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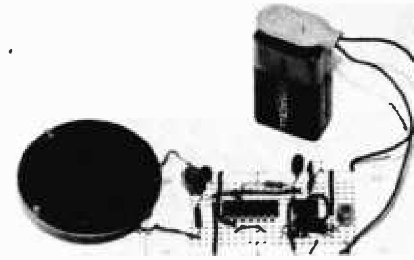

1979 EDITION

30 TRANSISTOR PROJECTS

FEATURES

REGULAR DEPARTMENTS

New Products

Loop Antenna

A new receiving antenna for the 80 and 160 meter amateur bands, the Broadcast and the VLF bands has been introduced by Palomar Engineers. The loop rotates 360° in azimuth and ±90° in elevation with calibrated scales for both. The elevation or "tilt" of the loop gives much deeper nulls than ordinary direction finder loops. Loop nulls are very sharp on local and ground wave signals but are broad or nonexistent on distant skywave signals. This allows local

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interference to be eliminated while DX stations can still be heard from all directions. The loop picks up much less noise than the usual transmitting antenna. This, along with its ability to null out specific interfering signals, improves reception considerably. A Loop Amplifier serves as the mounting base for the antenna. It contains a tuning capacitor to resonate the loop and an amplifier to boost the signal and preserve the high "Q" of the loop. The Loop Antenna plugs into the amplifier. Plug-in loops are available for 160/80 meters (1600-5000 kHz), broadcast band (550-1600 kHz) and VLF (150-550 kHz). The Loop Amplifier is $67.50 and the plug-in loops are $47.50 each. Add $2.00 shipping/handling. A free descriptive brochure is available from Palomar Engineers, P.O. Box 455, Escondido, CA 92025.

Booster Amp Shapes Up

Highway hi-fi gets a new boost with Sparkomatic's car stereo booster amplifier which enables the user to "see" the amplifier response shaped by the various tone controls on the unit. As the new AcoustaTrac GE-500's controls are moved to adjust for tone, an illuminated, flexible rod changes its shape in conformance with the control movement. The GE-500 offers integrated circuitry for maximum reliability, wide frequency response, and 40 watts of RMS stereo power. Other features include slide controls that adjust five different frequency bands, a front-to-rear fader control, a power indicator light and an audio by-pass switch. The unit can be used with all tape decks and radios and with all

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speakers that have a power handling capability of 15 watts or greater. Sells for $79.95. Get all the facts direct from Sparkomatic Corporation, Dept. EE, Milford, PA 18337 or call (717) 296-6444.

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

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them. You graphically learn while having the fun of assembling working projects. 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.

Telephone Amplifier

Now even the most diligent business-person or dedicated homemaker can continue working, with both hands free, when talking on the telephone—compliments of Panasonic's new telephone amplifiers, the Easaphones. Model KX-T1030 is a deluxe telephone amplifier featuring a built-in LED clock which may be used to time a phone call second by second (or a three-minute egg) or, when not in use, the LED clock displays hour

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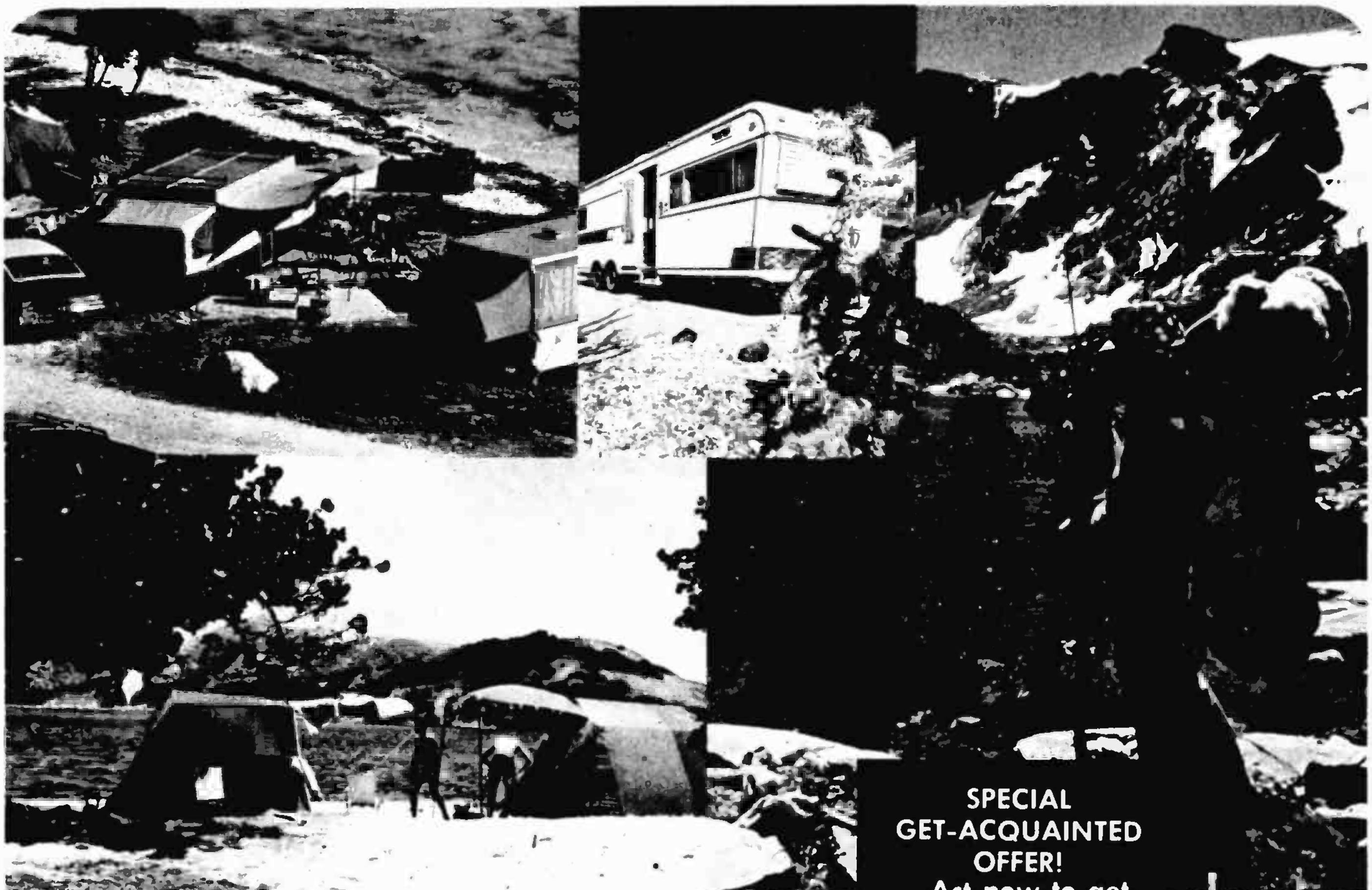

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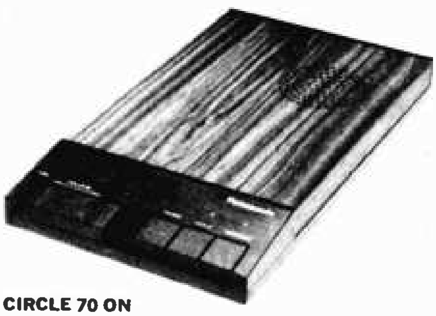
New Products

and minutes. Other outstanding features of the Panasonic Easaphone include a sensitive condensor microphone, 3-in. speaker, piano-key type controls for on/



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off, timer and bold functions in addition to a sliding volume control and LED indicators for hold and power. The unit is equipped with record out and external DC adaptor packs and includes an AC adaptor, and two AA size batteries for use as a backup power supply to keep the clock functioning in the event of a power failure. Panasonic Easaphones are available nationwide at Panasonic retailers. Sells for $125.00. Get all the info direct from Panasonic, One Panasonic Way, Secaucus, NJ 07094.

Shirt Pocket Micro Cassette

What's 10½ ounces and delivers 60 minutes of recording and playback operation? The answer is Panasonic's new RQ-165 AC/battery Micro Cassette recorder. The new unit is a combination of compact size, good sound and versatile performance. Panasonic Model RQ-165 also features: Capstan drive which helps provide constant tape speed; built-in condenser microphone; a battery recharge system with optional rechargeable battery pack RP-094; one-touch recording and cue and review controls. The unit also features Easy-Matic circuitry for automatic recording level; lockable pause control and LED record/battery indicator. It is equipped with

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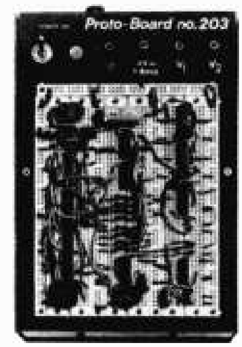
AC adaptor/recharger and operates on two AA-size batteries. Sells for $99.95. Details can be had by writing to Panasonic, One Panasonic Way, Secaucus, NJ 07094.

Powered Breadboard

TTL logic system designers are finding an attractive design shortcut available to them, thanks to the Continental Specialties Model PB-203 Proto-Board, a high capacity solderless breadboard that includes a built-in 1%-regulated 5 VDC power supply. The advantage to a TTL hobby designer is the ability to design directly in hardware, assuring proper circuit operation, before hand wiring. This helps prevent the confusion in translating from gate schematics to actual IC packages, often providing valuable insight into ways of simplifying PC layouts. The breadboard area on the Proto-Board 203 includes enough tie points to support 24 14-pin DIP ICs. Four binding posts provide power and signal connections on and off the board. The built-in power supply is 1% regulated at 5 ±.25 Volts, rated at 1 A, and boasts a low 10 millivolts combined ripple and noise at 0.5 A out. And it's short-proof. The 5½-pound package measures 9¾-in. long, just over 6½-in. wide and 3¼-in. tall. CSC's low suggested resale price for the PB-203 is just $80.00 (per unit). Further information is available from CSC deal-



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ers and distributors, or direct from Continental Specialties Corporation, 70 Fulton Terrace, New Haven, CT 06509.

Legal Linears

Telco Products new Ultra series of 450 MHz RF Power Amplifiers is specifically designed for Amateur, Police, Emergency, Business Band and Class "A" (special license) CB radio applications up to 50 watts. Four new Ultra line UHF Power Amplifier models are American manufactured in full compliance with latest FCC specifications. They are: Ultra I—1-2W input 15W output. Ideal for use with Low Power Hand-Held transceivers, $259.00; Ultra II—3-5W input 25W output, $289.00; Ultra III—3-5W input 50W output, the legal limit for Class "A" Citizen and Radio, $379.00; Ultra IV—3-5W input 100W output, the "Ultra" powered amplifier for maximum output, $499.99. Frequency range is from 400 to 512 MHz. Specify transmit frequency with order. For additional information,

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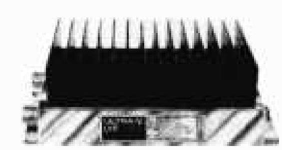
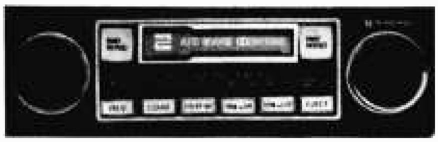


contract Telco Products Corporation, 44 Sea Cliff Avenue, Glen Cove, New York 11542 or call (516) 759-0300.

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



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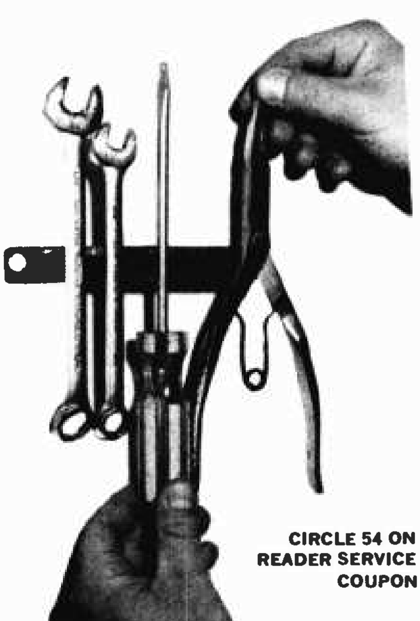
with Sanyo's "E-Z Install" system which includes mounting accessories and instructions. Suggested retail price is $199.95. Get more facts by writing to Sanyo Electric Inc., Consumer Electronics Division, 1200 West Artesia Blvd., Compton, CA 90220.

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 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.



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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.

Scientific Calculators

A family of three, new, hand-held scientific calculators featuring a new display size, error messages, custom literature and a new packaging design was introduced by the Hewlett-Packard Company. The HP031E, priced at $60.00 is an advanced scientific calculator for the professional to use as a basic tool. In addition to the standard arithmetic, logarithmic and trigonometric functions, the HP-31E also has fixed and scientific dis-

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play modes, and rectangular/polar, degree/radian, inch/millimeter, Farenheit/Centigrade and Pound-mass/kilogram conversion keys. The HP-31E also has the HP RPN logic system with four addressable storage registers. The HP-32E, priced at $80.00, incorporates all of the features and functions of the HP-31E with an engineering display mode and the first use of hyperbolic functions and their inverses in an HP hand-held calculator. It also features a U.S. Gallons/Liters key, a decimal degree and hour/hours, minutes, seconds key, and the most advanced collection of statistical functions ever offered on an HP calculator—including linear regression, correlation coefficient, x and y estimates, normal and inverse normal distribution and factorial. The HP-32E also features 15 addressable storage registers. The HP-33E, priced at $100.00, has all of the features of the HP-32E, except hyperbolics, metrics and certain statistical functions, and offers 49 lines of fully merged keystroke memory. Of particular interest is the calculator's capacity for three levels of subroutines. Get all the facts direct from Inquiries Manager, Hewlett-Packard Company, 1507 Page Mill Road, Palo Alto, CA 94304.

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 pick-up patterns. Accessories furnished with

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New Products

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

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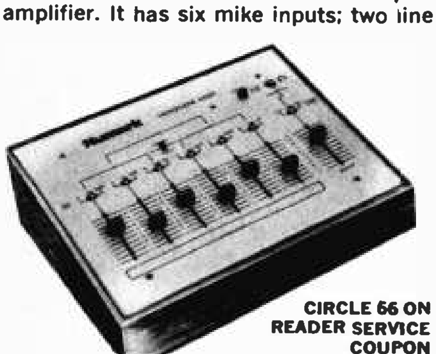
0.59 inches (15 mm) in diameter and two inches (52 mm) long. Specifications include frequency response of 50-15,000 Hz; —57 decibels sensitivity; —151 decibels EIA sensitivity; and 600-ohm impedance. The maximum input sound level is 130 decibels, and the signal-to-noise ratio is greater than 50 decibels.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

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



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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.

Stereo Tuner

The ST-1122 FM/AM stereo tuner made by Sharp comes in a black cabinet and has such professional features as an

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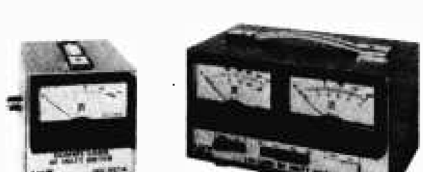
air check button. This is a special, built-in, 400 Hz tone generator which provides a signal to set the optimum levels when recording FM broadcasts. The unit also has a Field Effect Transistor front end for increased FM sensitivity and low distortion. Other features include a signal strength meter to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

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



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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 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

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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.

50-Channel Scanner

There's a new 50-channel scanning monitor receiver around with microcomputer control. Named the "Bearcat 250", the radio receives five public service bands. With its microcomputer control it can search a band of frequencies for the active, or "hot," channels and automatically store them in its memory. The operator can then retrieve all the active channels found by simply pushing a "recall" button. If desired, those

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frequencies can then be programed into the radio's scan memory. Up to 50 preprogrammed channels can be scanned. No crystals are needed. The operator simply uses the radio's keyboard to enter the frequency plus any special instructions for each channel. The Bearcat 250 can count the number of times a call is made on each scanned channel. When this information is recalled from the memory it gives the operator a clear picture of which channels are most active. The radio also has an accurate digital clock function which can display hours, minutes, and seconds. The radio covers low and high band VHF, the two-meter "ham" band from 146 to 148 MHz, and all UHF frequencies from 420 to 512 MHz (which includes the new "T" band assignments). Suggested retail price of the new Bearcat 250 is $399.95. Complete details are available from Bearcat dealers or by writing to the Electra Company, 300 E. County Line Road, South, Cumberland, IN 46229.

CB Pistol Mike

A new concept in two-way mobile radio microphones combines an electret-capacitor element with a compact pistol-grip case that tucks neatly into the palm. The JMR Mobile Ear Microphone, model 40, is specially engineered to be held at the steering wheel while transmitting, allowing you to talk, switch, and use both hands for driving simultaneously. The built-in Velcro pad lets you mount the unit anywhere. Just attach the mating Velcro pad to steering post, dash, or

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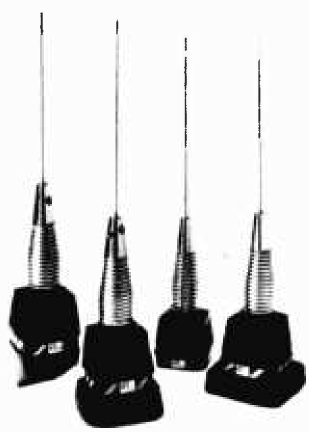
any other handy surface. The tiny electret-capacitor microphone picks up your voice anywhere within arm's reach with exceptional fidelity. There's no need to hold the microphone up to your mouth when transmitting. The specially designed frequency response plus the clear, distortion-free reproduction of the electret-capacitor microphone combine to create an on-the-air sound that punches through noise and interference. Variable microphone gain lets you adjust the level for optimum modulation under varying conditions. Sells for $44.95. Get the facts from JMR Systems Corporation, 168 Lawrence Road, Salem, NH 03079.

All New Antenna Line

Antenna Specialists has just released its Scorpion line—a whole new breed of CB antennas combining bold, contemporary styling with the latest in antenna technology. A new solid-state circuit replacing the loading coil delivers consistent per-



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formance over all 40 CB channels. The new Scorpion line is built for durability, and has an unique lever-action quick release system for protection from vandalism or car washes. The Scorpion antenna line now includes the four most popular mounts; roof mount, trunk lid mount, hatchback mount and magnetic mount. All four units come with 17 feet (24 feet on magnetic mount) of type 58/U coaxial cable with a permanently attached PL-259 type connector. They are priced at $29.50 to $34.50. For information, contact The Antenna Specialists Co., 12435 Euclid Avenue, Cleveland, OH 44106.

New Fit for Smaller Cars

Detroit has squeezed the rear deck in their new, smaller car models, so AFS has developed dual cone (Model 2031) and coaxial (Model 2032) 4-in. x 10-in. KLASSIC bulk pack speakers to fit where 6-in. x 9-in. speakers used to go. The new speaker size also fits nicely into the rear posts in most models of station wagons, under the dashboard up front in many cars, trucks and recreational vechicles, or anywhere in a boat or airplane. The specs for the Model 2032 are: 4-in. x 10-in. coaxial design, 10 oz. ceramic magnet, 1-in. voice coil, 25 watts RMS, 55 Hz to 18,000 Hz, 8 ohms; and sells for $24.60. The specs for the Model 2031 are: 4-in. x 10-in. dual cone design, 10 oz. ceramic magnet, 1-in. voice coil, 25 watts RMS, 55 Hz to 16,000 Hz, 8 ohms; and sells for $17.50. For further information on the 2032 and 2031, write

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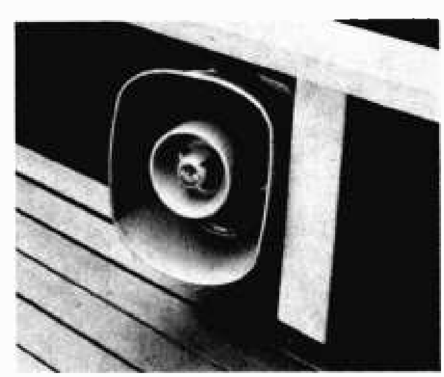
Acoustic Fiber Sound Systems, Inc., P.O. Box 50829, Indianapolis, In 46250 or call (317) 842-0620.

Rugged Indoor/Outdoor Speaker

Hi-fidelity sound for deck, patio, poolside and other outdoor areas is possible with a full-frequency all-weather speaker system pioneered by Atlas Sound of Parsippany, New Jersey. The all-weather speaker system, capable of providing high power music and voice reproduction comparable to some of the best indoor loudspeakers, is equally well suited for home use as well as such commercial applications as hotels, and motels, leissure areas, shopping malls, schools, service and industrial facilities. Power rating is 15 watts, with frequency response of 150-15,000 Hz and sound level of 117 dB. Rectangular in shape, model WT-15 speakers are all-metal coaxial units incorporating a weatherproof woofer, a high-efficiency compression driver, and associated crossover filter and network. Designed for use in areas with medium and high sound levels, the WT-15 provides optimum music reproduction together with unusually clear and intelligible voice projection when used as part of a public address system. The unit is finished in beige baked epoxy enamel, is equipped with 36-in. weatherproof connecting cable, and features a heavy-duty positive-lock steel mounting bracket suitable for wall, ceiling or pole installation with fully adjustable orientation. The WT-15 can be purchased from



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local retailers for $62.50. Complete details are available from Atlas Sound, 10 Pomeroy Road, Parsippany, NJ 07054.

Attache PA

The Sound Attaché P.A. from Perma Power Electronics is a complete public address system in an attaché case—designed for demonstrations, seminars,

New Products

club meetings or sales meetings. It has the power to cover a large audience, but weighs only 22 pounds with batteries. Identified as Perma Power Model S-210A, it includes a 35 watt amplifier, a cardioid microphone, and a full-fidelity

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speaker built right into the case, with 40-feet of cable supplied for free movement while you speak. The Sound Attaché is battery powered and will operate up to 200 hours on one set of alkaline flashlight batteries. Sells for $215.50. Literature is available upon request from Perma Power Electronics, Inc., 5615 W. Howard Avenue, Chicago, IL 60648 or telephone (312) 647-9414.

Kills TVI

Telco has a new addition to its line of Low Pass TVI Filters. The XLP-150 handles more than 150 watts AM/300 watts PEP SSB. According to the manufacturer it suppresses all harmonics above 41 MHz by more than 75 dB. The unit eliminates transmitted harmonics causing TVI. With all the fuss the FCC is now making about TVI, the SLP-150 is a must for CB stations. Easily installed in coax

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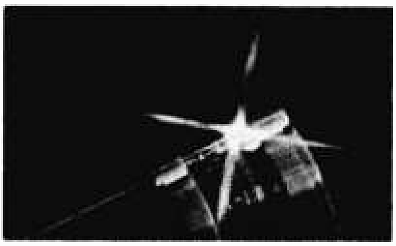
transmission line with standard PL 259 connectors. Sells for $14.50. No input/output polarity necessary. For information, contact Telco Products Corporation, 44 Seacliff Ave., Glen Cove, NY 11542.

Antenna Flasher

Shur-Lok's new CB antenna accessory, appropriately named "See Mee" Antenna Flasher, is designed to be used on loaded steel masted antennas or full-length steel whips. See Mee lights and flashes when the CB mike is keyed or a message is transmitted. The "See Mee"



CIRCLE 72 ON READER SERVICE COUPON

neon bulb is fired by the R. F. power generated by any CB Radio. The neon bulb is enclosed in a special unbreakable enclosure, decorative in the daytime, and a flashing beacon to friends at night. See Mee is easy to install, no wires to hook up, has a self locking feature, a lifetime 20,000-hour neon bulb and an unbreakable enclosure. Suggested retail price is $2.95. For more info, write to Shur-Lok Mfg. Co., Inc., 413 North Main, Hutchins, TX 75141.

Pinball Machine Kit

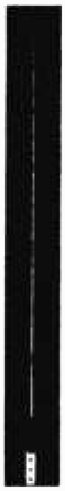
Heath is offering the Bally Fireball home pinball machine in kit form. Building the machine from a kit results in substantial cost savings over the assembled models. The Fireball machine features all solid-state electronics and a built-in computer which controls the game. Scores are displayed on a bright red LED readout and a special computer synthesizer plays dif-

CIRCLE 1 ON READER SERVICE COUPON

ferent tunes when bonuses or extra scores are made. Scores of each individual player, up to four at a time, are stored in the computer's memory and displayed automatically. Bonus balls are also awarded automatically. A *skill* control allows programming the computer for beginner or advanced play. The full-color playfield is the same size as commercial machines, and has *thumper bumpers*, *sling shots* and player-controlled flippers for plenty of ball action. The mail order price of the pinball machine, designated by Heath as model GD-1110, is $699.95. For further information, write for a free catalog to Heath Company, Dept. 350-480, Benton Harbor, MI 49022.

CB Sailboat Antenna

Ahoy, Captain! Now hear this! Gladding's U.S. Fiberglass Division introduced the CB Sailmaster. It is a fully tunable, high performance 40- and 23-channel citizens band antenna made

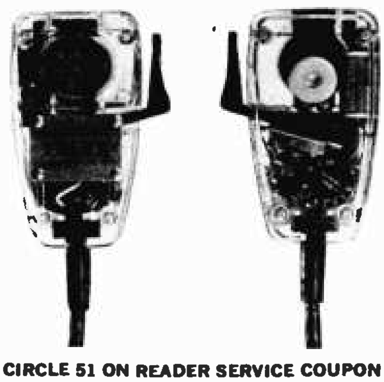


CIRCLE 71 ON READER SERVICE COUPON

especially for sailboats. It's 48-in. long and comes complete with "L" type mast mount. This CB marine antenna is constructed of military/commercial fiberglass to resist rust and corrosion. All tuning parts are completely sealed against weather and moisture for years of continued use. And the CB Sailmaster requires no ground plane—only mast mounting. Sold complete with 60-ft. white coax cable and sailboat mast mount (SMA-71). Suggested retail price is $45.95. Drop a message in a bottle to U.S. Fiberglass, Division of Gladding Corporation, 5101 N.W. 36th Avenue, Miami, FL 33142.

See-Through Case

When you report "loud and clear" on your Telex CB73 noise-cancelling power mike, you can believe it. The CB73



CIRCLE 51 ON READER SERVICE COUPON

comes in a clear, see-through case with all of the parts fully visible. You can call it a gimmick, but its three-stage integrated circuit amplifier maximizes "talk-power" without distortion—and that's no gimmick. And in a high-noise situation on the highway, you can switch to the noise-cancelling mode. Priced at $44.95, the CB73 also comes in a grey case should you not like the see-through feature. Get all the details from Telex Communications, Inc., 9600 Aldrich Ave. S., Minneapolis, MN 55420. ■

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
99 IC PROJECTS
380 Lexington Avenue
New York, NY 10017

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.

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.

Trim It

Where can I get a tuning capacitor that's exactly 365 pF? I've tried a few in a radio circuit and they tune from 550 kHz to 1430 kHz approximately. I have to get up to 1600 kHz.

—O. K., St. Louis, MO

Easiest way to get up to 1600 kHz is to trim the tuning capacitor with a trimmer capacitor placed in parallel across the tuning capacitor. The trimmer should be a 4 to 40 pF unit. Install with unit open all the way and tune by closing to raise to desired frequency. If you lose any of the bottom frequency, add some turns to the antenna coil.

Chat/Monitor Heads Up

Hank, is it against the law to operate a CB mobile rig using a headset and boom microphone as you drive a car?

—L. M., Newton, MA

No, but use your head for more than the headset. Just so happens I saw a bunch of Superex mike/phone headsets and alongside them in the showroom was the Superex mobile VOX (voice operated relay) unit, Model M-612, which permits hands-free operation while driving. Good idea. Also, one earpiece is enough when in motion, so don't get fancy and use two cutting out all road noise and sounds that will alert you to dangerous road situations. Almost all mobile headsets have only one earpiece.

No Blend At All

When playing my FM tuner, I experience the normal stereo effect. However, when I play a stereo record, much of the sound is distinctly heard at the left and right speakers rather than midway between them. What are the possible causes?

—A. S., Plainview, NJ

Sounds like your listening to those hard rock recordings where the drummer is on one channel and the lead guitar on the other. I suggest you flip to mono. Check the system out by playing a classical piece. You'll hear more blend between the channels making the stereo separation life-like.

Killocycle Kop Alert

Hank, I'm installing a phone patch on my CB radio. My question is, how do I find out which one of the pins in the microphone jack is the speech amplifier input?

—A. K., West Orange, NJ

Forget it! Phone patches on CB are illegal.

Little Sir Echo

I was wondering if you have a project that could be made to hook up to a CB radio so that when you talk your voice sounds like it came from an echo chamber or in a big empty room.

—R. S., Two Rivers, WI

I see no good reason why such an echo device should be used on CB. The purpose of CB is to communicate, for either business or hobby reasons. I don't believe in promoting "playtime" on CB.

Two-Way Communications

My dad and I are arguing over what is more important to have in a car—a radar detector or CB radio. What's your opinion, Hank?

—L. D., Fort Lauderdale, FL

That's easy to figure out. First, try calling for help with your radar detector. Get what I mean?

Poles Together

I would like to install a relaxation oscillator in my VOM so I can use it as an audible continuity tester. The speaker magnet would rest against the meter permanent magnet. Will this interfere in any way with the accuracy, life expectancy, etc. of the VOM?

—T. G., Sonnybrook, Alta.

Don't do it! Should you upset the delicate magnetic field of your VOM's meter magnet, the accuracy will be compromised.

Cops Get Religion

I have a problem with an amplifier and an electronic organ installed in our church. When a police car passes in front while transmitting, its signal overrides whatever program is on, whether it is a speech on the amplifier or music from the organ. Can you help?

—H. J., Val St-Michel, Quebec

The long leads on the PA system, are acting as antennas, and somewhere in the circuit a dielectric effect is taking place, causing rectification. Not good for the PA output. So, take some action by shielding all speaker leads and double shielding audio input leads. Ground the entire system to one common ground point. Place a small capacitor across the speaker leads at the amplifier terminals. Keep reducing the value until the capacitor does not affect sound performance. Also, talk to the cops about their chatting habits.

Where to Receiver Shop

I read about the Barlow-Wadley XCR-30, Mark III receiver in an old issue of ELEMENTARY ELECTRONICS *a while back and would like to buy one now. Who do I write to because I can't seem to buy one locally?*

—Y. L., Tucson, AZ

Write to Gilfer Associates, Box 239, Park Ridge, NJ 07656. They sell Barlow-Wadley and R.L. Drake receivers besides other goodies for the shortwave listener.

Wants More Info!

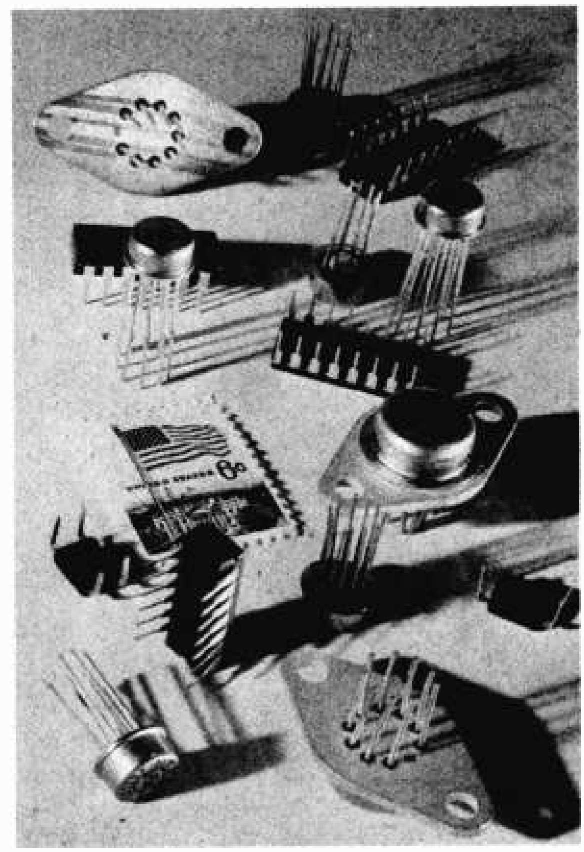
What are the advantages and disadvantages of a solid-state (semiconductor) diode over a vacuum tube diode? Please don't tell me about wasted filament power—I know about that!

