thus if you mount several reed switches next to each other, and rotate the magnet directly over the center of the switches, you obtain more or less simultaneous on-off action.

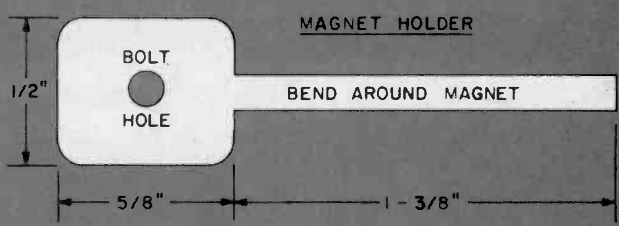
If two switches are crossed a vertically-mounted rotating magnet will turn one switch on and the other off when the magnet axis is parallel to the long axis of one reed switch. In the intermediate position, both switches are on; thus you can have on-before-off action with a very simple physical arrangement. To make a double-pole version, cross four reed switches in pairs.

A 4-pole, 4-position rotary switch can be made by arranging four reed switches in a "square" and adding a vertically-oriented disc magnet so that it can be swung in a circle over the centers of the reed switches. This provides an off-before-on switching action, each "on" switch first going off before the next one comes on.

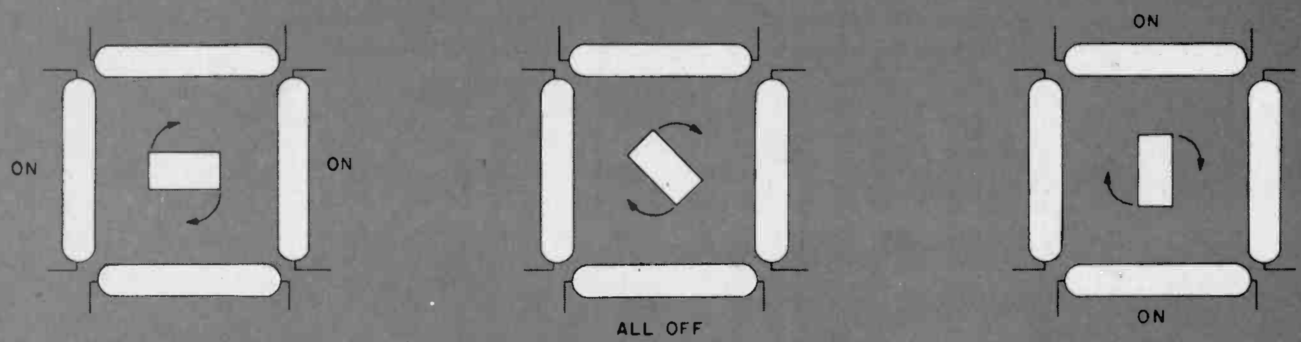
Some strangely useful things begin to happen if you mount the disc magnet horizontally instead of vertically. As the magnet passes over a corner of the square of reed switches so that it is partly over the ends of two adjacent switches, both switches go on. Rotate the magnet a little further, so that it is over just one switch and that switch stays on while the other goes off. Curiously, when the *horizontally* mounted magnet is over the center of a switch, that switch goes off. This is exactly the opposite of the on-action caused by a vertically-mounted magnet. Consequently, this type of rotary switch provides sequential double-pole and single-pole action, with four fully off positions.

Multi-pole Rotary. Such switches can be constructed by stacking additional reed switches atop the first four that make up a basic square. Mount the rotatable magnet inside the "box" formed from the stacked reed switches. When the long dimension of the magnet is perpendicular to stacks on opposite sides of the box, all of those switches will go on; other stacks at 90° to these will remain off because the magnet axis is parallel to them. By using one of the larger rectangular magnets, you can easily stack at least a half dozen switches on a side, for a total of 24 switches; 12 would be on at any one time, 12 off. When the magnet is in the intermediate, 45° position, all switches are off.





Here is a sliding switch designed to function as a double-pole, single-pole, double-pole sequencer. A locking device of a lock washer under the knob on the other side of the panel permits locking the movement at any desired position. The support arm is positioned to keep the magnet aligned properly.

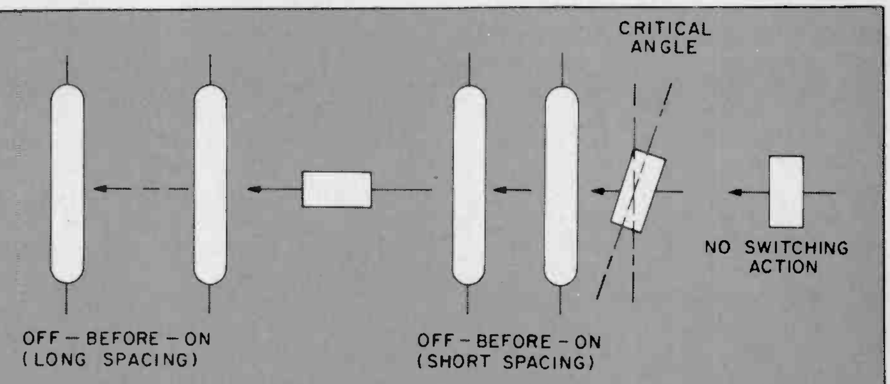


By positioning a rotatable magnet in the center of a square of four reed switches you have a double-pole rotary switch. By stacking magnets on top of the basic four, and using a larger magnet, as many as twelve on-positions are possible at each active orientation.

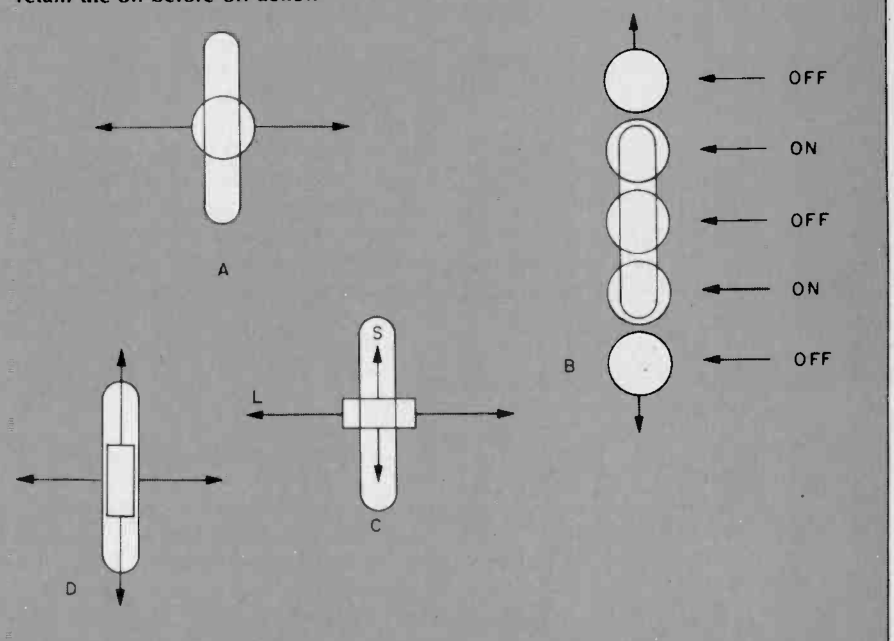
Linear Off-Before-On. Mount parallel switches far enough apart so that, as a vertically positioned magnet approaches the switches from one side, the first switch will go on and off before the next switch is affected. Here's a handy trick that enables you to pull the parallel reed switches much closer together to form a more compact switch: Position a small disc magnet over the center of the first switch so that its long axis (diameter) is parallel to the long axis of the switch. If you have been paying attention, you already know that in this position the magnet has no effect on the switch. Now slowly rotate the switch away from this parallel orientation until you hear the switch click on. Mount the magnet in its sliding holder so that it passes over the center of the reed switch in this slightly angled position. This deliberately weakened magnetic action permits location of the next switch much closer to the first—as close as about ⅜"—and still obtain off-before-on switching.

There's no problem, of course, if you want on-before-off action because then you can mount the reed switches as close to each other as you like. A magnet approaching from the side will turn the first on, then the second, before turning the first off. Bear in mind that if the magnet approaches the pair of switches from the end directions, you obtain approximately simultaneous double-pole switching.

If you have but one reed switch, and the vertically-oriented magnet approaches from one side of the reed switch, it has a longer "reach" and switching action occurs while it is relatively far from the center of the switch. This relative sensitivity, relating to direction of magnet travel, could be an important factor in some switch-design problems.



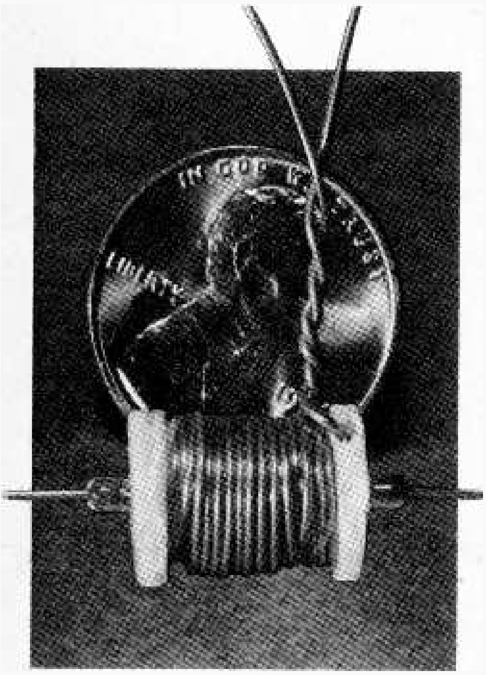
Spacing of adjacent reed switches is important if the first switch must go off before the next turns on. When the magnet is in its strongest orientation (left), the reed switches must be far apart. If the magnet is positioned at an angle slightly removed from where it does not switch, the two reed switches can be closer together and retain the on-before-off action.



Orientation and direction of movement of a disc magnet influence switching action. No switching occurs as a horizontal magnet moves across the reed switch as at upper left. If the magnet passes along the length of the reed (upper right), switching to "on" occurs when the magnet is near either end of the reed, but not when it is directly over the contact points in the center of the reed. Switching occurs if the magnet is vertically oriented as at lower left, but over a shorter range if the magnet moves along the "S" path than along the "L" path. If the magnet is turned 90° (lower right), no switching occurs when it is moved along either of the indicated paths.

Special Designs. As you play around with your reed switches and magnets you will undoubtedly discover many variations on the ideas given here. For example, suppose you wanted a sliding multi-pole switch that always switches the reed switches on in the same sequence. As the magnet travels over the parallel reeds, the switches come on in 1, 2, 3, 4 order. But as you slide the magnet back to its original starting position, the reeds would go on in reverse 4, 3, 2, 1 sequence—which is what you do *not* want. So what's the answer? Simply mount the magnet on a holder that permits it to be turned 90° at the end of each sweep. This way the magnet can be in its "active" orientation going one way, and in its "dead" orientation going the other way. Thus it is possible to return the magnet to the starting position, for subsequent normal switching order, without affecting the switches on the return sweep.

I have not tested these ideas, but it seems likely that you could construct such truly off-beat switches as, for example, a level-indicating switch by suspending the magnet on a short pendulum so that it will swing close to either of two parallel magnets to electrically signal tilting. And it may be feasible to create a vibration-detector in much the same manner, but mounting the magnet on the end of a flat or coil spring so that vibrations will swing it in-and-out of the switching range. ■



CUSTOM RELAYS ...AT MASS PRODUCED PRICES

By Erik Hyypia

☐ Custom build your experimental relays from magnetic reed switches and save a bundle. The reed switches are very inexpensive and all other components can be found in your junk box. The simplest relay will run you about thirty cents. There are even other advantages. The relays are highly sensitive and can be coupled directly to audio circuits for experimental purposes, their light weight and tiny size make them ideal for model applications, and they are even applicable to high speed switching circuits because of their extremely short response times.

The Basic Relay. Wrap a coil of wire around a reed switch (Radio Shack Cat. 275-034 "Mini" or 275-035 "Micro Mini") and hold it on by end pieces cut from some thin, rigid material such as cardboard. The reed switches—especially the "Micro Mini" size—are quite fragile, so play it safe and wrap the coil around a form of the same diameter as the reed switch (coat hanger wire, for example, for the "Micro Mini") then replace the form with the actual switch when the coil is complete. The length of wire used to wind the coil is not critical; about five feet of #24 gauge enameled magnet wire (Radio Shack Cat. No. 278-004) is sufficient. The coil will hold together better if you coat it with lacquer or model airplane dope.

A relay of this type will respond to as little as 0.5 volt. When connected to an audio signal generator, the relay responds to frequencies approaching 3000Hz and to somewhat higher resonant frequencies.

The basic relay can be modified in a number of ways. Though you will undoubtedly find more, here are a few basic examples.

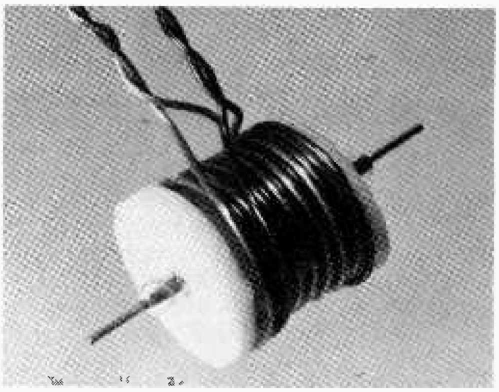
Multi-Pole Relays. Make these by using additional reed switches inside the coil. Four and five pole relays are simple to make, though extra windings may be needed to retain a high degree of sensitivity. If you need a relay with more than five poles, gang several smaller, fully assembled relays together by wiring their coils in parallel.

Latching Relays. Once triggered by a short pulse, this relay will remain on, it can be made by using two reed switches in the coil (see diagram). One switches the load, while the other is wired into the coil power circuit. When the momentary-on switch is pressed, the coil is energized, closing the two reed switches. Once the left-hand reed switch is closed, current will continue to flow through the coil even after the momentary-on switch is released. To turn the relay off, a normally-on, momentary-off switch is pressed to break the flow of current to the coil, thereby cutting off both reed switches.

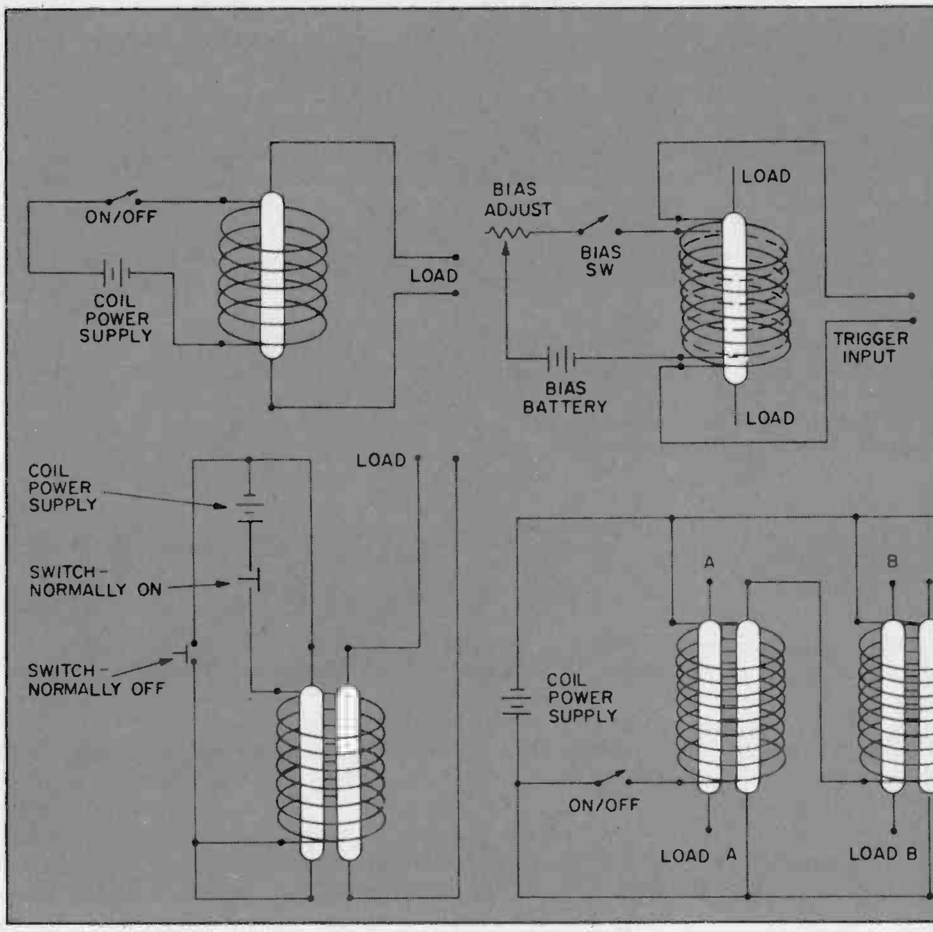
Biased Relays. In the simplest, basic relay the only magnetic field around the switch is that created by the trigger current flowing through the coil and it is this magnetic field that activates the reed switch. The sensitivity of the relay to the trigger current can be increased by biasing the magnetic field with either a permanent magnetic field or an electro-magnetic field.

The permanent magnetic bias is made simply by mounting a small magnet at the proper distance from the coil. To find the best positioning, move the magnet close to the relay until you hear the reed switch click on, then back off a tiny distance. The field created by the permanent magnet should be *almost* strong enough to turn the switch on, but not quite. Now any weak trigger current sent through the coil will be strong enough to kick the magnetic field above the threshold level needed to activate the reed switch.

A more flexible way of creating the magnetic bias is to double wind the coil using two wires instead of one. Connect your trigger input through one, as shown, and connect the other through the bias battery. The rheostat lets you set the bias field to the correct level, which, again, should be almost strong enough to make the reed switch click on. The resistance value of the rheostat will depend on what voltage bias battery you use.



The basic relay is as tiny as many commercial sub-miniature units, a whole lot cheaper, can be designed with greater versatility, and is a lot of fun to build. The basic relay, shown here, is nothing more than a coil of wire wound around a magnetic relay switch.



A basic relay (upper left) is simply a coil of wire wrapped around a magnetic relay switch. The coil is connected to a power supply and the switch to the load. A bias relay (upper right) is the next step in complexity and consists of a double-wound coil about a reed switch. The first coil is biased slightly so that a trigger input into a second coil can, with great sensitivity, trip the switch to the load. A latching relay (lower left) is a coil of wire wound about two magnetic reed switches; both of which remain closed once the relay is activated. A normally-on switch unlatches the relay. Finally, there is the relay cascade (lower right) which is simply a series arrangement of double pole relays. It can switch on any number of loads in a rapid, preprogrammed order.

One side note to all of this: if you use a transformer instead of a battery to power the relay coils, use a full-wave rectifier between the transformer and the relays. Alternating current or half wave D.C. will make the relay buzz on and off at 60Hz.

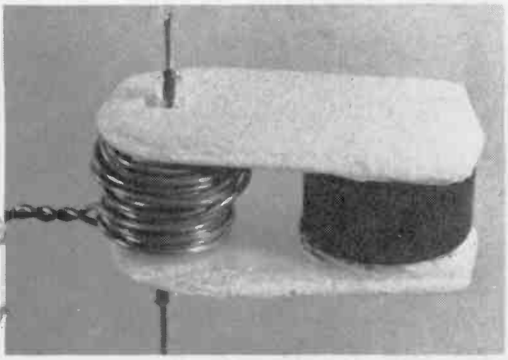
A Relay Cascade. This device lets you turn several items on with one flip of a switch, and have them come on in a specific order, one after another. The coil of relay A (diagram) is wired to the start switch, and the coil of each consecutive relay is wired through the reed switch of the previous relay. Thus, when the On/Off start switch is closed, relay A will come on, then relay B, then relay C, and so on. Theoretically, there is no limit to the number of relays you can cascade this way, although the power source may have to be increased to supply enough current. The current carrying capacities of both types of reed switches is 0.5 amps at 125 VAC.

The relays close and open extremely quickly—a "Micro-Mini" can cycle up to at least three thousand times per second, according to my rough tests, and will respond to resonant frequencies even higher. Thus, the closing time of the relay is, obviously, very short.

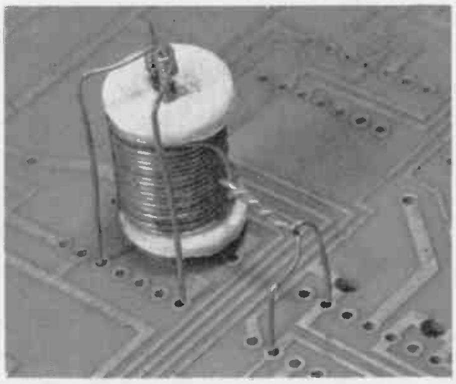
In closing. The applications of these relays are limited only by your imagination and the type of projects you build. Once you design something using one of these miniature marvels you may never again want to use one of the store-bought, bulky variety.

One tip: do *not* forget coating the coil of each relay with at least one good coat of lacquer or model airplane dope. Nothing is more aggravating than, sometime after the project is already built and functioning, having to rewind a relay coil which has spilled out of the form.

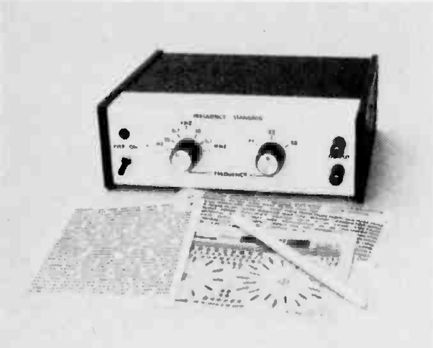
You're sure to find that switching with these relays is nearly as much fun as building them. ■



Here's a permanently biased relay, one of the more sensitive types you can design. Positioning the magnet nearby to the coil reduces the voltage necessary to trip the relay.

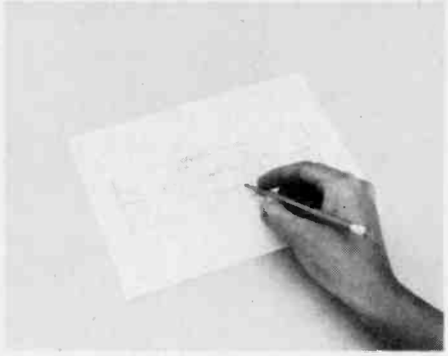


Because of their compactness, these home brew relays are easy to mount on a PC board. This particular double pole relay uses two switches within one coil.



1. Why not build projects you can be proud of, in appearance as well as circuit design? It is neither difficult nor expensive as you'll note when you follow this unit on a step-by-step journey from a blank, machined panel to real artistic beauty.

2. You will need spray and brush-on protective coating, plastic tape, various types of rub-on lettering and designs, and a burnishing tool (the white cylinder) to effect the transfer of the letters from the carrier sheet to a project's front panel.



3. You can't fashion it if you have never seen it before—at least seen it on paper. First, make a sketch and work on the arrangement until you are quite satisfied with it. Using the quadrille paper, as pictured here, makes the job easier.

LOVE THAT

Make your budget project

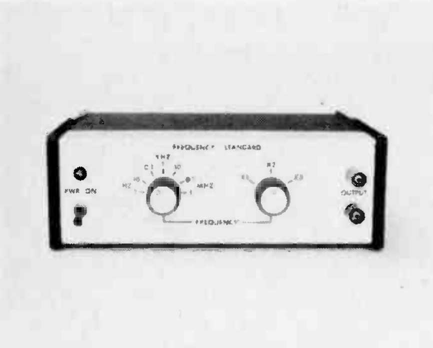
by Randall

WHEN YOU GIVE birth to an electronic project, don't send it into the world illiterate. As shown in this article, it's easy to apply lettering and designs to give your projects a professional appearance, as well as for functional reasons. This is accomplished by using a product called *rub-on lettering* (or *dry-transfer lettering*), which consists of letters, numbers, or designs with an adhesive on their back side so that they can be affixed to a panel or other surface. The letters come attached to the back of a transparent plastic *carrier sheet*, from which they are transferred to the panel by rubbing or *burnishing*. Follow the photos to see how it is done. The process may seem complicated at first, but with a little experience you will find that the steps go quickly.

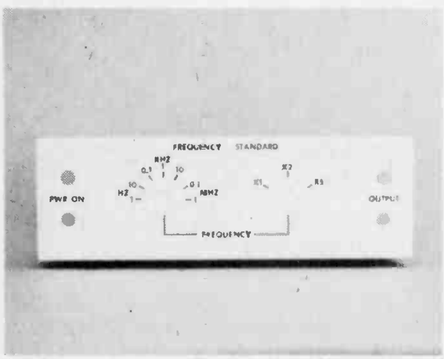
Rub-on lettering is available in various sizes and colors (black and white are the most common). Sets may contain complete words, individual letters or numbers, or a combination of these. Sets consisting of index marks and other designs for rotary switches and dials are also available.

A small set, which should see the average hobbyist through half a dozen projects or more, costs only about two dollars. Your local electronics store probably carries rub-on lettering and related supplies, if not, try the suppliers listed at the end of this article. Rub-on lettering is also available from art, graphic arts, and office supply stores. Although the type they carry is intended primarily for other purposes, it can be used for electronic projects.

In addition to the lettering and a few household items (cellophane or plastic

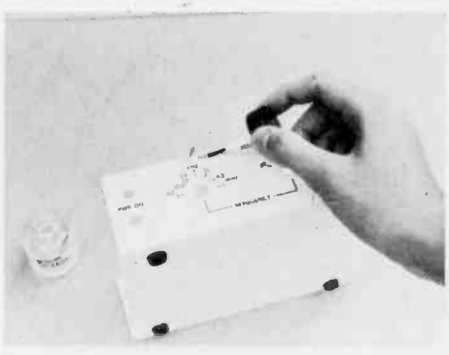


14. And now—the finished project, a delight to the eye! Once you try this method on one of your projects you'll never go back to ugly again. You don't have to be an artist, and it does not add much to the cost. Electronics can be beautiful!

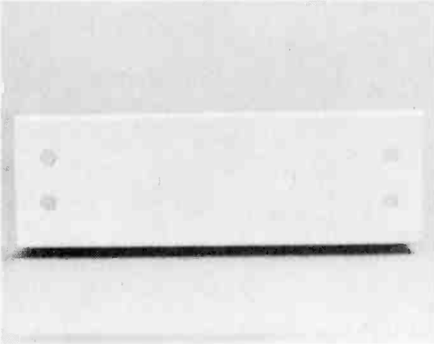


13. Here you see what the panel looks like after the lettering has been completed but before the parts have been mounted. It already has a clean, professional look, more like something out of an assembly-line factory than from your workbench!

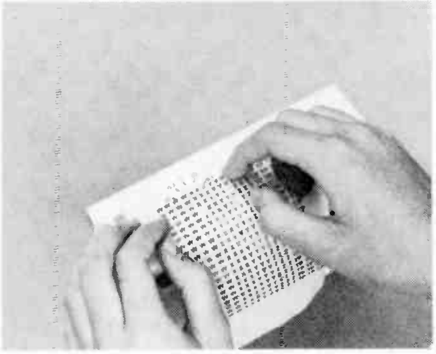
12. You can also buy spray overcoating as pictured here. Spray is more even than the brush-on, but the brush-on can be applied thicker. This method too requires that you carefully check for the compatibility of the overcoat with both letters and panel.



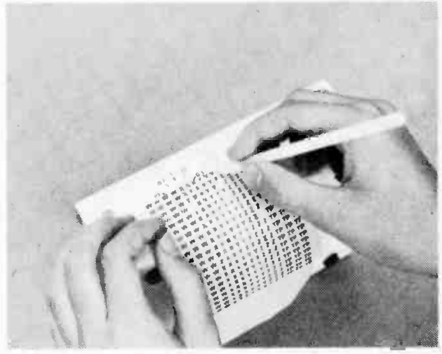
11. You'll want to protect that final panel, and there are two methods you can use. Here we show the brush-on method of overcoating. First, check on a scrap or hidden area for compatibility with both rub-on lettering and the panel finish.



4. Once you know where it is all going to be at, you can begin to machine the panel. Follow your quadrille-paper layout carefully and don't make last minute, poorly planned changes! Then make certain the panel is clean and dry and free of any imperfection.



5. Locate the desired letter (or word, or design) on the carrier sheet, place it in position on the panel and press the sheet against the panel. The back of the sheet is tacky so it will not easily slip. Here we have already applied some of the letters.



6. Transfer the letter to the panel by use of the burnishing tool. Rub over the letter several times, increasing the pressure each time until the transfer is complete. As you do this a slight change in the letter's appearance verifies transfer is working.

LETTERING

look like a million bucks!

Kirschman

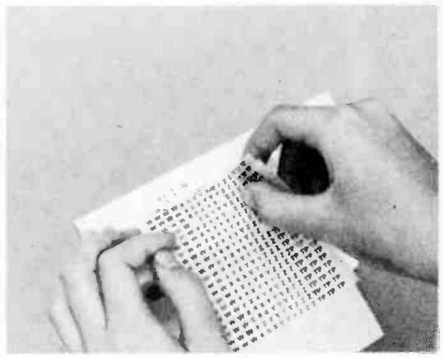
tape, ruler, paper, etc.), you will need a blunt-pointed tool to burnish the letters into place. Tools for this purpose can be obtained where art supplies are sold, or you may be able to find something around the house that will serve the purpose. However, a pencil or ballpoint pen tends to be too sharp, and may also obscure the lettering. The burnishing tool shown in the photos was made from ¼-inch diameter plastic rod sanded round on one end and tapered and rounded to about ⅛-inch diameter on the other end. It could also have been made from a wood dowel.

The panel or other surface to which you intend to apply the lettering should be clean and dry. Any oil, grease, dirt, or moisture will hinder adhesion of the lettering. Soap and water can be used for cleaning, except on bare aluminum. Rinse and dry the panel thoroughly; after wiping off excess water, use a heater or warm oven to dry. Solvents can also be used for cleaning; test first for compatibility with the finish. *Do not* use a heater or oven with solvents. To clean bare aluminum, solvents can be used, or chemical preparations for this purpose are available from paint and hardware stores. After cleaning do not touch the areas where you will apply the lettering.

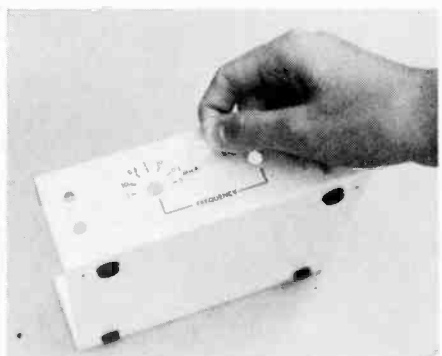
If you use solvents or other chemicals be sure to follow the manufacturer's directions and particularly observe the appropriate safety precautions. Spend a little extra time and effort to be safe and minimize the possibility of injury.

After you have applied the lettering, you will probably want to protect it

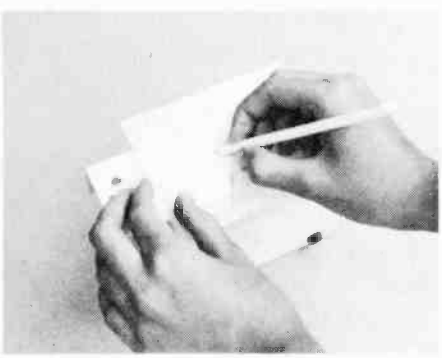
(Continued on page 117)



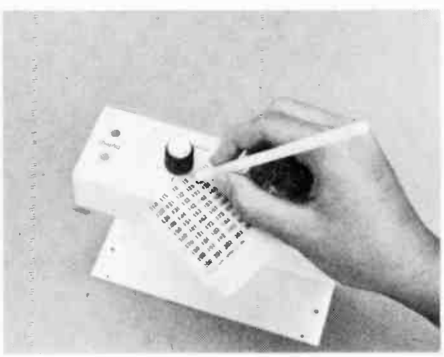
7. Peel the carrier sheet away from the panel, starting from one end and holding the other end in position against the panel. Check that the letter has completely transferred. If it has not, all you have to do is lay the sheet back down and burnish over.



8. Make a mistake? It's no disaster. To remove an error, press ordinary cellophane or plastic tape over the offending letter and then simply lift it off. This may be repeated if needed, until all is clear. An eraser may also be used.



10. Once all lettering is applied, and you are satisfied with it, burnish one more time. Use a backing sheet of slick paper, so the lettering will not stick to the backing sheet, and go over the whole panel. Use the blunt end of the burnishing rod.



9. Positioning index marks is done by temporarily mounting both a switch and its knob. Turn the knob to each position and align the mark with the pointer. As you see here, the number "1" makes a good index mark, certain other letters may be used.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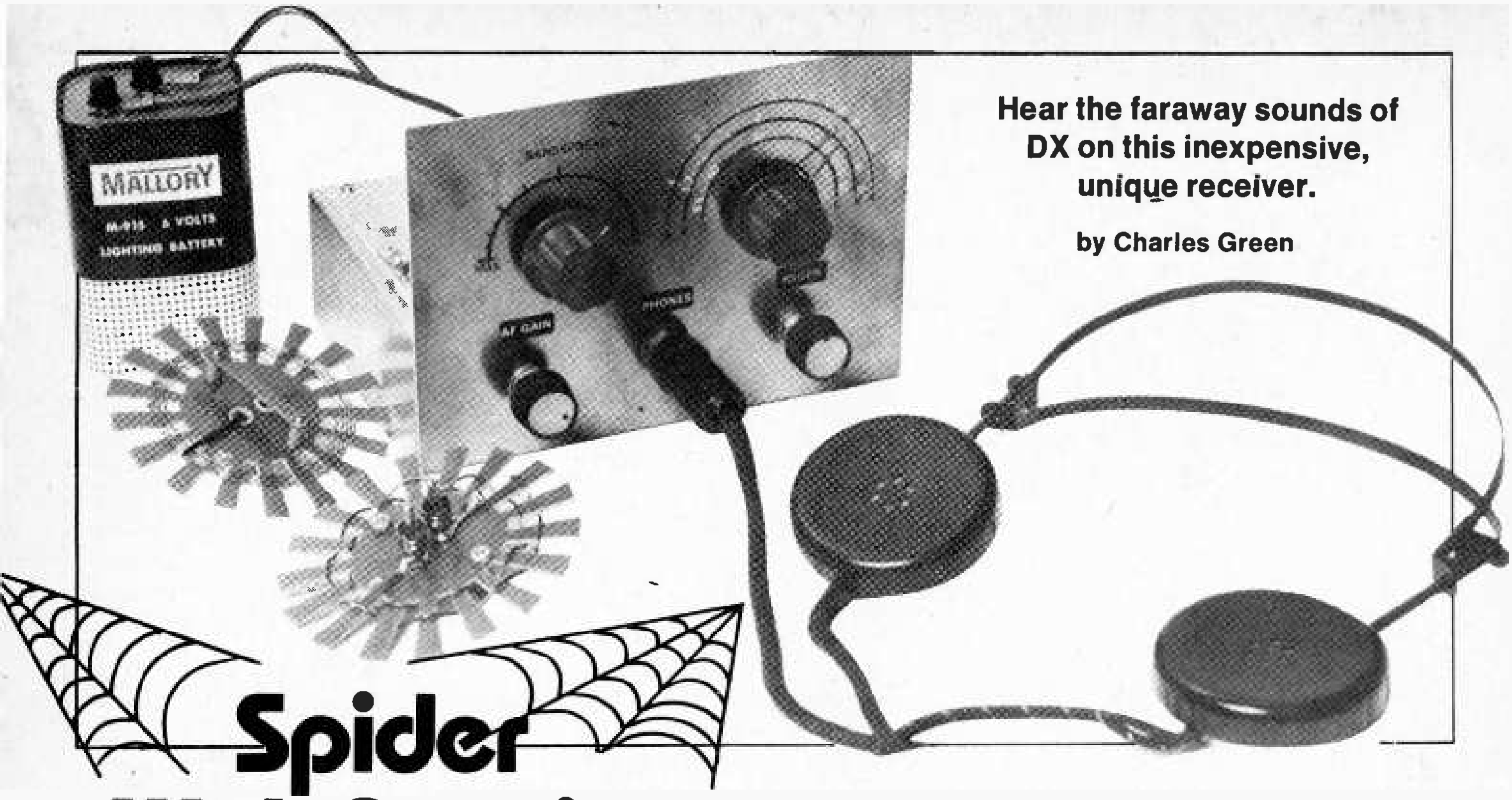


Hear the faraway sounds of DX on this inexpensive, unique receiver.

by Charles Green

Spider Web Receiver

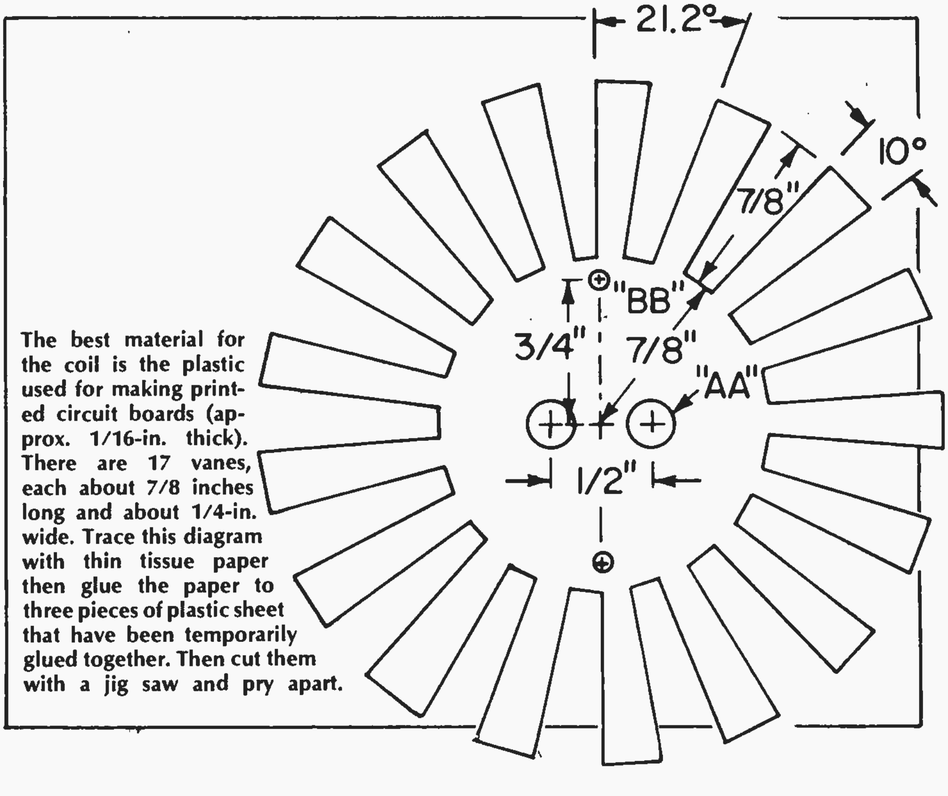
IN THE OLD DAYS OF RADIO, back when grandpa was building his first one tube radio, the spiderweb coil was the "cat's pajamas." This type of tuning coil was very popular with the home-constructors, and with good reason; the spiderweb coil is a high Q type, wound with interleaved turns for minimum residual capacity. Many of the old timers made long distance reception commonplace with this type of tuning coil in their radios.

The spiderweb coil is a type of coil in which the wire is wound on a flat form so that the radius of successive turns increases from the center outward. You can experiment with this type of coil by building our receiver model which combines the old spiderweb coil with present day solid state circuitry. The receiver covers from 550 kHz to 14 MHz, with three plug-in spiderweb coils in a FET regenerative-detector circuit. A stage of audio is included with a pnp transistor directly coupled for good headphone volume.

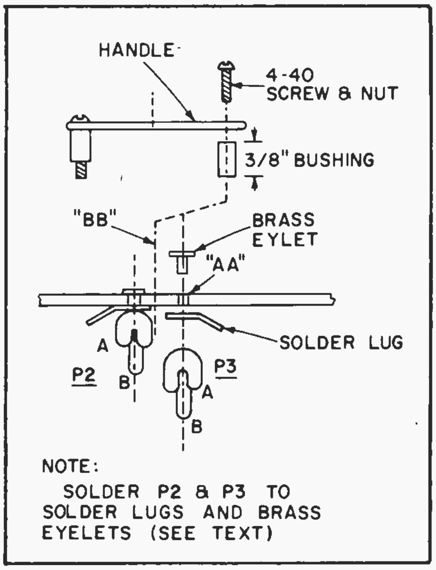
The Spiderweb Coil Receiver Circuit. Signals from the antenna are coupled through J1 and C1 to L1 and the tuning capacitor C3. The bandspread capacitor C2 is used to fine-tune crowded SW bands and the resultant signals are fed via C4 to the gate-leak R2 and the gate of FET Q1. The RF signals are detected and amplified by Q1 and a portion of the RF is fed back into L1 from the source circuit of Q1. This feedback RF is detected and further amplified by Q1. The regen control R1 varies the amount of RF feed-back to L1.

The detected audio signals in the drain circuit of Q1 are coupled through T1 to the AF Gain control R5 and to the audio amplifier circuit of Q2. The amplified signals are direct-coupled via the collector circuit of the pnp transistor Q2 through J4 to external high impedance phones. DC power for the circuits is supplied by an external 6 volt battery. Bias current for the Q2 base circuit is supplied by the R6-R7 divider circuit, and R8-C7 acts as the interstage decoupling network to minimize audio feedback between the stages via the DC power bus.

Three plug in coils are used for L1, each one covering a different band of



The best material for the coil is the plastic used for making printed circuit boards (approx. 1/16-in. thick). There are 17 vanes, each about 7/8 inches long and about 1/4-in. wide. Trace this diagram with thin tissue paper then glue the paper to three pieces of plastic sheet that have been temporarily glued together. Then cut them with a jig saw and pry apart.



Solder the phono plugs to each spiderweb by using small brass eyelets as rivets. A handle will simplify plugging-in.

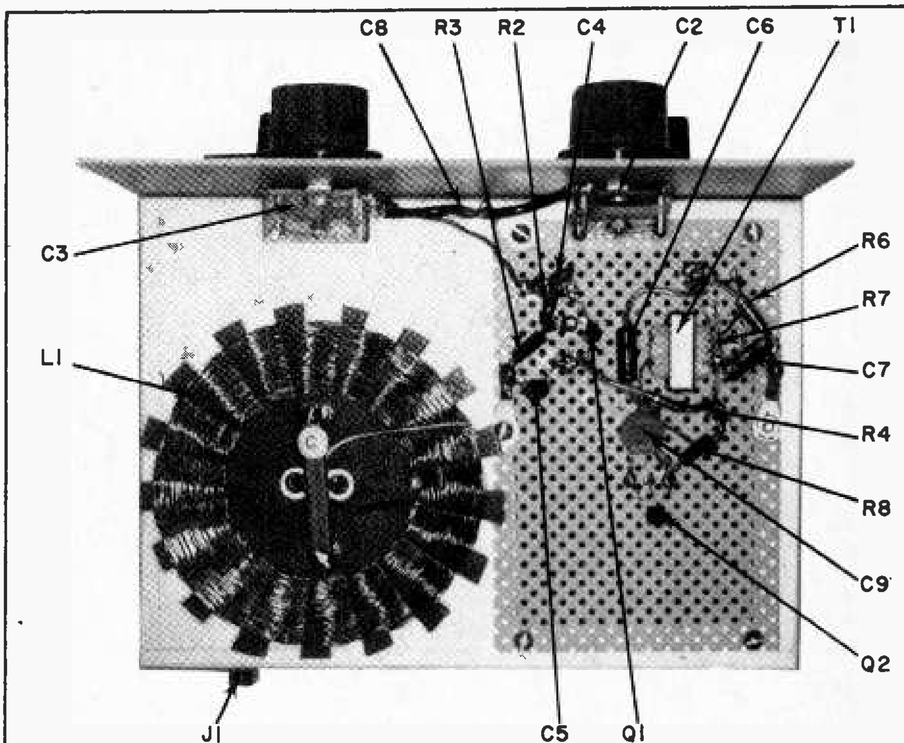
frequencies. L1 A tunes from 7 MHz to 14 MHz, L1 B tunes from 1.7 MHz to 5 MHz, and L1 C tunes from .55 MHz to 1.6 MHz.

Spiderweb Coil Construction. Look at the drawing of the spiderweb coil form. There are seventeen "vanes," ⅞-inch long and approximately ¼-inch wide, positioned around the perimeter of a 1½-inch disc. A good quality plastic should be used for the coil form; the coil forms shown in the receiver model photo are made from the type of plastic sheet used for printed circuit boards (approx. 1/16-inch thick).

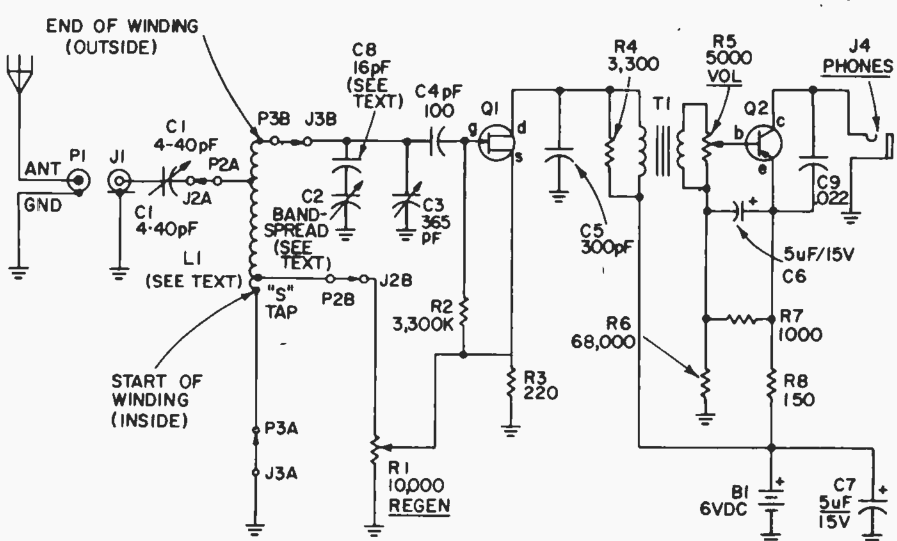
The easiest way to start construction of the coil forms, is to trace the outline of the spiderweb coil form drawing and temporarily cement the tracing onto a sheet of plastic. Then cut out the coil form with a hack saw. If desired, three sheets of plastic can be temporarily cemented together with rubber cement and the coil forms for all three bands can be cut out at the same time. After cutting out the forms, carefully pry apart the spiderweb coils.

Brass eyelets (available at notions counters in department stores) are soldered to lugs and P2-P3 as shown in the drawing. Carefully drill holes to fit the eyelets, positioned ½-inch apart, for each of the three spiderweb coil forms, and mount the phono plugs (P2-P3).

Refer to the Spiderweb Coil Winding Table and wind the coils with the turns indicated for each band. Start winding on the inside of each coil form and wind to the outside of the form. Allow enough wire at each end of the coil to solder to P3A-B as shown in the schematic. After winding the coil make the



This layout shows how best to locate the spiderweb coil to leave room for the perfboard. Note capacitor C8 which is used to help achieve the desired bandspread.



PARTS LIST FOR SPIDERWEB RECEIVER

C1—4 to 40 pF midget mica trimmer (ARCO 422 or equiv.)
C2—Bandspread capacitor (modified C3, see text)
C3—365 pF subminiature variable capacitor (Radio Shack 272-1341)
C4—100 pF capacitor
C5—300 pF capacitor
C6, C7—5uF/15 VDC Miniature electrolytic capacitor
C8—16 pF capacitor (see text)
C9—.022 uF capacitor
J1, J2, J3—Phone jacks
J4—Phone jack
L1—See Coil Table and text
P1, P2, P3—Phono plugs (see text)
Q1—FET (NPN), Motorola HEP-F0015, or equiv.)
Q2—Transistor (PNP), Motorola HEP-57 or HEP-S0019 (or equiv.)
R1—10,000-ohms linear taper potentiometer
R2—3,300,000-ohm resistor, ¼-watt
R3—220-ohm resistor, ¼-watt
R4—3,300-ohm resistor, ¼-watt
R5—5,000-ohm audio tape potentiometer
R6—68,000-ohm resistor, ¼-watt
R7—10,000-ohm resistor, ¼-watt
R8—150-ohm resistor, ¼-watt
T1—Audio transformer; PRI: 10,000-ohms, SEC: 2,000-ohm (Calectro D1-722 or equiv.)
Misc: 5 by 7 by 2-in. aluminum chassis, 5 by 7-in. copper clad board (for front panel), sheet plastic for L1 form (see text), knobs. 3 by 4½-in. perf board, two lug solder strip (to mount C1) 6 brass eyelets.

Spider Web

SPIDERWEB COIL WINDING TABLE

	WIRE SIZE	TOTAL TURNS	ANT TAP (P2A)	"S" TAP (P2B)
BAND A 7 MHz to 14 MHz	#18 Enam.	4	½-Turn from end	1-turn from start
BAND B 1.7 MHz to 5 MHz	#24 Enam.	17	1½-turns from end	2-turns from start
BAND C .55 MHz to 1.6 MHz.	#28 Enam.	52	10-turns from end	1-turn from start

taps as indicated in the table; carefully scrape the enamel off the wire for a good soldered connection to the tap leads to P2A-B.

Receiver Construction. Most of the receiver components are mounted on a 3- by 4½-inch perf board section installed on a cut-out portion of a 5-by 7- by 2-inch aluminum chassis. As shown in the photos, the perf board is installed on one half of the top of the chassis to leave enough room for the plug-in spiderweb coils. The tuning capacitor C3 and the bandspread capacitor C2 are mounted on a 5- by 7-inch section of copper-clad printed circuit board used as the front panel. A similar section of sheet aluminum would also be suitable for the front panel. The panel is held by the mounting nuts of the regen control R1, audio gain (volume) control R5, and the phone jack J4 that are mounted in holes drilled through the front of the chassis and the lower half of the panel.

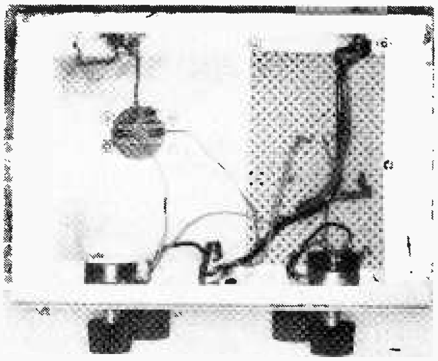
Begin construction of the receiver by cutting the perf board section to size and then temporarily positioning it upon the top of the chassis. Lightly draw the outline of the board on the top of the chassis, then remove the board and layout the chassis cut-out within the board outline. The cut-out section on the model shown is approximately 2½ by 4-inches. Drill holes near the inside corners of the cut-out section and use the holes to start a hack saw or jewelers saw. After the chassis section is cut-out, drill six mounting holes for the perf board edges. Install the perf board on the chassis with small machine screws and nuts.

Locate and install the board components with perf board clips. Do not install Q1 at this time to minimize any possible damage to the FET; solder Q1 into the circuit when all of the other components have been connected. Temporarily place an alligator clip across the source and gate leads (shorting them together) while soldering the FET in place. Cut the leads of all of the components to allow short, direct connections and to prevent any of the leads from accidently coming in contact. Make sure that you remove the alligator clip from the FET after soldering. For best results follow the component layout of the model shown in the photo. T1 is mounted by drilling holes in the perf board to fit the mounting tabs and then bending them over for a snug fit under the board. Position the three ground lugs on three of the board mounting screws, as shown in the photo.

Cut holes in the center of the remaining portion of the chassis top to fit J2 and J3. Space the two jacks to fit the plugs P2 and P3 mounted on the plug-in spiderweb coils. A dual jack was used on the model shown in the photo. But, it may be easier to use separate jacks for easier spacing in the front and rear of the chassis to fit the components to be installed; R1, R5 and J4 on the front and J1, C1 and the rubber grommet for the DC power leads on the rear chassis. C1 is mounted on a two lug terminal strip with a small access hole drilled in the chassis to allow adjustment.

Bandspread Capacitor Construction. The bandspread capacitor C2 is a modified tuning capacitor that originally had a 365-mmf capacity. The model in the photo utilizes a Radio Shack miniature type with plastic dielectric. In this particular make of capacitor, the stator blades are made from thin sheet metal and are fastened with only one screw and nut. Carefully remove the end nut (after removing the plastic outer cover) and pry out the stator blades one by one with small pliers until only one blade is left. Replace the nut and tighten it. Check with an ohmeter to see if the blade is shorted to the rotor blade assembly. If so, remove the nut and readjust the stator blade. The rotor blades should be able to rotate freely as the shaft is turned.

Front Panel. Mount the panel on to the front of the chassis by drilling the appropriate holes and securing it with the mounting nuts of the panel controls. After the panel is mounted with the copper clad surface facing outward, locate and drill the holes for C2 and C3. Install the two variable capacitors and then connect them to the circuit board with short leads. C8 is mounted between the stator of C2 and the stator of C3. The exact value of C8 is best determined by experiment after the receiver is operational for the desired bandspread. A good starting value is 16 mmf (as on the model shown in the photo).



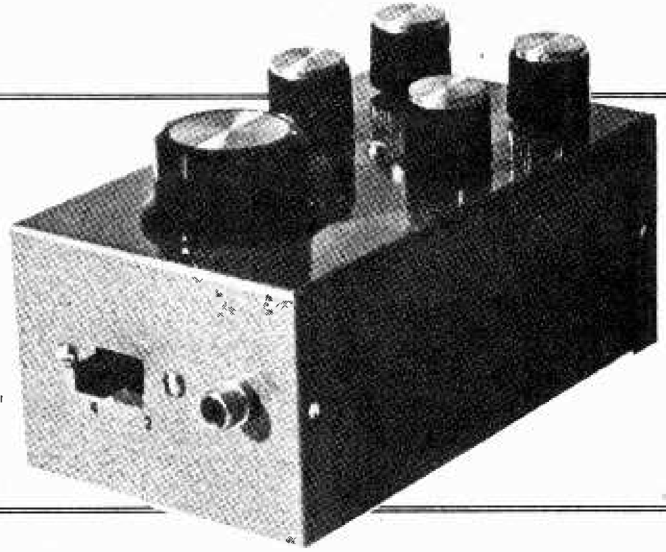
This bottom view of the receiver shows the jacks for the spiderweb and how they are hooked up to the antenna. Note how the perfboard is secured to the chassis.

Completing Construction. Complete the construction of the receiver by wiring the underchassis components. Make sure that the leads to J2 and J3 are as short and direct as possible; position these leads up and away from the chassis bottom. Connect the DC power leads to the circuit and mark them with the proper polarity. Or, a red lead can be used for positive and a black lead for negative polarity. Make a knot in the power leads before putting them through the rubber grommet on the rear of the chassis.

Install knobs on the shafts of the front panel controls. If necessary, cut the shafts of the controls for a uniform appearance. Cement a 1-in. length of Number 18 wire on the rear of the C3 knob. Or, a shaped section of clear plastic with a black line drawn down the center can also be used for a pointer.

Dial Calibration. The front panel dials are marked with rub-on lettering positioned on three concentric India-ink lines for the C3 dial, and one inked line for C2. Begin dial calibration by plugging in the "C" Band (Broadcast Band) coil and connecting earphones and a six

(Continued on page 116)



PASSIVE MIXER

Mix music like a pro with this low-cost passive mixer.

by Walter Sikonowiz

☐ One of the handiest accessories that an audio enthusiast can own is a mixer, a device to combine several channels of sound into one. Mixers are especially useful to the tape recordist, who mixes sounds from several sources so that they occupy a single track of his recording tape. For P.A. applications as well, a mixer is indispensable. Perhaps you too have wanted to try your hand at the creative effects possible with a mixer, but have been turned off by the high prices asked for these devices. Generally, commercial mixers provide other functions besides mixing (i.e., amplification, impedance-matching, filtering, sometimes reverberation, etc.), and it is the presence of these extra functions that causes the price to soar.

A bare mixer is an amazingly simple device that requires only passive components such as resistors and capacitors. Such a passive mixer is not only simple and cheap, but it is also free from the gremlins that haunt you whenever active elements are put into a device: distortion, hum and noise. If you can spare a few hours of your time plus less than ten dollars, you can easily duplicate the passive mixer presented here. In fact, if you shop wisely, you should spend considerably less than ten dollars.

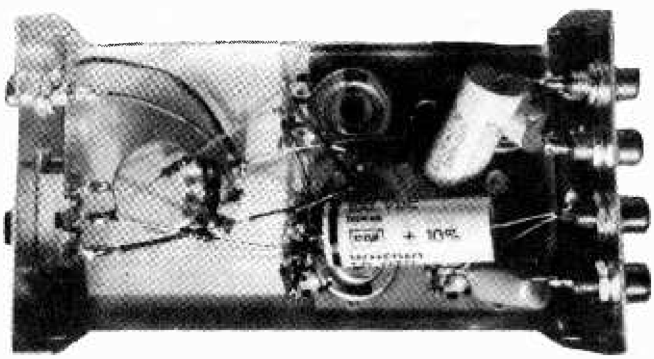
From the schematic you can see that this is a four-channel mixer. Potentiometers R1, R2, R3 and R4 control the relative levels of the four channels, and potentiometer R9 acts as a master gain control. Resistors R5, R6, R7 and R8 tie the four input channels to the single output. The input impedance of each channel is 10,000 ohms, while the output impedance ranges as high as 40,000 ohms.

When switch S1 is closed you have full four-channel mixing capability. Should you need to mix only two channels, open S1. This will give you about 70 percent more output voltage, and this may come in handy when your inputs are low-level. Remember, a 70 percent increase in the input voltage to an amplifier approximately triples the power delivered by the amp to its load.

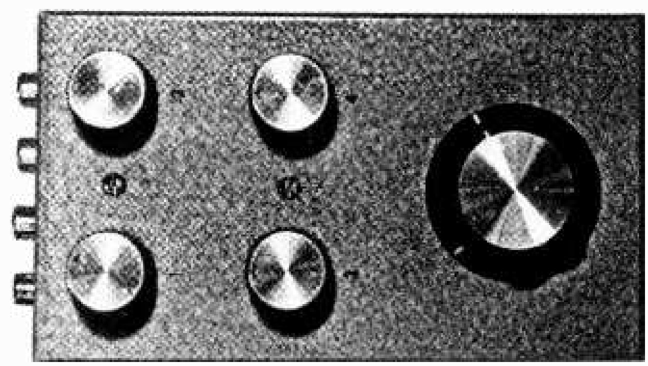
Construction of the mixer is noncritical, but a metal (aluminum) cabinet is recommended for shielding purposes. Such a shield will prevent the high resistances in the circuit from intercepting any unwanted electrical interference. The shield is denoted in the schematic by a dotted line that connects to system ground. Apart from providing a shield, you have a free hand in the mixer's construction.

One nice thing about a passive mixer is that you don't have to provide power, so you can build it into another piece of equipment, such as an amplifier, without much fuss. On the other hand, because the device is passive, its gain must be less than or equal to one. We can illustrate that fact like this. If your input consists of four sources having 10-volt peak-to-peak amplitudes, the largest possible composite output signal will be less than 10 volts peak-to-peak.

Use of the mixer is fairly obvious; just hook it up and experiment. However, you should keep an eye on impedances. The impedance of any source should be less than 10,000 ohms in order to avoid loading by the mixer. At the opposite end, the mixer should drive a load whose impedance is greater than 100,000 ohms. Both of these rules may



The passive mixer is a very simple device and it requires no complex or expensive parts. The unit pictured here is very obviously a junk box special. Note the two slightly different RCA jacks and the variety of capacitors used.

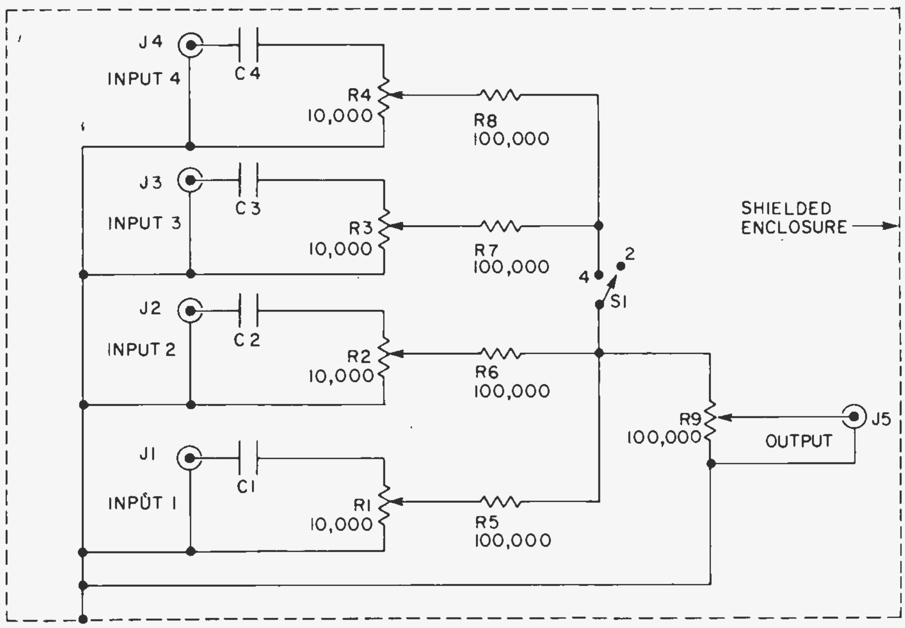


The concept of the mixer is simplicity in itself—the four inputs are individually controlled by the four variable resistors labled 1 through 4 and the overall output is governed by the large variable resistor.

MIXER

be violated, but at the expense of decreased output. However, you will find that neither of these rules is very restrictive. Low-impedance microphones, tuners, most preamplifiers and power amplifiers can all drive the mixer with ease. And so far as the load is concerned, most amplifiers and tape decks have high-impedance inputs that can be easily driven by the mixer. Note that since the mixer's output impedance is fairly high, it is wise to use a shielded coaxial output cable as well as shielded input cables. When building this project you might try putting all the inputs and outputs on the rear of the box and all the potentiometers and switches (you might like to add a switch to each input) on a nice looking front panel.

This wraps up the discussion on the mixer; the rest is up to you. After you've used this handy mixer for a while, you'll probably agree that the little money spent on this project was money well spent. ■



PARTS LIST FOR PASSIVE MIXER

C1, C2, C3, C4—1 uF., 250-Volt mylar capacitors
J1, J2, J3, J4, J5—Phono jacks
R1, R2, R3, R4—10,000-ohm audio-taper potentiometers
R5, R6, R7, R8—100,000-ohm, ½-watt, 10%
R9—100,000 audio-taper potentiometer
S1—SPST slide switch

5V/3A for Digital Projects

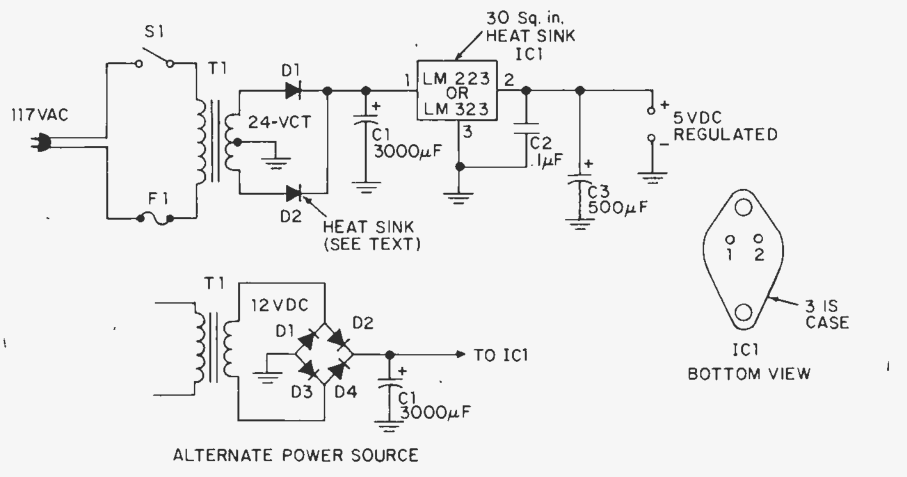
☐ The 5-volt power supply is almost the universal power source for digital projects. Only problem, is the 5 volts must be highly regulated, for a power line transient riding through the supply can zap a board full of ICs. This supply gives you full protection against transients, as well as providing tight regulation. The entire regulator is contained in IC1; no other components other than the filter capacitor and rectifier are needed. For full 5 ampere output IC1 requires a heat sink of 30 square inches; but if you use a metal cabinet 3 x 4 x 5 inches or larger the cabinet itself serves as the heat sink. Since pin 3 on IC1 is grounded (to the cabinet), all you need is some silicon heat sink grease between the IC and the cabinet—no insulator.

Power transformer T1 must be rated for the maximum current you will use or need. If you want the full 5 amperes T1 must be rated 5 amperes. But if you will need less current, say 2 amperes, T1 can be rated 2 amperes.

Rectifiers O1 through O2 are available with ratings up to 3 amperes in the standard coaxial mounting. For greater current capacity the rectifiers must be heat-sinked (electrically isolated) to the cabinet, or other sink. A 10-ampere bridge rectifier such as sold by Calectro and Radio Shack can be substituted, but make certain it is heat sinked to the chassis. ■

PARTS LIST FOR 5V/3A FOR DIGITAL PROJECTS

- **C1**—3000-uF, 25 VDC electrolytic capacitor
- **C2**—0.1-uF Mylar capacitor
- **C3**—500-uF, 10 VDC electrolytic capacitor
- **D1-D4**—See text
- **F1**—¼ ampere, 3AG
- **IC1**—5-volt regulator, LM223 or LM323
- **S1**—Spst slide or toggle switch
- **T1**— see text



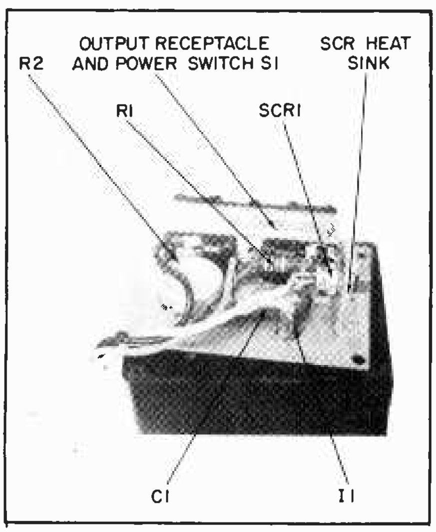
BUILD SELECT-A-SPEED MOTOR CONTROL

Beginner's project that provides choice of speeds for electric drill and other AC devices.

by the Electronic Assembly Class
Central High School, Bridgeport, Connecticut

□ We have all become conditioned to expect rapid transportation via fast cars, streamlined trains and supersonic jets. We've learned to expect instant . . . cash, credit, headache and stomach relief, rebates, replays and foods. No wonder we seldom think of speed in terms of anything less than maximum. 'Twould seem practically un-American.