—A. K., St. Louis, MO

For all practical purposes, the vacuum tube diode has no reverse current and the solid-state has. However, we are talking about reverse currents of one-thousandth or less, so that for all practical circuits you may build, there is no measurable effect. The solid-state diode cannot stand very high reverse voltages. Power supply solid-state diodes can be obtained with reverse-voltage or peak-reverse voltage (PRV) ratings up to several hundred volts, but in

(Continued on page 118)

99 Intergrated Circuit Projects



INTEGRATED CIRCUITS, digital and linear, are where it's at; that is, the state-of-the-art in electronics technology. For the newcomer to this fascinating area of electronics, we have tried to select a representative cross-section of the digital and linear integrated circuits available on the market, and design construction projects around them that not only entertain, but educate as well.

In truth, there is no easy way to learn electronic theory, at least in a manner that will prepare the individual to cope effectively with the influx of technical applications that are now reaching the home, the car, and your place of business. For those with no prior experience in the construction of electronic projects, we strongly suggest that you begin with the group of 30 Transistor projects found in a separate section of this magazine. By beginning with these simpler projects, where construction technique is less critical, you will learn, by necessity, the basics of component arrangement, lead trimming (or lead dress, as it is properly called), and the difficult art of translating those funny lines and squiggles on a schematic diagram into a working piece of electronic equipment.

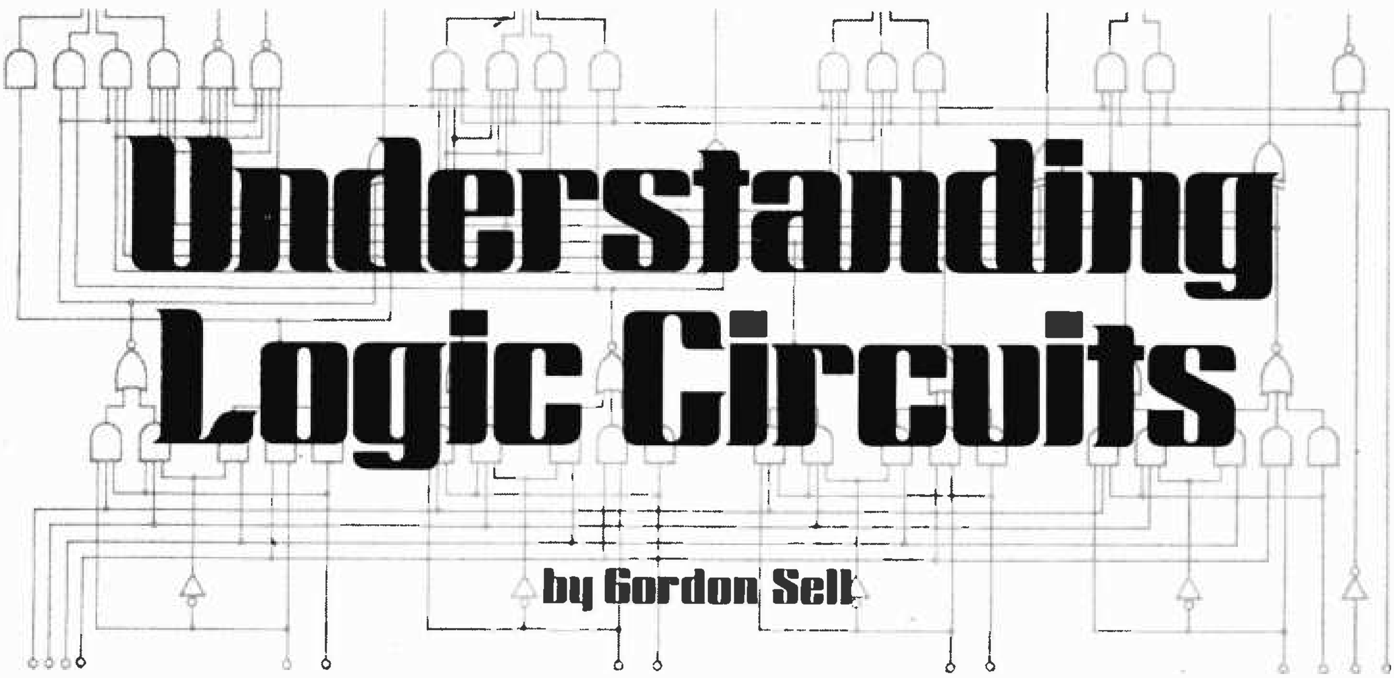
Caution! For those of you who have had experience in building transistor projects before, the word is *caution!* While integrated circuits are basically composed of groups of transistors and other common electronic components, many of them require special handling techniques. Some types, especially CMOS, are susceptible to damage in the weirdest ways. To protect your investment in these components, we have compiled a list of procedures and precautions for the handling of the ICs used in our projects with which we strongly suggest you become acquainted before you even take the trip to your local parts supply store for them.

Even though almost all devices now are designed with resistor/diode protection circuits on the input leads, it is possible for the static electrical charge built up in your body to cause damage to parts of the IC. You'll never know it happened until it's too late, so it might be a good idea to invest in a pair of non-conductive tweezers, or a standard IC puller/installer made expressly for the purpose.

Soldering. If you solder the IC leads directly into the circuit, which we don't recommend, be sure to use a heat sink on the lead between the chip and the tip of soldering iron. Use a low power iron, and apply heat for the shortest period possible. A fried IC is no fun, and it doesn't even taste good. Always ground the tip of the iron before applying it to an IC. Stray AC in the tip can also damage a chip severely, and again, you'll never know until it's too late. Unless you're using commercially made breadboards, such as Continental Specialty Corp.'s "Experimentor"™ series, whose holes accommodate IC pin spacings to begin with, we suggest that you invest in sockets for the particular ICs which you're planning to use. Through the use of sockets, solder connections can be made without the danger of damage to the IC, and voltage and input signal tests can be performed without the IC being exposed to their hazards.

When debugging a circuit, or testing for signals and voltages prior to firing your project up for the first time, it is important that you remember to NEVER apply an input signal to a chip unless the circuit is powered up. Damage will certainly occur. Also, in those projects which require a separate input signal, such as a clock source, which is not an integrated part of the circuit you're building, it's a good idea to use a power switch which is capable of controlling the supply to both circuits. This will minimize the possibility of applying a signal to a non-powered chip, both in turning on the circuit and turning it off. If you don't use this method, remember to remove the input signal before turning off the power to the IC circuit. Remember, we warned you!

Understanding Logic Circuits



by Gordon Sell

A simplified look at how logic circuits "think"

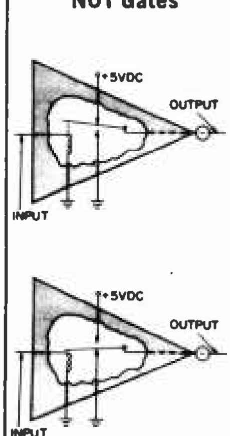
THE FIRST MISTAKE made by people trying to explain digital logic is their insistence on name dropping. They confuse a reasonably simple subject with technical terms such as CMOS, TTL, PMOS and so on and so on. There's plenty of time to learn about these later, but first we must learn what a digital logic circuit is.

A digital logic circuit is, for all intended purposes, a *solid state relay network*. After a statement like this there are probably a few engineers out there grinding their teeth and pulling out their hair, but this basic definition will help you more than any explanation of "electron movement through silicon substrates."

All digital logic circuits can be broken down into combinations of three basic *logic gates*. These gates receive information in the form of one or more inputs of a high- or a low-voltage level —usually +5 volts DC and 0 volts (ground potential). Depending on what type of gate it is, an appropriate voltage level appears at the output. The three basic gates are called NOT, AND and OR. Their operation can be simulated by using plain old-fashioned mechanical relays.

***NOT* Gates.** Now we will see where the relays come into action. Look at the diagrams of the NOT gate. When there is no input voltage the relay is not energized and the relay contact connects the output to the high voltage level. In other words, a low input is inverted by a NOT gate. When a high voltage level is applied to the input the relay energizes and connects the output to ground potential. The gate has inverted the high input to a low output. No matter what the input is, it is NOT the output.

NOT Gates



This is the magnetic-relay equivalent of a logical NOT gate. When the input is too low to energize the magnet the relay contact is connected to the 5-volt DC power source. So, when the input is low the output is high. In the second diagram the input is high enough to energize the relay and the contact is grounded. When input is high, output is low.

The next two gates, the AND and OR gates, are a bit more complicated since they have two or more inputs. When you think of them try to think of the AND gate as a *series* gate and the OR gate as a *parallel* gate. This may not be clear yet but it will help you to keep things straight in the future.

***AND* Gates.** In order for the output of an AND gate to be high all inputs must be high. If any of the inputs are low the output will be low. Look at the first of the AND gate diagrams. Both inputs are low and neither relay is energized. The relay contacts connect the output to ground and therefore the output is low.

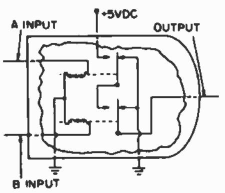
In the next two diagrams we try putting a high on one or the other inputs. In each situation the output is still connected to ground and the output is low.

When all of the inputs are high the relay contacts connect the output pin to 5 volts DC and the output of the gate is high. Any number of relays could be added in a similar manner and the output would be high only when all inputs were high, hence it is a series gate.

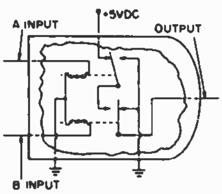
***OR* Gates.** An OR gate is a parallel gate and its output is high if any of its inputs are high. In the first diagram all the inputs are low and none of the relays are energized. The contacts of the relays connect the output pin to ground and the output is low. In the next two diagrams one of the inputs is high while the other is low. Now the output is connected to 5 VDC and the output pin is high. A resistor has been added to each ground line to prevent an internal short circuit when one contact is on high while the other is low. In the last sketch both relay contacts are connecting the output to the high-voltage source, and the output is high. As with the AND gate, any number of relay circuits could be added in this parallel format. If any number of inputs are high then the output will be high.

Now we have learned how our three basic digital logic gates work. Of course, in an actual logic circuit the relays are

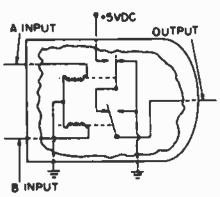
AND Gates



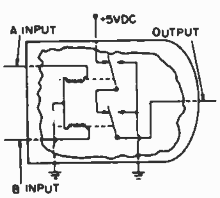
When both inputs to an AND gate are at a low level, as is shown in the first diagram, the relays are de-energized. Each set of contacts connects the output to ground.



In the second diagram input A is at a high voltage level (typically 5 volts DC) and the upper relay is energized, yet the output is still low.

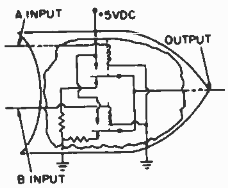


Now, in the third diagram, we put a high on the B input. The lower relay is energized but the output pin is still grounded.

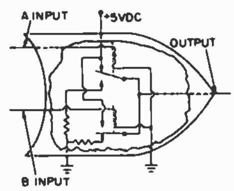


In the last diagram we see what happens when both input are high. The two relay contacts connect the output to 5 VDC. The output will be high only if both inputs are high.

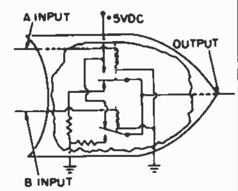
OR Gates



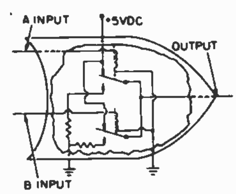
In the relay-equivalent circuit of an OR gate we have added a couple of resistors to prevent an internal short circuit. Note that when both inputs are low both relay contacts connect the output to ground.



In the second OR gate diagram the upper relay is energized by a high voltage level at the A input. This connects the output to the 5 VDC contact of the relay



In the third diagram the B input is high while A is low. Again you can see by tracing out the current flow that the output will be high.



By now the last diagram should need little explanation. Both relays are energized and the output is connected to 5 VDC through both relay contacts.

replaced by integrated circuit transistors that switch the levels from high to low, but the inputs and outputs are the same.

Combinations. By now you are probably asking why this article has ignored all the other gates you've probably heard about—the NAND and NOR gates for example. The reason is that these and all other logic gates are combinations of the three basic gates. A NAND gate is really a NOT/AND gate since it is a combination of the two. In the diagram of the NAND gate you will see that it is an AND gate who's output is inverted by a NOT gate. For example: When any of the AND gate's inputs are low the output is low, but now the input of the NOT gate is low so its output is high. If all AND gate inputs are high then the input to the NOT gate is high and its output is low. Therefore the output of a NAND gate is high unless all inputs are high, and then the output would be low. The output of a NAND gate is always the opposite of an AND gate if the inputs are identical.

A NOR or NOT/OR gate works in much the same way except that its output is the opposite of an OR gate. A NOT gate is added to the output of the OR gate turning the lows to highs and the highs to lows. A NOR gate's output will be high when both inputs are low, and its output will be low when one, or both, are high.

Exclusive Gates. Two more important gates are the exclusive OR and exclusive NOR gates. The exclusive OR gate has a low output when the inputs are either all high or all low. If one input is high and the other low then the output is high. An exclusive NOR gate, as you might have guessed, has a high output if the two inputs are the same and a low output if they are not the same. An exclusive OR or NOR gate can only have two inputs.

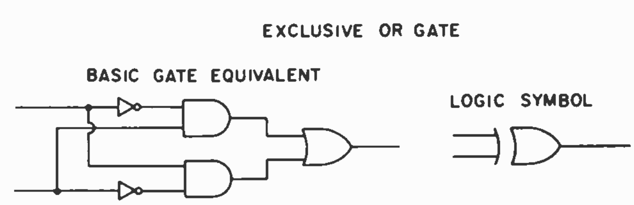
Making an exclusive OR gate is a little more tricky. It comprises two NOT gates, two AND gates and an OR gate. Study the diagram of this gate and see what happens. When both inputs are the same the two NOT gates cause each AND gate to receive a high and a low. They will, in turn, put a low on each input of the OR gate and its output will be low. Now, if we put different signals into the two inputs the NOT gates will criss-cross the signal levels so that one AND gate receives two lows and the other two highs. This will put a high on the OR gate's input and its output will also be high. To make this and exclusive NOR gate we just add a NOT gate to the final output.

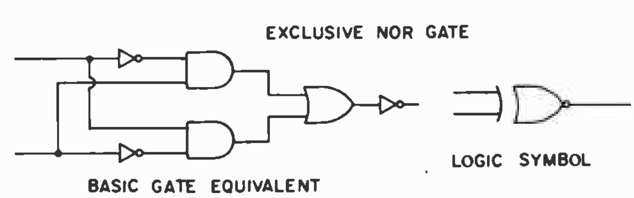
Flip Flops. You now have a pretty-good understanding of how digital logic circuits work, but there is one more type of device that needs some explaining—the flip-flop. The best way to understand about flip flops is to think back to your childhood when you used to play a game called "Red Light—Green Light." One kid was "it" and the others could only sneak up on him when he turned his back and said "green light." If he said "red light," everyone had to freeze in whatever positions they were in before he turned around and stay that way until he gave another "green light." A flip flop works just like that. When the circuit gets the "red light" its output freezes at whatever level is on the input at that moment. An actual flip flop may have a few more frills but if you remember red light, green light you should have no problems with these handy devices.

To see how a flip flop works we have to put our collection of logic gates together in a more-complex fashion. There are actually two main sections in a flip flop, the gating network and the flip flop itself.

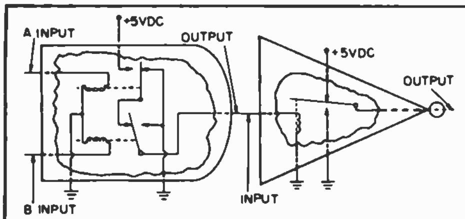
First, let's take a look at the gating network. There are two inputs—the data input and the latch (red light—green

Exclusive Gates are special combinations of logic gates. Use your knowledge of the three basic gates to see how the exclusive OR gate and exclusive NOR gate operates. First, see what happens when both inputs are low; then make A high and B low; then B high and A low; then try it with both A and B at a high level. See how the two gates are opposites.

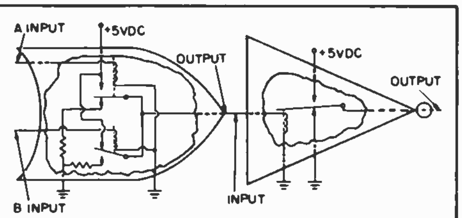




light) input. Now, consider what happens under green-light conditions when the latch input is high. This input is connected to one input on each of 2, two-input AND gates. (Refer to the gating network diagrams). The data input is split into two lines, one goes straight into one AND gate and the other goes through a NOT gate to put the opposite signal on the other AND gate. These two inputs are referred to as D and $\overline{D}$ ("data bar" is how "$\overline{D}$" is said), D being the data and $\overline{D}$ being its opposite or compliment.

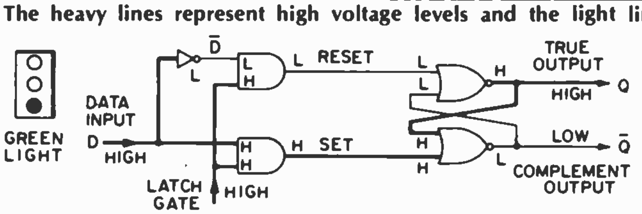


An AND gate in series with a NOT gate is a NAND gate. It is normally shown as an AND symbol with a circle to represent an inverted output. Trace out the current flow with different inputs.

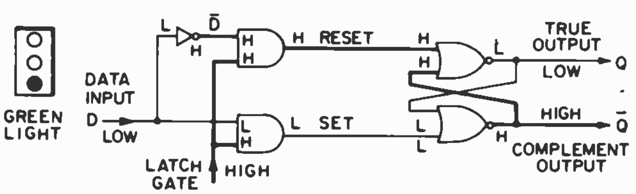


An NOR gate is an OR gate with its output inverted by a NOT gate. It is represented as an OR symbol with a small circle at the output. Again, trace out the circuit for all possible input combinations.

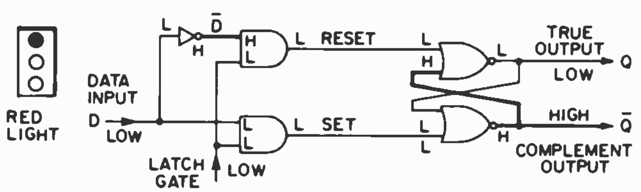
The heavy lines represent high voltage levels and the light lines represent low levels.



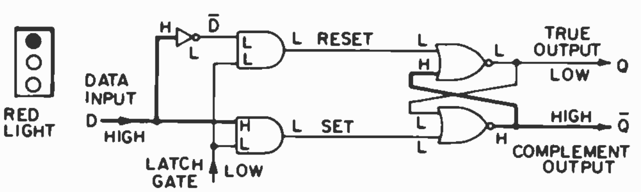
Under green-light (latch input high) conditions with a high data input, the set line is high and the reset low. The true output is high and it is fed back to reinforce the set line's data input.



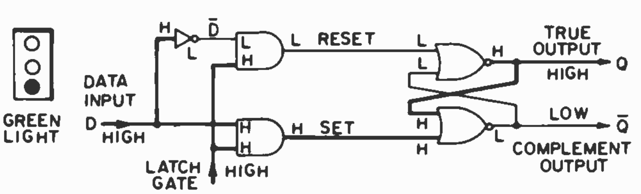
A low data input will toggle the set and reset lines to their opposite levels. Now the compliment output is high and it reinforces the reset line.



Changing the latch input to a low voltage level causes both AND gates to have a low output on set and reset. The compliment output, however, still keeps a high on the reset NOR gate and the true output is still low.



If the data input now toggles to a high value it will have no effect on either the true or the complimentary outputs. The flip flop is now latched tight.



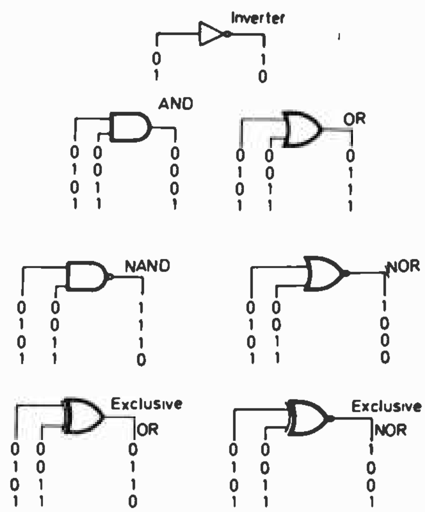
In this diagram we return the high voltage level to the latch input. The circuit is now free to toggle back and forth with the incoming signal.

The outputs of the AND gates are called set and reset. When D is high, set is high and reset is low. When D is low then reset will be high and set low. The levels on these two lines will toggle back and forth with the level of the input data.

The set and reset lines, known as S and R, feed into the two NOR gates that make up the flip flop section of the circuit. The second input of each NOR gate is fed by the output of the other NOR gate. As the levels on the S and R inputs change then so changes the output of the flip flop. Flip flop outputs are referred to as Q (the value equal to the true data input) and $\overline{Q}$ its compliment. Now, what happens when the light turns red?

Applying a low level to the latch input changes things around considerably. Both AND gates now have a low on one of their inputs. No matter what other signals they may receive, their outputs will both be low and therefore the R and S inputs to the flip flop will be low. If the flip flop is toggling back and forth, with the outputs alternately going high and low, when R and S both go low the toggling will stop. The outputs Q and $\overline{Q}$ will hold at the last value before the red light. If you study these diagrams for a few minutes then it will all become very clear.

Basic Logic Symbols



Above are all the elementary gates but this time we have used the common logic level indications of "0" for Low and "1" for High. This type of chart is called a truth table.

Once you have learned how all these different logical circuits operate you will be able to work out some more complicated arrangements, and perhaps even spend some time researching the differences between TTL, CMOS and all those other little digital details. ■

Transistor Logic Demonstrators

NOW THAT YOU fully understand the ins and outs of basic digital theory, (well, it made sense to us anyway) you're probably itching for a bit of hands-on experimenting to see if what we've said really works, and how it applies to the projects you're eagerly waiting to build. The following four quickie demonstrator projects can be assembled in a snap with parts you probably already have cluttering up the junk box. You might want to leave these demonstrators assembled as you build the IC projects, to serve as a logic guide for checking out and trouble-shooting the projects in their final phases.

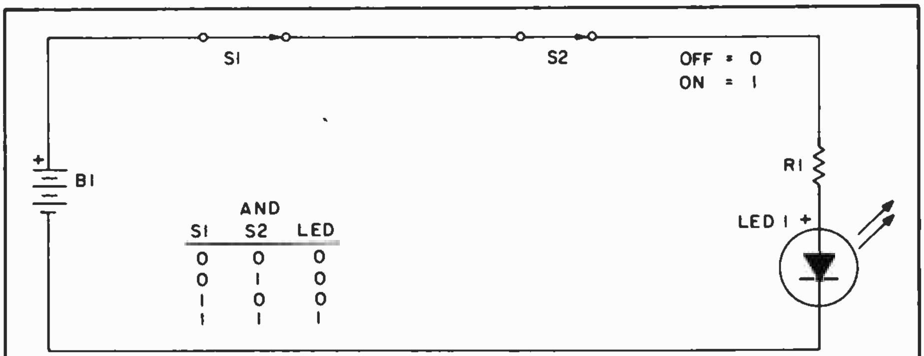
The size of these demonstrators also serves as an indicator of just how far the electronics industry has advanced in the space of just a few years, in terms of miniaturization of components, and component groups. Imagine what it would be like to build even the most rudimentary of our 99 Integrated Circuit projects, if each and every gate had to be hand-fabricated and wired point-to-point! By the time the builder got done with the making of the ersatz ICs, he or she wouldn't feel much like tackling the construction project for which they were intended. On this scale of construction, the Apollo spacecraft would have had to be as big as a Navy destroyer to contain all of the electronics necessary for the lunar voyage! While you may gripe about Detroit's shrinking cars, and your favorite restaurant's shrinking portions, be thankful for shrinking circuits!

Don't forget about the energy crisis either! Just because you're not queueing up in mile-long lines for gasoline, don't think that electrical power is all that free and easy to come by. These circuits require the full output of a nine volt transistor battery to make them operable. Their equivalents in IC form use, in many cases, half the voltage, and only one-tenth the current. In practice, the efficient use of energy by the new types of integrated circuits can allow them to be powered by some of the less conventional, and ostensibly cheaper, sources of electricity, such as small photocells, thermo-chemical body-heat generators, and the like. In fact, if electrical consumption in industry was reduced the way it has been for and by the new ICs, we probably wouldn't need all of the new generating facilities currently being planned and fought over today!

AND Logic Demonstrator

☐ In digital logic, an AND statement is true only if all parts of the logic leading to it (its inputs) are all true. If we take "true" to mean "on", a logic state we define as "1" (and not true = off = 0), we can see that a series switch configuration is a good way to illustrate the AND logical statement.

In integrated circuit logic, instead of actual mechanical switches, transistors are used as switches. Specifically, this circuit demonstrates the action on a "two-input AND gate." Only if both switches are on will the L.E.D. turn on. Similarly, you can expand the demonstrator to demonstrate as many inputs to an AND gate as you have switches to connect in series.



Once again, we present the "truth table" of this particular circuit which will tell you exactly what's happening and when. Truth tables are often used in digital design, and can be indispensable. Depending on the device they can be quite long.

PARTS LIST FOR LOGICAL "AND" DEMONSTRATOR

B1—9VDC battery
LED1—Light emitting diode
R1—470-ohm resistor, ½-watt
S1, S2—SPST switch

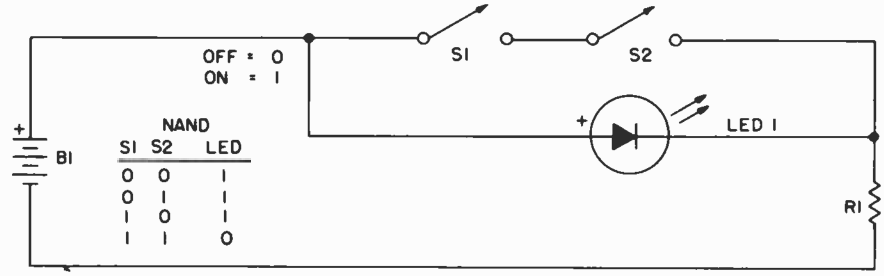
NAND Logic Demonstrator

☐ NAND is logic shorthand for "Not And." So a NAND gate has an output of 1 only when an AND gate would not. Compare the right column (results, or output) of an AND gate truth table to that for the NAND gate above and you will see that they are exactly opposite.

Here, the L.E.D. will turn on only if the two switches are *not* both turned on. Be careful that the series combination of S1 and S2 can short out only the L.E.D. and not R1 as well or your battery will not last more than a few seconds. R1 limits the current drain on the battery to about 20 milliamps.

PARTS LIST FOR LOGICAL "NAND" DEMONSTRATOR

R1—470-ohm resistor, ½-watt
S1, S2—SPST switch
B1—9 VDC battery
LED1—Light emitting diode

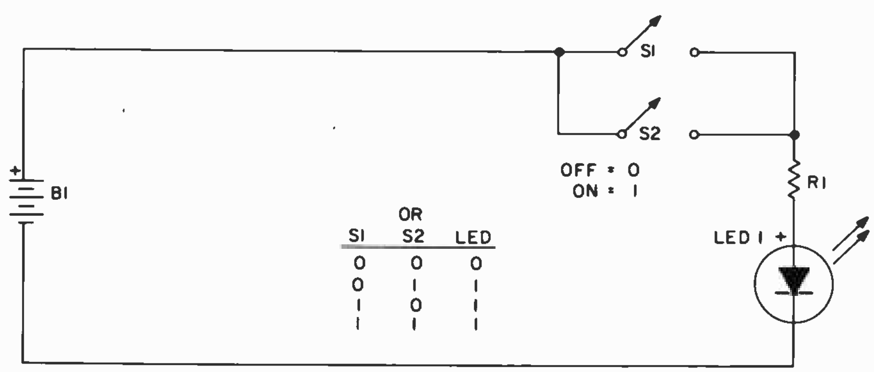


OR Logic Demonstrator

☐ In digital logic, an OR statement is true if any one of the statements leading to it is true. Parallel switches are a good analogy for the OR logic function. If any of the parallel switches are on (=true="1"), the L.E.D. turns on. While this circuit demonstrates the operation of a "two-input OR gate," you may add as many parallel switches as you like to demonstrate the action of "wider" OR gates.

OR gates are very widely used in alarm circuits, for example, where an alarm should be sounded whenever anything occurs at any one of the several inputs. The chart of numbers is known as a "Truth Table." The columns at the left identify the states of the various inputs, the column at the right the state of the output. Compare the results (right column) of this Truth Table with the results of other types of logic and you will see why digital logic systems can be so versatile.

The nice thing about this circuit is that it's so visual. You'll find that it's so much easier to understand digital logic when you can watch what's happening rather than reading about it.



PARTS LIST FOR LOGICAL "OR" DEMONSTRATOR

B1—9 VDC battery
LED1—Light emitting diode
R1—470-ohm resistor, ½-watt
S1, S2—SPST switch

NOR Logic Demonstrator

☐ Just as the output of a NAND gate is the opposite of that for an AND gate, this NOR gate produces results opposite those of an OR gate.

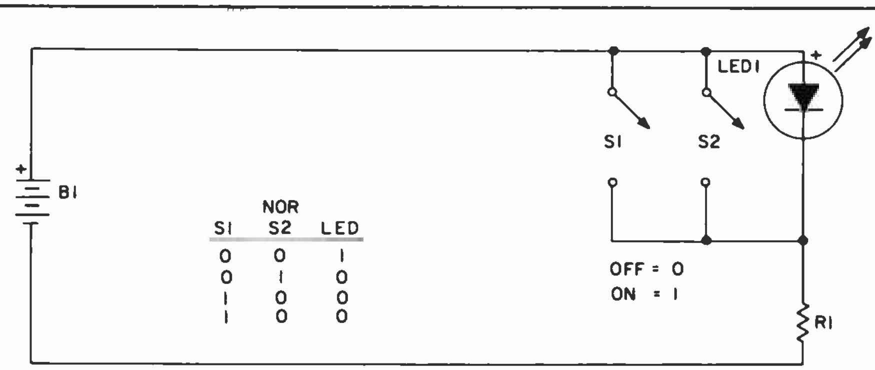
LED1 will turn on when neither S1 *nor* S2 are on.

A NOR gate is a good way to handle a failsafe system in which a circuit cannot operate unless all systems are "go"; in other words, if any of the inputs are on, the system cannot be.

This truth table compares the operation of different types of logic gates:

Think of 0=off=not true,
1=on=true

Digital logic is certainly in the forefront of modern electronics. Circuits such as this NOR Demonstrator can help to prepare you in understanding complex circuitry. The principles you learn remain the same as in actual digital circuitry—only the method of achieving demonstrable results changes.