However, those of us who have to work with non-ferrous metals, with plastics, or hard woods, find it important to get intermediate ranges of speed (rpm) with portable electric drilling equipment. The Select-A-Speed motor controls described here accomplish this goal. The smaller model continuously varies the rpm of portable ¼-inch electric drill motors, and the larger unit provides incremental speed changes using a switching arrangement,



View inside speed control which is continuously variable. Note SCR heat sink.

a feature not previously seen on a control of this kind.

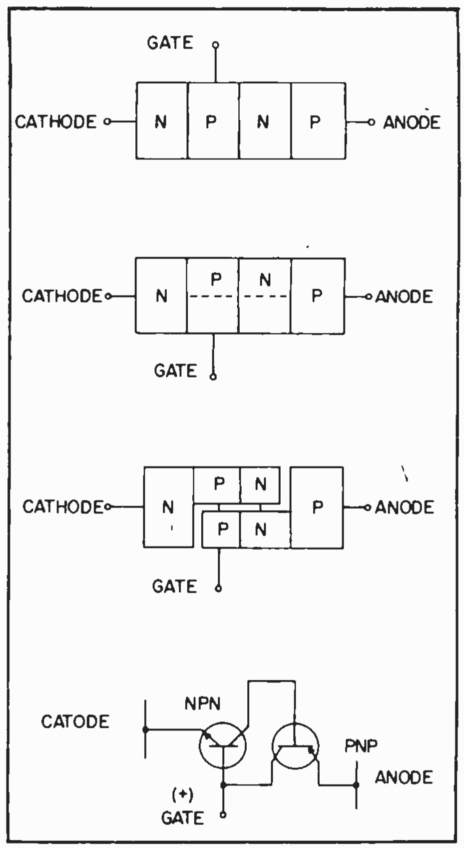
How It Works. The heart of these units, a silicon controlled rectifier (SCR) is a four-layer device whose construction is shown in the diagram. Alternate half-cycles provide the forward bias to cause the conduction, which occurs when the gate is properly triggered. The RC time constant, provided by the resistance and the capacitance controls the rate of charge of C1. Here's how the circuit acts.

C1 will discharge through I1 when the charge on C1 is equal to the ionizing potential of I1, thus providing the gate with a signal. Once triggered, conduction is sustained until the negative half-cycle reverse-biases the SCR at which time conduction ceases until the cycle is repeated. As more resistance is introduced the RC time constant is increased. The resulting increased phase shift further delays the time at which the gate is triggered. This causes the SCR to conduct for less time, and the available load power is thus diminished.

Can Control Many Devices. This versatile unit also functions well as a temperature-control device for pencil-type soldering irons, and also regulates the intensity of conventional desk lamps as well as photo-floods.

In addition it works well to control the speed of electric sewing machines and other small motor-driven hand tools. However, you *must not* try to use it to control devices which have transformers in them, such as soldering guns (pencils are OK), high intensity lights, etc. Of course it won't work at all with fluorescent lights, because lower voltage won't be sufficient to work the starter.

Any number of switch positions may be incorporated. One prototype of ours had ten. Whether you opt for three,



Silicon-controlled rectifier is a four-layered device. Simplification is shown at top. Gate voltage cuts off current between cathode (left) and anode (right). At bottom is a schematic diagram showing the SCR acts as though it were two transistors, an NPN and a PNP, together. Positive voltage on gate (of NPN) causes that "transistor" to conduct.

SELECT-A-SPEED

four . . . or ten, the option merits consideration. Having this choice eliminates sharpening drill bits so frequently as would be required without speed selection. Utilizing too high a speed for a given material is similar to "running in place" . . . neither gets you anyplace; both are dulling! Operating at speeds less than those recommended tends to cause breakage and invite physical harm to one's person.

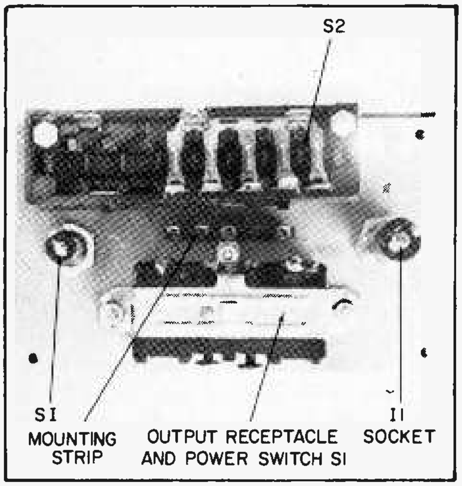
The resistors may be of any wattage and their ohmic resistance figured on the basis of the speeds most useful to you. We actually found the resistor values for optimum operation by using a resistance substitution box.

Parts placement is not critical. The controlling SCR should definitely be heat-sinked. Be sure that the SCR is electrically insulated from the sink or chassis. It is necessary to use silicone grease to insure proper heat transfer. Don't exceed the wattage rating of the SCR!

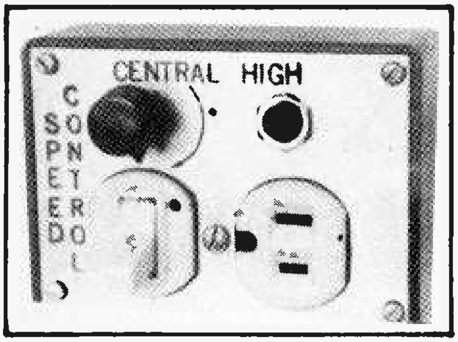
All switches used in our prototype models were bought through a source of surplus supplies. Each was modified to meet our particular needs. Incidentally, we noted no appreciable difference in speed between conditions of load and no load.

A photograph of the waveforms was taken across the load with the SCR as the controlling device. The SCR was apparently conducting during 90 degrees.

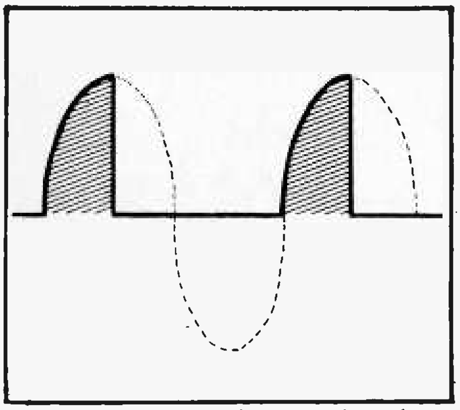
The industrial electronics class of the Career Education Department of Bridgeport Central High School worked on this project. Special credit is due Anthony D'Andrea, Torcato Caldas, Brad Hechler, and Chris Shamiss. Class instructor, under whose supervision this project was completed, is Edward M. Allen. ■



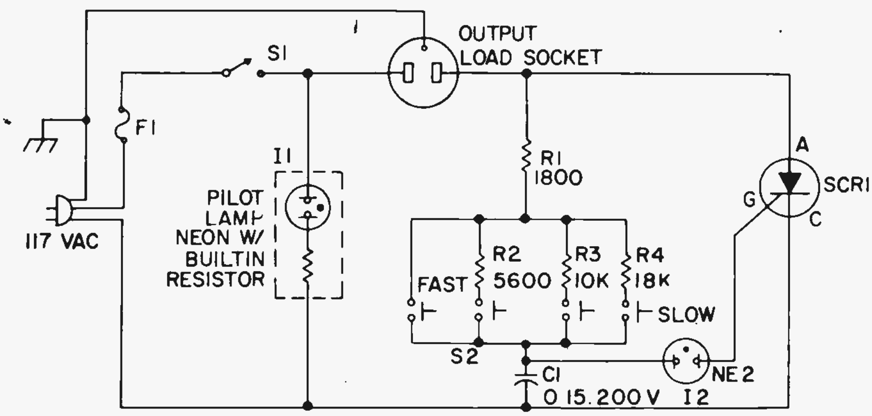
View inside 4-speed control shows pushbutton switch at top. Similar to fan controls.

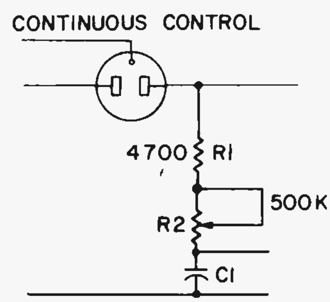


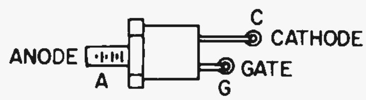
Variable-speed unit uses potentiometer for smooth, continuous control.



Oscilloscope screen shows portion of AC sine wave during which SCR permits current to flow (cross-hatched parts).







PARTS LIST FOR 4-SPEED CONTROL

C1—0.1 to 0.2-uF, 200-V DC (or better) capacitor
I1—Indicator light, neon, with resistor built into holder, 117 VAC
J1—Outlet socket and toggle switch, duplex unit, 117 VAC (from electrical or hardware store).
Q1—Silicon-controlled rectifier, 200 VDC or better, 8A (Motorola HEP-R1243 or equiv.)
R1—1800 ohm, ¼- or ½-watt resistor
R2—5,600-ohm, ¼- or ½-watt resistor
R3—10,000-ohm, ¼- or ½-watt resistor
R4—18,000 or 20,000-ohm, ¼- or ½-watt resistor
S1—part of J1, above
S2—4-position pushbutton switch, heavy duty electrical (10A or better). From electrical or hardware store (similar to switches used on large fans, blenders, etc.)
Misc.—Aluminum utility box, 6-in. x 3- or 4-in. x 2-in. or more

PARTS LIST FOR CONTINUOUSLY-VARIABLE CONTROL

Substitute the following parts in the 4-speed control list above:
R1—4700-ohm, ¼- or ½-watt resistor
R2—50,000-ohm potentiometer, linear taper
Note: omit **R3** and **R4**.

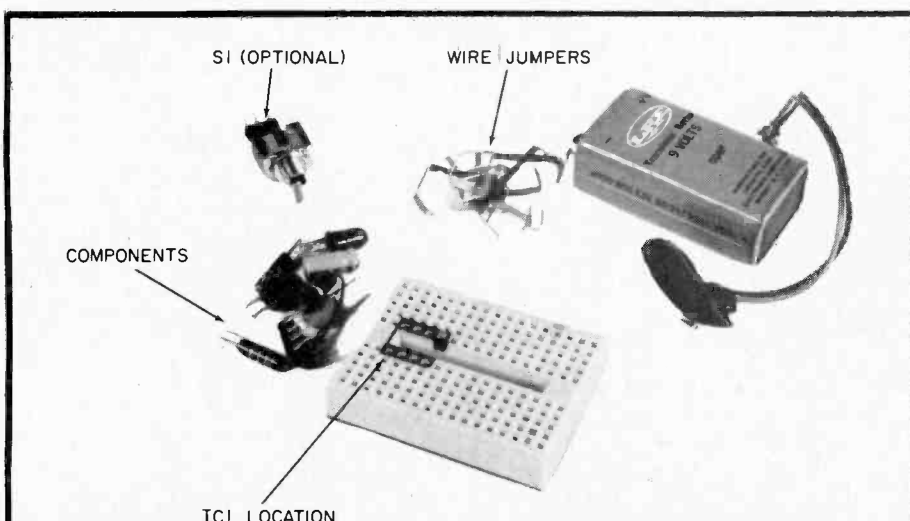
555 TESTER

by Martin Weinstein, WB8LBV, KDT5787

You can test surplus 555 integrated circuit chips in one second with this easy-to-build, simple, project.

ONE OF THE MOST frequently-used integrated circuits today is the 555 timer chip. It's an 8-pin IC, most often found in the Mini-DIP package (rectangular, with the pins in two rows or four each of the long sides). It's also seen in the less-common round transistor-like shape, the TO-5 or TO-99 packages.

It's an IC which can produce a time-delay from a few micro-seconds to about an hour, with five percent accuracy. It can also run free as an oscillator, at frequencies as high as a megahertz (1 MHz) or as low as one pulse per hour! The only external parts are one or two resistors and a capacitor. It can also be used as a comparator, a Schmitt trigger, a controlled switch, and much much more. And today, even though the prices of new integrated circuits are still coming down, you can find untested 555s on the surplus market at great bargains.



Handful of parts includes two LEDs, three resistors, two capacitors, two inches of #22 solid wire for jumpers, optional AP Products, solderless breadboard, switch.

This project shows a ready way to test these widely-used, widely-available ICs.

Inside, the 555 has many transistors and other components, arranged to make up the following circuits: two comparators, one flip-flop (which is a bistable multivibrator), and an output stage. Connections are brought out to several terminals (up to 8) which hobbyists call "pins."

Inside the 555. First we have a comparator, a kind of balancing beam. It looks at two inputs and compares them. Some comparators supply an output when the voltage at one of its inputs is *larger* than the other. Other comparators, like this one, provide an output when both inputs are *equal*.

Now look at the two inputs this comparator is connected to. One input is a voltage divider inside the 555. This consists of a string of three identical resistors connected between Vcc (B+) and ground (−). Since this leg of the comparator is connected 2/3 of the way up the resistor string, it always measures a voltage equal to two-thirds of the supply voltage.

The other input leg of the comparator is connected to the external timing chip capacitor you use in your particular 555 IC timer circuit. The timing capacitor is charged through a timing resistor (two, actually, series-connected and tapped by a connection to pin 7 in most applications). Together, the timing resistor and timing capacitor determine how fast the 555 will oscillate (or how long an output pulse it will deliver). Here's how.

When the charge on the timing capacitor at pin 6, the *threshold* input, reaches a value equal to the voltage at the on-chip voltage divider (2/3 Vcc), the comparator turns *on*. When the comparator turns on, it toggles the flip-flop that switches the 555 output.

The flip-flop also turns on a transistor that discharges the timing capacitor.

How It Works. To start the 555 working, a trigger pulse at pin 2 initially sets the flip-flop to turn the 555 *on*. It does this by comparing the input pulse to 1/3 Vcc at a second comparator. This turns off the transistor across the timing capacitor and allows the timing capacitor to begin to charge. The 555 stays *on* until the timing cycle turns it *off* again by resetting the control flip-flop.

The timing cycle can be made to start over again by applying a pulse to the *reset*, pin 4. This turns on the transistor that discharges the timing capacitor, thereby delaying the charge from reaching 2/3 vcc.

In some applications, the *reset* (pin 4) is connected to the *trigger* input

555 TESTER

(pin 2) so that each new input trigger signal restarts the timing cycle.

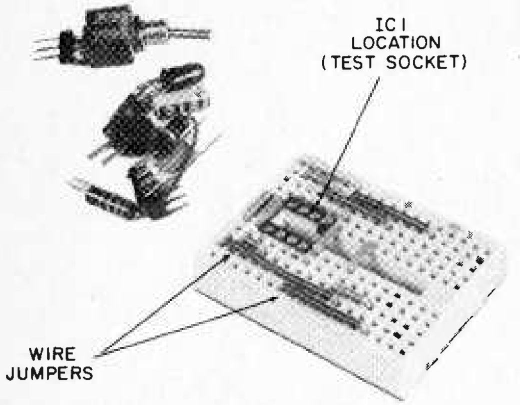
When the *threshold* voltage at pin 2 drops, at the end of a timing cycle, that voltage drop can be used to start a new timing cycle immediately by connecting pin 6 to pin 2, the trigger input. This is how the 555 works when it is used as an astable (free-running) oscillator.

The 555 output circuit includes two high current transistors, each capable of handling 200 ma. One transistor is connected between the *output* pin 3 and vcc, the other between pin 3 and *ground*. Thus, so you can use pin 3 to either supply Vcc to your load (*source*) or provide a ground for your load (*sink*).

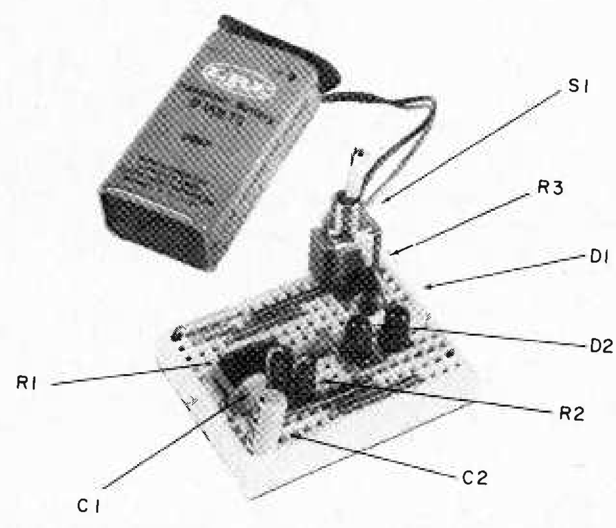
Testing is Fast and Easy. I once asked an applications engineer friend of mine how he could tell if a particular gadget of his would work. "Make sure it isn't between you and the door, and then plug it in and turn it on!" he said.

This 555 tester borrows on his advice. Instead of trying to measure specific conditions at each pin (the way most tube and transistor testers make their tests), it plugs the 555 under test right into a simple circuit and puts it to work. A good 555 will flash the LEDs alternately. A bad 555 will cause either or both of the LEDs to light and remain lit, but without flashing.

Construction is Fast. The prototype circuit you see here is built on a modern solderless breadboard, this one an A P Products terminal strip. A spring clip behind each hole grips both wires and component leads. Since each conductive metal spring clip is five "holes" long, the breadboard is organized as a group of five-tie-point terminals.



#22 solid wire cut to length for 14 short jumpers has been bent and inserted into breadboard. Eight holes used for test socket are outlined with fine-tip felt pen for convenience. Be sure to place dot near pin 1 to ensure plugging 555s in their right way. Circuit may be built up on perf board or other chassis if desired.



Circuit assembled on solderless breadboard, a 555 plugged in, and optional switch S1 in place. Use of different-colored wires makes it easy to trace circuit. Polarity of diodes is important.

Jumper wires are used to connect between terminals, and component leads may be inserted directly. Any solid wire from #30 to #20 slips right in and holds securely. I prefer to use #22 solid, and I've bought it in several colors to help me keep track of what's going where. A quarter inch or so of insulation stripped from each end provides a perfect jumper.

The Tester's Circuit. The 555 performs as a simple astable oscillator, alternately flashing the two LEDs. We can drive both LEDs from the single output (pin 3) because of the way the 555 is designed. It is made to either *source* (provide a positive voltage, and thereby current, to its load) or *sink* (provide a minus voltage—ground connection, for the load current) its output. So by connecting one LED from B+ to pin 3 (sinking output) and the other between pin 3 and GND (sourcing output), we can take advantage of both capabilities.

You will notice that I've not included the usual current-limiting resistor in series with each LED. What actually happens is that a single resistor, R1, limits current through the entire circuit. In addition to protecting the LEDs from too much current, it does the same for the 555 under test, and it also prolongs battery life. Finally, it also protects the tester's circuitry in case the 555 under test has a dead short between any combination of pins, as often happens when ICs are removed from surplus printed circuit boards, leaving solder bridges.

The circuit's time constant, which governs the flashing rate, was chosen to make the flash easily discernible. Too quick a flash rate could appear to be a steady *on*. Too slow a flash might look like just one LED lighting. You can alter the flashing rate by changing the value of C2.

R2 and R3 also affect the flash rate, and the ratio of their values determines the *duty cycle* (how long one LED is illuminated versus how long the other is on, in this case). While other values for R2 and R3 could have been chosen, the values shown here were used for several reasons. For one, they're standard and easy to find. Second, they yield a very readable flash rate. And most important, they fit within the ratio-of-resistances required by the internal workings of the 555.

Building It. If this is your first experience with solderless breadboards, it's only fair to warn you that they can be habit-forming.

You'll have the circuit together in less time than it takes to lay out a printed circuit board or solder up a haywire circuit. You won't need any hardware at all. You can even leave out the switch if you like, and plug and unplug the leads to the battery.

One of the reasons these solderless broadboards are so fast and easy is that they're designed with a .1-in. x .1-in. hole spacing. Modern DIP (dual in-line package) ICs are designed with leads spaced in multiples of .1-in. So everything we use can plug right into the breadboard. An IC socket here would only be redundant.

This standard .1-in. spacing appears in another handy device that AP Products makes called a *header*. The header is a plastic strip with small contact posts every .1-in. You can break off as many of these as you need, with 36 of them being supplied on each strip. I soldered a piece of header to the back of a small toggle switch so it could plug right in, too. Another small piece soldered to the battery connector makes the entire project plug-in easy.

Follow the diagrams and illustrations as you place each part in position in the breadboard. Mark the breadboard with a felt-tipped pen to show where the 555 under test plugs in, and be sure to index pin 1. Also mark the positive and negative battery connection points.

Jumper Wires. Use #22 solid wire. Cut about ½ inch longer than jump (connection) needed. Strip ¼-inch of each end bare and bend at right angles. You will need one .1-in. jumper, one .2-in., six .3-in., one .4-in., one .5-in., one .6-in., two .7-in. and one 1-in. long.

Be very careful removing 555s from the tester to avoid bending their pins. Use an IC removal tool if you have one. If you don't a small screwdriver used as a lever in the deep depression in the center of the IC will let you ease it out safely.

Smoke Test. It won't burn up, if you've been careful. There aren't very many ways to do this circuit wrong. But just to be on the safe side, double check your wiring before you connect the battery.

Then, with no 555 in the circuit, connect the battery and turn the switch (if you've included it) *on*.

If you've wired everything correctly, both LEDs will light. The most likely cause of a LED not lighting, assuming your wiring is correct, is that it has been plugged into the board backwards.

Now go ahead and plug in a 555. Choose one you know is good. The LEDs should start flashing. Play with the value of C2 to alter the rate.

Using the Tester. Since the solderless breadboard is its own chassis, you're ready to go.

I have yet to find a surplus 555 that isn't in a DIP package, but even those 555s that come in transistor-style TO-5 or TO-99 cases usually follow the same lead arrangement. So identify pin 1, plug your 555 in and turn it on.

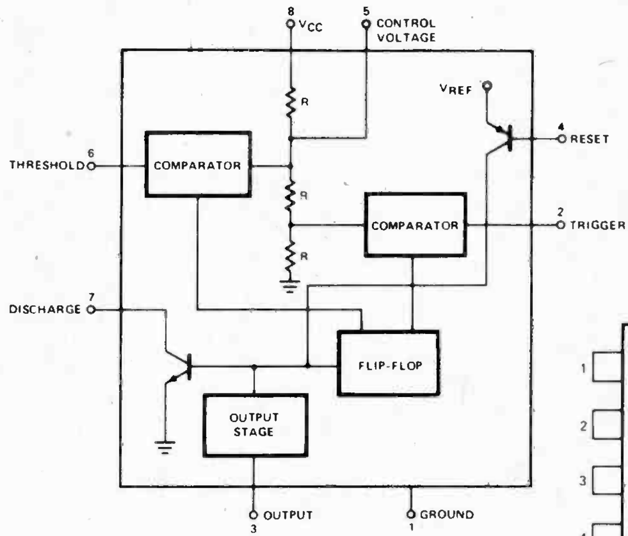
If both LEDs come on, your 555 is open. If only one comes on, or if neither comes on, your 555 is either open or shorted. If there are no visible solder bridges between pins and no pins are missing, the open or short must be internal. Perhaps you could use a 555 that tests bad as an ornament; you sure can't use it for electronics.

A good 555 will always flash both LEDs. It's that simple.

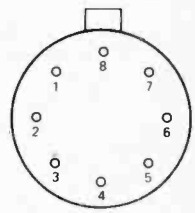
Your handy tester even provides a bonus. With a good 555 in place, you can use the pin 3 output as a clock pulse to drive TTL circuitry. You can use the pulse directly, but a small resistor or capacitor will help keep things safe. Remember to use pin 1 for *ground*.

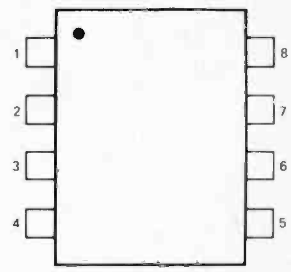
By the way, it probably took you longer just to read this article than it will take you to build your tester. ■

INSIDE THE 555

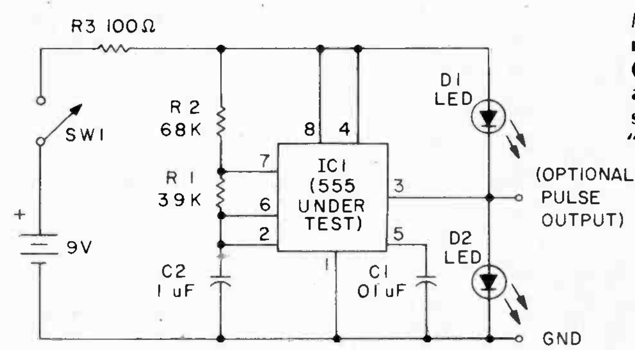


Block diagram shows major components of timer.



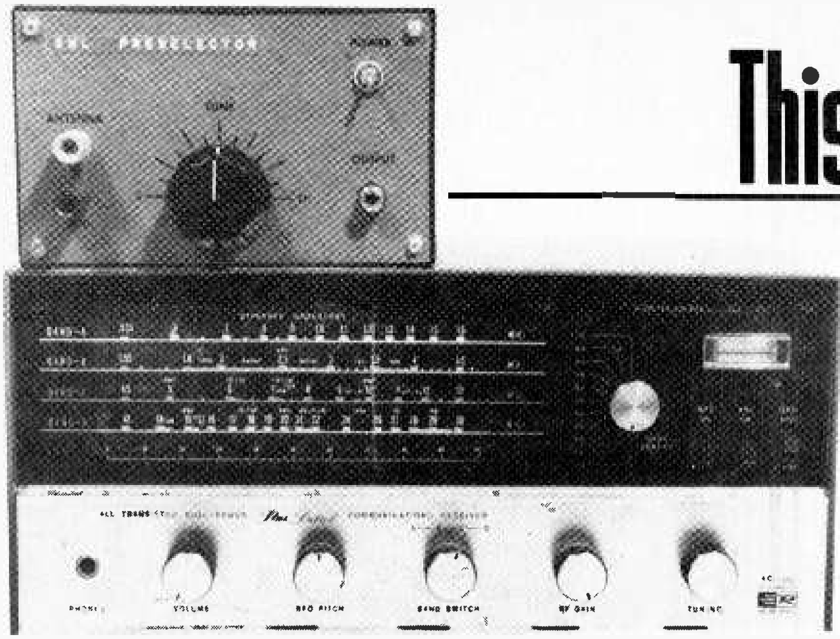


Most 555s come in rectangular mini-DIP (dual in-line package), but they're also found in round "TO-" package.



PARTS LIST FOR 555 TESTER

C1—.01-uF capacitor
C2—1-uF, 16-volts or better electrolytic capacitor
D1, D2—LED red indicators
R1—100-ohm, ½-watt resistor
R2—68,000-ohm, ½-watt resistor
R3—39,000-ohm, ½-watt resistor
S1—SPST subminiature switch (optional—see text)
Misc.—Jumper wire, #22 solid, insulated, various colors. Solderless breadboard and header strip—AP Products 217L terminal strip. Available at dealers, or order AP 923273, $4.75; Headers are 929834-01, $.87 for a strip of 36. Add $1.00 for postage and handling on mail orders to AP Products Inc., Box 110-EE, 72 Corwin Drive, Painesville, OH 44077.



This Piggyback SWL

Add 20 dB of valuable signal-grabbing power

by Herb Friedman W2ZLF

BACK BEFORE EVERYTHING came in transistorized subminiature packages, virtually all serious SWLs and radio amateurs used a preselector ahead of the main receiver. No, not a *preamplifier,* we said a *preselector.* A preamplifier simply provides amplification, usually over a broad range of frequencies. With early single-conversion receivers, and the new solid-state high performance, budget-priced, single-conversion receivers, a preamplifier amplifies the image signal interference along with the desired signal. But a preselector, that's a whole 'nother thing. A preselector is a tuneable, high-Q preamplifier that passes only the desired signal frequency, and usually provides considerable attenuation at the image frequency.

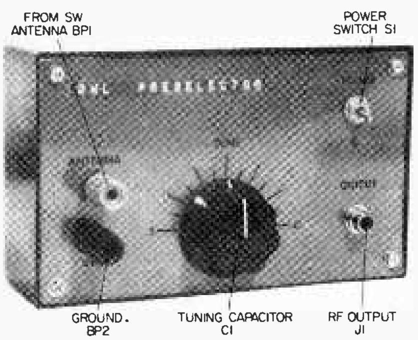
Unfortunately, preselectors have so much gain and sensitivity they had to be built like the Rock of Gibraltar in a cabinet almost as large as the rock itself in order to avoid self-oscillation. Many preselectors were as large as the boat anchors we used to call receivers, so like those old tube-type boat anchors, the preselector went the way of the Dodo.

But a preselector can still give a receiver a good solid kick in the antenna terminals, often digging out signals where you thought none existed. And the preselector can still reduce image interference in those inexpensive solid-state receivers that have terrific sensitivity and great stability, but poor image rejection because they're only single-conversion. What's that? You've got no room for a big boat anchor? Who mentioned anything about size? Using up-to-date technology and components, the same as you've got in that new receiver, you can build a rock-stable preselector that's got more selectivity than those old monsters, will work off an ordinary transistor radio 9-volt battery (or a lightweight line-powered supply) and will provide enough extra front-end selectivity to practically *squash* image interference in single-conversion receivers. Best of all, you can make the whole thing so small it can be glued right to the back of a sub-miniature tuning capacitor—hence the name—"Piggyback Preselector." The unit shown in the schematic and photographs provides from two to three S-units extra sensitivity (about 12 to 20 dB extra gain), depending on the particular receiver it's used with.

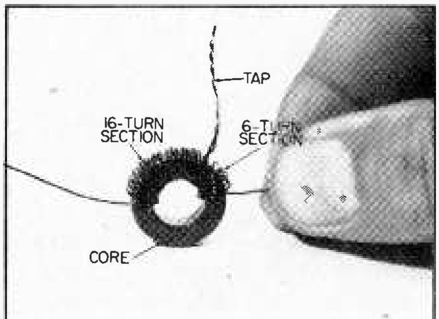
The Design. Input coil L1 is home-brewed on a toroid form. Since toroids have exceptionally high Q the input tuning is razor sharp—sharp enough to attenuate the image frequencies. In fact, if this unit is tuned to 10 MHz while the receiver is tuned to 20 MHz virtually no signal will pass through the preselector into the receiver. On the other hand, when the preselector is tuned to the desired frequency it can really snatch signals up out of the noise level.

Don't worry about static signals blowing Field Effect Transistor Q1 because it's a special type with built-in protection diodes from the gates to the source and drain. In normal operation the diodes are inactive, and Q1's input impedance is extremely high and does not load down L1. Transistor Q2 acts as a matching device and power amplifier, providing a low impedance output for the input of the associated receiver.

Both L1's input impedance and the preselector's output impedance have been adjusted so the unit delivers good performance with every combination of antenna and receiver. While it might be



Plastic cabinet may be used but the front panel should be aluminum or other metal. Input (BP1) and output (J1) connections must be kept apart.



A toroid coil is the easiest home-brew because neatness doesn't count. If the turns aren't spaced just so, or the turns unwind a bit as you make the coil, it won't make any difference. Just spread the turns so they take up about one-half of the form. Don't spread turns to take up entire form.

Preselector Will Make You a Pro in One Evening

possible to get slightly improved overall performance by specific tailoring of the input and output for a given antenna type and receiver, we make no recommendations and suggest you build the model as described with no changes or substitutions. Only if you cannot obtain the specified Q1 should you try a substitute, and a 40673 is suggested. The 40673, however, might require some experimentation with the values of R1 and R2. The correct values provide approximately 5 mA to Q1 and 1 mA to Q2. Bear in mind, however, that we suggest the unit be assembled exactly as described.

The unit shown covers the SWL frequencies from approximately 5 to 21 MHz, actually reaching the top of the 15-meter amateur band. To get optimum coverage of the 15-meter band one turn can be removed from L1 (we'll explain this later). This modification will provide a greater 15 meter adjustment range for tuning capacitor C1.

C1 is a sub-miniature tuning capacitor with a *long shaft* and a plastic dust cover over the stator and rotor plates. (It is available from Radio Shack as No. 272-1341. Do not substitute a similar capacitor that has a calibrated tuning knob and lacks the dust cover. The shaft on the specified capacitor also provides the panel mounting while the dust cover is the support for the rest of the project.)

Construction. We built the entire preselector, except the transistor radio battery which supplies the power, on a special type of perf board which has circles on the back of each hole to facilitate soldering and securing the components in place. We recommend, however, that you make a printed circuit board from the layout shown, unless you are somewhat experienced in point-to-point wiring. The location of the components on the circuit board is shown in another drawing.

You'll have no special assembly problems as long as you follow the parts layout shown in the photographs. The unit will be completely stable and free of birdies and dead spots as long as the input is at one end of the board and the output is at the other end. But if you re-arrange the layout and get the input and output within an inch or so of each other it will almost certainly oscillate, and fail to work.

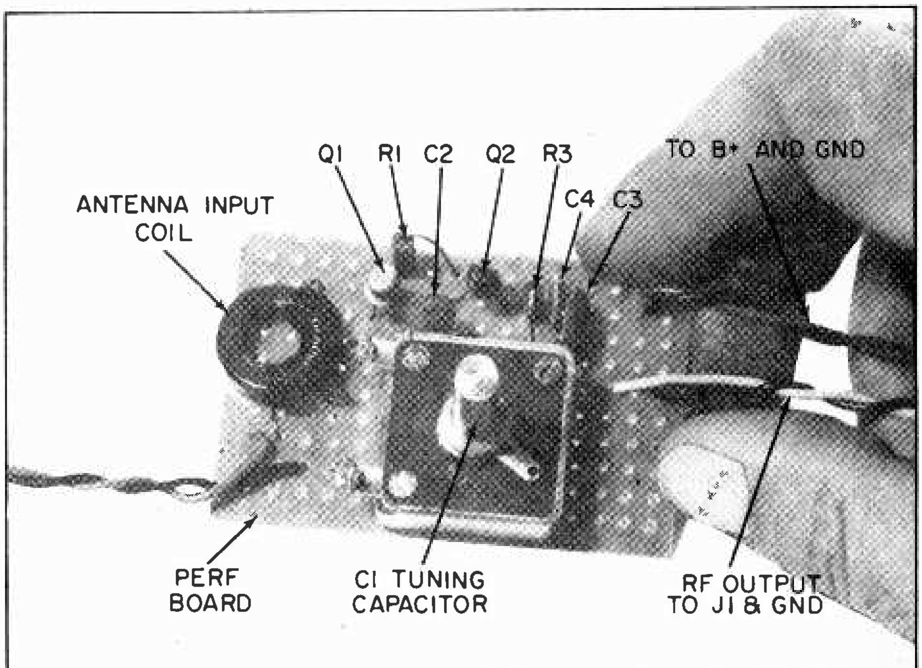
Mark off the approximate location of the tuning capacitor on the circuit board and then complete the board assembly, including the power, input and output wires. These can be about six inches long.

Toroid Assembly. L1 presents no winding problems as even sloppy assembly will work—that's the nice part about toroid coils. Use solid, enameled #24 copper wire to wind the coil. Clamp about three feet of wire in a vise and pull gently on the free end until the wire goes dead slack. By thus taking the spring out of the wire you make it so it won't unwind as you make the coil. Wind six turns, tightly, around the toroid core and bring the end out about two inches. Fold the wire back to the core, forming the ground tap, twist the wires a few times to secure them, and then wind sixteen additional turns *in the same direction as the first six.* Using a knife or razor, scrape the insulation from the wire ends and the tap. Then tin the wires and the tap with solder. Spread the turns so they are roughly equal-spaced, using about one-half the total core. Do not spread the turns to take up the entire core, as is usually suggested. This time, half way is best.

This coil will give frequency coverage with this tuning capacitor about 5 MHz to 21 MHz—just about to the top of the amateur 15 meter band. If you want to be able to tune through 15 meters with tuning capicitor C1, eliminate one turn of the coil's longer winding—make it 15 turns. Do not make any changes to the initial six turn winding. This is the antenna winding and remains the same.

Board. Construction. Assemble the perf board circuit as shown—everything except C1. Using silicone rubber adhesive such as G.E.'s RTV, cement the circuit board to the back of C1. After the adhesive has set (overnight), connect C1 across L1's secondary. Make certain C1's rotor, which connects to the tuning shaft, is wired to L1's grounded tap. Use an ohmmeter to determine C1's ground (shaft) terminal if you can't tell by looking. But don't guess; if you guess wrong the tuning will change when you remove your hand from the tuning knob.

Okay, it's all wired. What will you do with the piggyback preamplifier? Since the total current drain is about



The completed preselector ready for installation in a cabinet. The circuit board cements to the back of the tuning capacitor. Note that L1 is flat against the board and all wiring to other parts is also installed on the board. Board may be perf-type shown, or, recommended for beginners, the printed circuit type described in text.

PIGGYBACK SWL PRESELECTOR

5 mA you can use an ordinary transistor radio battery for a power supply and shove the whole thing into a plastic utility cabinet as shown. Just as long as the front panel is aluminum (or other metal) a plastic cabinet can be used.

If you don't like using battery power you can use a slightly larger cabinet and assemble the power supply shown in the schematic. But remember, you only need a 5-mA capacity, so keep T1 small. If you end up using a standard filament transformer for T1 the cost might exceed several years' supply of batteries.

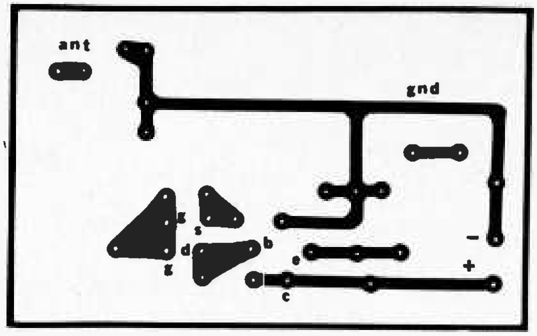
Final Connections. Use some kind of coaxial output connector for J1. Even a standard phono jack can be used. Use coaxial cable such as RG-58 or RG-59 between the preselector and receiver and keep it as short as possible.

If you have a *longwire* or *random* antenna use 5-way binding posts for the input (remember, the antenna post must be insulated from the panel). If you have a coaxial antenna system eliminate the ground binding post and substitute a coaxial connector for BP1. This connector can also be the phono type.

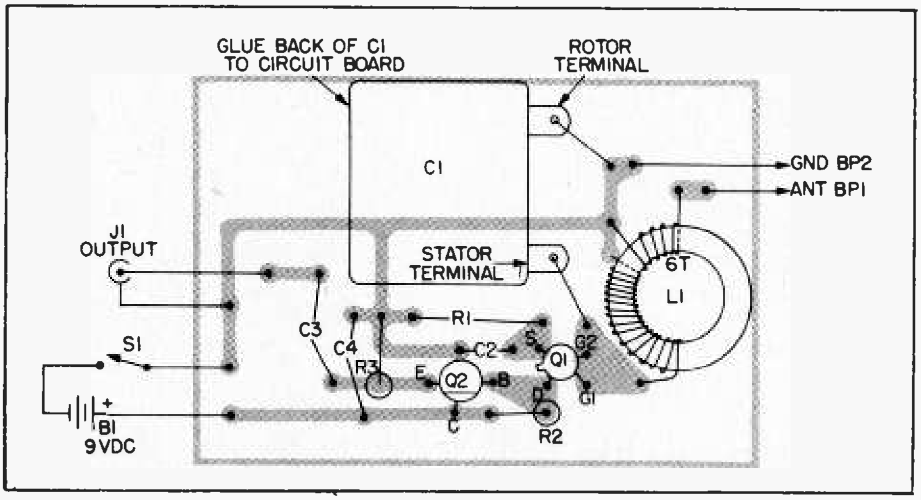
Calibrate! The tuning is so sharp the preselector must be tuned near the desired frequency or you might not hear anything at all in the receiver. Use whatever calibrations on the panel you find necessary to put the preselector tuning inside the ballpark.

After a signal is tuned in on the receiver, peak it with the preselector. If the receiver has an antenna trimmer or tuning control make certain you also peak the signal with the trimmer.

If some local signals come in strong enough to overload the unit, just detune it slightly to reduce its sensitivity and get rid of the overload. ■



Full-size layout for printed circuit board (foil side up) is shown here.



If you use the printed circuit board shown above you can locate the various components on the board by means of this drawing. Parts side is shown.

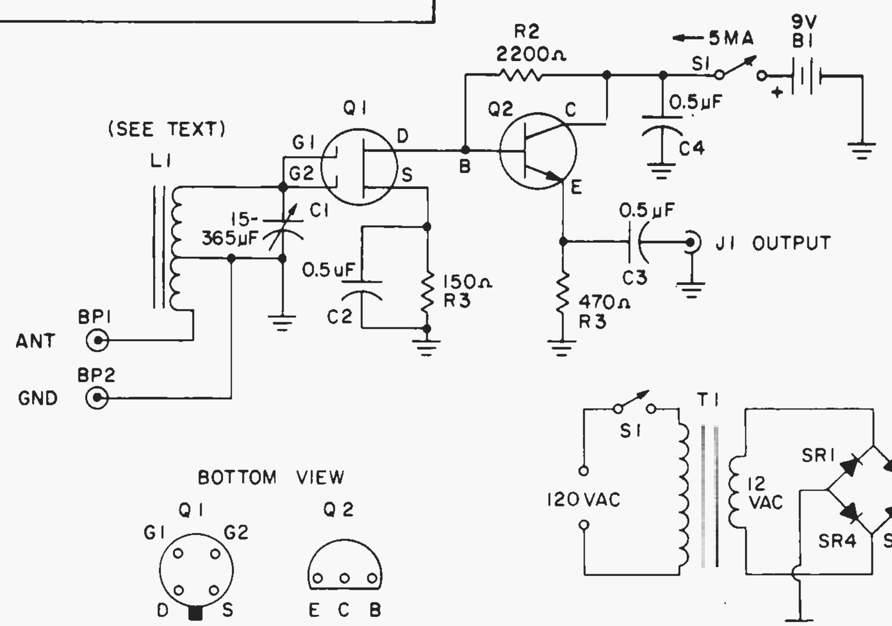
PARTS LIST FOR PRESELECTOR POWER SUPPLY

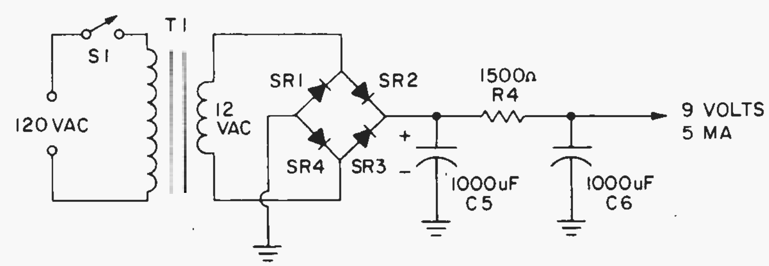
C5, C6—1000 uF 15 VDC capacitor
R4—1500 ohms, ½-watt resistor
SR1 through SR4—Silicon rectifier bridge, 50 PIV
T1—Power transformer 12-VAC secondary

PARTS LIST FOR SWL PRESELECTOR

B1—9VDC transistor radio battery
BP1, BP2—5-way binding posts
C1—365 pF subminiature variable tuning capacitor
C2, 3, 4—0.01 or 0.5 uF ceramic disc capacitors, 100 VDC
J1—Phono input jack
L1—Amidon T68-2 toroid coil form, $1.75 postpaid from Amidon Associates, 12033 Otsego St., No. Hollywood, CA 91607.
Q1—FET with internal protective diodes, RCA type 40822* or RCA-40673*
Q2—2N3394 transistor
R1—150 ohms ¼- or ½-watt resistor
R2—2200 ohms, ¼- or ½-watt resistor
R3—470 ohms, ¼- or ½-watt resistor
S1—SPST switch

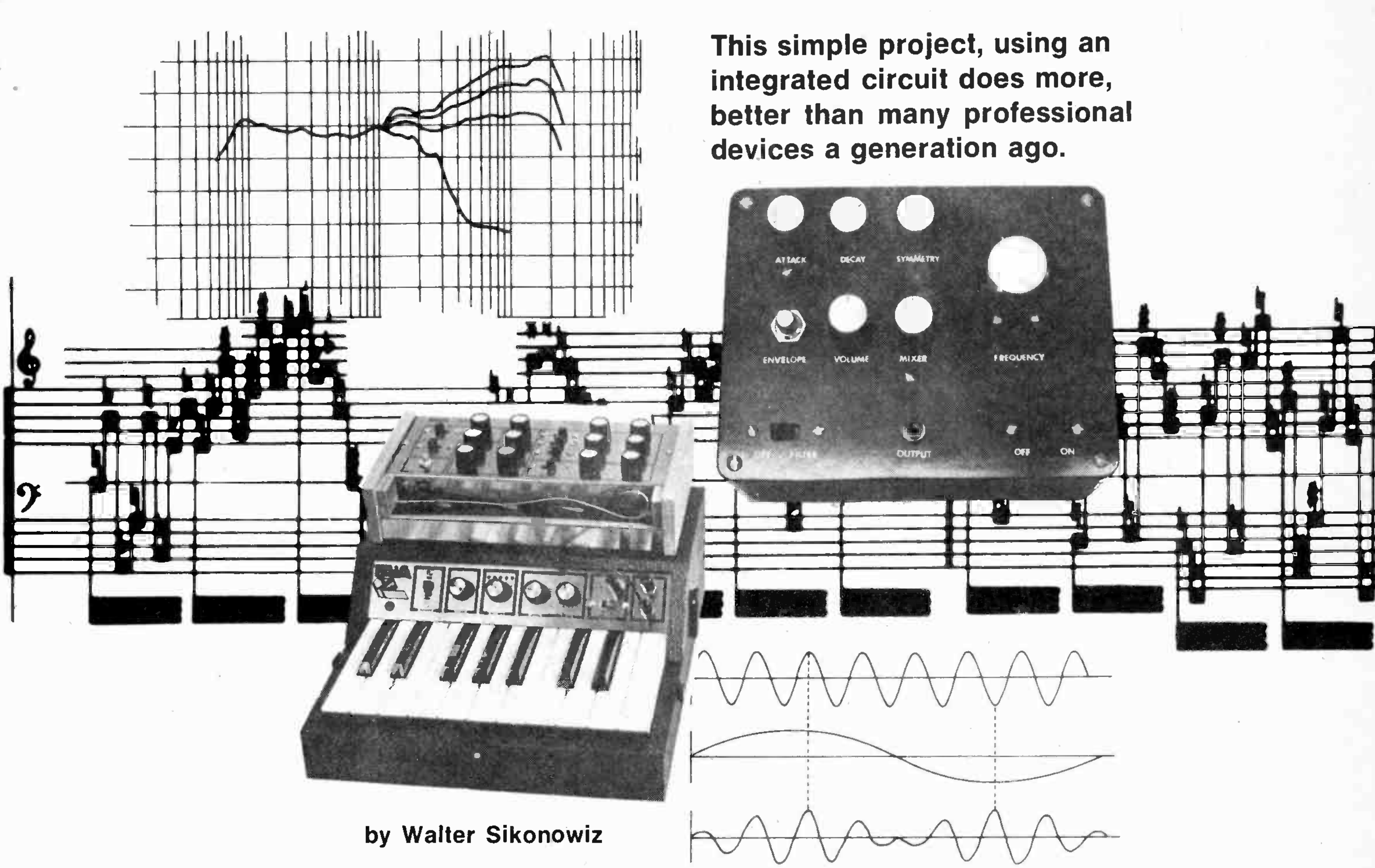
*Available at industrial distributors of RCA solid-state products.





SIMPLE-SYN, THE MUSIC MACHINE

This simple project, using an integrated circuit does more, better than many professional devices a generation ago.



by Walter Sikonowiz

IT WAS INEVITABLE that modern man would use electronics to imitate the sounds of earlier musical instruments. Just as the pipe organ has been used for centuries to produce sounds similar to trumpets, flutes, and strings, for the past thirty years electric pianos and organs have been used to mimic the pianoforte and the pipe organ. Only today, with the advent of microelectronics—integrated circuits and other improvements on the vacuum tube and discrete transistors—we are seeing an explosion in the design and manufacture of electronic musical instruments.

In the Beginning. We've had electronic instruments as far back as the 1930's, though they were far simpler than even today's toys. In France the Martinot and the Oniolone used piano-like keyboards to control electronic oscillators which produced sustained tones. They were the forerunners of the keyboards which most rock-pop groups use today to produce those massive 120-dB sound crushers at festivals and concerts—to say nothing of thundering dance halls and discotheques.

Early Instruments. The best-known electronic instrument before today's was the Theremin. It consisted of two radio-frequency oscillators. One had a fixed frequency, and the frequency of the other was controlled by the player moving one hand nearer to, or farther from a sensing plate. The difference between the frequencies of the fixed and the variable oscillator produced a tone capable of being shifted throughout the audio range. The volume was controlled by slight movements of the player's other hand. Because nothing was actually touched to produce the frequency and volume changes, the Theremin made a weird, gliding tone which could, in the hands of a skilled performer, be extremely effective. However, it could produce only one tone at a time, and the world of music had to await the development of much more sophisticated circuitry before true electronic musical instruments were developed.

Electronic Music Today. The modern electronic synthesizer came into being with the construction of a vacuum-tube monster with thousands of tubes and other components. Called the Mark I RCA Synthesizer, and built at Princeton, New Jersey, it was dismantled after several years of experimentation to supply parts for the Mark II. This machine is still in use, and though smaller than the Mark I, it measures about 17 feet square and 7 feet high. It is still in use in the Columbia-Princeton Music Center, in New York City.

In the early 1960s Robert Moog (pronounced like "vogue") began developing and producing a line of electronic music synthesizers which revolutionized music. Within the next few years several other firms began producing synthesizer equipment, and in the last several years the microminiaturization made possible by the development of integrated circuits has made possible synthesizers controlled by keyboards—so now real performance instruments exist.

The Nature of Music. Before describing the construction of our simple syn-

SIMPLE-SYN

thesizer, Simple-Syn, we should first examine the composition of its end product—the music itself. Musical instruments all produce sounds, which can be defined in terms of their *frequency* (also called pitch), *dynamics* (often described, inaccurately, as loudness), and *timbre*.

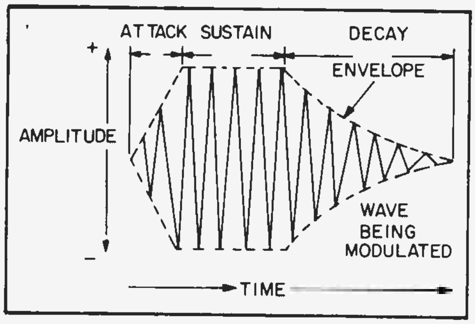
Timbre. This is the quality of sound that differentiates a trumpet from a violin when both are playing the same frequency. The timbre is the result of "secondary" frequencies (harmonics—also called "overtones") being present in the sound of the respective instruments. If there are many harmonics present, the sound is called bright. If there are only a few present, the sound is called dull or mellow.

These harmonics are *above* the basic pitch being played. The timbre of each instrument is different because each instrument has its own particular pattern of harmonics.

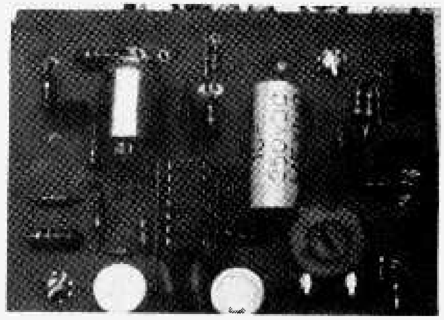
Assume both the violin and clarinet are playing the same pitch, A440. Then A440 would be called the fundamental. The first overtone has a pitch of 880 cycles per second (2x440); the second overtone has a frequency of 1320 cycles a second (3x440); the third overtone has 1760 cps (4x440) and so on.

The clarinet and violin have different overtones. The violin produces the fundamental and all the *odd* and *even* numbered overtones. The clarinet on the other hand produces the fundamental and the odd numbered overtones. The overtones are not as loud as the basic frequency and are therefore not recognized as the fundamental. The loudness of the higher numbered overtones decreases rapidly.

In other words, every instrument has its own set of overtones that make up its timbre. The two factors that account for the difference in timbre are: which overtones are present; and the relative strength of those overtones.



Typical musical note shows approximate areas of attack, sustain, and decay, Any or all of these may be much shorter or longer.



Closeup view of printed circuit board shows placement of the components. Be sure to use an IC socket for the IC.

There are four basic combinations of fundamental and overtones that are important in electronic music. These specific combinations are named: sine, triangle, square, and sawtooth. A sine wave is like a flute in quality.

A triangular wave consists of a fundamental and the odd numbered overtones. The overtones that produce the triangle wave are very weak in strength. The quality of the sound produced by a triangle waveform at an audible pitch is like a wooden recorder.

A square wave, like the triangular waveform, consists of the fundamental and the odd numbered overtones. The overtones that make up a square wave are more numerous and louder than the same overtones in the triangle. The square wave has a "hollow" sound to it, like a clarinet.

Lastly, the sawtooth waveform consists of the fundamental frequency and the even and odd numbered overtones. The sawtooth sound quality is very "bright" like a string or brass instrument.

Dynamics (loudness). Dynamics is the third property of sound. It has two important aspects. It includes *overall loudness*, which can vary from the rustle of leaves to the blast of a rocket. It also includes the changing ratios of sound as time passes.

For most musical sounds the loudness versus time characteristic may be broken into three parts:

1. Attack time—the time period from silence to when the sound reaches its maximum loudness.
2. Sustain time—the period during which the sound is maintained at some loudness level.
3. Decay time—the period during which the sound fades away to silence.

The voice is an example of a sound that has flexible loudness. A sound from a voice can begin very quietly and increase in volume, then hold some volume level for a time, and finally decrease the loudness of sound until it is silent.

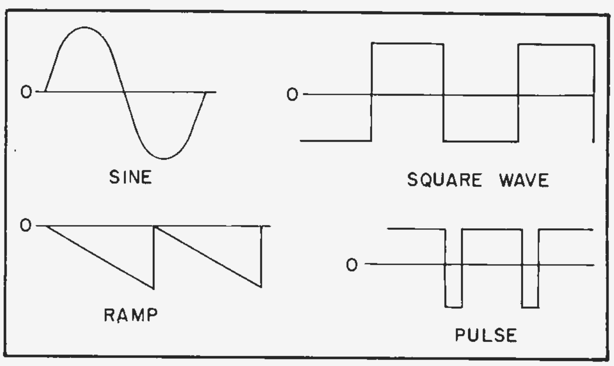
A graph of the variations in loudness in a typical sound is shown.

Two sine waves drawn in dotted lines are labeled "A" and "B." As you can see from the drawing, waveform "B" goes through two cycles in the time that it takes waveform "A" to complete a single cycle. Waveform "B" is therefore twice the frequency of "A" and is said to be the *first* harmonic of the *fundamental* frequency "A." If we draw another wave three times the frequency of "A" it will be the *second* harmonic, four times will be the *third* harmonic, and so on.

If at every point in time we sum together the amplitudes of waveform A and B the result is the waveform shown by the solid line. Note that while the new wave is shaped differently than

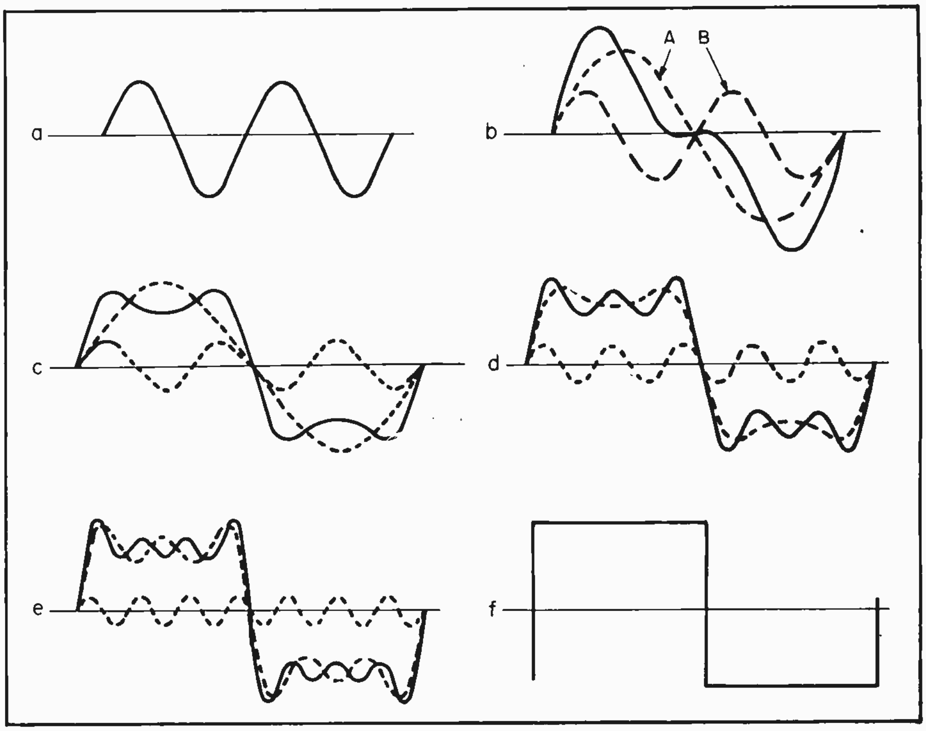
Small electronic musical instruments may be built from kits like this one from PAIA Electronics (address at end of article)

Musical tones may be generated by oscillators making simple sine waves, or any of several other shapes. The most common of these are shown. Note that the frequency of each note is the same, but the timbre (sound quality) will be different, depending on the wave-shape.



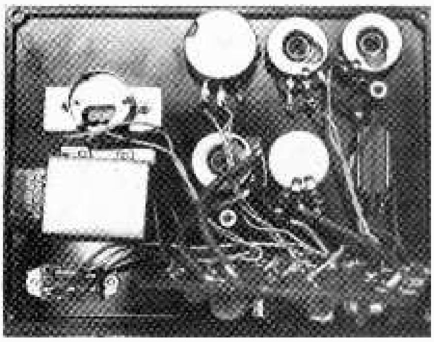
either A or B it has the same frequency (and consequently pitch) as the fundamental frequency A. If third, fourth, fifth and higher order harmonics were added into this wave the result would continue to change shape but the frequency would remain the same.

It is not necessary that every harmonic of a fundamental frequency be included in a wave and indeed the most musically interesting sounds have certain harmonics deleted. The square wave is a good example. It is difficult to imagine that the sharp-edged wave illustrated could be built up from smoothly changing sine waves, but it can, as shown in the progression of diagrams (a) through (e). In (b) the fundamental frequency is added to its third harmonic, producing the waveform shown by the solid line. In (d) the fifth harmonic has been added to the result of (b) to produce the new solid waveform and in (e) the seventh harmonic has been added to all the rest. You can see that the trend as higher order harmonics are added is to steepen the sides of the square and flatten and reduce the ripple in the top. When enough harmonics have been added the result will be a square wave. Notice in particular that not all harmonics are added together for a square wave, only the *odd* harmonics (3rd, 5th, 7th, etc.) are included.



Waveforms show how harmonics of sine wave, added sufficiently, can form square wave. At (b) the fundamental (A) and its first harmonic (B) add to produce shape (b). At (d) and (e) additional harmonics begin to approximate square wave. An infinite number of harmonics would make a perfect square wave, as in (f).

Making Waves. It is much easier to generate a complex ramp or square wave than a sine wave. Since synthesizers operate with harmonic-rich waveforms as their primary signal source there is no need to start out with a sine wave at all. The VCO's supplied with most synthesizers provide a variety of waveforms each of which provides different harmonic structures. Common practice is to use a relaxation oscillator to generate a voltage ramp which is then converted to triangle and pulse waves using simple shaping circuits. In some cases the triangle will also be shaped into a sine wave. These waveforms and their harmonic contents are listed in the Table.



Underside view of front panel shows printed circuit board in place, ready to be dropped into its case.

Building Blocks. Modern synthesizers are made up of one or more each of several different kinds of building blocks, just the way all component hi-fi systems include similar blocks (preamplifier, controls, power amplifier). These building blocks are mostly *oscillators, filters, envelope generators, mixers,* and *amplifiers.* Each circuit is itself fairly simple. When a number of them are connected together they can comprise a performer's synthesizer. To demonstrate the basic principles of the most important of these building blocks we are presenting Simple-Syn—a one-tone synthesizer which incorporates most of the principles needed for practical music synthesizers.

The simple synthesizer in this project shows how basic oscillators (tone generators) work, and how the frequencies they produce are modified to produce a wide variety of sounds.

Simple-Syn is capable of simulating many naturally-occurring sounds, as well as some unnatural ones. It will be useful as a demonstrator of the characteristics of sound, as well as a sound-effects machine for tape recordists. The output of Simple-Syn is sufficient to drive the *Aux* input of an amplifier or the *Line* input of a tape recorder. It may also be adapted to other uses, as will be discussed later.

Shown here is a diagram of a burst of sound. The time interval during which the sound's volume builds from zero to some reference level is called the *Attack* time, while the interval during which the sound remains at the reference level is called the *Sustain* time. Finally, the period during which the sound level decays exponentially back to zero is the *Decay* time.

As you can see, what we have here is an amplitude-modulated sine wave. Now suppose that this sine wave is replaced by some other periodic waveform of the same frequency but with a different waveshape. For instance, consider the ramp, square, and pulse waveforms shown. If you think that they will sound different from the sine wave, you're right. Although these waveforms all have the same frequency as the sine wave, they are aurally perceived as having different timbre.

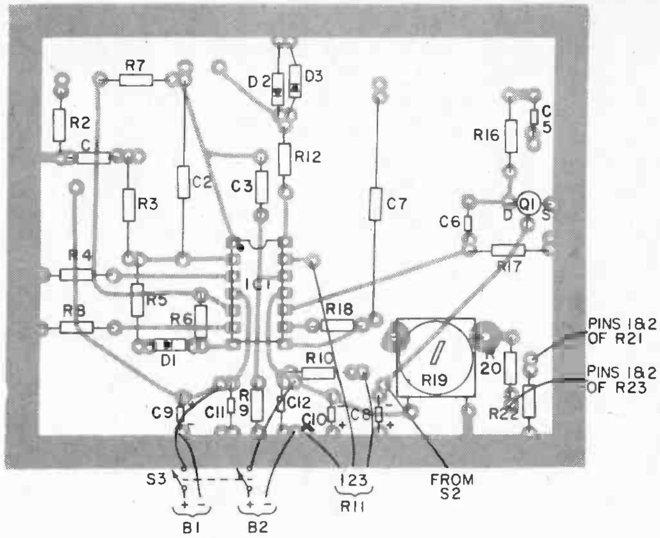
An important characteristic of natural sound generators is that they filter the waveshapes of the sounds they generate. For example, the body of a violin and the horn of a trumpet are natural resonators which reinforce some frequencies, and attenuate others. The overall shape of a waveform is correlated with the relative amplitudes of its harmonics. So, if a harmonic-rich waveform is filtered, we will alter its shape, since some of its harmonics will be attenuated more than others. Thus, *filtering* produces changes in *timbre.*

How the Circuit Works. Now let's turn

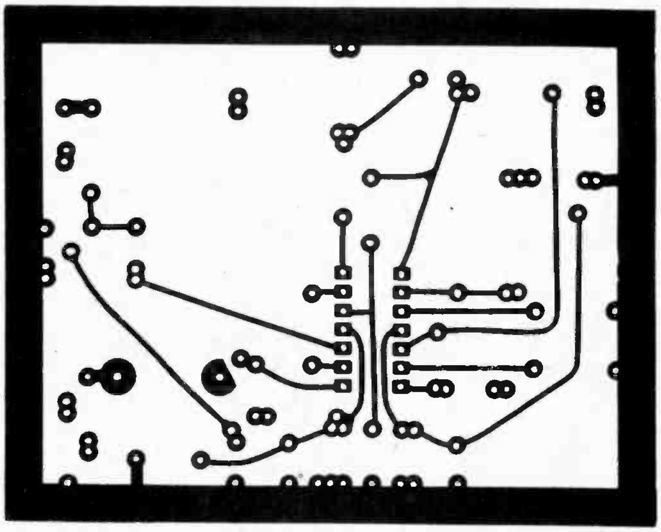
SIMPLE-SYN

to the schematic of the synthesizer. Sections A and B of IC1 comprise a voltage-controlled ramp generator, whose control voltage is supplied by potentiometer R1. C1 bypasses contact noise generated by rotation of R1. Section A is an integrator, which when fed a constant positive input voltage, produces an output voltage that decreases linearly with time. Section B is a Schmitt trigger which senses the output of A. When A's output drops below some lower reference level, Section B's output drops low, causing current to flow through D1 and R5. This current flow is opposite to (and greater than) the current from R1 that passes through R3. Therefore, A's output is forced rapidly upward. When A's output rises above some upper reference level, B's output swings high, D1 ceases to conduct, and A's output can once again begin to linearly drop. Thus, the whole process repeats itself.

The ramp waveform is fed through C3 to section C, which acts as a comparator. By adusting the *Symmetry* control, R11, we can shift the reference level at which the comparator switches, and thus the ratio of "high" time to "low" time of the rectangular wave at C's output. This rectangular wave is clipped by D2 and D3. The ramp and rectangular waves are mixed in R13 and fed to volume control R15. Closing S1 connects C4 across R15, thus forming a low-pass filter. C5 couples the signal from R15 to the voltage divider formed by R16 and Q1, an N-channel JFET whose resistance decreases as its gate bias decreases.



Placement of the components on printed circuit board. Perf board construction may be used since placement is non-critical. Controls, however, should be positioned approximately as indicated, for manual convenience.



Printed circuit board layout for Simple-Syn is easy to make even if you haven't made one before. Radio Shack has inexpensive kits for boards.

Large synthesizer, the ARP 2600, has four-octave keyboard, three voltage-controlled oscillators which can produce tones from three Hertz up to 20 kHz. In addition to voltage-controlled oscillators, filters, etc., it includes a ring-modulator, two envelope generators and an envelope follower, a random noise generator, three voltage processors, and a reverberation unit.

Gate voltage for Q1 is developed across C8, which we can consider initially discharged with S2 in the position shown. Therefore, Q1's resistance is minimal and the audio signal at its drain is also minimal. Flipping S2 upwards causes C8 to gradually charge through R19, R20, and R21; consequently, Q1's resistance increases and so does the volume. Flipping S2 down again causes C8 to slowly discharge through R22 and R23, and the volume drops once again. Finally, the audio signal from Q1's drain is coupled by C6 to the buffer amplifier formed by section D of IC1.

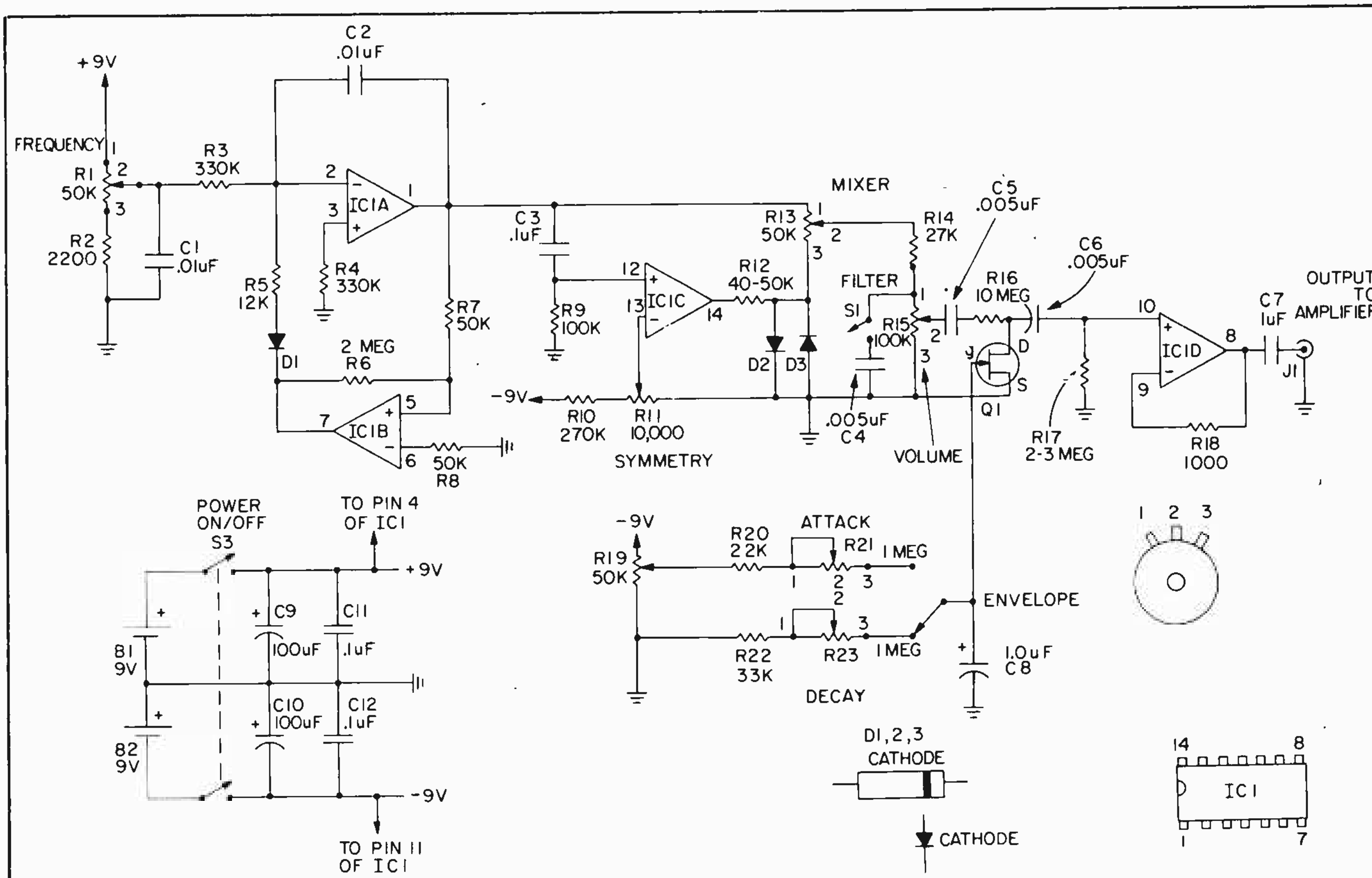
Building Simple-Syn. Construction of the synthesizer is not critical. The best method would be to copy the printed circuit layout shown. The board is simple enough to be copied using one of the kits available at Radio Shack and elsewhere. My Simple-Syn was built in a plastic box but a metal case is recommended in order to eliminate hum-pickup problems. The control layout shown in the photograph should be used. The completed printed circuit board will mount behind the control pots, with its foil side facing them, using 1¼-inch spacers.

After you have fabricated the board, install the IC socket. The other components may be installed in any order, but solder Q1 last. Be sure to observe proper orientation of Q1, D1, D2, D3, C8, C9, and C10. Trimmer R19 used in my prototype was mounted horizontally. The two large upper pads connect to its wiper. If you use a vertical-mounting trimmer instead you will have to change the position of the pads to accommodate it. Finally, install IC1 in its socket and set the board aside temporarily.

Try to copy the construction of Simple-Syn's prototype cabinet as closely as possible. *Frequency control* R1 mounts in the upper-right-hand quadrant and is actuated by the largest knob. Directly below that pot is an aluminum bracket holding B1 and B2. Right below the bracket is *Power* switch S3.

The first row of controls on the left-hand side of the front cover contains R21, R23, and R11 (from left to right). The second row contains S2, R15, and R13. Below the second row are *Filter* switch S1 and *Output* jack J1. With this arrangement, the interconnecting wiring is shortest, and all components mount on the cover, which is convenient when batteries have to be changed. Incidentally, the battery drain is less than 2 ma., so the batteries will last a long time.

After you've located and drilled all holes in the front panel, including those for the spacers that mount the printed circuit, solder short lengths of #22 stranded wire to the appropriate lugs of the controls, then mount them. Six-inch lengths of wire will suffice. This is easier than mounting the controls and then trying to solder to the leads in close quarters. Note that R14 is not on the



PARTS LIST FOR SIMPLE-SYN TONE SYNTHESIZER

C1—.01-uF capacitor
C2—.01-uF mylar capacitor
C3, 11, 12—.1-uF capacitor
C4, 5, 6—.005-uF capacitor
C7—1.0-uF, 250-VDC capacitor
C8—1.0-uF tantalum capacitor
C9, 10—100-uF, 16 VDC electrolytic capacitor
D1, 2, 3—1N914 silicon diode
IC1—LM324 quad operational amplifier IC
Q1—2N3819 JFET (N-Junction field-effect transistor)
R1—50,000-ohm, audio taper potentiometer (Allied Electronics 854-7333 or equiv. See end of Parts List for Allied's address)
R2—2200-ohm, ½-watt resistor
R3, 4—330,000-ohm, ½-watt resistor
R5—12,000-ohm, ½-watt resistor
R6—1.8 to 2.2-megohm, ½-watt resistor
R7, 8—47,000 to 51,000-ohm, ½-watt resistor
R9—100,000-ohm, ½-watt resistor
R10—270,000-ohm, ½-watt resistor
R11—10,000-ohm, linear taper potentiometer
R12—39,000 to 47,000-ohm, ½-watt resistor
R13—50,000-ohm, linear taper potentiometer
R14—27,000-ohm, ½-watt resistor
R15—100,000-ohm, audio taper potentiometer
R16—10-megohm, ½-watt resistor
R17—2.2 to 3.3-megohm, ½-watt resistor
R18—1000-ohm, ½-watt resistor
R19—50,000-ohm, linear taper potentiometer
R20—22,000-ohm, ½-watt resistor
R21, 23—1-megohm, linear taper potentiometer
R22—33,000-ohm, ½-watt resistor
S1—SPST slide switch
S2—SPDT pushbutton switch
S3—DPDT slide switch
Misc.—knobs, cabinet (preferably metal); 9-VDC transistor radio batteries (2); battery clips; socket for IC1, wire, solder, etc.

Allied Electronics' address is 401 East 6th St., Ft. Worth, TX 76102.

Workbenches are alive with the sound of music—wherever Simple Syn is being built! When the first caveman whistled the first tune, who would have thought that just five million short years later such sweet music would be floating from an electronics filled box? Well, Cro-mag-non Man didn't have the editors of e/e backing him up. Today, you'll find that building a state-of-the-art music machine can be as simple as Do-Re-Mi following our PC board foil and component side layouts. You'll find dozens of uses for the Simple-Syn, especialy if you make tape recordings and are in need of special effects. Besides music, Simple-Syn can be used to imitate foghorns, sirens, whistles and can make eerie, creepy, wailing noises like from the soundtrack of a Grade B science-fiction movie of the Fifties. But, more to the point, Simple-Syn can be calibrated to produce some really outrageous music. Just calibrate the frequency control, and the Simple-Syn can span more than three full octaves, a wider range than many popular singers of today command.

SIMPLE-SYN

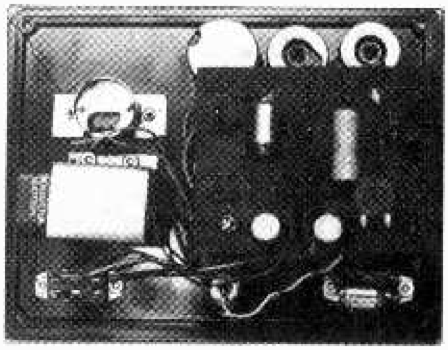
circuit board—it mounts point-to-point between lug #2 of R14 and lug #1 of R15. Likewise, C4 is off the board, wired between S1 and R15 as the schematic indicates.

Position the front panel face down on a table, and next to it place the printed circuit board, foil side up. Connect the control leads to the pads indicated on the board by inserting each lead into the appropriate hole from the foil side and then soldering. Trim off the excess wire that protrudes from the component side of the board. When the connections have all been completed, mount the board foil side down behind the controls. All the wiring will now be underneath the board, and your project will not be cluttered by dangling wires.

Final Adjustment. When Simple-Syn is completed, only one adjustment must be made. Turn on the power and adjust R21 for minimum attack time, and then R15 for maximum volume. Press S2. Now turn R19 fully to the right, and then fully to the left. Leave it at whichever end provides a loud tone in your speaker (the opposite extreme should produce silence). Now turn R19 back until there is a just barely-noticeable diminishing of sound intensity. The correct position for R19 is anywhere between R19's present position and the position it was in previously. You will notice that the position of R19 affects the attack and decay times somewhat if you play with those controls. Choose a position for R19 (within the two bounds previously indicated) that produces the most pleasing attack and decay behavior.

Using Simple-Syn. If you make tape recordings, Simple-Syn can be used to imitate foghorns, train whistles, sirens, musical instruments, insect buzzes and hums, as well as surreal science-fiction-movie sounds. In conjunction with a small amp and loudspeaker it can provide realistic horn and whistle effects for a model railroad. You might use it to replace your humdrum doorbell with some really wild sounds. Finally, Simple-Syn can be used as a musical instrument. All that is necessary is that you calibrate the frequency control, perhaps using a pointer affixed to the frequency knob and a scale with the positions of the various notes marked on it. Simple-Syn spans more than three octaves, so the larger scale you use, the easier it will be to calibrate. Calibration is easiest with a frequency counter, but you can also tune it by ear, using a piano as reference. In addition, you can

Completed prototype shows layout of controls. If your cabinet is larger you should still stick to this physical layout, to keep internal leads as short as author did.



Here's what the author's prototype looks like inside. Everything mounts on the top panel, so the cabinet body is used just for support. If you use a metal cabinet (recommended) it will also serve to minimize possible hum pickup.

replace the 9V. batteries with 8.6V. mercury cells, since the frequency of the ramp generator is voltage-sensitive. Your calibration with mercury cells will stay accurate because, unlike zinc-carbon cells whose voltage decreases with age, a mercury cell's voltage remains quite constant throughout its useful life.

Final Remarks. A few final remarks about operation of the synthesizer might be helpful. First, the *Symmetry* control will have its maximum effect when the *Mixer* is rotated to yield a pure rectangular wave; its effect will be inaudible when *Mixer* is rotated to pure ramp. The effect of *Symmetry* and *Mixer* controls, which vary the harmonic structure of the output, will be most evident at low frequencies. This is because the important harmonics (all those up to about the thirtieth) of the higher frequency tones fall above 15 kHz. Beyond 15 kHz the human ear has a rapidly diminishing sensitivity. Thus, a high frequency ramp won't sound tremendously different from a high frequency rectangle because the human ear does not respond to all the important harmonics.

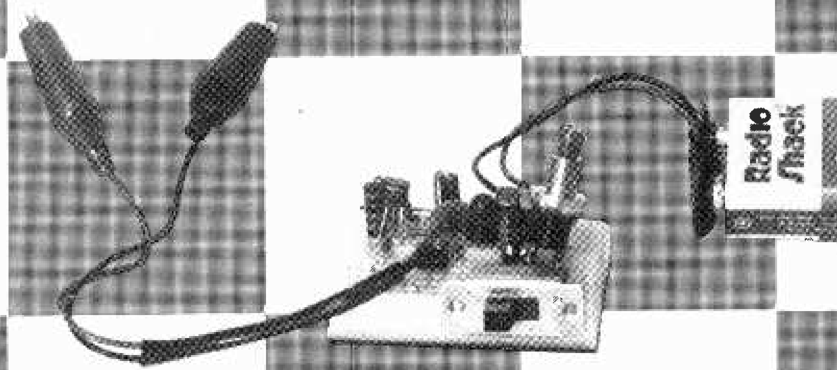
The effect of the *Filter* control will be to attenuate the higher harmonics of a waveform, and produce a more mellow sound. In most natural sounds decay time is longer than attack time. Try using a long attack time together with a very short decay time for a really strange effect. Finally, if you are feeding the synthesizer's output into your hi-fi system, be careful not to sustain a loud tone for too long a time. Home speaker systems can handle large amounts of power only on a transient basis; sustained operation at high power can burn out voice coils.

Learning More About Synthesizers. If you'd like to learn lots more about how today's practical electronic musical instruments work you can get an excellent booklet called the *Synthesizer Primer* by writing to Electronic Music Laboratories, Box H, Vernon, CT 06066. If you're interested in knowing more about their extensive line of Synthesizers, say so, and they'll send you literature and prices, as well as a fascinating 7-inch phonograph disc of five short selections performed on EML synthesizers.

Another good source of information on the subject is PAIA Electronics, Inc., Box 14359, Oklahoma City, OK 73114, the makers of a wide variety of kits for synthesizers and allied instruments. They have several very interesting low-cost modules for producing all sorts of sounds, including wind, surf, chimes, in addition to musical and other sounds. The PAIA "Gnome" micro-synthesizer produces many sounds, such as winds and flutes. Gnome kit costs $48.95. For more information circle number 71 on the Reader Service coupon.

If you're into really heavy performing instruments you can look over the state-of-the-art models being sold by ARP Instruments, 45 Hartwell Ave., Lexington, MA 02173. ARP will send you a record demonstrating the sounds of the ARP Omni, which they call the world's first symphonic electronic keyboard, for $1.00. Moog and Buchla synthesizers are also still being produced, and are available in many music stores. ■

BUILD CHECKERBOARD FOR QUICK TESTING



A handful of parts plugged into solderless breadboard make a tester for crystals, diodes, LEDs and lots more.

by Martin Weinstein

☐ I built a crystal tester several years ago and had an accident. Two of the connections were accidentally shorted together when I soldered the parts together. As a result, I soon discovered that my crystal tester was also good as a diode tester, a LED tester, a continuity tester, an electrolytic tester and more.

Now *that's* what I call a *happy accident!*

The whole circuit was built onto a scrap of printed circuit board and mounted in a small plastic box. I've used it for years, and it's come in handy dozens of times. Recently, while chatting with a couple of ELECTRONICS HOBBYIST editors it occurred to us that some of you might enjoy this handy little gadget. So I rebuilt it one evening on a small, inexpensive solderless breadboard. And now I can pass the secrets of this marvelous little *Checker Board* on to you.

What It Can Do. Checker Board started out as a crystal tester, with the desired action that a good crystal lights the LED and that a bad crystal won't. You can also use it to check out so many other components with just as simple an indication. These are some of the things you can test with your Checker Board: lamps, switches, diodes, LEDs, cables, capacitors, crystals, printed circuit traces, connectors and more. You can even use Checker Board to test itself!

How It Works, Part One. Transistor Q1 and the parts near it, R1, R2, C1, and C2, work together with the crystal you connect into the circuit as a simple crystal oscillator. Without a good crystal, the circuit will not oscillate. When it does oscillate, a signal appears at the emitter of Q1.

Capacitor C3 passes this signal to diodes D1 and D2, which are connected as a rectifier. They convert the signal (which is a high-frequency AC signal, at the frequency of the crystal) to a bumpy DC signal. C4 smoothes out most of the bumps. As result, the signal that leaves Q1 arrives at Q2 as a small DC voltage. Q2 then acts as a switch. When the DC voltage appears at its base, it completes the circuit from the battery and switch, through R3 and the LED, to ground. When this happens, the LED turns on.

With no signal coming out of Q1, no voltage appears at the base of Q2 so it doesn't turn on, and neither does the LED. R3 limits the current that can go through the LED to keep it from burning out and to help give it a very long life. It also lengthens Checker Board's battery's life.

And that's how Checker Board checks crystals.

How It Works, Part Two. Take a good look at R4. It acts as a kind of cheater, connecting the cathode end of the LED to the red clip. So, when there's no crystal in the circuit, R3, R4 and D3 are the only parts of the circuit actually connected to the clips, the switch and the battery. The equivalent circuit is shown nearby. As you can see, whatever you connect to the alligator clips then completes the circuit to light the LED. The purpose of R4, here, is to keep this mode of operation from interfering with Checker Board's performance as a crystal tester, since that's why we built it.

Building Checker Board. Use any construction technique you feel comfortable with. Nothing is very critical, and you can try lots of other values for any given component and still have a Checker Board that works.

The Checker Board you see here was built on a small solderless breadboard from AP Products. It's fully described in the Parts List. You can use any size wire from #20 to #28 to make the connections between terminals, and most components' leads plug right in.

You can help the switches, battery leads and alligator clip leads plug right in, too, if you use AP Headers. They're small contact posts embedded in a plastic strip at precise 1/10-inch intervals, so they can plug right into the breadboard. Just break off the number of posts you need from the rest of the strip, solder your connection to the short end and plug the long end into the breadboard.

I used small U-shaped pieces of bare wire plugged into several holes in a row to form a contact pad area, connected to each clip lead. This makes testing larger components as easy as touching

CHECKERBOARD

their leads to the bare wires.

You can use either a momentary switch, like a pushbutton, or any spst switch, or both for S1. It depends on whether you prefer on-off or push-to-test operation.

If you have trouble relating the schematic to the solderless breadboard, it should clear up quickly once you understand how the solderless breadboard is arranged.

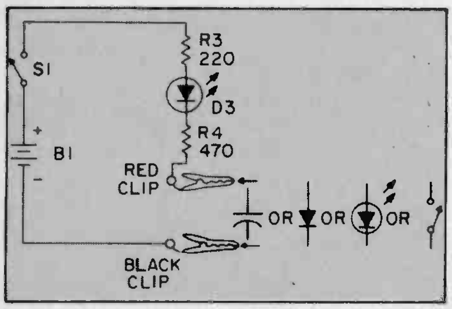
There are 17 rows of five holes each on each side of the center of the breadboard, a total of 34 rows in all. Underneath each row of five holes is a connecting spring clip. The clip holds onto whatever lead you push through the hole. And all the leads you've inserted in any one row (on each side of center, independently) are connected together.

In other words, there are 34 places where you can tie up to 5 leads together, 17 on each side of the center.

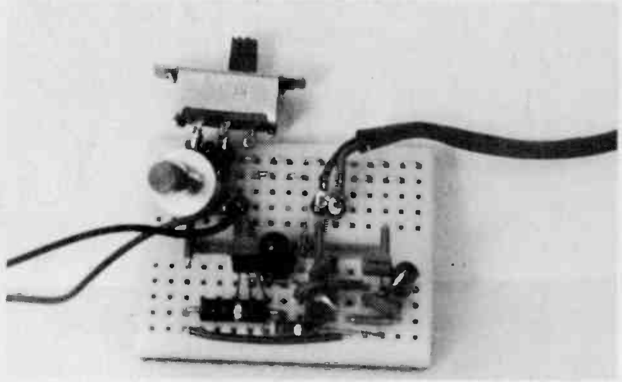
Once you know that, you can custom-design a circuit in just a few minutes, working directly from your idea onto one of these breadboards. Or you can translate a circuit like Checker Board into a solderless breadboard layout very, very quickly indeed. You can solder switches and cable leads to headers, like these from AP products, and plug them right into either solderless breadboards or female headers, the darker strips near the center of the photo. Headers come in rows of 36 contact posts, and either cut or can be broken to length. A single row of male headers, widely available, costs less than a dollar.

Using Checker Board. Follow the instructions below as you test each component. Generally, components can either be clipped-to with the alligator clips, plugged directly into the solder-

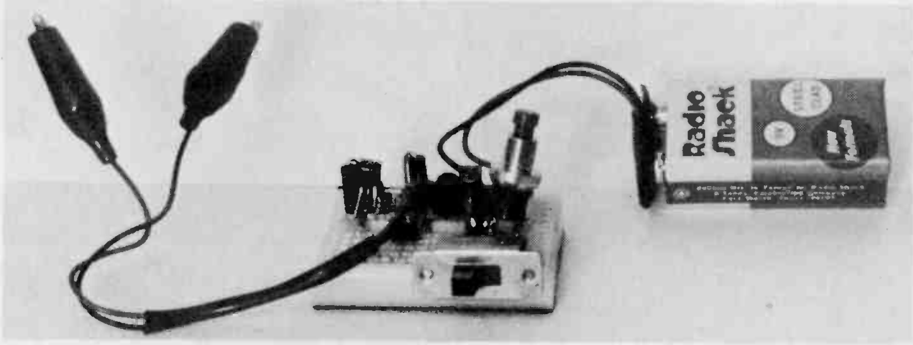
(Continued on page 122)



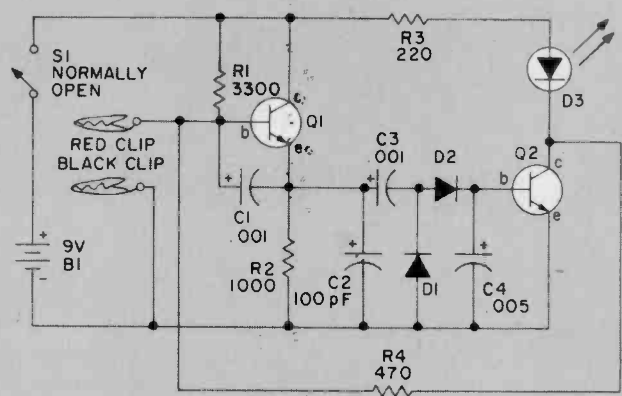
If you use Checkerboard circuit to test capacitors (electrolytics, tantalums, etc.) or diodes, LEDs, or switches, here's the actual working circuit, simplified from the complete Checkerboard circuit, which can check crystals.



Top view of Checkerboard tester assembled on solderless breadboard shows where the parts go if you use this method of assembly.



Prototype Checkerboard was built on AP Products' solderless breadboard for ease of construction and flexibility in layout. Perf board can also be used.



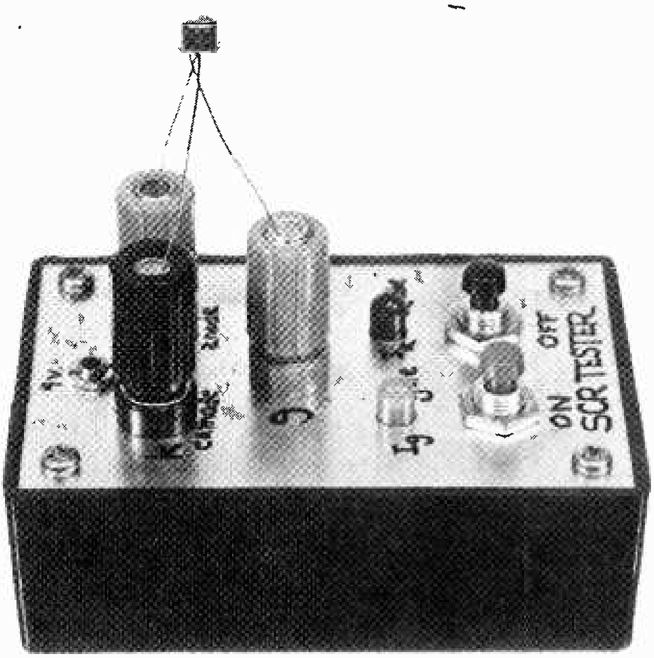
PARTS LIST FOR CHECKER BOARD

C1, 3—.001-uF capacitor
C2—100-pF capacitor
C4—.005-uF capacitor
D1, 2—1N914 or other general-purpose, rapid-response silicon diode
D3—LED (light-emitting diode)

Q1, 2—General-purpose, small-signal NPN transistor, 2N3904 or similar
R1—3300-ohm, ½-watt resistor
R2—1000-ohm, ½-watt resistor
R3—220-ohm, ½-watt resistor
R4—470-ohm, ½-watt resistor

S1—SPST toggle switch, or normally-open pushbutton. Use either, or both in parallel, as desired.
Misc.—Solderless breadboard (AP Products, Inc. distribution strip part number 923273-for AP dealer see end of Parts List); headers (AP Products), alligator clips with pastic covers, 9-V battery connector, 9-VDC transistor radio battery, hookup wire, solder, etc.
For name of dealer nearest you who carries AP Products telephone 800-321-9668 toll free.

The 470 ohm resistor (R4) is included to keep the continuity tester from interfering with the crystal checker. In the crystal tester mode, the crystal being tested plus C1, R1, R2 and Q1 act as a simple oscillator circuit. If the crystal is good a signal will appear at the emitter of Q1 and be rectified by D1 and D2 into a bumpy DC that will turn on Q2. If the crystal is bad nothing will get past Q1 and, therefore, there will be nothing to turn on Q2 and light LED 1.



"Bad SCR" LEDIT Said It

Here's a device to check those cheap, surplus bargains.

by David R. Corbin

☐ Everyone loves a bargain, and bargain bags of semiconductors often yield great buys in the form of perfectly good, but unmarked and untested diodes, transistors, and silicon-controlled rectifiers (SCRs). The trouble is, how do you go about identifying the leads and testing these semiconductors?

A simple, one-evening project using light-emitting diodes (LED) both as indicators and as functional circuit parts in the testing process can now be built for less than five dollars. This LED-indicating tester (LEDIT) will check out diodes and SCRs, and to some will even identify leads of and test many transistors for opens and shorts.

While transistors are actually quite easy to check on a standard ohmmeter, using the lower voltage, middle-range scales to prevent excessive voltage or current through the transistor, an SCR is a bit more difficult. As shown in the drawing, an SCR contains the equivalent of two transistors connected in a closed feedback loop. One lead is the *anode*, the other the *cathode*. A third lead is called the *gate*.

How SCRs Work. Whenever the gate is brought close enough to the voltage on the anode to cause a specified minimum current to flow in through the cathode and out of the gate, the SCR will suddenly turn *On* and exhibit a "short," similar to the action of a conducting diode, provided current is permitted to flow in the cathode-to-anode circuit. It will stay in this mode even if the positive voltage is removed from the gate. Only by reducing the anode current below a specified minimum level can the SCR be turned *Off* again.

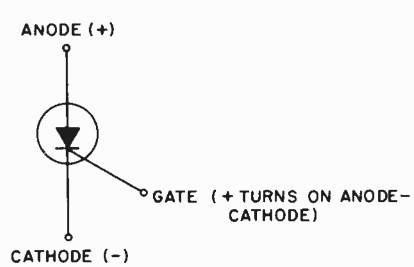
The problem with trying to check most common, small-size SCRs with an ohmmeter is that the minimum gate current and minimum holding current are naturally provided by the ohmmeter. All but the cathode-to-gate path may check "open," making it impossible to identify the leads on an unmarked SCR. What LEDIT does is to provide a quick and low-cost way of putting a safe current through the SCR gate and anode circuits, while providing enough current to turn on and latch virtually all small SCRs found in grab-bag assortments.

By placing an adjustable resistance and a current meter in series with the anode and gate, you could obtain the specified current levels, but for most quick testing of SCRs (open, shorted, or perhaps not even an SCR after all) LEDIT will provide all the information needed.

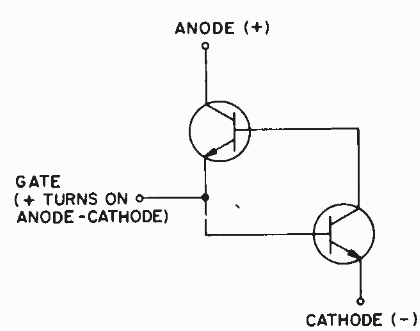
Checking SCRs. There are five ways to misconnect an SCR to the three posts, and one correct way. None of the incorrect ways will damage a good SCR among the vast majority of those around today. The correct connection, when identified, provides for short tests between gate and cathode, cathode and anode, and anode to gate. It also provides for open tests between cathode and anode, and cathode to gate, and turn-on/turn-off functions.

Here's How It Works. Light emitting diodes D2 and D3 have a current rating of about 10 milliamps, with between 1.5 and 1.8 volts across them. This is normally enough current to turn on any common SCR connected to terminals J2, J3 and J4, and to keep the SCR conducting after the gate voltage is removed. With the SCR turned on, current will flow through D3 in the anode circuit until the current is interrupted. Then the SCR will turn off again, and power can be reapplied to the circuit without illuminating D2 or D3.

As the schematic shows, voltage is supplied through J1, or from a 9-volt battery if you prefer. A 9-volt DC transistor radio or tape player AC sup-



Silicon-controlled rectifier (SCR) is really a diode which conducts only when a third element, the gate, lets it. Circuit between anode (+) and cathode (—) is normally open, until the voltage on the gate approaches the anode. When that happens electrons flow from cathode to anode almost as though the diode were a "short."



Equivalent circuit of an SCR looks like this—two NPN transistors connected. Gate is same as base of lower. It can turn On the lower transistor, which turns On the base of the upper.

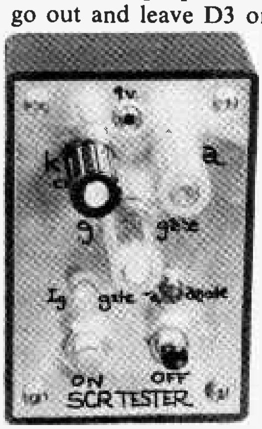
LEDIT Said

ly is a very convenient way to power small projects like LEDIT which have very low current requirements. More importantly, if LEDIT is used only occasionally a battery may tend to run down, leak, and become a nuisance when left on the shelf too long. One 9-volt DC supply can power any number of projects simply by plugging it in, if you use an external supply jack as shown here.

A negative 9 volt potential is applied through diode D1 to the rest of the circuit as a precaution against applying reverse power. Resistor R1 is a 1000-ohm cathode-to-gate resistor which shunts the flow of current rushing into the internal capacitance of the anode-to-gate junction whenever voltage is first put across an SCR under test. If it were not for R1, the SCR would turn on every time it was connected, even without a gate signal voltage, an effect called *dv/dt* and meaning "change in voltage with a change in time." The rapidly-applied anode voltage causes a small current to flow which charges the junction capacitance, and it flows through the cathode-to-gate circuit unless shunted by R1. Since cathode-to-gate current is what normally turns on an SCR, there is nothing very mysterious about this dv/dt effect.

More on LEDIT's Action. Two pushbutton switches control the gate and anode currents of the SCR under test. Switch S1 is in series with R2 and D2 and is normally open. This is the gate signal voltage. Since "ground" is positive in this design, pressing S1 lets cathode-to-gate voltage flow through D2 and R2. R2 limits the current to a safe value for both the SCR and D2.

If the gate is either normal or shorted, D2 will emit red light. But only if the gate is normal will D3, the anode current indicator, come on with a clear light. Letting up on S1 should let D2 go out and leave D3 on. If it does not, then the SCR either cannot remain on with a 10 mA anode current (which is not too likely, but possible) or it is defective.



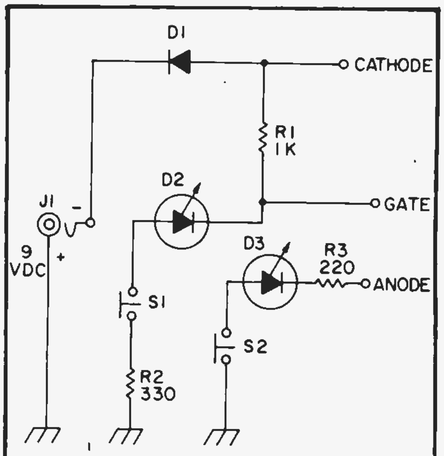
Author's LEDIT is finished and ready to test unknown SCRs as well as units which have their leads identified. The LEDIT is an easy project for a weekend builder. Find out the truth about those SCRs and diodes!

Pushing normally-closed switch S2 interrupts the anode current. The clear light will go out. When that switch is released, the light should not come on again. If it does, there is likely a problem with the SCR, or possibly R1 is not small enough for that particular device. This is not very likely since 1000 ohms is getting near the minimum value used with most SCRs.

If S1 is pressed and D2 (red) does not light, then the gate is open. Actually, D2 will light very weakly through the 1000-ohm shunting resistor even without an SCR in the tester, but it is easy to tell the difference between a good light-up and this weak glow.

Put It Together. None of LEDIT part values are critical, and any convenient "next-size" part can be used with reasonable results. Resistors R2 and R3 are necessary to limit the current to D2 and D3 (LED indicators), and shouldn't be much smaller than indicated in value. If anything, use slightly larger values. The gate turn-on current is rather stiff for small devices so don't hold them "on" with the turn-on button any longer than necessary. I've tested innumerable smal devices and none were damaged by LEDIT but when dealing with unknown parts, it's

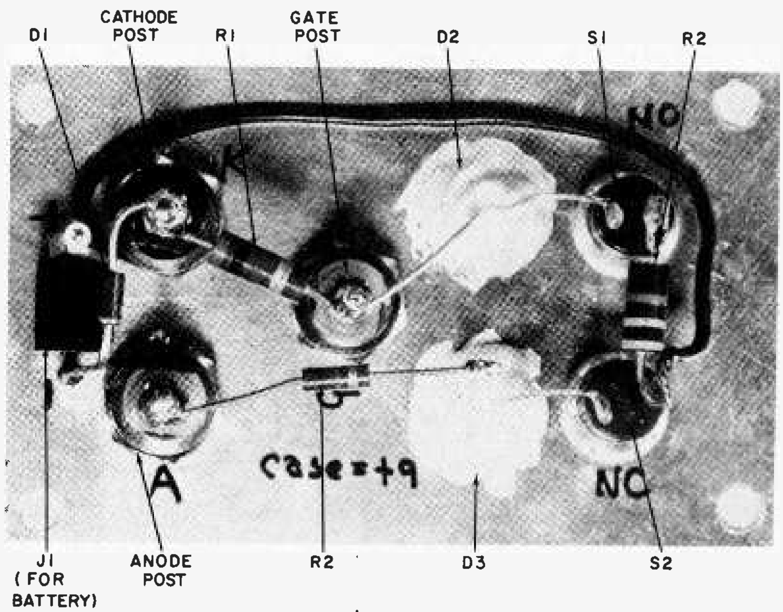
(Continued on page 118)



PARTS LIST FOR LEDIT SCR TESTER

D1—1000-PIV, 2.5-A rectifier, HEP R0170
D2—Red LED
D3—Clear LED
R1—1000-ohm, ½-watt resistor
R2—330-ohm, ½-watt resistor
R3—220-ohm, ½-watt resistor
S1—SPST normally-open pushbutton switch
S2—SPST normally-closed pushbutton switch
Misc.—Cabinet 4-in. x 2½-in. x 2½-in., approx., jack for battery connection (any convenient type), 5-way binding posts.

The circuit used in LEDIT is extremely simple and should take little time to assemble. The parts, with the possible exception of the two LEDs, will probably be in your junk box. Mount the panel on an old plastic box—perhaps from a broken midget volt/ohm meter that's seen better days or been canibalized for its meter. The resistors can be 10 percent, but no smaller than indicated.



Here we have a view of LEDIT's interior, specifically the reverse side of the front panel. No PC board is necessary or recommended, just follow the author's design of direct point-to-point wiring for neat and easy assembly.

LONE RANGER LIGHT METER

LED readout saves meter cost, and is more rugged too.

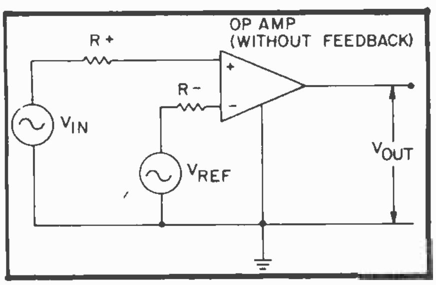
by Walter Sikonowiz

☐ Lone Ranger is a photographic light measuring instrument without the usual (needle-and-scale) mechanical meter. Instead, it uses light-emitting diodes (LEDs for short) to tell you what lens opening to use. In addition to cutting the cost by more than 50 percent, eliminating the meter has other advantages. The chance of damage from dropping is much less. People with no knowledge of photography can easily use this exposure indicator once taught the significance of the displays.

Finally, because the readout is on LEDs, it's always easy to see, even in low light where an ordinary meter's needle might be hard to read accurately.

This comparator-LED light meter is ideal for the serious beginning or intermediate photographer because most people shoot with the same speed film most of the time. And if you do use two or three different speed films, it's easy to apply a conversion factor to the Lone-Ranger's lens-opening scale.

It's a one-speed-range photographic light meter which tells you at what f-stop diaphragm opening to set your 35 mm or other precision camera lens. It provides readings for setting your camera lens opening between f-stops as large as 2.8 and as small as 32. These are based on the most popular black-and-white film for 35 mm use, Plus-X, a widely available fine-grain film.



Operational amplifier without feedback has extremely high gain. It can be used to compare an input signal voltage (unknown) with a known (reference) voltage, and indicate clearly (by its output's going to saturation, or by staying at its initial (very low) voltage that the unknown voltage is either below or above the reference voltage. This makes it a "comparator."

Photo Basics. First before showing how the meter works, let's review some basic photography. The photographer is concerned with three numbers when making an exposure: 1) the ASA rating (the speed) of his film, 2) the f-stop of the lens aperture, and 3) the speed of the shutter. Let's see how these factors interrelate. Suppose you take a correctly-exposed picture under light of intensity **I**, with f-stop **n** and exposure time equal to **T**. If the intensity suddenly jumps to **2I**, you must compensate by either reducing the aperture (multiplying the f-stop by 1.4) or by reducing the exposure time by half—**T/2**. And if the light intensity is reduced by half you would compensate either by making the f-stop 1.4 times larger, or by increasing the exposure time to **2T**. This assumes, naturally, that the film's speed (ASA) remains constant.

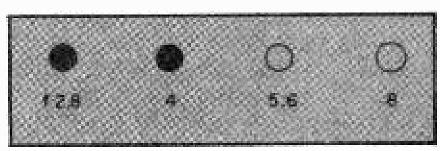
Now suppose that a correctly-exposed photograph is made under light of intensity **I**, with f-stop = **n**, and exposure time = **T**. To take the same picture with a film whose ASA rating is twice that of the original, you'd compensate by making the f-stop = **1.4 n** or by making the exposure time = **T/2.** To take the same picture with a film whose ASA rating is half that of the original film, make the f-stop = **n/1.4**, or make exposure time = **2T.** Now let's look at an electronic circuit to measure the ambient light.

Use a High-Gain Amplifier. Suppose we take a high-gain differential amp and place a known voltage on one input, an unknown on the other. Since we're using the amp open-loop (without the usual feedback), only a small voltage difference at the two inputs is required to send the output either to saturation, or to cut-off. Specifically, if the voltage at the non-inverting (+) input is a few millivolts greater than that on the inverting (−) input, the output will go high. Likewise, if the voltage on the inverting input is the greater, the output will go low.

There are limitations to the size of the voltages which may be compared. For the LM339, input voltages should be less than supply voltage (V)— 1.5V. Furthermore, these input voltages should be much greater in magnitude than a few millivolts, to swamp out measurement errors due to the inherently imperfect nature of the comparator itself. Between these extremes a comparator can give a very accurate answer to the question, "Is the unknown voltage above or below the reference voltage?"

The LM339 incorporates four comparators on a single chip. If one input of each comparator reads some common, unknown, voltage, while the other four inputs connect to different reference levels, then the size of the unknown voltage can be estimated by observing the output states of the comparators.

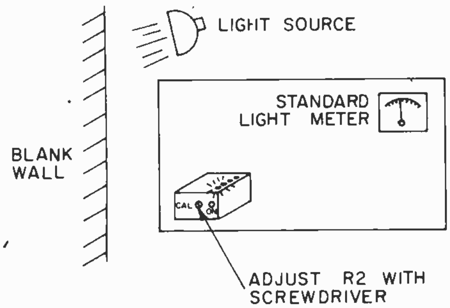
Figure 1 shows the LM339 as the



This is the way the LED readout of the Lone Ranger would look if the amount of light being measured was enough for a camera opening of F-stop 5.6. The two LEDs at the left are dark, the two on the right are lit up.

LONE RANGER LIGHT

heart of a light meter. All the inverting inputs go to the junction of PC1 and R1, and thus sense a voltage whose magnitude increases as the intensity of the light being measured increases. C2 bypasses any interference caused by fluorescent lighting in the vicinity. The non-inverting input of each comparator goes to a reference voltage,

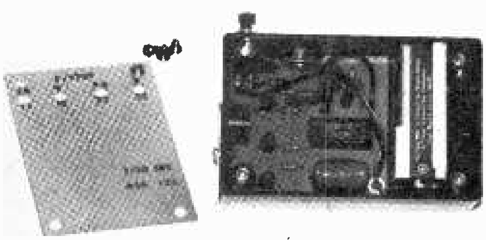


This is the setup you use to calibrate the Lone Ranger light meter. You'll need to borrow an old-fashioned (analog) light meter for this procedure.

with section A connected to the lowest reference voltage and section D to the highest. Consequently, in very dim light all four comparator outputs will be at cutoff, hence all four LEDs will be extinguished.

As the light intensity increases, section A will be the first to change state (rise toward saturation) and thus cause LED1 to light. At higher intensities LED1 and LED2 will both be turned *On*. The reference voltages I used were chosen to correspond to differences in lens aperture of one f/stop. Thus, a display like the one shown here would indicate that the correct photographic exposure is between f/4 and f/5.6.

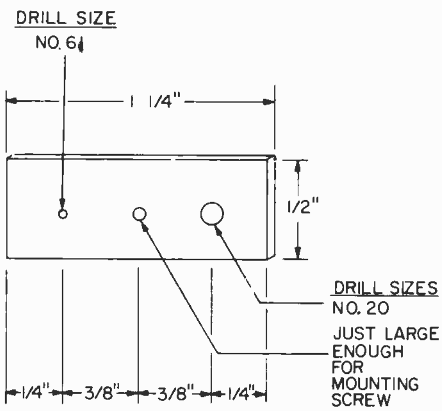
Extending the Meter's Range. Notice that in contrast to the continuous readout of an analog meter, this comparator system of voltage measurement indicates proper exposure as being between two levels. In order to get better resolution (more detailed information as to lens opening) we would need more comparators. We would also need more comparators if a larger measurement range is desired. To accomplish such a range expansion we could add another LM339—inputs 4, 6, 8, and 10 would go to the junction of PC1 and R1, while pins 5, 7, 9, and 11 would go to new (added) reference voltages. However, there is a cheaper method of range expansion. We simply install a variable aperture in front of the photocell. In this way the measurement range of the photometer is doubled to 8 stops, by using two apertures whose areas are in the ratio of 16:1. This is the scheme I adopted for Lone Ranger.



Here's how author's Lone Ranger looks inside. To keep it small, make a printed circuit board like his. Perf board is OK too, but requires bigger box.

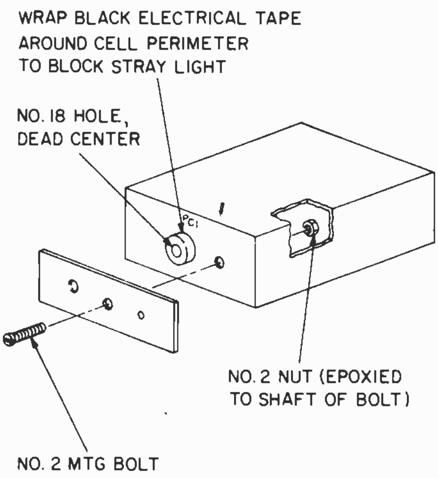
The total measuring range of this instrument thus spans from f/2.8 to f/32 with ASA 125 film (such as Plus-X) at a shutter speed of 1/30th second. Later on we'll discuss the simple mathematical conversion necessary to allow use of the light meter with different film speeds and different exposure times.

Building Lone Ranger. Actual construction of the Lone Ranger meter is non-critical, but will require some care because of its small size. A printed circuit board was used in my Lone Ranger prototype, and although it is not neces-



Dimensions of the range-extender for Lone Ranger are shown above. It's a simple piece of aluminum with two different-size holes in it. The middle hole is for mounting the strip to the front of Lone Ranger.

sary that you use the printed circuit, it would be wise to copy the same general layout as the prototype. My Lone Ranger is housed in a 3¼ x 2⅛ x 1⅛-inch plastic minibox. If you use the same box, note that the mounting post in the upper-right-hand corner must be removed to make room for S1. A soldering gun with a cutting tip was used to slice out the mounting post, leaving three posts to hold down the metal cover of the box. If you are inexperienced in small-scale construction, by all means use a larger box. Regard-



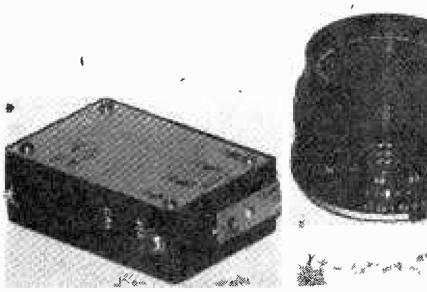
Here are the details for mounting the range extender to the front of the case, and for taping around the photocell to keep it from receiving stray light which can cause misreading of the ambient light.

less of the box size used, however, the following construction details given will still apply.

When the board has been completed, mount the IC socket, trimmer R2, and all resistors and capacitors. Next, solder the negative lead from the battery clip to its hole near pin 12 of the IC socket. Solder a 2-in. length of flexible wire to the hole indicated in the upper-right-hand corner of the board. This wire will later be connected to S1. Now mount the photocell so that its light-sensitive face is perpendicular to the board and facing toward its upper border. Finally, mount the four LEDs into the circuit board, but be sure to observe proper orientation. The tops of the LEDs should all extend the same distance above the board—about ⅞-in. if you have a cabinet of the same depth. Now plug IC1 into its socket and set the board aside temporarily.

The range selector is just a simple aluminum plate (about 18 gauge) with the dimensions shown in the diagram. Note that two holes, one #20 and one #61, must be *carefully* drilled. Further note that the plate must be absolutely flat. Don't cut it out with tin snips. Use a nibbling tool or hacksaw, which will cut the aluminum without distorting it. Now use a file to round off all the edges, and then buff it with steel wool. This will make the range selector rotate readily when you're out shooting.

More On Construction. The drawing of the cabinet shows how to mount the photocell relative to the range selector. When the proper holes have been drilled, mount the range selector with #2 hardware and tighten until the fit is just snug. Use a drop of epoxy to



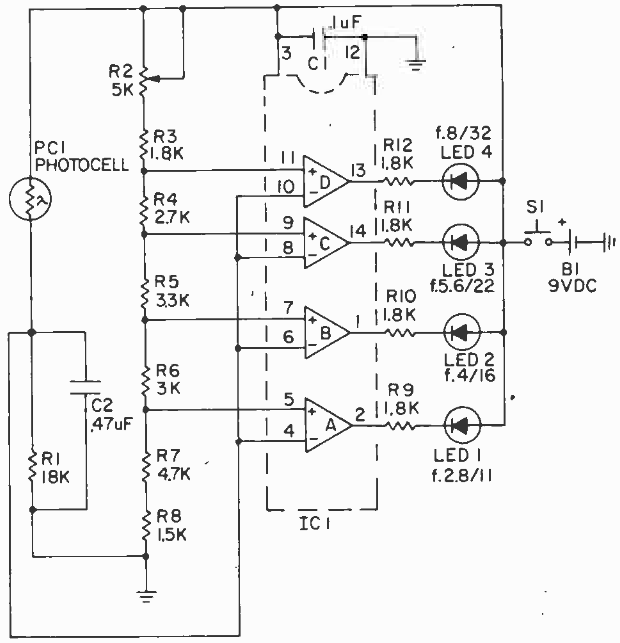
Lone Ranger light meter is about the size of a good lens, as shown here (Pentax Rokkor f=1.7, 50 mm).

lock the nut to the shaft of the bolt, and let the cement dry.

S1 may be placed wherever it is convenient. Be sure to drill a hole to allow calibration-adjustment of trimmer R2 from the outside. Now locate and drill four holes in the cover to allow the LEDs to be visible. The exact location of these holes will depend upon the dimensions of your case and the dimensions of your board. Simply insert the board into the bottom of the box and measure how far from the sides each LED's center is located. Transfer these dimensions to the cover and drill four #22 holes.

Mount the board in the cabinet so that the photocell lies directly behind and flush against its mounting hole. If you used the same size box as I did the ¼-in. spacers will be needed between the board and the bottom of the case to allow the LEDs to protrude slightly through the thin metal cover. After the board has been securely mounted, take a ¼-in. wide, 1½-in.-long strip of black electrical tape and wrap it around the perimeter of the

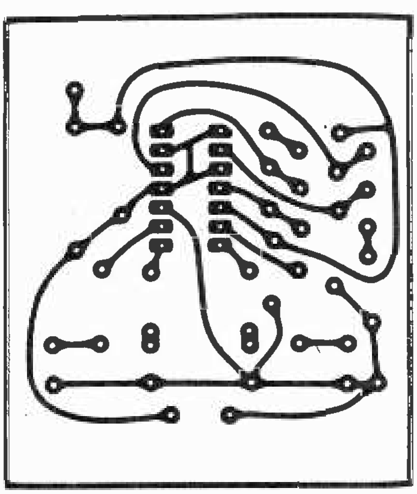
(Continued on page 118)



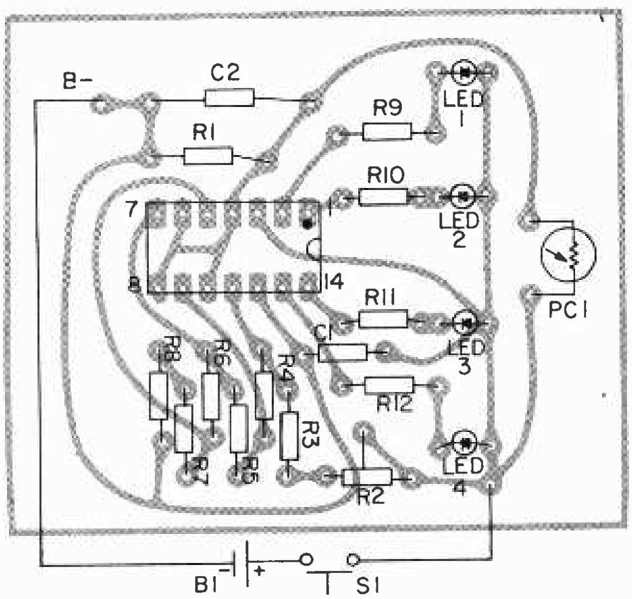
LONE RANGER PARTS LIST

C1—.1-uF capacitor
C2—.47-uF capacitor
IC1—Quad comparator integrated circuit LM 339
LED1, 2, 3, 4—Light-emitting diodes
PC1—Cadmium sulfide photocell
R1—18,000-ohm, ½-watt resistor
R2—5,000-ohm potentiometer, printed circuit board-mounting
R3, 9, 10, 11, 12—1800-ohm, ½-watt resistor
R4—2700-ohm, ½-watt resistor
R5—3300-ohm, ½-watt resistor
R6—3000-ohm, ½-watt resistor
R7—4700-ohm, ½-watt resistor
R8—1500-ohm, ½-watt resistor
S1—SPST momentary on switch
Misc.—Minibox 3¼-in. x 2⅛-in. x 1⅝-in. (or larger), socket for IC1, 9-VDC transistor radio battery, clip for battery, wire solder, printed circuit board kit, etc.

A light meter without the meter. Sure enough, Pardner, if it's the Lone Ranger you're talking about. The circuit enables you to build a meterless light meter to solve your F-stop woes. The Lone Ranger uses Light Emitting Diodes to tell its story, rather than an all too breakable meter. It's absolutely great for the beginning and intermediate shutterbug to use for great picture results. Next time someone asks you, "Who was that masked meter?" you'll know it was the Lone Ranger!

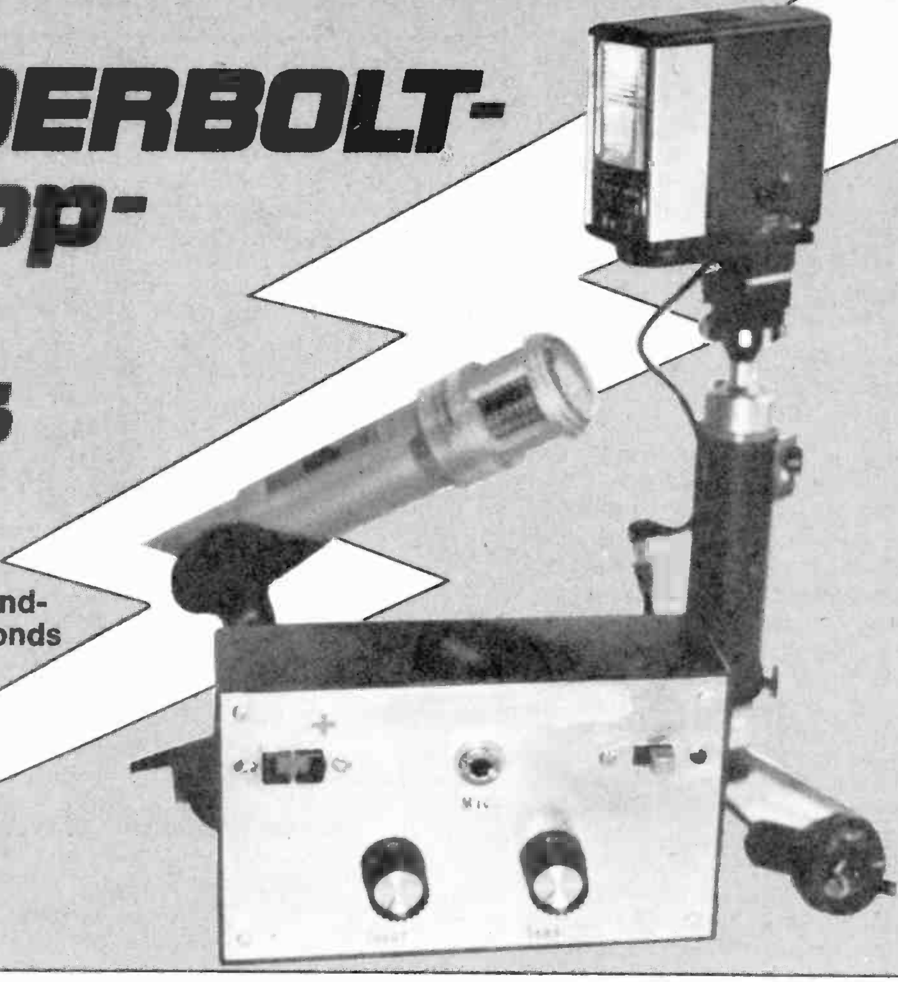


This is a full-size template for the printed circuit board, if you want to make yours just like the author's. See the text for suggestions on making printed circuit boards if this is your first.



Placement of parts on Lone Ranger's printed circuit board. If you use perf board instead you can put the parts wherever you want, but you'll find this general arrangement most convenient.

THUNDERBOLT-For Stop-Action Photos



Quick as lightning, this sound-activated flash switch responds to get your picture.

by Frank I. Gilpin

HOW WOULD YOU LIKE TO CAPTURE the sphere-capped minaret of a drop of water at the precise moment it strikes the surface of a pool, or a bursting balloon with the piercing dart still in mid-air? All you need is this easily-constructed, sound-activated, electronic flash—Thunderbolt.

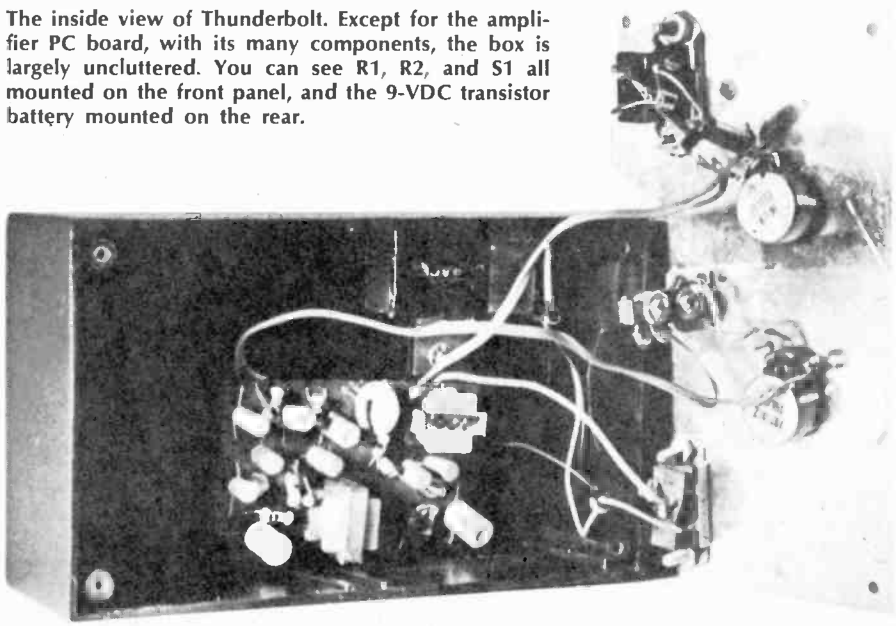
Sound-activated switches have been around a long time. The first one I built 18 years ago weighed 25 pounds and would have cost nearly $100 if I hadn't cannibalized some old radios for the parts and tubes . . . remember tubes? When I built Thunderbolt a few months ago it cost five dollars and weighed in at about eight ounces. What made the difference? Solid-state components, including a silicon-controlled rectifier, make it lighter and cheaper—and it works much better and faster.

How It Works. Sound picked up by a microphone is boosted by an amplifier which feeds the signal in the form of a rectified pulse (via R3 and D1) to the gate and cathode of the SCR. The SCR is internally like three diodes connected (alternately) in series—positive-negative-positive—so it acts like a conventional rectifier in the reverse direction. Thus, the SCR's forward conduction is controlled by operating the "switch," or *gate*. Since the sound we are picking up is a single, sudden sound of short duration, it acts like a pulse, when magnified by the amplifier, and it causes the SCR to conduct. An electronic flash unit connected across its anode and cathode "sees" this conduction as a direct short so it flashes.

In practice, you will find a wide latitude of application techniques possible. You can control the microphone's sensitivity so it will respond only to certain higher level sounds, if the ambient noise level is high. Additionally, you can select the time at which an event is photographed by varying the distance between the event and the mike.

Various Applications. Let's say, for example, the event to be photographed is a coin dropping into water. By placing the mike very close to the container of

The inside view of Thunderbolt. Except for the amplifier PC board, with its many components, the box is largely uncluttered. You can see R1, R2, and S1 all mounted on the front panel, and the 9-VDC transistor battery mounted on the rear.



water, and by turning up Thunderbolt's sensitivity control, you can freeze the coin as it first touches the water. On the next shot, repeat the event, but place the mike farther away from the point of impact. The sound must now travel farther to reach the mike and the flash will go off at a later stage in the splash sequence.

By repeating this process, you can get a series of shots to cover the entire sequence from the coin first touching the water, to the final catapulted droplet falling back into the water. It could be a club flattening a golf ball, a dart bursting a balloon, a hammer shattering a light bulb, or a (patient) athlete diving into a swimming pool. Any event which produces a sound, faint or deafening, can be recorded on film at the decisive moment chosen by you.

The great advantage of Thunderbolt is that it is totally electronic, as opposed to the electromechanical heavyweights of a few years ago. The older devices depended on mechanical relays and electromagnets to close a switch. This mechanical energy transfer added milliseconds to reaction time. Even that is a significant interval when you are planning to break up into sequences such events as bursting firecrackers and shattering lightbulbs. Once the sound gets to Thunderbolt's mike the reaction time approaches the speed of light. That's about as fast as you're going to get—in *this* world.

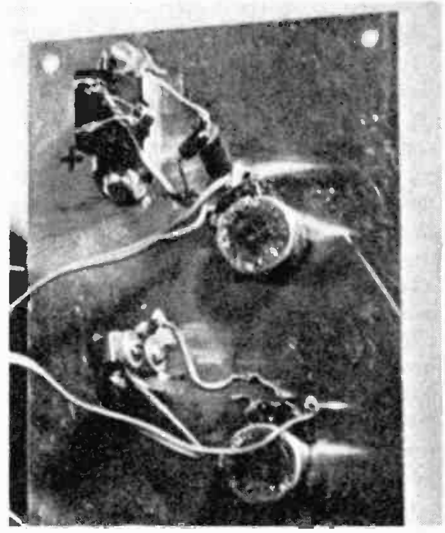
Putting Thunderbolt together is easy, because the most complicated part—the amplifier—is a module, ready to wire into a circuit with just a few simple connections and a handful of other parts.

Building It. Begin by selecting an amplifier. Almost any inexpensive module will do as long as it has an output transformer. Note that most modern transistor amps don't have an output transformer. Radio Shack and Lafayette Electronics sell suitable amp modules for less than six dollars apiece. Any amp capable of delivering a couple hundred milliwatts is sufficient. I scavenged the amp for my Thunderbolt from an old, discarded portable tape player. You can find many of these old reel-to-reel relics in second-hand stores for a dollar or two. Goodwill and Salvation Army Thrift Shops are a good hunting ground. All you need do with these old units is carefully trace and identify the input and output leads and the battery supply leads. If you get a unit that's fairly intact, it may even have volume and tone control pots which are of the correct value for your Thunderbolt.

The cabinet I show in the parts list will accommodate almost any transistor amp you select. You could even get ambitious and build a simple transistor amp. Most any old tube amp will also work fine, though it'll be quite bulky.

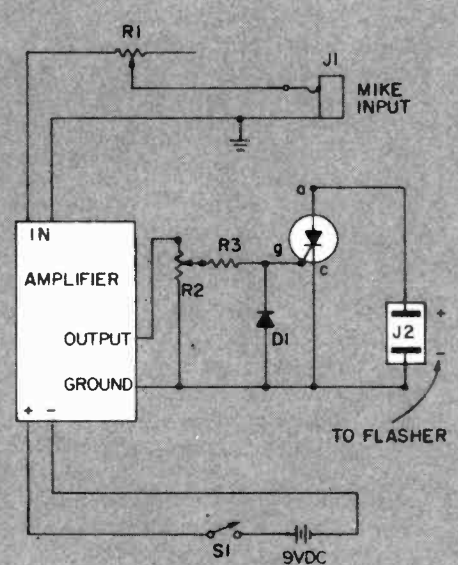
Just which mike jack, you use will depend on the plug on the microphone you use. It may be a standard phone jack, or the miniature type—whatever, as long as it matches your mike plug. When you have all the parts in hand, arrange them on the cabinet's front panel and mark the panel for the mounting holes to be drilled. Parts placement is not critical, but the leads to R1 and R2 should be kept short. If you locate S1 close to the *sensitivity* control, R2, then you can use point-to-point wiring for the SCR, D1 and R3. They are rigid enough to be self-supporting if the leads are kept short; otherwise a tie-point terminal can be used. Follow the schematic and wiring illustrations carefully and you'll have no trouble. You must use shielded (co-ax audio cable) for the input connections from R1 to your amp.

Hookup To Flashgun. After making all the connections, double check your work. Be sure you have connected the SCR's three leads correctly and check the polarity of D1. When you are sure everything is in order, you'll need to

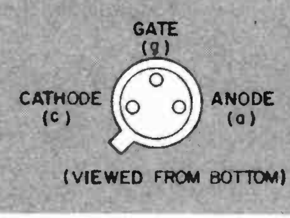


Closeup of the front panel, showing the way SCR1 is mounted directly on S1, and D1 and R3 attached to R2.

make a connector cord for your flash unit. Insert the PC plug of your flash extension cord into the flash unit's sync cord. Both ends of some brands of extension cords look almost alike and you don't want to cut off the wrong end. With one end plugged into your flash unit to make sure, cut off the other end close to the plug. Strip off the insulation and carefully separate the braided



Schematic diagram for Thunderbolt. As you see, most of the components are encapsulated in the amplifier, which is described fully in the text. Virtually any amplifier will do, as long as it produces a couple hundred milliwatts. The diagram below shows the connections to SCR1.



PARTS LIST FOR THUNDERBOLT

R1—10,000 ohm potentiometer
R2—5,000 ohm potentiometer
R3—2,200 ohm half-watt resistor
D1—PIV 50 volts Rectifier Diode
J1—To suit your mike. (see text)
J2—AC chassis-mount receptacle
S1—SPST slide switch
SCR—Silicon Control Rectifier (General Electric C5G or equivalent in TO-5 type case.)
Misc.—Wire, solder, two control knobs, chassis box (see text), a PC type extension cord for electronic-flash sync cord, and an AC plug. Total cost for all parts should not exceed $12, excluding chassis.

You'll find Thunderbolt to be one of the most useful photographic accessories. It's easy to build, both at the worktable and on the pocketbook, and is a truly fun project. Before you know it, you'll be happily strobing away roll after roll.

THUNDERBOLT

shielding from the inner conductor of the co-ax cord. There is little or no standardization in the photo industry, so you can't be sure that the inner conductor of any given sync cord is connected to a positive voltage when plugged into a flash unit. Some units have a positive ground and some have a negative ground. In order to make sure your Thunderbolt will work with any flash unit, you need a plug which can be reversed for any polarity match. You may have more than one flash unit and they may not be the same, hence the adaptor cord.

Plug one end of your modified cord into Thunderbolt and the other into the flash unit's sync cord. Set the *sensitivity* control, R2, at the center of its rotation and *input* control, R1, fully counterclockwise. Plug in a microphone and apply power to both the switch unit and the flash unit. The flash may fire once or twice by itself before it settles down. If the flash unit keeps firing as fast as it recycles, reverse the plug in J2 to get the correct polarity match.