PARTS LIST FOR LOGICAL "NOR" DEMONSTRATOR

B1—9 VDC battery
LED1—Light emitting diode
R1—470-ohm resistor, ½-watt
S1, S2—SPST switch

Solderless Breadboarding

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

by Paul Kaufman

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

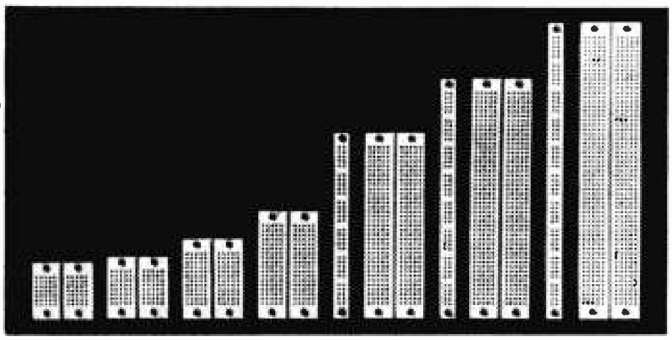
More Work in Less Time. To the electronics professional, engineering and technician time is a valuable resource, and it's really no different for electronics enthusiasts who spend late weekday hours or entire weekends experimenting with new circuits. But how, exactly, is the time spent? With solder in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

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

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

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

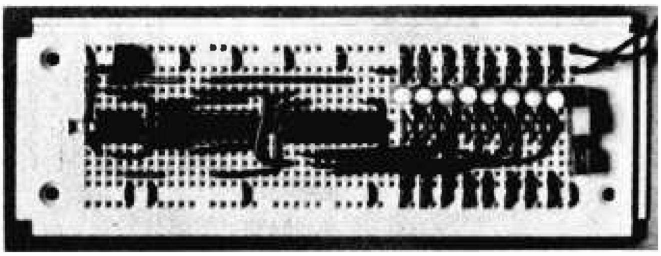
Figure 1.



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

Leads from all components, including DIP (dual-inline

Figure 2.



package) integrated circuits, are inserted directly into the sockets, and interconnections are accomplished with short lengths of #22-30 AWG solid hookup wire, stripped of insulation at either end. The result is a neat, compact layout that can be used for testing, or actually built into a housing or mounted on a baseplate and used as a completed project. Changes are no problem either. Changing a wire from one lead or another typically takes less than 10 seconds even if the socket is crowded with components.

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

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

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

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

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

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

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

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

Figure 3.

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

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

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

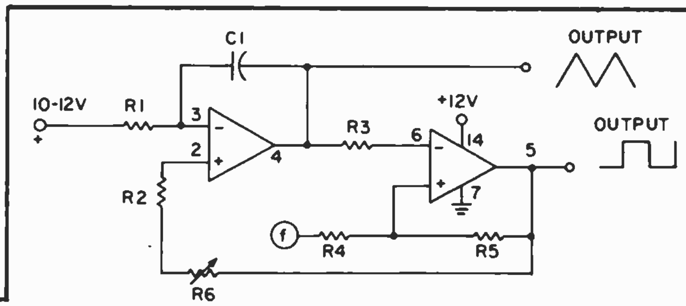
To jump two or more tie-points, you'll need short lengths of wire. Almost any #22-30 solid hookup wire will do. Strip insulation a bit more than ⅜ inch from each end, to allow for insertion and bending, and be careful not to nick the wire when stripping it. When estimating jumper length, allow a total of a bit more than ¾ inch (for the ⅜ inch-plus of bare wire you'll need at each end), plus any extra wire required for bending, to make a neat layout. And don't throw those jumpers away! They can be re-used again and again, so store them on an unused portion of your socket, or in a plastic box.

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

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

1. Double Feature

☐ The versatile quad op amp LM-3900 (or MC-3401) can easily be persuaded to deliver two different waveforms from two of its sections, reserving the other two for mixing or amplification purposes. Section one is an integrator, furnishing a fine triangular waveform, the other unit supplies a square wave signal. Adjusting R6 varies both frequency and duty-cyle (symmetry) of the two waveforms. A C1 value of .001 uF will give a frequency of about 1 kHz, while .01 uF will be close to 100 Hz.

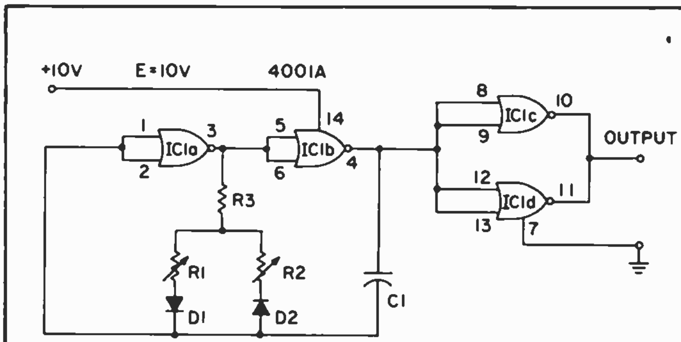


PARTS LIST FOR DOUBLE FEATURE

C1—.001 or .01-uF ceramic capacitor
IC1—LM-3900 or MC-3401 op amp
R1, R4—1,000,000-ohm, ½-watt resistor
R2, R3—100,000-ohm, ½-watt resistor
R5—120,000-ohm, ½-watt resistor
R6—500,000-ohm, linear-taper potentiometer

2. Basic Pulse Maker

☐ Need a basic square-wave generator for all those digital projects? This quad NOR gate 4001A CMOS chip which can be easily obtained, stands ready to do the job with great simplicity. Note the two pots, R1 and R2. These govern both frequency and duty-cycle (symmetry), via diodes D1 and D2. C1 determines the overall frequency range. A C1 value of 0.1 uF, produces a range of about 11 to 2500 Hz. Using a 0.2 uF value, the range is about 4 to 700 Hz. The remaining two gates (pins 8-13) act as buffers, to isolate the oscillator from the effects of circuit loading. Duty cycles of almost 10 to 1 can be obtained.

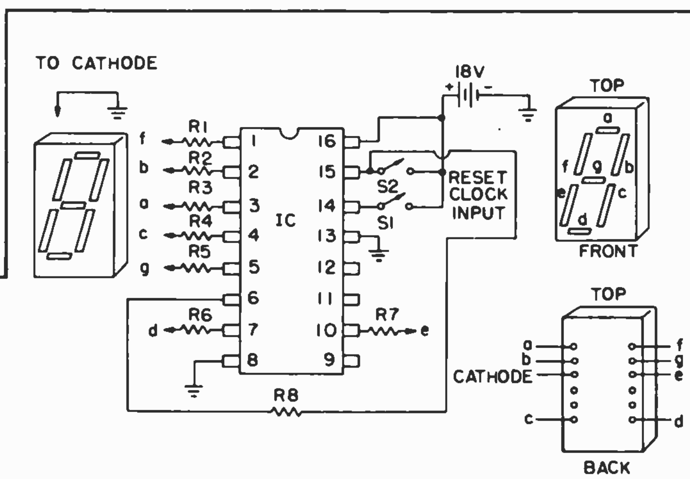


PARTS LIST FOR BASIC PULSE MAKER

C1—0.1-uF capacitor for 11-to-2500 Hz range, 0.2 uF capacitor for 4-to-700 Hz range
D1, D2—1N4148 diode
IC1—4001 A quad NOR gate
R1, R2—500,000-ohm, linear-taper potentiometer

3. Quicker Than The Eye

☐ The faster you can repeatedly press S1, the faster the segments of the digit "8" will fly around the LED display. The fun of this quicker than the eye game is to see if you can make the 8 look like a solid number. We have here the basic multiplex principle used in calculator displays. In calculators only one segment of a digit is on at a time, but the rapid change makes it appear that all are on. Pin 6 above is used to reset to zero.

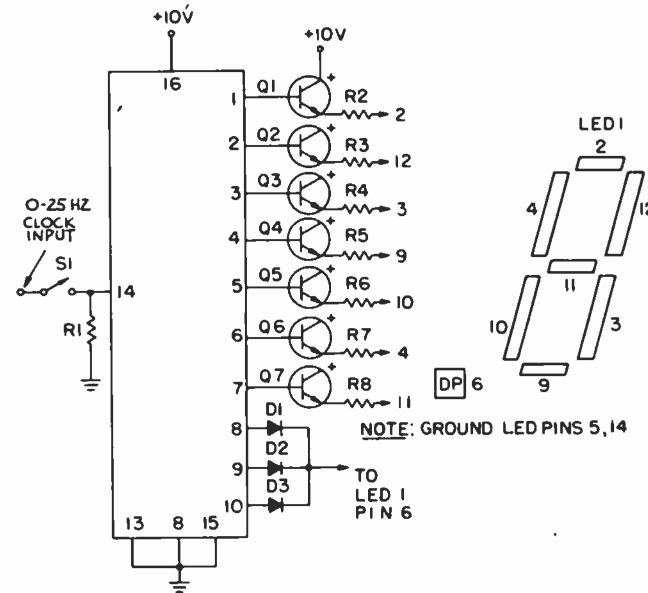


PARTS LIST FOR QUICKER THAN THE EYE

IC1—4017 decade counter
LED1—DL-750 7-segment display
R1 through R7—680-ohm, ½-watt resistor
R8—1,200-ohm, ½-watt resistor
S1, S2—SPST momentary-contact pushbutton switch

4. Common Cathode Casino

□ The counter-display circuit of the "Quicker Than the Eye" project can be adapted to a game of chance for up to seven players, with a built-in provision to insure that "The House Never Loses." Note that all seven display segments, like the previous circuitry, have only one connection. Three outputs (pins 8, 9, 10) now go to the decimal point, via isolating diodes D1, D2, and D3. This gives "The House" a 3 out of 10 chance to take all bets. The clock should be set to provide a rapidly flickering display when the push-button switch is depressed. When the player holds down the switch for a few seconds and releases it, one of the segments, or the decimal point will remain lighted . . . and the odds are on the Point!

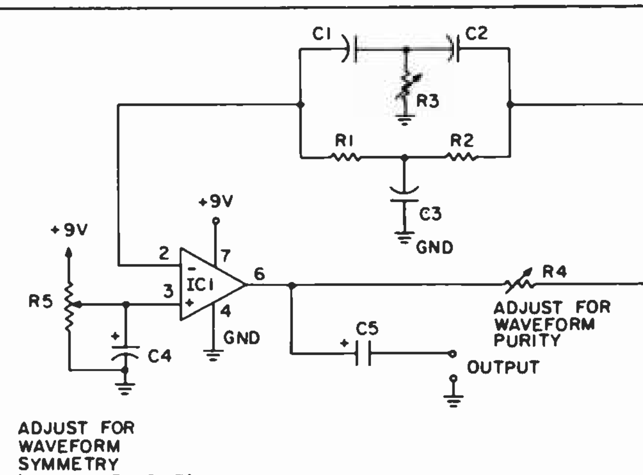


PARTS LIST FOR COMMON CATHODE CASINO

D1, D2, D3—1N4148 diode
IC1—4017 CMOS decade counter
LED1—DL-750, 7-segment display
Q1 through Q7—2N4401
R1 through R8—1,000-ohm, ½-watt resistor
S1—SPST momentary-contact switch

5. Sinusoidal Source

□ The 741 op amp has become a classic for IC designers. Here it is as a Parallel-T audio oscillator, operated from a single power supply, which can be a 9 volt transistor battery. Note that the frequency-determining resistors and capacitors are fixed in the ratio of C1 = C2, C3 = 2 × C1 and R1 = R2, R3 = R1 × 0.1. To vary the frequency, all three pots should be ganged, but a fair degree of adjustment can be accomplished by varying R3 alone, although the output amplitude will fall on each side of the optimum value.



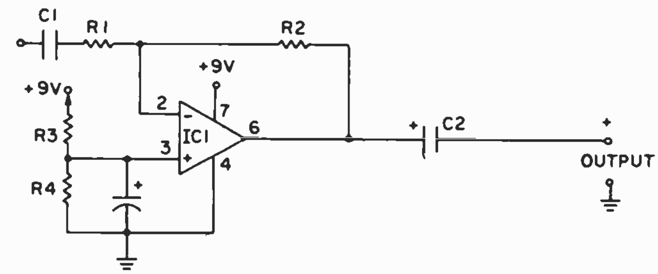
PARTS LIST FOR SINUSOIDAL SOURCE

C1, C2—0.022-uF, 10 VDC ceramic capacitor
C3—0.047-uF, 10 VDC ceramic capacitor
C4—100-uF, 15 VDC electrolytic capacitor
C5—10 to 20-uF, 15 VDC electrolytic capacitor
IC1—741 op amp
R1, R2—47,000 to 56,000-ohm, ½-watt resistor
R3, R5—5,000-ohm, linear-taper potentiometer
R4—100,000-ohm linear taper potentiometer

6. Single Supply Signal Shifter

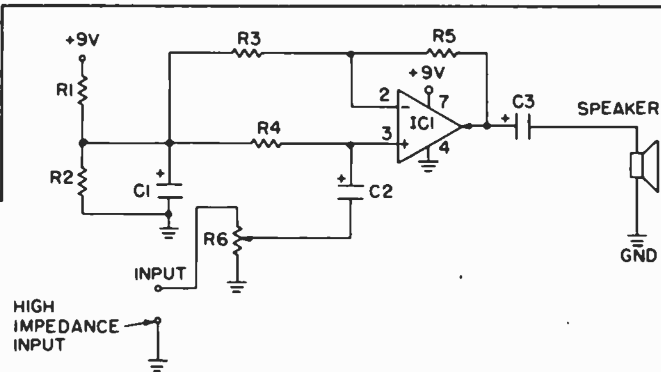
□ Op amps, like the popular 741, are usually operated with matching plus and minus power supplies. However, for simple signal amplification applications, the single positive supply shown below has been found to work quite nicely. Resistors R3 and R4 may be fixed at about 5000 ohms each, or replaced with a 5K or 10K potentiometer, if it is desired to adjust the no-signal output level so that high-amplitude signals will not be clipped. Sometimes, intentional clipping is desired, so this feature may be retained for general experimental applications. Note: If a potentiometer is used for R3, R4, connect center terminals of pots to pin #3 of IC1.

PARTS LIST FOR SINGLE SUPPLY SIGNAL SHIFTER
C1—0.01-uF ceramic capacitor, 15 VDC (gain=10)
—0.10-uF ceramic capacitor, 15 VDC (gain=100)
C2—1 to 100-uF electrolytic capacitor, 15 VDC (increase value with frequency)
C3—100-uF electrolytic capacitor, 15 VDC
IC1—741 op amp
R1—10,000-ohm, ½ watt resistor
R2—100,000-ohm, ½ watt resistor (gain=10)
—1,000,000-ohm, ½ watt resistor (gain=100)
R3, R4—5,000-ohm, ½ watt resistor or 5,000-10,000 ohm linear taper potentiometer



7. Micro-Mini PA

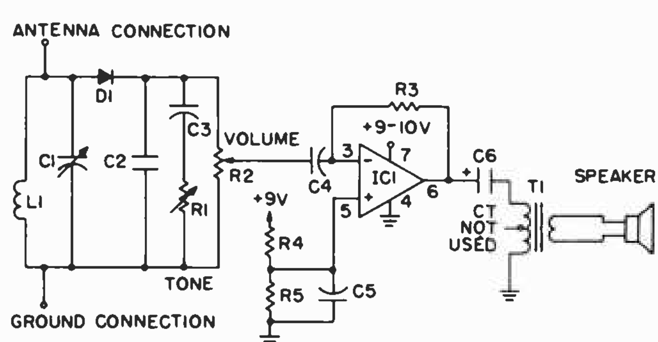
☐ Designed for *very* private listening, this little amplifier sports a tiny loudspeaker of 1½ to 2 inches diameter. The gain may be varied through the feedback resistor from about 1 to 100. Only a single power supply, which may be a nine volt transistor radio battery, is required.



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

8. Mini-Modern Crystal Set

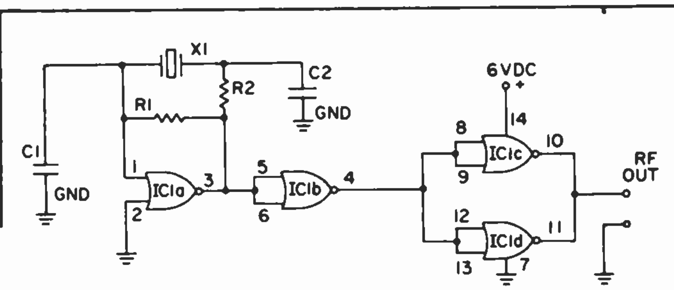
☐ A 741 mini-power-amplifier can update those 1N34 "cat's whiskers" crystal receivers right into the Space Age. Depending on antenna and ground facilities, good reception is possible with clear volume from the tiny speaker. A 9-volt transistor battery provides portable radio convenience for escaping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



PARTS LIST FOR MINI-MODERN CRYSTAL SET
C1—365-pF variable capacitor
C2—0.01-uF ceramic capacitor, 15 VDC
C3, C4, C5—0.1-uF ceramic capacitor, 15 VDC
C6—50-100-uF electrolytic capacitor, 15 VDC
D1—1N34 diode
IC1—741 op amp
L1—loopstick coil
R1—25,000-ohm linear-taper potentiometer
R2—25K to 50,000-ohm audio taper potentiometer
R3—1,000,000-ohm, ½-watt resistor
R4, R5—4,700-ohm, ½-watt resistor
T1—500/8-ohm audio output transformer
MISC.—8-ohm 2 in. PM type speaker; snap type 9 V battery clip

9. Crystal-Controlled CMOS

☐ An inexpensive crystal is the color-control TV crystal, operating at approximately 3.58 MHz. With the circuit shown below, a handy signal, suitable for dividing down to many other frequencies, including a 60 Hz reference for portable clocks, is easily obtained. Unused gates from the 4001 quad-NOR chip are used as buffers.

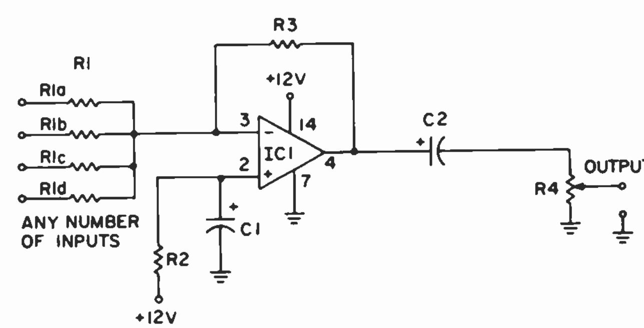


PARTS LIST FOR CRYSTAL-CONTROLLED CMOS

C1—33-pF mica capacitor, 15 VDC
C2—27-pF mica capacitor, 15 VDC
IC1—4001AE quad NOR gate
R1—1,000,000-ohm ½-watt resistor
R2—10,000-ohm ½-watt resistor
X1—3.58 MHz crystal (TV color carrier type)

10. Mixing It Up

☐ When a number of audio signals are to be mixed or blended, isolation should be maintained between the originating sources. Using the almost identical LM 3900 or MC 3401 quad op amps, twelve organ tone generator outputs were combined into one output via one section. In the circuit below, signals of 4 to 5 volts peak amplitude were mixed at unity gain. Resistor R2 is usually twice the value of feedback resistor R3, but it can be varied to shift the output level and avoid or purposely introduce waveform clipping.

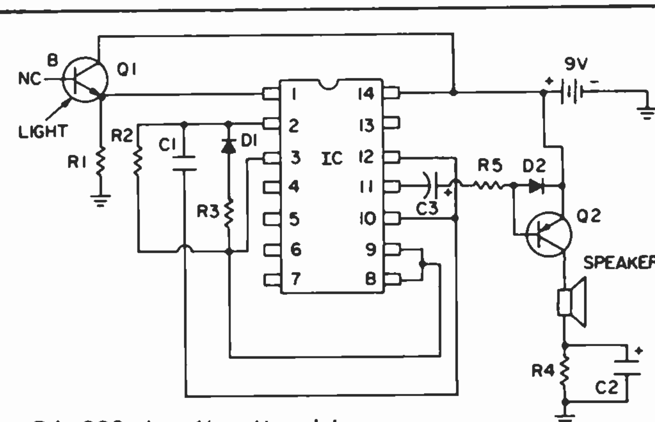


PARTS LIST FOR MIXING IT UP

C1—7 to 10-uF electrolytic capacitor, 25 VDC
C2—50-uF electrolytic capacitor, 25 VDC
IC1—LM-3900 or MC-3401 quad op amp
R1—100,000-ohm ½-watt resistor (as many as needed)
R2—200,000-ohm ½-watt resistor (see text)
R3—100,000-ohm ½-watt resistor (see text)
R4—25,000-ohm audio taper potentiometer

11. Sun-Up Alarm Clock

☐ Phototransistor Q1 is very sensitive to light. The sun shining on this small device will cause a 100 Hz tone to wake you in the morning. Or you can use it in dozens of



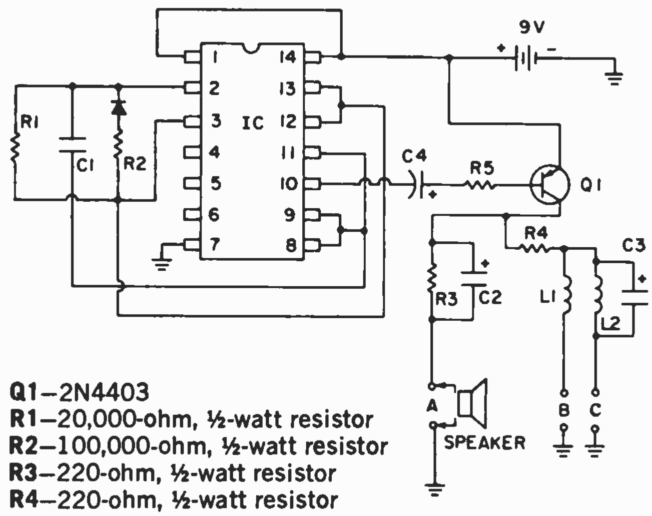
PARTS LIST FOR SUN-UP ALARM CLOCK

C1—0.1-uF disc capacitor, 15 VDC
C2—6.8-uF electrolytic capacitor, 15 VDC
C3—2-uF electrolytic capacitor, 15 VDC
D1—1N4001 diode
IC1—4011 quad NAND gate
Q1—FPT100 phototransistor
Q2—2N4403
R1—300,000-ohm, ½-watt resistor
R2—15,000-ohm, ½-watt resistor
R3—150,000-ohm, ½-watt resistor
R4—220-ohm, ½-watt resistor
R5—1,000-ohm, ½-watt resistor

other ways, anywhere you want to sense a light beam. Light left on in the garage? Headlights working? This circuit is the start of interesting ideas. The base of Q1 is not connected to anything. The speaker can be a small 8 ohm unit and you will find that a small 9V transistor radio battery works well and lasts a long time.

12. Organ-Plus Tone Generator

☐ Musical organ-like sounds can be generated with this CMOS circuit. The IC generates a nearly square-wave output from pin 11 and the spacings on that output stream of pulses can be varied by changing R1 and R2. If you change them smoothly, you can get a slide-trombone effect. Outputs A, B, and C are different from the pin 4 output in that the square wave now becomes a sawtooth, a spike and a complex combination of both. Rich overtones result that you can hear with the 8-ohm speaker.

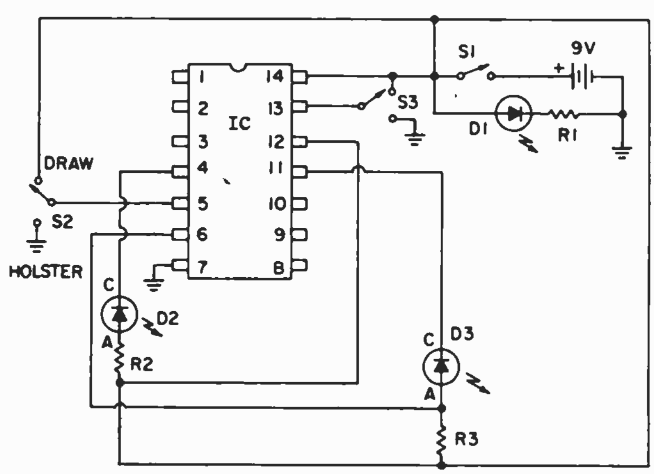


PARTS LIST FOR ORGAN–PLUS TONE GENERATOR

C1–0.2-uF disc capacitor, 15 VDC
C2–4.7-uF electrolytic capacitor, 15 VDC
C3–6.8-uF electrolytic capacitor, 15 VDC
C4–2-uF electrolytic capacitor, 15 VDC
D1–1N4001 diode
IC1–4011 quad NAND gate
L1–2.5-millihenry RF choke
L2–2.5-millihenry RF choke
Q1–2N4403
R1–20,000-ohm, ½-watt resistor
R2–100,000-ohm, ½-watt resistor
R3–220-ohm, ½-watt resistor
R4–220-ohm, ½-watt resistor
R5–1,000-ohm, ½-watt resistor
SPKR.–8-ohm PM type

13. Quick Draw

☐ The object of "Quick Draw" is to test your reaction time against your opponent's. A third person acts as referee and begins the duel by pressing S1, which lights LED D1. Upon seeing D1 lit, you try to outdraw your opponent by moving S2 (or S3) from "holster" to "draw" before he does. If you do, D2 (or D3 if you use S3) will light first and will automatically prevent the other LED from lighting. A clear winner every time.



PARTS LIST FOR QUICK-DRAW

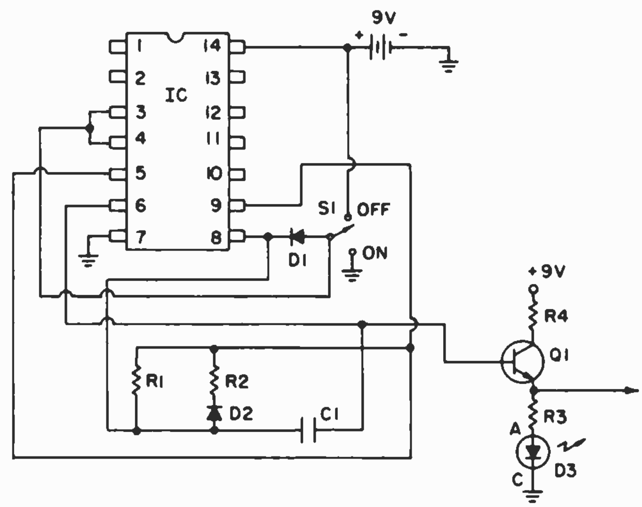
D1, D2, D3–large LED
IC1–4011 NAND gate
R1–2,000-ohm, ½-watt resistor
R2, R3–1,000-ohm, ½-watt resistor
S1–pushbutton (doorbell) SPST switch
S2–toggle-type SPDT switch
S3–toggle-type SPDT switch

14. Pulsed Alarm

☐ This circuit is great for driving alarms because it pulses the bell or buzzer with a frequency you can select via R1 and R2. The pulsing action not only gets attention faster, but saves battery power as well, because the alarm can run longer. And the beauty of this circuit is its low power consumption. In the off state, before the panic switch S1 is thrown, the circuit uses microwatts of power, so it can sit ready for months. That's one of the beauties of CMOS.

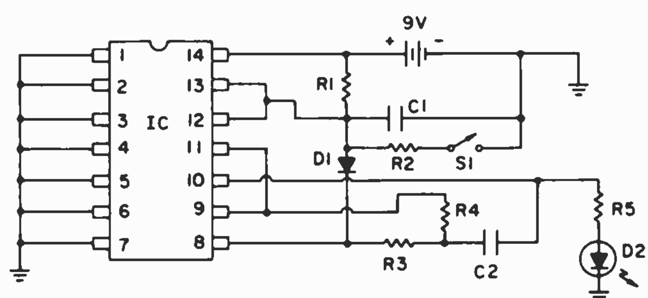
PARTS LIST FOR PULSED ALARM

C1—0.68-uF tantalum capacitor, 15 VDC
D1, D2—1N4001 diode
D3—small LED
IC1—4000 NOR gate
Q1—2N4401
R1—10,000,000-ohm, ½-watt resistor
R2—1,000,000-ohm, ½-watt resistor
R3—1,000-ohm, ½-watt resistor
R4—10-ohm, ½-watt resistor
S1—SPDT toggle switch



15. LED Blackjack

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

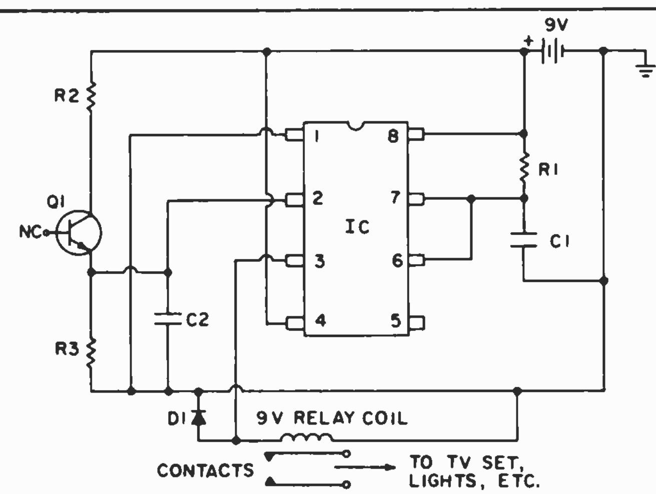


PARTS LIST FOR LED BLACKJACK

C1—4.7-uF tantalum capacitor, 15 VDC
C2—0.1-uF ceramic disc capacitor, 15 VDC
D1—1N4001 diode
D2—small LED
IC1—4000 NOR gate
R1—5,000,000-ohm, ½-watt resistor
R2—30,000-ohm, ½-watt resistor
R3, R4—10,000,000-ohm, ½-watt resistor
R5—1,000-ohm, ½-watt resistor
S1—SPST pushbutton (doorbell) switch

16. Automatic TV Turnoff

☐ This circuit can save you steps, time, and electricity. When you leave a room and turn out the lights, for example, this circuit will sense that the lights are off and will activate the relay coil. Use it to turn off the TV, hi-fi, or another light in another room without bothering with extra house wiring. Or you can use the circuit to help



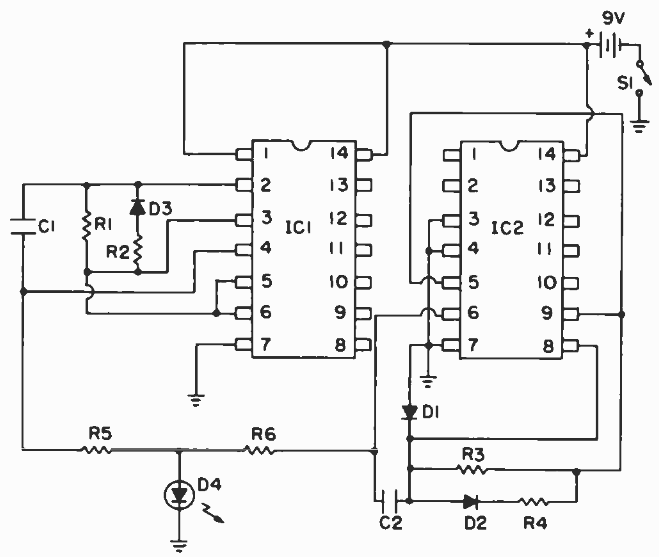
PARTS LIST FOR AUTOMATIC TV TURN-OFF

C1—0.01-uF ceramic disc capacitor, 12 VDC
D1—1N4148 diode
IC1—555 timer
Q1—FPT100 phototransistor
R1—5,000,000-ohm ½-watt resistor
R2, R3—820,000-ohm, ½-watt resistor
RELAY—9 VDC coil with switch contacts rated at 120 VAC/15 amps

keep burglars away. With Q1 sitting at the window, it will turn on house lights when the sun goes down. R1 and C1 keep the relay in operation for a minimum of one-half second to avoid bouncing of the relay contacts.

17. Crazy Flasher

☐ This crazy flasher will drive you crazy, especially if you make R1, R2, R3 and R4 variable resistors. LED D4 will flash some wild beats. For a wild party effect, hook up a relay in place of D4 and drive a spot light. Combine with disco music and you have a crazy scene!