With the polarity established, whistle or hum into the mike as you slowly turn R1 clockwise. The flash should go off. From this point, it's a matter of see-sawing controls R1 and R2 back and forth until you get the hang of your mike's sensitivity. The best way to discover what your Thunderbolt can do is to use it in a closely controlled test set-up. This procedure is easier

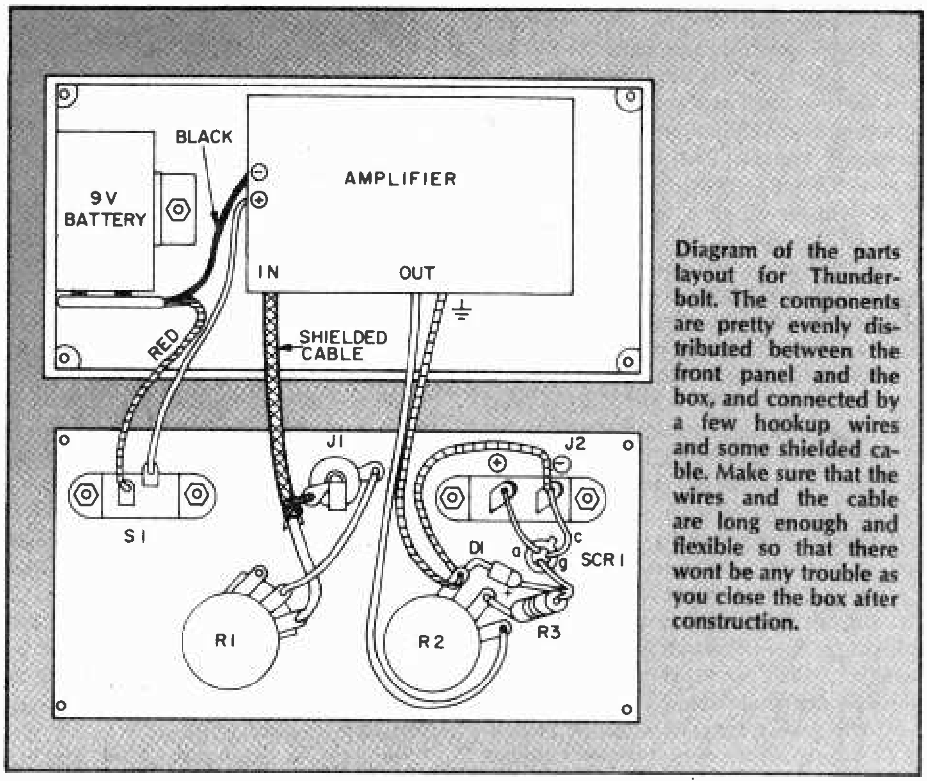


Diagram of the parts layout for Thunderbolt. The components are pretty evenly distributed between the front panel and the box, and connected by a few hookup wires and some shielded cable. Make sure that the wires and the cable are long enough and flexible so that there wont be any trouble as you close the box after construction.

This is one of the things you can do with Thunderbolt. You can use it to capture any sound-producing motion instantaneously, as long as the object to be photographed is within the range of your electronic flash gun.

with an assistant, so recruit a friend.

Against a dark background, set up a clear glass, or bowl, of water. Place the mike as near to the bowl as possible without it getting into the picture area. Position the flash on a tripod and aim it at the bowl. The camera, also tripod mounted, should be aimed at the bowl at a 45 degree angle to the flash. Focus on the surface of the water and compute your f-stop as you normally would for a flash shot using the flash's guide number divided by its distance to the subject. (For instance, if the manufacturer's recommended guide number for your flash is 45 when used with ASA 25 film and your flash is placed five feet from the subject, divide 45 by five. Since the answer is nine, choose the f-stop closest which is f-8).

Set the camera's speed control on "B" as you would for a time exposure. Attach a locking type shutter release cable to the camera and position your assistant close to the bowl, but out of the camera's field of view.

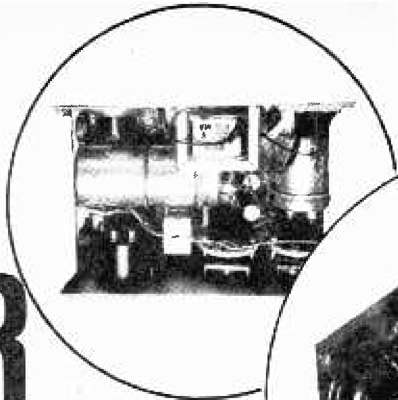
Turn off all the lights in the room and open the lens with the shutter release cable, but *do not* remove the lens cap yet. With your assistant poised over the bowl, ready to drop a coin into the water, turn on the flash unit and the switch unit. The flash may go off, triggered by the sound of its own switch, which is why you've left the lens cap on. Wait for the flash to recycle, then snap your fingers. It should go off again. When it recycles, remove the lens cap and give your assistant a visual signal to drop the coin. As the coin hits the water, the flash will go off and you can close the shutter and replace the lens cap.

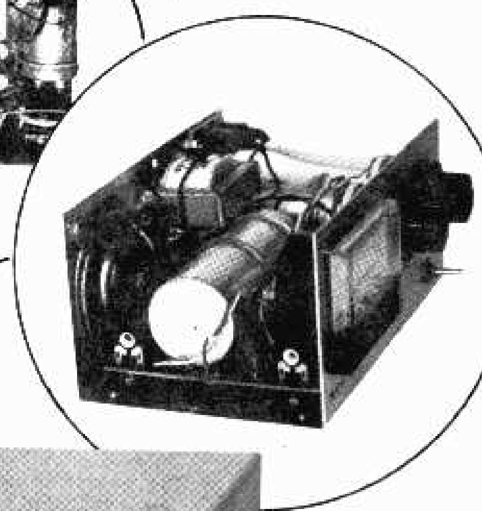
On the next shot, move the mike a foot or two farther away and repeat the process. On successive shots, move the mike exactly the same distance farther away. You should have a complete sequence after about six to eight shots.

The film should be a very slow film, that is one with a very low ASA number, such as Plus-X by Kodak, which has an ASA of 125. If you have a set-up which requires you to have more room illumination in which to work, use an Othro type film which is insensitive to red light. With this film, you can use a fairly bright red light in the room without affecting the film image while the lens is open.

Once you've done a series such as the water bowl and coin, you will know what Thunderbolt can do for you and how to predetermine its sensitivity to a given sound. When you have all its parameters for operation understood and set up, you can start thinking of things to do with Thunderbolt. Its applications are virtually limitless, since the principle of stopping sound-producing motion is an especially fascinating one. You can use it indoors in ordinary ways, such as the coin and bowl technique, or you could even use it for crime detection, by fixing it at night on a window or door you expect an intruder to come through. Any sound he makes will take his picture. Good luck! ■

PRO-TIMER





Get split-second accuracy for your darkroom prints with this IC timer.

by Walter Sikonowiz

IF YOU WORK IN THE DARKROOM or have a chemical process or other program which can use an adjustable interval timer you can use PRO-TIMER. Particularly if you need to time a program which runs on electricity, or which requires an alarm to be sounded at the end of the prescribed interval, *Pro-timer* is for you. You can adjust it to measure intervals as brief as 10 seconds, or as long as nearly six minutes (5:50). With a simple modification you can set it up for much longer periods, too.

While Pro-timer is busy keeping track of the amount of time left before it sounds the alarm, and cuts off the electricity to the device (or process or program) you want, a meter on its front panel shows what percentage of the timed interval has gone by, and how much is left.

Most electronic timer projects share a common fault: the lack of any indication of elapsed time. Suppose, for instance, that a process needs to be timed for two minutes. Further suppose that when one-half of the total time has elapsed, some subordinate task, such as the addition of a chemical, has to be performed. If your timer provides no indication of the elapsed time, how do you tell when the first minute is up? It's simple, however, if you build Pro-timer because its panel meter shows the fraction of the total timed interval that has already elapsed.

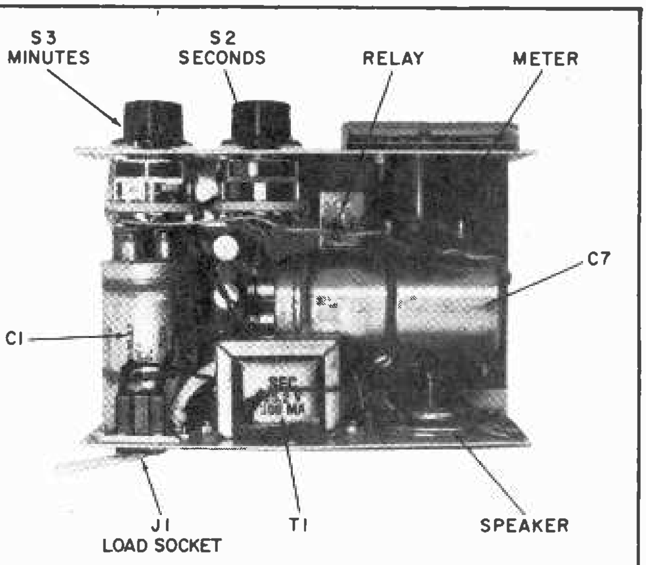
For example, suppose that you've selected an interval of four minutes and thirty seconds by means of the two front-panel switches. When the meter needle shows .5, one-half the total time, two minutes and fifteen seconds, has gone by. The timed interval can be adjusted from 5 minutes and 50 seconds down to ten seconds in ten-second increments. For the duration of the timed interval, the timer will supply power to an electrical device. When the time is up, power to the load is cut off, and an audible alarm sounds. This feature permits you to use the timer on tasks under manual control as well as those under electrical control.

How The Circuit Works. To see how Pro-timer works, refer to the schematic diagram on the next page. IC1, a 555 integrated circuit (which is widely used in timing circuits) operates here as a monostable multivibrator.

Applying power to the timer triggers IC1 due to the action of D9 and R5 on the IC's trigger input, pin 2. In order for IC1 to be triggered, pin 2 must be held at ground potential momentarily. When the unit is turned *On,* the supply voltage rises gradually, taking about .01 second to reach full potential. However, D9 and R5 hold pin 2 at ground potential until the supply voltage exceeds D9's rating: 9.1 volts. This causes IC1 to trigger. Consequently, its output (pin 3) goes high, K1 gets energized, and power is supplied to whatever is plugged into the AC socket, J1. Furthermore, the fact that IC1's output is high causes Q2 to conduct, thus shorting out C6 and keeping the alarm signal from sounding.

Transistor Q1 is connected as a constant-current source, which acts to charge up capacitor C7. The actual charging current is determined by the net resistance selected by S2 and S3. Selecting a smaller emitter resistance for Q1 results in a larger charging current, and C7 thus gets charged up at a correspondingly accelerated rate. Because the capacitor is being charged by a constant current, the voltage on C7 rises linearly with time. When the voltage on the capacitor reaches a threshold level, determined here by adjustment of R8, IC1 will reset itself and

PRO-TIMER



Internal view shows how highly packed the author's prototype is. Parts layout is not critical in this unit, so you have a good deal of freedom with the arrangement of components in the unit. Don't move things around too much, but if this is your first project, you might want to use a larger box, so the parts will be spread out.

discharge C7 through pin 7. This means that the timed interval is up, and pin 3 of IC1 drops to a low potential. Consequently, K1 becomes de-energized, cutting off power to the load. At the same time, Q2 stops conducting and, in the process, turns on the relaxation oscillator formed by R3, R4, C6, and Q3. During operation of the relaxation oscillator, C6 alternately charges through R3 and discharges through Q3's emitter. Since the speaker is in series with Q3's emitter, an audible warning signal is produced at the end of the timed interval.

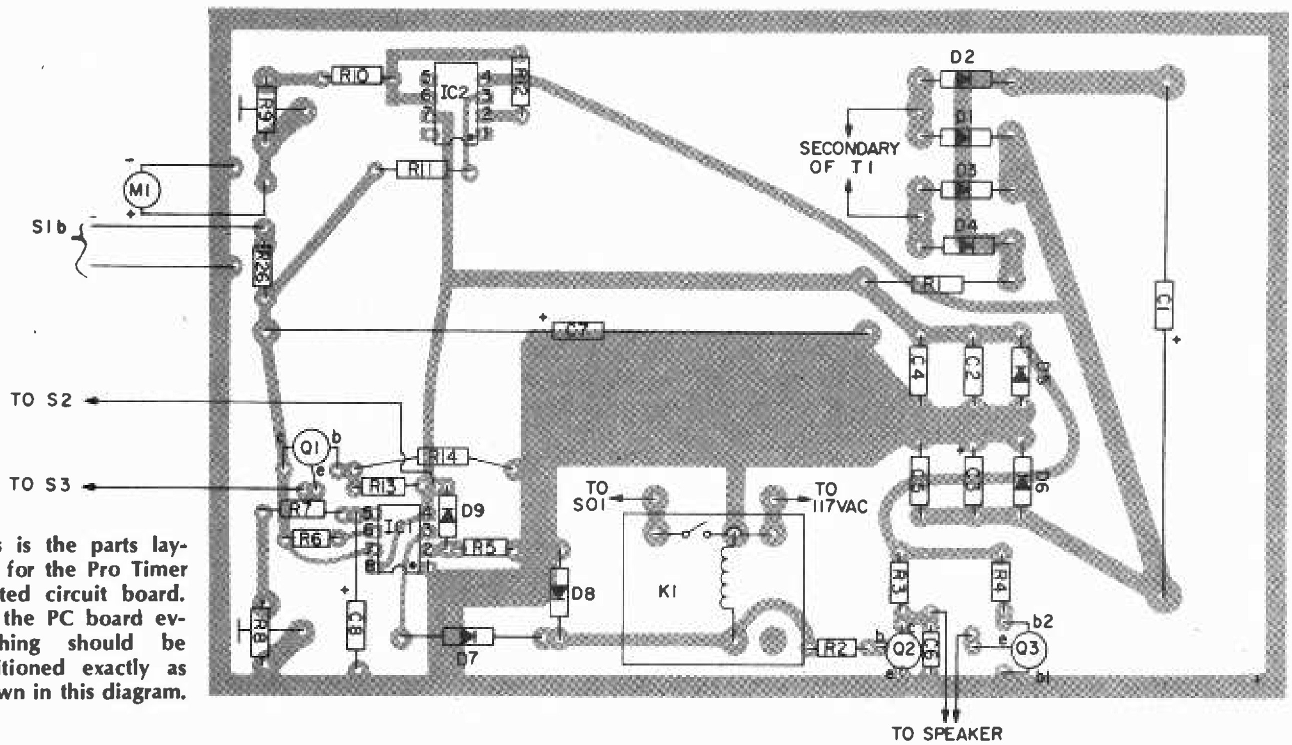
Let's go back now to capacitor C7. The meter reads the voltage on C7 through unity-gain buffer IC2. If we calibrate the meter, by adjustment of R9, so that it reaches full-scale when the voltage on C7 reaches its maximum level, then any reading on M1 may be interpreted as relative elapsed time because the voltage on C7 is a linear function of time. When we select the required time interval, by means of S2 and S3, we change only the rate at which C7 charges—the threshold voltage level to which the capacitor eventually charges remains fixed. Therefore, the meter readout is valid for all timed intervals.

More On How It Works. Fuse F1 limits the load current to 1 ampere, which is about the maximum that the relay's contacts can handle. Use a slow-blow fuse since loads such as a lamp will draw initial current much higher than the normal operating current. If you were to use a heftier relay, then larger loads could be accommodated, and F1's rating could be increased accordingly. However, different relays will require different coil currents, which would require re-design of the power supply. So unless you know what you're doing, stick with the relay specified.

T1 supplies power to a conventional full-wave bridge rectifier system, whose output is regulated and split into two voltages, +15 volts and −6 volts, by zeners D5 and D6. Note that the negative supply connects to only one point in the circuit: pin 4 of IC2. Power for all the rest of the circuit comes from the positive supply.

Diodes D7 and D8 protect IC1 from the inductive kickback generated by relay K1. Resistor R15 limits the maximum current through Q1 to a safe level in case both S2 and S3 should be turned to their "0" positions. Finally, note that power switch S1 is a double-pole affair. In the *Off* position, the AC power is disconnected, and C7 is discharged through R26. This provides a rapid discharge of the capacitor should the timer be turned off before completion of a timed interval.

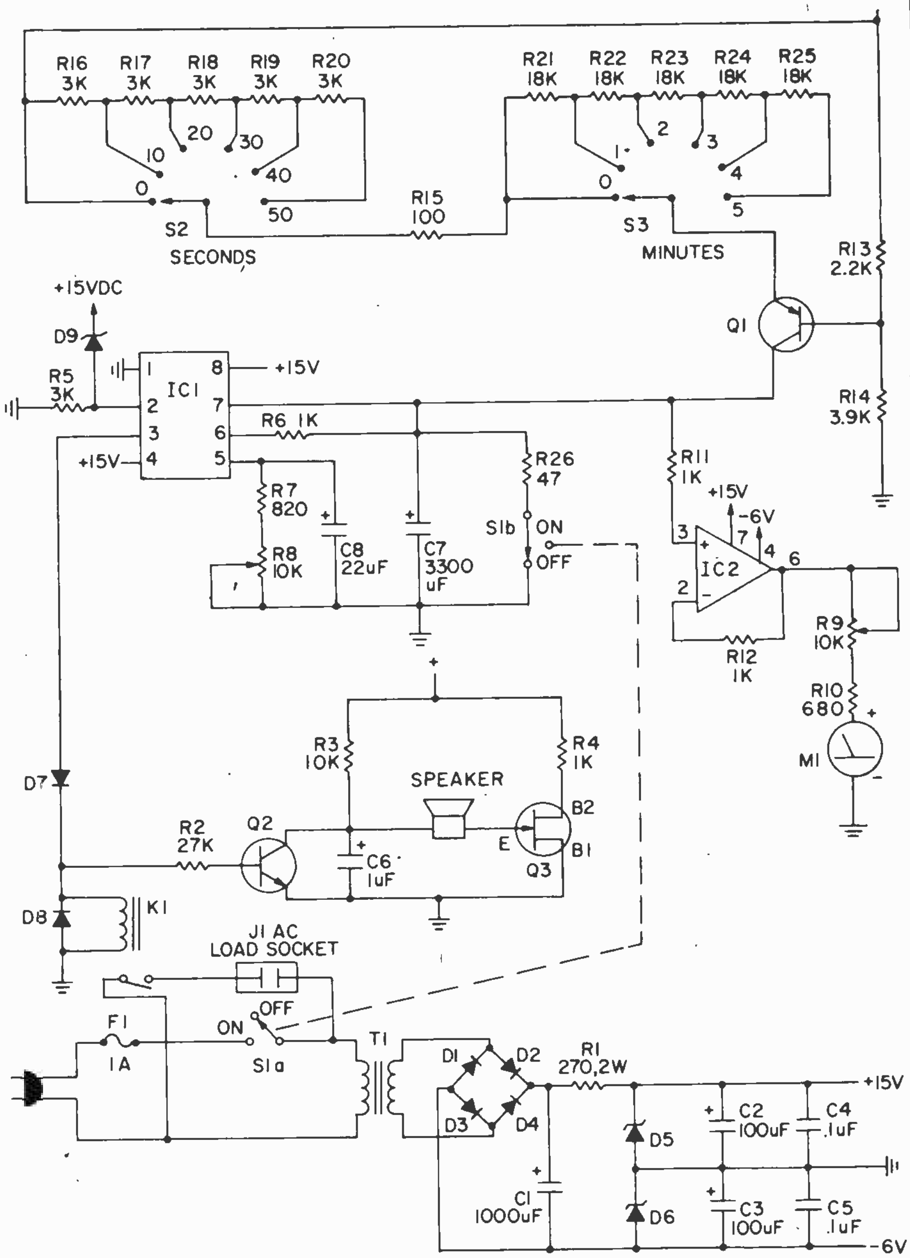
Construction. Parts layout of Pro-timer is entirely uncritical, so you may use any method you like: a printed circuit, perfboard, or whatever else. The prototype shown here is housed, rather tightly, in a 3 x 6 x 4-inch aluminum mini-box. Use a larger case if you like lots of room in which to work. The



This is the parts layout for the Pro Timer printed circuit board. On the PC board everything should be positioned exactly as shown in this diagram.

meter and switches mount on the front panel of the cabinet, while J1 and the speaker go on the back. Don't worry that the alarm's volume will be reduced by a back-mounted speaker. Since the alarm signal operates at about 300 Hz, it gets reflected well enough to be audible in all directions. Switches S2 and S3 are single-pole, six-position rotary devices, whereas the Radio Shack unts specified are double-pole units. Just ignore one section on each switch.

Timing resistors R16 through R25 can be mounted point-to-point on the lugs of the two rotary switches. Be sure to use a good-quality, low-leakage capacitor for C7. The capacitor you see in the photographs has screw terminals, while the Radio Shack unit specified has wire leads. Eletcrically, the units are identical. Since C7 and C1 are physically rather large, strap them securely to the board with wire. Don't rely solely on the capacitor's leads to



The Pro-Timer is based on the IC1 (the familiar 555 intergrated circuit timer module) which acts as a monostable multivibrator. The application of power to pin 2 is delayed by D9 and R5 long enough to have it appear as ground potential compared to the rest of the IC's circuit. This triggers IC1 and the output is felt at pin 3 which turns on relay K1 and puts power to the electrical outlet. The pin 3 output also causes Q2 to turn-on and short-out the speaker—keeping it quiet. Transistor Q1 controls the charging of C7 with the rate of charging contolled by the 5 percent resistors on the two time-switches. When C7 reaches its threshhold voltage (determined by the adjustment of R8), it discharges through pin 7 of IC1 and kills the output of pin 3, which shuts off K1 and the electrical outlet.

PARTS LIST FOR PRO-TIMER

C1—1000-uF, 50-Volt electrolytic capacitor
C2, 3—100-uF, 35-volt electrolytic capacitor
C4, 5—.1-uF capacitor
C6—1-uF tantalum capacitor
C7—3300-uF, 35-volt electrolytic capacitor
C8—22-uF tantalum capacitor
D1, 2, 3, 4, 7, 8—1-ampere rectifier
D5—15-V, 1-watt zener diode
D6—6.2-V, 1-watt zener diode
D9—9.1-V, 1-watt zener diode
IC1—555 integrated circuit timer module
IC2—741 integrated circuit operational amplifier
K1—12-V, 1200-ohm single-pole, single-throw relay
M1—0-1 mA, DC panel meter
Q1—General-purpose PNP silicon transistor 2N3906
Q2—General-purpose NPN silicon transistor 2N3904
Q3—Unijunction transistor (Radio Shack 276-2029 or equiv.)
R1—270 to 300-ohm, 2-watt (Allied Electronics 823-270 or equiv.)
R2—27,000-ohm, ¼-watt resistor
R3—10,000-ohm, ¼-watt resistor
R4, 6, 11, 12—1000-ohm, ¼-watt resistor
R7—820-ohm, ¼-watt resistor
R8, 9—10,000-ohm potentiometer, circuit-board mounting
R10—680-ohm, ¼-watt resistor
R13—2200-ohm, 5%-tolerance, any wattage resistor (Allied Electronics 824-405 or equiv.)
R14—3900-ohm, 5%-tolerance, any wattage resistor (Allied Electronics 824-202 or equiv.)
R15—100-ohm, ¼-watt resistor
R16, 17, 18, 19, 20—300-ohm, 5%-tolerance, any wattage resistor (Allied Electronics 824-427 or equiv.)
R21, 22, 23, 24, 25—18,000-ohm, 5%-tolerance, any wattage resistor (Allied Electronics 824-565 or equiv.)
R26—47-ohm, ¼-watt resistor
Note: Any of the ¼-watt resistors above may be replaced with ½-watt resistors. And if 5% resistors are not available, 10% resistors will do, but accuracy of the timer will be slightly lower.
S1—DPDT toggle switch
S2,3—DP, six-position rotary switch
T1—power transformer, 115-VAC primary, 24-V, 300 mA secondary
Misc.—1-ampere fuse; fuse holder; small loudspeaker—any 3.2, 4, or 8-ohm speaker cabinet is OK; IC sockets; solder, wire, etc.

PRO-TIMER

hold them in place.

Also make sure that C7 is formed before wiring it into the circuit. To do this, connect the capacitor, in series with a resistor of about a thousand ohms, across a 9-volt battery or power supply with capacitor (+) connected to positive. Leave it there for half an hour, then disconnect everything, and discharge the capacitor through the resistor.

For best accuracy, it is desirable to use 5-percent tolerance resistors for R13, R14, and R16 through R25. Alternatively, for R16 through R25, you might try hand-selecting and matching resistors, using an accurate ohmmeter or bridge, but this is a tedious process. The object is to get the closest possible match among the elements of either set of resistors (R16-R20, or R21-R25), and at the same time to have the mean resistance of the second set equal to six times the mean resistance of the first. Precision restistors could be used, but excellent results were obtained in the prototype using commonly-available 5% resistors.

Be certain to observe proper polarities with C1, C2, C3, C6, C7, C8, the meter, and all the semiconductors. Incidentally, leads for all the semiconductors are properly identified on the packages in which they are sold.

Q3 is a UJT, and its lead terminology may be unfamiliar; B2 connects to R4, while E goes to the speaker, and B1 goes to ground. As always, use rosin-core solder and a low-heat (25-watt or less) soldering iron when making the connections. Finally, you'll note that no connection is made to pins 1, 5, or 8 of IC2. These may be clipped off before mounting.

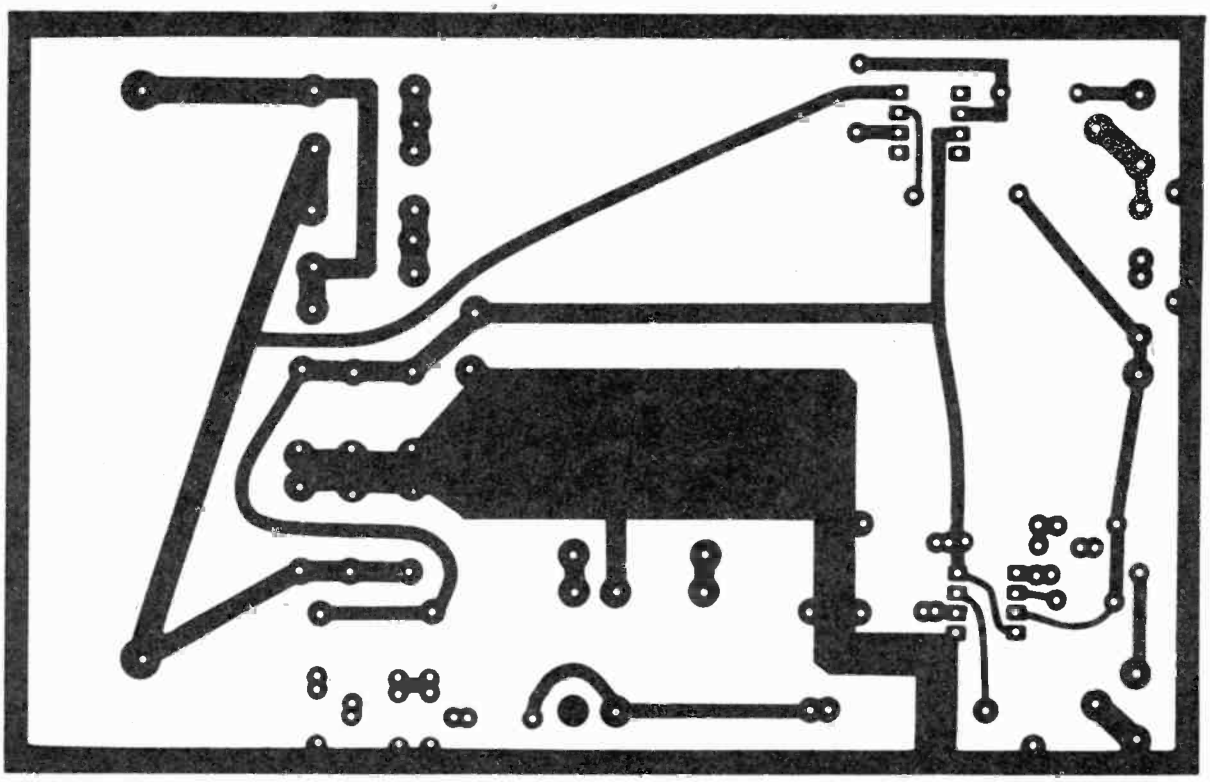
Operation and Calibration. Operation of the Pro-timer is literally a snap. Dial in the desired time via S2 and S3, and flip S1 to *On*. At the end of the timed interval, the speaker will alert you with a raucous tone. To re-initiate another timed interval, switch S1 to *Off*, and wait a few seconds. Then switch it back *On* again. Before you can use Pro-timer, it must be calibrated. Begin by adjusting R9 so that its resistance is at maximum. Set R8 to the mid-point of its range of rotation. Dial in a time of 1 minute on S2 and S3. Flip S1 to *On* and, using a clock with a sweep-second hand as a reference, time how long it takes for the tone to sound after turn-on. Adjust R8 in small steps until the timed interval is exactly one minute. When that is done, start up Pro-timer, again set at one minute, and adjust R9 so that M1 just reaches full-scale at the end of the timed interval. You should use your clock as a reference here, too. As one minute approaches, adjust R9 so that full-scale deflection occurs at the one-minute mark. Your Pro-timer is now calibrated. Now you should check its accuracy at other time settings. When I checked my prototype, the following results were obtained:

SWITCH SETTING	ACTUAL TIME
10 sec.	11 sec.
20 sec.	21 sec.
30 sec.	32 sec.
40 sec.	42 sec.
50 sec.	52 sec.
1 min.	1:00
2 min.	2:00
3 min.	3:01
4 min.	4:03
5 min.	5:03

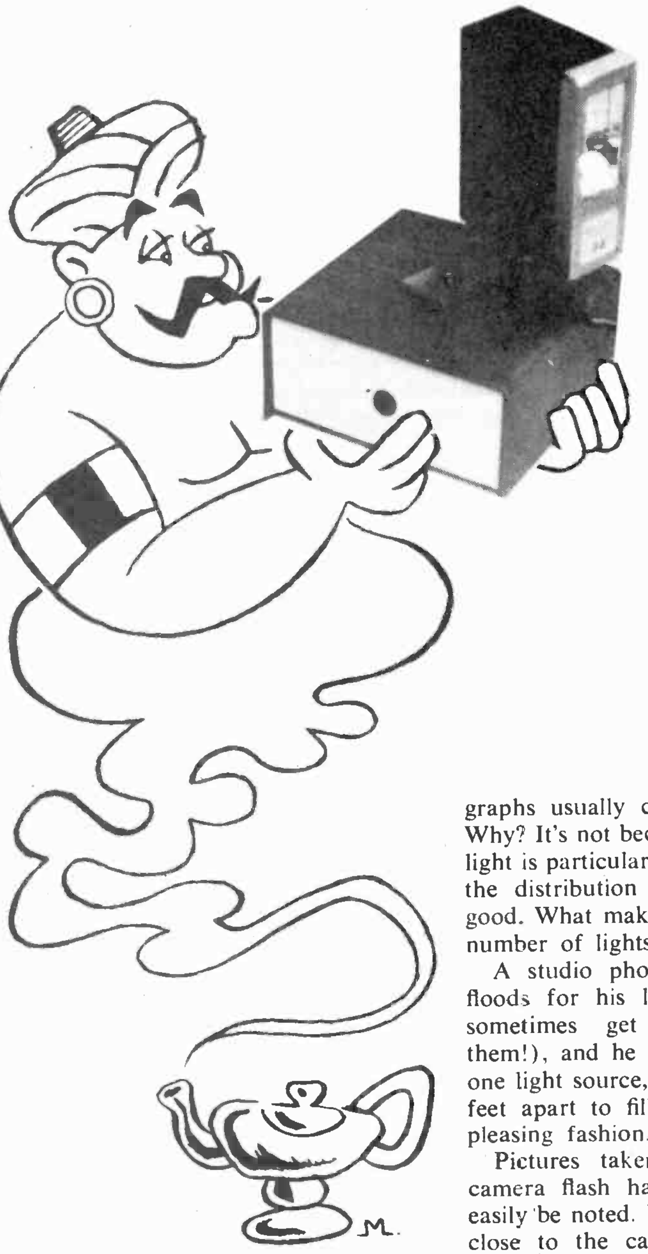
Note that percentage-wise the accuracy is excellent on times over one minute, and only fair at times less than a minute. Since accuracy is a chance affair, your results will be different. Should you desire better accuracy, hand-select the timing resistors as described earlier. For most readers, however, rseults similar to those of the prototype will be more than adequate.

The Components Board. In this project the parts layout is entirely uncritical so the parts may be mounted on a printed circuit board, using the board pattern shown, or a similarly-sized piece of perf board, with flea clips inserted into holes at roughly the same locations as are indicated in the components location diagram. If you're

(Continued on page 116)



This is the printed circuit board layout for Pro Timer. It is shown in the exact size corresponding to the actual PC board you will need for the unit. If this is your first time making a PC board, be sure to exercise great care so that no hair-thin bridges short between conductive paths.



LET LIGHT/JINN SERVE UP SNAPPIER SNAPSHOTS

This cable-free slave flash uses only two resistors, one LASCR, one choke, and an optional diode bridge.

by C. R. Lewart

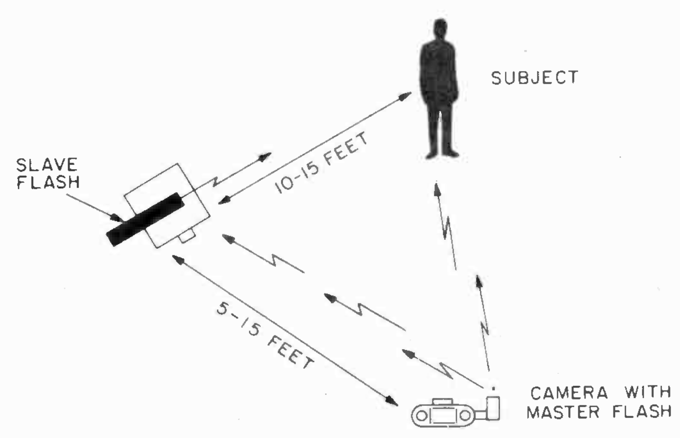
GREATLY IMPROVE your flash pictures by using the flashgun on your camera to control one or more "slave" flashes by means of our Light/Jinn—a magical genie which has no cables to the master flash, but triggers from the light of the camera flash—at your command. You can use two or more Light/Jinns at the same time, but the greatest improvement in your flash pictures will come with the addition of the first Light/Jinn to your regular on-camera flash. The time delay between the master and slave flashes is on the order of 1 millisecond (1/1000 sec) so that you can take pictures at the shortest exposure times your camera permits.

Multiple Flash is Better. If you compare most ordinary flash pictures to other shots taken with photofloods (high intensity incandescent lamps, such as are often used for motion pictures, as well as for professional still pictures) the single flashgun-illuminated photographs usually come out second best. Why? It's not because the quality of the light is particularly inferior, but because the distribution of that light isn't as good. What makes the difference is the number of lights used.

A studio photographer uses photofloods for his lighting (those models sometimes get awfully hot under them!), and he always uses more than one light source, spaced at least several feet apart to fill in the shadows in a pleasing fashion.

Pictures taken with a single, on-camera flash have defects which can easily be noted. If you have subjects up close to the camera they often look washed-out or overexposed, and the shadows are usually harsh and too contrasty, particularly if the subject is near a wall or other large background. Automatic flash units, coming into wider use now, can control some of these problems partially. But the automatic flash can't fill in the shadows it creates. Using bounce flash (aiming the flash at a white ceiling) provides more even illumination, although most on-camera flash units can't readily be aimed at the ceiling. And with bounce flash you must open the lens diaphragm to compensate for the lower overall light level. This decreases the depth of field, which can be another problem. Furthermore, bounce flash with color film can put the color of the ceiling or wall, if not white, into the subjects' faces. All in all, taking flash pictures with a single flash is something you'll learn to avoid wherever possible.

Adding just one more flash, if it's properly placed, will give you shadowless pictures, with greater depth, more modeling of subject's features, and



Adding another flash at the side of subject improves pictures by wiping out harsh shadows. Slave flash triggers on light from camera flash.

LIGHT/JINN

clearer details. Or, in other words, your pictures will be a lot closer to studio photographs.

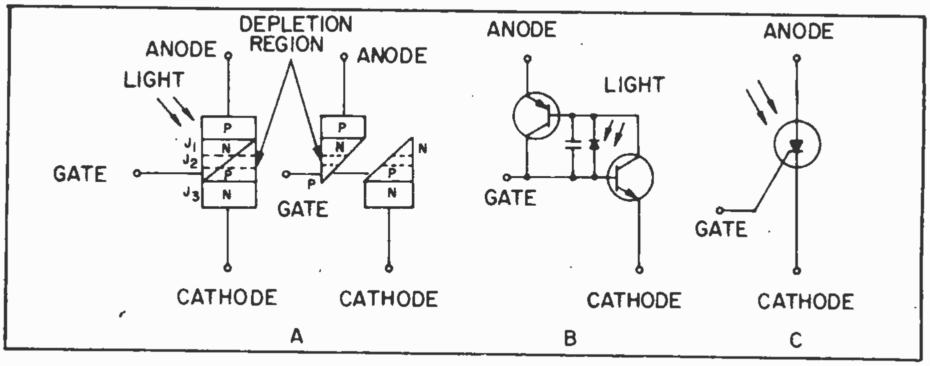
Better Flash Shots. To take such pictures you need one more flash unit and some way to support it, and of course some way to make it fire at the same time as the main flash. The first flash unit mounts in the usual way on the camera (or slightly off it, with an extending bar), while the second flash, which now becomes the "main" light (the primary source of illumination), is placed near the subject and interconnected to flash at the same time as the first flash, in synchronism with the shutter opening.

The usual way to synchronize the two flashes with the shutter is to use a long connecting cord—if your camera or first flash has a receptacle for it (most do not).

Get Rid of Cables. Long cords can lead to problems. They can come loose at either end or both; they can be tripped over; and their length is either too long for most shots, or not long enough for some. But these problems can all be eliminated if you use a flash connected to the main unit by *light!* That's right. You can use the light from the first flash to set off the second one. It takes less than a millisecond (1/1000 of a second) for the second flash to fire. Since you'll be using a 125th or 250th of a second shutter opening, the camera will think both flashes go off at the same time, and the effect is exactly as though they do.

The project is simple to build and inexpensive—the basic parts cost less than $5. Light/Jinn requires no power source; it "borrows" its energy from the flashgun it operates. It also is an improvement over many previously-described similar circuits, because Light/Jinn will not be triggered by even a strong beam of ambient light falling on its sensor. Only another flashgun, or direct sunlight can trigger it. In addition this project will familiarize you with one of the most modern optical semiconductor devices, the *Light Activated Silicon-Controlled Rectifier,* or LASCR for short. The unique properties of this device can lead you to other electro-optical projects which also can be built simply and inexpensively.

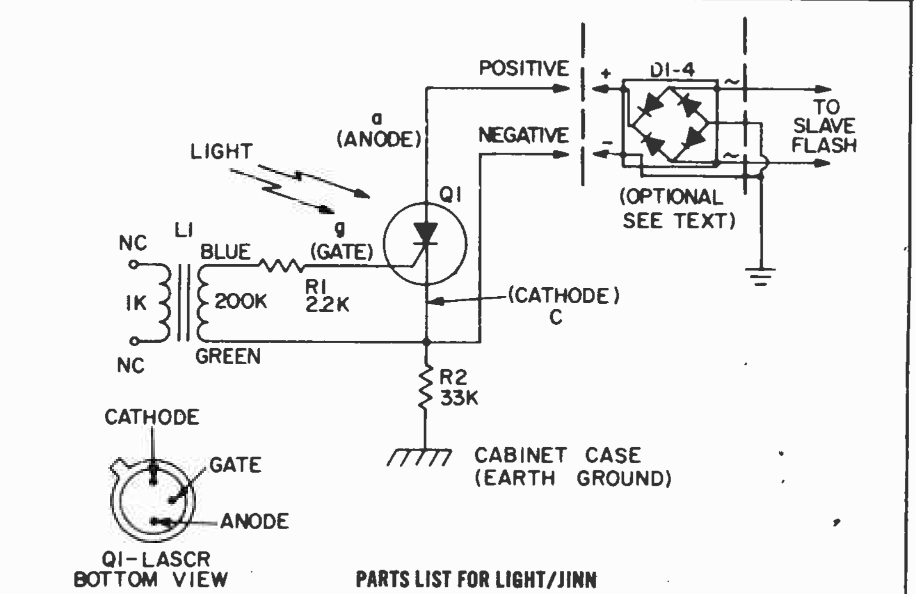
What Is An LASCR? Its tongue-twisting name, Light Activated Silicon Controlled Rectifier, explains its function. It is an SCR (silicon controlled rectifier) operated by light falling on its sensitive area. The LASCR is the brain of our project, the understanding of which, though not essential for successful completion of the project, should nevertheless interest you.



Operation of the LASCR (light-activated silicon-controlled rectifier) is shown above. It's equivalent to combined NPN and PNP transistors, as shown in A and B, above.

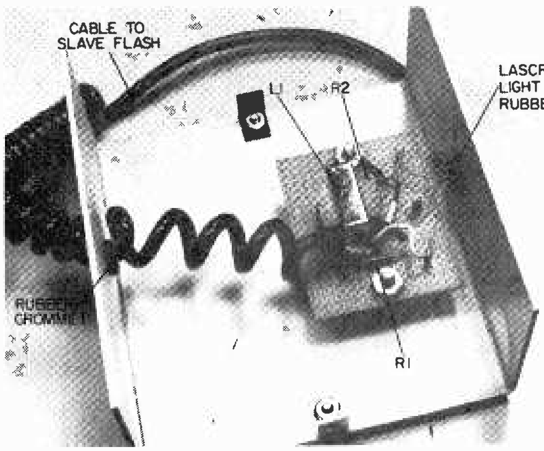
Refer to the three small drawings (above the schematic diagram) marked A, B, and C, for a description of how the LASCR works. With positive voltage applied to the anode, junctions J1 and J3 are forward-biased, and they will conduct if sufficient free charge is present. Junction J2 is reverse-biased however, and it blocks current flow. Light entering the silicon creates free hole-electron pairs in the vicinity of the J2 depletion region which are then swept across J2. As light increases the current in the reverse-biased diode will increase. The current gains of the NPN- and PNP-equivalent transistors also increase with current. At some point the current gain exceeds unity and the LASCR starts conducting.

Slave Flash Circuit. The LASCR is sensitive both to visible and invisible light, and will normally trigger at as low as 200 foot-candles. To limit its response so it responds only to another flash, we put the inductance of a small audio choke L1, and resistor R1 between the gate and cathode terminals of the LASCR. This novel approach prevents the LASCR from being triggered even by strong ambient light. For steady ambient light the inductance of the transformer behaves like a very small resistor and prevents the LASCR from firing by bleeding the charge generated by



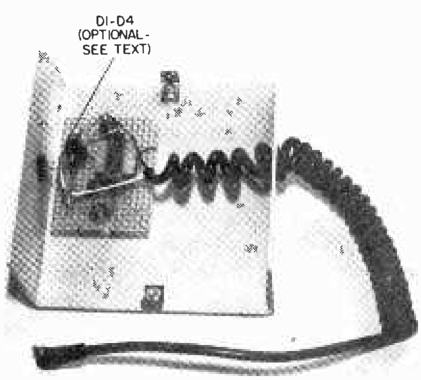
PARTS LIST FOR LIGHT/JINN

- D1-4—Diode rectifier bridge module, 400 V, 6A
- L1—Small audio transformer, 200K/1K
- Q1—Light-operated silicon-controlled rectifier, 200 V, 1.6 A
- R1—2200 ohm, ¼- or ½-watt resistor
- R2—33,000 ohm, ¼- or ½-watt resistor
- Misc.—Case, aluminun, 4-in. x 2-in. x 1½-in. or larger, two rubber grommets, ⅜-in. O.D., flashgun support bracket, flashgun extension cable to match receptacle on flashgun.



Light/Jinn with cover removed showing all the parts except optional diode bridge rectifier. Top cover has flash mount.

light directly to ground (the cathode). A sudden burst of light coming from an electronic or other flash makes the inductance of the transformer appear as a high resistance which causes the LASCR to conduct, triggering Light/Jinn. Finally, resistor R2 connects the circuit to the cabinet and lowers the



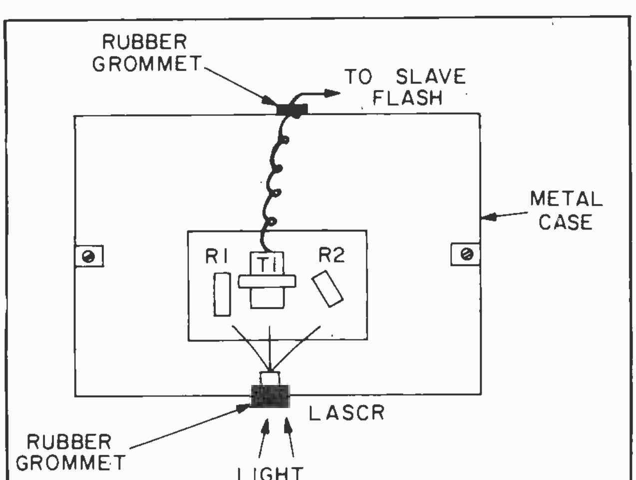
This photograph shows the unit including the diode bridge rectifier, which is needed if Light/Jinn will be used with flash units whose polarity is unknown.

possibility of flashes caused by static electricity.

An inexpensive audio frequency choke is most readily obtained by using an ordinary audio transformer and leaving the secondary unconnected.

Construction. Although the actual components of the simple circuit for Light/Jinn take very little space we selected a good-sized box (4-in. deep by 4½-in. wide by 2-in. high) to provide a substantial stand for the slave flash. A flash gun mounting shoe and flash gun extension cable can be obtained in most photo supply stores. Mount the flashgun shoe on top of the cabinet. Cut off and throw away the male jack on the flash gun extension cable and strip the two wires leading to the female jack. If the flash gun you are planning to use for Light/Jinn has a "hot" shoe you will not need the extension cable. You should now determine which wire is positive. In most, but not all, flash guns the positive is the one which leads to the inner part of the jack (the center lead). If you plan to use Light/Jinn with a slave flash whose polarity you do not know, add the bridge rectifier (labeled "optional") at the right hand of the schematic. Then the polarity does not matter.

Using Light/Jinn. Mount the second flash unit on Light/Jinn, connect it to the cable extension, and charge the gun from its built-in batteries (or AC). It may flash once or twice by itself, but then it should stabilize. If it keeps going off spontaneously check the circuit for mistakes. If the wiring looks OK you may have to try another LASCR. This is because they have different sensitivities, and some trigger more easily than others.



Drawing at left shows there is much spare space in the metal enclosure. This is because the box must be large enough to provide a substantial mounting base for the flash unit.

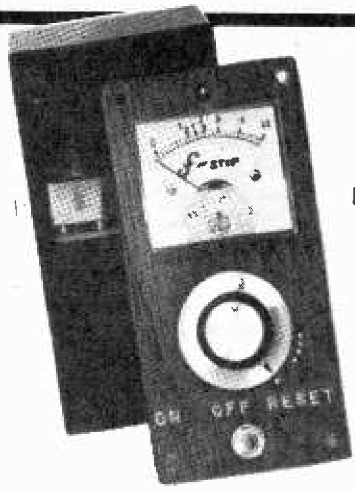
For the best pictures set Light/Jinn five to ten feet to one side of the subject, with the sensor (LASCR mounted in rubber grommet) pointing directly at your camera, and Light/Jinn's flash unit pointing directly at the subject. Make sure that neither the slave flash nor its reflections are in the picture. Test the setting by looking in the camera viewer and releasing the master flash before taking a picture. If Light/Jinn does not go off, point the LASCR at the camera or move it closer. Light/Jinn can be set 10-15 feet away from the camera depending on the strength and direction of the master flash. If your camera has various flash settings (X, M, F) use the setting recommended for the master flash (X for electronic flash, M or F for flash bulbs).

The key to success in multiple flash photography is correct placement of the flash units. If you follow the basic rules for good studio photography you'll be able to take much improved flash photographs. The basic studio setup calls for just two lamps. In our setup the basic, on-camera flash becomes the "fill" light, and the second, added flash unit becomes the main light source. This is often called the *key* light, and its placement is critical to the production of a good photograph.

The key (off-camera) flash must be mounted on a chair, tripod, or something similar, such as a chair back or bookcase. If all else fails have a friend hold it for you. Putting this light high, and off to one side, about 45 degrees, will provide both depth and modeling. The on-camera flash, being much further away from the subject than the key flash, will be much weaker, and need not be considered when figuring the correct camera aperture.

Since the key light is the only one that matters (in figuring the exposure) the calculation is quite straightforward. You just divide the number of feet from the key flash to the subject into the flash guide number. This gives the approximate *f* stop for the key flash mounted on Light/Jinn.

Caution. A charging flashgun may develop as high as 200 Volts, so keep the cabinet closed when the circuit is in operation. Also, do not get the flash gun close to your eyes, because when it is charged it may go off accidentally due to static electricity pulses. ■



FLASHMATE–THE PHOTOGRAPHER'S DREAM

Photoflash problems vanish with this easy-readout solid-state meter.

Frank I. Gilpin

☐ Any photographer, amateur or pro, will tell you the biggest bane of his life is figuring exposures for electronic flash photography. *If* you know the manufacturer's guide number for your flash unit, and *if* that number is close enough to being accurate for your production line unit, and *if* you can remember it from one shooting session to another, and *if* you remember how to use it, and *if* your flash is fully charged, and *if* you use straight, harsh flash instead of bouncing it, and *if*. . . . Well, flash photography is very often *iffy*.

Theoretically, you divide the guide number by the number of feet between the flash and subject, and the answer you get is the f-stop. This has to be figured for every shot, if you move between shots and this guide number is only good for one film type. Again, it gets pretty iffy. There are, to be sure, flash meters on the market, but the least expensive one I know of costs nearly $100, and they are all rather bulky.

The answer to these problems is Flash-Mate. It's smaller than an Instamatic camera, inexpensive to build, reliable and accurate, and easy to build, with readily-available parts. It takes all the IF variables in stride, and gives you the right f-stop for *any* flash at *any* distance and for *any* film type from ASA 10 to ASA 400. Flash-mate can be either of two basic types of meters. One, called an *ambient* light meter, measures the light output of your flash, aimed right at it. The other type, for measuring *reflected* light, is aimed at the subject and reads the light reflected by the subject. Your Flash-Mate can be calibrated for either type, as you choose.

How Circuit Works. The silicon phototransistor used as the light-sensing element in Flash-Mate has a very high resistance to ambient light, therefore the unit will work effectively under a wide range of lighting conditions, even including sunlight. The *sudden* light provided by the electronic flash causes a sudden drop in the phototransistor's resistance. This sudden drop in resistance pulses the trigger circuit of Q2-Q3. This pulse allows Q3 to charge capacitor C2 to a value proportionate to the intensity of the energy-producing light striking Q1. The value of this charge on C2 is then measured by FET Q4, and indicated on the meter. Because of the high input resistance of the FET, C2 does not discharge for several minutes and you have plenty of time to take a reading.

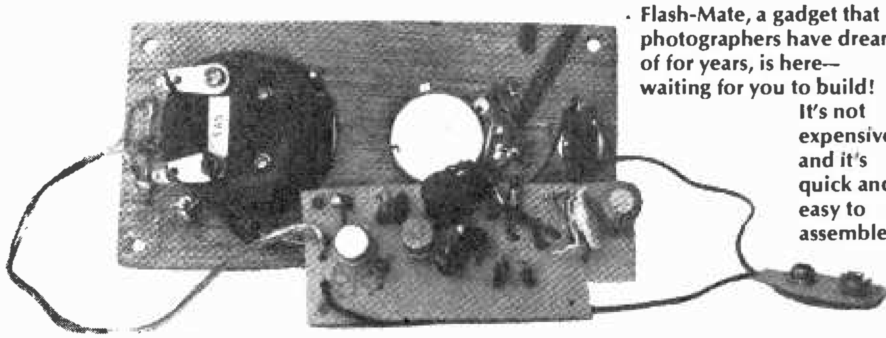
A discharge path for the meter and C2 is provided by R4 and S1. The switch turns the unit off and simultaneously discharges C2, leaving it ready for another reading, in about two seconds.

Sensitivity adjustments for various film types are effected by adjusting R8. A rotary switch could be used to connect a different trimmer resistor to the meter for each ASA number, but that would boost the cost, increase the size of the unit and limit the number of ASA numbers for which Flash-Mate can be calibrated.

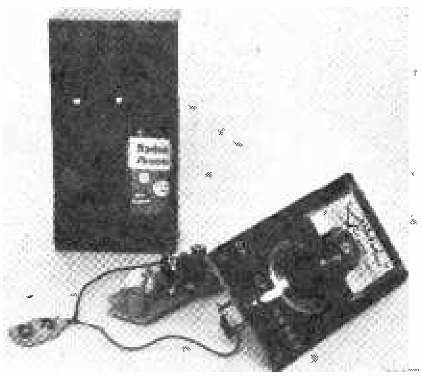
Potentiometer R8 can be calibrated for any ASA value, and as many as you want. You can even add more calibrations later. The only drawback to this compromise is that you must take care to set the pot directly on the reference marks before taking readings for a given ASA. If you exercise care and patience when calibrating the unit, this will present no problems in later use.

The two PNP transistors Q2 and Q3 are audio signal types and almost any high gain experimenter grade units will do. There are, however, few substitutes for Q1. It has a very high resistance to ambient light, has a reaction time on the order of 2.8 microseconds and has a wide range of illumination sensitivity. You can use a HEP-312, or a Clairex CL902, which also have the necessary reaction times and ambient light resistances required to keep the trigger circuit biased off until a bright, sudden light is sensed. The FET, Q4, is a P-channel, small signal unit and there are a number of substitutions possible, such as 2N5461 through 2N5465.

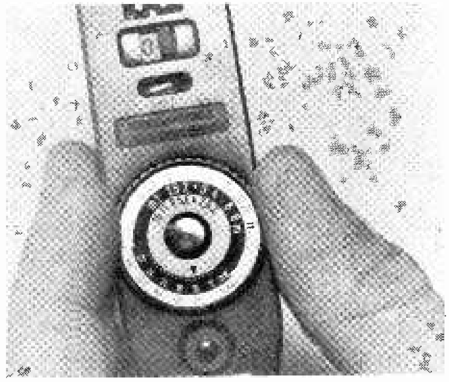
Assembly Options. You have a choice of assembly methods. Your Flash-Mate can be assembled on a perforated board using point-to-point wiring, or on a printed circuit board, for which the foil pattern is shown. Layout is not overly critical and you can vary the arrangement. Q1 is made with a clear epoxy lens which is quite durable, but an extra measure of protection can be provided by covering it



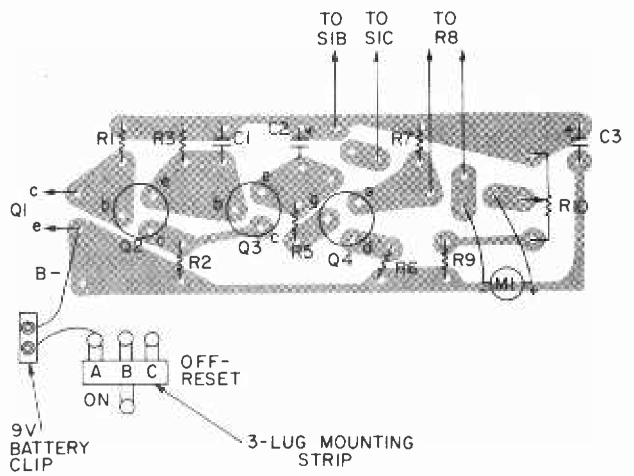
Flash-Mate, a gadget that photographers have dreamed of for years, is here—waiting for you to build! It's not expensive and it's quick and easy to assemble.



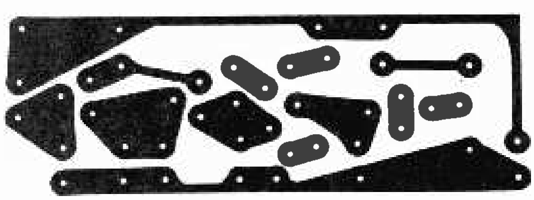
The layout of Flash-Mate's perf (or PC) board is uncritical and the arrangements of the components may vary. The roominess of the box allows for a clean layout



To calibrate Flash-Mate you will need an accurate electronic flash with an f-stop computer disc. Calibration can be done either for ambient light or bounce flash.



Here's the component side of Flash-Mate's PC board. The layout is simple and straightforward, which helps keep assembly time to a minimum. Flash-Mate is a great weekend project; accurate, unique, and goes together easily.



The foil side of Flash-Mate's board is quickly etched, especially if you use this full-size pattern. You could reduce or enlarge this as size and layout are not critical in this circuit.

with a clear pilot light lens or other clear plastic dome. The phototransistor can be mounted in several ways. You can press-fit it through a rubber grommet in the front panel of the cabinet, epoxy it through a hole, or it can be mounted on the chassis board so that it is rigidly suspended behind a hole in the front panel.

After all components are mounted and wired to the chassis board and connected to M1, R8, Q1 and S1 on the front panel, check to make sure all polarities are correct. Remember that when the chassis board is mounted in the cabinet, you have to be able to reach R10 to make adjustments. If the shaft is slotted you can drill a small hole in the cabinet facing the adjustment slot in the trimmer.

Some potentiometers have a knurled plastic wheel for adjustment which can be manually roated regardless of its mounting position.

When you are sure all is in order and you have double checked your wiring, apply power to the unit with S1. Turn R8 fully clockwise for least resistance and adjust R10 until the meter needle rests on zero. After this one internal adjustment, you can close the cabinet, screw down the front panel and prepare for the calibration procedure. You'll need a tape measure, a tripod and a flash unit.

To calibrate Flash-Mate either for ambient readings, or the reflected light reading mode, you will need a reliable electronic flash with an f-stop computer disc. You should also be sure the unit is charged fully, or has fresh batteries.

Ambient Light Reading Calibration. Set the flash computer to ASA 400. Determine the distance-from-subject necessary for an f-stop of f22. For instance, if your computer says a distance of three feet for f11, two and a half feet for f16 and 18 inches for f22, place the meter on a table and the flash mounted on a tripod exactly 18 inches in front of it. Carefully remove the clear plastic meter cover. Turn on the meter and set R8 fully clockwise and after a few seconds to stabilize, fire the flash. The meter needle should travel all the way upscale. Adjust R8 until the needle rests exactly on the uppermost reference mark of the meter scale. Label this spot "f22." Reset the meter with S1 and consult your flash computer once more to determine the distance for f16. Measure off this distance, set the flash at that spot and fire it at the flash meter. The needle should rest at a spot lower than the first. Mark this spot on the meter scale "f16." Take care not to disturb the setting of R8 during this calibration step.

Follow this procedure all the way through the scale to f2, remembering to reset the meter after each reading. When you've finished this step, replace the cover on the meter face and label the panel adjacent to R8's indicator knob "400."

This completes the calibration of the meter scale for all ASA values and the calibration of R8 for ASA 400. Select the next highest ASA on the computer and find the distance for an aperture of f16. Set the flash that distance from the meter and fire it. Adjust R8 until the needle rests exactly on the previously established mark for f16. Now mark the panel adjacent to R8's indicator knob and label it for the ASA number used to determine the distance. The meter is now calibrated for that ASA. Repeat this step for each ASA value desired. I have my meter calibrated for 25, 64, 80, 125 and 400, the five films I use most, but I can easily add more at some later date by using a reliable flash and the above procedure.

Reflected Light Calibration. The best situation is to find any wall which is an 18 percent gray, but any neutral color wall, or off-white bedsheet will do. In this procedure, the wall (or a sheet tacked up on a wall) becomes your "subject." Using the reference flash

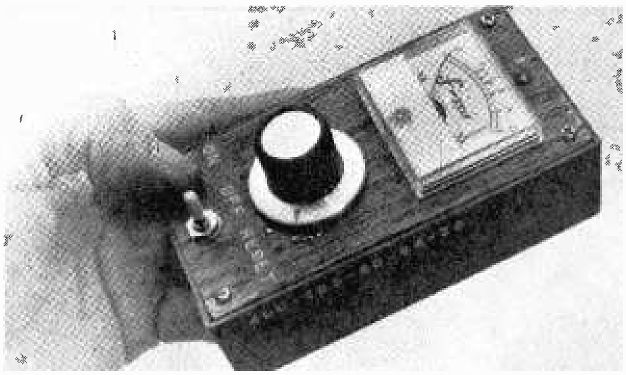
FLASHMATE

unit's computer to determine the first distance for f22 at ASA 400, place the meter and flash this distance from the wall. Both the flash and meter are aimed at the same spot on the wall. Fire the flash from just above and a few inches behind the meter to avoid "blinding" it with a strong sidelight from the flash. Mark the meter face for f22 and continue moving the meter and flash farther from the wall until f2 is calibrated. Repeat for other ASAs as in the previous step.

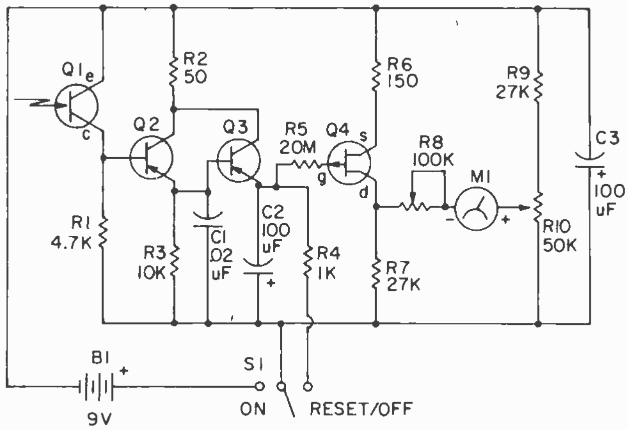
Using Flash-Mate. For the ambient light reading model, the procedure for taking a reading is as follows: Place Flash-Mate at the same location as the subject, facing the flash, and set R8 for the ASA of the film you're using and turn it on. Place the flash where you want it and fire it using the open flash button. Read the f-stop from Flash-Mate and set your camera to that f-stop.

To use Flash-Mate calibrated for reflected light readings, place it facing the subject in the same position as the flash. Fire the flash, take the reading from Flash-Mate and set your lens to that f-stop.

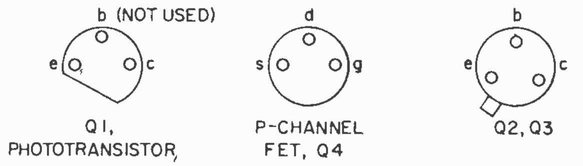
Personally, I prefer the direct, or ambient reading mode of calibration. For me, it offers more versatility. For example, your model need not be present to take a reading in advance. If you were going to shoot portraits using direct flash, bounce flash, or the popular umbrella reflector technique, you need only set up the flash and select where the model will sit or stand for the picture. Place Flash-Mate at that position, take a reading and set your camera lens. When the model arrives, all you need do is focus and shoot with no wasted time and wow, will you appear professional with no fumbling over f-stop computations or camera fiddling. If you plan to shoot from several positions during the session, these spots and their readings can be determined beforehand and noted. A piece of masking tape on the floor with the appropriate f-stop marked on it will remind you of the correct setting for that position. This technique is also handy for those special awards luncheons, handshakes, weddings, graduations, or any other planned events. You can go a little early before the event and take your readings and pick your spots from which to shoot and when that once-in-a-lifetime event occurs, you'll have a perfect exposure of it. ■



Flash-Mate is one useful gadget-bag stuffer. Forget about computing f-stops and concentrate on composing those pictures. The photo-sensitive transistor (above the meter) measures the light, and the meter reads directly in f-stops. The unit can be calibrated to read either ambient light or for bounce flash photography, depending on your own artistic preferences.



Schematic for Flashmate circuitry. Be sure when wiring in the transistors that you carefully observe lead keying, and always avoid allowing them to heat too much.



PARTS LIST FOR FLASH MATE

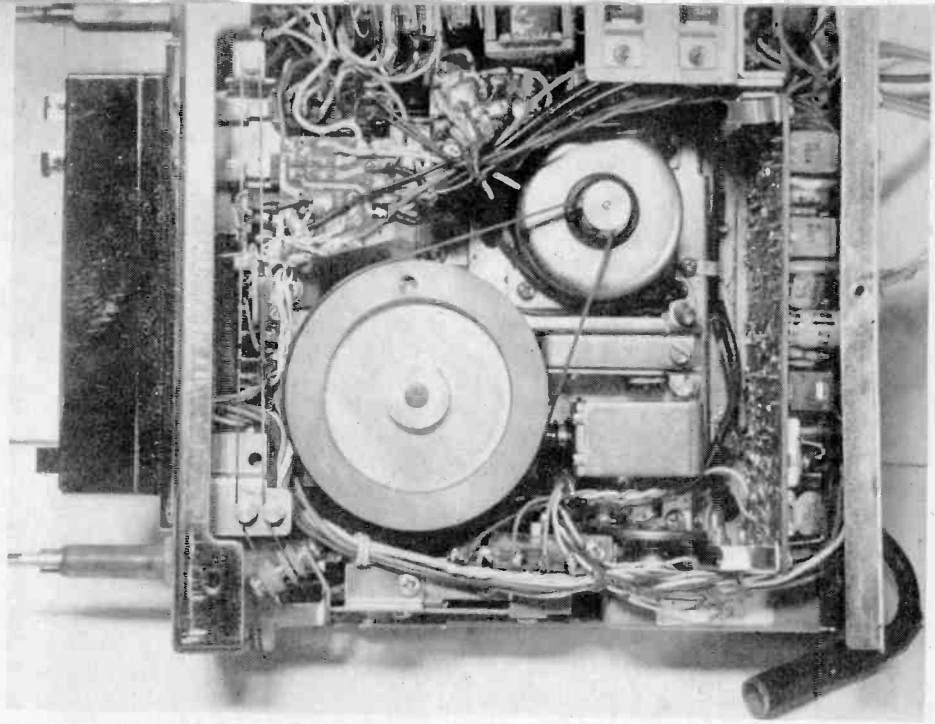
- **C1**—.02-uF capacitor
- **C2, 3**—100-uF, 16-VDC electrolytic capacitor
- **M1**—0-50 microampere DC panel meter
- **Q1**—Photo-sensitive transistor HEP-312 or Clairex CL902
- **Q2, 3**—General-purpose PNP silicon transistor, 2N5139 or HEP-51
- **Q4**—Field-effect transistor, P-channel, 2N-5460 or 2N5461
- **R1**—4700-ohm, ¼-watt resistor
- **R2**—47 or 50-ohm, ¼-watt resistor
- **R3**—10,000-ohm, ¼-watt resistor
- **R4**—1000-ohm, ¼-watt resistor
- **R5**—20-megohm, ¼-watt resistor
- **R6**—150-ohm, ¼-watt resistor
- **R7, 9**—27,000-ohm, ¼-watt resistor
- **R8**—100,000-ohm printed circuit board-mounting potentiometer
- **R10**—50,000-ohm printed circuit board-mounting potentiometer
- **S1**—Single-pole, double-throw switch

Misc.—Printed-circuit board kit cabinet 6¼-in. x 3¾-in. x 2-in. or larger; knob; hookup wire, hardware, solder, etc.

Note: If you use construction such as perf board, axial-lead capacitors will be more convenient to mount.