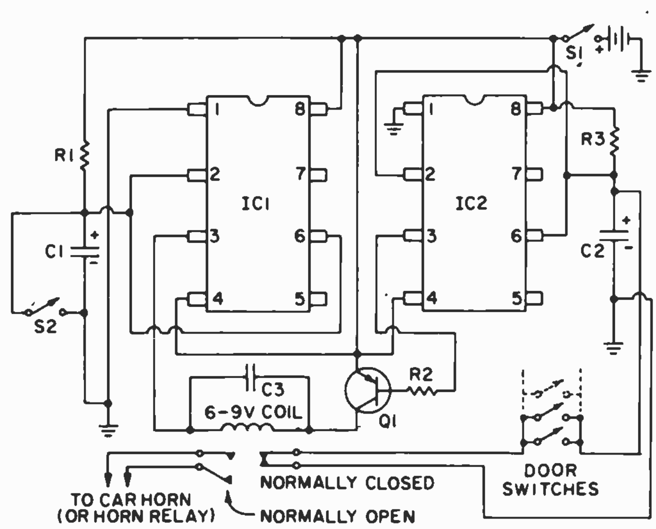


PARTS LIST FOR CRAZY FLASHER

C1—0.1-uF ceramic disc capacitor, 15 VDC
C2—0.68-uF tantalum capacitor, 15 VDC
D1, D2, D3—1N4001 diode
IC1—4011 NAND gate
IC2—4000 NOR gate
R1—5,000,000-ohm, ½-watt resistor
R2—100,000-ohm, ½-watt resistor
R3—10,000,000-ohm, ½-watt resistor
R4—1,000,000-ohm, ½-watt resistor
R5, R6—2,000-ohm, ½-watt resistor
S1—SPST toggle switch

18. Auto Burglar Alarm

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



PARTS LIST FOR AUTO BURGLAR ALARM

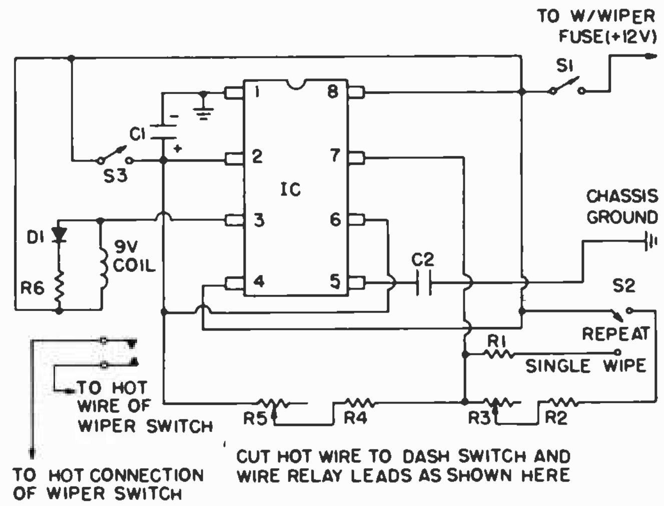
C1—10-uF electrolytic capacitor, 15 VDC
C2—1-uF electrolytic capacitor, 15 VDC
C3—0.1-uF ceramic disc capacitor, 15 VDC
IC1, IC2—555 timer
Q1—2N4403
R1—500,000-ohm, ½-watt resistor
R2—270-ohm, ½-watt resistor
R3—2,000,000-ohm, ½-watt resistor
RELAY—6 to 9 VDC coil with switch contacts rated at 15 VDC/30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

19. Glo-Slo Wiper Control

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

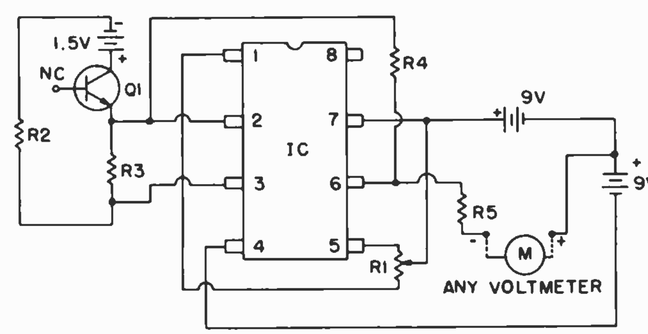
PARTS LIST FOR SELECT-DELAY WINDSHIELD WIPER CONTROL

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



20. VOM Light Meter

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

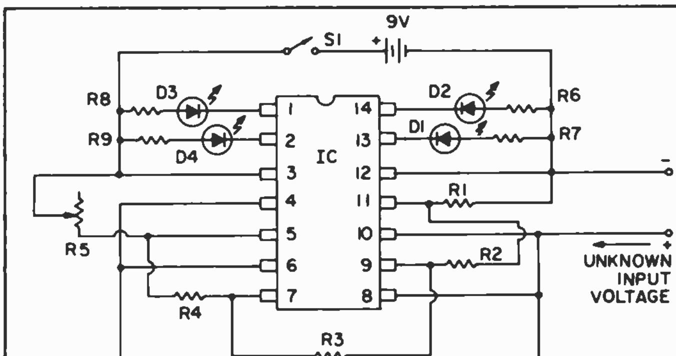


PARTS LIST FOR VOM LIGHT METER

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

21. Meter Eliminator

☐ This circuit introduces the principle of a digital voltmeter and actually provides a very sensitive, high impedance meter for your workbench. The LM-339 is an IC containing four separate operational amplifiers of a special type. These op amps compare the reference voltage set on one input pin with an unknown voltage on the other. If the unknown voltage exceeds the reference, the output goes high and lights an LED. D1 lights first. With a slightly higher input voltage, D2 will light, etc. Variable resistor R5 allows you to set the voltage steps between D1, D2, D3 and D4 from about .02 volts per step to about 0.5 volts per step.

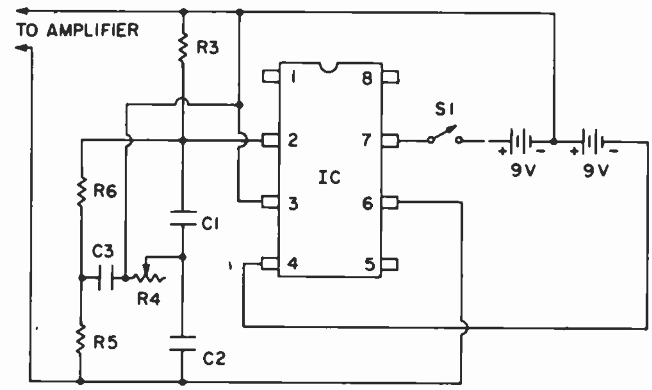


PARTS LIST FOR METER ELIMINATOR

D1, D2, D3, D4—large LED
IC1—LM339 quad comparator
R1, R2, R3, R4—1,200-ohm, ½-watt resistor
R5—1,000,000-ohm linear-taper potentiometer
R6, R7, R8, R9—470-ohm, ½-watt resistor
S1—SPST toggle switch

22. The Howler

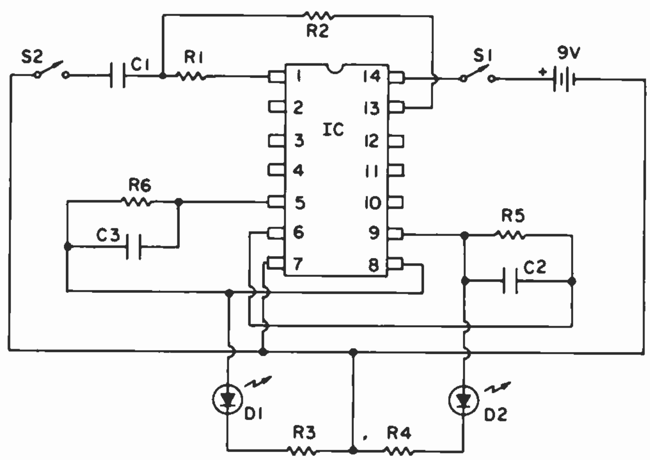
☐ This howler will produce a loud dog-like howl that starts strong and slowly grows weaker and weaker until it stops. To start it again, just press S1. Useful for alarms, bicycle horns, a different type doorbell, or as a Halloween trick. Changing R4 will change the frequency, or pitch of the howl, but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



PARTS LIST FOR THE HOWLER
C1, C2—.001-uF ceramic disc capacitor, 15 VDC
C3—.005-uF ceramic disc capacitor, 15 VDC
IC1—741 op amp
R1, R2—20,000-ohm, ½-watt resistor
R3—10,000-ohm, ½-watt resistor
R4—1,000,000-ohm, ½-watt resistor
R5, R6—220,000-ohm, ½-watt resistor
S1—SPST momentary-contact switch

23. Op Amp Wink Circuit

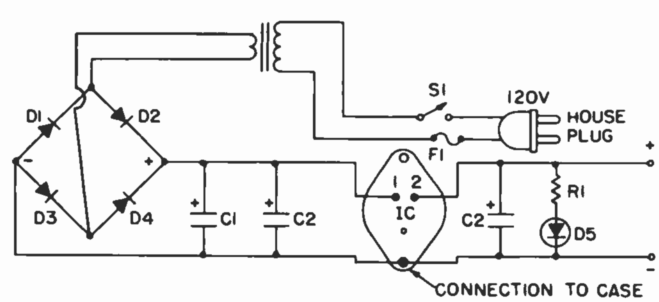
☐ This op amp flip-flop circuit causes the two LED's to alternate winking each time S2 is pressed. It is a very fast response circuit. If S2 is bounced even the slightest amount, the LEDs will flip. When you think you are pressing S2 only once, therefore, you may see D1 and D2 flip more than once. That is switch bounce in S2, a common problem in the computer world. It is possible to connect an oscillator in place of S2 which will cause D1 and D2 to beome dual flashers. Either replace S2 with a relay driven by the oscillator, or connect the oscillator output between C1 and pin 7.



PARTS LIST FOR OP AMP WINK CIRCUIT
C1, C2, C3—1,000-pF mica capacitor, 15 VDC
D1, D2—small LED
IC1—LM3900 quad op amp
R1, R2—1,000,000-ohm, ½-watt resistor
R3, R4—510-ohm, ½-watt resistor
R5, R6—1,000,000-ohm, ½-watt resistor
S1—SPST slide switch
S2—SPST momentary contact pushbutton switch

24. TTL Power Supply

☐ This IC project will provide you with a flat, ripple-free, and locked-on 5 volts for any use around the house

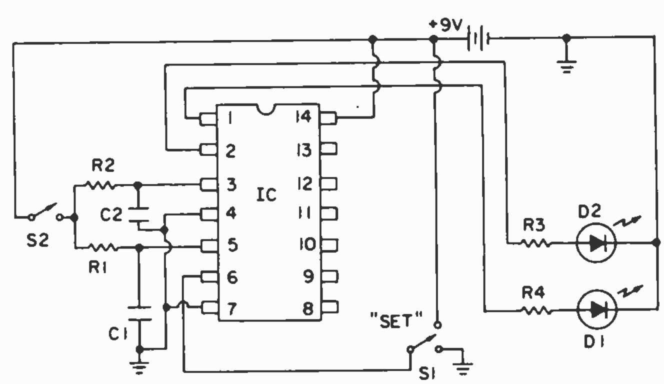


PARTS LIST FOR TTL POWER SUPPLY
C1, C2, C3—1,000-uF electrolytic capacitor, 25 VDC
D1, D2, D3, D4—1N4003 diode
D5—large LED
F1—120 VAC ½ amp fuse, fast acting type
IC1—LM309
R1—500-ohm, 2-watt resistor
S1—SPST toggle switch rated at 120 VAC/15 amps
T1—120 VAC to 12.6 VAC transformer

or on your work bench. It will prove to be very handy for the TTL projects in this magazine, i.e., those projects using any IC that starts with the two numbers 74. The LM309 is a remarkable IC containing over a dozen transistors and several diodes. It can handle up to about 1 amp without a heat sink. If you mount it on a heat sink, a 4 by 4 inch piece of aluminum will do, it can supply up to 4 amps without dropping its 5 volt output.

25. Capacitor Match Maker

☐ This useful, but simple circuit will allow you to match two capacitors or to tell if one has greater capacitance than the other. Suppose you have one capacitor of known value, say 1 uF. Put it where C1 is in the circuit. Suppose you have another capacity of some unknown value. Put it where C2 is in the circuit. Now flip S1 from "set" back to ground. Then press S2. If D1 goes off and D2 goes on, it means C2 is less than C1, like 0.5 uF. If D1 stays on and D2 off, it means C2 is equal or greater than C1. You can use this circuit to help you quickly sort through a pile of old capacitors.

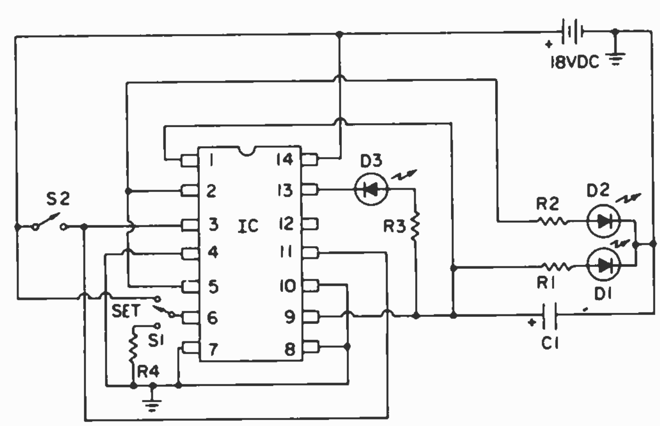


PARTS LIST FOR CAPACITOR MATCH-MAKER

- **C1, C2**—see text
- **D1, D2**—small LED
- **IC1**—4013 dual flip-flop
- **R1, R2**—30,000-ohm, ½-watt resistor
- **R3, R4**—1,000-ohm, ½-watt resistor
- **S1**—SPDT slide switch
- **S2**—SPST momentary-contact pushbutton switch

26. Lightning-Speed Reaction Tester

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

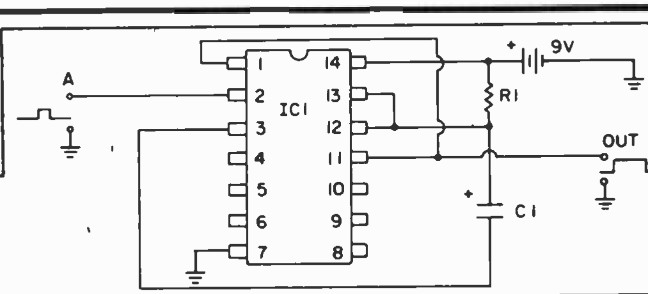


PARTS LIST FOR LIGHTNING REACTION TESTER

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

27. Pulse Puller

☐ Ever need to stretch a pulse? Maybe you can't quite pull up a self-latching relay, or maybe your bike-blinker is on too little and off too much. It can be made longer by increasing R1 or C1. All unused pins of the IC should be grounded.

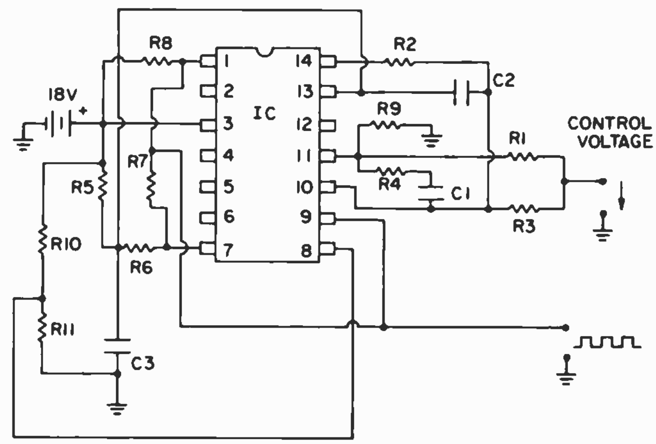


PARTS LIST FOR PULSE PULLER

- **C1**—1-uF electrolytic capacitor, 15 VDC
- **IC1**—4001 quad NOR gate
- **R1**—1,000,000-ohm, ½-watt resistor

28. High Frequency VCO

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

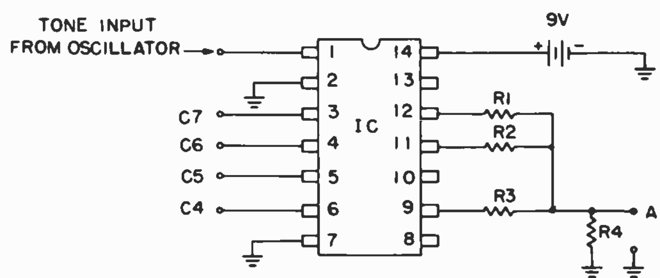


PARTS LIST FOR HIGH-FREQUENCY VOLTAGE CONTROLLED OSCILLATOR

C1—0.1-pF ceramic disc capacitor, 15 VDC
C2—500-pF mica capacitor, 15 VDC
C4—.01-uF ceramic capacitor, 15 VDC
IC1—LM339 quad comparator
R1, R7—100,000-ohm, ½-watt resistor
R2—50,000-ohm, ½-watt resistor
R3—20,000-ohm, ½-watt resistor
R4—10,000-ohm, ½-watt resistor
R5, R8—3,000-ohm, ½-watt resistor
R6—5,100-ohm, ½-watt resistor
R9, R10—30,000-ohm, ½-watt resistor

29. Octave Music Maker

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

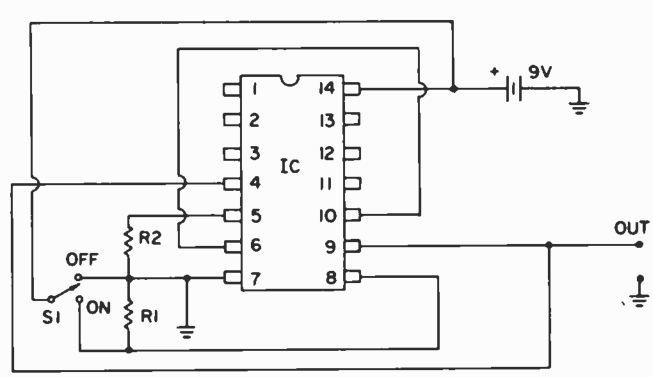


PARTS LIST FOR OCTAVE MUSIC MAKER

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

30. Clean Switch

☐ There is nothing worse in a circuit than a noisy switch. Even the slightest bounce will cause a double "on" and lead to double digits on your calculator display, or extra pulses into a million dollar computer system. So what to do? This circuit shows the basic idea used throughout the computer indusrty. The CD 4001 NOR gates are hooked up in flip-flop fashion so that once they flip, they stay that way. Double bounces still lead to a single, solid "on" pulse at the output.

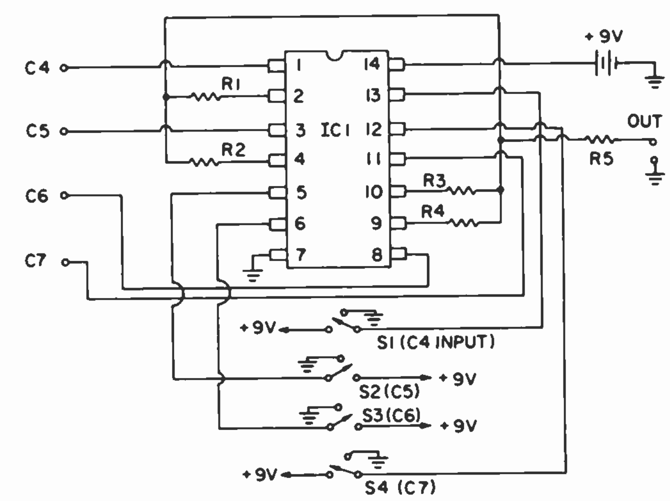


PARTS LIST FOR CLEAN SWITCH

IC1—4001 quad NOR gate
R1, R2—870,000-ohm, ½-watt resistor
S1—SPDT slide switch

31. Multi-Input Music Synthesizer

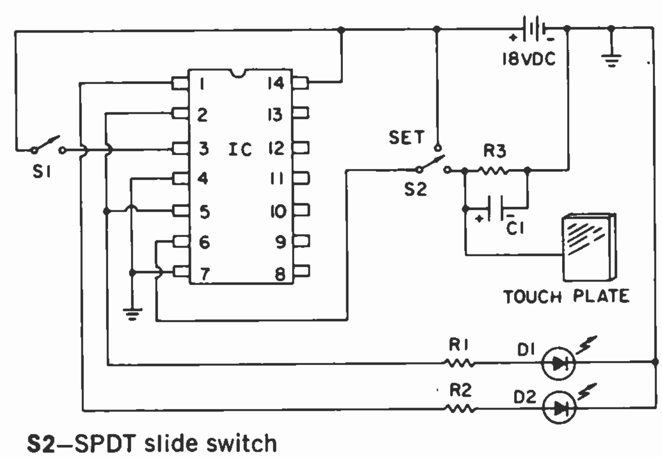
☐ The inputs to this synthesizer can be from any musical instruments. C4 can be from an electric guitar, C5 from an electronic organ, etc. Or the inputs can be from the outputs of the "Octave Music Maker" project. The voltage should not exceed 9 volts at these inputs. The output will be a combination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



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

32. Touch 'N Flip

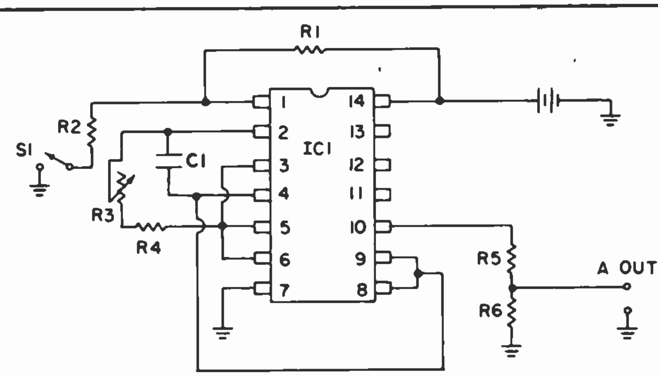
☐ Ever wonder how a touch plate, like the kind you see on some elevator buttons, works? This circuit will give you a good feel for how the touch plate works in a circuit and lets you experiment further. The plate can be just a small piece of metal or aluminum foil. Start by sliding S2 to "set" then back to R3. Now press S1. LED's D1 and D2 will flip. Now touch the plate to flip them back. The sensitivity of the touch plate will depend on humidity in the room and on R3 and C1. You can experiment with those in various ways.



PARTS LIST FOR TOUCH 'N FLIP
C1—4.7-uF electrolytic capacitor, 15 VDC
D1, D2—large LED
R1, R2, R3—2,000-ohm, ½-watt resistor
S1—SPST momentary contact pushbutton switch
S2—SPDT slide switch

33. Code Practice

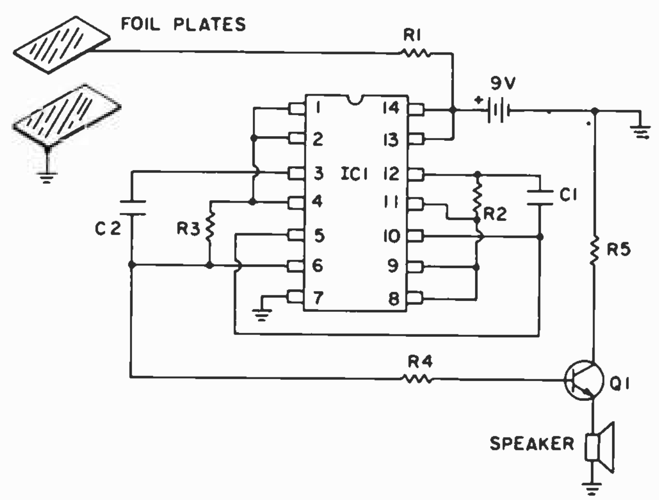
☐ Boning up for your Amateur code exam? Pushbutton S1 makes a very inexpensive Morse code key. The tone out of the circuit, at point A, can drive an amplifier or a pair of high-impedance headphones.



PARTS LIST FOR CODE PRACTICE OSCILLATOR
C1—0.1-uF ceramic capacitor, 15 VDC
IC1—4001 quad NOR gate
R1—91,000-ohm, ½-watt resistor
R2—220-ohm, ½-watt resistor
R3—500,000-ohm, linear-taper potentiometer
R4—50,000-ohm, ½-watt resistor
R5, R6—2,200-ohm, ½-watt resistor
S1—SPST momentary-contact pushbutton switch

34. Rain Detective

☐ Have some problem with water now and then? Trying to keep rain from ruining your top-down convertible? This circuit will sound an alarm when rain gets between the aluminum foil strips to keep you high and dry.

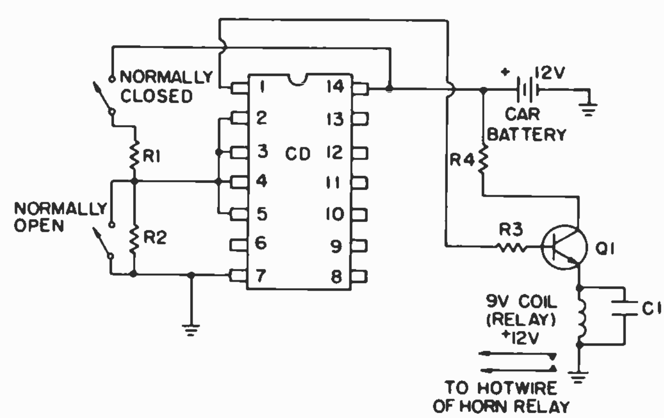


PARTS LIST FOR RAIN DETECTIVE

C1—0.47-uF ceramic disc capacitor, 15 VDC
C2—0.01-uF ceramic disc capacitor, 15 VDC
IC1—4001 quad NOR gate
Q1—2N4401
R1—5,000,000-ohm, ½-watt resistor
R2—1,500,000-ohm, ½-watt resistor
R3—100,000-ohm, ½-watt resistor
R4—2,000-ohm, ½-watt resistor
R5—100-ohm, ½-watt resistor
SPKR.—8-ohm PM type speaker

35. Open-Sesame Auto Alarm

☐ This simple auto alarm lets you use either normally open switches (like on the ignition or a door button) or normally closed switches (like on a hood or a radio switch). Or, both may be used simultaneously. The relay coil will operate and the contacts can be used to blow the car horn, or to operate a siren circuit.

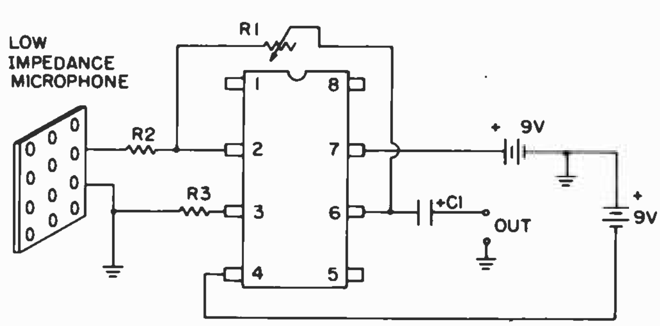


PARTS LIST FOR OPEN-SESAME AUTO ALARM

C1—0.1-uF ceramic disc capacitor, 15 VDC
IC1—4002 dual NOR gate
Q1—2N4401
R1—2,000-ohm, ½-watt resistor
R2—100,000-ohm, ½-watt resistor
R3—5,000-ohm, ½-watt resistor
R4—100-ohm, ½-watt resistor
RELAY—9 VDC coil with SPST contacts rated at 15 VDC/15 amps

36. Low Z Mike Booster

☐ A low-impedance microphone has the property of being able to pass sufficient current to be directly in the feedback path of this 741 amplifier. The gain is controlled by changing R1. This circuit can feed into your hi-fi unit to give greater power output.

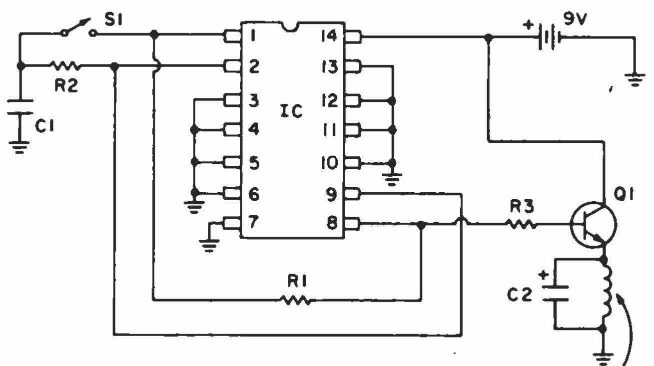


PARTS LIST FOR LOW Z MIKE BOOSTER AMP

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

37. Alternate Action Button

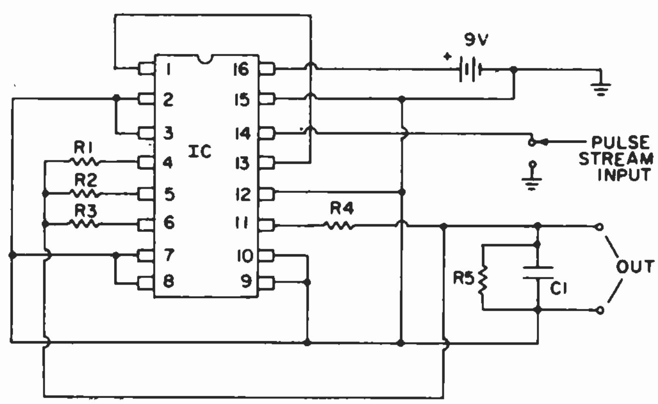
☐ The pushbutton at "A" will cause the relay of this circuit to go off one time it is pressed, and cause the relay to go on the next time the button is pressed. In other words, the pushbutton has alternate action. First it makes an "off", and later, an "on". This type of circuit is very handy for projects around the house. All unused pins should be grounded.



PARTS LIST FOR ALTERNATE ACTION BUTTON
C1—0.1-uF ceramic disc capacitor, 15 VDC
C2—1-uF electrolytic capacitor, 15 VDC
IC1—4069 hex inverter
Q1—2N4401
R1, R3—10,000-ohm, ½-watt resistor
R2—91,000-ohm, ½-watt resistor
S1—SPST momentary-contact pushbutton switch

38. Sine Wave Generator

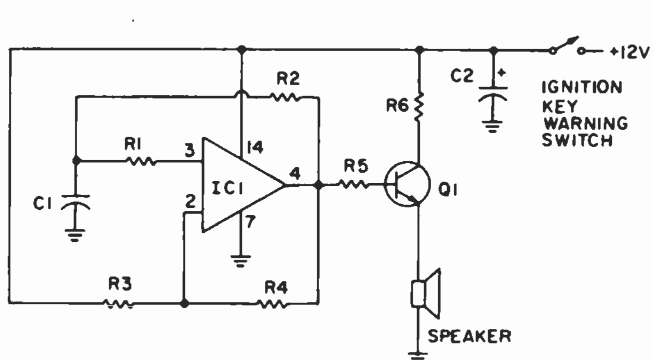
☐ Think it is possible to have a pulse stream turned into a nice smooth sine-wave? This circuit will do it! In fact, you can have the lowest sine-wave frequency you can imagine by slowly pressing a button to generate your own manual pulse stream, if you like. The IC is a counter that has been made to divide the input pulse rate by ten. The outputs feed through resistors R1, R2, R3, and R4 to build up a sine wave.



PARTS LIST FOR SINE WAVE GENERATOR
C1—10-uF electrolytic capacitor, 15 VDC
IC1—4018 dividing counter
R1, R2, R3, R4—20,000-ohm, ½-watt resistor
R5—47,000-ohm, ½-watt resistor

39. Ignition Key Tone Generator

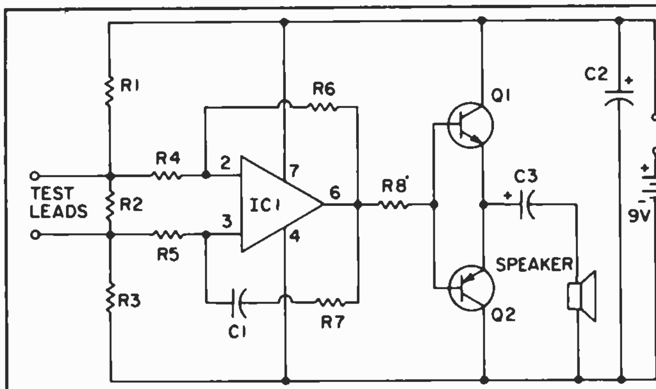
☐ This ignition key tone generator replaces the loud, annoying buzzer in your car with a pleasing tone of about 2000 Hertz. One section of an LM3900 quad operational amplifier is connected as a square wave generator, which is rich in harmonics and produces a pleasant sound. Current amplification to drive the speaker is provided by Q1. The frequency of oscillation is determined by C1 and R2. Total current drawn by the circuit is about 75 milliamperes at 12 volts.



PARTS LIST FOR KEY TONE GENERATOR
C1—0.01-uF ceramic capacitor, 15 VDC
C2—10-uF electrolytic capacitor, 20 VDC
IC1—LM 3900 quad amplifier
Q1—2N4401
R1—2,700,000-ohm, ½-watt resistor
R2—33,000-ohm, ½-watt resistor
R3, R4—10,000,000-ohm, ½-watt resistor
R5—10,000-ohm, ½-watt resistor
R6—100,000-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker

40. Continuity Checker

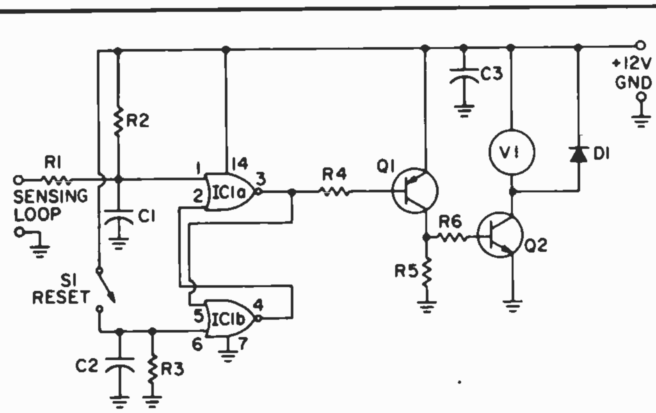
☐ After wiring a new electronic project or troubleshooting an old one, it is often good practice to make several continuity checks to be sure that certain connections in the circuit are correct. In the days of vacuum tubes this was accomplished with an ohmmeter, but for today's solid state circuitry you can't use most ohmmeters for several reasons. Some ohmmeters have far too much battery voltage and deliver as much as hundreds of milliamperes into a short circuit. This can easily damage expensive solid state devices. Also, the ohmmeter is an unreliable method to measure circuit continuity, since it will read through an emitter-base or diode junction. This continuity checker is a handy accessory for troubleshooting circuits, and is safe to use on any solid state device or circuit. The maximum voltage at the input terminals is about 40 millivolts, and negligible current is passed through the circuit when continuity is indicated. The circuit will not indicate continuity for resistance values of about 35 ohms or greater, and will not register through an emitter-base junction or diode. The circuit is powered by a standard 9 volt transistor battery and draws about 1 milliampere when the input leads are open. Shorting the lead causes an audio tone to be generated and draws about 15 milliamperes of battery current.



PARTS LIST FOR CONTINUITY CHECKER
C1—.001-uF ceramic disc capacitor, 15 VDC
C2—10-uF electrolytic capacitor, 15 VDC
C3—15-uF electrolytic capacitor, 15 VDC
IC1—741 op amp
Q1—2N4401
Q2—2N4403
R1, R3, R4, R5, R8—10,000-ohm, ½-watt resistor
R2—100-ohm, ½-watt resistor
R6—4,600,000-ohm, ½-watt resistor
R7—100,000-ohm, ½-watt resistor
R9, R10—10-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker

41. Burglar Alarm

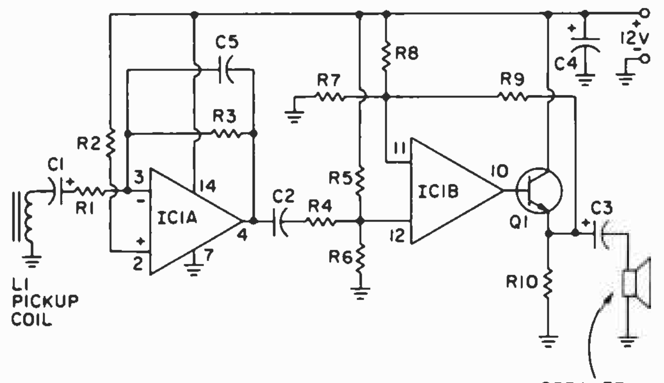
☐ This burglar alarm circuit uses one integrated circuit and operates from a 6 volt battery. It is activated upon the breaking of a circuit. Since the sensing loop operates in a high impedance circuit, there is virtually no limit to the length of wire you can use. You can protect every window and door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



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

42. Telephone Pickup

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

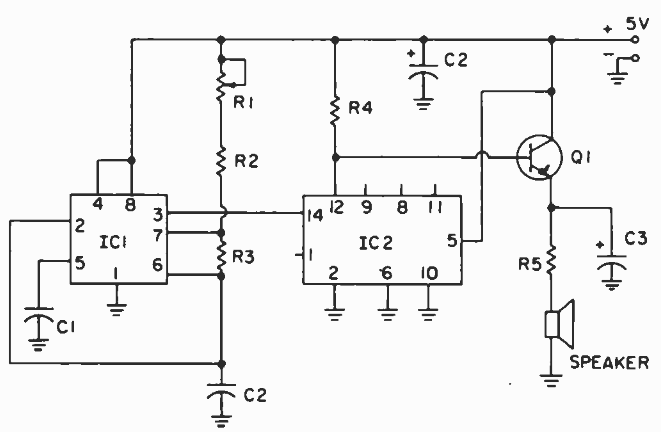


PARTS LIST FOR TELEPHONE PICKUP

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

43. Guitar Tuning Aid

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

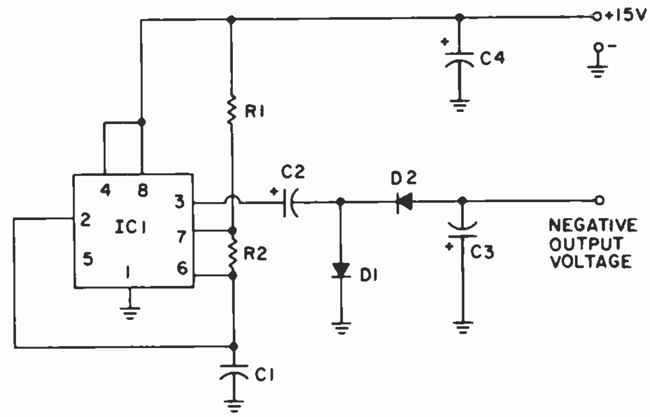


PARTS LIST FOR GUITAR TUNER

C1—0.1-uF ceramic capacitor, 15 VDC
C2—15-uF electrolytic capacitor, 15 VDC
C3—100-uF electrolytic capacitor, 15 VDC
IC1—555 timer
IC2—7490 decade counter
Q1—2N4401
R1—50,000-ohm linear-taper potentiometer
R2, R4—4,700-ohm, ½-watt resistor
R3—33,000-ohm, ½-watt resistor
R5—33-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker

44. Negative Power Supply

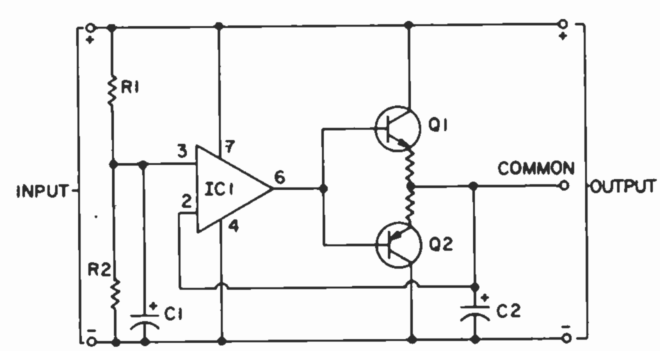
☐ Many operational amplifiers operate from a dual-polarity power supply. For low current applications, it may be easier to construct this negative power supply using one IC, rather than rectifying from the power line or transformer. IC1 operates in an astable mode with essentially square wave output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



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

45. Dual Polarity Power Supply

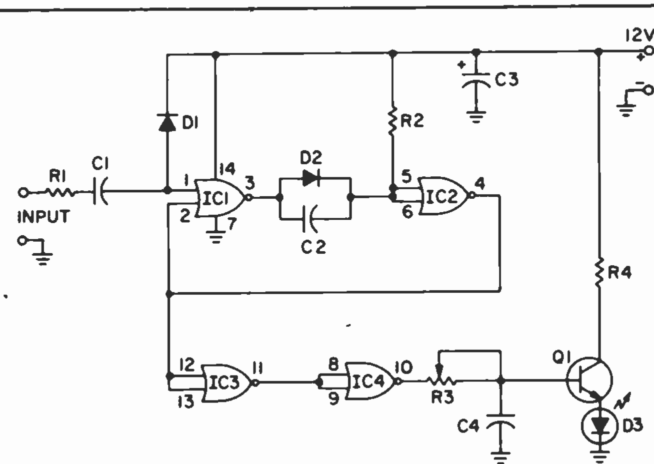
☐ Many operational amplifiers require both positive and negative supplies for proper operation. With this simple circuit you can take a floating power supply and convert it into a dual polarity supply. To provide ±15 volts as most op amps require, you will need a 30 volt supply to drive the circuit.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



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

46. Automotive Speed Indicator

☐ The speed of an automobile can be indicated by detecting the pulses generated by the ignition system and causing an LED to light. This circuit utilizes 2 NOR gates connected as a one shot multivibrator which produces a fixed duration pulse each time the primary circuit of the automobile ignition system opens the circuit to the ignition coil. The two remaining sections of the IC are used as buffers which provide an accurate rectangular pulse to the integrating circuit composed of R3 and C4. As the number of pulses per second increases, the voltage fed to the base of Q1 becomes high enough to cause

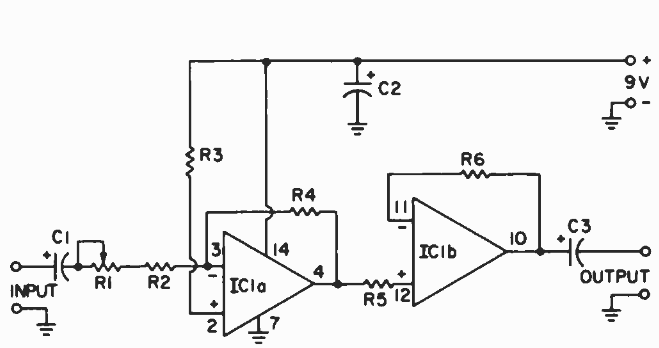


PARTS LIST FOR AUTOMOTIVE SPEED INDICATOR
C1—.01-uF ceramic capacitor, 15 VDC
C2, C4—0.1-uF ceramic capacitor, 15 VDC
C3—10-uF electrolytic capacitor, 15 VDC
IC1—4001 quad NOR gate
Q1—2N4401
R1—10,000-ohm, ½-watt resistor
R2—47,000-ohm, ½-watt resistor
R3—100,000-ohm, linear-taper potentiometer
R4—470-ohm, ½-watt resistor

Q1 to conduct and light the LED. The speed at which LED 1 lights is set by adjustment of R4. To place the circuit in operation, connect the input terminal (R1) to the distributor side of the ignition coil or to the tachometer connection on those cars equipped with electronic ignition.

47. Power Mike Amplifier

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

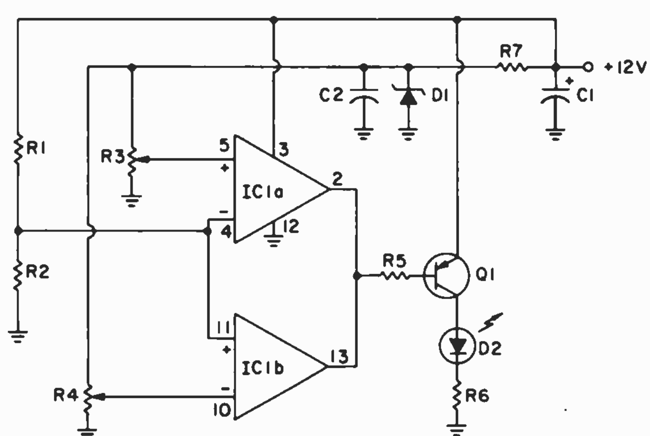


PARTS LIST FOR POWER MIKE AMPLIFIER

C1, C2, C3—10-uF electrolytic capacitor, 10 VDC
IC1—3900 quad amplifier
R1—100,000-ohm audio taper potentiometer
R2—10,000-ohm, ½-watt resistor
R3—220,000-ohm, ½-watt resistor
R4—100,000-ohm, ½-watt resistor
R5—1,000,00-ohm, ½-watt resistor

48. Alternator Monitor

☐ This circuit will monitor the output of the alternator of any car with a 12 volt electrical system and indicate if the charging system is either undercharging or overcharging. This is accomplished by using 2 sections of a quad voltage comparator IC and connecting the outputs in an "OR" configuration so that the LED will become lit if section A or section B of the comparator detects an improper voltage level. The circuit is connected into any circuit which is active when the car is in operation, such as the ignition or radio circuit. This prevents drain on the battery when the car is not in use. To calibrate the circuit, connect an adjustable DC power supply to the + and – inputs of the circuit. Set the power supply to 13.4 volts and adjust R3 so that the voltage at pin 5 of IC1A is maximum. Then adjust R4 so that the LED just goes out. Set the power supply to 15.1 volts and adjust R3 so that the LED just goes out. The LED will now become lit if the voltage is outside the permissable range of 13.5 to 15.0 volts when the engine is running.

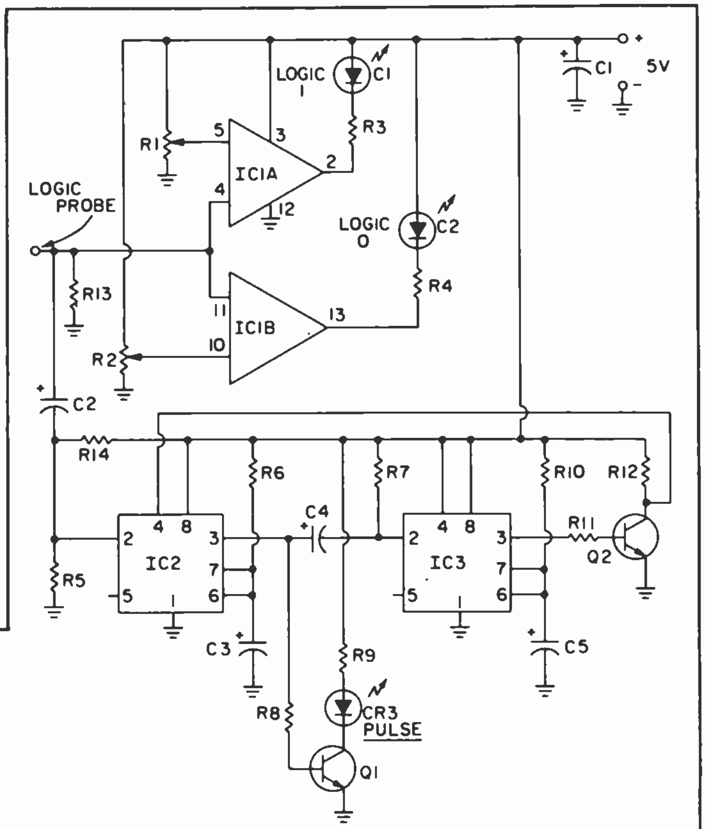


PARTS LIST FOR ALTERNATOR MONITOR

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

49. TTL Logic Probe

☐ This circuit can be used as an indicator of the logic conditions at any point in a TTL digital circuit. It will indicate the presence of a continuous logic 1 or logic zero, an illegal voltage level, or the presence of pulses at any frequency or duty cycle. The presence of a continuous logic level is detected by IC1A and IC1B, which are voltage comparators set to detect levels of 2.0 and 0.8 volts respectively. The presence of pulses is detected by a 555 timer connected as a one-shot multivibrator which illuminates an LED for about 0.5 second if pulses are present. A second 555 timer is used to disable IC2 for about 0.5 second each time it fires. This provides a flashing LED regardless of the frequency of the detected pulses. The circuit is powered by the 5 volt supply feeding the digital circuit under test. To calibrate the circuit, apply a voltage of 2.0 volts DC to the logic input terminal. Adjust R1 so that D1 is on the borderline between off and on. Apply 0.8 volts to the logic input terminal and adjust R2 so that D2 is on the borderline between off and on. When using the circuit either D1 or D2 or both must be lit to indicate a correct logic level. If both are out, the detected voltage is between 0.8 and 2.0 volts and is an illegal voltage level. D3 will flash only if there are pulses present on the line under test.

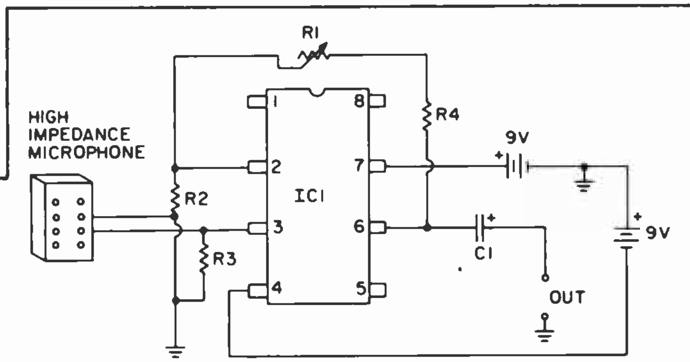


PARTS LIST FOR TTL LOGIC PROBE

C1—10-uF electrolytic capacitor, 25 VDC
C2—0.01-uF ceramic capacitor, 15 VDC
C3—1-uF electrolytic capacitor, 15 VDC
C4—0.01-uF ceramic capacitor, 15 VDC
C5—1-uF electrolytic capacitor, 15 VDC
D1, D2, D3—large LED
IC1—339 quad comparator
IC2, IC3—555 timer
Q1, Q2—2N4401
R1, R2—50,000-ohm linear-taper potentiometer
R3, R4—220-ohm, ½-watt resistor
R5, R7, R14—100,000-ohm, ½-watt resistor
R6, R10—470,000-ohm, ½-watt resistor
R8, R11, R12—4,700-ohm, ½-watt resistor
R9—180-ohm, ½-watt resistor
R13—10,000-ohm, ½-watt resistor

50. Hi Z Mike Amp

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



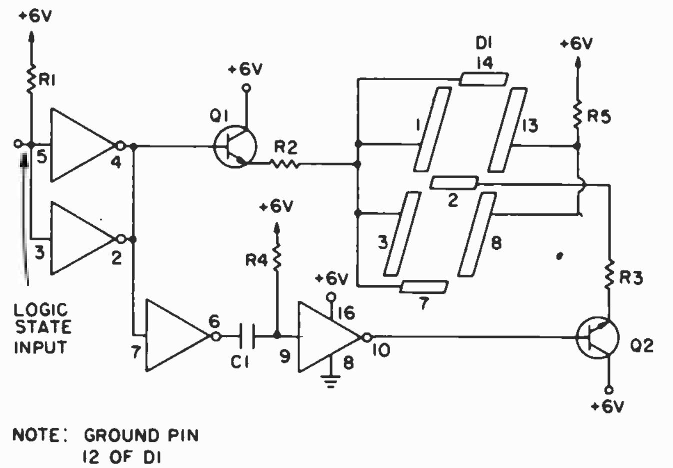
PARTS LIST FOR HI-IMPEDANCE MIKE AMP

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

51. Logical Probe

☐ This simple but useful CMOS probe goes beyond LEDs to tell the status of a logic circuit. It shows, via a numerical readout, whether the condition is literally 0 or 1. In addition, if the switching action is high enough to cause 0 and 1 to merge into an ambiguous blur, the center (G) segment comes into play, causing the display to show a distinct 8. In operation, when the probe is at a logic-high, the 1 is illuminated, as it is when the probe is open-circuited, to show that the circuit is operative. When a logic-low is touched, segments C, D, E, and F are illuminated, producing the 0 indication. Every time a transition is made between high and low, this action is gated by the capacitor to the inverter driving the G segment. Thus, all states are covered.

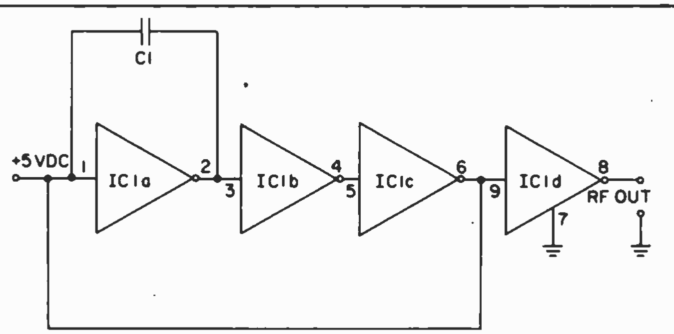
PARTS LIST FOR LOGICAL PROBE
C1—0.1-uF ceramic capacitor, 15 VDC
D1—DL-702 LED display
IC1—4009A hex buffer
Q1, Q2—2N4401
R1, R4—100,000-ohm, ½-watt resistor
R2, R3—1,000-ohm, ½-watt resistor
R5—330-ohm, ½-watt resistor



52. Ultra-Simple RF

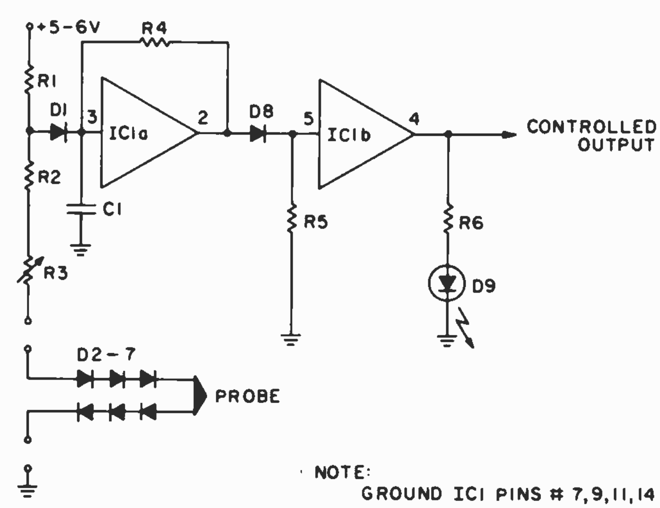
☐ A single capacitor can turn a TTL hex-inverter into an RF generator with good solid waveform output. The circuit was checked out on both a 7404 standard TTL chip and the low power Schottky 74LS04 with about equal results, though slight departures in frequencies must be expected. One or more buffer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

PARTS LIST FOR SIMPLE RF GENERATOR
C1—0.01-uF ceramic disc capacitor, 15 VDC
IC1—7404 hex inverter



53. Diode Thermostat

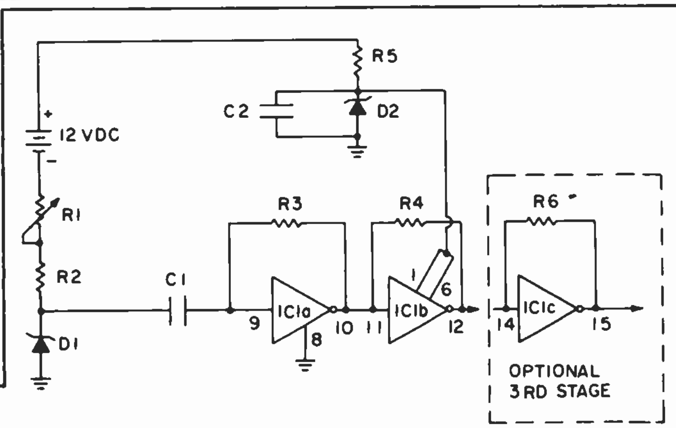
☐ All semi-conductors are, to varying extents, temperature sensitive. The type 1N914 or 1N4148 silicon diode has a negative temperature coefficient of 2 millivolts per degree Centigrade. While this may seem insignificant, it can be multiplied by adding diodes in series. In the circuit shown below, six 1N4148 diodes were series-wired in a small package, which could then be encapsulated in epoxy (though this slows the response time). The biasing potentiometer is set for an "off" indication of the LED at room temperature. As the temperature rises, resistance decreases, until the Schmitt Trigger trips. Hysteresis (the "dead-band" between on and off actions) is furnished by diode D1. Its action may be modified by replacing, or shunting it, with a 25,000-ohm potentiometer. Since the sensor is practically at ground potential, it may be well appreciated by heated aquaria dwellers and owners alike!



PARTS LIST FOR DIODE THERMOSTAT
C1—.05-uF ceramic capacitor, 15 VDC
D1 through D8—1N4148 diode
D9—small LED
IC1—4050 hex buffer
R1—4,700-ohm, ½-watt resistor
R2—1,000-ohm, ½-watt resistor
R3—1,000-ohm linear-taper potentiometer
R4—470,000-ohm, ½-watt resistor
R5—2,200-ohm, ½-watt resistor
R6—270-ohm, ½-watt resistor

54. Useful Noise

☐ The diode-generated radio-frequency noise has such a wide spectrum of energy that it can be detected by both long and short-wave receivers. Bringing a transistor radio near the circuit shown below will demonstrate the power and limitations of the generator. The noise generator may be used in checking out a defective receiver through RF and IF stages by injecting it at various points. In the circuit, RF amplification was provided by running CMOS inverters in a linear mode. To reduce heating, an operating potential of about five volts was established through the use of a 1N751 zener diode, functioning normally, and not a noise generator in its own right, we hope!

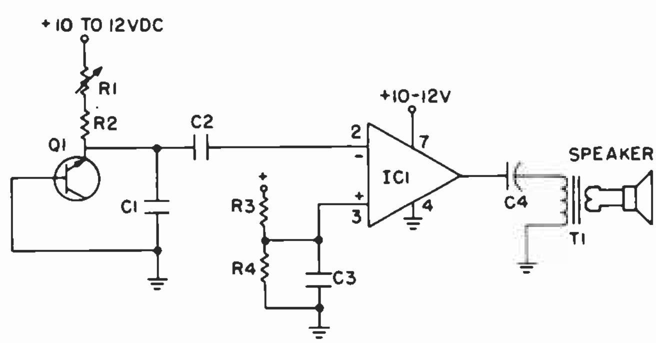


PARTS LIST FOR MORE USEFUL NOISE

C1, C2—0.1-uF ceramic disc capacitor, 15 VDC
D1—1N758 or 1N759 diode
D2—1N751 diode
IC1—4009A hex buffer
R1—500,000-ohm linear-taper potentiometer
R2—10,000-ohm, ½-watt resistor
R3 R4—1,000,000-ohm, ½-watt resistor
R5—300-ohm, 1-watt resistor
R6—1,000,000-ohm, ½-watt resistor

55. More Useful Noise

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

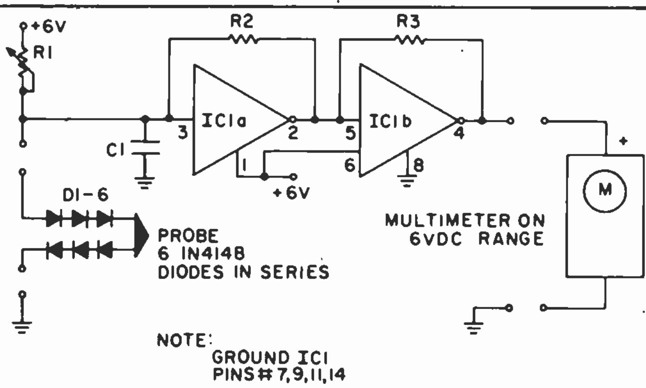


PARTS LIST FOR USEFUL NOISE

C1—.005-uF ceramic capacitor, 15 VDC
C2, C3—0.1-uF ceramic capacitor, 15 VDC
C4—75-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
Q1—2N4401
R1—100,000-ohm linear-taper potentiometer
R2—10,000-ohm, ½-watt resistor
R3, R4—4,700-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker
T1—audio output transformer with 500-ohm primary/8-ohm secondary

56. Diode Thermometer

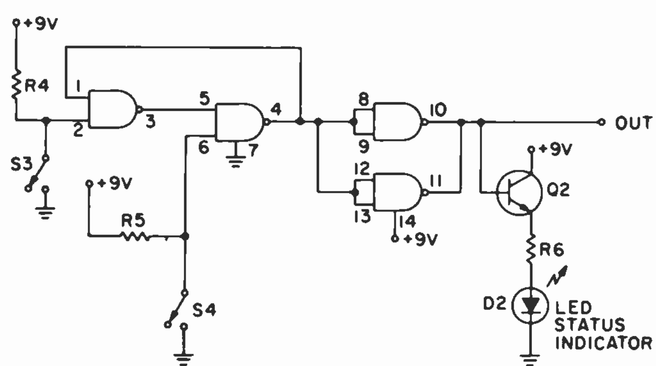
☐ In another project, it was shown how a package of silicon diodes could be developed into a solid-state thermostat. Here is an analog version, which can be interfaced with a voltage-to-frequency converter for use with a frequency counter, or can be directly read by a 10 to 20 thousand-ohms-per-volt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

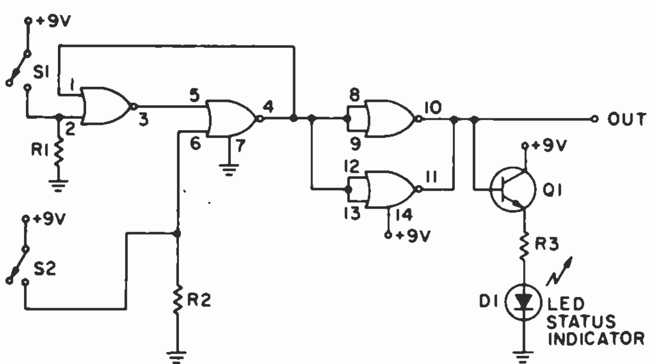


PARTS LIST FOR DIODE THERMOMETER
C1—0.1-uF ceramic capacitor, 15 VDC
D1 through D6—1N4148 diode
IC1—4009A hex buffer
R1—100,000-ohm linear-taper potentiometer
R2, R3—1,000,000-ohm, ½-watt resistor

57. Twin Switches

☐ Two switches and a choice of logic gates make up this "bounceless" package. One switch turns "on," the other turns "off." Either a 4001A NOR gate, or 4011A NAND gate set can be used, giving the constructor a choice of chips.