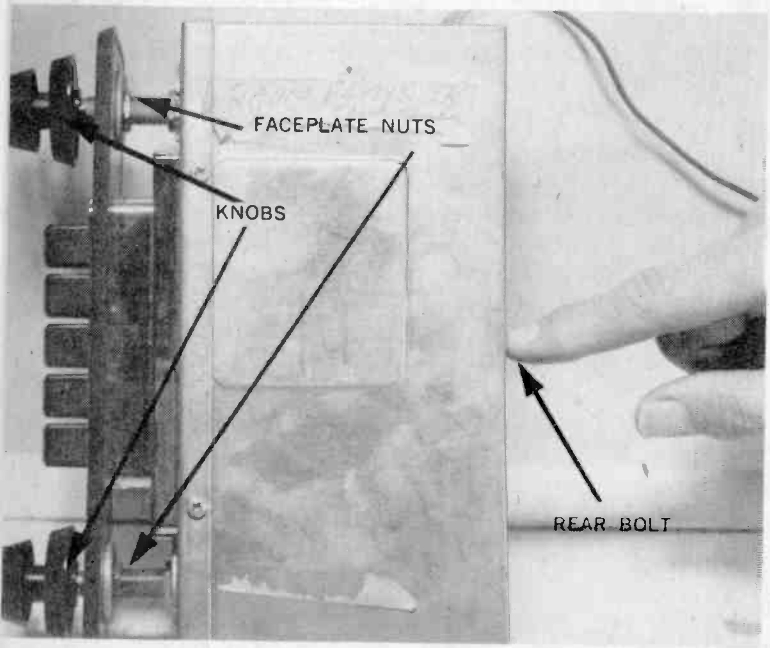
Flashmate can be built either with the printed circuit board layout presented with the article, or you could just use a perfboard and point-to-point wiring as the layout is not critical. A few final reminders: Once all components are mounted to the chassis, and wired, check to make certain you have not reversed any polarities; reall that you have to reach R10 to make adjustments so don't forget the small hole in the cabinet facing that trimmer's adjustment slot. The phototransistor, Q1, is made with a clear epoxy lens which is fairly durable and should hold up under most circumstances. If, however, you seek a measure of extra ruggedness, cover the phototransistor lens with a clear pilot light lens or any other clear plastic dome. Properly built and cared for your Flashmate will be calculating F-stops for you for years of parties, weddings, or just plain shutterbugging.

TEN



Ninety percent of auto radio repair problems don't require a trained technician with thousands of dollars worth of test equipment. Many car radio problems concern mechanical connections—a broken wire, loose capacitor or a broken dial cord —others are caused by defective power supplies or overheating parts. What ever the problem it can almost always be fixed without taking it into a shop and running up a big bill—just learn these tricks-of-the-trade and get down to business.

An auto radio, however, can be very tricky to work on. Sometimes it includes FM as well as the standard AM, not to mention FM multiplex, 8-track, cassette and even CB. When all of this is jammed into a seven-inch wide package it can be pretty confusing to figure out what is what, so you don't want to make things harder than they need be.



1. Before removing the radio make sure the troubles are definitely in the unit itself. You may have a blown fuse, defective speaker, antenna or bad wiring connections. First thing: locate and check the fuse. The fusebox is normally under the dash and to the left of the steering wheel. When a tape player is included in the radio you will find it in the plug or harness. If you can't find it trace the largest wire out of the radio and see where it goes. The color of the "A" lead wire may be black, red or blue.

A defective speaker may be causing the problem and the type of sound is a clue to the cause. If the music is intermittent then the speaker voice coil wires may be partially broken into. A dropped speaker cone will produce a tinny and mushy sound. Typically on loud volume certain vibrations may be caused by a torn or loose speaker cone. Excessive blatting music may result from a loose voice coil support. You should check the speaker for continuity with ohmmeter or a flash-light battery. When using a small battery just temporarily touch the speaker leads and listen for a clicking noise. If you don't get a new speaker.

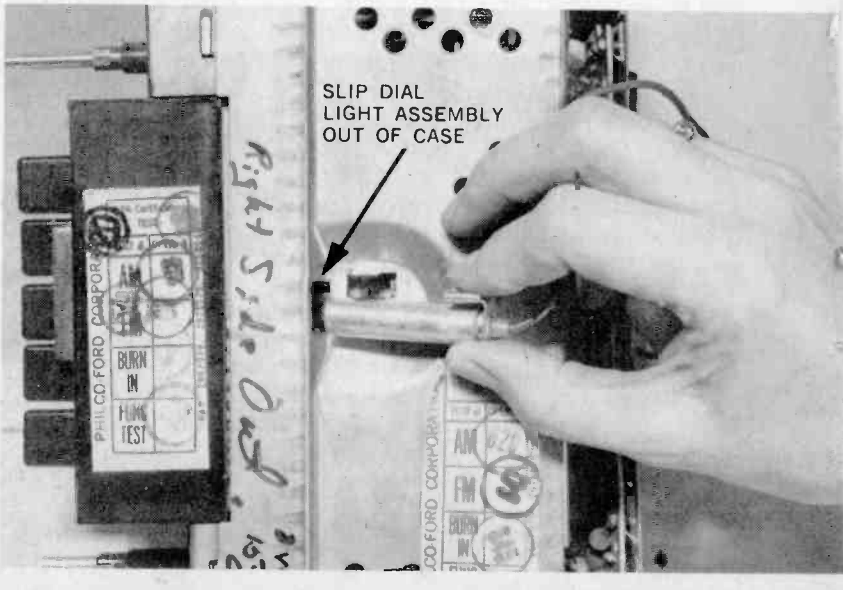
Check the radio wiring for possible loose or broken connections. If the radio is a universal type, mounted under the dashboard, it's likely that the speaker and "A" lead connections are just twisted together. Remove the tape and solder all connections then retape with plastic tape. In case of stereo speakers, with one side intermittent or dead, inspect the speaker wiring to see if it is frayed.

An open or poor antenna connection may cause weak or noisy reception. If radio reception is very noisy, check the bond between antenna base and metal car body. Another source of car noise may be a broken shielded cable where the male plug enters the radio. With antennas molded into the front windshield check for a broken connection at the bottom of the windshield. Be real careful and don't pull on the antenna connection or you may end up replacing the whole windshield. If another auto antenna is handy simply plug it in and hold the base outside the car window. You would be surprised how many antenna problems are identified by this test.

2. Doing without a dial light on a car radio is like fixing a flat tire with a dead flashlight after Friday night's football game. Most car radios must be pulled out to replace the dial light. Before removing the radio check to see if the pilot light may be wired to the dash light control switch. Trace two (black) wires leading to the fuse block or auto wiring harness. A defective plug or poor wiring connection may be the trouble.

After removing the radio, inspect the front dial assembly to locate the defective dial light. On some radios you unclip the dial light assembly from the radio chassis. Other models mount the dial light close to the bottom of the dial assembly. You may have to remove the whole front dial assembly to get at the dial light mounted behind a white plastic cover. Within some Japanese models, you may find a dial light with long wire leads.

Most American-made radios use a 12-volt bayonnet dial light such as an 1891, 1892, 57 or 47. Foreign radios may have screw type bulbs which are sometimes difficult to obtain. They can be replaced with a bayonnet type or one with leads. Since all dial lights are 12-volt types you can solder a bayonnet bulb in place of a screw type. If not, replace it with one having a 12-volt flexible lead (like those found in tape players) and cement it in position with black silicone cement.



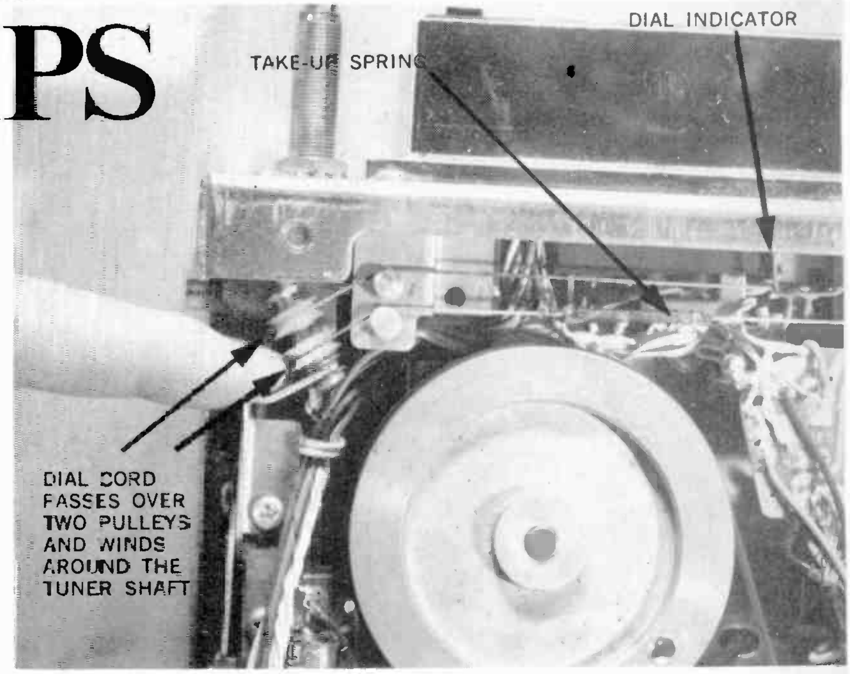
CAR RADIO REPAIR TIPS

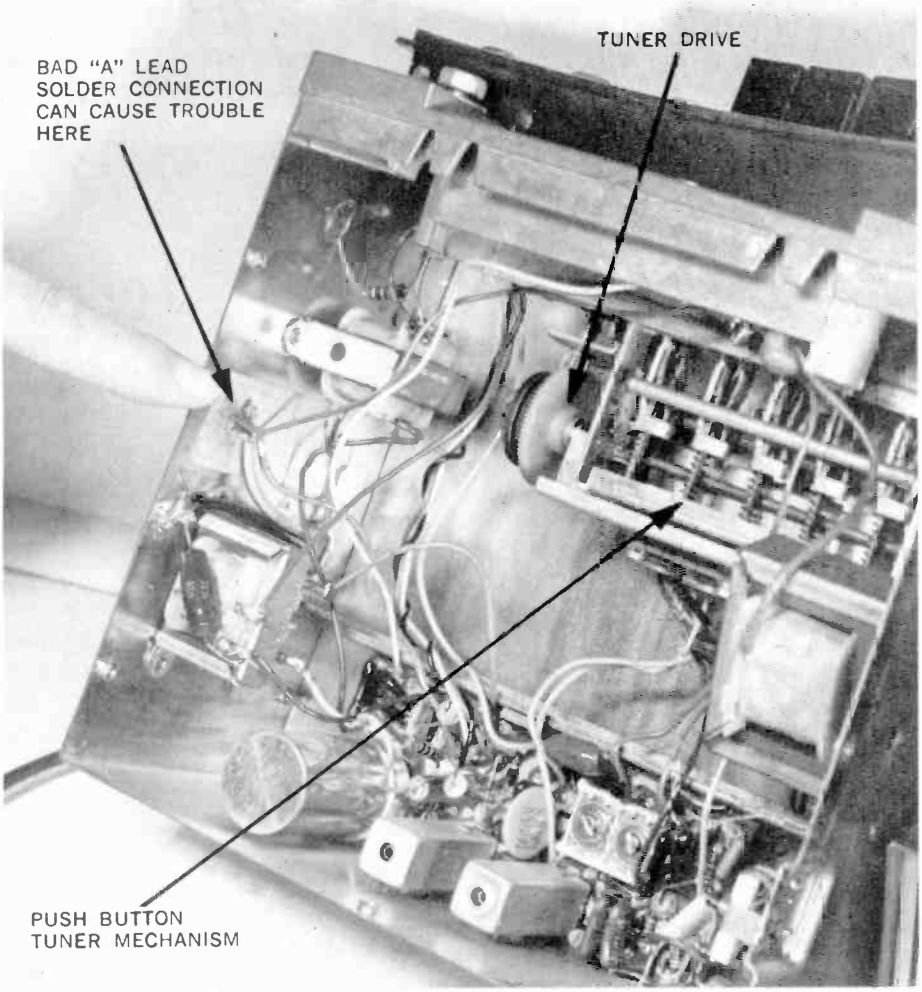
by Homer L. Davidson

3. There are two different types of dial mechanisms found in an auto radio—mechanical and dial cord operations. The mechanical system employs a couple of worm and gear assemblies. The most common problem with mechanical tuning is slippage between the clutch and tuning coil assembly. Clutch tension may be adjusted with a set screw, or liquid rosin and phono-grip may be applied to prevent the clutch from slipping.

You should suspect a broken dial cord if the radio will tune in stations, but the dial pointer doesn't move. You will find two basic dial cord arrangements; a simple one with tuning shaft, two small pulleys and dial pointer; the other with additional small pulleys and dial cord spring. When a spring is not used to take-up the slack, most of the dial cord is wound around the tuning shaft. The small spring keeps the dial string taut around larger pulleys.

Do not attempt to tie a knot in the broken dial cord and make it do. Select a cord of medium or fine dial cord (found in most radio and TV supply houses). If a dial stringing schematic is not handy, draw a diagram the way you found the broken dial wound. Nine times out of ten you have come up with the right method. Remember, when the tuning coil cores are all the way into the coils, your dial pointer should rest at the low end of the dial. Another helpful method is to tie the end of the dial cord to the tuning drum and leave the dial spring to attach at the end of the line.





4. If your car radio won't produce a sound, look at the small fuse. Visually inspect the fuse holder and "A" lead. Most solid-state radios may pull from 1 to 5 amps.

Always replace the defective fuse with one of the same value. You will find this stamped in the metal edge of the fuse. If in doubt, check the correct radio fuse listed in your car manual. Most Japanese car radios will have a 1- or 2-amp fuse for protection. American manufactured auto radios are protected with a 3- or 5-amp fuse. Very large Japanese radios with tape players may be protected with a 3- or 5-amp fuse, while American made radios with tape players may be fused with a 10- or 20-amp fuse.

Trace the hot lead inside the radio to the spark plate and on-off switch. A poor or broken switch connection can put a radio completely out of action. If the dial light is on you know the switch is good. If not, clip a jumper around the switch connection and check for a 12-volt source at this point.

Substitute a new PM speaker. An open voice coil or poor speaker lead may cause problems. If the sound returns after speaker substitution you may want to check out the defective speaker. With the speaker still connected, push down on the cone of the speaker and see if the sound cuts in and out. A poor or broken voice coil lead may cause intermittent sound conditions. Disconnect the leads and check for continuity across the voice coil leads with the ohmmeter. If the PM speaker is defective, replace it with one of the same voice-coil impedance. You may encounter a 3, 2, 4, 8, 10 or 20-ohm speaker on a car radio. Replace a Japanese radio's speaker with an 8-ohm speaker.

When you turn on the radio switch and a click is heard on the speaker, you may assume that the power output transistor and power voltage are normal. An open or shorted power output transistor may not product any sound on the speaker. If the output transistor becomes leaky you should at least hear hum or distortion on the speaker.

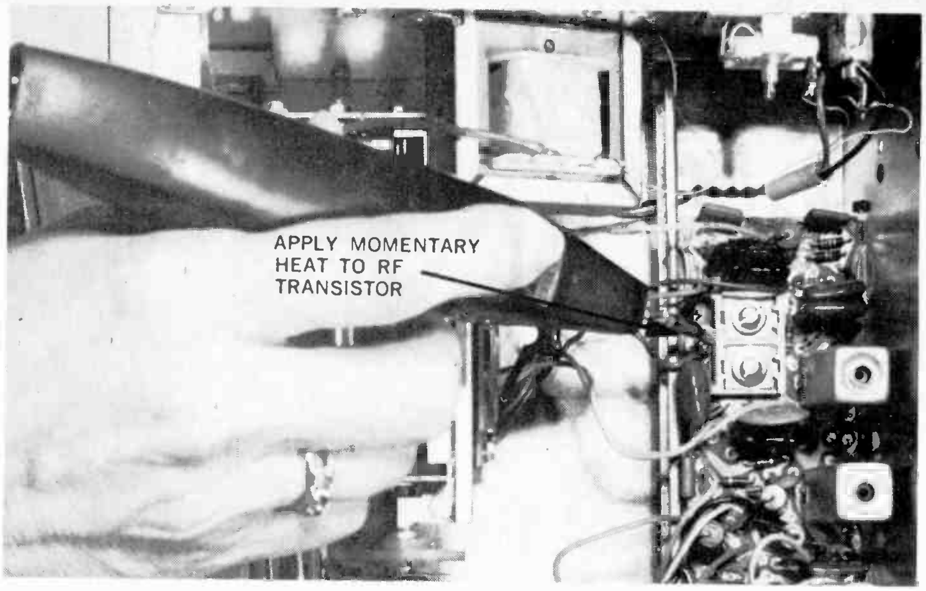
REPAIR TIPS

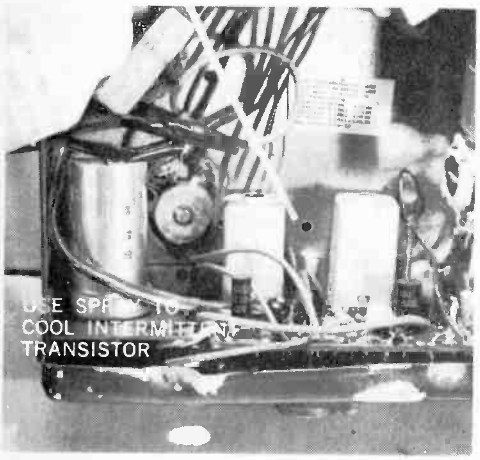
5. Does your auto radio start to play only after it's been turned on for twenty minutes or so? Perhaps, it's real weak in volume and then comes on with a bang! These symptoms are caused by intermittent transistors. Since transistors are solid-state devices, cold or heat may make them become open or leaky. Sometimes after applying heat or cold spray the defective transistor will return to normal operation.

Problems caused by heat and cold usually occur in the RF oscillator and IF transistors. If the radio is cold and does not come on instantly, apply heat to the body of each transistor. Start at the RF transistor and apply heat for no more than a second or two. If left on too long you may damage the transistor. Then move on to the oscillator and IF transistors. Sometimes just moving the suspected transistor may cause it to "pop" on. Apply heat when the radio will not come on and coolant if the unit cuts out or becomes weak after it warms up.

Weak conditions may be caused by transistors, the antenna or bad capacitors. When you can hear every station on the dial but weakly, suspect a defective antenna system or RF transistor.

You have eliminated the antenna system as a possible problem if the same weak condition exists on the workbench. Go to the RF transistor and take voltage measurements. A very high collector and very low, or no, base voltage indicates the transistor is open. You may have the same condition if the emitter bias resistor opens up. Check for broken wires or replace it.

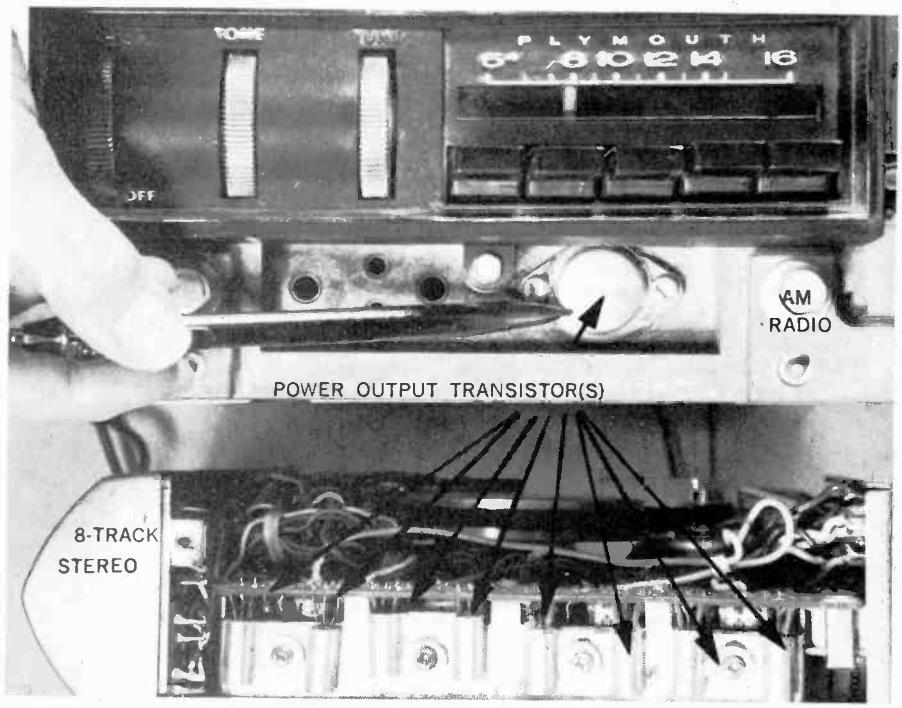




6. A coolant or cold spray is essential for locating intermittent transistors. Your radio may play for several hours before cutting down in volume or maybe it will only do it once a week. But, it always acts up while listening to your favorite song or football game.

You may waste hours and even weeks trying to locate an intermittent transistor if it only happens once a week or twice a day. Play it until it begins to really act up—like every hour or two. Then carefully remove it from the auto and connect it to the workbench. Of course, you must have a 12-volt DC source to operate the auto radio, or you may be able to extend the power leads from the auto to the radio and check it out on the front seat. Always, observe and connect each wire to its hookup.

Try to isolate the intermittent problem. Start at the volume control when the radio is in the intermittent state and notice if the audio section is functioning. Simply hold a screw-driver blade on the center tap of the volume control and you should hear a loud hum. If not, the audio section is intermittent. Then start at the driver transistor and work towards the front of the receiver. Spray each transistor at least three or four times. If the music begins to play you have located the defective transistor. Don't remove that transistor just yet. Let the radio go into the intermittent condition and spray it once more—to make sure the transistor is intermittent. You may also find coolant sprayed upon certain areas of the PC board will bring out those poor, soldered connections.

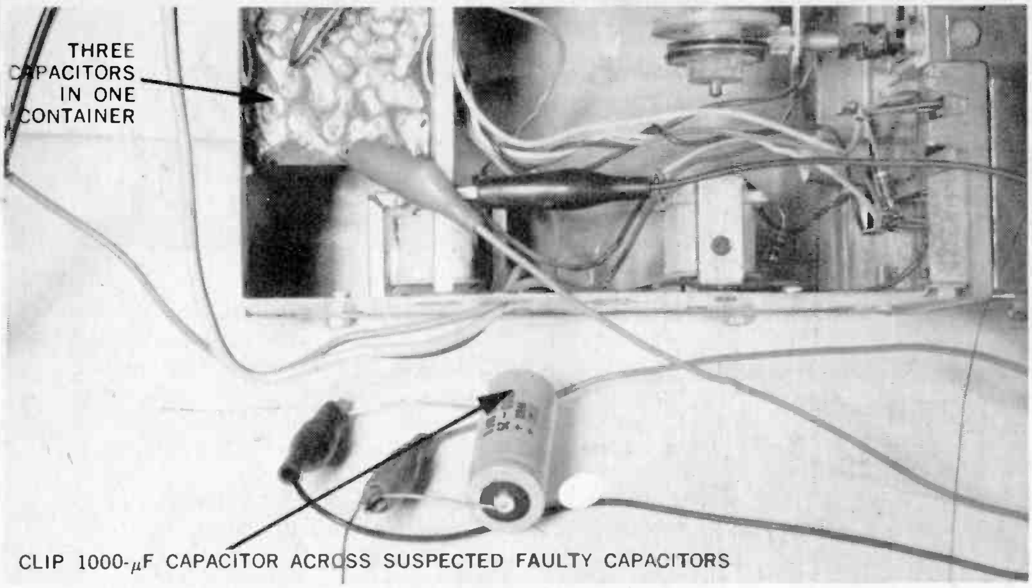


7. You may find one, two or possibly four power output transistors in your receiver. Within the AM radio you may locate one single or two push-pull power output transistors. Generally, four power output transistors are found in the AM-FM-MPX and tape player receivers. If your radio incorporates an eight-track tape player there are eight power output transistors. Just go slow and easy when replacing the defective output transistors.

After locating the defective output transistor check to see if the transistor and mounting screws are insulated from the heat sink with a piece of mica or plastic material. In a push-pull output circuit you may find one transistor insulated from the heat sink and the other mounted directly upon it. Sometimes a single output transistor may be mounted upon the heat sink and the heat sink is insulated away from the radio chassis. Remove only one transistor at a time if both output transistors are being replaced.

Replace the power output transistor with an identical unit. If a piece of mica insulation is found between the transistor and heat sink apply silicone grease to both sides of the insulation. You will find most output transistor replacements enclose an insulator in each package. Remove the old grease and dirt with alcohol and a cloth. Now firmly tighten down both mounting screws. Be careful, too much pressure may bite through the insulation and short out the transistor.

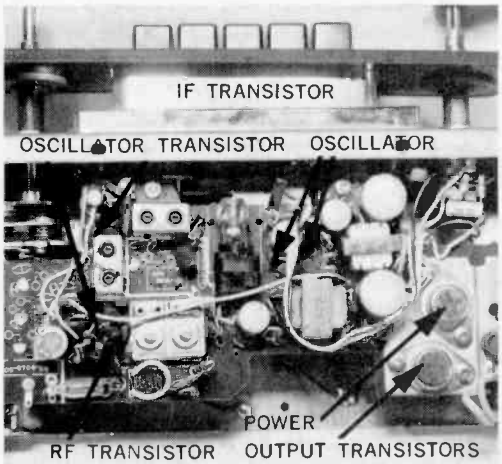
When mounting output transistors with only one mounting screw be sure the three terminals of the transistor go through the correct holes of the insulator. The terminals are then bent at a right angle and fitted into the transistor socket. Make sure the terminals are clear through the socket piece to make a good contact. In many cases these flat type transistors are soldered directly to the audio PC board. You may find this single-hole mounted transistor at the rear heat sink, on the chassis near the volume control or just inside of the front tuning panel.



8. With all those odd noises coming out of the speaker you may think a swarm of bees or mice are trapped inside the radio. Actually, all of these noises can be caused by an open filter capacitor in the power supply. Locate either a filter pack or a single filtering capacitor upon the radio chassis. To find out which one is defective, turn off the power and clip a new capacitor (1000 mfd) across the suspected one. This test will uncover an open capacitor.

When more than one filter capacitor is located in one container, shunt the clips to the tie point (+) and chassis ground. To test a single filtering capacitor, clip the new capacitor across those found upon the PC board. You may find two or three single filter capacitors on the board. Observe correct polarity (+) in testing and replacement. The negative terminal (outside metal case) connects to chassis ground. Clip the new capacitor across each suspected one until the noise stops being very bothersome.

If you locate a defective capacitor in a container with several other capacitors, replace the entire filter network. Replace the defective capacitor with one of the same capacitance and voltage value. If you cannot locate one of the same value, use one with a little higher capacitance and operating voltage.



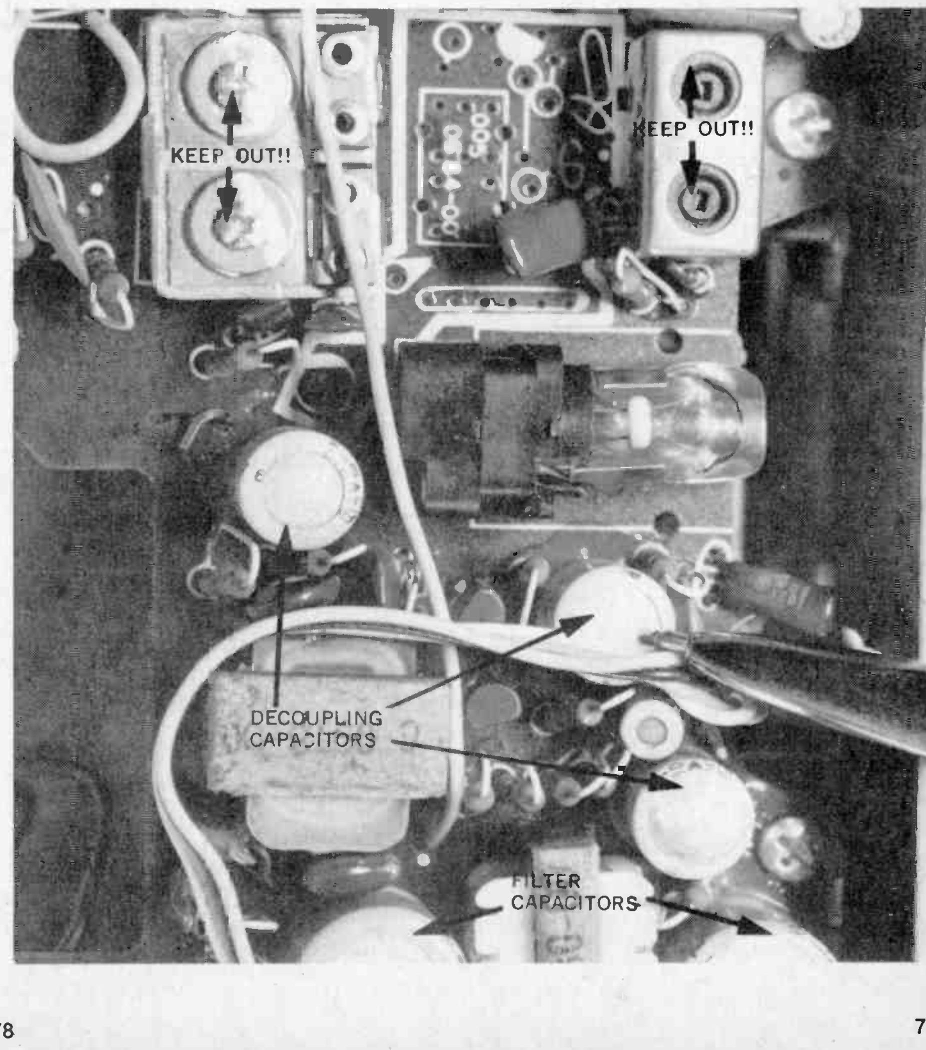
9. Don't be too surprised if your car radio begins to sound like a small gasoline engine. The put-put noise you may hear in the speaker may be a sign that excessive motorboating is occurring in the RF, AF and power supply circuits. Go directly to the filter circuits of the power supply and shunt a large (1000 mfd) electrolytic capacitor across each one. Always, remember to turn off the receiver and clip the capacitor in place to prevent damage to other transistors. Also, observe correct capacity polarity. When the motorboating noise quits, you have located the defective filter capacitor.

If the filter capacitors in the power supply are not causing the motorboating action, shunt smaller electrolytic capacitors in the B+ and decoupling circuits. These (100- to 250-uF) capacitors may be found anywhere in the PC board. Also, check for defective bypass capacitors in the emitter circuits of RF and AF circuits for motorboating problems. Simply shunt a new one of the same value across the suspected capacitor.

Excessive motorboating may be caused by an audio output or AF transistor. Try to isolate the AF or driver transistor by shorting the base and emitter terminals together. Be careful to make sure you are on the right terminals. If motorboating ceases either the transistor is defective or the fault is in the preceding stage. Replace the audio output transistor if suspected of motorboating. Most of these audio output transistors are easily replaced since they are mounted to the heat-sink with a couple of screws.

10. Suspect a defective oscillator transistor when one half of the tuning dial is alive. Usually the high end of the dial is dead but it may be either end. The oscillator transistor is located close to the tuning mechanism oscillator coil and padder capacitors. In some auto receivers it may be marked on the PC board. A transistor test may show that the transistor is good but will not oscillate across the whole broadcast band. Simply remove the transistor and install a new one.

One important thing to remember is to avoid the temptation to put a small screwdriver into the tuning coils and capacitors. It is improbable that you will be able to improve the radio's performance this way. You should never adjust these unless you have the proper test equipment and have been trained in its use. More radios go to the junk pile thanks to well-meaning coil and capacitor adjusters. Most of the time these adjustments are made at the factory and then sealed with wax so they can't vibrate out of tune.



This easy conversion takes four little parts and some new

SCAN THE

☐ Now that the 18 wheelers have moved to channel 19, how can we monitor 19, and 9, and one or more "preferred" channels all at the same time? The logical answer would be to get a 4-channel scanner but every scanner I have seen has been for VHF-FM or UHF-FM, hence is incapable of receiving the CB channels. There are just two solutions to this problem—trade in your present transceiver for one with built-in scanning, or convert a VHF/Lo band scanner to the CB frequenices.

The most practical scanner for such a conversion is the Realistic PRO-6 VHF Hi-Lo Pocket Scanner. It has a low profile when placed on my base station transceiver, the price is low, it covers 30 to 50 MHz as well as 148-174 MHz, and the conversion to CB frequencies can be done by almost any CBer. Perhaps the most important reason for selecting the PRO-6 is the use of a discriminator to detect FM and the lack of limiter circuits. This because limiter circuits will clip amplitude modulation, thus preventing detection of CB signals, which are AM (amplitude modulation).

Figuring the Circuit Values. To make the conversion of the PRO-6 from 30 to 50 MHz to the 27 MHz region of CB frequenices, we have to lower the resonant frequenices of the RF circuits and the crystal oscillator circuit. The schematic illustrates the PRO-6 front end (RF/Mixer circuits) and the crystal oscillator for both Hi and Lo bands. Capacitors C10, C11, and C14 in the front end RF stages are 33 picofarads which resonate at the center of the 30-50 MHz band. This gives us a 40 MHz center frequency and the ideal CB center frequency would be Channel 12 or 27.105 MHz. From a Sylvania Electric Products Inc. nomograph on Inductance-Capacitance-Reactance, we calculate the new values for C10, C11, and C14 to be 69 picofarads and the inductance to be 0.5 microHenries. Now we insert these values into the formula for resonant frequency:

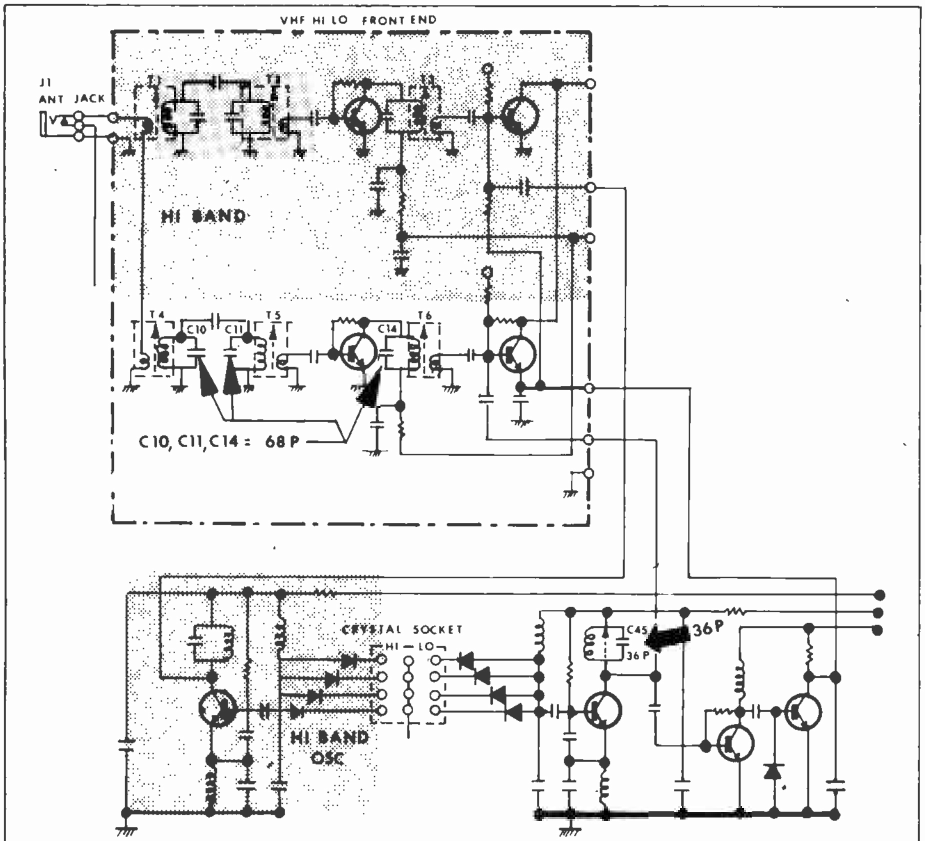
$$fr = \frac{1}{2\pi \sqrt{LC,}}$$

where fr is in MHz,
2π is equal to 6.28,
L is equal to 5×10^{-7}, and
C is equal to 60×10^{-12}.

This figures out to a center frequency of 27.308 MHz, which is well within the range of variable inductance to tune downward to 27.105 MHz: Channel 12. 69 picofarads would be ideal (since it calculates out to 27.110 MHz) but it is not a standard capacitor value. Too, this is less than two percent variation from the standard value of 68 pF.

The actual conversion of the front end for 27 MHz use requires only that one replace C10, C11, and C14, plus a little retuning of T4, T5, and T6. In fact, the only problem lies in getting into the inside of the PRO-6.

First, remove the battery box and the two Phillips head screws on each side of the PRO-6's case below the battery box. Once these two screws are removed, grasp the set's case about mid-

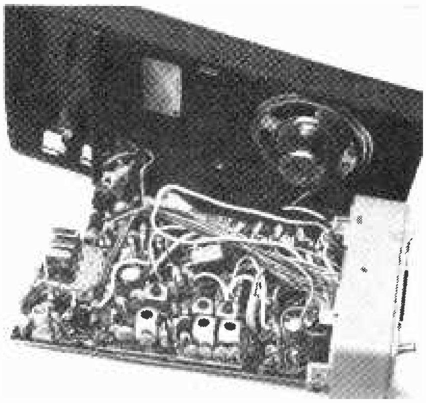


Schematic diagram of PRO-6 scanner shows the three capacitors C10, C11, and C14 which are replaced in the front end (top). One capacitor, C45, is changed in oscillator. Slight retuning of T2 through T6 is only other task required.

crystals—it lets you monitor any CB channels you want with this off-the-shelf-scanner.

TOP OF 40

by James A. Gupton, Jr.



Top case removed to show crystals (left) and transformers (front, center). See the drawings for component identification.

section and apply a squeezing pressure to the sides while lightly lifting the case bottom section. Once the bottom section of the case is removed, the printed circuit board is accessible. Note the Phillips head screw in the center of the printed circuit board. Remove this screw and carefully remove the upper section of the case. Proceed carefully, for all the wires connecting to the scanner head are also connected to the board, and must not be pulled lose.

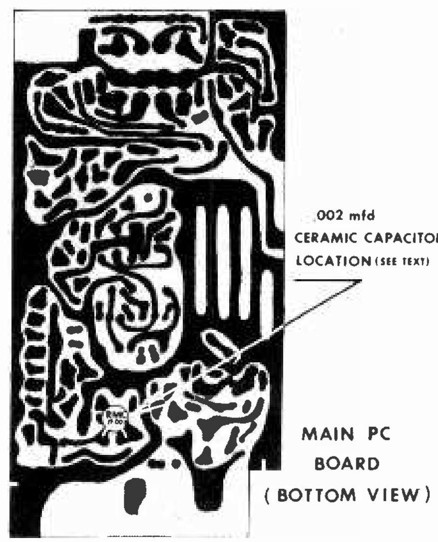
Careful Work. Once the case has been removed, we have full access to the component side of the printed board. The first thing one sees is the high density of components–there is not much room to work, and the close spacing of components requires careful work to prevent accidental shorting of leads during the solder operations. I solved this minor problem by winding a short length of No. 14 solid copper wire around the tip of my solder iron and filing a chisel solder tip on the end of the wire. This makes a long-reach solder tip that can get in between the closely mounted components without spreading solder over anything which might cause a short.

Follow the photographs and board layouts to correctly locate and identify capacitors C10, C11, and C14. You will note that C10 and C11 are located on the outside edge of the front end circuit board, and can be easily removed for replacement. C14, on the left side of T6, is difficult to remove without damaging the front end circuit board. If you have carefully removed C10 and C11 and have not damaged or shortened these capacitors leads, you can use one of these 33 pF capacitors to parallel C14 by forming a small hook on each lead and soldering these hooks to (the original) C14.

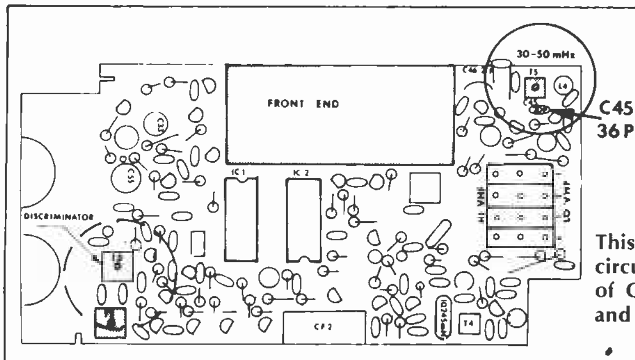
The next step is to replace crystal oscillator capacitor C45. This is a 20 pF ceramic capacitor that we will replace with a 36 picofarad silver mica capacitor. A ceramic capacitor works as well as silver mica, if that's what you happen to have on hand. Space is limited, but since the foil side of the board is readily available, C45 can be removed without difficulty.

Now the Crystals. Before the retuning can be done, we must insert the crystals into the crystal socket. The PRO-6 uses type HC crystals and they must be 10.7 MHz *higher* in frequency than the desired frequency. As an example, for Channel 12 we would order a crystal frequency of 37.805 MHz instead of 27.105 MHz. It is also advisable to separate each of your crystal frequencies by one or two channels to prevent co-channel reception. This is because the PRO-6 scanner is broader-tuned than most CB transceivers.

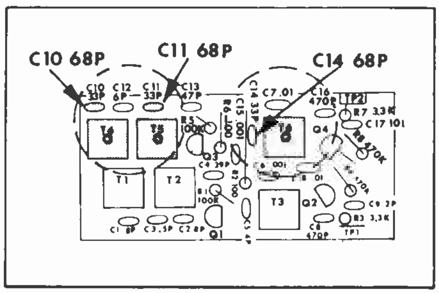
To retune the front end section, the best method uses a modulated RF generator set at 27.105 MHz and a detector probe attached to *Test Point* 2. Then T4, T5, and T6 are tuned for maximum output. The best way to peak the crystal oscillator is to inductively couple a digital frequency counter to oscillator coil T-5. However, since not many CBers have such elaborate test equipment, we must fall back on the gear we have, and use the output of our base or mobile station as a signal



Bottom view of main printed board shows location of additional .002 uF capacitor which is sometimes also required.



This view of the main printed circuit board shows locations of C45 and T5 (upper right) and T3 and T2 (lower left).

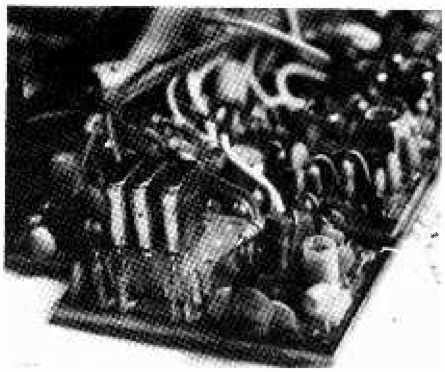


Front end layout shows location of the three small capacitors which are replaced along with transformers T2 through T6.

SCAN TOP 40

source. To do this, we prepare a dummy load connector by soldering a 5 watt-52 ohm carbon resistor to a PL-259 connector as shown in the drawing. Remove the antenna coax and replace it with the dummy load connector. Next attach a short-wire antenna (12-20 inches) to the antenna socket on the scanner and drape it near the dummy load. You may have to place the antenna inside the case for maximum signal. Now attach the PRO-6 ear plug, and activate your transmitter with some form of modulation such as a portable radio playing music. Tune T4, T5 and T6 for maximum output. For more precise tuning, connect the leads of an AC voltmeter across the speaker leads and tune for maximum output.

Discriminator Adjustment. Since the PRO-6 employs a discriminator for FM detection, the AM of CB can be detected by *slope* detection. Note the circled discriminator transformers T2 and T3 in the circuit board pictorial. Alternatingly adjust the core slugs of T3 then T2 for distortionless detection. Should you be unable to eliminate voice distortion, install a 0.002 uF. ceramic capacitor across the detection diode as



Front end crystals are plugged into socket at left above. Three crystals are shown, but PRO-6 accepts up to four.

shown.

After completing the retuning, and adjusting the discriminator for AM detection, replace the top case section. Again be careful that no undue strain is applied to the circuit board leads and that the Charger/Operate AC socket is not dislodged from its position.

Replace the small Phillips head screw and attach the case bottom section. Be sure that the case ends engage with the scanning head and Charge/Operate AC socket before you permit the locking tabs to snap into place. Replace the two long Phillips head screws and the battery box. Your converted PRO-6 scanner is now ready to scan the desired

40-Channel CB Frequencies

MHz	MHz
26.965	27.235 **(24)**
26.975	27.245 **(25)**
26.985	
27.005	
27.015	27.255 **(23)**
27.025	
27.035	
27.055	27.265 **(26)**
27.065 **(9)**	27.275
27.075	27.285
27.085	27.295
27.105	27.305
27.115	27.315
27.125	27.325
27.135	27.335
27.155	27.345
27.165	27.355
27.175	27.365
27.185 **(19)**	27.375
27.205	27.385
27.215	27.395
27.225 **(22)**	27.405

CB frequencies. To use your base antenna, simply solder the short scanner antenna lead to the *Receive* section of the receive/transmit relay.

The Realistic PRO-6 pocketable Scanner for VHF-Hi/Lo, which covers the 30-50 and the 148-174 MHz bands, is Radio Shack number 20-171. and

(Continued on page 117)

Scope Your CB Signal

☐ Critical inspection of a transmitter signal and accurate measurement of modulation is possible only with an oscilloscope. Note that you must use your scope's vertical *plate* connection. The RF signal can't travel through the vertical amplifier unless your scope happens to cost a kilobuck or more. Unfortunately, a CB transmitter's RF output is so low the scope pattern is barely discernible—unless you use this booster.

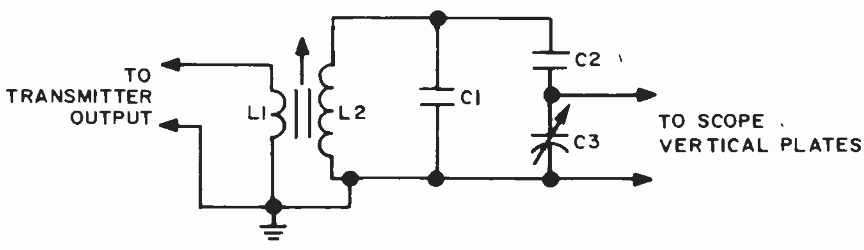
Since a scope's vertical plate connections operate at a high input voltage, it requires that a CB transmitter's output be fed to a resonant circuit to step up to high RF voltage. The circuit shown will just about fill a 5-in. scope from edge to edge with virtually no loss at the transmitter.

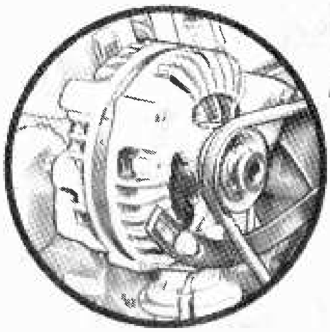
First, wind L2 on the center of a ⅜-in. slug-tuned form. Then wind L1 adjacent to the ground end of L2. Connect L1 across the transmitter output with the CB antenna system also connected.

Adjust L1's slug for minimum standing-wave ratio (SWR). If the coil is correctly made, there should be no change in the antenna system's SWR. Adjust C3 for the desired scope trace height; it may be necessary to reset L1 each time C3 is adjusted. ■

PARTS LIST FOR SCOPE YOUR CB SIGNAL

- **C1, C2**—5-pF silver mica capacitor
- **C3**—60-pF trimmer capacitor
- **L1**—3 turns #22 solid, plastic-insulated wire, adjacent to ground end of L2
- **L2**—4 turns #18 enameled wire, centered on form
- 1—⅜-in. RF slug-tuned coil form (J. W. Miller 4400-2)





ALTERNATOR TESTER

Your alternator may be building for a big breakdown without your knowing it. This simple circuit lets you check it out.

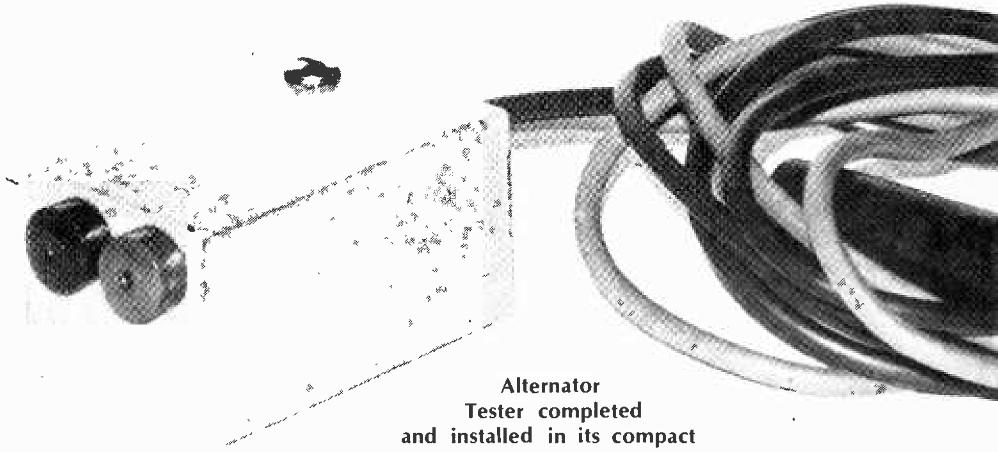
by Anthony Caristi

AUTOMOBILES have been coming off the production lines with alternators instead of generators for some 13 years now, and these units have proven to be reliable and superior to the ones they replaced. Being alternating current machines, they are inherently more complicated than generators and require slightly more sophisticated testing procedures to indicate their condition. This problem is brought about by the fact that automotive alternators are three phase machines, with full wave rectification of the output to produce direct current as required by the automobile and its battery. The schematic shows a typical automotive alternator connected to its three-phase full-wave rectifier circuit.

Rectification is accomplished by six high-current silicon diodes in the alternator, and this is where the problem comes in. Many of the troubles encountered with automotive alternators are due to failure of one or more of the diodes, either by opening or shorting. Neither of these conditions will result in an inoperative alternator, and no doubt some of the automobiles on the road today have just such a problem. A shorted diode is the more serious of the two conditions, since it will result in the loss of about 50 per cent of the output capability of the alternator. Such a condition is easily detected by an ordinary output test on the alternator. However, an open diode is another matter. This condition will result in loss of only a few amperes of output capability of the alternator due to the fact that only one half of one phase of the machine is disabled. Some of this lost capacity is carried by the other two phases, which will be overloaded when the alternator is required to produce full output as demanded by the automotive electrical system. Such a condition may well result in further failure of more diodes. An ordinary output. test of an alternator with an open diode generally will not detect any malfunction. Because of those testing problems, another test method to determine the condition of alternators has been developed, and the construction of the Alternator Tester is the subject of this article.

The ability of Alternator Tester to detect defective diodes, both open and shorted, depends on the fact that the output ripple voltage of an alternator with a defective diode rises dramatically higher than that produced by a normally-operating alternator. When the pulsating DC waveform output voltage of an automobile alternator is measured the magnitude of the ripple voltage is about 0.2 to 0.5 volts, peak-to-peak. When one of the diodes in the alternator fails the ripple voltage increases to 1-volt peak-to-peak or more. The Alternator Test measures the peak-to-peak ripple voltage so that the condition of the alternator can be determined.

Construction Details. In order to keep construction costs low, the Alternator Tester was designed to be used with an ordinary VOM or VTVM as the indicating device. Since the output impedance of the test instrument is close to zero, any meter of at least 1000-ohms-per-volt sensitivity can be used. The circuit is constructed on a small printed circuit board and fitted into a metal or plastic cabinet. Two tip jacks are mounted in the cabinet which serve as the connection to the VOM. A pair of test leads is brought out through a grommet and these provide the DC power to operate the circuit



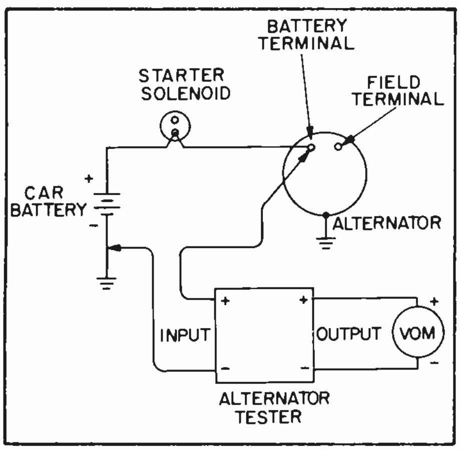
Alternator Tester completed and installed in its compact metal cabinet, shown with its test leads.

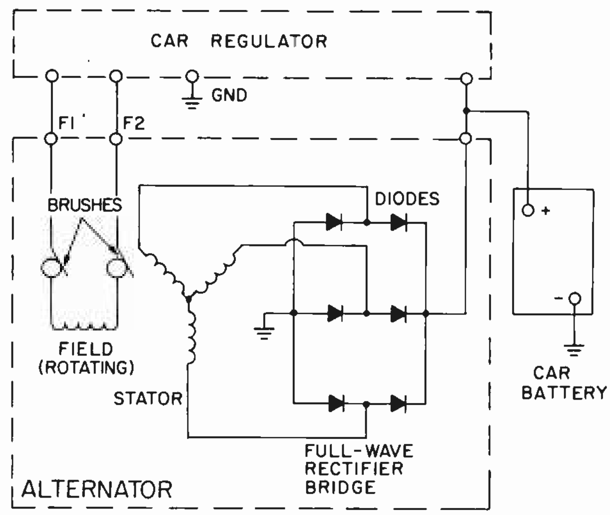
ALTERNATOR TESTER

as well as the connection to the alternator output (battery) terminal where the ripple measurement is to be made.

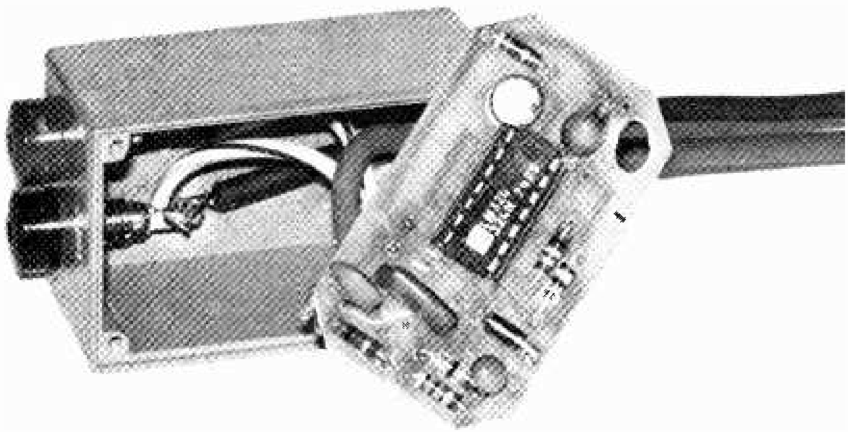
About the Circuit. The Alternator Tester is basically a peak detector circuit which responds to the peak-to-peak value of an AC voltage fed to its input terminal. Power to operate the circuit is derived from the output of the alternator on the same lead which feeds the ripple voltage to the input of the peak detector. The DC output of the alternator is blocked by C1, which allows only the ripple voltage to pass through.

Operational amplifier IC1A and IC1B are connected together to form a peak detector circuit. The ripple voltage from the output terminal of the alternator is fed to the positive input of IC1A after the DC voltage of the alternator is blocked by C1. D1 clamps the ripple voltage to ground, so that it varies between zero and some positive value. Op amp IC1A charges C4 to the peak value of the ripple voltage. Op amp IC1B is a voltage follower which feeds back the peak value of the ripple voltage to the negative input of IC1A. This stabilizes the circuit so that the voltage appearing at the output of IC1B holds to the peak-to-peak value of the ripple voltage fed to the input of IC1A. Capacitor C4 is prevented from discharging through IC1A by D2, and can discharge only through R4 at a rate much slower than the ripple frequency of the alternator. This holds the meter reading constant between voltage peaks of the alternator. Amplifier IC1C has an adjustable gain of slightly more than unity to compensate for the slight error (loss) caused by D2, as well as providing a means for calibration of the instrument. Voltage follower IC1D

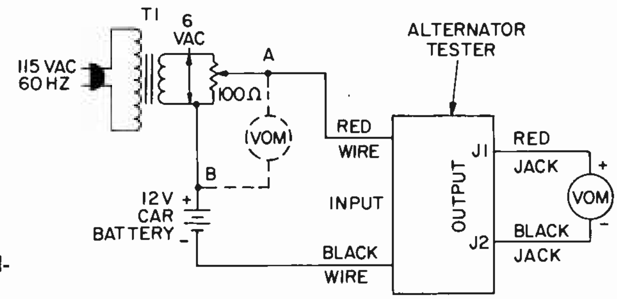




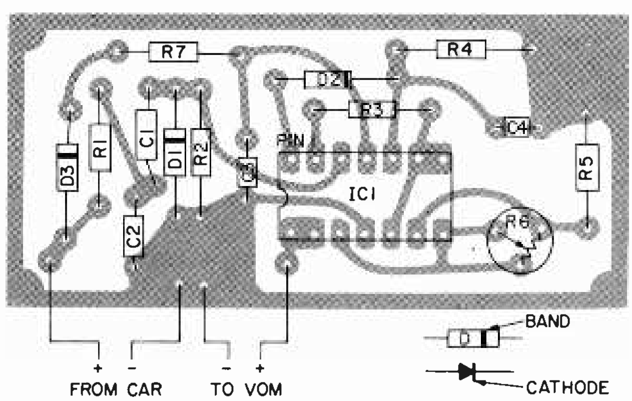
Typical automotive charging circuit. Latest model alternators have solid-state regulator circuit built into alternator frame.



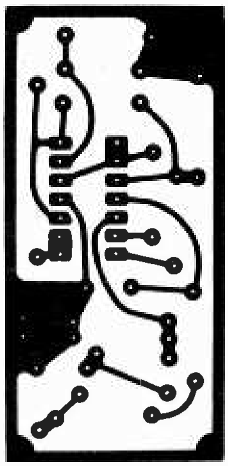
Alternator Tester opened, showing printed circuit board. Comparison with this early version of printed circuit board reveals improvements made by the editors.



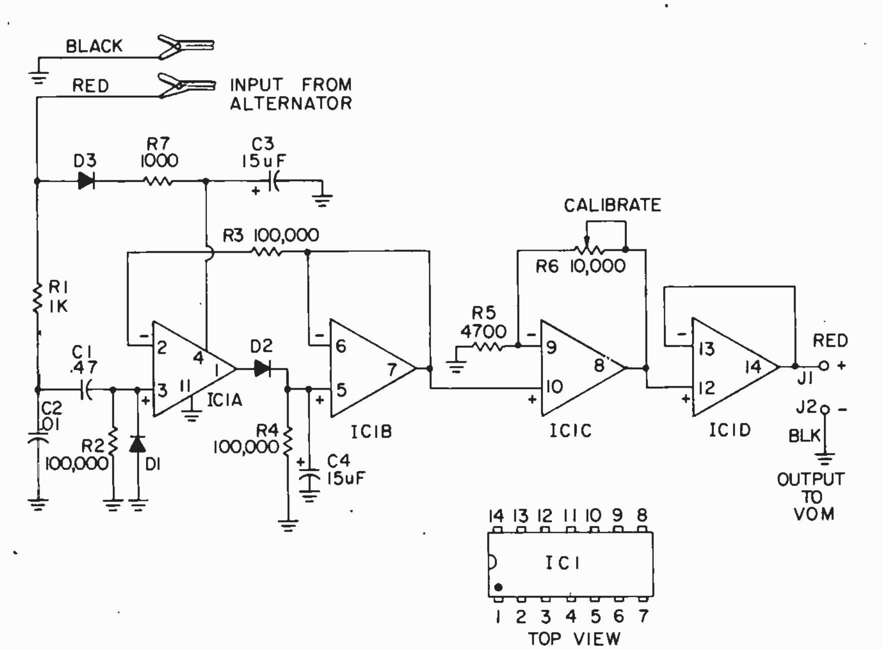
Calibration of the Alternator Tester.



This shows the parts placement on the printed circuit board. Shown larger than actual size for clarity.



This pattern shows the printed circuit board (foil side up) for the Alternator Tester. You can construct the unit on a perf board if printed circuit board fabrication seems too much touble.



With the three-phase output of automobile alternators, which is rectified by a six diode full-wave rectifier, it is possible for the output of the system to appear normal even though one diode is open. With this circuit a mechanic can test the rectifier output and discover the increase in the ripple voltage that would be caused by such a failure.

PARTS LIST FOR ALTERNATOR TESTER

C1—0.47 uF ceramic capacitor
C2—0.01 uF ceramic disc capacitor
C3, C4—15 or 22 uF, 25 VDC tantalum capacitor (Allied Electronics 852-5671 or equiv.)
D1—1N34A, 75 VDC, 5 mA germanium diode (Allied Electronics 578-0034 or equiv.)
D2, D3—1N487, 75 VDC, 100 mA silicon diode
IC1—LM324 (Quad 741) operational amplifier (James Electronics, or equiv.—address below)
J1, J2—red, black tip jacks (Allied Electronics 920R0181, 2, or equiv.—address below)
R1, R7—1,000-ohm, ¼-watt resistor
R2, R3, R4—100,000-ohm, ¼-watt resistor
R5—4,700-ohm ¼-watt resistor
R6—10,000-ohm potentiometer (Allen Bradley Type A, Radio Shack 271-218, or equiv.)
Misc.—2¾ x 2⅛ x 1⅝" utility box, hardware, 14-pin IC socket, printed circuit board or printed circuit kit, red, black test leads with alligator clip termnials.
Allied Electronics' address is 401 E. 8th St. Fort Worth, TX 76102.
James Electronics' address is 1021 Howard Ave., San Carlos, CA 94070.

provides an extremely low output impedance to drive any meter of 1000-ohms-per-volt or more. Power for the circuit, about 2 mA, is taken directly from the alternator output terminal. Diode D3 prevents damage to the circuit in the event of any reverse polarity connections.

Calibration of The Instrument. Calibration of the Alternator Tester is accomplished by feeding an AC voltage of known amplitude between the input terminal and ground, and adjusting R6 for the correct meter reading. The calibrating AC voltage input can be measured by the AC voltmeter function of the VOM, which reads RMS volts. To convert RMS to peak-to-peak voltage multiply the value by 2.83. The calibration circuit uses a 6-volt filament transformer and potentiometer as a source of low voltage AC. To calibrate the instrument connect the filament transformer, potentiometer, and alternator test circuit as shown, using any twelve volt DC supply for power. (Be sure there is no ripple voltage on the output of the supply, since this will cause an error in the calibration.) Set the VOM to read AC volts, and connect it between points A and B as shown. Set the potentiometer so that the VOM reads 0.35 volts RMS. This is equivalent to 1 volt peak-to-peak. Disconnect the VOM, set it to a 1.5 to 3 volts DC scale, and connect it to the output terminals of the Alternator Tester. Calibrate potentiometer reading of 1 volt. This completes calibration of the Alternator Tester.

Alternator Testing. The testing of an automotive alternator consists of two parts. The first test is the output test, which determines if the alternator can deliver the full current that it was designed to produce. Bear in mind that the following procedure tests both the alternator and voltage regulator at the same time, and failure of the alternator to deliver rated output also may be caused by a defective voltage regulator. Before making the following tests inspect the connections to the alternator and battery to be sure they are tight. A loose or bad connection between the alternator and the battery may cause an excessive ripple measurement even though there are no defective diodes in the alternator.

The alternator output test requires the use of only the VOM which is set to read DC volts on a 0 to 15 volts or greater scale. Connect the VOM directly across the battery, observing correct polarity. Start the engine and turn on the headlights (high beam), windshield wiper, blower motor (high speed), and radio. Race the engine to a moderate speed (about 2000 RPM) and note the reading of the meter. A properly operating charging system should maintain at least 13.5 and not more than 15 volts across the battery. Voltage readings below 13.5 indicate a defective alternator or voltage regulator. Voltage readings above 15 indicate a defective voltage regulator. Some automobiles have voltage regulators which can be adjusted. Refer to the service manual for your car for voltage regulator tests and adjustments. If the above test indicates satisfactory performance proceed to the ripple voltage test, using the connections shown in the testing diagram. Note that the posi-

(Continued on page 118)

RF from your Calculator

Your pocket calculator can save you sums, when you use it as an RF signal generator.

by Bob Baxter

☐ The virtues of portable electronic calculators are by now so well-known and their prices have dropped so low that the units are found almost everywhere. Many presently-available machines—especially those employing LED displays—can be used as quick troubleshooting aids in addition to performing their usual day-to-day calculating chores. Whenever you need a fast, convenient, and portable amplitude-modulated RF source for equipment checkout, your calculator can often fill the bill.

Here's why. Just about all battery-powered calculators emit strong, wideband RF signals which extend well up into the tens of megahertz. These signals are generated primarily as side-effects by the operation of two components of the calculator: the power supply's DC-to-DC converter and the multiplexed LED digital readout.

Not every calculator has a DC-to-DC converter. But those operating from two or three penlight or nicad cells usually do, using it to step the low battery voltage up to a higher level more suitable for operating the MOS ICs which do the arithmetic. The converter produces a harmonic-rich square-wave output at a fundamental frequency typically between 20 kHz and 100 kHz—but the harmonics extend well up into the megahertz region.

Even if your calculator is one of those without a DC-to-DC converter, it's still almost certain to use a multiplex system to drive the output digital display. Multiplexing means that each selected segment of the digital readout is rapidly turned on and off many times each second rather than staying on continuously. When this switching is done rapidly enough, the readout appears to stay on all the time because of the relatively slow response time of the human eye. Readout devices are multiplexed for two reasons. First, multiplexing drastically reduces the power required to operate the readout at any given *apparent* brightness level because the readout is actually on and drawing current for only a small percentage of the time. As a consequence, batteries last much longer. Secondly, multiplexing permits a great reduction in the total number of IC's needed to actuate the calculator's readout display with an attending cost reduction at the time of purchase.

With a standard calculator's seven-segment LED readout and anywhere from 8 to 12 display digits, the multiplexing frequency is typically around 100 kHz. When currents of 20 mA or so are abruptly switched on and off through the LED display segments, significant amounts of RF energy at multiples of the multiplexing frequency are generated. These harmonics may extend well into the tens of megahertz. In fact, this harmonic radiation is one of the main reasons there are so few AM clock radios with LED time displays on the market today. The standard AM broadcast band is almost totally obliterated if the receiver's RF sections are within a foot or so of the multiplexed readout display unless extensive shielding is employed. Fortunately, there are two more practical and less expensive solutions than shielding. The first is the addition of resistance-capacitance networks to slow the rise and fall times of the multiplex waveform—and consequently filter out most of the higher-order harmonics. The second method is to drive each display digit directly and not use multiplexing at all. This second technique is much more practical in a clock radio than in a calculator for two reasons. First, clock radio displays normally have considerably fewer digits than most calculators; hence, the circuit problem isn't nearly so complex. And secondly, with a clock operated from the AC power line, the problem of rapidly discharging the batteries unless the output is multiplexed is eliminated. National Semiconductor Corporation has recently introduced a clock chip with direct drive of all readout segments to eliminate RF interference. It was designed with clock radio applications in mind.

One of the many uses for your calculator other than calculating. Here it is being used to check a windshield antenna.

But now back to your calculator, which almost certainly is multiplexed and unfiltered and produces a rich harmonic output. Turn it on and slowly bring it near a standard AM radio which is tuned either to a weak station or between stations. You should hear a mixture of buzzes and tones as the calculator is brought within several inches of the radio or its antenna. These tones probably will shift in frequency if you key different numbers into the display.