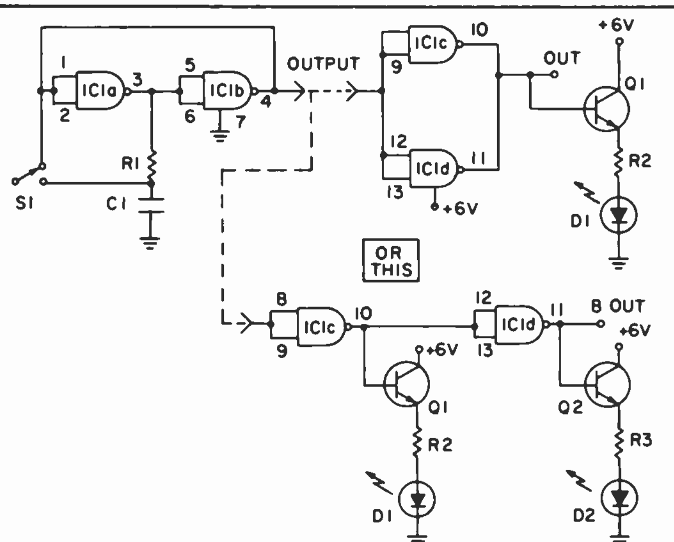




PARTS LIST FOR TWIN SWITCHES
D1, D2—small LED
IC1—4001A quad NOR gate
IC2—4011A quad NAND gate
Q1, Q2—2N4401
R1, R2, R4, R5—1,000 to 4,700-ohm, ½-watt resistor
R3, R6—1,000-ohm, ½-watt resistor
S1, S2, S3, S4—SPST toggle switch

58. Push-On, Push-Off

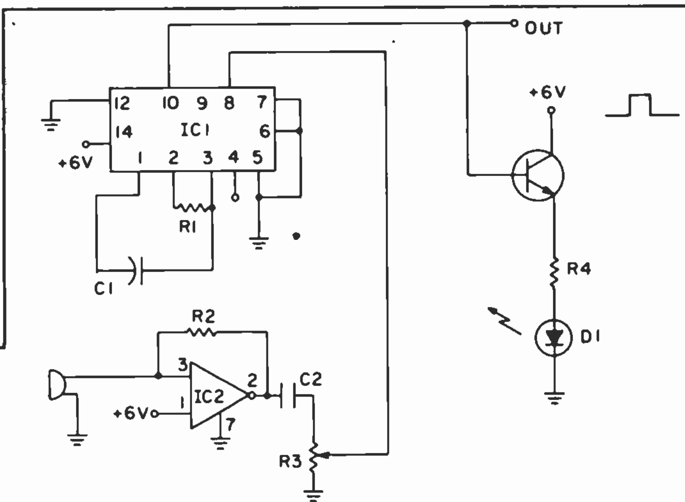
☐ This simple circuit enables a single-pole/single-throw pushbutton switch to function in a push-on/push-off manner. Closing the switch initiates a flip-flop latching action. The extra gates of the 4011 quad NAND chip may be used in parallel for greater output loading or in series to provide an alternate on-off output to external circuits.



PARTS LIST FOR PUSH-ON, PUSH-OFF
C1—0.1-uF ceramic capacitor, 15 VDC
D1, D2—small LED
IC1—4011A quad NAND gate
Q1, Q2—2N4401
R1—27,000-ohm, ½-watt resistor
R2, R3—1,000-ohm, ½-watt resistor

59. The Robot Ear, CMOS

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

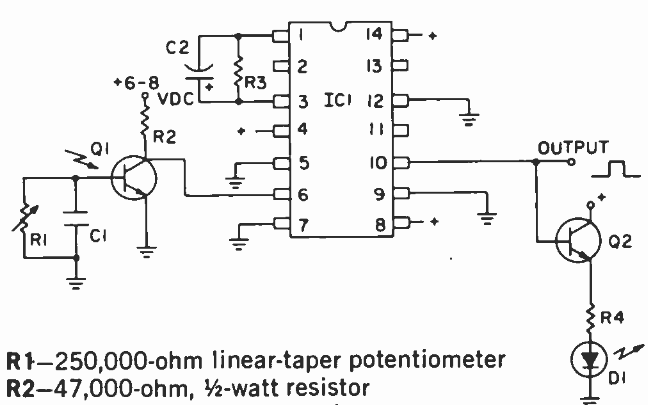


PARTS LIST FOR THE ROBOT EAR, CMOS

C1—1-uF electrolytic capacitor, 25 VDC (see text)
C2—.01-uF ceramic capacitor, 15 VDC
D1—small LED
IC1—4047 multivibrator
IC2—4009 or 4049 hex buffer
Q1—2N4401
R1—1,000,000-ohm, ½-watt resistor (see text)
R2—1,000,000-ohm, ½-watt resistor
R3—1,000,000 linear-taper potentiometer
R4—1,000-ohm, ½-watt resistor

60. The Robot Eye, CMOS

☐ The Robot Ear described elsewhere can be given visual capability through a type FPT-100 phototransistor. In this application, use is made of the negative trigger input. Sensitivity control can be a 100K or 250K potentiometer to the base connection. By-pass the base connection to avoid false triggering by pick-up of electrical noise. With the components shown, a delay interval of about 4 seconds was obtained. The Robot Eye is always alert to unexpected light sources and never falls asleep, as may a watchdog or watch-person.

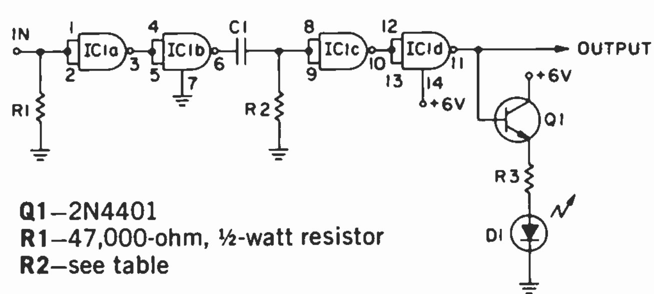


PARTS LIST FOR THE ROBOT EYE, CMOS

C1—0.1-uF ceramic capacitor, 15 VDC
C2—4.7-uF electrolytic capacitor, 25 VDC
IC1—4047 multivibrator
Q1—FPT100 phototransistor
Q2—2N4401
R1—250,000-ohm linear-taper potentiometer
R2—47,000-ohm, ½-watt resistor
R3—220,000-ohm, ½-watt resistor
R4—1,000-ohm, ½-watt resistor

61. Improvised Monostable

☐ Like the preceeding projects, this one is also dedicated to the art of improvisation. While TTL and CMOS prepackaged monostable multivibrators are available, one may not be at hand when such a useful device is called



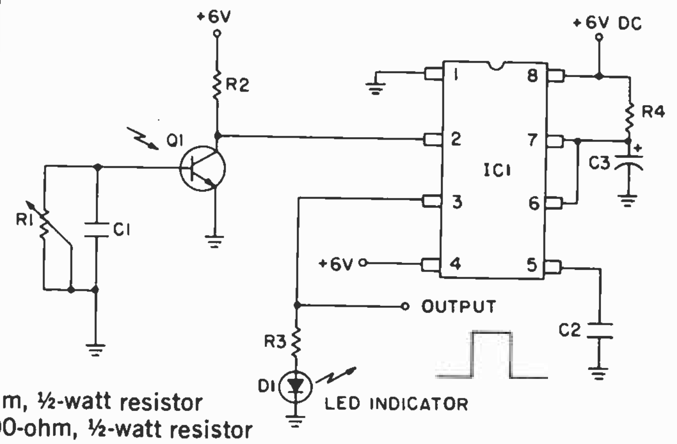
PARTS LIST FOR IMPROVISED MONOSTABLE

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

for. Once again, two very common gates, the 4001 quad NOR and the 4011 quad NAND will equally fill the bill. In operation, when the input is made high, the output of the first inverter goes low, forcing the output of the second high, charging the capacitor C through resistor R2. For a while, the output of the third gate is driven low, causing the output stage to go high, activating the LED indicator. In this elementary circuit, it is only necessary that the turn-on signal remain high for at least the duration of the timed interval.

62. The Robot Eye, TTL

☐ A useful chip, at home with both TTL and CMOS logic, is the type 555 timer, which can be used both in the mono-stable and astable or free-running modes. In the mono-stable mode shown here, timing RC can run from 1000 ohms to over 1 megohm, and 0.001-uF to over 100-uF. A combination of 2.2-uF and 220K ohms gave a delay interval of about one second. The Robot Eye can thus extend from a tiny wink to an intent gaze!

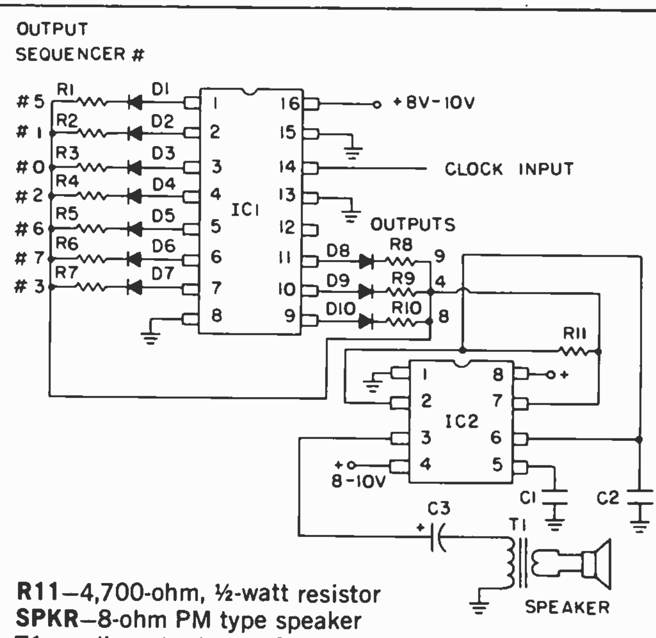


PARTS LIST FOR THE ROBOT EYE, TTL

- **C1, C2**—0.1-uF ceramic capacitor, 15 VDC
- **C3**—2.2-uF electrolytic capacitor, 15 VDC
- **D1**—small LED
- **IC1**—555 timer
- **Q1**—FPT100 phototransistor
- **R1**—250,000-ohm linear-taper potentiometer
- **R2**—47,000-ohm, ½-watt resistor
- **R3**—470-ohm, ½-watt resistor
- **R4**—220,000-ohm, ½-watt resistor

63. Programmed Music

☐ "Music" may be a little optimistic, but sequential tones are entirely possible with this circuit, and with a little experience, simple but recognizable themes can be produced. The system combines the 4017 decimal decoded counter with the 555 timer in astable oscillation. As the counter steps through its ten outputs, a different frequency-determining resistor (R1-10, which may range from 1K-100K) is activated, through an isolation diode. The input clock frequency may be 1 and 5 Hz; use slower tempos for chime-like notes for an electronic door-bell. Notes may be made longer by giving succeeding steps, like 5 and 6, the same value tuning resistors. Rhythm may be accomplished by skipping one or more outputs. For very short themes, the next stage can be made to reset the counter. Composition, anyone?

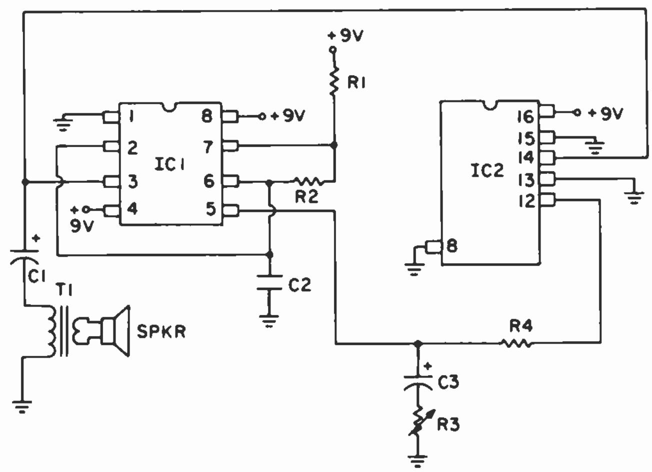


PARTS LIST FOR PROGRAMMED MUSIC

- **C1, C2**—0.1-uF ceramic capacitor, 15 VDC
- **C3**—1,000-uF electrolytic capacitor, 25 VDC
- **D1 through D10**—1N4148 diode
- **IC1**—4017 decade counter
- **IC2**—555 timer
- **R1 through R10**—1,000 to 100,000-ohm, ½-watt resistor (see text)
- **R11**—4,700-ohm, ½-watt resistor
- **SPKR**—8-ohm PM type speaker
- **T1**—audio output transformer 500-ohm primary/8-ohm secondary

64. Two Tone Alarm

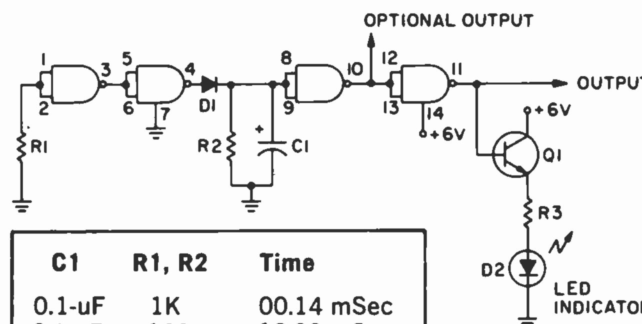
☐ When this circuit is triggered into action, it is hard to ignore for very long! A 555 timer is operated in the astable free-running mode, with its output powering both a loudspeaker and clocking a 4017 counter. Pin 12 of the counter provides a high-low output which changes with every five input pulses counted. This output is applied via a resistor of from 2.2K to 10K ohms to pin 5, the modulated input of the timer. This produces a strident warble that calls immediate attention. More mellow, but interesting, tones can be obtained with the addition of the RC filter shown.



PARTS LIST FOR TWO TONE ALARM
C1—100-uF electrolytic capacitor, 25 VDC
C2—0.1-uF ceramic capacitor, 15 VDC
C3—1-uF electrolytic capacitor, 25 VDC
IC1—555 timer
IC2—4017 decade counter
R1, R2—4,700-ohm, ½-watt resistor
R3—10,000-ohm linear-taper potentiometer
R4—2,200 to 10,000-ohm, ½-watt resistor (see text)
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

65. Do-It-Yourself Delay

☐ Medium-scale integrated circuits, like the 555 timer, are all very fine, but it is instructive to know how to make do with simple gates. The following circuit, employing a single type 4011 quad NAND, or 4001 quad NOR, provides a hold-in delay, ranging from at least one second down to 20 miliseconds. In operation, when a positive potential is applied to the input, the output follows immediately, operating a relay or some other properly interfaced component. When the input is removed, the output continues high for a period determined by the RC time-constants. The polarity of the output may be reversed by omitting the last gate section. Likewise, the input can be enabled low by returning the biasing resistor to the positive supply and applying a negative-going signal.

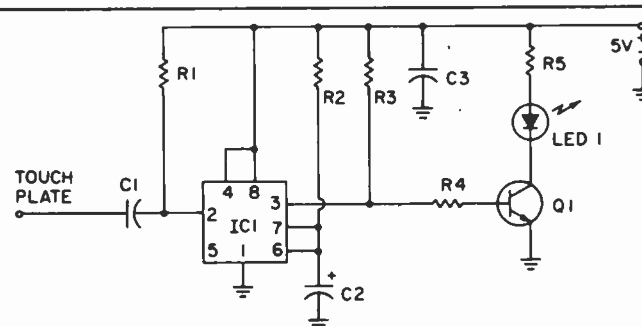


C1	R1, R2	Time
0.1-uF	1K	00.14 mSec
0.1-uF	100K	13.00 mSec
0.2-uF	1K	00.30 mSec
0.2-uF	10K	02.70 mSec
0.2-uF	100K	25.00 mSec
1.0-uF	1K	01.30 mSec
1.0-uF	100K	00.12 mSec
1.0-uF	1Meg	01.10 seconds

PARTS LIST FOR DO-IT-YOURSELF DELAY
C1—see table
D1—1N4148 diode
D2—small LED
IC1—4001A or 4011A quad NAND gate
Q1—2N4401
R1—47,000 to 56,000-ohm, ½-watt resistor
R2—see table

66. Touch Control

☐ Have you ever been in an office building where the

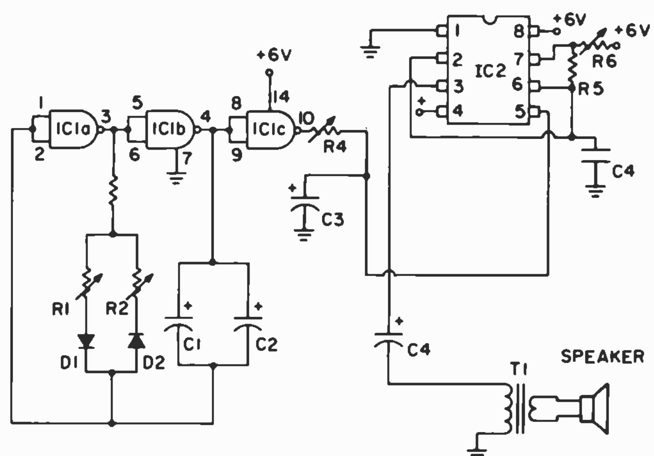


PARTS LIST FOR TOUCH CONTROL
C1—0.01-uF ceramic capacitor, 15 VDC
C2—1.0-uF electrolytic capacitor, 15 VDC
C3—0.1-uF ceramic capacitor, 15 VDC
IC1—555 timer
LED 1—large LED
Q1—2N4401
R1—10,000,000-ohm, ½-watt resistor
R2—4,700,000-ohm, ½-watt resistor
R3, R4—4,700-ohm, ½-watt resistor
R5—470-ohm, ½-watt resistor

elevator up-down buttons aren't switches at all, but work by touch? You can build a similar touch control circuit using a 555 timer IC. The circuit shown operates an LED, but you can easily modify it to control a doorbell or any other device. IC1 is connected as a one shot or monostable multivibrator with the trigger input, pin 2, wired to a high-impedance network. When the input terminal is touched by a finger, stray AC voltage pickup is impressed upon pin 2 of IC1, causing it to trigger. This causes pin 3 to go positive and provides forward bias to Q1 which illuminates the LED. R2 and C2 determine the time interval that LED 1 is illuminated, and for the values shown is about 3 seconds. The circuit is not fussy about power supply voltage.

67. Siren Circuit

☐ When switched on, this little screamer sounds like its official counterpart, with authentic-sounding rise and fall in pitch. Since the siren-sound is subjective to a large extent, plenty of variable components have been included in order to obtain the "perfect pitch." The circuit consists of a 555-type timer in astable mode, modulated by a varying DC, which is developed from a long-term multi-vibrator or clock. The high-low action of the clock causes capacitor C3 to charge and discharge through a resistance R4, the potential on the capacitor being applied to the "modulation input" (pin 5) of the 555. The long-period clock may be derived from another 555, or from the circuit shown.

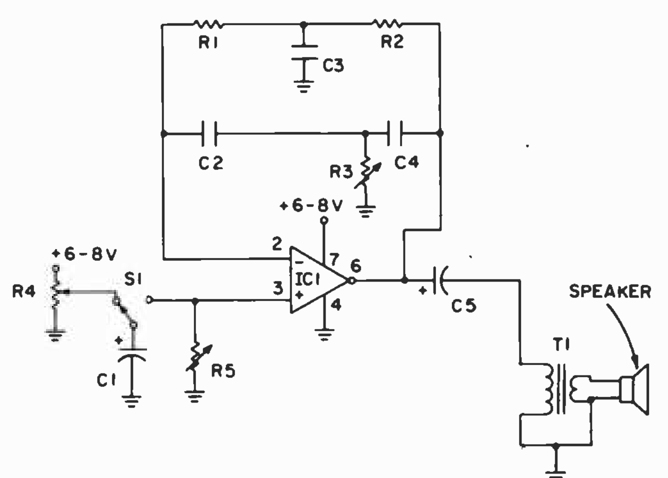


PARTS LIST FOR SIREN CIRCUIT

C1, C2—4.7-uF tantalum capacitor, 25 VDC
C3—500 to 1,000-uF electrolytic capacitor, 25 VDC
C4—100-uF electrolytic capacitor, 25 VDC
C5—0.1-uF ceramic capacitor, 15 VDC
IC1—4011A quad NAND gate
IC2—555 timer
R1—500,000-ohm, ½-watt resistor
R2—500,000-ohm linear-taper potentiometer
R3—47,000-ohm, ½-watt resistor
R4—10,000-ohm linear-taper potentiometer
R5—4,700-ohm, ½-watt resistor
R6—25,000-ohm linear-taper potentiometer
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

68. The Whistler

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



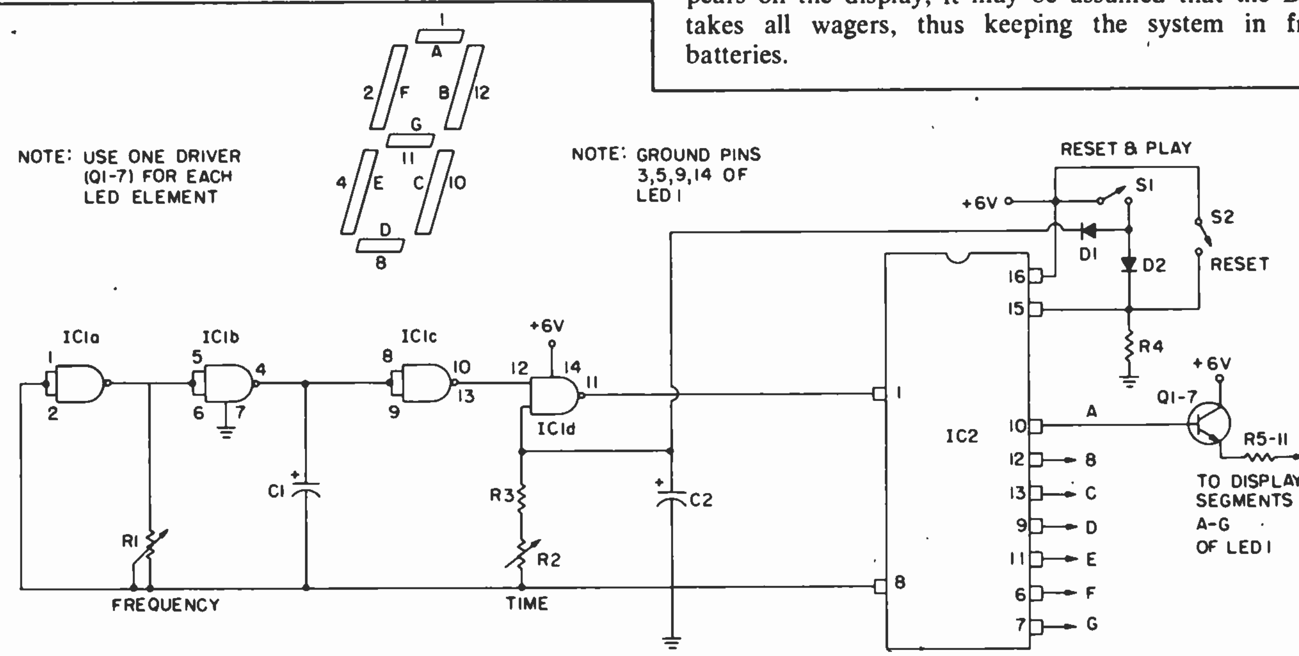
PARTS LIST FOR THE WHISTLER

C1—100 to 200-uF electrolytic capacitor, 15 VDC
C2, C4—0.001-uF ceramic capacitor, 1 VDC
C3—0.002-uF ceramic capacitor, 15 VDC
C5—100-uF electrolytic capacitor, 15 VDC
IC1—741 op amp
R1, R2—100,000-ohm, ½-watt resistor
R3, R4, R5—10,000-ohm linear-taper potentiometer
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

The output can be further amplified, but is sufficient to drive a small loudspeaker directly. With a little consideration in control settings, a very provocative "wolf whistle" can be produced!

69. Mini-Digital Roulette

☐ A more adult form of entertainment can be obtained from the 4026 counter and display previously described. The clock input terminal is connected via a pushbutton switch to the "Basic Pulse Maker" and two to nine players select a number. Then, press the button. The input frequency should be 10-Hz or higher and the Reset may zero the display first, although there is statistically little or no effect upon subsequent outcomes. When the switch is released, the counter holds on one number, which is displayed until reset or new counts arrive. If a Zero appears on the display, it may be assumed that the Bank takes all wagers, thus keeping the system in fresh batteries.

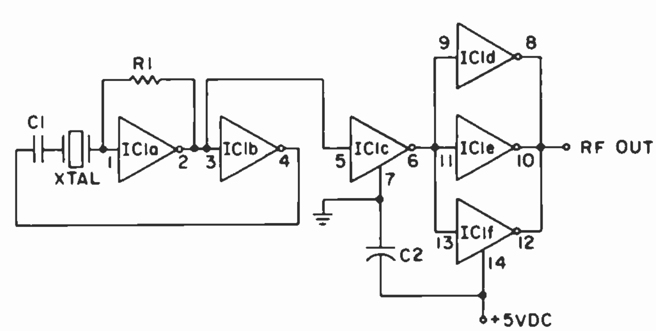


PARTS LIST FOR MINI-DIGITAL ROULETTE

C1—0.47 to 2.2-uF electrolytic capacitor, 15 VDC
C2—100-uF electrolytic capacitor, 15 VDC
D1, D2—1N4148 or 1N914 diode
IC1—4011 quad NAND gate
IC2—4026 decade counter
LED 1—DL-750 7-segment display
Q1 through Q7—2N4401 transistor
R1—500-000-ohm linear-taper potentiometer
R2—100,000-ohm linear-taper potentiometer
R3—10,000-ohm, ½-watt resistor
R4 through R11—1,000-ohm, ½-watt resistor
S1, S2—SPST momentary-contact switch

70. Crystal-Controlled TTL

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

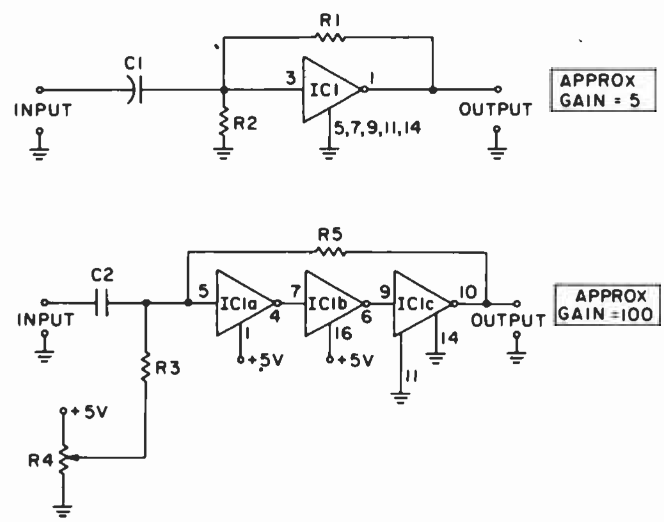


PARTS LIST FOR CRYSTAL-CONTROLLED TTL

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

71. Digital Goes Linear

☐ Digitally-oriented ICs are best at their intended On-Off tasks, but can be persuaded into linear operation if care is taken. CMOS lends itself better than TTL for linear operation, but good by-passing and layout is essential to avoid pickup and exotic self-oscillations. The 4009 CMOS hex-inverter sections can be biased as shown below. A typical single stage yields a gain of about 5. The triple combination can give a gain of 100 with care. These circuits could be useful where a high-impedance input circuit does not quite have sufficient amplitude to operate the digital gate.



PARTS LIST FOR DIGITAL GOES LINEAR

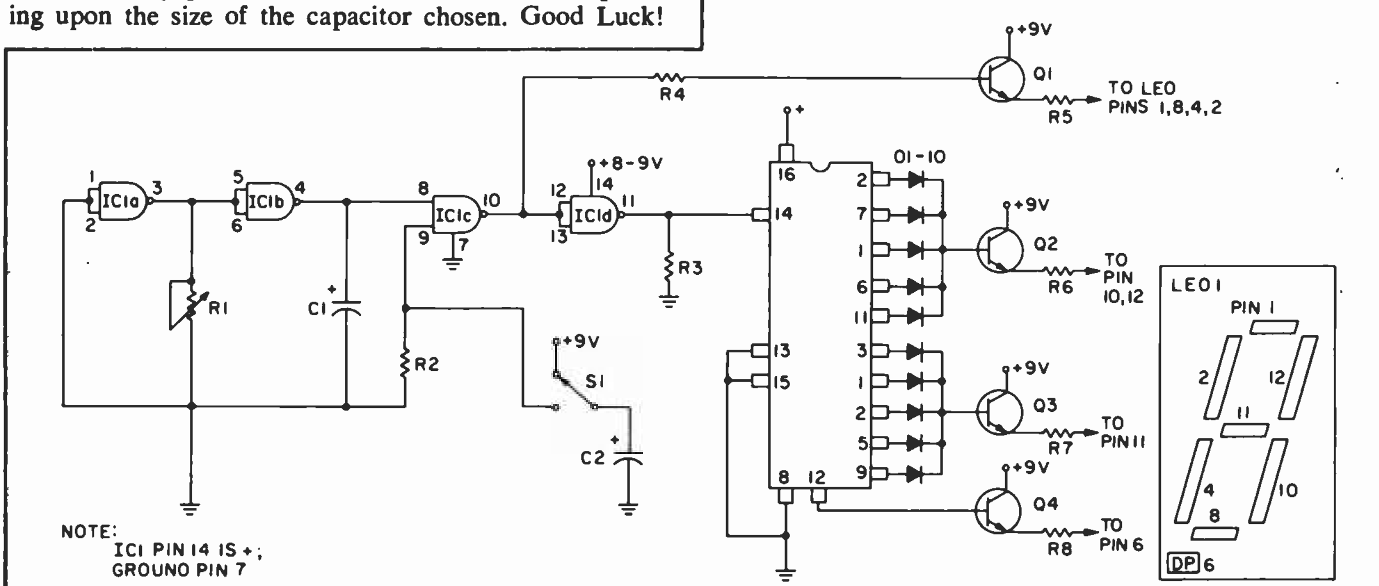
C1, C2—0.1-uF ceramic capacitor, 15 VDC
IC1—4009 hex buffer
R1, R2, R3—1,000,000-ohm, ½-watt resistor
R4—500,000-ohm linear-taper potentiometer
R5—5,000,000 to 10,000,000-ohm, ½-watt resistor

72. Even Odds

☐ The continued versatility of the 4017 counter and DL-750 digital display is demonstrated in this Odd-Even or Coin Toss simulator. As an added feature, the decimal point of the display is illuminated for an Odd or Even "Low Count," 0, 1, 2, 3, or 4 count from the counter. Even numbered counts (0 is considered even, for the sake of symmetry) cause the display to present an E, while odd-numbered counts result in a 0. Segments A, D, E and F are common to both 0 and E, but they are driven by the clock along with B, C, and G to stimulate all the segments into "random" motion. Holding down the pushbutton, causes C to discharge through R, giving an uncertainty period of five or seven seconds, depending upon the size of the capacitor chosen. Good Luck!

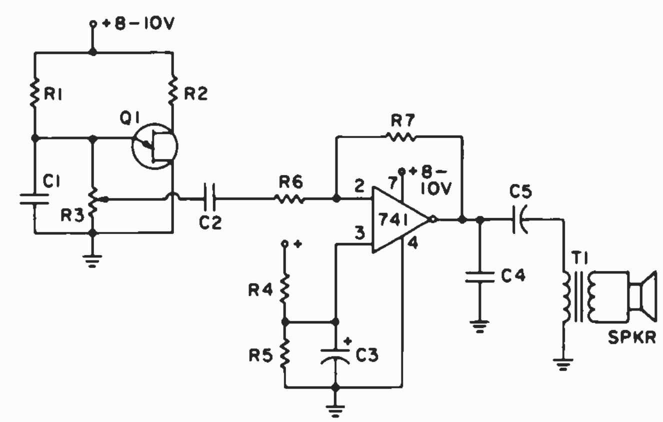
PARTS LIST FOR EVEN ODDS

C1—0.47 to 2.2-uF electrolytic capacitor, 15 VDC
C2—50 to 100-uF electrolytic capacitor, 15 VDC
D1 through D10—1N4148 diode
IC1—4017 decade counter
Q1 through Q4—2N4401 transistor
LED 1—DL-750 7-segment display
R1—500,000-ohm, ½-watt resistor
R2—100,000-ohm, ½-watt resistor
R3—1,000-ohm, ½-watt resistor
R4—560-ohm, ½-watt resistor
R5, R6, R7, R8—1,000-ohm, ½-watt resistor
S1—SPDT momentary-contact pushbutton switch



73. Sawtooth Sounds

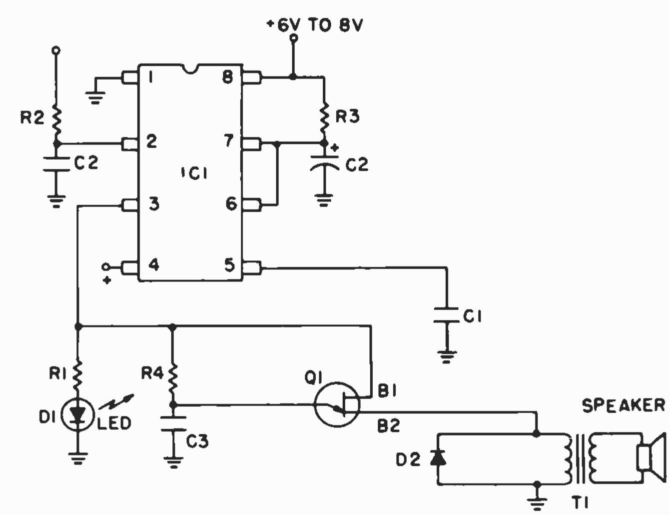
☐ The Micro-Mini-PA described earlier can put the sound of the unijunction transistor oscillator in the air and demonstrate its operation via the charge and discharge of its timing capacitor. The tone, about 300 Hz with the components shown below is roughly musical and can be shaped with filtering. The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



PARTS LIST FOR SAW-TOOTH SOUNDS
C1—0.47-uF ceramic capacitor, 15 VDC
C2—0.1-uF ceramic capacitor, 15 VDC
C3—6 to 8-uF electrolytic capacitor, 25 VDC
C4—0.01-uF ceramic capacitor, 15 VDC
C5—50-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
Q1—2N2646 unijunction transistor
R1, R4, R5—4,700-ohm, ½-watt resistor
R2—100-ohm, ½-watt resistor
R3—50,000-ohm linear-taper potentiometer
R6—10,000-ohm, ½-watt resistor
R7—100,000-ohm, ½-watt resistor
T1—audio outut transformer 500-ohm primary/8-ohm secondary

74. Hands Off!

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



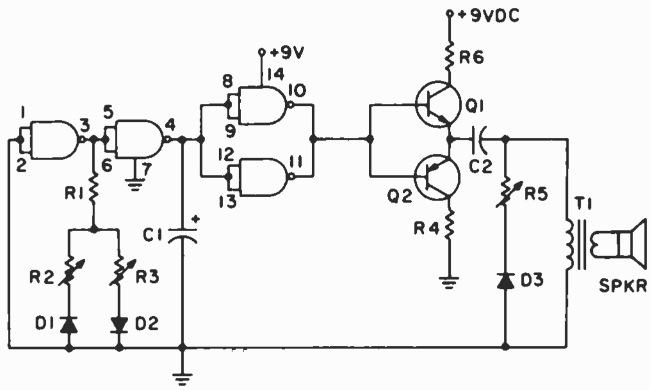
PARTS LIST FOR HANDS OFF
C1—0.1-uF ceramic capacitor, 15 VDC
C2—0.01-uF ceramic capacitor, 15 VDC
C3—0.1-uF ceramic capacitor, 15 VDC
D1—small LED
D2—1N4148 diode
IC1—555 timer
Q1—2N2646
R1—470-ohm, ½-watt resistor
R2—1,000,000-ohm, ½-watt resistor
R3—220,000-ohm, ½-watt resistor
R4—15,000-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

75. Mini-Micro Metronome

☐ Transforming IC pulses into sound, this tiny ticker goes both tick *and* tock, at a rate of about 2 seconds per tic to 6 tocks per second. The timing capacitor, C1, should be a low leakage mylar type of about 2-uF or else a quality tantalum of about 4.7-uF. Although the reversed flow of current through the transformer's primary winding causes a different sound in the speaker from the positive-going inrush, diode D3 and potentiometer R5 can be added to make the "tock" more definitive in its sound quality.

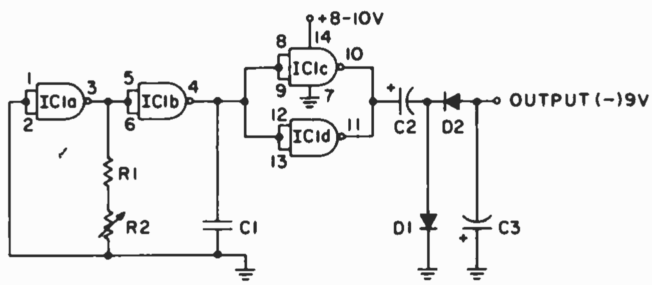
PARTS LIST FOR MINI-MICRO METRONOME

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



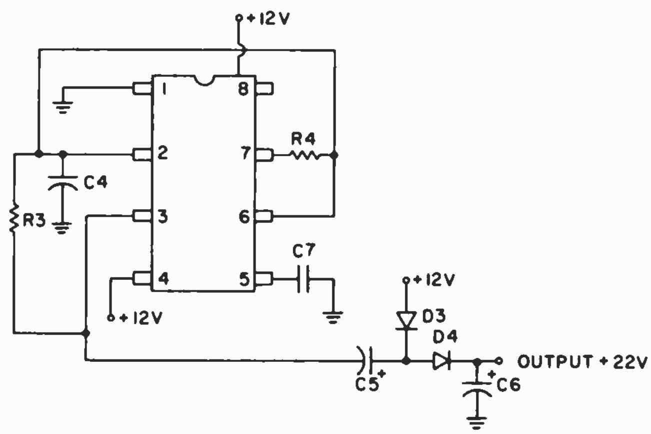
76. Positive Into Negative

☐ Certain IC chips and other circuit elements often require small negative potentials of small current drain, necessitating the construction of bulky transformer-operated supplies. Operating at 1 KHz or higher frequency, the pulse generator shown below drives a voltage-doubler circuit furnishing a negative potential approaching that of the positive input supply. With a 10 volt input, an output of about –9 VDC was measured into a 20,000 ohm load. A voltage tripler or quadrupler circuit may also be employed for higher potentials (positive or negative) as well. For loads requiring up to 50 ma, the type 555 timer in astable mode is an ideal choice.



PARTS LIST FOR POSITIVE INTO NEGATIVE

C1—0.01 to 0.1-uF ceramic capacitor, 15 VDC
C2, C5—10-uF electrolytic capacitor, 25 VDC
C3—10 to 100-uF electrolytic capacitor, 25 VDC
C4—0.001-uF ceramic capacitor, 15 VDC
C6—25-uF electrolytic capacitor, 25 VDC
C7—0.01-uF ceramic capacitor, 15 VDC
D1 through D4—1N4001 diode
IC1—4011 quad NAND gate
IC2—555 timer
R1—500-ohm, ½-watt resistor
R2—50,000-ohm linear-taper potentiometer
R3—33,000-ohm, ½-watt resistor
R4—4,700-ohm, ½-watt resistor

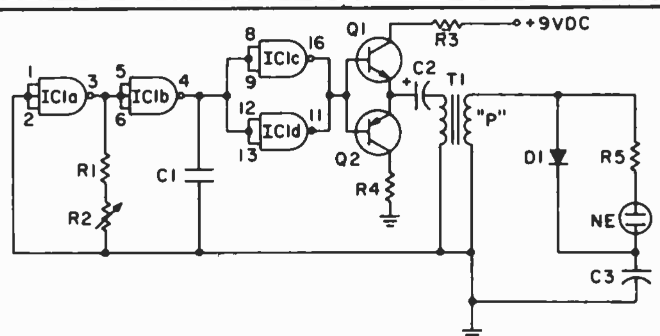


77. Nine Volt Neon Lamp

☐ High voltage, sufficient, at any rate, to power a type NE-2 neon bulb, can be obtained via an interstage trans-

PARTS LIST FOR NINE VOLT NEON LAMP

C1—0.01 to 0.1-uF ceramic capacitor, 15 VDC
C2—10-uF electrolytic capacitor, 25 VDC
C3—0.47-uF ceramic capacitor, 400 VDC
D1—1N4002 diode
IC1—4011A quad NAND gate
Q1—2N4401 transistor
Q2—2N4403 transistor
NE—NE-2 neon lamp

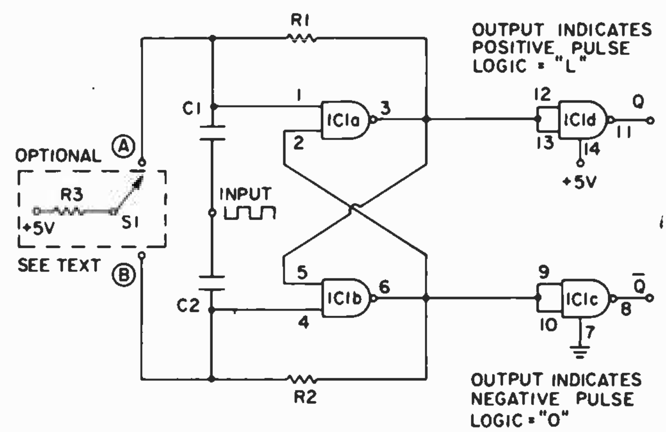


R1—500-ohm, ½-watt resistor
R2—10,000-ohm linear-taper potentiometer
R3, R4—10-ohm, ½-watt resistor
R5—10,000 to 22,000-ohm, 2-watt resistor
T1—audio output transformer 1,000-ohm primary/75-ohm secondary

former with the high-turns side feeding the lamp. (The transformer used here is one with windings of 75 ohms and 1000 ohms impedance.) One kHz or higher frequencies from the pulse generator are stepped up and rectified as shown. (Possibly other transformer combinations could be obtained to fire the lamp directly.)

78. Do-It-Yourself Logic

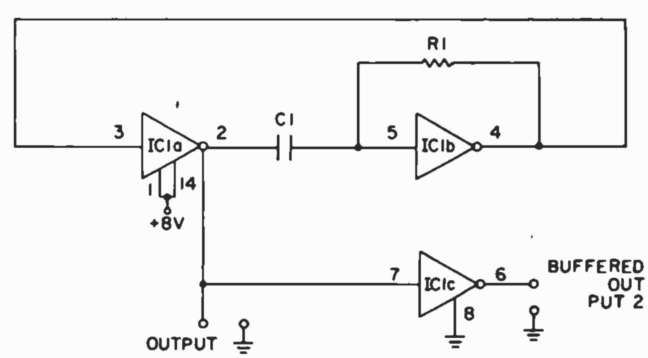
☐ Sometimes the integrated circuits taken for granted are not always available, and one must fall back on more basic components. We do not go quite as far as discrete transistors here, but show how a frequency divider flip-flop can be improvised from simple gates. The following divide-by-two circuit was used for dividing a 60 Hz square wave, but should work well at other frequencies. A 7400 or 74LS00 quad NAND gate was selected, with the two extra gates employed as buffers to keep the input toggle clock from appearing when the flip-flop was biased off. If the cut-off resistor R3 is the same value as R1 and R2, a lock-out will be obtained. If it is about doubled, then the circuit will function, but will hold one output high (or low) when the clock signal drops out.



PARTS LIST FOR DO-IT-YOURSELF LOGIC
C1, C2—0.01 to 0.1-uF ceramic capacitor, 15 VDC
IC1—7400 quad NAND gate
R1, R2—50,000 to 100,000-ohm, ½-watt resistor (see text)
R3—50,000 to 200,000-ohm, ½-watt resistor (see text)
S1—SPDT toggle switch

79. CMOS Logic-al For RF

☐ CMOS logic, of the 4000 Series, has sometimes been put down against TTL when speed is involved. However, the following circuit shows that oscillations of over 5 MHz are quite possible, and simple to obtain as well. With C = 27-pF, the following frequencies were obtained with varying R. The output at pin 2 is sinusoidal, but the buffer shown (between pins 7 and 6) reduces frequency shifts from circuit loading.

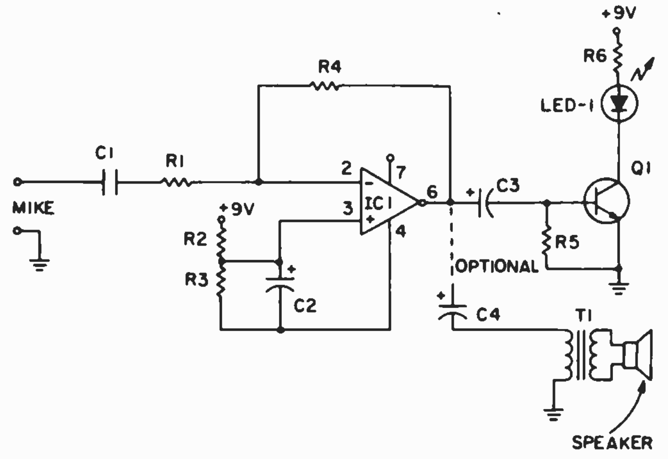


R1 (ohms)	freq. (MHz)
680	6.33
1,000	5.30
2,200	3.50
3,300	2.70
4,700	2.00
10,000	1.10

PARTS LIST FOR CMOS LOGIC-AL FOR RF
C1—27-pF mica capacitor, 15 VDC
IC1—4009AE hex buffer
R1—see table

80. LED Adds Luster

☐ Through the addition of a transistor driver, a small LED indicator can give the visual state of an op amp, such as might be used to detect noise impulses, as in an alarm system. The 2N4401 NPN transistor provides plenty of power and gain for such an application. The method can be used both with and without an audio indicator, like a small loudspeaker, as well. You will have to experiment with the value of R1 to obtain triggering depending upon the impedance of the mike used.

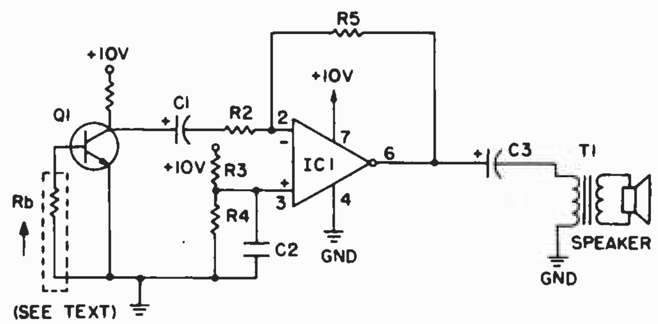


PARTS LIST FOR LED ADDS LUSTER

C1—0.1-uF ceramic capacitor, 15 VDC
C2—10-uF electrolytic capacitor, 15 VDC
C3—2.2-uF electrolytic capacitor, 15 VDC
C4—50 to 100-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
LED1—small LED
Q1—2N4401 transistor
R1—500 to 500,000-ohm, ½-watt resistor (see text)
R2 R3—4,700-ohm, ½-watt resistor
R4—500,000-ohm, ½-watt resistor
R5—10,000 to 50,000-ohm, ½-watt resistor
R6—100-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

81. Light Into Sound

☐ While another project in this book illustrates how sound impulses could be converted into light signals, via an LED indicator, here, a type FPT-100 phototransistor turns light into sound. When connected, the system may be quick-checked with a flashlight, while listening to the speaker and/or observing the op amp output on a scope. Modulating the light source mechanically with a pocket comb produces a buzzing tone, as the teeth of the comb alternately gate the light source. A modulated LED can be used, with proper optical interfacing, as a communication source. The phototransistor is at its greatest sensitivity with the base lead open, though this may introduce unwanted hum. A 100K to 1 Meg resistor (R6) may be run to ground to check the best compromise.



PARTS LIST FOR LIGHT INTO SOUND

C1 C2—10-uF electrolytic capacitor, 15 VDC
C3—50-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
Q1—FPT100 phototransistor
Rb—100,000 to 1,000,00-ohm, ½-watt resistor (see text)
R1—47,000-ohm, ½-watt resistor
R2—1,000 to 10,000-ohm, ½-watt resistor
R3 R4—4,700-ohm, ½-watt resistor
R5—500,000-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

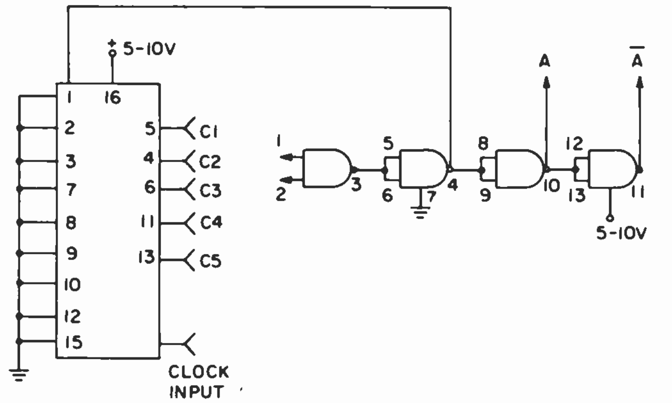
82. Dividing It All Up

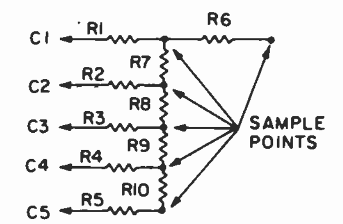
☐ The type 4018 programmable counter is a useful digital tool, especially where a basic clock frequency must be divided down for various timing operations. With proper connections, divisors of from 2 through 10 may be configured. The table shown below gives the connections. The odd divisors do not give symmetrical outputs, but close ratios, such as four-high, three-low for a divide-by-seven setup. Digital-to-Analog Conversion may also be studied by connecting the outputs as shown. Interesting waveforms may be obtained by trying out the various dividing connections, while tying an oscilloscope into the different resistor network junctions. With the circuit set for a divide-by-ten function, a *digital sine wave* may be discovered at certain points along the network. With clock frequencies above 1 KHz, this output may be heard on an audio amplifier. Computer Music, anyone?

PARTS LIST FOR DIVIDING IT ALL UP

IC1—4018 dividing counter
IC2—4011A quad NAND gate
R1 through R6—100,000-ohm, ½-watt resistor
R7 through R10—47,000-ohm, ½-watt resistor

To Divide By	Connect Pins 1&2 of IC2 To Pin 1	Pin 2
2	C1	C1
3	C2	C1
4	C2	C2
5	C2	C3
6	C3	C3
7	C3	C4
8	C4	C4
9	C4	C5
10	C5	C5

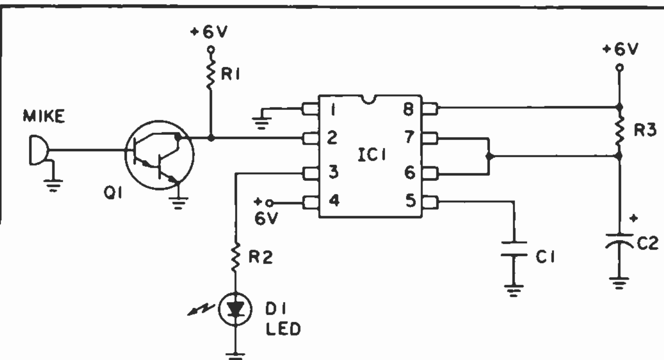




DIGITAL TO ANALOG CONVERSION NETWORK

83. The Robot Ear, TTL

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

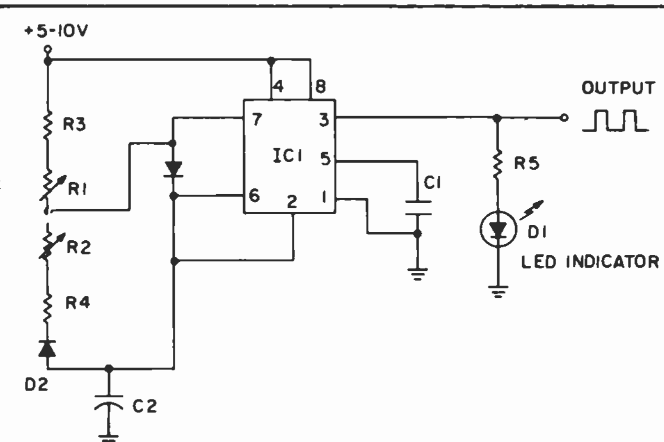


PARTS LIST FOR THE ROBOT EAR, TTL

- **C1**—0.1-uF ceramic capacitor, 15 VDC
- **C2**—5-uF electrolytic capacitor, 15 VDC
- **D1**—small LED
- **IC1**—555 timer
- **Q1**—Motorola MPS-A13 transistor
- **R1**—47,000 to 100,000-ohm, ½-watt resistor
- **R2**—470-ohm, ½-watt resistor
- **R3**—220,000-ohm, ½-watt resistor

84. Universal Pulser

☐ The type 555 timer, in its astable mode, can furnish pulses ranging in duration from about one microsecond to minutes. The version shown allows both frequency and duty cycle (on-off ratio) to be adjusted. The 555 is husky for its size, and can drive over ten TTL gates and a far larger number of CMOS gates.



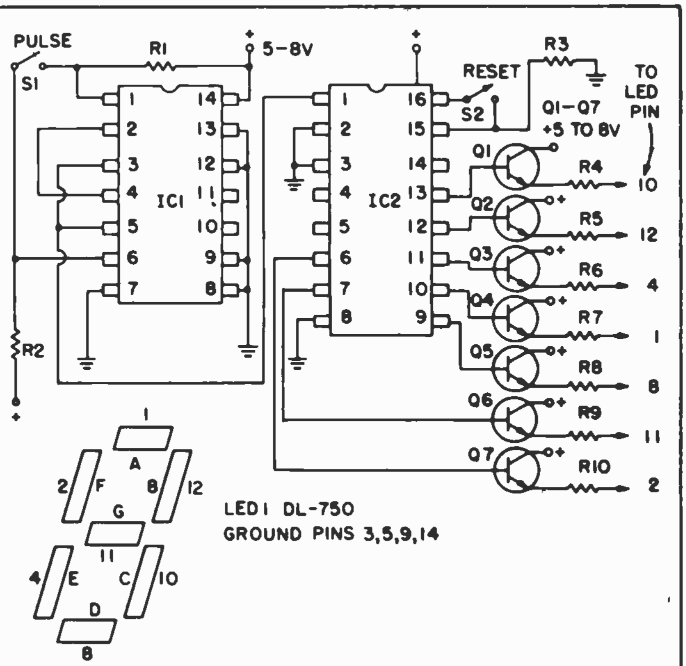
PARTS LIST FOR UNIVERSAL PULSER

- **C1**—see table
- **D1, D2**—1N4148 diode
- **D3**—small LED
- **IC1**—555 timer
- **R1, R2**—see table
- **R3, R4**—1,000-ohm, ½-watt resistor
- **R5**—470-ohm, ½-watt resistor

85. Taking the Count

☐ The type 4026 and its companion 4033 CMOS counter-decoders are so versatile and useful, that the IC experimenter should make their acquaintance without delay. What they do is to count incoming pulses (positive-going) and *directly* drive those seven-segment LED (or other) digital indicators. The 4026 and the DL-750 display provide a particularly happy pair as no interfacing drivers or current-limiting resistors are needed for voltages in the 5 to 8 volt supply range.

For an introduction to this most useful IC, connect as shown below. Reset the display to "0". Using a bounceless push-button switch, step through the digits one-by-one. The display makes a good teaching aid for the pre-school set, letting them "learn their numbers" by pushing the switch five times for "5," etc.

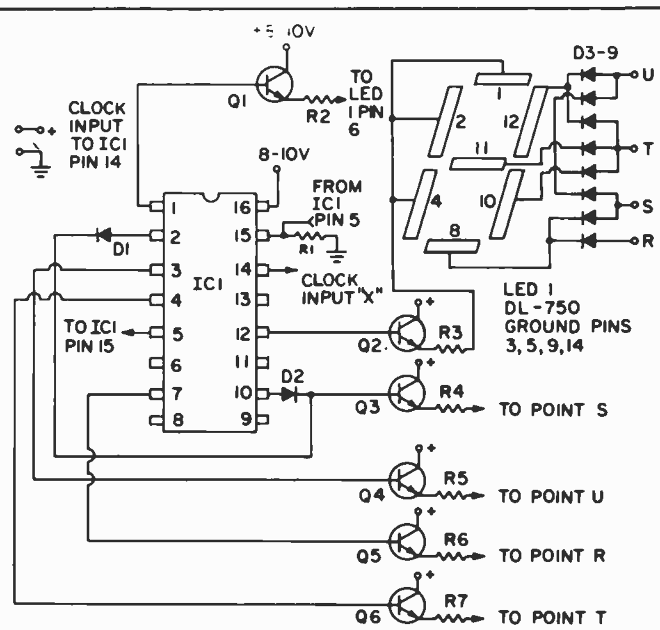


PARTS LIST FOR TAKING THE COUNT

IC1—4001 AE quad NAND gate
IC2—4026 decade counter
LED—DL-750 7-segment display
Q1 through Q7—2N4401 transistor
R1 through R10—1,000-ohm, ½-watt resistor
S1—SPDT slide switch
S2—SPST momentary-contact push-button switch

86. Spelling It All Out

☐ The title, we must hasten to admit, is a slight misnomer. The seven-segment digital display finds it difficult to handle letters such as K, M, and Z, for example. But the following demonstration proves it's far from illiterate. Part of the trick here is to make use of letters sharing common display segments, in this case A, E, and F. Through the use of steering diodes, each step of the 4017 counter spells out the letters P-E-A-C-E. (the period being the decimal point). The next step resets the counter. Note that the common segments are powered up only during the 0-4 steps, when the "divide-by-ten" or "carry" output, pin 15, is high. Other words, up to nine letters in length may be programmed with suitable diode matrices.

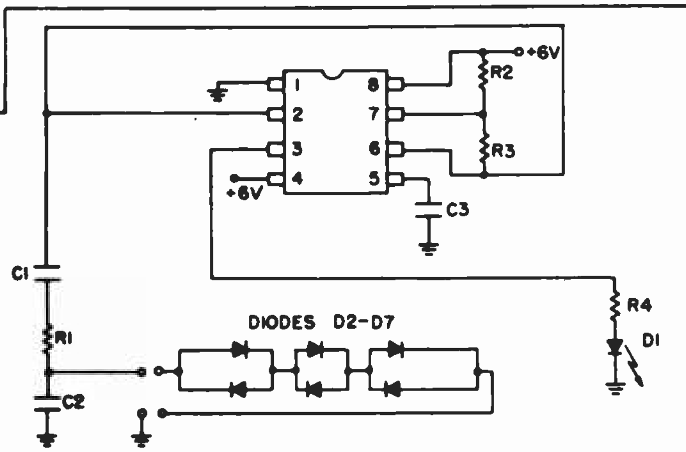


PARTS LIST FOR SPELLING IT ALL OUT

D1 through D9—1N4148 diode
IC1—4017 decade counter
LED1—DL-750 7-segment display
R1—2,200-ohm, ½-watt resistor
R2, R6—680-ohm, ½-watt resistor
R3, R4, R5, R7—330-ohm, ½-watt resistor

87. Tempera-Tone

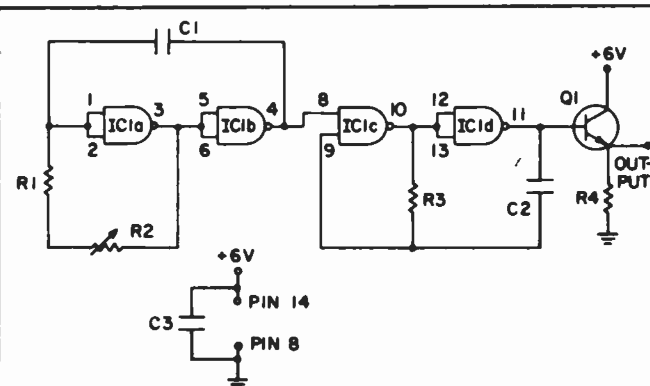
☐ Another application of the 555 timer teams it up with the temperature sensitivity of common germanium diodes, like the 1N270. The 555 is configured as an oscillator operating in an area of from 700 to 1500 Hz. The tuning capacitor, instead of returning to ground, goes through R1 and a string of three or four 1N270 diode pairs connected back-to-back as a temperature probe. This probe may be positioned some distance away from the circuit to monitor a device or environment where the temperature, or its change, is of concern. An increase in temperature causes the frequency to decrease, while a temperature fall increases the frequency. The audio output may be monitored via the "Micro-Mini PA" amplifier circuit in this book. Larger values of C1 will cause temperature variations to be detected by varying the flashing rate of the LED, which shows that the system is in operation.



PARTS LIST FOR TEMPERA-TONE
C1—0.01-uF ceramic capacitor, 50 VDC (see text)
C2, C3—0.01-uF ceramic capacitor, 50 VDC
D1—small LED
D2 through D7—1N270 diode
IC1—555 timer
R1—22,000-ohm, ½-watt resistor
R2— **R3**—100,000-ohm, ½-watt resistor
R4—560-ohm, ½-watt resistor

88. Digital Modulator

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

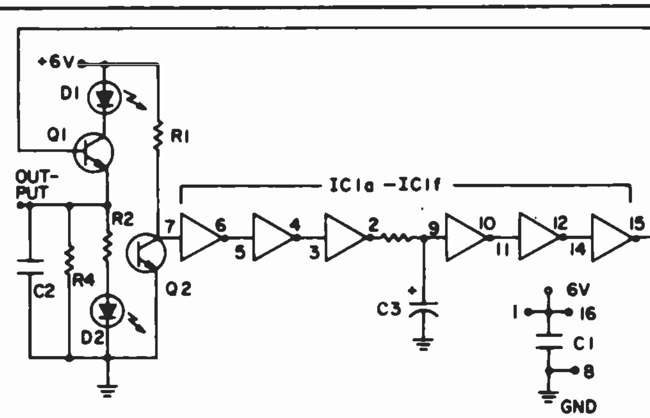


PARTS LIST FOR DIGITAL MODULATOR
C1—0.01-uF ceramic capacitor, 15 VDC
C2—100-pF mica capacitor, 15 VDC
C3—0.1-uF to 0.22-uF ceramic capacitor, 15 VDC
IC1—4011A quad NAND gate
Q1—2N4401 transistor
R1—10,000-ohm, ½-watt resistor
R2—100,000-ohm, ½-watt resistor
R3—2,200-ohm, ½-watt resistor
R4—150-ohm, ½-watt resistor

89. The LED Connection

☐ Opto-isolators are popular for coupling two remote or incompatible signal inputs and outputs. Using the FPT-100 photo-transistor and a suitable LED, an opto-isolator may be simulated. A medium-sized or large LED, red or clear, is brought into proximity with the photo-surface of the transistor. A rubber grommet can be used to both tightly hold the two units and prevent external light from affecting the transistor.

For demonstration purposes, an oscillator is shown. It



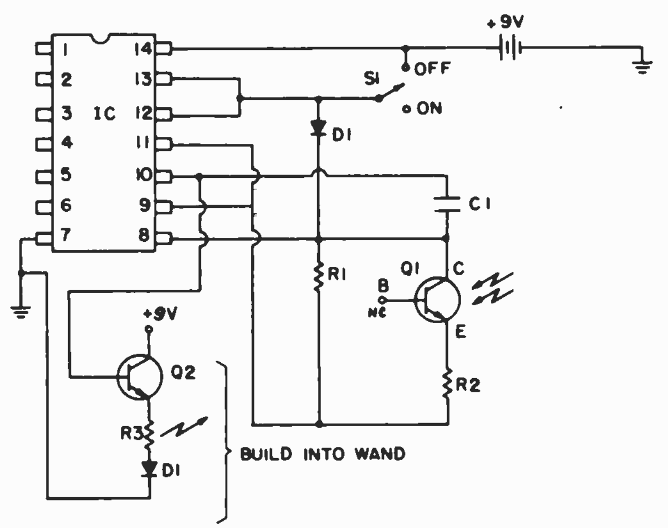
PARTS LIST FOR THE LED CONNECTION
C1, C2—0.1-uF ceramic capacitor, 15 VDC
C3—0.001-uF to 0.1-uF ceramic capacitor, 15 VDC, depending upon desired frequency.
D1—small LED
D2—large LED
Q1—2N4401 transistor
Q2—FPT100 phototransistor
R1, R3—100,000-ohm, ½-watt resistor
R2—100-ohm, ½-watt resistor
R4—1,000-ohm, ½-watt resistor

employs the LED-phototransistor coupler, with a 4009A or 4049 hex-inverter IC and an NPN transistor as an emitter-follower driver. Frequency is determined by C3.