Now that you've verified that your calculator is a portable, wideband, RF source, what can you use it for? Well, a number of applications are obvious. Anytime you need a quick check to see if the RF and IF stages of an AM receiver are working, your calculator can provide a test signal. Probably its handiest use, though, is in continuity testing antennas and connecting cables. Auto antennas and their accompanying cables and connectors are easily tested for opens and shorts by bringing the calculator near the antenna while monitoring the radio output. Perhaps the ultimate example of this technique you can perform in your automobile. Place a calculator near the windshield antenna of a late model General Motors car. In cases of poor or non-existent reception, one or both of the two thin antenna wires imbedded inside the glass may be broken. By carefully tracing the path of each individual wire, a break or faulty connection can be located when the radio's output changes abruptly.

And one final thought. Those of you with LED digital watches might experiment with them. The power is much lower, and the metal watch case provides a lot of shielding, but there just might be enough RF coming from the display to be useful. ■

Ring-A-Thing

Don't miss that money-making call, build Ring-A-Thing and hear them all!

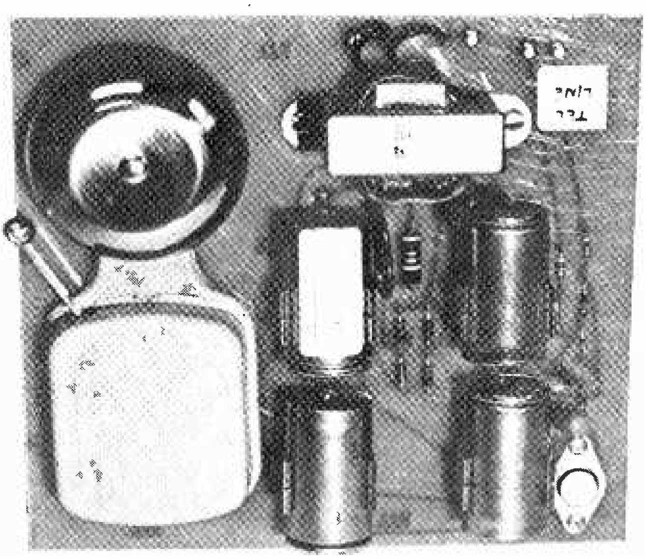
by Anthony Caristi

DID YOU EVER MISS an important telephone call because you were out of range of sound of the telephone bell? It doesn't have to happen again if you build and install this inexpensive remote telephone bell. It is battery operated and can be located anywhere inside or outside your home. Since it is self-powered it requires virtually no energy from the telephone line. The input impedance of the circuit, as seen by the telephone line, is almost 100,000 ohms and the input resistance is infinite. When connected across the telephone line it is undetectable and has no effect on telephone performance.

No Power Problems. The circuit derives its power from four rechargeable NiCad cells connected in series which provide 4.8 volts to drive an ordinary doorbell. Since the power demand on these cells occurs only when the telephone rings, the battery will operate the bell over 1000 times on one charge. This should last several months, depending upon how many calls you receive. A built-in battery charger is included in the circuit so that the cells may be conveniently charged from the AC power line at any time. Full recharge takes 14 hours, but the charger may be left in operation indefinitely, if desired, with no damage to the cells due to overcharge. This is possible since the charging circuit has been designed to deliver a limited current to the cells. The NiCad cells used in this circuit are size C, but other sizes may be used. This is possible since the charging circuit has been designed to deliver a limited current to the cells. The NiCad cells used in this circuit are size C, but other sizes may be used. This will be covered later in this article.

How It Works. When the telephone rings, a 20 Hertz AC voltage of about 220 volts peak to peak is impressed across the telephone line. The series circuit composed of R1, R2, R3, C1, and C2 is connected across the line to provide isolation and act as a voltage divider for Q1. C1 and C2 provide DC isolation, since the line normally has a DC voltage of about 48 volts across it when the telephone is not in use. Q1 responds to the 20 Hertz ringing signal by conducting current during each positive half cycle applied to its base. CR1 prevents Q1 from being reverse biased during the negative half of the ringing signal. The emitter current of Q1 is applied to the base of Q2 causing it to saturate and act as a switch. This applies full battery voltage to the bell, causing it to ring. The voltage applied to the bell is essentially a 20 Hertz square wave which produces a slightly different sound than that produced by pure DC. CR2 and C3 protects Q2 from any reverse voltage spikes produced by the collapsing magnetic field of the bell.

The battery charger circuit is composed of T1, a 4 diode bridge rectifier, and R5. T1 provides isolation from the AC power line while reducing the voltage to about 6 volts RMS. The ouput



This view is from the top of Ring-A-Thing, looking down on the PC board. There really aren't many components, so you'll see how neatly spaced they are. The board has to be large, because of the size of the bell, which is mounted on it at left.

Ring-A-Thing

of the bridge rectifier, a pulsating DC of about 9 volts peak, is applied to the four cells through a current limiting resistor, R5. This type of circuit is recommended for NiCad cells, and provides essentially a constant charge current regardless of the state of charge of the battery or power line voltage. By limiting the current to not more than one tenth of the ampere hour rating of the cells, the charger may be operated for any length of time without damage to the battery due to overcharge. When the cells attain full charge, the gases produced within the cell are recombined chemically preserving electrolyte.

Construction. The entire circuit is built on a 6½-inch x 9½-inch printed circuit board. The foil layout is shown half size in figure one and the component layout is shown in figure two. The cells are securely mounted to the printed circuit board using steel clips. This method of assembly is recommended since it would not be good practice to rely on the connecting wires of the cells to hold them in place. If the cells you are using do not have solder tabs, the wires can be soldered directly to the positive and negative metal parts of the cell. In this case do not use excessive heat when soldering so that the cells do not become damaged. When mounting the cells be sure to follow the exact polarity as shown in figure two.

The printed circuit layout for the bell connections may be changed to accommodate the type of bell you are going to use. Be sure to locate the mounting holes for the bell before laying out the printed circuit to avoid a conflict between the copper foil and mounting screws. Do not solder R5 into the printed circuit until insrtucted to

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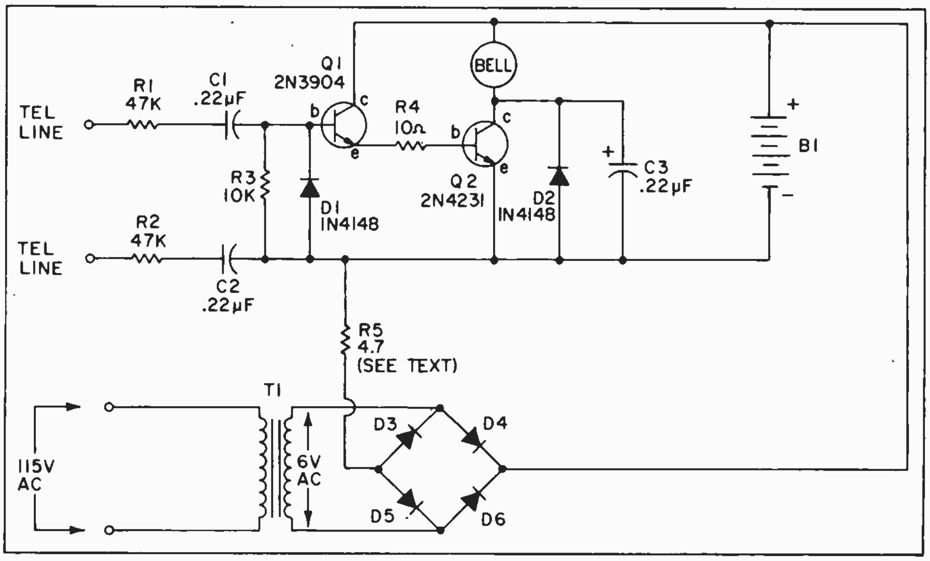
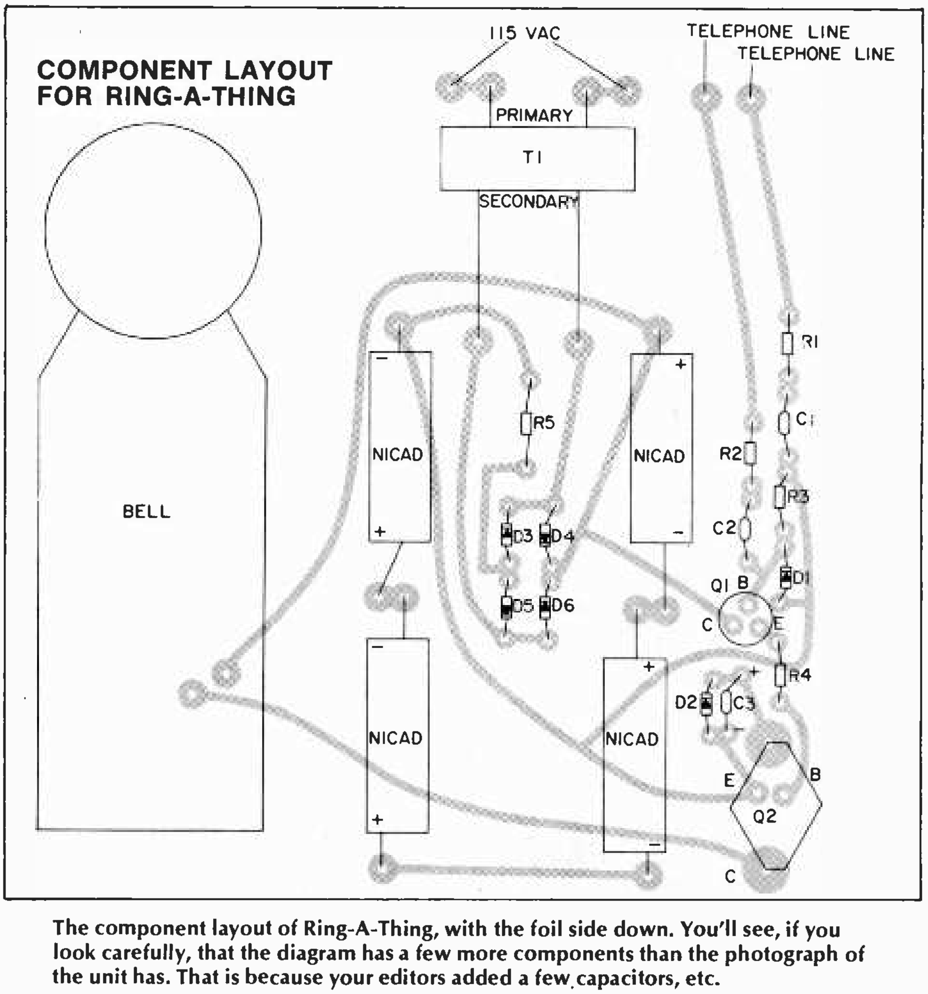


PARTS LIST FOR RING-A-THING

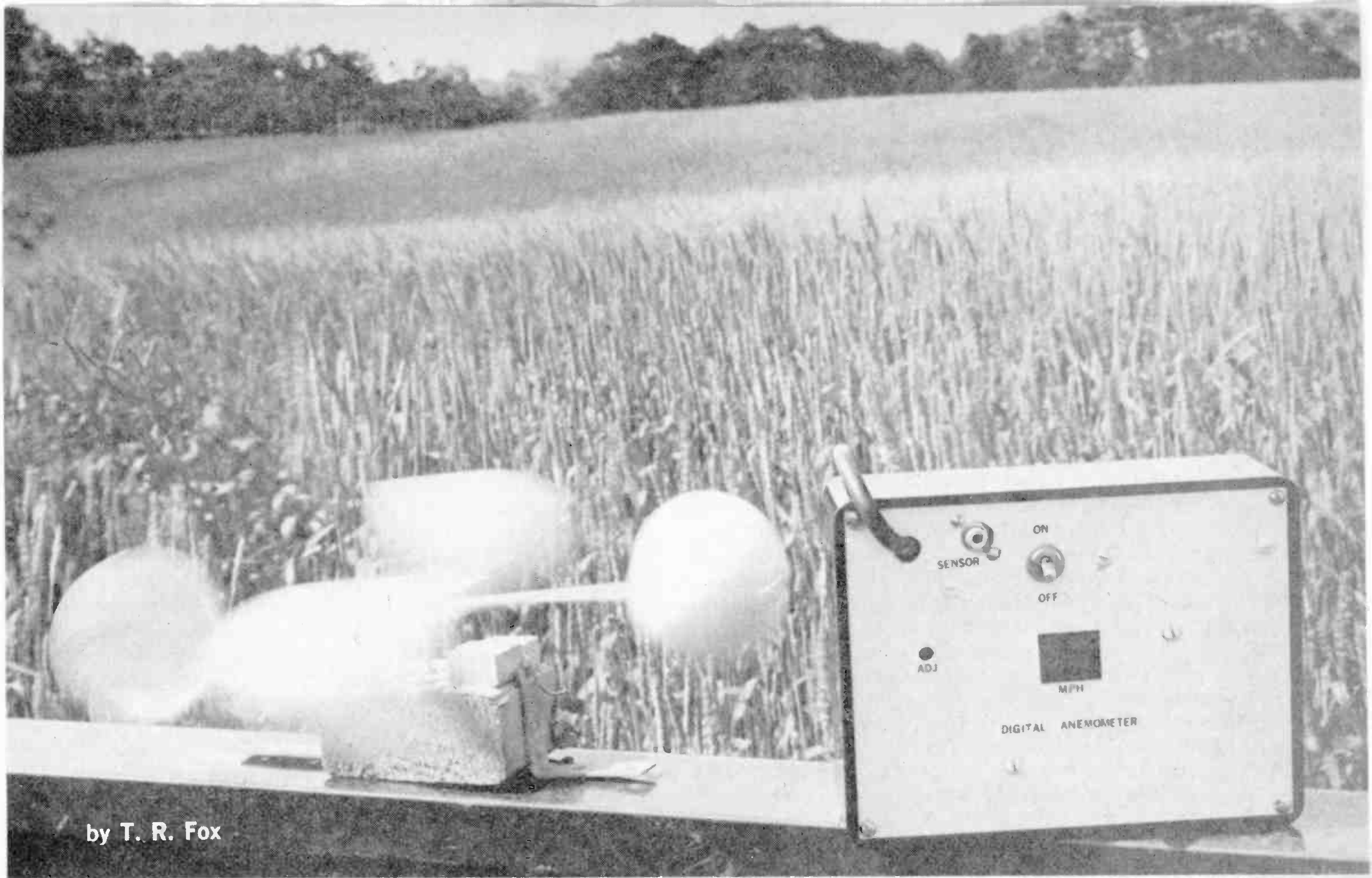
B1—Size "C" NiCad cell
C1, 2—0.22uF, 250-volt tubular or ceramic capacitor
C3—22-uF, 16-volt tantalum capacitor
D1, 2—General purpose silicon diode
D2-6—0.5A, 100-volt or greater silicon diode
Q1—NPN silicon transistor, 2N3904
Q2—NPN Silicon power transistor, 5-A, 2N4321
R1, 2—47,000-ohm, ¼-watt, 10% resistor
R3—10,000-ohm, ¼-watt, 10% resistor
R4—10-ohm, ¼-watt, 10% resistor
R5—4.7-ohm, 1-watt, 10% resistor (Allied Electronics—address below—824-5049 or equiv., see text)
R6—2.2-megohm, ½-watt resistor, 5% tolerance
R7, R8—51,000-ohm, ½-watt resistor, 5% tolerance
R12—39,000-ohm, ½-watt resistor
R17—2.2-megohm, ½-watt resistor
C2—.01-uF capacitor, 5% tolerance
S2—SPDT pushbutton switch, momentary action
T1—6.3-volt, 1-A filament transformer
Misc.—Bell (Standard 6-volt doorbell), battery clips, wire, solder, etc.

Allied Electronics' address is 401 E. 8th St., For Worth, TX 76102.

To obtain a printed circuit board template free from ELEMENTARY ELECTRONICS that will speed up your construction of **Ring—A—Thing** send a stamped, self-addressed number 10 business envelope to The Editor, ELEMENTARY ELECTRONICS, 229 Park Ave. So., New York, NY 10003.



The component layout of Ring-A-Thing, with the foil side down. You'll see, if you look carefully, that the diagram has a few more components than the photograph of the unit has. That is because your editors added a few capacitors, etc.



by T. R. Fox

MEASURE THE WIND!

Easy-to-wire, accurate, anemometer uses ICs and LED-readout.

Increasing energy costs have driven many people to thinking of alternate sources of power, such as solar energy and water power. But the technology for these natural energy sources is still quite expensive and complicated to install. It'll be at least several years before the cost of most natural energy systems comes down enough and the parts are easy enough for most people to install. Wind power for generating electricity, on the other hand, has been available for many years. For several decades farmers and others in rural areas have used windmill generators as standby electricity and in some cases, as their main power supply. Windmills and wind-driven electrical generators can be bought off the shelf by anyone, and require no expertise other than the usual home mechanic skills to set up.

Have you wondered if there's enough wind where you live to drive a windmill electrical generator? Do you know if there's enough wind to fly that big kite you've often thought of constructing? Is there enough wind coming over the hills near your area so you can get into hang-gliding? Or do you live in an area where tornadoes or hurricanes sometimes strike? If so, it could literally be a matter of life-and-death for you to read the windspeed easily, with an accurate, easy-to-install anemometer (windspeed meter). That's what the Digital Windspeed Meter is—an accurate anemometer using the latest digital TTL (transistor-transistor logic) integrated circuits.

Though this project isn't recommended for someone who's never built any solid-state projects before, it should be easy enough for anyone who has built one or two simpler projects such as most of those published in *Electronics Hobbyist*.

In addition, it's the sort of project which will get you started easily in digital logic circuitry, the circuits and components which are the basic building blocks of computers and most other advanced electronics today.

How Anemometers Work. There are two types of electronic anemometers in general use. One type uses air cups or a wind turbine to turn a tiny electric generator whose output is directly connected to a milliammeter. The faster the wind blows, the faster the generator turns and the higher the meter reads. This type of anemometer is simple and reliable but it usually is not accurate.

A more sophisticated type uses air cups to turn a shaft to produce electric pulses. The pulses are integrated by a capacitor and related circuitry to produce a DC voltage whose magnitude is directly proportional to the wind speed. This voltage is aso displayed on a meter. This method is easier to calibrate, and thus is more accurate than the simple generator method. By

DIGITAL WINDSPEED METER

using state-of-the-art digital electronics, improvement can be made upon this method of measuring the wind's speed. Instead of the round-about method of adding up the electric pulses by charging up a capacitor, why not just count them directly? The digital anemometer described here does just that. The result is a more accurate sophisticated instrument that is easier to read and cheaper to build.

How It Works. The theory behind the digital anemometer is simple. See Fig. 1. The wind turns a shaft which has streamlined plastic cups attached to it. On one rod that holds two oppositely directed cups are placed two small magnets. A reed switch is mounted on the stationary base beneath the rotating cups so that it will be operated by the rotating magnets above. Each time the cups make a full revolution, the reed switch opens and closes twice. The pulses generated by this reed switch trigger a one-shot multivibrator (TTL-7412) which cleans up the pulses, eliminating contact-bounce and other error pulses. The cleaned-up pulses are then fed to a TTL NAND gate which is controlled by the 555 one-shot multivibrator. The 555's one-shot output pulse is manually adjustable to let us calibrate the anemometer. Another 555 astable multivibrator provides automatic triggering pulses for the 555 one-shot as well as supplying reset and blanking pulses for the counters and decoders. The resulting controlled and cleaned up pulses (which originated in the reed switch) are counted on two TTL decade counters and displayed on two LED displays.

Construction. The rotating wind sensor is made up of 4 plastic cups, mounted with 3/32-in. or 1/8-in. rods to a slot-car motor or similar cheap and readily available bearing. (The brushes of the motor can be removed if desired.) The egg-shaped containers in which *Leggs* nylons are sold are ideal for the plastic cups which catch the wind.

The rods which support the cups can be steel welding rods or (better) copper or brass. One rod should be one foot long and the other two should be six inches long.

Next, obtain a small cylindrical piece of a solid metal that is easily solderable —brass or copper is best. Drill two holes, using bits the same size as the rods, at right angles to each other through this cylinder of metal as shown in Fig. 2.

Now center the 12-in. rod in the cylinder. Insert the two shorter rods in the remaining two open holes in the cylinder, as shown in Fig. 3. Using acid-flux, solder the rods to the cylinder.

Mount the motor, which is used as the bearing, in a 2-in. long piece of two-by-four. To mount the motor, drill and file a hole in the wood large enough to take the motor. Cover the motor's case with epoxy glue and insert it in the hole as shown in Fig. 4.

Using a bit as close to the diameter of the motor's shaft as possible drill a hole about ½-in. deep in the bottom of the cylinder (see Fig. 3) which now has rods soldered to it. Insert the motor shaft into this hole and solder it, using acid-core flux.

(If steel is used, secure with epoxy glue.)

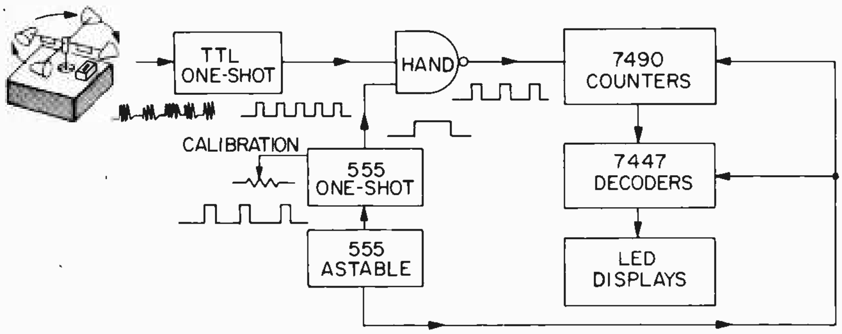


Fig. 1—Block diagram for digital anemometer. As the calibration control is varied it changes the duration of the pulse put out by the 555 one-shot. This acts as a variable window for the pulses coming from the windspeed sensor permitting accurate readout of the LEDs.

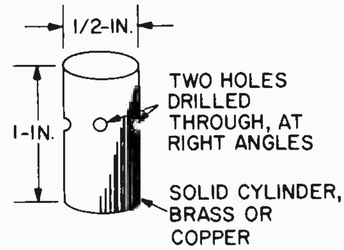


Fig. 2—Centerpiece of windspeed sensor.

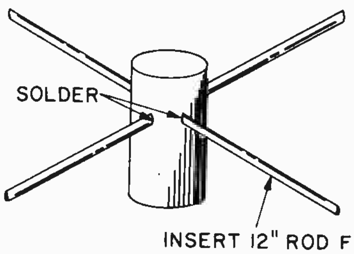
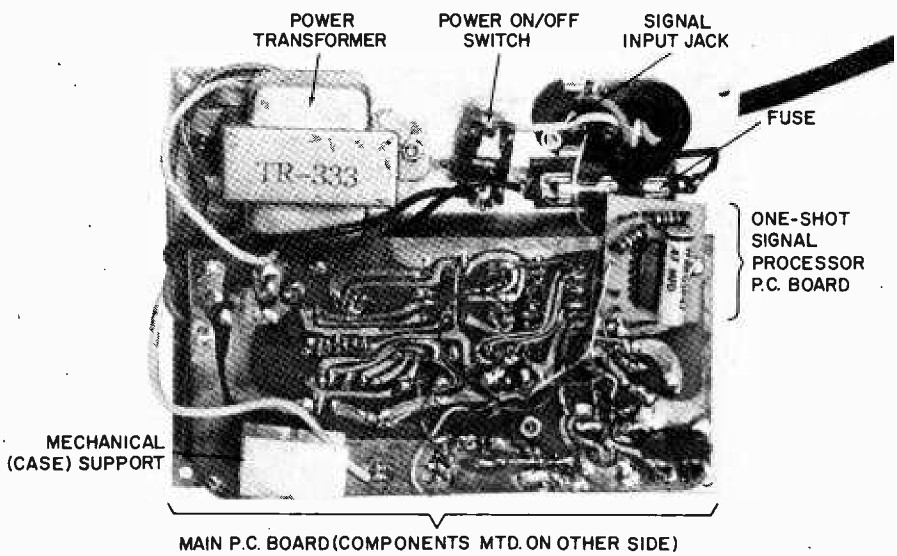


Fig. 3—Assembly of rods and centerpiece to form rotor.



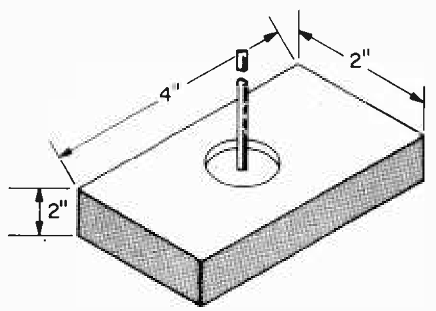


Fig. 4—Wood block mount with bearing.

Now mount the four plastic cups to the rod, taking care to correctly orient the cups. Drill holes in the cups and insert the rods in the holes. Keep the cups in place with epoxy or other good glue.

Next we mount the magnets on the rods. If copper or brass rods are used, great, just solder or glue the magnets to the undersides of two opposite rods, centering them one inch from the pivot. The reed switch is then mounted on the wood base so the magnets pass a quarter of an inch above it.

If the rod is iron or steel, we have a problem because it will distort the magnet's magnetic field. This problem is overcome by using a non-magnetic spacer between the magnet and the rod —¼-in. is enough space. A ¼-in. x 1-in. piece of wood is glued to the rod and then the magnet glued to the wood. Since there is very little weight involved, a good glue will hold the magnet fine. This completes the construction of the wind sensor.

Circuit Assembly. To build the cir-

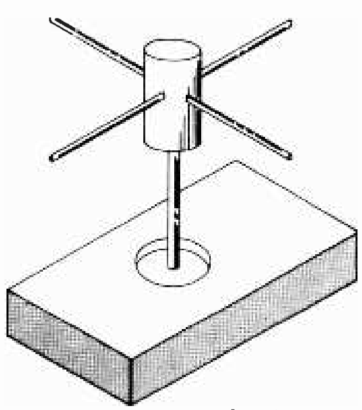


Fig. 5—Rotor in place on bearing.

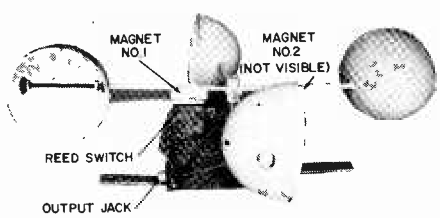


Fig. 6—Completed unit. Adjust height of reed switch so magnets pass about ¼-in. over it or less.

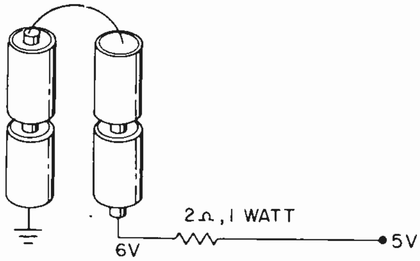
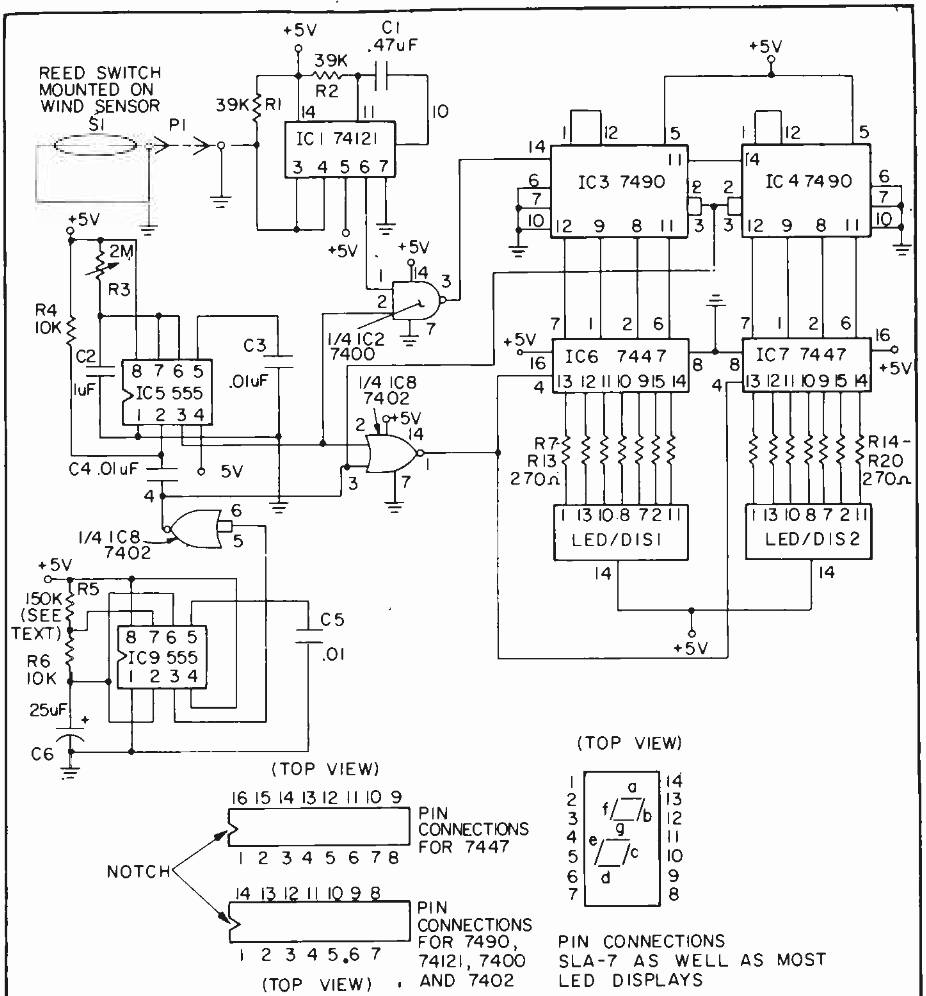


Fig. 7—Temporary battery power supply for use when calibrating the instrument in an automobile.



Be very careful when inserting ICs into their respective sockets. Be sure right types are inserted and oriented so that IC half-moon keys align correctly with sockets.

PARTS LIST FOR DIGITAL WINDSPEED METER

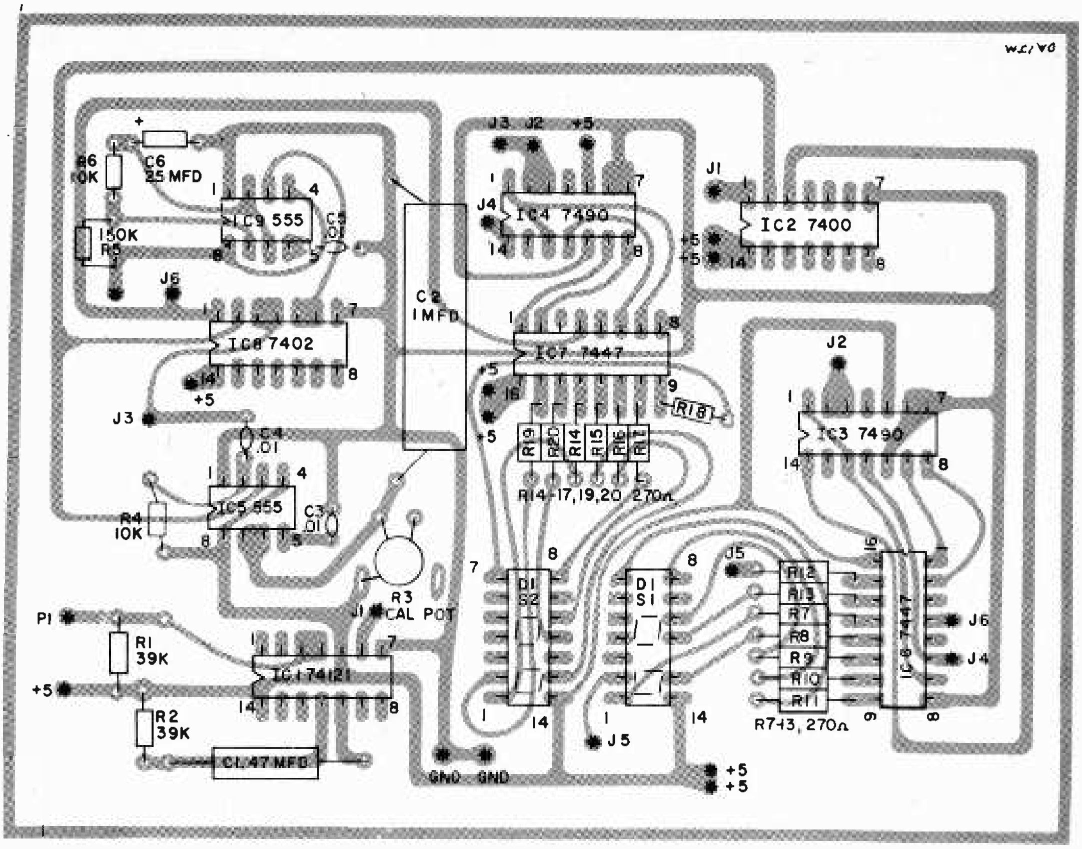
C1—0.47-uF, 50-VDC capacitor
C2—1.0-uF, 50-VDC capacitor
C3, C4, C5—0.01-uF, 50-VDC capacitor
C6—25-uF, 35-VDC or more electrolytic capacitor
LED1, LED2—LED display numerals (Radio Shack 276-053 or equiv.)
IC1—74121 monstable multivibrator integrated circuit, TTL type
IC2—7400 NAND gate integrated circuit, TTL type
IC3, IC4—7490 decade counter integrated circuit, TTL type
IC5, IC9—NE555 integrated circuit
IC6, IC7—7447 BCD-to-Decimal decoder, TTL type
IC8—7402 NOR gate, TTL type
P1—2-connector jack (& matching plug for cable) RCA-type phono plug recommended
R1, R2—39,000-ohm, ¼-watt resistor
R3—2-megohm printed circuit board-mounting potentiometer (Allied Radio 854-6287 or equiv.)
R4, R6—10,000-ohm, ¼-watt resistor
R5—150,000-ohm, ¼-watt resistor
R7—R20—270-ohm, ¼-watt resistor (14 needed)
S1—Miniature reed switch (Radio Shack 275-033 or equiv.)

Misc.—Four plastic cups such as the containers Leggs stockings come in. Two small magnets such as the "Magic" magnets most hardware stores carry. One 12-in. and two 6-in. pieces of copper or brasss rod, ⅛- or 3/32-in. diameter. One slot car motor or equiv.), for use as bearing. One piece of copper or brass rod about 1-in. long, ½-in. diameter (solid). One 2-in. piece of wood two-by-four. Epoxy glue, solder, mounting brackets (two) for wood block, screws. Ten IC sockets.

POWER SUPPLY

The Digital Windspeed Meter requires a regulated five-volt DC power supply. The easiest way to do this is to hook a 2-ohm resistor in series with a six-volt battery. This is also the safest power.

DIGITAL WINDSPEED METER



The pictorial shows the location of compenents as seen from the bottom (the components are on the far side of the board, from the viewers perspective) with the foil-side up. It is best to secure the ICs by using IC sockets, although you can solder them directly by using a low-wattage soldering iron (25 watts would be good). You might use sockets when mounting the display sockets to allow easy replacement if necessary. Since the location of components isn't critical, this circuit can be assembled on perf board if that's easier.

cuit use any convenient layout on a perf board. The position of the components is not critical. If you haven't worked with ICs before you'll be better off soldering IC sockets in place on the perf board, and connecting the other components to the pins of the IC sockets. If you've had a fair amount of experience and can solder ICs directly into a circuit without overheating the pins (using a pair of long-nose pliers as a heat sink while soldering to each pin), do it that way.

The main job in wiring the anemometer lies in making the printed circuit board. The pattern shown can be made by using the simple resist method. Simply draw the pattern with a felt-tipped resist pen on the foil side of the printed circuit board, place in etching solution for an hour or so and drill the holes marked. The somewhat more sophisticated, yet still easy, non-camera photo method can also be used.

If a small 25-watt soldering iron is used, the *ICs* can be soldered directly to the board, although IC sockets are less risky. Be sure to orient the notch on the *ICs* as shown in the component layout diagram. It is always wise to use IC sockets when mounting display LEDs. Be sure to either bend back or cut off pin 12 on the socket which is used to mount Display No. 1.

Unless double sided PC boards are used, jumpers made up of hookup or bare wire are needed. Place jumpers between the two J1s, J2s, J3s, J4s, J5s and J6s. In addition, interconnect the +5 VDC points on the PC board with jumpers (6 needed).

Connect the two leads from the remote mounted reed switch to points P1 and to one of the two GNDs.

Connect the plus power supply lead to the +5 point at the top of the board. Connect the other supply lead to the other GND point which is also located at the top of the board.

The 5-volt regulated TTL power supply described by Herb Friedman on page 61 of this issue of Electronics Hobbyist is ideal for this project. This power supply is compact enough to easily fit in the same case as the logic unit.

The entire circuit can be mounted in any convenient size bakelite or aluminum case with aluminum panel. For a smart appearance, spray paint the panel with some auto-touch-up white lacquer. Use dry transfer decals for the lettering.

Cut a slot in the panel so the two digit LED display can be readily seen. If desired, the switch to turn on the power can be an inexpensive slide switch but a toggle switch is more reliable and easier to mount. The circuit board and all other components should be mounted to the back of the front panel for ease of accessibility.

If one desires a longer display time, increase R5 from the recommended 150k to 220k or even 270k.

Any type of two-conductor connecting jack can be mounted on the front panel (I used an RCA-type jack) as long as the appropriate plug is used. The two wire cable which connects the rotary wind sensor to the electrical unit must be long enough to reach from the roof to the place in your home where you want to keep the display unit. Any kind of shielded cable, including audio cable or microphone cable is OK. Coax such as RG-59/U is fine, but don't buy it special for this job because it costs much more than other (audio) cable.

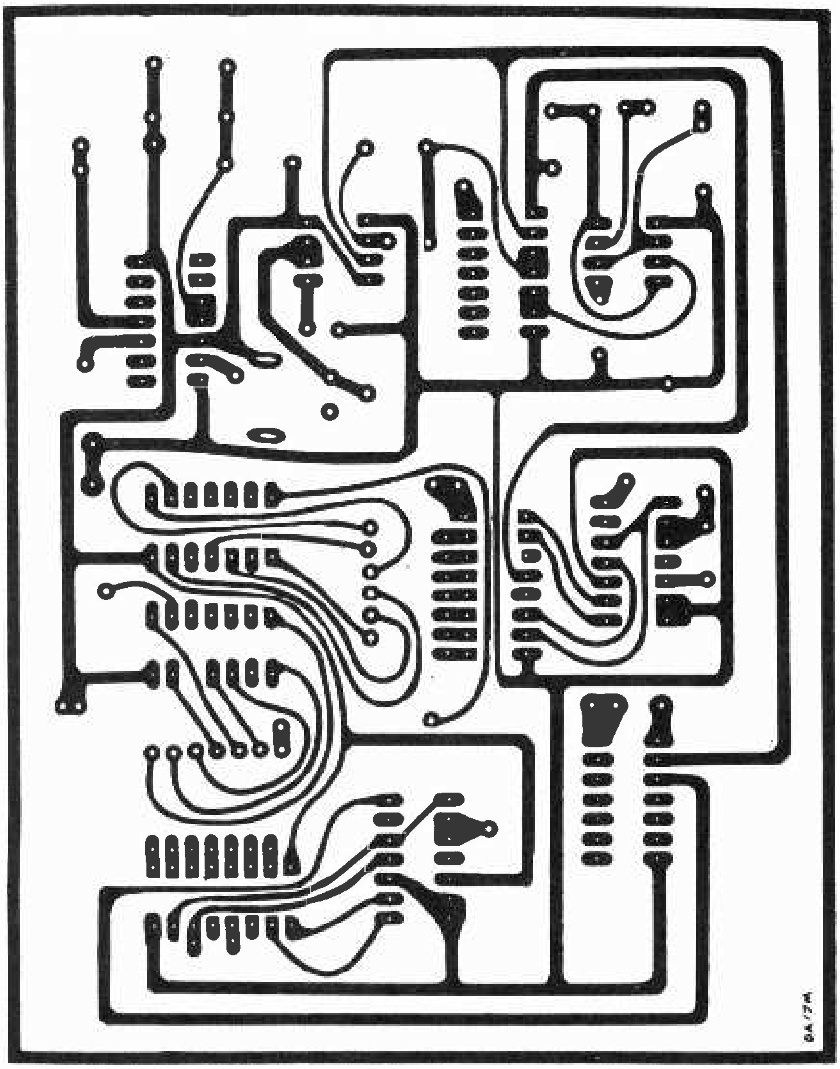
Calibration. This anemometer is easily calibrated since there is just one pot to adjust. As an initial test, plug the unit in and connect the wind sensor to the display unit. After a few seconds warmup the unit should show 00 then go momentarily blank. Turn the cups by hand and a number should appear on the display for a second or two and then disappear for a second. Now turn the cups as fast as you can by hand and adjust the calibration pot to read as close as possible to 20. If everything so far works OK, it is time to take the anemometer for a ride. If not, go back to Square One and check your wiring and the seating of the LED display modules.

The anemometer should be calibrated against an accurate automobile's speedometer. Since the anemometer will be away from the regular house supply, you will have to take along a 5-volt battery supply. In order to drop the voltage to the required 5 VDC, you must connect a 2 ohm resistor in series with a 6 volt battery.

With someone else driving, take the unit in an auto on a nearly calm day and drive as steadily as possible at a certain definite speed, say 30 mph. Drive up and down a quiet road, with the wind sensor held out the window and adjust the calibration pot so the display will read an average value of 30.

Use. The wind sensor should be mounted on a roof or other location where there are few obstructions. Because of the one-shot ahead of the NAND gate, the anemometer may suddenly go blank, when winds are of hurricane speed. So if the display one minute shows 75 mph and the next minute 00, don't stick your head out the window to see if something happened to the wind sensor on your roof, a tree might just be sailing by.

A simple way of checking your speedometer is to drive down an expressway at 55 and have someone time you betwen two mileposts. Then get your hand calculator out and divide 3600 by the number of seconds it took you to travel the mile. The result is your true speed. ■



The key to building a successful Digital Windspeed Meter is the making of an accurate printed circuit board. As you can see, many of the foil strips are in close proximity to each other. Be sure not to let any of the lines touch where they aren't supposed to; the resulting short circuit would probably damage one of the integrated circuit chips. Probably the best method for this circuit, if you are not equipped to use a photo-etching technique, is to use a resist type felt tipped pen and sketch the patterns on the copper-plated board. The board is then soaked in an acid etching solution for an hour or so. After the pattern is reproduced in copper you should drill all the holes. If you have a small drill-press, use it—a hand-held drill is likely to slip and damage the circuit.

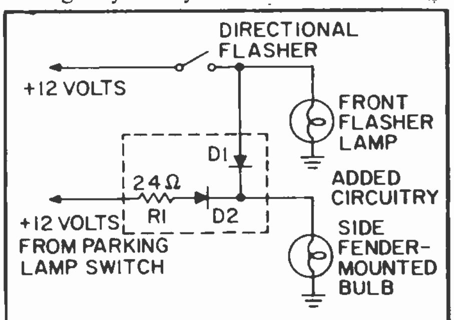
Turn Signals from Side Marker Lights

☐ Side clearance lights are the lamps usually mounted on the front and rear fenders. These lights can be made to provide additional driving safety by adapting them to flash *in unison* with the directional flashers if the auto does not now have rear flashers.

The circuit diagram shows how the present auto or pick-up electric wiring is modified so the side lights will also flash. A 24 ohm resistor is added in series with each side-clearance lamp bulb filament. This reduces the brilliance of the side bulb to about half of what it was originally. An epoxy diode is used to isolate the parking lamp filament from the flashing light circuit.

A separate wire lead is run from the side lamp to the directional flasher lamp on the same side of the auto. The side clearance lamp will then flash in unison with the front directional flasher lamp. A second diode is used to isolate the flasher filament from the parking light circuit so that it will not turn on when the parking light turns on.

Make good electrical connections by using instant auto electric connectors or soldering with a good soldering iron. Wrap all connections and components with a good amount of black plastic electrical tape so that they will withstand the weather. The side clearance lights will now flash not only with the directional signals but also when the emergency 4-way flasher is turned on. ■



PARTS LIST FOR ADD-ON TURN SIGNALS

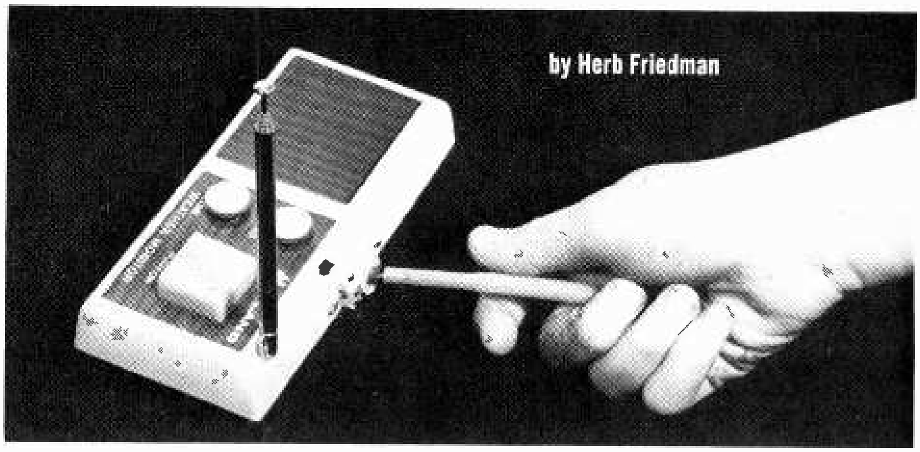
D1, D2—Diode 1 amp, 50 PIV or better (Radio Shack 276-1135 or equiv.)

R1—24-ohms, 1-watt resistor (Radio Shack 271-1000 or equiv.)

Misc.—wire, electrical tape.

ROCK BOTTOM COST

HIGH BAND MONITOR



Getting bored by the temp-humidity index? Slide an inexpensive weather monitor up or down for some exciting signal hunting!

BECAUSE they're priced so low, generally from $10 to $20, the "weather monitor" has been a hot gift item for the electronics experimenter, so you probably have one. Tuning the weather station frequencies of 162.40 and/or 162.55 MHz, these small, inexpensive radios are supposed to keep you up to date on the latest weather conditions. But as you've probably discovered yourself, unless you're a boat owner with need for tide and sea conditions, you get a more up-to-date report from your local news station—AM or FM.

Also, reception is probably not all that great. The recommended receiver sensitivity for weather station reception is 0.6 *u*V for a 50-mile range, and these inexpensive weather receivers can't get anywhere near this kind of sensitivity..

But there's no need to let an unused weather receiver sit on the shelf. Fortunately, very few models use crystal control tuning, and they are easily converted to a police or fire monitor, or even a sound channel receiver for the higher VHF TV stations. But remember, there won't be any super-sensitivity. TV stations might be received some 30 or 40 miles from the transmitter, but you'll have to be within 2 miles or so of the average police or fire transmitter to pick them up. If you live near an airport you might get coverage of the aircraft frequencies above 108 MHz, but with sharply reduced sensitivity.

The weather monitors are generally similar in electronic design, though the packaging might be anything from a cube to a desk-top pen holder. The circuits are bare-minimum superhet receivers with a local oscillator tuned over a limited range by a panel control. Generally, there are two panel controls, one for *volume* and one for *fine tuning*. The fine tuning knob might have calibrations for *both* weather frequencies, or no calibration at all. It doesn't make any difference as long as the local oscillator is tunable.

To change the weather monitor tuning range, all you need do is connect a small external trimmer capacitor across the oscillator tuning capacitor—the fine tuning control. The value of capacitor will determine which frequencies are tuned. Keep in mind that as you tune lower in frequency the sensitivity is sharply reduced, particularly below about 160 MHz. A capacitor with a maximum value of 7 pF will get you down to the police/fire frequencies. A 60 pF maximum trimmer will get you about to the top of the FM band, but tuning will be extremely critical and sensitivity will be very low.

A 60 pF trimmer will also get you some of the TV sound carriers above 162 MHz. How can you receive signals above 162 MHz if the tuning range is lowered? Simple. The harmonics of the local oscillator are used to receive the TV stations. For example, if you lower the monitor's oscillator to, say, 100 MHz, the oscillator's harmonic output is also 200 MHz, and a very weak 300 MHz. (The monitor's front end appears to pass the frequencies above the design-range, 162 MHz, with greater sensitivity than lower frequencies.)

Tear It Down. To experiment you must first get the circuit out of its cabinet. Keep in mind these weather monitors are inexpensive and designed to be assembled quickly by unskilled workers. Don't go looking for tricky or difficult assembly sub-systems. Generally, one or two screws are all that's holding the cabinet together. If necessary, unsolder the speaker wires, battery wires and on-off switch wires, and remove the circuit board from the cabinet. Locate the trimmer capacitor used for the fine tuning and its two solder terminals. Solder a 3-in. length of solid, insulated wire to each terminal.

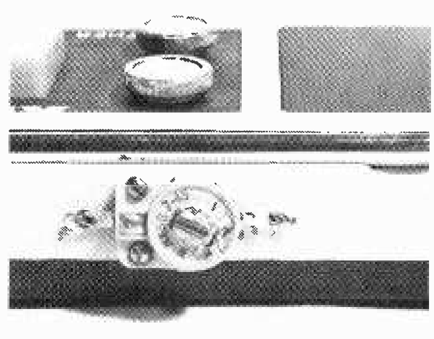
Check how the board fits the cabinet and mark the outside of the cabinet nearest the fine tuning. Drill two small holes at the mark and then install a trimmer capacitor on the cabinet near the holes. Or, you don't have to secure the trimmer if you feel you will experiment with different capacitor values, but it will be difficult to tune the stations with a "floating" trimmer. You can't hand-hold the trimmer because the capacitance from your hand will affect the tuning adjustments.

Slip the wires from the fine tuning control through the holes you've drilled in the cabinet and seat the circuit board. Then reassemble the monitor.

Connect the wires protruding through the cabinet to the trimmer capacitor using the shortest possible leads (cut off the excess).

That's the whole bit. Use an insulated alignment-type screwdriver to adjust the trimmer. You'll probably be able to tune a few TV stations immediately. Tuning police/fire calls or anything else will be more difficult because transmissions in these services are short and fast. You can preset the tuning by using a signal generator or a well calibrated grid dip oscillator.

Remember, this is a fun project. Don't hope for more than acceptable reception. But then who knows, you might be able to tune your favorite TV channel and keep track of the program while working in your shop. ■



Install a small trimmer on the cabinet at a point just outside the internal trimmer.

Las Vegas LED

Always win on the red with electronic roulette

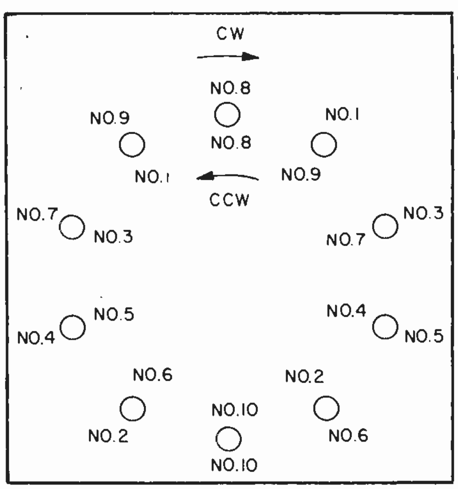
by Walter Sikonwiz

PEOPLE HAVE ALWAYS BEEN fascinated by games of chance, as diversions and obsessions. Inveterate gambler or not, chances are you'll really like *Las Vegas LED,* our version of that old favorite, Roulette. Here's more good news—you won't have to drop a bundle to cash in on the fun.

Las Vegas LED's spinning wheel of fate is a revolving dot of light, provided by a ring of ten LEDs. A glance at the photographs will show you that play is governed by three controls: *Accelerate, brake,* and *decay.* You start by pressing the *accelerate* button, which causes a red dot of light to revolve at an ever-increasing rate until a terminal velocity is reached. If you release *accelerate,* the spinning light will gradually coast to a standstill. The rate of deceleration is determined by the *decay* control. Pressing *brake* while the light is coasting causes a more rapid, but not instantaneous, halt to the spinning.

At least two games are possible, with this control format. Using a little imagination, you can probably devise more. The first possibility is similar to standard Roulette. A player presses *accelerate,* then releases it, and hopes that the number he has predicted beforehand will be the one at which the light ultimately comes to rest. Alternatively, the player starts the light into motion; then, upon the release of *accelerate,* he tries to stop the light on a number designated by his opponent, using only one pulse of the *brake* switch for this purpose. This second variation is quite a frustrating game; particularly so if various decay times are used. Decay times from about 1.5 to 15 seconds can be selected via the *decay* potentiometer.

How It Works. Before discussing construction, let's delve into the theory behind our Roulette game. We start with a very simple voltage-controlled oscillator. We then devise some means for converting the oscillation of our VCO into the apparent revolution of a spot of light (this might seem hard, but we'll see how simple it is later); the velocity of the light will be directly proportional to the VCO's frequency. The VCO's frequency, however, is proportional to the control voltage applied to it. We can produce acceleration of the revolving light if we cause the VCO's control voltage to gradually rise while the *accelerate* button is depressed. Conversely, deceleration of the light is synonymous with a gradual reduction in control voltage. How do we produce a control voltage that behaves in such a manner? We can charge and discharge a capacitor through resistors, and use the voltage across the capacitor as our control voltage.



Mount the LEDs in one of the two orders shown here, which one depending on whether you wish your wheel to "rotate" clock-wise (cw) or counter-clockwise (ccw).

Take a look at the schematic diagram. The voltage across capacitor C3 is our control voltage, and you can see how pressing S2, the *accelerate* button, charges the capacitor through R13. Once S2 is released, charge accumulated on C3 drains away through R13, R11, and *decay* control R12. Setting R12 to its maximum resistance produces the slowest rate of capacitor discharge; hence, as we'll see later, the revolving light will take a maximum amount of time to come to rest.

Brake switch S3 also discharges C3, this time through R14. Since the resistance of R14 is set to a relatively small value, the rate of discharge is quite rapid, and produces a quick cut in the speed of the light. It is the voltage on C3 that is to be our control voltage. Transistor Q11, functioning here as an emitter follower, reads C3's voltage; and because the emitter follower configuration is used, Q11 will not significantly contribute to the discharge of capacitor C3. At Q11's emitter we now have a voltage proportional to that on C3, which is used to drive our VCO.

Unijunction transistor Q13, along with R16, R17, R18, R19, and C4, comprise a relaxation oscillator, the frequency of which is proportional to the input voltage present on the left-hand end of R16. We don't have the nice, linear, voltage-to-frequency conversion of fancier VCOs, but what we have serves our purpose well enough. The output signal of our VCO appears across R19, and is a series of short-duration spikes with an amplitude of a volt or two. Such a signal won't be acceptable to the circuitry that follows, so we first feed it to transistor Q12, set up so that only a small input signal saturates it fully. The resultant output signal, available at Q12's collector, is a well-defined series of negative-going pulses, approximately 9 volts in amplitude.

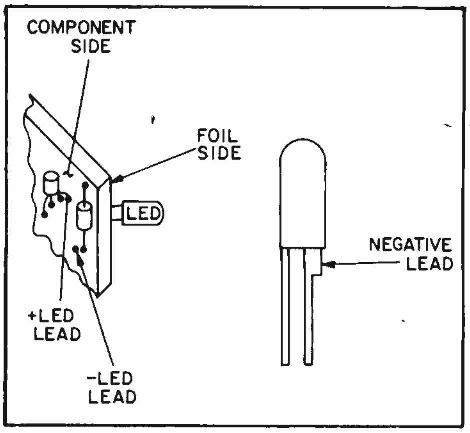
Now we convert the variable-frequency pulses from Q12 into the apparent revolution of a dot of light by using an integrated circuit known as a decade counter. One essential characteristic of such an IC is that it has ten outputs, and at any given instant of time, nine of these outputs will be at a low potential, while the tenth will be high. The second important feature of the decade counter is that whenever its input, (pin #14 in this case), senses a specific change in potential (high-to-low in this case), the lone high signal advances serially along the outputs. Specifically, successive input pulses to IC1 will cause the high signal to advance from output #1 all the way to output #10, and then back to output #1 again. You might logically assume output #1 to be available at pin #1, and so on; however, this is not the case. We won't discuss the actual location of the individual outputs, because this information is available on the data sheet that accompanies this Radio Shack IC.

From the schematic, we see how Q12's output feeds IC1's input, pin 14. The outputs of IC1 (pins 1 through 7, plus pins 9, 10, and 11) connect to ten LEDs through buffer transistors Q1 through Q10. These buffers are emitter followers; they're necessary because the IC alone cannot supply sufficient current to illuminate an LED. Whenever a particular output is high, its associated driver transistor will supply current to a LED, and light it.

We arrange these LED's in a circle so that as we progress in a clockwise direction, starting at the LED associated with output #1, we encounter, *in proper consecutive order*, those LEDs associated with output #2 through output #10. When we feed an input signal to our IC, we see the LEDs fire sequentially so that a spot of light appears to be revolving in a counterclockwise direction. One full revolution of the light requires ten input pulses, and the rate of revolution is in direct proportion to the input frequency.

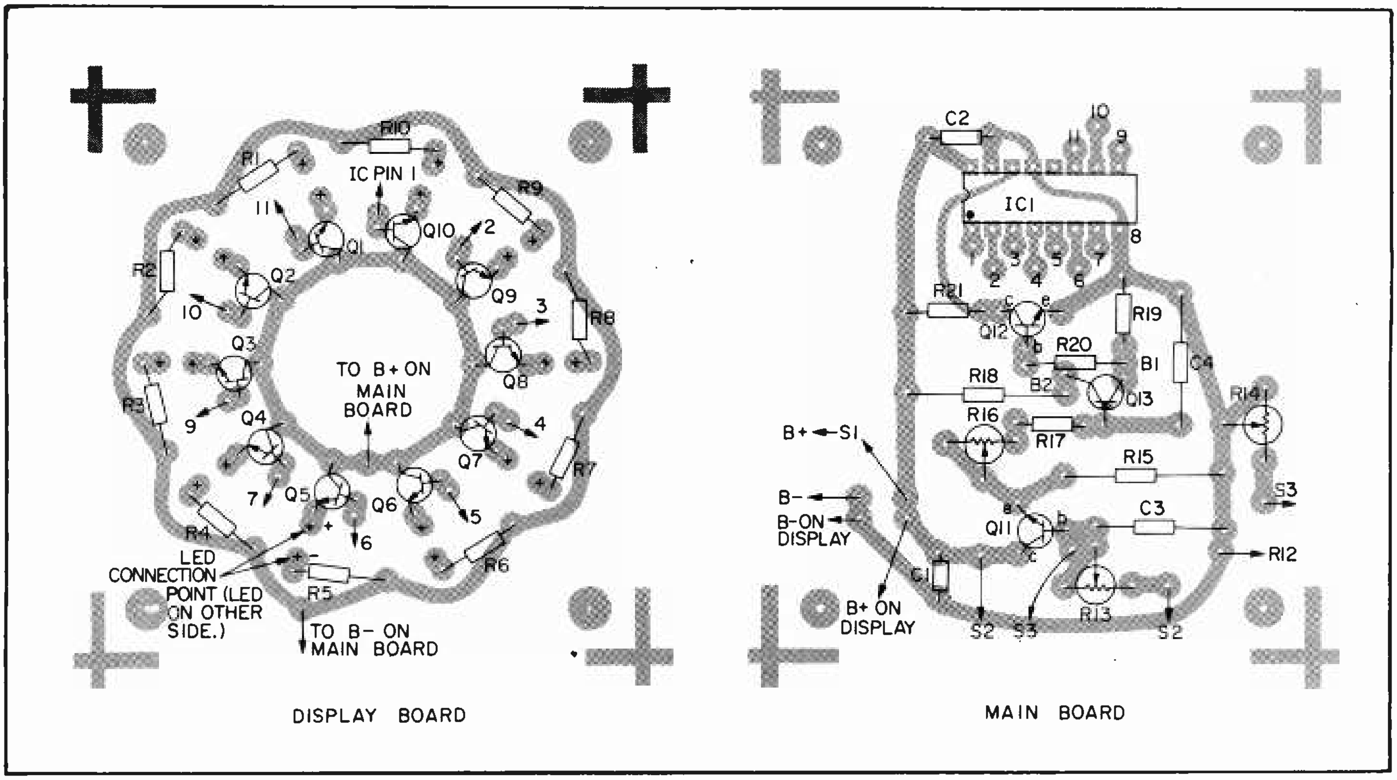
Let's review what we have: 1) the frequency of our VCO is controlled by the gradual charge and discharge of a capacitor; 2) the variable-frequency signal from the VCO feeds a decade counter, which drives ten LEDs; and 3) proper LED arrangement results in the apparent revolution of a single dot of light, with a velocity proportional to the frequency of the VCO. That's all there is to it.

Wiring. Since nothing about the circuit is critical, you may build it any way you wish. Perfboard construction is good. Alternatively, you might want to copy the PC layouts provided; the choice is up to you. A good place to begin construction is by drilling your



LEDs are to be wired to the foil side, with their leads left long enough that their heads poke through the front cabinet (see text). Observe polarity; the negative leads of the LEDs are notched, as shown, and should be connected as both the pictorials and the schematic indicate.

cabinet to accept the ten LEDs. With a compass, lay out a small circle on a sheet of paper. If you intend copying the PC layout provided, the circle's radius should be exactly .9 inch. With a protractor centered at the circle's center, divide the circle into arcs at 36-degree intervals. Trim away any excess paper, leaving just the circle and a small border around it. Position the circle conveniently on your cabinet, and tape it down. With a fine, sharp awl make



The component sides of the main and display boards are shown in this pictorial view. Make certain that the main board's IC pins are all interconnected properly to the solder-points on the display board, as labeled. Connect, for example, IC pin 1 to Q10. Don't forget about R11 which is not shown and is wired point-to-point between R12 and S2.

slight indentations in the cabinet at the points where the circle is subdivided into arcs. Remove the circle, and at each indentation drill holes through which the LEDs can protrude.

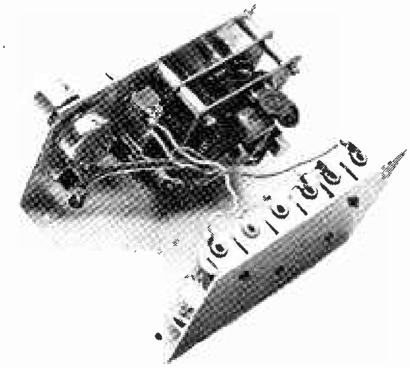
The drawing given shows the order of mounting of LEDs for both clockwise and counterclockwise revolution. The PC layout supplied for the display board provides counterclockwise revolution of the light.

The majority of the components mount on two circuit boards—either the main board or the display board. Even if you decide not to use a PC board, the PC layout provided for the display board may be helpful to you. Note that the arrangement is particularly simple, even though a good many parts are involved, because a radially symmetric pattern is employed instead of the usual rectilinear layout.

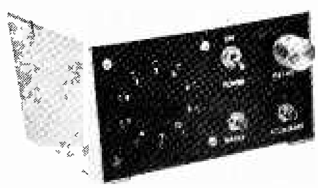
When installing components on the display board, follow the dimensional details in the accompanying drawings. Note that Q1 through Q10, and R1 through R10 mount on the component side of the board. LED1 through LED10 mount on the opposite foil side, with leads of such a length that the tops of the LEDs extend beyond the spacers and through the cabinet's panel. The semiconductors that mount on the display board are not especially fragile, but as is the case with all solid-state devices, excess heat can be damaging. Solder all connections quickly, using a 25-watt iron and fine, rosin-core solder. Twelve wires will run between the display board and the main board; ground, +, and the ten counter output leads.

The main board contains the rest of the components. Note that if the PC patterns supplied are copied, the main board may be stacked right behind the display board. This makes for a very dense packing arrangement, but if you have ample space, the boards may be mounted in any manner you like. R11 does not appear on either circuit board; instead, it is wired point-to-point between R12 and S2. Be sure to use a 16-pin socket for IC1. This IC is a CMOS unit, and should be inserted into its socket only after all soldering is finished. If, in checking out your unit, you should find an error that requires re-wiring, remove IC1 before applying a soldering iron to the board.

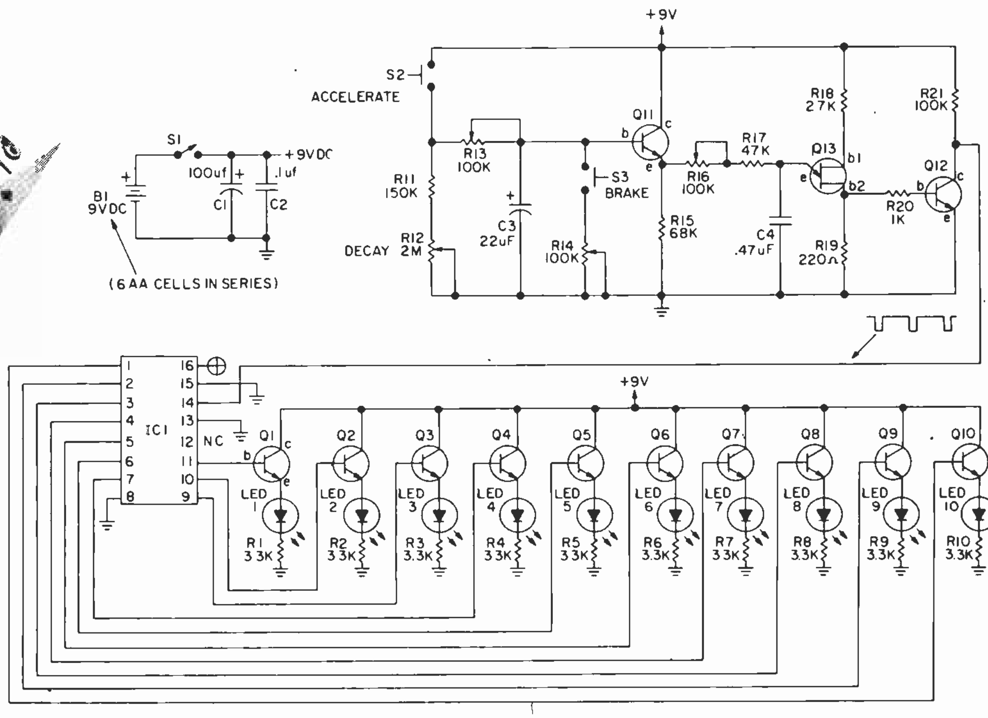
In assembling the circuit, pay atten-



Inside view of Vegas LED showing stacking of PC boards.



Completed Vegas shown fully assembled, and installed in case.



PARTS LIST FOR LAS VEGAS LED

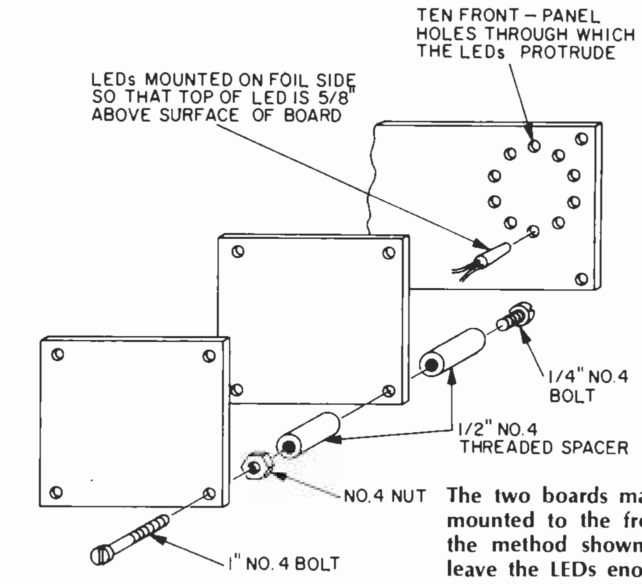
B1—Six AA (penlight cells) 1.5 VDC
C1—100-uF, 16-VDC capacitor
C2—.1-uF capacitor
C3—22-uF, 16-VDC tantalum capacitor
C4—.47-uF, capacitor
IC1—Decade Counter/Divider CD4017
LED1-LED10—Light Emitting Diodes
Q1-Q12—2N3904 transistors
Q13—Unijunction transistor
R1-R10—3300-ohm resistor
R11—150,000-ohm resistor
R12—2-Megohm potentiometer
R13, R14, R16—100,000-ohm trimmer
R15—68,000-ohm resistor
R17—47,000-ohm resistor
R18—2700-ohm resistor
R19—220-ohm resistor
R20—1000-ohm resistor
R21—100,000-ohm resistor
S1—SPST toggle switch
S2, S3—SPST pushbutton switches, normally open
Misc.—Battery clips, IC socket, aluminum spacers, wire, solder, hardware, etc.

You might not be able to afford a trip to Vegas; but Las Vegas LED will bring the glittering, gambling glamor of that city right into your own home town. When you assemble the circuit, just pay strict attention to the orientation of C3 and C1. It also pays to doublecheck the positions of all ICs and transistors; you'd be surprised how often a simple positioning error can lead to hours of fruitless trouble-shooting. The boards may be mounted in any way you like within the cabinet, but remember to leave room for the batteries to fit into later on. Finally, make absolutely sure you have positioned the LEDs properly depending on whether you want clockwise or counter-clockwise rotation of your "wheel." Follow the diagram on the first page very exactly. Once it's all together just get your bet down and start Las Vegas LED spinning around.

Las Vegas LED

tion to the orientation of C3 and C1. Likewise, make sure the transistors and IC are correctly positioned. The LEDs must also be properly oriented. The leads of all these devices are identified on the packages in which they are sold. Because of the circuit's low power consumption, six 1.5-volt penlite cells in series will power it for a long, long time. A single 9-volt transistor battery could also be used.

Because this is not a finicky circuit, the operating controls and circuit boards can be mounted in any convenient way inside your cabinet, but be certain to allow sufficient room to accommodate the batteries. When you've completed cutting and drilling the cabinet, finish off the front panel with press-on decals. As shown in the photographs, LED1 through LED10 should be identified with numerals applied in a random order.



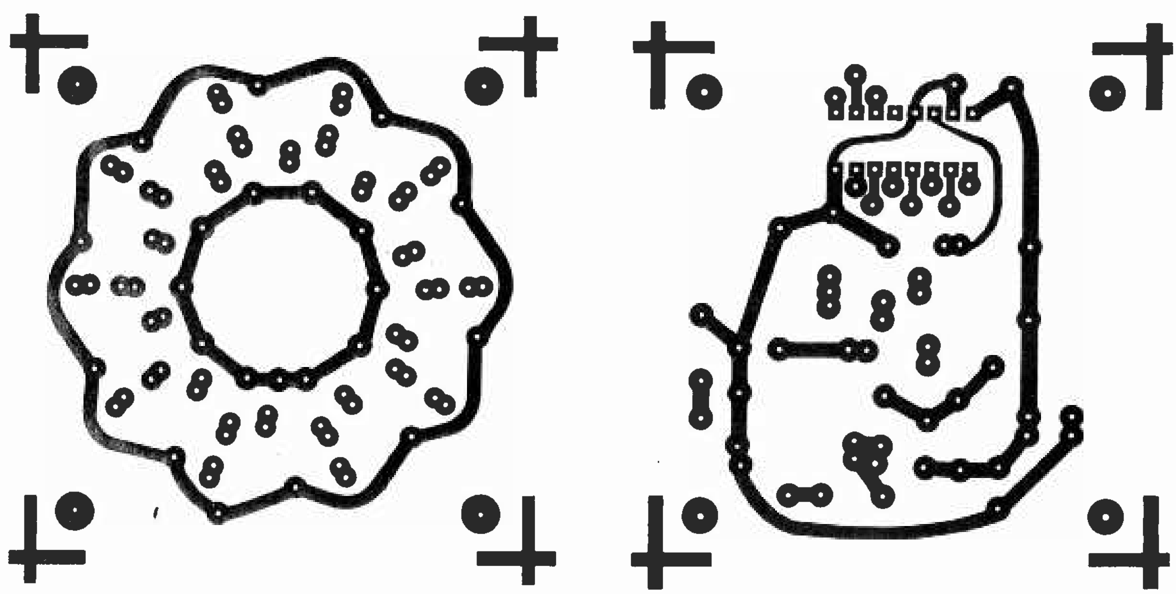
The two boards may be easily and neatly mounted to the front panel by following the method shown here. Make sure you leave the LEDs enough lead, and that you mount them to the foil side of the display board.

Final Calibration. After assembly is complete, only a few simple adjustments are necessary to put the circuit into operation. Turn R12 so that its resistance is at a minimum. Set R13, R14, and R16 to the midpoints of their ranges of rotation. Apply power, and depress the *accelerate* button. Within several seconds you should see a spinning dot of light. Adjust R16 for the desired maximum velocity. Too high a maximum speed blurs the image and spoils the effect, whereas a slow-poke display is equally undesirable.

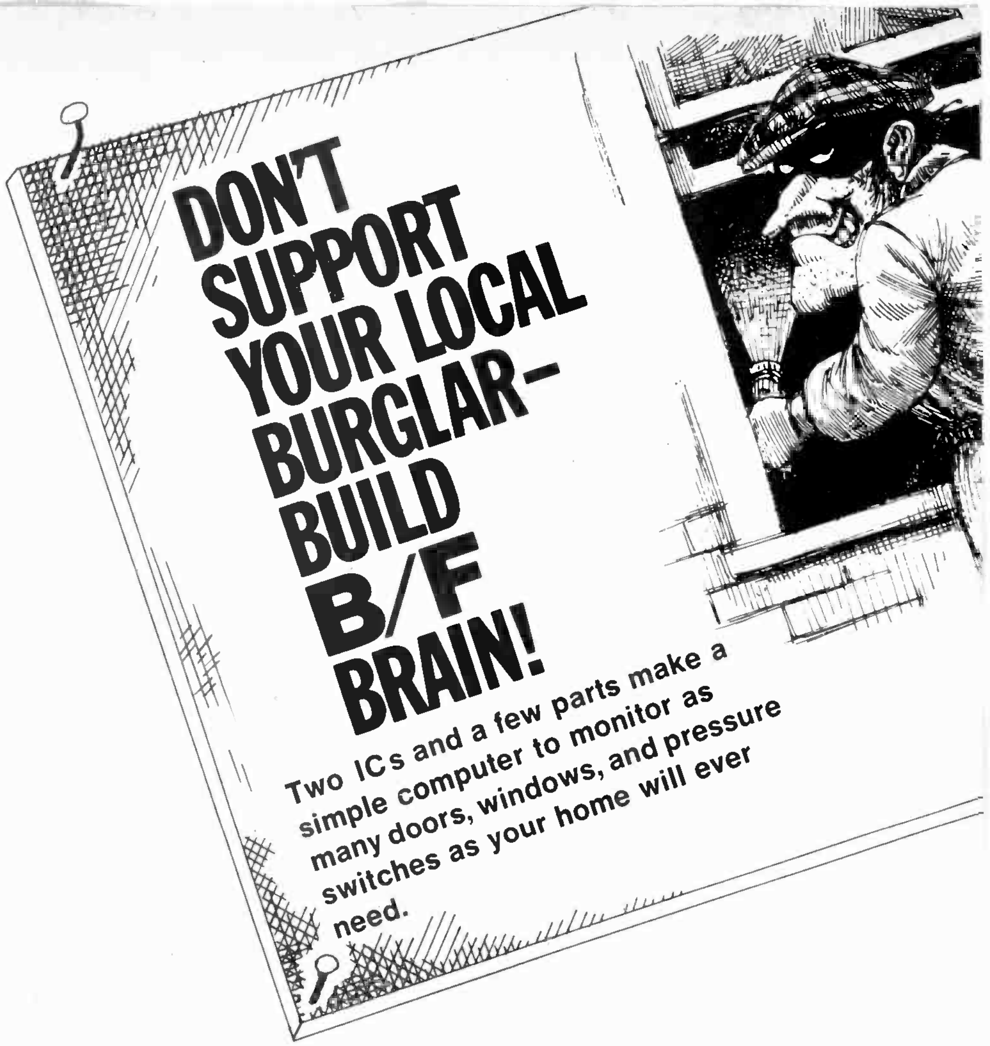
Release the *accelerate* button, and the velocity of the light will diminish rapidly. Press *accelerate* again, and then release it, repeating the cycle several times, and at the same time adjust R13 to get an acceleration response that you like. In general, the best position for R13 will be somewhere in the middle of its range of rotation.

Turn R12 so that its resistance (and the decay time) is a maximum. Press the *accelerate* button until the display reaches maximum velocity, then release it, and press *brake*. Note the rate at which the display is slowed down. Adjust R14 while alternately pressing *accelerate* and *brake* until you obtain a rate of deceleration that you like. A very rapid braking action is undesirable; the brake should diminish the velocity, not halt motion instantaneously.

The game may be used as already described in the opening paragraphs. However, just as dice can be found as constituent parts of many other games, so too can Las Vegas LED be adapted to games of your design. ■



Las Vegas LED uses two compact PC boards to keep its "wheel" spinning. The display board, on the left, takes advantage of a repetitious circuit to achieve a neat, clean symmetry of design. The main board, on the right, is also simple to etch and wire. Use these two full-size patterns as templates for your own Las Vegas LED.



DON'T SUPPORT YOUR LOCAL BURGLAR—BUILD B/F BRAIN!

Two ICs and a few parts make a simple computer to monitor as many doors, windows, and pressure switches as your home will ever need.

☐ It's an unfortunate sign of our times, but the burglar alarm is becoming a necessary part of home electronics. Robberies of homes is one of the fastest increasing crimes. In many cases homes are left vacant during the day when both husband and wife work, leaving an unprotected home to the mercy of thieves. If you haven't been victim of such a crime yet, consider yourself lucky. Better yet, consider electronic protection of your home.

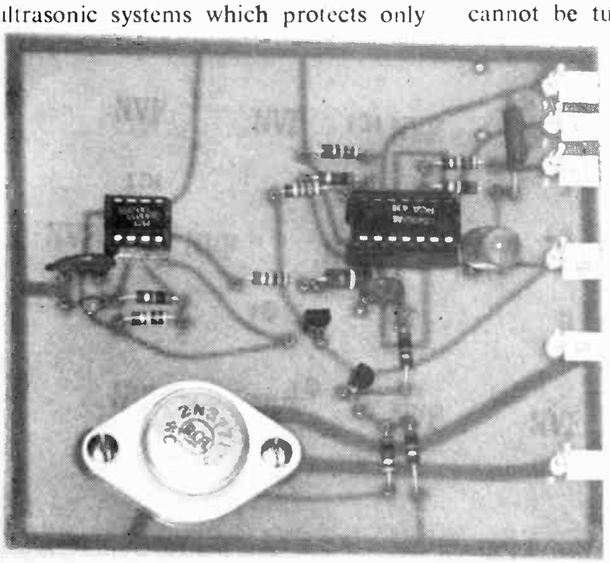
There are many burglar alarms available for the home. However, a good alarm system may cost as much as $500 when installed by professionals. Even the do-it-yourself units available from electronic supply houses or discount stores cost $100.00 and more.

There's no need for you to spend this kind of money to achieve home security if you are handy at building electronic circuits. B/F Brain can do the job a at fraction of the cost of a do-it-yourself kit, and will be just as effective and reliable as any on the market. By using modern electronic technology an extremely simple circuit has been designed which produces excellent performance at very low cost. The circuit uses two integrated circuits which cost less than $2.00.

Works Open or Closed. B/F Brain has several desirable features. It may be used as a closed circuit in which all points of entry into the house are protected by a loop of conductive foil and normally-closed switches. There is no limit to the length of the loop or number of switches which may be employed, since they are connected in series. This allows protection of any number of doors and windows, and additional points for protection can be added at any time without any changes in the alarm itself. This type of installation has a distinct advantage over ultrasonic systems which protects only the room in which they are installed.

Provision has also been made to use normally-open switches as desired. in addition to the series circuit of conductive foil. Thus it is possible to add foot-operated switches in hallways and doorways and as additional protection. This also permits the burglar alarm to be used in an automobile, where the opening of a door, which normally activates the dome light switch now also operates the alarm. Once the alarm is activated by opening or closing a circuit, it cannot be turned off by just restoring the disturbed circuit to its original condition (i.e. closing the door or window). A reset switch must be pressed, otherwise the alarm will continue to sound.

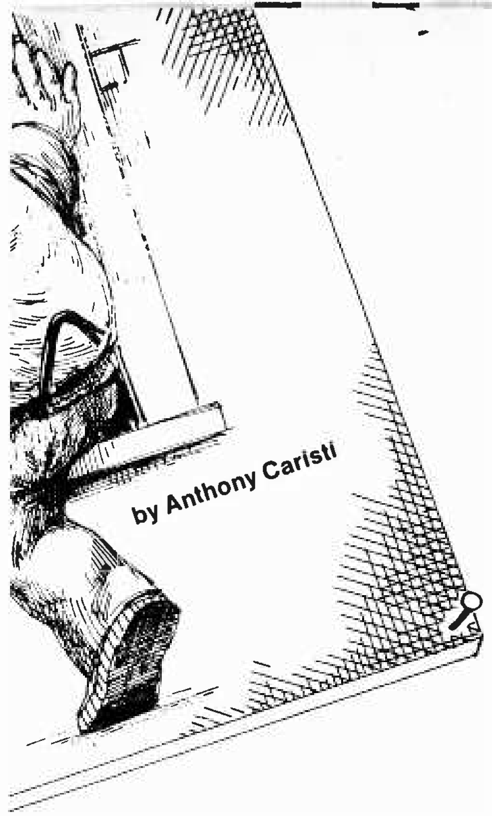
Works For Fires, Too. B/F Brain becomes a fire sentry as well, simply by buying easily-available fire sensors and installing them wherever you feel they are necessary. Again, there is no limit to the number of sensors which can be added to the circuit. Both open- and closed-circuit sensors may be used.



Photograph at left shows completed board with the two ICs. Large power transistor at lower left is Q2 which drives alarm speaker. Six terminals at right edge of board connect to speaker, foil loop, switches, Reset switch, and power source.

Inexpensive Alarm. There is no need to purchase an alarm bell. Any inexpensive eight-inch or larger, 3.2-or 4-ohm speaker will do the job nicely. The alarm circuit produces a 12-volt peak-to-peak square wave which will deliver 9 watts of power into a 4-ohm load. This will produce sufficient sound for most applications. If desired, more power may be obtained simply by increasing the supply voltage to the speaker. For example, if a 24-volt supply is used, the power delivered to the speaker will increase by a factor of 4, to 36 watts. B/F Brain produces an up-and-down wailing sound which will command lots of attention, even at the 9-watt level.

Window Protection. Conductive foil for windows and doors is relatively inexpensive. A 150-foot roll of ⅜-in.



wide tape costs only three or four dollars. This tape has an adhesive backing and it is not necessary to use the full width of tape. By cutting the tape in half you provide greater sensitivity to glass breakage and a more pleasing appearance. One roll of tape will easily do any average size home.

Timer Delay. An optional feature of the circuit is provision to add a capacitor to produce a delay of several seconds. This feature will allow you to arm the alarm circuit before going out, and then leave the house by a protected door. It also permits you to enter the house through a protected door without sounding the alarm, since you can shut the circuit off before the alarm sounds.

The basic circuit is shown first. This is the complete alarm circuit, constructed on a small printed circuit board.

Also shown is a layout of the foil pattern of the board, viewed from the copper side. We also show the component layout as viewed from the top of the board. Note that Q2, the power output transistor, does not have any heat sink. None is required since Q2 operates as a switch and not a class-A amplifier. When Q2 is conducting it is in a saturated state. This means that the collector-to-emitter voltage is about 0.3 volts. Thus, the total dissipation in Q2 is 0.3 volts times 3 amperes or 0.9 watts. The average dissipation of Q2 is half of this, since it is cut off for half of each cycle when the alarm circuit is delivering power to the speaker.

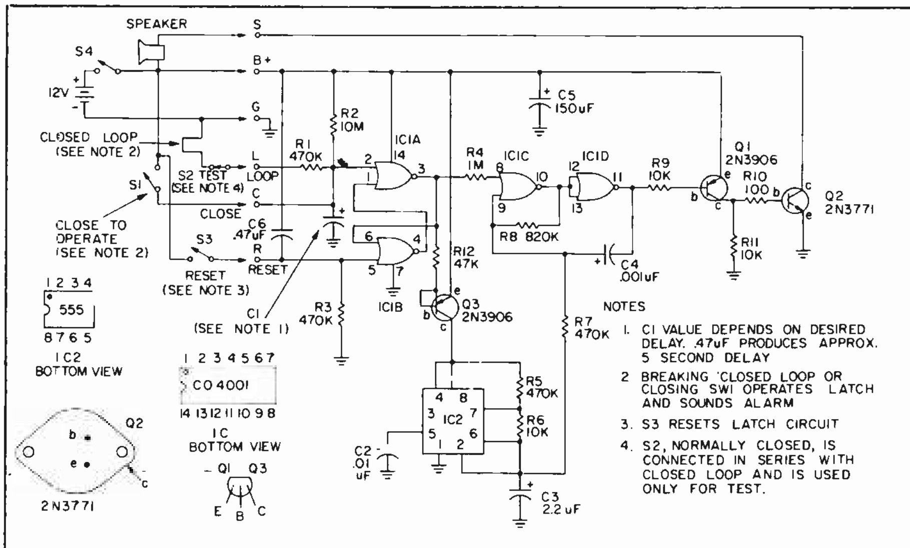
Note the series of six connections located at one side of the board. These are the required connections to the *Power Supply*, *Speaker*, *Open-circuit*, or *Closed-circuit* loop, and *Reset* control. It is recommended that sockets be used for the integrated circuits. This makes it easy to solder to the board without endangering the integrated circuits with the iron's heat. It also will permit you to remove each IC in the event the circuit ever needs servicing. Once an IC is soldered into a printed circuit board it is extremely difficult to remove. Be sure to insert the ICs into the sockets (or board) in the correct direction. Pin 1 of each IC is marked on the IC itself, as well as on the copper foil side of the printed circuit layout.

About the Circuit. B/F Brain uses two integrated circuits. IC1 is a four-section, 2-input NOR gate constructed in COS/MOS (Complimentary-Symmetry / Metal-Oxide Semiconductor) form. The advantage in using COS/MOS integrated circuits is the extremely low current drain of the chip. The CD4001 chip IC used in this circuit draws only 5 microwatts of power from the 12-volt supply.

A NOR gate is a digital building block which obeys the following rule: If the voltage at either input terminal (or both input terminals) exceeds 70 percent of the supply voltage, the output voltage falls to zero. If the input voltage to both input terminals is less than 30 percent of the supply voltage, the output voltage rises to the supply voltage. Input voltages between 30 and 70 percent of the supply voltage have no logic definition and are not considered legitimate voltages when they're applied to the input terminals.

IC1A and IC1B are connected in a configuration called a *Bistable Latch*, or *Flip-flop*. This circuit can rest in either of two states: Pin 3 at 12 volts and pin 4 at zero volts, or pin 3 at zero volts and pin 4 at 12 volts. The voltages fed to the input terminals, pins 2 and 5, determine which state the circuit rests in. The normal input condition for the bistable latch is approximately zero volts at both input terminals. Pin 2 is held to about 0.5 volts by means of R2, R1, and the closed loop circuit of conductive foil between terminal L and ground. Pin 5 is held to zero volts by means of resistor R3. Under this condition the output voltage at pin 3 is 12 volts. In order to flip the voltage at pin 3 to zero volts, the voltage at input terminal pin 2 must approach 70% of the supply voltage, or 8.4 volts. This would be caused by the closed loop at terminals L to G being opened, or a connection between terminals C and B+. When either of these conditions exists, even for a few microseconds, the output voltage at pin 3 is flipped to zero. Removing the voltage at pin 2 will have no further effect on the circuit. It can be restored only by applying a voltage to pin 5 through the reset switch.

More on Circuit Operation. Capacitor C1, between pin 2 of IC1A and ground, controls the amount of time delay between the opening of the loop circuit and the activation of the alarm. When the loop circuit is closed, the voltage across C1 is held to about 0.5 volts through the voltage divider action of R2 and R1. When the loop is opened, C1 begins to charge through R2. The latch circuit will change state when the voltage at pin 2 approaches 8.4 volts. Thus, the amount of time delay is



Complete schematic of system shows the NOR gates, IC1A through IC1D, which are part of the CO 4001 integrated circuit. Circuit may be assembled on perf board if desired. Be sure to use IC sockets unless you're experienced soldering directly to ICs.

B/F BRAIN!

determined by the value of C1, and will be about five seconds for a .47 uF capacitor. If no delay is desired, C1 may be deleted from the circuit.

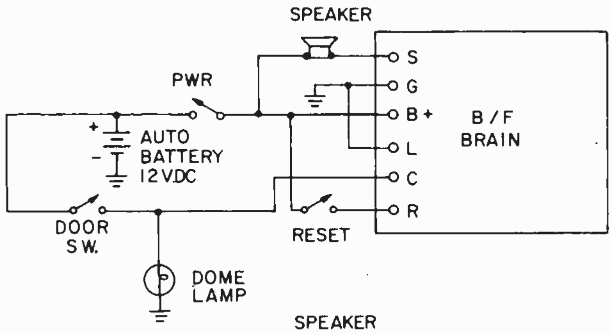
IC3C and IC3D are considered in a configuration which operates as an astable (free running) multivibrator. DC feedback through R8 and AC feedback through C4 allows the circuit to oscillate at a frequency (about 1500 Hertz) determined by the RC time constant. However, the oscillator circuit will operate only if there is no input voltage at pin 8, IC1C. Thus, the latch circuit of IC1A and IC1B controls the operation of the oscillator.

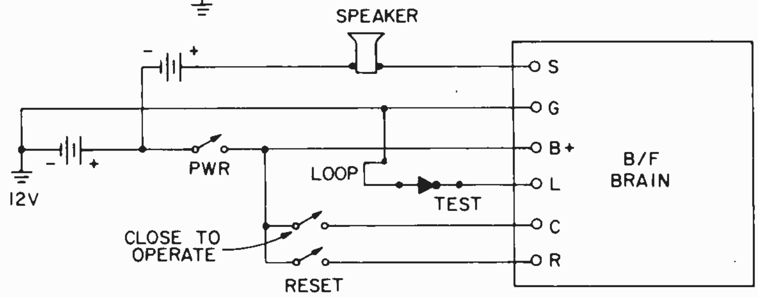
The Timing Circuit. IC2 is a timing circuit which is connected to operate as an oscillator. The frequency of oscillation for this circuit is about two Hertz, and is determined by the RC time constant of R5, R6, and C3. The voltage across C3 is a sawtooth varying between 5 and 9 volts. This voltage is fed to IC1C, causing the basic frequency of the alarm oscillator to vary up and down to produce the familiar siren effect.

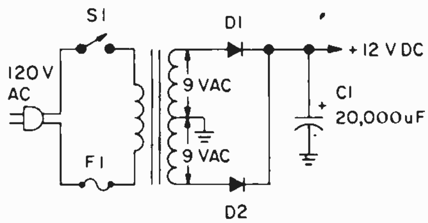
To keep the standby current drain of B/F Brain low, the supply voltage to IC2 is normally cut off by Q3. Since, in the quiescent state, the voltage at pin 3, IC1A, is +12 volts, Q3 has no forward bias and is cut off. When the latch circuit changes state Q3 receives forward bias through R12, turning on IC2.

Output Circuit. A two-transistor circuit is used to drive the speaker. When the alarm circuit is in its resting state, the voltage at pin 11 of IC 1D is +12 volts. Thus, Q1 has no forward bias and is cut off. Q2 base current is zero, and it too is cut off. The circuit of Q1 and Q2 therefore does not draw any current from the supply. Once the circuit of IC1C and IC1D is activated, the output voltage at pin 11 IC1D becomes a 12-volt (peak-to-peak) square wave. This causes Q1 and Q2 to switch on and off at the 1500 Hertz rate. Q2 drives the speaker with the 12-volt square wave, producing 9 watts of audio power. A square wave output is actually more desirable than a sine wave, since it is rich in harmonics. This produces a more natural-sounding siren.

If higher output power is desired, the speaker can be returned to a voltage higher than 12 volts. This will produce a peak-to-peak voltage across the speaker an amount equal to the higher voltage. Such a connection is shown







PARTS LIST FOR B/F BRAIN ALARM

R1, 3, 5, 7—470,000-ohm, ½-watt resistor
R2—10-Megohm ½-watt resistor
R4—1-Megohm, ½-watt resistor
R6, 9, 11—10,000-ohm, ½-watt resistor
R8—820,000-ohm, ½-watt resistor
R10—100-ohm, ½-watt resistor
R12—47,000-ohm, ½-watt resistor
C1—see text
C2—.01-uF capacitor
C3—2.2-uF, 15-VDC electrolytic capacitor
C4—.001-uF capacitor
C5—150-uF or larger, 20-VDC electrolytic capacitor
C6—.47-uF, 35-VDC capacitor
IC1—CD40001 COS/MOS Integrated circuit
IC2—555 timer integrated circuit
Q1, 3—Motorola 2N3906 PNP general purpose amplifier transistor
Q2—NPN power transistor, Motorola 2N3771, 40 or more volts, 10 or more A.
Misc.—Alarm bell; fire sensors; window foil; window foil connectors; contact switches; perf board or printed circuit board kit; solder, wire, hardware, etc.

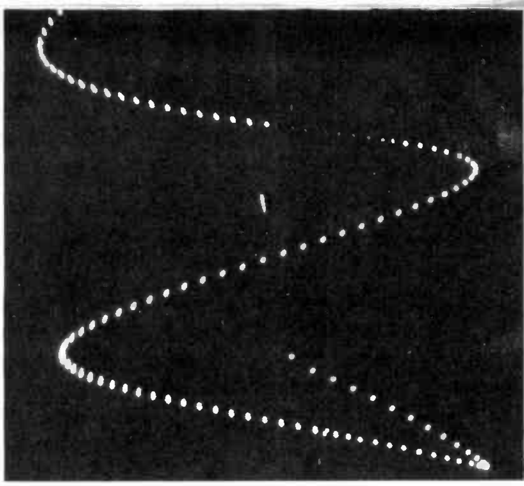
When used as an automobile burglar alarm the B/F Brain is wired to the dome-light switches inside the door frames. An outside alarm-disarm switch has to be installed —make sure it is hard to find and very securely installed. You could install fire sensors on the auto system as well but the accident that might be caused by the sudden blare of an alarm would be far more serious than any fire. Perhaps you can redesign the system with fire detectors and a light-on-the-dash warning system— you might try putting a relay on the ignition system that would switch the speaker system off and turn a warning light circuit on. With the B/F Brain at its heart, almost any combination of switches and sensors will work at home or on the road.

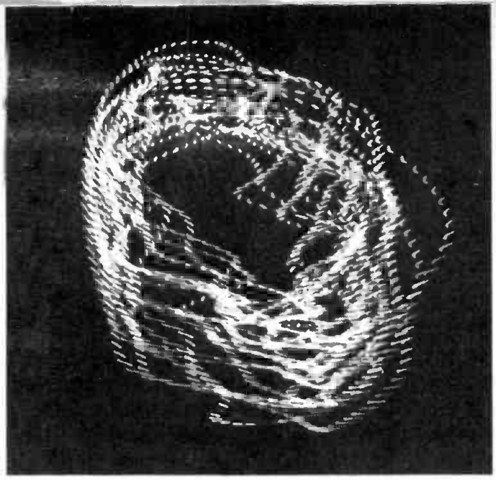
in the schematic. If you use this circuit be sure to feed the higher voltage only to the speaker, and not the alarm circuit. The maximum allowable supply voltage to the CD4001 chip is 15 volts.

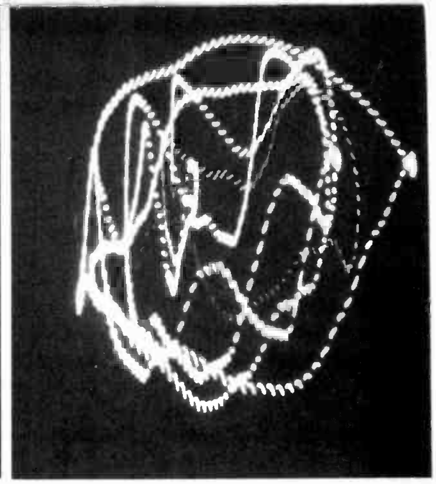
Power Supply. The full-load current of the alarm is about ¾ amperes, but this is only when the circuit has been tripped. Under normal operating conditions the standby current is less than 10 microamperes since only the COS/MOS integrated circuit, R2, and R1 are drawing current. The extremely low current drain makes it practical to use eight D cells connected in series to provide 12 volts. Such a power supply will last more than a year (providing the alarm does not go off). Battery operation provides several advantages including, freedom to locate the alarm anywhere, prevention of a burglar from defeating your alarm by shutting off electrical power, and prevention of false alarms due to line voltage interruptions or surges, and low cost.

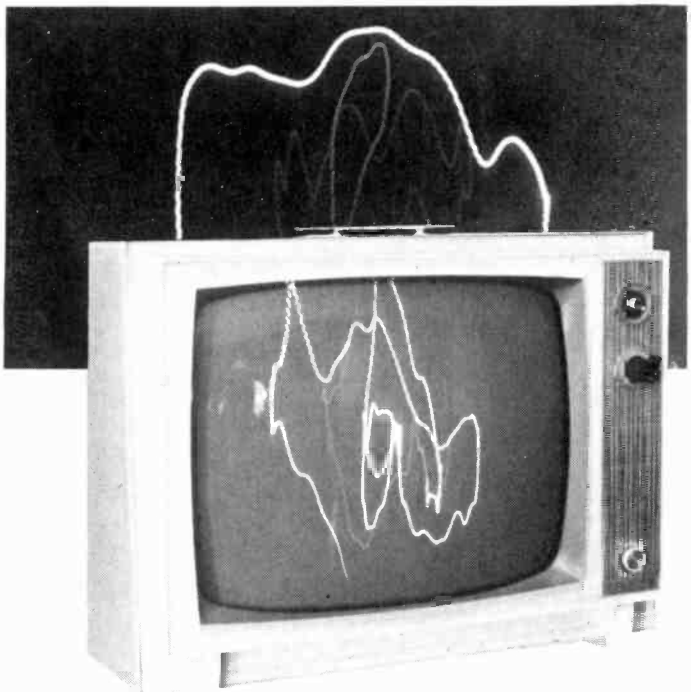
DC or AC Power. It is recommended that alkaline cells, Eveready type E95 or equivalent, be used. These cells can deliver more current than ordinary cells and they last much longer. They cost

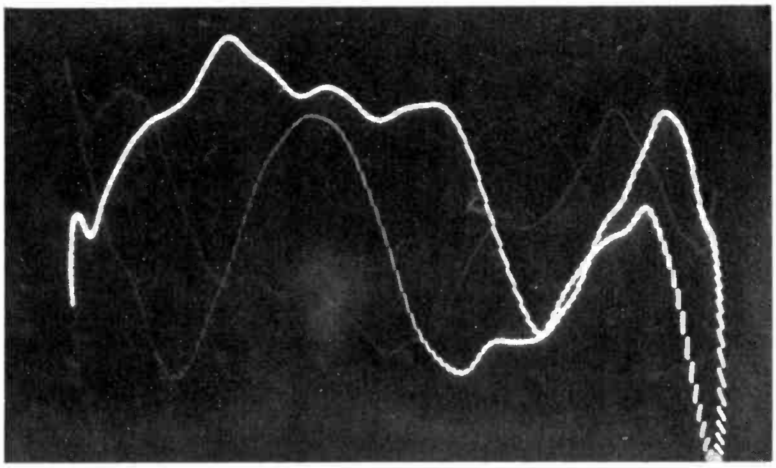
(Continued on page 117)











LISSY, THE TV LIGHT PEN

Lissajous patterns on your old TV add excitement to stereo.

by Dean Hock

☐ Are you an avid stereo enthusiast looking for a new way to experience your favorite music? Have you tried conventional "color organs" and found them fun for a few minutes, but dull as dishwater thereafter? Have you perhaps seen an oscilloscope hooked up with a microphone on its input and watched in fascination as the sound waves dance on the screen in perfect synchronism with your voice?

If you'd like something new to stretch your visual sense and expand the aural connection with your eyes, look no further. *Lissy*, the adapter which turns any beat-up old TV set into an oscilloscope for stereo sound, displays myriad sound patterns on the receiver screen. Its *Lissajous* patterns respond to both right and left-hand stereo signals—although it can also work with just one channel—providing an infinitely-variable light/sound display for your friend's pleasure and amazement.

What's a Lissajous? Let's go back to basics for just a minute, and review what a Lissajous figure is. Those of you who read our Basic Course in the March/April issue (*Using the Oscilloscope,* pages 83-88) will recall that Lissajous figures are 'scope displays of *two* signal inputs to the display screen —not just the usual vertical input signal which we use when we want to measure the amplitude of a voltage or watch how its amplitude changes with respect to time (the most common use of the oscilloscope).

With signals going to both the vertical *and* the horizontal inputs of an oscilloscope we can measure the relationship with respect to time (it's called *phase*) between the two signals.

For example, if a known signal is applied to the horizontal input and an unknown signal is applied to the vertical input, the resulting Lissajous pattern shows the phase relationship of the two signals.

Lissajous patterns can also be used to measure frequency. A known frequency is applied to the horizontal amplifier and an unknown frequency is applied to the vertical. By counting the number of tangency points at the top and at one side, a ratio of unknown-to-known frequency can be obtained. By multiplying the ratio times the known frequency, you can determine the frequency of the unknown.

A Simple Pattern. The drawing shows a Lissajous pattern for two sine waves. Numbers have been assigned to corresponding voltage points on the two signals. Extensions of these points are brought to the screen. The intersection of corresponding numbered lines is the position of the electron beam at that instant of time. In this case the two sine waves are in phase.

In the figure below, voltage/time relationships are different; corresponding voltage points are 45° apart. Therefore the waveforms are 45° out of phase.

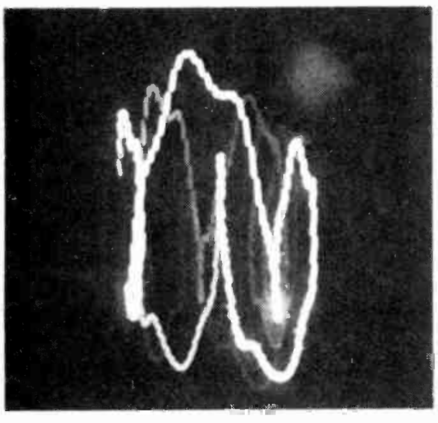
Lissy's Pictures. A continually shifting Lissajous pattern results when the phase relationship between the two input signals is constantly changing. The more complex the pattern (resulting from a frequency ratio having large numbers, such as 17/13) the harder it is to interpret. But since were not trying to *analyze* Lissy's pictures, we can just lean back and enjoy. *(Please turn page)*

LISSY TV LIGHT

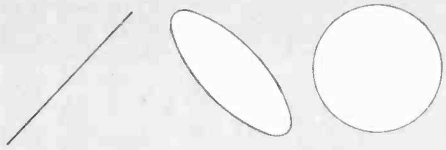
How Lissy Does It. By connecting the parts of an old TV set so that the output from one channel of a stereo set (for example, the left) drives the electron beam of TV tube vertically, and the output of the stereo set's right channel drives the beam horizontally, we can use the TV set to display Lissajous figures created by the signals from the two stereo channels. What we do is make the old TV set/stereo amplifier combination into an uncalibrated oscilloscope. Then we feed it the two signals without worrying what they mean.

Putting It Together. Begin with an old television set. You can use one in which the tuner, IF, and sound sections do not work since they will not be used. You'll also need an extra deflection yoke from another old set. Most of the older tube-type black and white sets have yokes the same size. As long as the extra yoke will fit over the neck of the set's picture tube it can be used. A junked TV is the best place to look. You must also have a stereo set with amplifiers capable of producing 12-15 watts of output power per channel. Even better is a spare (second) stereo set. This will insure better results and will also allow you to adjust the tone, volume and balance controls to the TV set without upsetting your listening pleasure, by changing the volume setting while you listen.

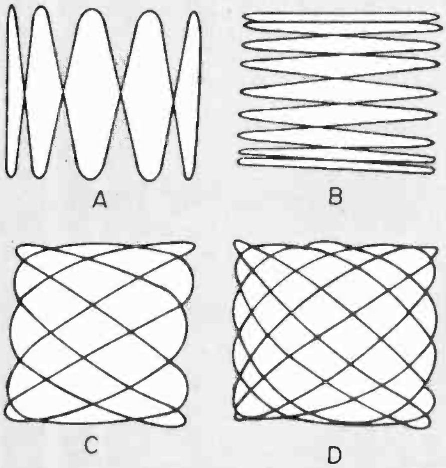
Begin by removing the back from the old TV set. Disconnect the socket from the rear of the picture tube. Loosen the clamps holding the deflection yoke and slide it off the neck of the tube. Do not disconnect any of the wires from the



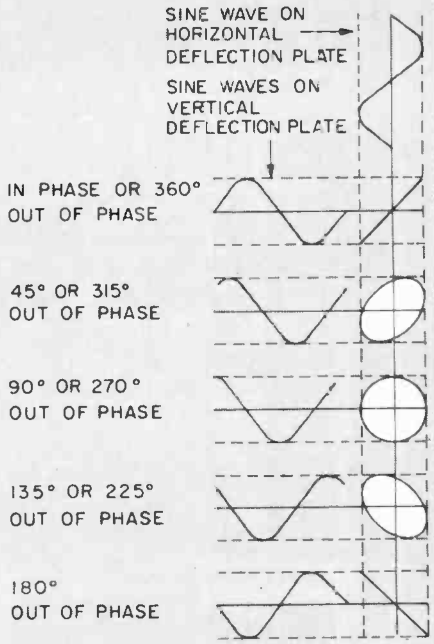
These patterns appear from moment to moment on the TV screen when it's being driven by signals from music. To see what they really look like you'd have to have motion pictures.



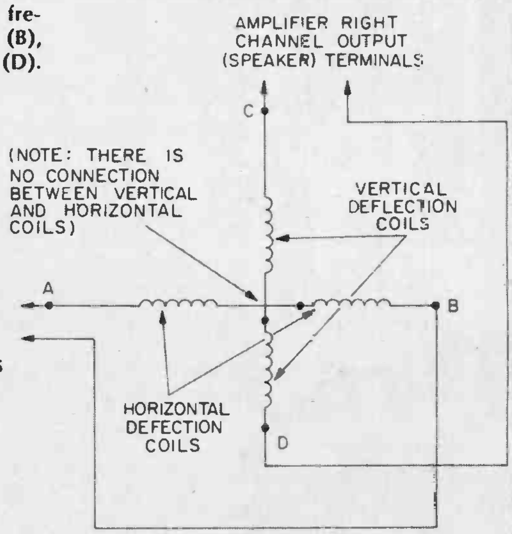
Simple Lissajous figures like these result from putting the same (or almost same) signal voltages on horizontal input and vertical input of oscilloscope (or TV picture tube).



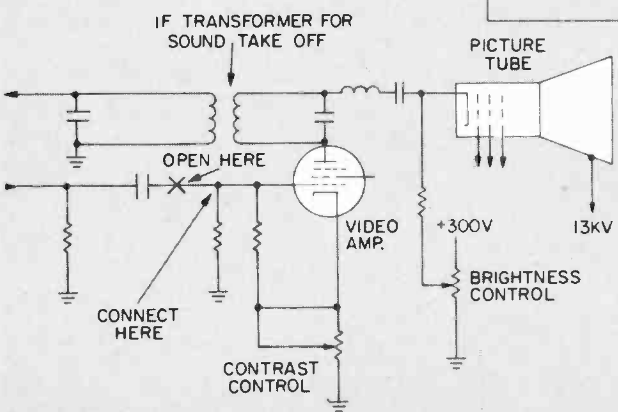
These more-complex Lissajous patterns are created by feeding a simple sine wave to the horizontal input of a scope and sine waves of exactly five times as high a frequency (A), one-ninth the frequency (B), 3/5 frequency (C), and 5/6 frequency (D).



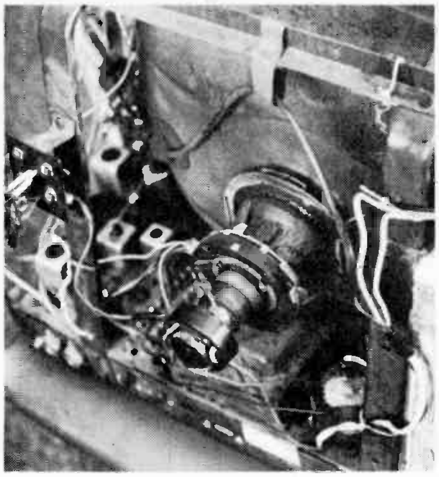
If your two stereo channels put out exactly the same signals (or you put a mono signal into both) you should get a straight (diagonal) line on the screen. If not, adjust gain of one channel. Other Lissajous patterns like these will result from out-of-phase signals. Music waveforms are extremely complex compared to the signals used to derive simple patterns shown here.



The added deflection yoke from second TV set is connected as shown above to the two stereo channels of an amplifier or receiver. Using a separate amp (from the one you listen to) is recommended, but not essential.

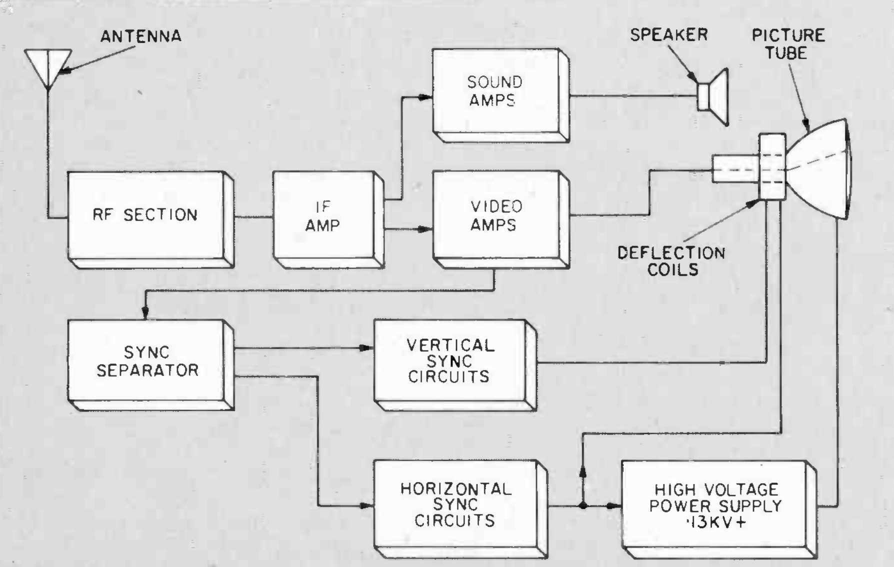


This schematic shows a typical video amplifier tube for TV sets six to 15 years old. Disconnect the video input signal on the grid side of the grid-coupling capacitor and connect your Lissy oscillator at the same point to make Lissy do extra tricks.

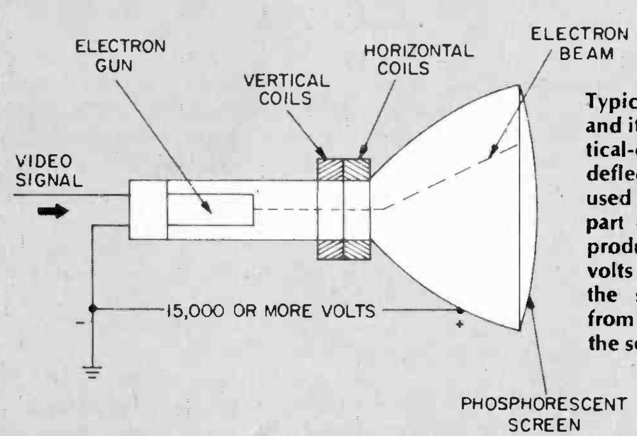


Here's how the back of author's set looks with the new picture tube yoke (deflection coils) on neck of picture tube. Original deflection yoke is removed from tube but kept hooked up because it's also used in the circuit which generates high voltage for picture tube. It's tied out of way at upper right, atop high voltage cage.

Closeup of picture tube neck shows large circular positioning magnet which some sets have behind yoke. Be sure to replace any magnets your set had into their original position after you replace the yoke.



Simplified block diagram of TV set shows how vertical and horizontal sweep currents are derived from the synchronizing signals sent from the transmitter. Vertical and horizontal sweeps feed vertical and horizontal deflection coils.



Typical TV picture tube and its horizontal and vertical-deflecting coils. Old deflection yoke is still used in Lissy because it's part of the circuit which produces thousands of volts required to attract the stream of electrons from the electron gun to the screen.

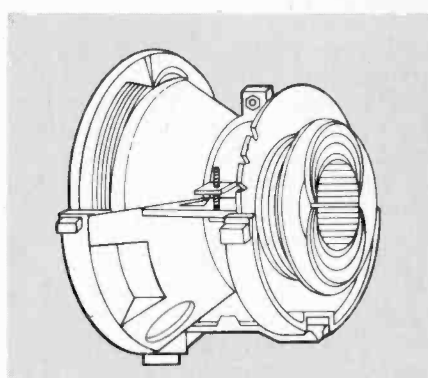
yoke since it is part of the circuit for putting the beam on the screen. Secure the old yoke to the chasis of the TV somewhere out of the way, taking care in seeing that it does not short circuit.

Preparing the Deflection Yoke. There are two coils in the deflection yoke of a TV set. One is called the horizontal and one the vertical.

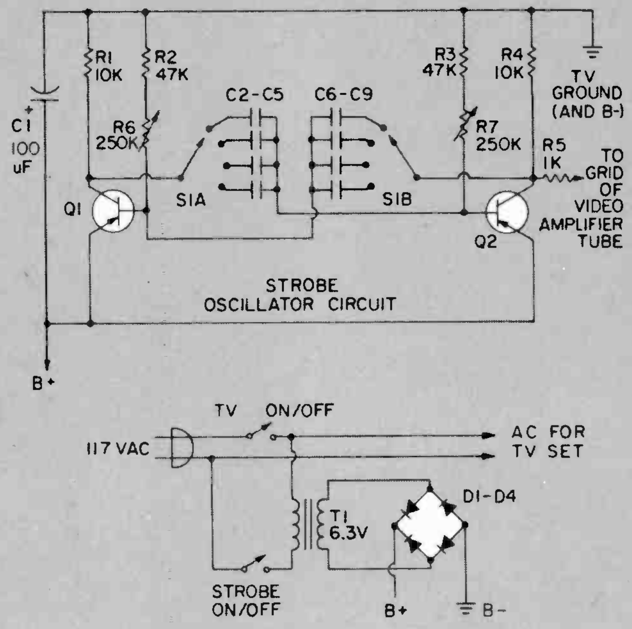
Each of these two coils is divided into two sections, and we must eliminate any extra parts such as a small resistor or capacitor which are often connected to one or both of the yokes. They are usually connected to the midpoint of the horizontal coil or vertical coil. Simply remove any resistor or capacitor connected to any parts of the yoke, and if this separates the two sectional parts of either the horizontal or vertical coil, put a jumper between the two sections. Check with a voltmeter to be sure which terminals are connected (through the two coils) together. Mark them in some way so that you'll know which two leads of each coil are connected together (through each coil). Solder 2 three-foot lengths of speaker wire to the terminals of the vertical and horizontal coils.

Putting It Together. Take the yoke and slide it on to the neck of the picture tube securing it with a clamp. Return the socket to the back of the tube along with any magnets that may have been removed. Put the magnets back exactly where they were. (Adjust to center beam, later.) Route the speaker wire out the back of the TV set as you put the cover back on. Run wires from the speaker outputs on your stereo to the TV set and connect the two sets of wires together using a terminal strip.

You are now ready to test out Lissy. Leave your stereo off and turn on the TV set. After warmup a small dot should be visible in the middle of the screen. Adjust the magnets, if any, to



Most old TV sets have deflection yokes which look like this. Large end (left here) goes snug up against the flare of the picture tube. May require loosening of screw which secures clamp around coils.



PART LIST FOR LISSY—THE TV LIGHT ORGAN

TV receiver—which has light (raster) on the picture tube. It need not have a working tuner or IF section, nor sound.
Picture tube deflection yoke—in working condition. (Most are—this is a part that rarely fails in TV sets.)
Speaker wire—8-10 ft.
Stereo amplifier or receiver—preferably 12-15 watts or more per channel.
Misc.—Solder, wire, switches, etc.

PARTS LIST FOR STROBE CIRCUIT FOR LISSY

C1—100-uF, 16-VDC electrolytic capacitor
C2, 6—.002 or .22-uF capacitor
C3, 7—.01-uF capacitor
C4, 8—.1-uF capacitor
C5, 9—1-uF capacitor
D1, 2, 3, 4—rectifier diodes, 30 PIV or better, any amperage
R1, 4—10,000-ohm, ¼-watt resistor
R2, 3—47,000-uF, ¼-watt resistor
R5—1000-ohm, ¼-watt resistor
R6, 7—250,000-ohm potentiometer (or 500,000 if 250,000 not available)
S1—Single-pole, 4-position (or more) rotary switch
Q1, 2—General-purpose PNP silicon transistors, HEP-242 or similar
T1—Power transformer, 117 VAC primary, 6.3 VAC secondary, any amperage

You can call Lissy's designs Lissajous patterns, but your friends will call them "out-of-sight"! The twisting, convoluted, ever-changing, swirling designs are truly a visually exciting wonder which can't fail to draw the viewer's eye into almost hypnotic attention. You can convert almost any old television from a boob tube to a groove tube with just a little effort, and at almost no cost at all. Just an evening's work, and your place will be jumping like never before.

center the beam. If necessary turn the brightness control up or down. Now turn on the stereo set and turn up the volume slowly until you start to notice the dot moving. By adjusting the balance control you should be able to make the dot move about an equal amount horizontally and vertically. It may be necessary to disconnect the speakers in order to move the beam enough. Adjust the brightness for a pleasing light level without burning the screen phosphor. Low bass notes will show up as rotating circles. Each tone has its own pattern which intensifies with the volume.

Now that you are finished sit back and enjoy the added dimension of the music TV in a dark room. It will provide you with many hours of listening and viewing pleasure.

More Fun With Lissy. Once your Lissy is working you may want to add an extra circuit which will strobe the moving pattern on and off, making a more unusual and interesting light display. By connecting the output of an oscillator to the grid of the TV set's video amplifier tube you can turn on and off the electron beam in the picture tube. This will produce dots and dashes as the beam is moved around on the screen. The effect is quite pleasing. A stop-action type of display (called "strobe") is only one interesting improvement you'll see.

The added circuit is a simple two-transistor oscillator. The switches and potentiometers allow you to select different dot line lengths and frequencies. By connecting the output of the oscillator to the grid of the video amplifier you force the tube alternately into conduction and cutoff.

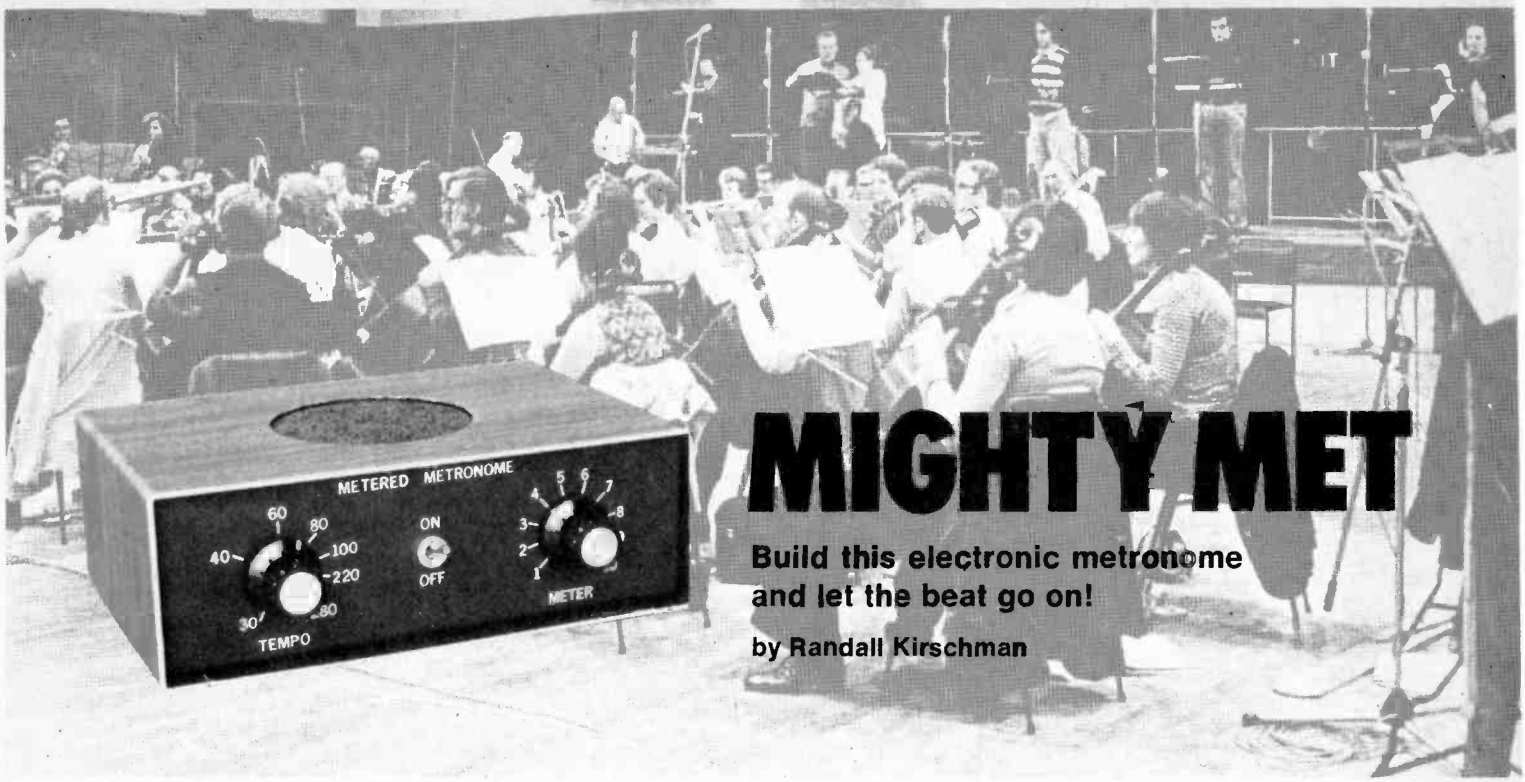
The oscillator and power supply are not critical and can be constructed any way that is convenient, as long as safe construction practices are used. The circuit in the prototype was built on a terminal strip using point-to-point wiring and then mounted inside the TV. Almost any general purpose PNP transistors can be used for Q1 and Q2.

If you can't get a schematic of the TV set you are using the best way to locate the video amplifier tube is to look at the tube placement chart (usually on the side or back of the TV) and find the tube which is labeled *Video Amp.* If the video amp tube also contains other elements in the glass envelope you will have to trace down that part of the tube which has its plate connected to the sound trap transformer (usually a metal can type) and its cathode connected to the contrast control. This may vary slightly in your set.

Once you have found the video amplifier cut one of the leads of the capacitor going to the grid and replace it by connecting the oscillator output to the tube in its place, (see the schematic). Connect the negative lead on the oscillator's power supply to the TV common ground.

Fire Her Up. Now you are ready to test the circuit. Look it over for any wiring errors. Set the potentiometers to maximum resistance and set the rotary switches at the .01 uF capacitors. Turn on the TV set and allow it to warm up. Get a music display on the screen. Turn down the brightness control until you can no longer see the raster (white lines). Turn on the strobe oscillator and adjust the brightness control as needed. The display should be chopped up into little line segments. By adjusting the controls you can get different line lengths and frequencies—anything from star-like dots to a pulsating array of stopped action traces.

Now you can lean back and enjoy your Lissy—the TV light organ which will amuse and amaze your friends for many evenings ahead. ■



MIGHTY MET

Build this electronic metronome and let the beat go on!

by Randall Kirschman

FROM THE TICK-TOCKING of a timepiece to the clickety-clickety-clacking of a musical tempo, here's a metronome for all reasons. It's a *Mighty Met*, and features an easy-to-build design that will help you tick away many happy hours.

Mighty Met not only provides steady beats like an ordinary metronome, but also keeps track of the downbeat in each measure. An ordinary metronome produces beats that are all the same, but Mighty Met allows one beat in a group, for example every fourth beat, to be made either louder or softer than the others. In order to match the meter of the music, a ten-position switch allows the user to emphasize (or de-emphasize) every beat, every second beat, very third beat, and so forth, up to every tenth beat. The "odd" beat can then be used to indicate the first beat or downbeat in each measure of music.

The unit can also serve as an audible darkroom timer. For this application, the tempo can be set to 60 (one beat per second) with every tenth or every fifth beat emphasized to help keep track of the count. Its advantages over other timers are that it can be used in complete darkness, and does not need to be watched or set.

Pulsing Right Along. The circuit is built around a 555 timer and three CMOS IC's. CMOS type IC's (also called COS/MOS) were used in the design because of their low power requirements and ability to operate from a wide range of supply voltages. These characteristics allow the circuit to be powered by a 9-volt transistor-radio battery. Battery drain is about 5 to 10 milliamps, comparable to that in a pocket transistor radio.

The 555 timer, IC1, and associated components R1, R2, R3, and C1 form an astable (free-running) multivibrator which generates a continuous series of pulses. The pulses appear at pin 3 of IC1, and are used to produce the basic metronome beats. Potentiometer R2 varies the pulse rate to adjust the tempo. The pulses also drive a divider comprising IC2 and IC3. A division factor of from 1 to 10 is selected by rotary switch S2. For example, if S2 is set to 4, then for every four input pulses from IC1, the divider will produce one output pulse. The output pulses from the divider, at pin 4 of IC3, are used to produce the downbeat. How the divider works is explained later.

The output pulses from the divider go to two places. First they go to IC4C where they are inverted. From the output of IC4C, pin 10, comes a series of negative-going pulses used for the downbeat. Second, they are combined logically with the basic beat pulses in IC4A. The result, at the output of IC4A, is a series of beat pulses with the downbeat missing. These pulses are inverted by IC4B so that they are negative-going also. Again, taking as an example S2 set to 4, the fourth beat would appear at the bottom of pot R7 (pin 10 of IC4C), while the other three beats would appear at the top of R7 (pin 11 of IC4B).

If the wiper of pot R7 were set to the midpoint, both sets of pulses would be fed equally to the output circuitry and Mighty Met's output would be a succession of equally loud clicks, like those from an ordinary metronome. Rotating the wiper of R7 toward the bottom end would accentuate the fourth pulse and decrease the other three pulses. Thus every fourth click would be louder. The greater the rotation, the greater the contrast. Conversely, rotating the pot in the opposite direction, toward the top, would decrease the fourth pulse and accentuate the three other pulses. Thus every fourth click would be softer. For metronome purposes, the fourth click serves as the first beat or downbeat of the measure of music.

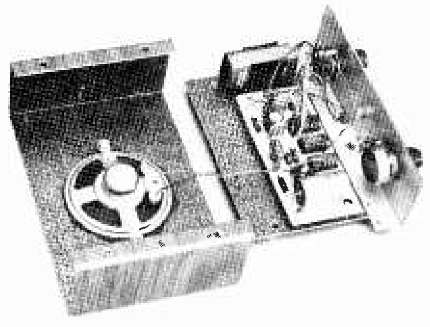
From the wiper of R7, the pulses are fed through R8 and are amplified by transistors Q1 and Q2, which are connected in what is known as a Darlington configuration. Between pulses, pins 10 and 11 of IC4 rest at the positive supply voltage. Thus no current flows, in the base of Q1, and it is cut off. Likewise, Q2 is also cut off. During a pulse, when either pin 10 or 11 of IC4 goes low, base current flows in Q1, turning it on. The resulting current through Q1 turns Q2 on, causing a momentary surge of current through the speaker, which is heard as a click. To provide sufficient current to pulse the speaker (about half an amp), a large electrolytic capacitor, C5, is connected to the output circuit. Capacitor C6 takes the sharp edges off the pulses to mellow the click a bit, and also eliminates any stray spikes from the fast switching of the IC's.

R4, R6, C2, C3, and C4 in the +9-volt supply line provide decoupling to isolate the various sections of the circuit and avoid unwanted interactions which could cause faulty switching. Having a 0.2 uF capacitor, C3, in parallel with the 100 uF capacitor, C4, may be puzzling. The reason is that although electrolytics do a good job of bypassing low frequencies, they generally have too

MIGHTY MET

high an impedance at high frequencies to be effective for bypassing high frequencies or very fast pulses. To take care of these another capacitor must be added, in this case a disc ceramic, C3. This scheme is used fairly frequently. The power switch, S1, is connected in such a way that switching the metronome off shorts the +9-volt line to ground and quickly drains C4 and C5 and stop the clicks immediately.

Divide and Conquer. The heart of the divider is IC2, a CD4017 decade counter/divider. This IC contains five flip-flops interconnected to form a counter which has ten possible states. The states are usually identified by the ten decimal digits 0, 1, 2, 3, . . . , 9. For each input pulse fed into the CD4017 at pin 14, it changes from whatever state it was in to the next state. When it reaches state 9, the next pulse causes it to change to state 0. So that the counter can be started from a known state there, is also a provision to reset it: a logical high (+V) applied to pin 15 sets the counter to the 0 state, regardless of the state it



Here the speaker has been mounted to the top-side of the cabinet, though you may wish another arrangement entirely. If you choose, a slightly larger speaker can be used to increase Mighty Met's volume.

was in previously.

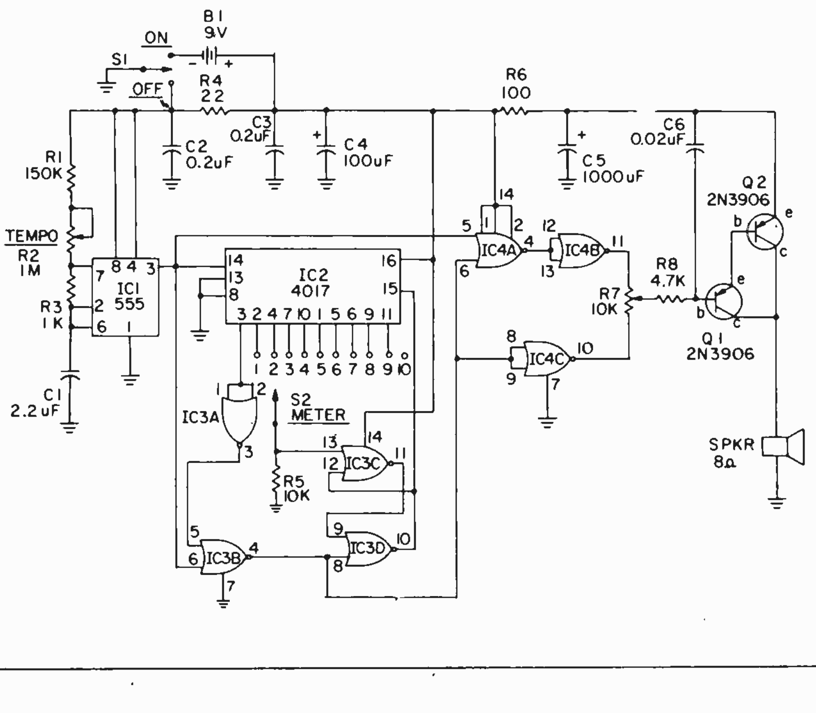
In the CD4017 the ten states are also decoded, which means that for each state there is a corresponding output pin which goes high when the counter is in that state. For state 0 (reset) pin 3 is high while all the other output pins are low; for state 1, pin 2 is high while all other output pins are low, and so on. Having this decoding function built in simplifies Mighty Met's construction.

To understand how division is accomplished, suppose we choose a division factor of four. In this case the output pin for state 4 (pin 10) will be used to reset the counter. Assume the counter starts in state 0 (reset). As pulses are fed in, the first pulse advances it to state 1, the second pulse to state 2, the third to state 3, and the fourth to state 4. The output pin for state 4 is now high which causes the counter to reset, and the cycle will repeat indefinitely. For every four input pulses there will be one reset pulse, in other words the input pulse rate is divided by four, as required. To divide by any other factor from 1 to 9, the appropriate output pin is used to reset the counter (to divide by ten, this scheme is not necessary since the counter resets by itself every ten pulses). Besides IC2, the divider also includes S2 to select the division factor, and IC3 to carry out the resetting of IC2.

Theme and Variations. Mighty Met can be designed according to the desires of the builder. For the parts specified, the *tempo* range is about 30 to 280 beats per minute. The tempo is equal to the pulse rate of the multivibrator, which is determined by the time constant of R1 + R2 and C1 (the effect of

PARTS LIST FOR MIGHTY MET

B1—9 VDC transistor radio battery
C1—2.2-uF electrolytic capacitor
C2, C3—0.2-uF capacitor (author used disc ceramic)
C4—100-uF electrolytic capacitor
C5—1000-uF electrolytic capacitor
C6—.02-uF capacitor (author used disc ceramic). All capacitors are 10 VDC or greater.
IC1—555 timer IC
IC2—CD4017 CMOS decade counter/divider IC
IC3, 4—CD4001 CMOS quad two-input NOR gate IC
Q1, 2—PNP general purpose transistor, 2N3906 or equal
R1—150,000-ohm resistor
R2—1-megohm linear taper potentiometer
R3—1000-ohm resistor
R4—22-ohm resistor
R5—10,000-ohm resistor
R6—100-ohm resistor
R7—10,000-ohm trimpot (CTS X201-R103, Radio Shack 271-218 or equiv.) All resistors except R2 and RT are ¼ or ½ watt, 10%
R8—4,700-ohm resistor
S1—SPDT miniature toggle switch
S2—1-pole, 10 position, non-shorting rotary switch (Calectro E2-161 with one position unused, or equiv.)
Spkr—8-ohm speaker, size to suit
Misc.—cabinet, battery holder and connector knobs, perforated board, IC sockets—2 14-pin, 1 16-pin, speaker grille, wire, solder, etc.



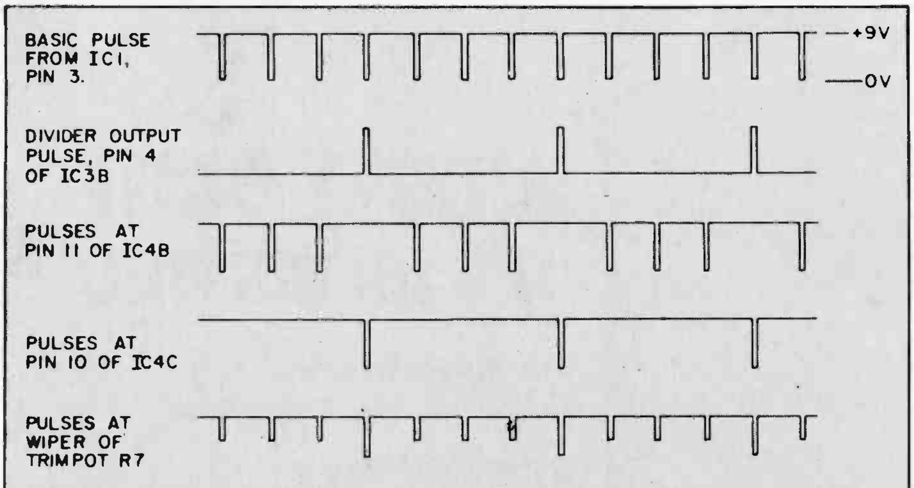
The ICs used in this circuit can be obtained from a number of sources. If they are not available at your local parts store then try one of the following suppliers:

Digi-Key Corporation
P.O. Box 677
Thief River Falls, MN 56701

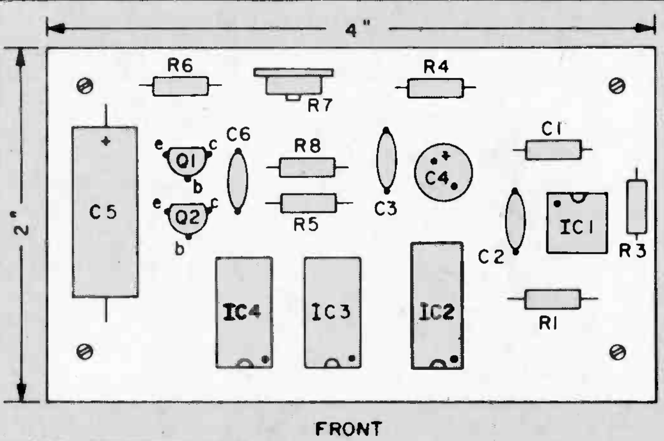
Quest Electronics
P.O. Box 4430A
Santa Clara, CA 95054

Circuit Specialists Co.
P.O. Box 3047
Scottsdale, AZ 85257

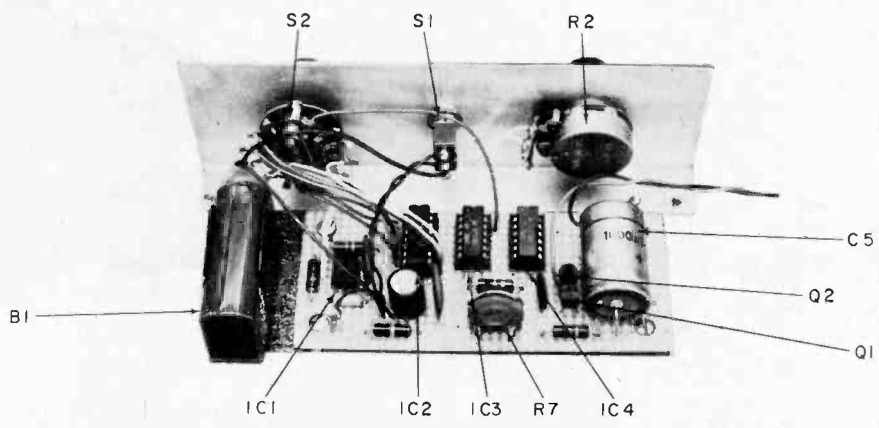
Burstein Applebee
3199 Mercer Street
Kansas City, MO 64111



Mighty Met utilizes digital logic circuitry which, at first glance can seem a bit of a mystery. Diagrams such as this, along with a careful reading of the text, can serve as a good initiation. You'll soon understand just how it is that Mighty Met makes such a tuneful beat. This pictorial shows the "meter" control set at 4. The bottom waveform is the result when wiper of R7 is set toward the end connected to pin 10 of IC4C, emphasizing downbeat. Follow it through a few times in the text and refer back to this diagram as you read. Pretty fast, you'll unravel the Mystery of Mighty Met!



Mighty Met uses a perfboard construction, so it is important to follow this layout as given. Use sockets for the IC's and treat them as the text says to, they are very sensitive to any static charges. Wiring can be point-to-point beneath the board, or you can use flea clips. No matter how you build it, Mighty Met is one swell way to let the old beat go on!



As you can see, following the author's perfboard layout results in a very neat and professional appearance, a fine-looking Mighty Met. If you complete the construction with a nicely finished cabinet and press-on lettering you'll have a finished product that would be more than welcome (by the wife) in any room of the house.

R3 is negligible). A different range may be had by changing the values of R1, R2, or C1. R1 determines the upper tempo limit, while R2 determines the lower limit. Changing C1 will affect the overall tempo range. The sound quality of the clicks can be changed by increasing or decerasing the value of R3, which changes the width of the pulse from IC1. Do not make R3 less than 200 ohms, however.

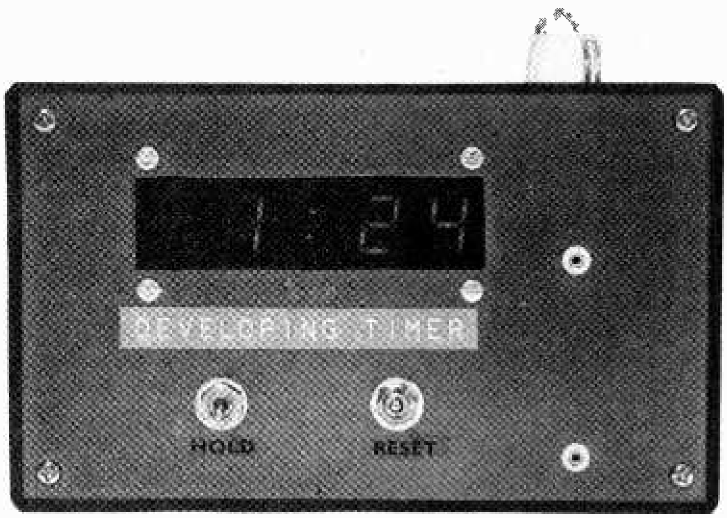
To make Mighty Met louder, substitute a larger speaker for the one suggested. Since fidelity is not a concern in this application, an inexpensive speaker can be used. On the other hand, if the clicks are too loud, increase the value of R8.

If the unit is to be used as a darkroom timer, the *tempo* control, R2, can be a trimpot. Also the divider can be simplified. For example, if every fifth click is to be emphasized, then pin 13 of IC3 can be connected directly to pin 1 of IC2 and S2 and R5 can be eliminated. Similarly if every tenth click is to be emphasized, pin 13 of IC3 can be connected to ground, and S2 and R5 eliminated. Another possibility is to replace S2 with an SPST switch to select either every fifth or every tenth click, leaving R5 in.

On Composition. First, a word about precautions which should be observed when working with CMOS IC's, like those used in this project. CMOS IC's can be damaged by static electricity or other excessive voltage. Although this is true to some degree for all types of IC's, the CMOS type are particularly susceptible. They should be left in their protective packaging until they are needed and should not be handled unnecessarily. The use of sockets is highly recommended for the three CMOS IC's in Mighty Met. They should not be inserted until all wiring is completed, and should be inserted or removed only with power off. When inserting or removing a CMOS IC, first "ground" your body to the circuit by touching your free hand to the wiring or by a similar method. This helps to avoid a difference in potential or static charge between the IC and the socket.

Construction of the Metered Metronome is straight-forward. Most of the parts values are not critical. Use a linear-taper pot for R2, as specified, rather than an audio taper. An audio taper would result in excessive crowding of the scale at the upper end of the *tempo* range. In the prototype, most of the circuit was assembled on a piece of perforated board, about 2 x 4 inches. If you use this method, be sure to get a board with holes spaced 0.1 in. apart

(Continued on page 120)



MIDGET DIGIT -IT'S THE BIG TIME

This little device can save expensive headaches.

by Herb Friedman

☐ At first thought a digital time clock that only indicates to nine-minutes fifty-nine-seconds might not appear to have any particular value; yet commercial models sell for up to $150, so there must be something in 9:59 that's commonly overlooked.

Actually, the 9:59 digital clocks are really timers with push-button reset to zero while running, and a hold control that permits several short time intervals to be accumulated.

Radio stations, recording studios, and tape fans use them to time records and program segments when preparing tapes. More importantly, photo hobbyists use the 9:59 time clock when developing color film and prints.

Here's a typical use: Assume you're using the Besseler color system to make color prints. The first developer needs two minutes, the second developer needs one-and-a-half minutes. You set the timer running, pour the developer into the tank and then roll the tank to start the developing. At the instant your hand rolls the tank your other hand hits the reset switch on the timer. The timer resets to zero and starts counting. At two minutes you dump the first developer and the time clock keeps running. You pour in the second developer and roll the tank. At the instant the tank is rolled you hit the reset switch, the timer returns to zero, and you follow the timing to one minute and thirty seconds.

Until the moment you need to reset to zero you can simply ignore the timer and concentrate on developing. If you want to totalize developing time you simply press the hold switch after each procedure. At the end you'll have a total elapsed time to 9:59.

The reason commercial 9:59 timers run upwards of $100 to $150 is because they are jam-packed with integrated circuits. Most models were designed when IC technology was still in its infancy. By using a modern clock module that utilizes large-scale integration you can now build a slightly better timer than the commercial model for about $20 to $25, and all the parts are available at most parts stores.

In fact, our Midget Digit can also be used as a Black and White enlarger exposure timer because the red glow of the 0.5-inch LED digits won't fog B&W paper.

Building Midget Digit. The timer consists of a twelve hour LED display, digital electronic clock module, a DPDT spring-return switch (or a push-button switch), a SPST toggle switch for hold, a power transformer for the clock module, and any cabinet you care to use. Though the clock module is the standard twelve hour type, by connection of the switches to existing terminals you can time minutes and seconds without making any modifications to the module.

The first step is to prepare a cabinet for Midget Digit. Use anything you prefer: a plastic cabinet, a Minibox, a utility case, etc. Don't worry about a protective red filter for the clock's LEDs; it's already part of the clock module.

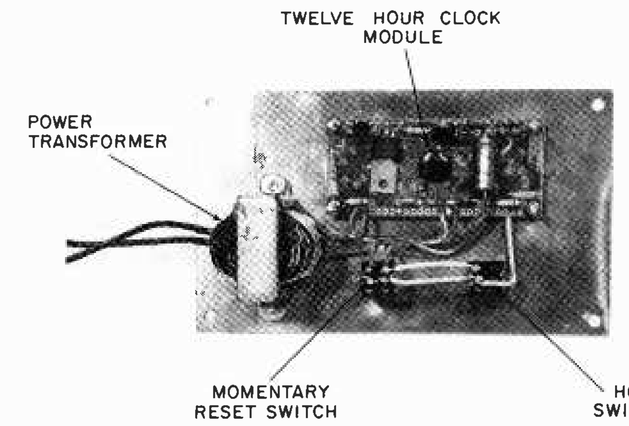
Before installing the module in the cabinet install a set of fine wire jumpers from terminals 24 to 14, and 14 to 7. We say fine wire because you can't squeeze two ends of standard #22 hookup wire into the #14 terminal.

All terminals, from 1 through 24, run along the bottom edge of the module and the instructions supplied very clearly indicate which terminal is what number. Just double check your count before soldering. The terminals are plated-through so you can solder to either side of the module's printed circuit board.

To avoid shorting the module's wiring to a metal panel use an ⅛-inch spacer or stack of washers between the panel and the module at each mounting screw.

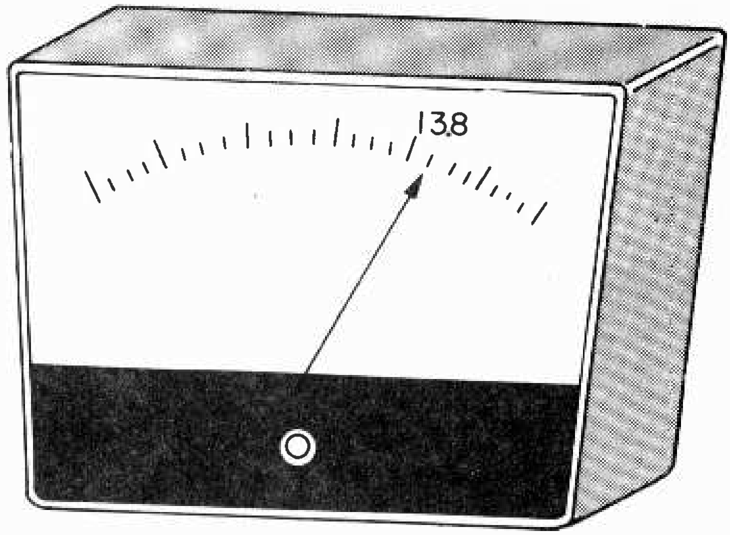
The color-coded wires for the matching power transformer had absolutely no relationship to the instructions on the transformer itself. We don't know if this is true for all transformers in all stores, or just the ones in our local store. So follow this procedure: The black wires are 120 VAC; the two red

(Continued on page 122)



The Midget Digit is built around a standard twelve hour clock module. The module consists of a small printed circuit board with an oversize red filter that conceals several relatively large 0.5-inch LEDs. Though the LEDs are rather bright when on, they will not normally fog B&W enlarging paper.

CB Power Mate for Maxi-Output



Here's the partner to power your mobile CB rig at home to its maximum capability—four watts RF output.

By Herb Friedman, W2ZLF

SO YOU'VE JUST upgraded your Citizen's Band setup with a shiny new transceiver specified to give you four watts out—the legal maximum—or perhaps, if you've converted to the more efficient SSB (single sideband) operation, as many progressive CBers are doing these days, 12 watts, P.E.P. You've paid a couple of hundred dollars for this new equipment and are going to use it at home as your base station—even though it could be operated mobile, in your car, from its 12-volt system.

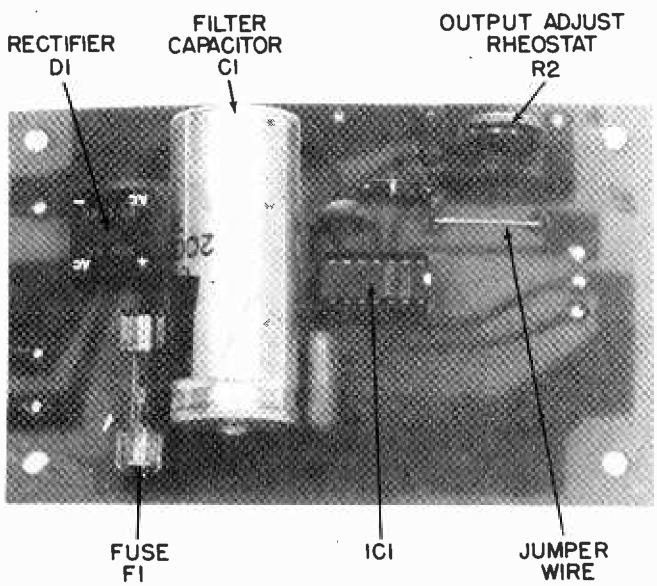
You hook it up to the 12-volt DC power supply you used at home with your old, lower-powered rig and it seems to work fairly well. You contact a few nearby CBers easily enough. But it doesn't seem to be getting out much farther than your earlier transceiver, which has considerably lower power output. What's wrong? Where did the power go?

You're probably not feeding the new set the 13.8 volts it was designed to get from the electrical system of your car when the generator is running, charging the battery, as well as powering the rest of the electrical system in addition to accessories like a mobile transceiver.

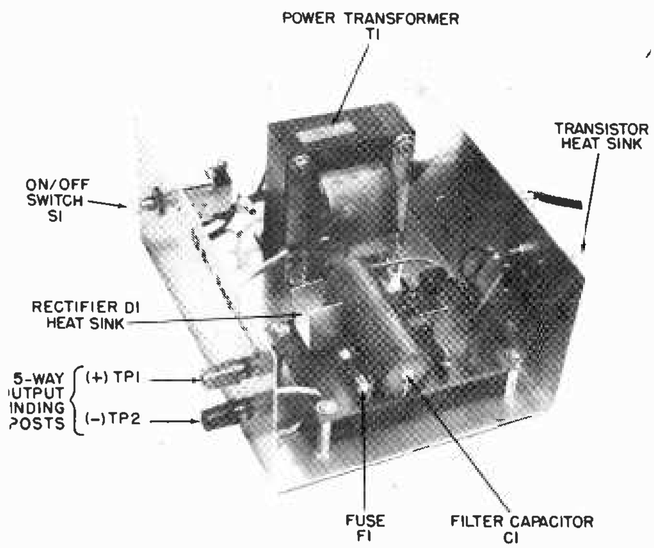
The 117-volt AC to 12-volt DC power supply you used with the earlier transceiver may have supplied it with current at 12 volts, but it can't provide the 13.8 volts, at higher current, which your new set needs to put its rated power on the air.

To be sure, check the actual power supply voltage you're feeding to the CB set.

What Voltage? To check the actual output of your old power supply, get out your voltmeter and measure the voltage being fed to your transceiver. It probably reads around 12 volts (maybe a bit more when the transceiver isn't turned on). You turn the CB set on to *Receive* and get a good solid 12 volts (or maybe as high as 13). So far so good. Now switch the set to *Transmit.*



13.8-volt regulator parts mounted on circuit board. Low-powered (1.5 amp) model does not require heat sink for rectifier.



Complete CB Power Mate, top removed. Higher-current (3-amp model), with U-shape heat sink (homemade) for rectifier. Large heat sink on rear is for transistor.

Power Mate

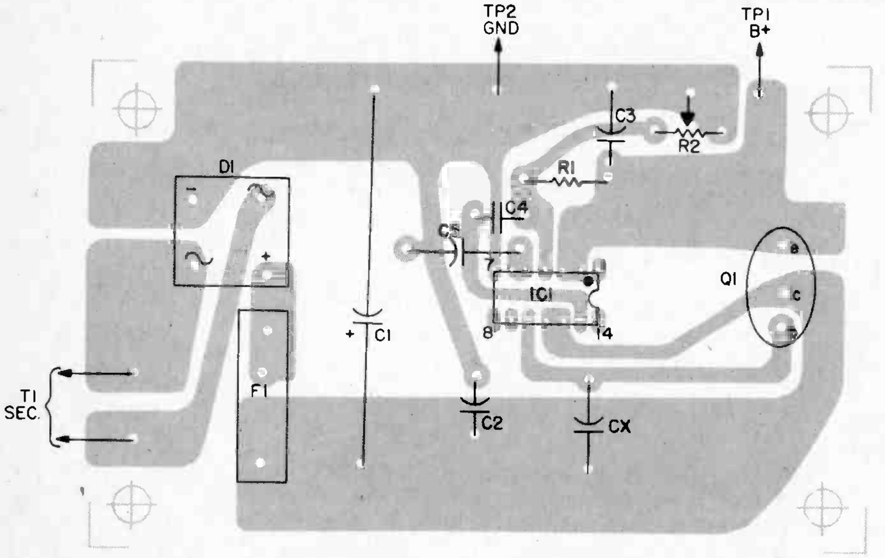
The input power voltage drops to around 10 volts! Turn it off.

That power supply might have been OK with a lower-powered unit, but it just doesn't make it with this higher-powered job. The four watts of transmitting output you paid for when you bought this new rig is only 2.5 to 3 watts now. This is because your power supply hasn't got the output *voltage regulation* it needs—the ability to put out constant voltage, within its specified limits, regardless of variations in the required current. In addition, your mobile transceiver was designed to work from a DC power supply of 13.8 volts; when the car is running that's what it gets, to charge the battery. (Ever notice how the lights are dimmer when you run them without the motor turning over? That's the difference between 13.8 and 12 volts (or even less, if your battery is on low charge or about to conk out with a weak cell).

It's Only 1.8 Volts. "So what's 1.8 volts?" some people may ask. "Most electronic components are manufactured to a tolerance of 10%, and we see that most schematics have their voltages specified "± 20%."

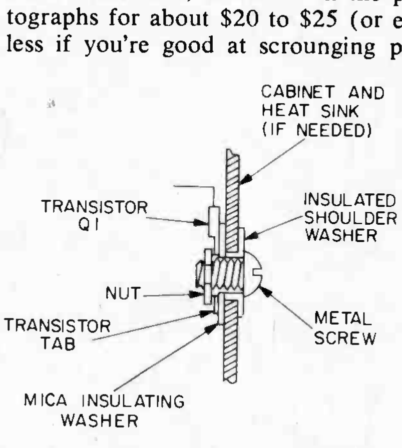
Won't most equipment and circuits operate over a wide range of voltages from their power supplies? Yes, they will often operate, in many cases quite well, but not power output circuits. They just won't deliver the specified output. Equipment which draws substantial current can only produce its rated output when it gets power at the voltage specified by the design engineers. The difference between 12.0 and 13.8 volts amounts to 15% less transmitter power. If the supply puts out only 10 or 11 volts when it's under a heavier-than-usual load the loss can be as high as 25 percent. It could be a lot less. If that power supply's output regulation is so poor that it puts out only eight or nine volts with your new CB transceiver the transmitter might not work at all.

To insure maximum performance from your mobile transceiver when powering it with AC house current, you must use a 13.8 volt *regulated* power supply. Regulation provides exactly 13.8 volts under a wide variety of loads —from full load to no load—and also compensates for AC line voltage fluctuations if they occur.

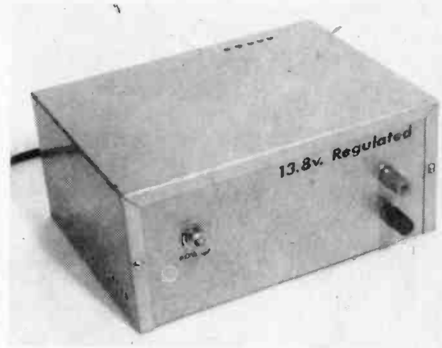


You can make it easily from kit purchased at electronic parts stores. Positions of parts shown actually are located on back side of board. See full size template in story. Copper foil side of board is shown down.

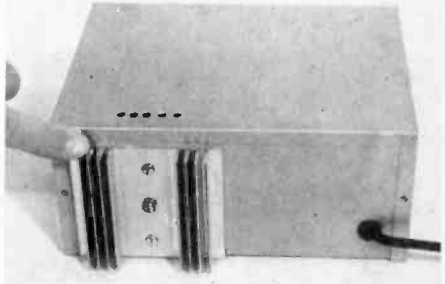
Although a regulated supply can cost from $50 to $100, you can build the *CB Power Mate*, as shown in the photographs for about $20 to $25 (or even less if you're good at scrounging parts



How to mount transistor to dissipate heat into metal cabinet (and external heat sink, in 3-amp model). Use silicone grease on both sides of insulating mica washer. Tape over screw head (outside case) to protect against external short.



Front view of CB Power Mate shows On/Off switch, red (+) and black (—) power output binding posts. Rear view of higher-powered version has finned heat sink to dissipate heat from regulating transistor. Quarter-inch holes on top of unit are for ventilation.



or have a junkbox of used components). The same supply can be used as an AC-to-DC power source for high power walkie-talkies (one-watt or more output) which require exactly 12 volts, because this supply can be adjusted at the flick of a finger to any mobile power voltage—even six volts. Your regulated supply can be built to handle any current needed, up to three amperes. The current capacity is determined by the output of the power transformer, T1, and filter capacitor C1, the two most costly items in this project. Thus you can save money by building only the current capacity you actually need.

How It Works. The first section of the CB Power Mate (the 117-volt step-down transformer T1, the rectifier, and the large capacitor, C1) supplies *unregulated* current at between 15 and 35 volts, depending on the number of turns in the secondary of T1. The rest of the supply is the regulator section. The size of the voltage drop across the regulator depends on the resistance of transistor Q1, which varies according to its base bias. The bias is controlled by the action of the IC, which gets its commands from the voltage applied to pin 4. This voltage is taken from the junction of R1 (1800 ohms) and R2 (500-ohm rheostat), which are a voltage divider across the power supply output. Initially R2 is set to provide the desired voltage—13.8 or whatever—at the emitter of Q1 (the supply output).

When the load (the transmitter) starts to draw more current, the voltage at the power supply output begins to drop. This lowers the voltage at IC pin 4. The IC then applies a higher (more positive) voltage to the base of Q1 (IC pin 10). Since the transistor is an NPN, the positive-going base signal lowers Q1's collector-emitter resistance, increasing the collector current and raising the voltage at the emitter (power supply output). When a change in load draws less current, tending to raise the supply voltage, this increase is sensed by the voltage divider, which now applies a lower (more negative; less positive) voltage to IC pin 4. This increases Q1's collector resistance, lowering the voltage at the supply output.

This all takes place almost instantly, so the output voltage remains steady, at the value at which it was originally set. This happens even though the transmitter current (the load) is changing all the time.

Two Versions Can Be Built. The schematic diagram shows the supply for loads up to three amperes at 13.8 volts. For lighter loads, up to 1.5 amperes (still 13.8 volts) capacitor Cx is not needed, and the power transformer can be a lighter, less expensive one. In addition, capacitor C1 can be rated at 25 VDC, instead of the 35 or more required for the higher-powered version. Also, the smaller power supply doesn't need heat sinks for the bridge rectifier and the series transistor (also called a "pass transistor") because all the current used by the transceiver passes through it.

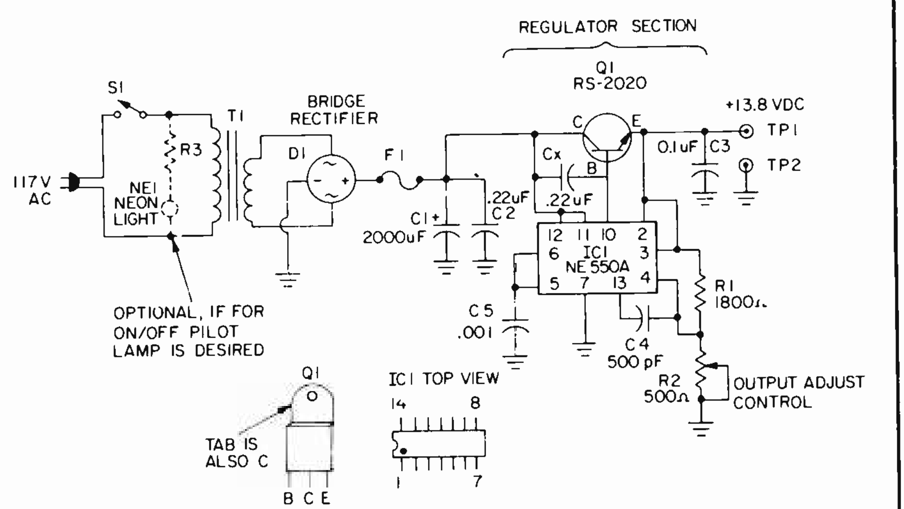
Check the Voltage. First you should find out what the power requirement of your transceiver is when you are transmitting. It will usually be one amp or more (*receiving* will take much less current). It may be as high as 2.5 amps. Once you know how much current your transceiver needs, you'll know whether to build the model which supplies up to 1.5 amps or the three-amp one. Now take the parts list and check your junk box for parts you can use.

Construction. The heart of the CB Power Mate is the regulator, which consists of integrated circuit IC1, series regulating transistor Q1 (which is controlled by IC1), and their associated resistors and capacitors. C1 is the main filter capacitor, which initially smooths the varying DC supplied by the bridge rectifier from the AC output of the power transformer secondary.

The printed circuit board, which you can easily make with a kit from any parts distributor, has been designed to work in either the 3-amp model or the 1.5-amp unit. The photograph, showing the board with its components mounted, is of the lower-powered one. The completed supply pictured is the higher-powered unit. You can see that the assembled boards for both versions are almost identical. One difference is that the 3-amp supply (completed unit) has a piece of U-shaped aluminum you can bend to make the heat sink for the bridge rectifier. This is not needed for the lower-current supply. The photograph of the completed unit also shows the fins of the large heat sink for the transistor mounted on the back of the box behind the transistor. This heat sink isn't needed in the 1.5-amp power supply.

Fuse F1 is a fast-acting type which protects the bridge rectifier and the power transformer from blowing out if you should make a wiring error or short-circuit the output. The fuse listed will blow out before the components, so don't use any other kind of fuse, even if it has the correct current rating (three or five amps). Use only type AGX, not slow-blo or 3 AG. Try to get a fuse-holding clip made for soldering to the printed circuit board. That kind is easier to install than those which mount with screws.

Solder the pins of the 14-pin IC socket to the board, but don't insert the IC into its socket until the socket has cooled off. Heat can ruin an IC or a tran-



Ultra-simple circuit delivers regulated output.

PARTS LIST FOR CB POWER MATE (3-AMPERE MODEL)

C1—2000-uf, 35-VDC electrolytic capacitor
C2—0.22-uF, 100-VDC capacitor
C3—0.1-uF, 100-VDC capacitor
C4—500-pF, 100-VDC capacitor
C5—.001-uF, 100 VDC capacitor
D1—Bridge rectifier diode package, 6-amp rating, 100 PIV (peak inverse volts)
F1—Fast-acting fuse, 5-A rating
IC1—Voltage regulator integrated circuit, NE550 (DIP package, Hamilton Avnet, 364 Brookes Drive, Hazlewood, MO 63042. NE550 or equiv.)
Q1—NPN silicon transistor (Radio Shack RS-2020 or equiv.)
R1—1800-ohm, ½-watt resistor
R2—1000-ohm printed circuit (end mounting) potentiometer
S1—SPST power switch, 120 VAC. If self-illuminating switch with built-in neon light is desired, use Radio Shack 275-671 or equiv.)
T1—Power transformer, 117-120 VAC primary, no center tap needed. Secondary 18 to 21 VAC at three amperes (Allied Radio 705-0133 or equiv.)
TP1, TP2—Binding posts, 5-way, one red, one black
Misc.—Printed circuit board materials, or perf board; fuse clip for mounting on PC board; heat sink for transistor Q1; heat sink compound (Radio Shack silicone grease 276-1372 or equiv.); IC socket for integrated circuit IC1 (Radio Shack RS276-027 or equiv.); scrap aluminum piece approx. 1-in. x 3-in. x ⅛-in. thick; standoffs (aluminum) four, ½-in. for mounting pc. board (Radio Shack 270-1394 or equiv.) with machine screws, nuts, and lock-washers.

PARTS LIST FOR CB POWER MATE (1.5-AMPERE MODEL)

Use all same parts as above, except for the following changes:

C1—Same, or use 25-VDC rating, which costs less
C2—Cx is not needed
F1—As above, except 3-ampere rating
T1—As above, except 12.6 to 16 VAC, at 1.5 amperes (Allied Radio 705-0121, or equiv.)
Heat sink for transistor not needed.
Scrap aluminum for heat sink not needed

Power Mate

sistor. Also be sure to hold each transistor lead with a pair of long-nose pliers as a heat sink when you solder to the transistor leads.

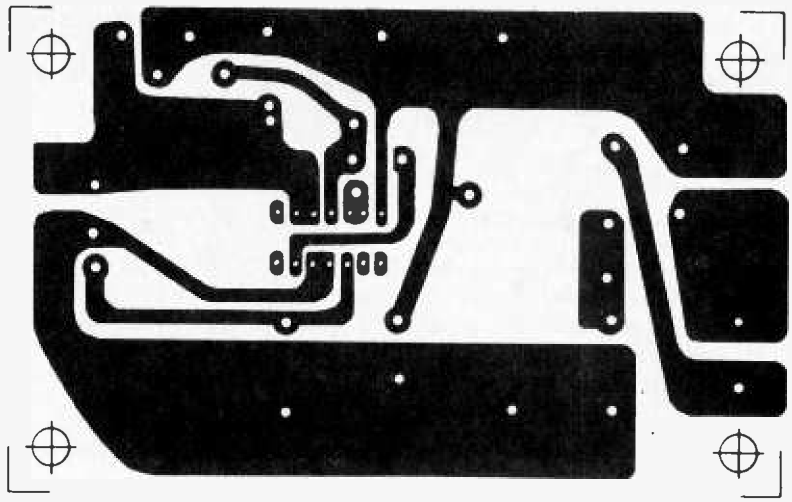
For the high-current CB Power Mate the bridge rectifier has a hole in the center to which you can secure the homemade heat sink. To make this, take a piece of scrap aluminum the width of the sink or larger and bend it in a U-shape with the ends sticking up in the air about an inch. Secure the sink to the rectifier with a #6 screw, a lockwasher between the screw and the rectifier, and a lockwasher and a nut on top of the heat sink. (The screw feeds in from the terminal or lead side of the rectifier.)

Also, for the high-current Power Mate the transistor uses the special heat sink with fins on the back of the cabinet (as shown in the picture). Q1 is installed the same way for both models. Drill a ¼-in. hole through the sink and the cabinet. Bend Q1's leads outward, away from its mounting tab. Using a mica insulator from a power rectifier (preferably) or a power transistor mounting kit, coat both sides of the mica with silicone heat sink grease. Position the insulator over the hole in the cabinet and place an insulated shoulder washer (from a 5-way binding post) in the cabinet hole, from outside the cabinet. Pass a #6 screw through the sink, the cabinet, and the mica insulator.

Then install Q1, a lockwasher, and a nut. Tighten the screw slightly more than hand tight. Check with an ohmmeter to be sure there's no short between the tab of Q1 and the cabinet. You should read infinity—no connection. If you have a short (one ohm or less) look for an improperly-seated shoulder washer or for a metal chip from the drilling.

Final Assembly. Before final assembly, with the parts *not* mounted in the box, drill a row of five ¼-in. holes in the cabinet directly over Q1, and five more holes in the lower left of the cabinet, near the transformer. These will provide adequate ventilation. Then put a small piece of tape over the head of the screw which secures the transistor, to prevent a (possible) external short.

Complete all wiring before installing the IC. Plug it into its socket so that pin 1, which has a dot molded next to it, faces the edge of the printed circuit board farthest away from the rectifier. Pin 1 should be toward the wires going to the board from the transistor. Install the fuse in its clips, set the rheostat,



Exact-size template for printed circuit board you can make. Location of holes for integrated circuit are critical—exercise care in drilling. Copper foil side is shown up.

R2, to its mid-position, and connect the voltmeter to the output of the power supply (the binding posts). Plug in the CB Power Mate's AC cord and observe the meter. It should rise to some value and stay there. If it wanders, or rises and falls back down to zero, disconnect the AC power and check for a wiring error. If the voltmeter remains steady, adjust R2 very slowly for the desired voltage, 13.8 volts (or 12, or whatever depending on the set you are going to power with it). That's it—your CB Power Mate is ready to use.

Optional Protection. If you want to build-in the *maximum current limiting* (to make sure the supply will turn off if a short suddenly appears outside it), you can substitute a resistor for the jumper on top of the board. To figure the value of the resistor, follow these steps:

1. Find the value in ohms of the resistor, which we will call "R." The formula is: $R=\frac{0.6}{X}$ where "X" is the current the transceiver draws when transmitting.

2. If the current is 2 amps, then the formula gives us: $R=\frac{0.6}{2}=0.3$

3. Now we must find the power rating of the resistor. Power is $W = I^2R$, where I is the current. Since we know that R is 0.3 ohms, and that the current is 2 amps, we get: W = 2 x 2 x 0.3 or W = 4 x 0.3 = 1.2 watts. For safety we double the rating, giving us 2.4 watts.

4. So, we need a 0.3 ohm, 2.4 watts (or more, since that exact wattage isn't available). The nearest larger wattage rating should be used. Two 0.6 ohm, 2-watt resistors in parallel would do nicely.

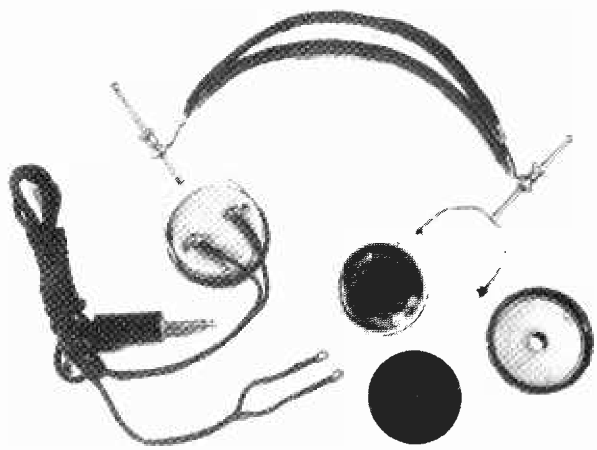
In Use. Now plug your CB Power Mate in, connect the positive and negative leads of the 13.8-volt power supply to the Plus and Ground connections on your transceiver, and start contacting your fellow CBers . . . with the maximum legal power which you paid for with your new set. Why not get it?

Of course the CB Power Mate is only needed in your home. In your car the transceiver will be getting the 13.8 volts it needs, if that electrical system is operating correctly.

Caution: Don't try to use the CB Power Mate at settings higher than 13.8 volts with a transceiver which requires that voltage. Trying to increase a transmitter's RF power output that way will probably result in blowing out components in the transceiver, because many transceivers are designed to just accept 13.8 volts, with not much safety factor above that. Be sure the Power Mate is set for exactly 13.8 volts before you turn on the transceiver, not any higher.

If you're not certain that your voltmeter is reading DC volts accurately, you can calibrate it very closely by using several new flashlight cells (not nicads—just ordinary, good condition—tested in flashlight—batteries). These cells, in good condition, put out exactly 1.56 volts each. Four cells in series should read 6.24 volts. 8 x 1.56 V = 12.48 V. Or you can get 13.94 V from nine cells. ■

LOW-COST FILTER IMPROVES CODE RECEPTION



A few snips of aluminum and an old reed make headphones into high quality filter.

by George X. Sand

Amateur radio operators and short wave listeners often find CW (continuous-wave code) reception difficult, if not impossible, when several radiotelegraph stations are transmitting on, or near, the same frequency. Such interference can be eliminated, or at least greatly reduced, by a narrow band electronic filter circuit that can be installed in the radio receiver or transceiver. However, this extra equipment can cost up to $150.

What You Need. A mechanical filter that will do the job can be built for $15, or less. In fact, should you already own a pair of earphones—the old-fashioned kind with metal diaphragms—and have access to a music store that will sell a used steel reed removed from an accordion (the writer was given his at no cost by such a store) you can build this effective filter for practically nothing.

A low-frequency reed should be used. A 440-Hertz (A) reed will work well. In fact, anything from about 300 to 1000 Hertz will be ok.

Should you have access to a steel (not brass) reed from an old harmonica, that could be used, too.

The removed reed is installed in one earphone of the headset so that it vibrates only when an incoming CW signal sets up a beat note at the reed's resonant frequency. All other interfering signals will automatically be eliminated since they will be of a different beat frequency, and the reed will not respond (audibly) to them.

To Get More Volume. Should you wish to have both earphones of the headset operate in this manner, the *matching* reed of the same length (they come in pairs in the instrument) must be installed in the second earphone.

A thin piece of aluminum is cut to same size disc as the original iron diaphragm of the 'phones. Rectangular center opening is for the iron frequency-resonant instrument reed. Small hole at right of rectangle is for rivet (or nut and bolt) to secure reed.

Here's how it's done: Use a pair of tin snips to cut from a thin sheet of aluminum (about 1/32-inch thick) a disc that will replace the earphone diaphragm. At the center of the aluminum diaphragm make an elongated hole that will permit the reed to vibrate freely (see picture) when it is riveted fast at one end of the opening.

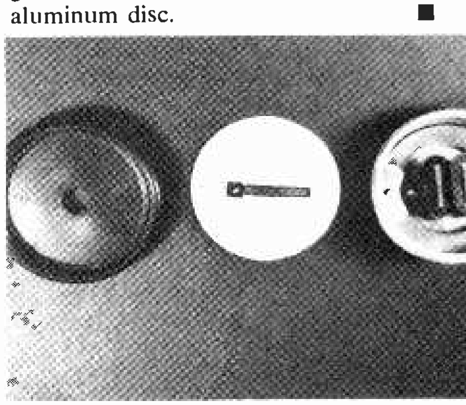
In installing the reed it is important that the little strip of steel extend into its opening for the *same* vibrating distance that it did when it was in the musical instrument.

The operation is simple. The aluminum diaphragm, being non-ferrous metal, will not be influenced by the magnets in the earphone. Only the reed will vibrate, instead. In use, only the desired CW signal will be heard loudly as the receiver or transceiver is tuned. The resulting silence can be uncanny!

PARTS LIST FOR CW FILTER

Communications-type headphones, 1000-ohms or more. (**Not** stereo headphones, which are all wrong for this project).
Steel reed(s) from accordion or harmonica.
One (or two) small rivets of the same size as were used to hold the reed in place in the instrument.

Use These Tools. You'll need a pair of tin snips or metal cutting shears. An electric (or hand) drill, with bits the right size for drilling out the rivet(s) which secure the reed(s) in the instrument will be needed, and you'll find a small square-edge (or triangular) file good for dressing the opening in the aluminum disc. ■



Original hard rubber cap (left), original magnet and coil assembly (right) and new aluminum diaphragm (center) with steel reed in place.

Pro Timer

(Continued from page 64)

projects, you'll find as you progress to more complex propects that making up a printed circuit board saves construction time and improves the project by making it neater and much more reliable (rigid mechanically) than other construction methods. However, you may, like many other beginners be hesitant about making such a board the first time. If so, making a fairly simple printed circuit board such as the one shown for this project is a good idea. Although not necessary for this project, it is good practice and training for much more complex projects, where use of a printed circuit components board is virtually mandatory.

You can get good kits for making printed circuit component boards from almost any electronics supply store. With one of these kits, making professional looking boards is a snap.

What Determines the Time Interval. If math bothers you, you might be scared off by being thrown a formula like this:

$$T = \frac{B \times Rt \times C7}{a - \frac{Vbe(Q1)}{V+}}$$

However, if you take it slow, you'll find that there's nothing here any high school student who knows simple multiplication and division can't understand. Slowly now, here we go.

T is the Time, the interval we're setting up.

B is a constant—a fixed value which is determined by the size of R8 (R7, too, which is a small, limiting resistor).

Rt is the net resistance selected by the positions of the two switches.

C7 is the capacitor which charges up.

Vbe (Q1) is the voltage across the base and emitter of transistor Q1.

And **V+** is the supply voltage, 15 volts in this case.

Finally, **a** is the ratio of R13 to the sum of R13 and R14.

Put another way, the **Time** is equal to the **Capacitance** times **Resistance** (the familiar formula for time constants, remember?), multiplied by **B**, which depends on the size of R8,—all this divided by whatever R13/(R13 + R14) comes to, minus the ratio of Q1's **base-to-emitter voltage** (0.8V) divided by the supply voltage (15 VDC).

From this you can see that increasing either the size of the resistances selected by the switches, or increasing the size of charging capacitor C7 will make the timed interval, **T**, longer. Decreasing either the resistances or the size of C7 will naturally shorten the interval.

Now, in this particular instance, we leave capacitor C7 fixed and change the timed interval **T** by changing the net resistance **Rt**. The **B** term which precedes **Rt** in the above equation is simply a scale factor which we choose by adjustment of R8 (during calibration of the timer). Once the appropriate **B** factor has been found, we leave R8 alone, and **B** is thereafter a constant factor in our equation. The only *intended* variable is **Rt**.

Let's assume we've constructed the timer circuit using randomly selected, off-the-shelf components. Could we expect our prototype to behave precisely as predicted mathematically? The answer is NO because our equation is a simplification, and therefore incomplete. For one thing, it does not tell us that components like resistors and capacitors never have fixed, perfectly precise values. For instance, a 1000-ohm, 10%-tolerance resistor could have a resistance anywhere from 900 to 1100 ohms, and C7's capacity is a nominal 3300 mfd., +100% or −20%, which means that the capacitance of a randomly selected unit could be anything from 2600 mfd. to 6600 mfd. It is for this reason, non-ideal components, that the calibration, term **B**, is incorporated into the timing equation. By adjusting R8 we change the **B** term's magnitude, and thus compensate for our inability to find components with precise values.

O.K., so we have a fudge-factor built-in, and the **B** factor minimizes the ill effects that component variations produce.

Additional Use. Once you've built Pro-timer you'll surely think of other uses for it outside the darkroom or the process laboratory. One good use is in timing TV games. ■

Spiderweb

(Continued from page 32)

volt battery to the receiver. Set the Bandspread capacitor C2 to minimize capacity and the Tuning Capacitor C3 to maximum capacity. Connect a signal generator to J1 and then calibrate the dial with the generator. Adjust the AF Gain R5 and R1 as necessary for a good received signal. Make sure that the signal generator output is kept low enough to prevent overloading of the receiver. Begin with a modulated signal generator frequency of 550 kHz and mark the receiver dial accordingly. Proceed up the dial to 1600 kHz and mark the scale at convenient points. Then replace the "C" with the "B" plug-in coil and calibrate the scale from 1.7 to 5 MHz with the signal generator. Also, calibrate the "A" plug-in coil with a generator from 7 to 14 MHz. If a signal generator is not available, you can calibrate the bands with markings noted from received radio stations of known frequency. The Bandspread dial is not calibrated, but, a set of points can be marked over the range of C2 to aid in tuning the dial, or for logging purposes in the crowded SW bands.

Operation. For best results a good antenna and ground are required. Also high impedance earphones (2000 ohms or more) are needed. If a DC power supply is used in place of the 6 volt battery, make sure that the supply does not have any hum in the output as this will affect the receiver sensitivity. Tune C3 for a received station, while at the same time adjusting the Regen control R1 for a whistle. If the station is AM, back off R1 until the station is received clearly. If the received station is CV, adjust R1 for a convenient "beat note." Many strong side-band stations can alse be received by experimentally tuning R1 and C2 for best reception. Adjust the AF Gain control for good earphone volume. Adjust C1 for best reception for each coil. The position of the "S" tap can be experimented with (moving up or down on L1) for best regeneration over the band. Also, try several FET's as Q1 for maximum sensitivity over the higher SW frequencies.

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Ring-A-Thing

(*Continued from page 86*)

do so in the test procedure outlined below. Q2 is mounted directly to the printed circuit board without a heat sink. None is required since the transistor operates as a switch, resulting in almost no power dissipation.

The method of connecting the telephone line and AC power cord to the printed circuit is left up to the builder. If the unit is to be used at a location not convenient to AC power you may want to use a small terminal strip or connector for the telephone line. This permits easy removal when battery charging is required.

Watch It, Buddy! It is recommended that the cells be handled in a discharged state. NiCad cells are capable of delivering very large short circuit currents (50 amperes or more) even when only partially charged. Once the cells are mounted and wired to the printed circuit any accidental short circuit between the cells or other components on the board may cause a very large current flow. Such currents can easily burn out printed circuit wiring.

Checking The Circuit. After the unit is assembled and wired it is recommended that the charger current be measured so that the proper value of R5 can be placed in the circuit. Since different 6.3-volt filament transformers can vary considerably in output voltage and internal impedance, the current delivered by the charger should be checked and adjusted if necessary. The best method of measuring charging current is to insert a 0-1 ampere DC meter in series with R5. An alternate method is to measure the resistance of R5, connect it into the circuit, and measure the DC voltage across it. Current can then be calculated by dividing the voltage measurement by the resistance.

The recommended charge current for the C cells specified in the parts list is 120 milliamperes. This will charge the battery in 14 hours, and there would be no danger of overcharge if the line power was connected for several days. If you prefer to leave the charger permanently connected to the AC power line the charge current should be reduced by a factor of three, to 40 milliamperes. This will keep the cells at 100% charge without any danger of cell damage. If NiCad cells of other capacities are used the charge current should be set up to one one tenth of the ampere hour rating of the cells, or to 1/30 the rating if the charger is to be operated permanently. For example, if size D cells with a 3.5 ampere hour rating were used, the charge current would be set to 350 milliamperes or 115 milliamperes. The value of R5 should be changed, if necessary, to provide the desired current. Note that it is not necessary to set the current to exactly one tenth of the rating of the cells. Less current can be used with the disadvantage being that it would take longer than 14 hours to fully charge the battery. Do not use a larger current than specified. To do so will damage the cells on overcharge.

Installing Ring-A-Thing. The unit is connected across the telephone line as shown in the schematic. The only exception to this will be for two party telephones. In this case the telephone ringing signal is impressed between one of the telephone lines and ground. (The other party's ringing signal is impressed across the other line and ground). You will have to experiment to determine which of the two lines has your ringing signal. If you inadvertantly connect the circuit to the wrong line, you will be answering the other party's calls! For the ground connection you may use any convenient ground point such as a BX ground.

Before installing the unit you should operate the charger at least 14 hours to fully charge the battery, unless you plan to leave the charger connected permanently to the power line. With a fully charged battery the unit will operate several months before a recharge is necessary. The power demand of the charger is about 2 watts, and will have little effect on your electric bill if left operating. In this case the unit would need no further attention, and you can forget it.

When You Start. You'll need a template to build Ring-A-Thing's printed circuit board. Take a look at the parts list under the schematic diagram to find out how to get it. ■

Mighty Met

(*Continued from page 109*)

in a square pattern. Flea clips could be used to support the wiring, but it is just as easy and less expensive to run the component leads through the board and connect them on the underside with fine wire, like the type used for wire-wrapping. Double check the orientation of the ICs and transistors, and the polarity of the electrolytic capacitors and battery. The prototype was assembled in a 2 x 6 x 4-inch cabinet, but another size or type could be used. The circuit board was mounted to the bottom of the cabinet with four ¼-inch spacers. The speaker was mounted by means of two ground lugs soldered to its frame. For the sake of appearance, the two bolts holding the speaker and grille were epoxied to the inside of the cabinet.

Performance and Revision. After all wiring is complete, plug in the IC's, then connect the battery and adjust trimpot R7 to midrange. Turn the Mighty Met on and it should produce a continuous series of clicks whose rate can be varied by the *tempo* control. Adjust trimpot R7 for the desired difference in loudness between the initial beat and the other beats, and check the function of the *meter* switch. Finally, calibrate the *tempo* control, using a watch or clock that indicates seconds. For the faster tempos, set *meter* to 5 or 10 and count the initial beats. If there are problems, try to determine which part of the circuit is faulty: If there are no clicks, first check that there is about +9 volts between the +V supply line and ground. If not, check for a wiring error or short. Next check for pulses at pin 3 of IC1; an oscilloscope is preferable, but an audio amplifier can also be used. If there are no pulses, the problem is in the multivibrator circuit. If everything is operating up to this point, check pin 4 of IC3 for pulses to see if the divider is working, then check pins 10 and 11 of IC4, and finally the output circuit.

Marking Time. Use of Mighty Met is straightforward. A word of caution is in order, however. When a metronome of this type is used for practicing on an instrument, there may be a tendency for the player to accent the first note of each measure, even when it is not appropriate for the particular piece of music being played. This tendency is more likely if the initial metronome beat is louder than the others. The Metered Metronome was designed to allow the initial beat to be made softer than the others, by suitably adjusting trimpot R7, as a means of counteracting this tendency.

For darkroom use or other timing applications a natural concern is how much the timing changes as the battery voltage drops with use. Specifications for the 555 timer IC used in the circuit indicate only a fraction of a percent timing variation per volt; variation with temperature is also only a fraction of a percent over an ordinary range of temperatures. Tests of the prototype showed no significant change (less than one second in 5 minutes) for a battery voltage variation from 10 volts down to 7 volts. ■

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Checkerboard

(Continued from page 50)

less breadboard, or placed in contact with the bare wire groups. You can test as you go by using a slide, toggle or rocker switch at S1, or push-to-test with a momentary switch.

Checking Diodes. A properly operating diode will conduct in one direction only, and will not conduct when the leads are reversed. So you can check a diode with just two passes on Checker Board. If it lights the LED no matter which way it's connected, your diode has an internal sort. If it won't light the LED no matter which way it's conected, it's opened up. If it lights the LED only when connected, then you can identify the anode end (the triangular arrowhead on schematic representations) as being connected to the red alligator clip (at the junction of R1, C1 and the base of Q1). The cathode (bar) end is then connected to the black alligator clip (ground).

Checking LEDs. You can follow the instructions for checking diodes to check LEDs, but that's the hard way. The LED you test will light up, too, assuming it's good, when you test it on Checker Board. Make sure you get the polarity right. You can also trace 7-segment and multiple-digit LED displays to see which pin does what.

Checking Electrolytics. The thing that most often goes wrong with electrolytic capacitors is that they short out. And that's the easiest thing to spot with Checker Board. Connect the + lead to the red alligator clip and the – lead to the black, or plug the electrolytic right into the solderless breadboard. This test will be more fun with the momentary switch. Push it and watch the LED. You should see a bright flash that decays into darkness. The bigger the electrolytic, the longer the flash lasts. A shorted electrolytic won't go out—an open one won't flash.

Checking Crystals. Connect the two crystal leads to the alligator clips. If the LED lights brightly, the crystal is good. If it lights dimly, the crystal is good but will not work in all kinds of oscillator circuits. If the LED does not light at all, it probably means the crystal is bad. But it *may* mean that the crystal is one of the few, obscure types that cannot make Q1 oscillate in the Checker Board circuit. Most crystals, if good, will light the LED brightly.

Checking Switches. With Checker Board connected to any pair of switch contacts, the LED will light whenever there is continuity between the contacts. When there is no continuity, it will not light. With this information, a sheet of paper and a pencil, you can methodically analyze when continuity occurs with each change of setting of an unknown switch. This can tell you what kind of a switch it is. And, of course, when you know what kind of a switch you have, Checker Board can tell you whether or not it's working properly.

Checking Continuity. A closed circuit will light the LED, an open circuit won't. (We're speaking of DC continuity here). With this in mind, you can check cables, connectors, printed circuit paths, relays, light bulbs and many other devices. As long as the testing-path resistance doesn't get too high (just how high is too high depends on your particular LED and what shape your battery is in), anything that needs to maintain continuity in order to work (or discontinuity, in case you're looking for shorts) can be checked on the Checker Board.

Checking Out Checker Board. Yes, Checker Board even checks itself out. Just clip the two alligator clips together. If everything is working, the LED will light up! ■

Midget Digit

(Continued from page 110)

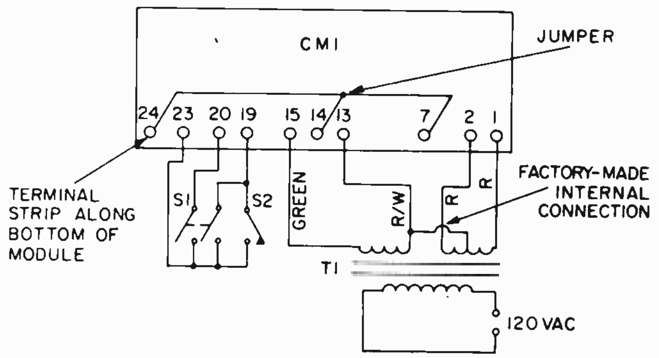
wires connect to terminals 1 and 2 (either way will do); the red wire with white tracer is the centertap for the red wires and connects to terminal 13; the green wire connects to terminal 15. Connect reset *switch* S1 and *hold* switch S2 as shown in the schematic. That's the whole construction.

Checkout Procedure. Apply power to Midget Digit (our model does not use a power switch). The display will be some random time that blinks on and off, incrementing seconds with each blink. If you don't get the incrementing effect you have made a wiring error or the module is defective.

Pressing the *reset* switch will stop the blink, the display will remain on and reset to zero, then start incrementing in one second intervals. Each time the reset switch is pressed the display should return to zero. If the *hold* switch is depressed (remaining depressed) the timer should hold. Releasing the switch should cause the timer count to resume without a reset to zero.

If you don't get the proper reset and hold functions you most likely have a wiring error rather than a defective module. In particular, check the wiring on *reset* switch S1. The two wires should be shorted only when the switch is closed. When the switch is open the wires from module terminals 19 and 20 should not be shorted.

A timer is a must for every photographer. Why pay five times as much for a commercial model when our Midget Digit is so easy to build and actually performs better in the bargain? ■



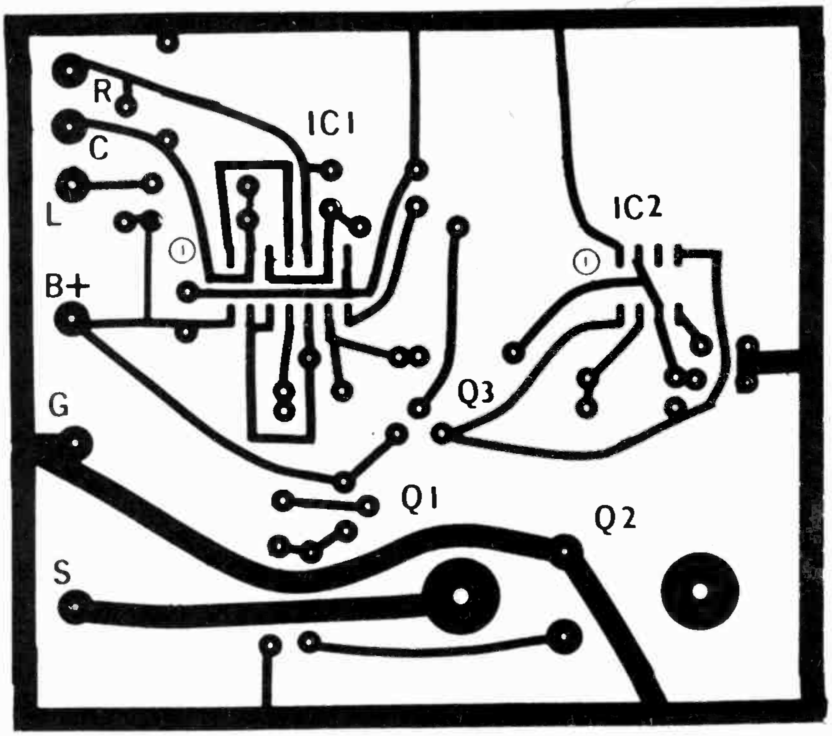
Parts List For Midget Digit

CM1—Twelve hour LED display digital electronic clock module
S1—DPDT spring-return or push-button switch (Allied 757-0730 or equiv.)
S2—SPST toggle switch
T1—Special transformer for clock module
Misc.—Cabinet (see text); thin, insulated hook-up wire (Allied 708-348N or equiv.); standard hook-up wire.

B/F Brain

(*Continued from page 102*)

When installing the alarm in an automobile you must add a key-operated power switch which is accessible from the outside of the car, or place the power switch in the trunk. Otherwise the circuit would be tripped as you open the door to leave the vehicle. ■



Here's the way the parts are located on the printed circuit board. No heat sink is needed for the big transistor. Use an IC socket for IC2.

Lettering

(*Continued from page 25*)

with a brush-on spray coating. It's best to use products made for this specific purpose, which should be available from the same sources as the rub-on lettering. Ordinary lacquers, clear fingernail polish, etc., are likely to damage the lettering. Always make a test beforehand or you may end up with an ugly mess.

Here are some additional suggestions:

1) Read the instructions (if any) that accompany the lettering set.
2) If this is your first experience with rub-on lettering, practice on scrap material first to get the feel of it.
3) When applying the lettering, keep a backing sheet beneath the part of the carrier sheet that you are not using. This prevents unwanted letters from transferring and also keeps the lettering clean. Dirt or skin oils can interfere with adhesion.
4) To align rows of letters or words, tape a strip of paper to the panel about 1/16-inch below where the row will go.
5) A word made from individual letters can be centered by starting in the middle and working outward to both ends. ■

Grandpa's Whisker

(*Continued from page 15*)

CAUTION. *Make sure that the battery is disconnected for this initial adjustment.*

Connect an antenna to J1, a ground to J2, and a pair of high-impedance headphones to J5 and J6. A pair of 2000-ohm phones was used with our model; do not use low impedance headphones (8, or 16 ohm stereo types). Do not connect the 6-volt battery at this time.

Make sure that the catwhisker is not touching the crystal or the crystal cup (open circuit to the carborundum crystal), and then connect the crystal diode across J7 and J8 (the polarity is not important; it will work either way). Connect both of the clip leads (lead to J8 and lead to C1A-C1B) to L1 coil taps; any of the mid-coil taps will do for an initial start. Set C1A-C1B to mid-capacity range and then tune C2 until you hear a radio station in the headphones. Readjust the setting of C1A-C1B for best headphone volume. Then readjust each one of the clip leads for best headphone volume of the received radio station. All of the adjustments and coil tap settings will interact, and will require careful retuning of both C1A-C1B and C2 for best results.

When a radio station is tuned in for best headphone volume, carefully disconnect the germanium crystal diode from J7 and J8 without disturbing the tuning capacitor settings or the positions of the L1 tap connections. Then place a carborundum crystal in the detector assembly and connect the 6-volt battery to J4 (negative lead) and J3 (positive lead). Adjust the catwhisker until it touches the carborundum surface and then set the bias control R1 to mid-range.

Carefully adjust the catwhisker for a sensitive spot on the crystal surface at the same time adjusting R1 for best volume of received signal. If this seems like a lot of trouble to hear a radio station, remember the radio pioneers around the turn of the century would spend considerable time with equipment even cruder than Grandpa's Whisker in order to capture the elusive wireless signals. After a station is found with the carborundum detector, it may be possible to achieve a bit more received volume by readjusting the coil taps and tuning capacitors.

You can experiment with different types of silicon and germanium crystals as well as other materials with this circuit; but remember, do not use the battery unless it is with a carborundum crystal. The battery will burn out the more conventional germanium and silicone crystals. You can also try chips of carborundum broken off of sharpening stones, etc. and held with melted solder or lead. Or you can also try packing the crystals with sections of crumpled aluminum or lead foil in place of the melted lead bodies. The received crystal set volume will vary according to the type of crystal used; generally germanium will be loudest, and silicon a bit less, and the carborundum crystal will usually be lower in volume. ■

Scan Top of 40

(*Continued from page 80*)

sells for $119.95. Other PRO-6 models are available, at the same price, for 450-470 MHz (PRO-5, UHF), and for 148-174 MHz only (PRO-4A) at $99.95. For more information, Circle number 32 on the Reader Service coupon. ■

Lone Ranger Light

(Continued from page 57)

and the case is covered. Solder the positive lead from the battery clip to one side of S1. To the other terminal of S1 solder the short lead from the circuit board. Finish off by mounting the cover and applying press-on decal labels as desired.

Calibrating Lone Ranger. Set the range selector to the low-light measurement position (the larger hole), then point the meter towards a bright light bulb and depress S1. One or more LEDs should light, depending upon the brightness of the source. If not, go back and check whether any components have been improperly oriented. When all is working well, only the calibration of the meter remains. Borrow a good light meter for this task. Choose a large, preferably blank wall and evenly illuminate it (avoid using fluorescent light sources, however). Adjust the light source and the distance until your reference meter indicates f/8 at ASA 125 and 1/30 sec. When you have obtained the correct reading on your reference meter, hold your Lone Ranger in the same spot and point it in exactly the same direction that the reference meter had been facing. Press S1 and adjust R2 so that LED4 (the one farthest) extinguishes. Now turn R2 back the other way until LED4 just comes back ON. The meter is now calibrated. To use the meter with different film and shutter speeds, consult the Table.

Film Speed ASA	Exposure Correction
400	+2
250	+1
125	0
65	−1

Shutter Time	Exposure Correction
1/125	−2
1/60	−1
1/30	0
1/15	+1
1/8	+2

ASA = 125
+ — go to higher f-stop
− — go to lower f-stop

Additional Circuit Uses. You may have noticed that the comparator circuit presented here has great potential. A thermistor might be submitted for photocell PC1 and the circuit becomes an electronic thermometer. Or mount a potentiometer so that its control shaft spins as another shaft rotates. The LED display would then indicate angular position, perhaps for an antenna rotor. The information here plus your own imagination should produce many new devices. ■

LEDIT

(Continued from page 52)

better to be safe than sorry.

In thousands of parts tested I've never had a false indication except in the case of a few rare *dv/dt* turn-ons. When this happens, here's what to do. Just interrupt the power with S2 several times and see if the indicator D3 lights every time, or just part of the time. Part-time turn-on indicates a definite *dv/dt* situation. Full-time turn-on usually indicates a short. That's all there is to it! ■

TERMINAL POST			BUTTON PRESSED			LED ON			INDICATES
Anode	Cath.	Gate	None	On	Off	Red	Clear	None	
a	c	g	x					x	a-c not shorted
a	c	g		x		x			g-c short or a-c open
a	c	g	x				x		a-c short or possible dt/dv
a	c	g		x				x	g-c open
a	c	g		x		x	x		normal turn-on
a	c	g			x			x	normal turn-off
MISCONNECTIONS									
g	c	a	x				x		
g	c	a		x		x	x		
c	a	g	x					x	
c	a	g		x				x	
a	g	c	x					x	
a	g	c		x				x	
c	g	a	x					x	
c	g	a		x				x	
g	a	c	x					x	Clear LED may be on weak
g	a	c		x				x	Clear LED goes out
DIODES									
a	c		x				x		normal
a	c		x					x	open
c	a		x				x		shorted
c	a		x					x	normal

Alternator Tester

(Continued from page 83)

tive lead of the Alternator Tester is connected directly to the battery terminal of the alternator. The reason for this is that the ripple measurement depends upon the small, but finite, resistance between the alternator and battery. In order for the ripple test to be accurate, the alternator must be delivering a sizeable current. This is accomplished by slightly discharging the battery. Before starting the test, shut the engine off and turn on the car headlights for about ten minutes. During this time you can connect the Alternator Tester to the car. Leave the headlights on while making the test. Start the engine and bring the RPM up to about 2000. Note the reading of the meter. An alternator in proper operating condition will have a ripple voltage somewhere between 0.2 and 0.5 volts peak-to-peak. Should one or more of the diodes be defective the ripple voltage will increase to 1 volt peak-to-peak, or more. If this is the case you will have to remove the alternator from the car to disassemble it and locate the defective diode. ■