Since the coupler effectively conceals the operation of the main LED, a secondary LED in the collector of the driver transistor gives visual indication of oscillation.

90. Magic Blinker

☐ Imagine a small black box that you place on a table in front of your friends. Connected to the box with a thin wire is a wand with a small red light (LED) on the end. The light flashes about twice a second, but at your command, it flashes faster and faster. You hand it to your friends, but they cannot do it. The secret? In the box is a small hole with photo transistor Q1 showing through. As D1 gets closer to Q1, it flashes faster and faster but it will take your friends a long while to catch on. It's especially effective when all the room lights are out. Have fun.

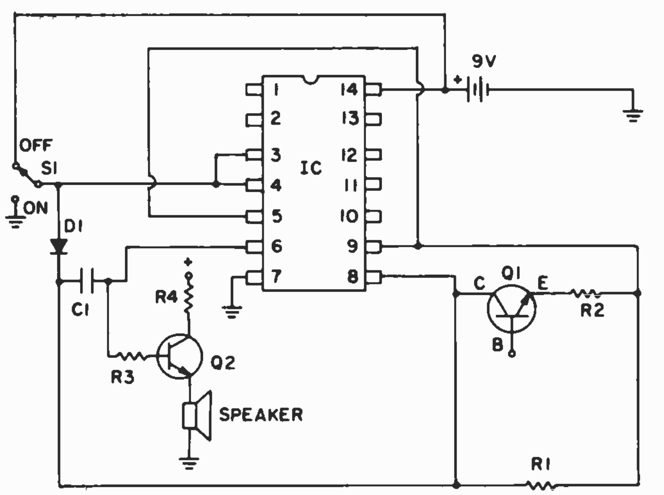


PARTS LIST FOR MAGIC BLINKER

- C1—0.01-uF ceramic capacitor, 15 VDC
- D1—small LED
- D2—1N4001 diode
- IC1—4000 dual NOR gate w/inverter
- Q1—FPT100 phototransistor
- Q2—2N4401 transistor
- R1—5,000,000-ohm, ½-watt resistor
- R2—1,000,000-ohm, ½-watt resistor
- R3—680-ohm, ½-watt resistor

91. Haunted House

☐ An eerie sound comes from a small box in a dark room. As your friends shine a light toward the sound, it whines with a higher pitch, but falls again as they drop the light and run. The output at A can also be run into your hi-fi system to cause a very loud witch's squeal. The principle is a NOR-gate oscillator with a pitch controllable via the light-sensitive transistor Q1. Changing R1 to a higher value will give a lower-pitched wail.



PARTS LIST FOR HAUNTED HOUSE

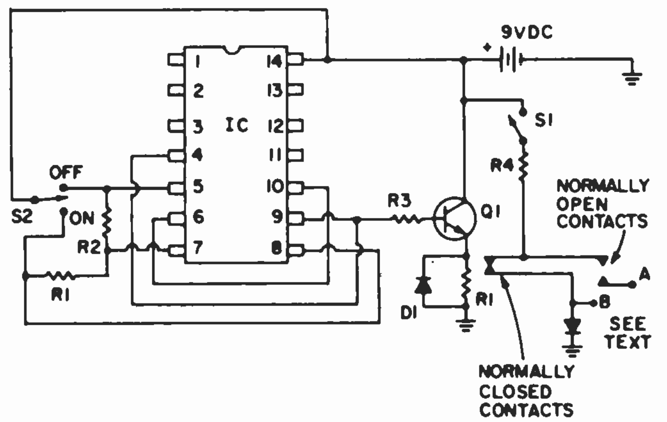
- C1—0.01-uF ceramic capacitor, 15 VDC
- D1—1N4001 diode
- IC1—4000 dual NOR gate w/inverter
- R1—30,000-ohm, ½-watt resistor
- R2—1,000,000-ohm, ½-watt resistor
- R3—2,000-ohm, ½-watt resistor
- R4—500-ohm, ½-watt resistor
- S1—SPDT toggle switch

92. One- or Two-way Reflex Tester

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

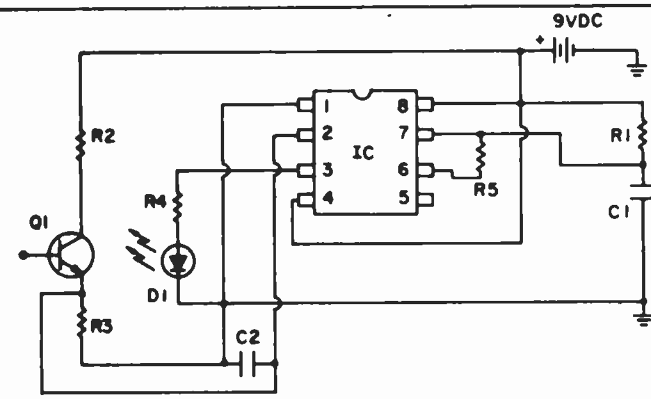
In the dual-circuit (competitive) version, two identical circuits are built and S1 becomes a DPST switch. The two circuits are interconnected by using a second set of normally open contacts on the relay. Point "A" of one competitor's circuit is connected to point "B" on the other's. When this is done,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

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



93. Optical Confusion

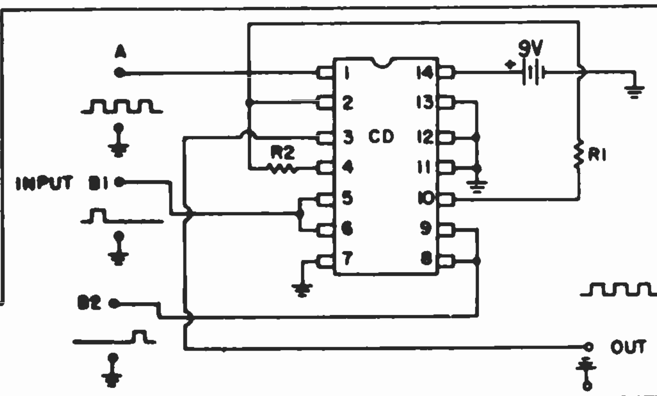
☐ "As anyone can plainly see, the LED (D1) flashes rather rapidly," you say to an unsuspecting guest. "But in fact, the flashes are an optical illusion. Just hold this white paper in front of the LED and look at the light through the paper. You will see that in fact the LED is not flashing, at least not until you remove the paper." Your guest will be the victim of optical confusion. The trick lies in the fact that the LED flashes only as long as its light shines on Q1. Put the paper between D1 and Q1 and the LED shines continuously.



PARTS LIST FOR OPTICAL CONFUSION
C1–0.01-uF ceramic capacitor, 15 VDC
C2–0.1-uF ceramic capacitor, 15 VDC
D1–large LED
IC1–555 timer
Q1–FPT100 phototransistor
R1–10,000,000-ohm, ½-watt resistor
R2, R3–1,000,000-ohm, ½-watt resistor
R4–220-ohm, ½-watt resistor
R5–2,000,000-ohm, ½-watt resistor

94. Pulse Pulser

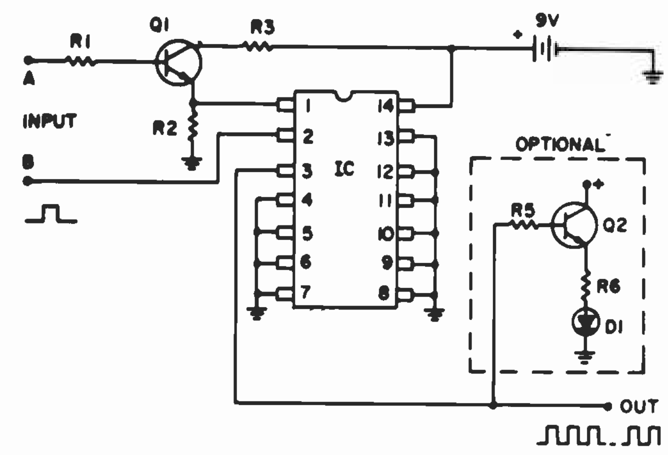
☐ This simple circuit allows a lot of experimenting, especially if you try combining it with the "Pulse Stopper" circuit. Here, we have a case where the pulse stream coming in at A will not make it through to the output unless either B1 or B2 has an input pulse signal. If A is connected to a CMOS oscillator circuit, and B1 or B2 are connected to a Morse Code keyer, you can practice code with someone on B1 and someone on B2. The output will drive an amplifier like the "Micro-Mini PA" project.



PARTS LIST FOR PULSE PULSER
IC1–4001 quad NOR gate
R1, R2–1,000-ohm, ½-watt resistor

95. Low Level Pulse Stopper

☐ The object of this simple circuit is to show how you can take a low-level (around ¼ volt to 1 volt) stream of input pulses and take a chunk right out of it without disturbing the rest of the pulse stream. The pulses come in at point A, actually between A and ground. The size of the chunk you want to take out is controlled by the width of the positive pulse you put in at point B. The output will be your desired pulse stream, and an optional LED circuit can be added for indication. The unused pins of the IC should be grounded.

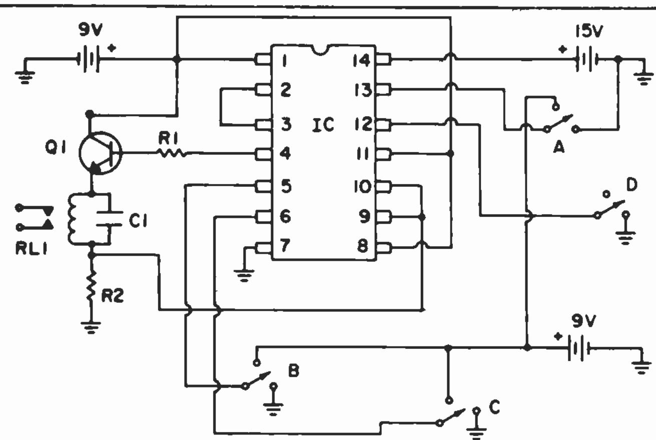


PARTS LIST FOR LOW-LEVEL STOPPER

- **D1**—small LED
- **IC1**—4001 quad NOR gate
- **Q1, Q2**—2N4401 transistor
- **R1**—33,000-ohm, ½-watt resistor
- **R2, R3**—4,700-ohm, ½-watt resistor
- **R4**—10,000-ohm, ½-watt resistor
- **R5**—1,000-ohm, ½-watt resistor

96. Electronic Combination Locks

☐ The CD4016 contains four electronic switches that can be operated with control current. The relay in this circuit will operate only if A and B switches are on (switched to the +9V side) and if C and D are off. You can experiment with different connections to make your own combination, or substitute rotary switches with additional contacts.

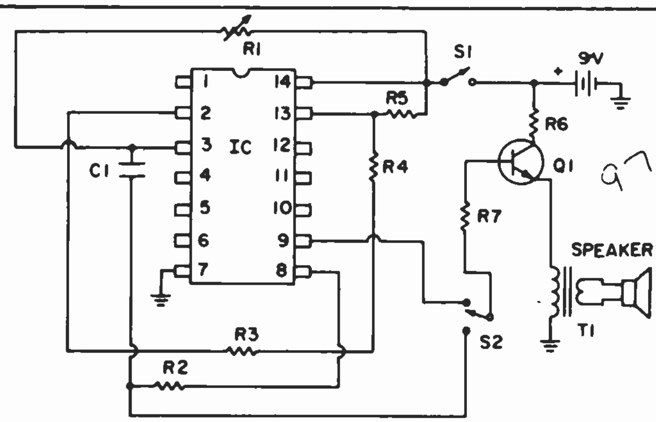


PARTS LIST FOR ELECTRONIC COMBINATION LOCK

- **C1**—0.1-uF ceramic capacitor, 15 VDC
- **IC1**—4016 quad bilateral switch
- **Q1**—2N4401 transistor
- **R1**—10,000-ohm, ½-watt resistor
- **R2**—100-ohm, ½-watt resistor
- **RL1**—any relay w/9 VDC coil to suit application
- **SWITCHES (A, B, C, D)**—SPDT slide type

97. Two Tone Siren

☐ This circuit lets you generate an up-and-down siren sound by varying R1, and lets you change the type of sound by flipping S2. The output from pin 4 is a sawtooth waveform which causes one type of sound by



PARTS LIST FOR TWO-TONE SIREN

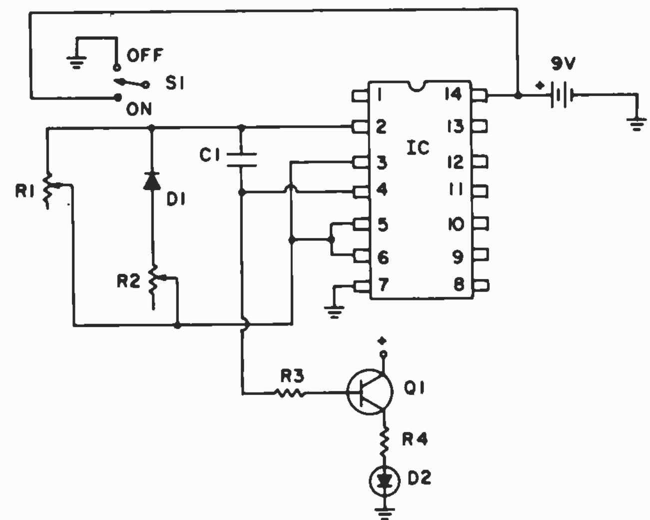
- **C1**—0.01-uF ceramic capacitor, 15 VDC
- **IC1**—3900 quad op amp
- **Q1**—2N4401 transistor
- **R1**—1,000,000-ohm linear-taper potentiometer
- **R2**—100,000-ohm, ½-watt resistor
- **R3**—510,000-ohm, ½-watt resistor
- **R4**—120,000-ohm, ½-watt resistor
- **R5**—1,200,000-ohm, ½-watt resistor
- **R6**—1,000-ohm, ½-watt resistor

R7—2,000-ohm, ½-watt resistor
S1—SPST toggle switch
S2—SPDT slide switch
T1—audio output transformer 500-ohm primary/8-ohm secondary

flipping S2. The output from pin 4 is a sawtooth waveform which causes one type of sound through the speaker. The other type of sound, sharper and higher than the first, comes from the square wave output of pin 9. Flipping between the two types of sounds while varying R1 produces the sound of a French Police car siren.

98. Basic CMOS NAND Oscillator

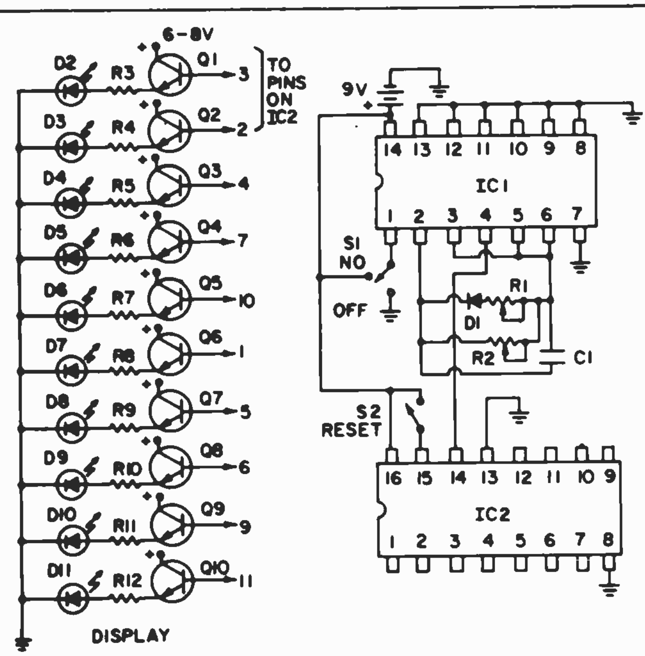
☐ Closing S1 causes this CMOS NAND oscillator to flash the LED. The "ON" time is controlled by R1 and the "OFF" time is controlled by R2. This oscillator can sit for months with S1 open because, being CMOS, it draws very little power. It is a basic oscillator useful for driving buzzers, computer clocks, counters, various alarm circuits, windshield wipers and uncountable other applications. The output from pin 4 can drive small loads, even small relays, directly, or you can drive a transistor or SCR to handle bigger loads.



PARTS LIST FOR BASIC CMOS NAND OSCILLATOR
C1—0.1-uF ceramic capacitor, 15 VDC
D1—1N4001 diode
D2—small LED
IC1—4011 quad NAND gate
Q1—2N4401 transistor
R1—10,000,000-ohm linear-taper potentiometer
R2—100,000-ohm linear-taper potentiometer
R3—1,000-ohm, ½-watt resistor
R4—10,000-ohm ½-watt resistor
R5—570-ohm, ½-watt resistor
S1—SPDT slide switch

99. Rippling Wave

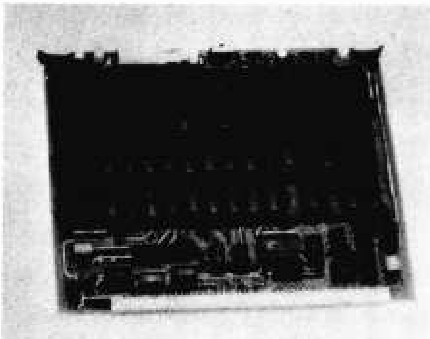
☐ The rippling effect on the ten LEDs is a beautiful and interesting sight, especially if they are mounted atop a nice wooden case and placed in the living room. A nice conversation piece. The speed of the ripple is controllable via R1 and R2, where a smaller R1 and R2 makes the ripple go faster. The "on" of each LED overlaps perfectly with no momentary "off," so the ripple travels very smothly.



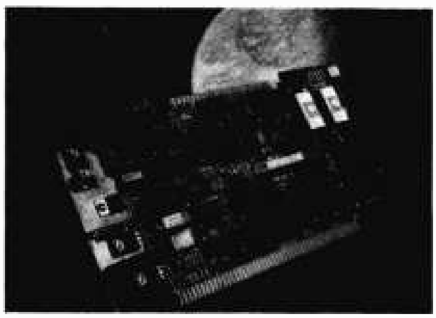
PARTS LIST FOR RIPPLING WAVE
C1—0.01-uF ceramic capacitor, 15 VDC
D1—1N4401 diode
D2 through D11—small LED
IC1—4011 quad NAND gate
IC2—4017 decade counter
R1—10,000,000-ohm linear-taper potentiometer
R2—500,000-ohm linear-taper potentiometer
R3 through R12—1,000-ohm, ½-watt resistor
S1—SPDT slide switch
S2—SPST momentary-contact pushbutton switch

COMPUTER NEW PRODUCTS

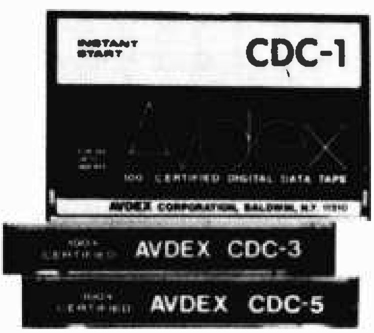
Here you will find information on the newest hobby computers and accessories.



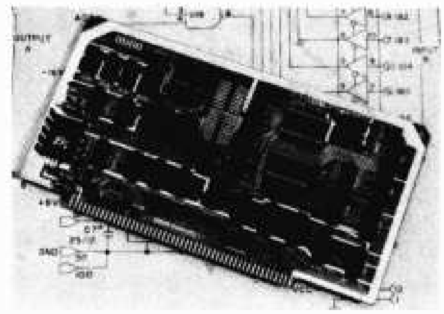
High Density Memory Module—PCS, Inc. offers a high density PCS 1814 CMOS RAM Memory Module that features 8K bytes of CMOS RAM and a 450 nanosecond memory cycle that ensures memory will run at CPU speeds. This is a low power module with built-in battery backup and charging circuitry which will retain information for a minimum of seven days. There's also provision for an external battery for increased battery support if needed. A switch selectable write protect is helpful for development and debugging purposes. The unit is available in two versions. The basic module has 4K bytes of RAM installed in sockets, with sockets provided for the additional 4K bytes. A switch selectable base starting address permits memory to be easily interlaced with existing systems while another switch allows disabling of the upper 4K bytes of RAM so that other memory in the system can utilize that memory space. Price of this basic module is $795. The second version ($995) has a full 8K bytes of RAM installed. Multiple 1814 CMOS RAM Memory Modules can be used in the same SuperPac 180 Series microcomputer system, facilitating sophisticated control techniques in a cost-effective manner, according to PCS. Circle No. 49 on Coupon.



General Purpose I/O Board—This general purpose I/O board from Infinite, Inc., designated the MFIO-1, is S-100 compatible and contains a major portion of all circuitry required for a complete microcomputer. Some of the features: Memory or I/O mapped parallel input port for keyboard; memory or I/O mapped serial I/O port with crystal controlled switch selectable baud rates of 50 to 19200; jumper selectable RS232 or 20mA current loop; memory or I/O mapped cassette interface with switch selectable data rates of 300 (Kansas City Standard), 600, 1200 and 2400 baud; 128 bytes of RAM; slots for two each 2708 EPROMs. A 21 command, two chip monitor program is available in PROM firmware as option 001. The total power requirement is less than 1A. Available in three versions: assembled, $282; kit, $234; bare boards, $49. A set of two ROMs costs $65.95. Circle No. 73 on Coupon.



Data Cassettes for Hobby and Business Use—A full line of data cassettes specifically designed for use in hobby computers and small business computers are available from AVDEX Corp. The cassettes come in 1-, 3-, and 5-minute lengths for more convenient use than cassettes which have too much tape to be handy for hobby and business applications. According to the company, the cassettes have high quality computer shells, polyolefin slip sheets, machined guide rollers, stainless steel pins, special oversize pressure pads with Tyvec liners and oversize hubs for smoother, more uniform tape transport. The cassettes are custom loaded with extra short leaders to prevent the leaders from contacting recording heads, thereby providing instant start operation and eliminating the possibility of lost data. Prices for the short-load cassettes are: CDC-1, $4.95; CDC-3, $5.65; CDC-5, $6.35. Also available are three other cassettes in C-20, C-40 and C-60 configurations ($4.50, $5 and $5.50 respectively) which utilize the same computer shell components and are loaded with high quality, high density calendered ferric oxide formulation. Circle 68 on Reader Service Coupon.



"Bit Streamer" I/O Board—Vector Graphic's "Bit Streamer" I/O board combines two parallel input and output ports, and a serial I/O port using an 8251 programmable universal synchronous/asynchronous receiver-transmitter. Communications with board circuitry is accomplished by the CPU. One parallel port also can be used as a keyboard input port. The USART is designed to interface easily to an S-100 bus structure, and is capable of being configured for a wide variety of communication formats. Without introducing changes to the pre-jumpered options, the board can be installed in a computer and will operate as an RS232 serial port using the initialization and I/O software on the Vector Graphic option C PROM. Prices: kit, $155; assembled, $195. Circle No. 44 on Reader Service Coupon.

Paper Tape Transmitter—This Model 612 stand-alone paper tape reader, from Addmaster Corp., provides greater capacity than earlier models. The new features include an ability to read 5 to 8-level tape and to transmit 7 to 11 frames per character at 50 to 9600 baud. Other features: starting and stopping on character at all speeds; choice of manual control or X-on, X-off; 90 to 260 volts; 50 to 60 Hz; even, odd or no parity. Available options include RS 232, current loop or parallel outputs, choice of desk top or rack mounting. Single unit prices: $625 to $725. Circle No. 28 on Reader Coupon. ■

30 Transistor Projects

☐ One of the best aspects of these 30 transistor projects is that they represent a great opportunity to gain hands-on experience wih a variety of different electronic components.

JFETS (*J*unction *F*ield *E*ffect *T*ransistors) are more sensitive than standard bipolar transistors. They respond to voltage changes at very small currents (in other words, they offer a high input *impedance*), and operate much more like vacuum tubes than transistors. Yet, they are small, easy to work with, and very versatile.

SCRS (*S*ilicon *C*ontrolled *R*ectifiers), the solid state equivalent of a latching relay, can be thought of as a transistor with a built in "gotcha." Bring an SCR's gate voltage to its turn-on point and you'll have to open the circuit to turn it off again.

Phototransistors let light (sometimes voltages too) control their output. You can use them to detect light, signal with light, and more.

UJTs (*Uni*junction *T*ransistors) are natural-born relaxation oscillators. This is due to an unusual quality they possess called "negative resistance." They're small, inexpensive, and easy to work with.

Zener diodes work like regular diodes when hooked "frontwards" (forward biased), but act as voltage regulators when hooked "backwards." This can lead to interesting applications, as you'll see on the pages that follow.

And, you'll find many new ways to apply transistors, LEDs, diodes, switches, relays and more.

Don't be afraid to combine these circuits with each other. The worst thing that can happen is they won't work together. The best that can happen is you'll learn something. ■

1 Slide Show Stopper

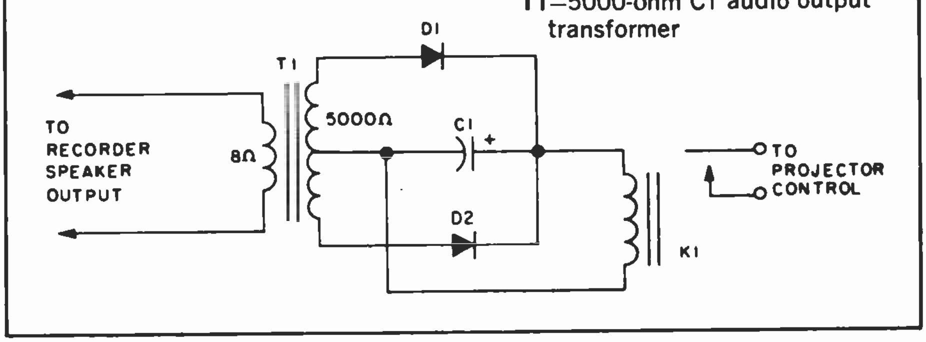
☐ Soundless slide shows are dull, dull, dull! But a stereo recorder can automate the whole show so slides change automatically in step with the commentary.

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

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

PARTS LIST FOR SLIDE SHOW STOPPER

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



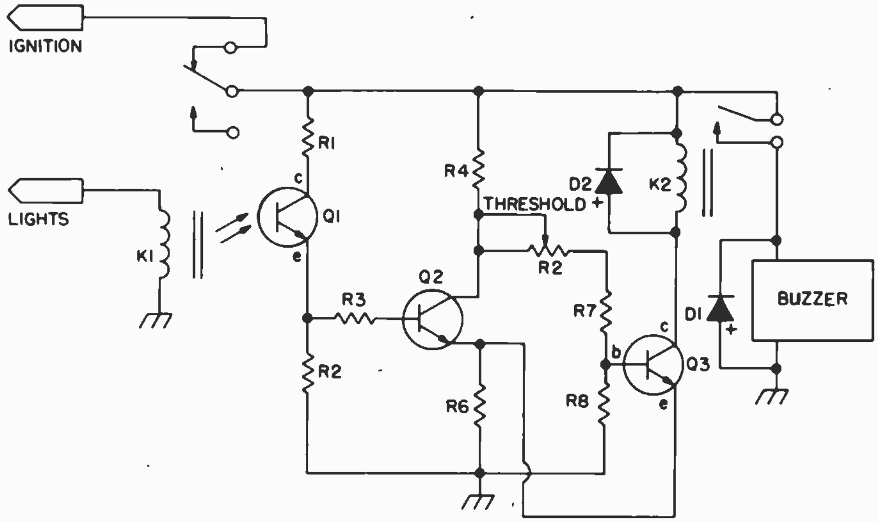
2 Highway Nightfall Alert

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

K1 turns on with your headlights. When it's on, it disables the rest of the circuit. So a warning can only sound with your headlights off. As long as light strikes Q1, Q2 remains on, holding Q3 off. Voltage divider R5-R7-R8 determines the turn-on point for Q3. Q3 drives K2, which triggers a buzzer or other signalling device. A photoconductor may be substituted for R1-Q1, if desired.

PARTS LIST FOR HIGHWAY NIGHTFALL ALERT

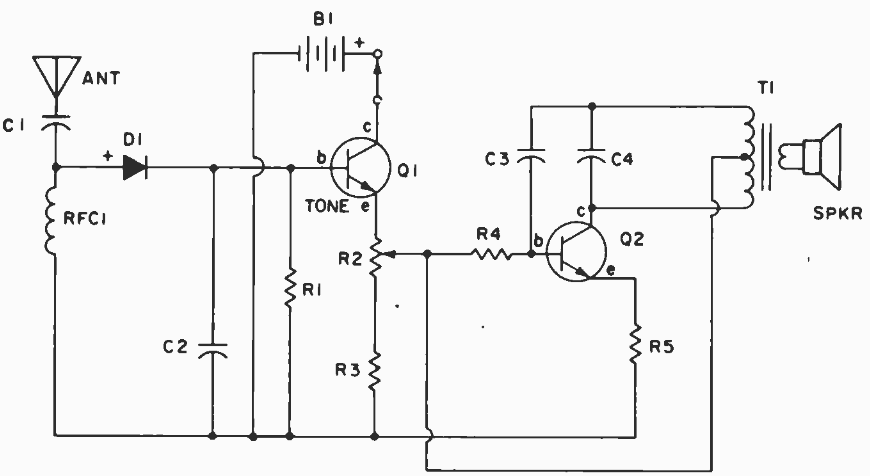
D1, D2—diode, 1N914 or equiv.
K1—SPDT relay, 12VDC
K2—SPST relay, 12VDC
Q1—Phototransistor, FPT100 or equiv.
Q2—NPN transistor, 2N3904 or equiv.
Q3—NPN transistor, 2N2222 or equiv.
R1, R4, R7—4700-ohm resistor, ½-watt
R2—560-ohm resistor, ½-watt
R3, R5, R8—10,000-ohm resistor, ½-watt
R6—220-ohm resistor,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



3 Sidetone Oscillator

☐ CW (continuous wave, the form of modulation involving a simple turning on and off of the RF carrier) is the simplest way for a beginning ham to transmit to his fellow hams. And the famous Morse Code is how he gets his message across. But Morse is a lot easier to send if you can hear what you're sending. This circuit lets you do just that.

A short length of wire near the transmitter picks up RF as it's transmitted and acts as the antenna for our circuit. This RF is detected by D1, smoothed by C2, and used to turn Q1 on and off, following the transmitted signal exactly. Q1 switches the positive supply through R2 to beep oscillator Q2 through the center tap of T1. The values shown produce a pleasant, easily distinguishable tone.



PARTS LIST FOR SIDETONE OSCILLATOR

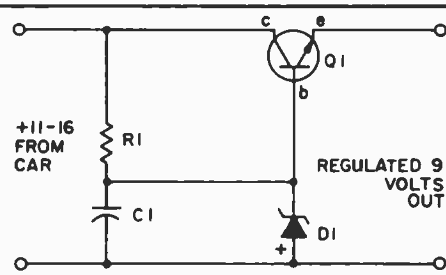
B1—9VDC battery
C1—50-pf capacitor
C2—470-pf capacitor
C3, C4—.01-uF capacitor
D1—Diode, 1N914
Q1, Q2—NPN transistor, 2N2222 or equiv.
R1—470,000-ohm resistor, ½-watt
R2—5000-ohm potentiometer
R3—4700-ohm resistor, ½-watt
R4—100,000-ohm resistor, ½-watt
R5—100-ohm resistor, ½-watt
RFC1—2.5-mH choke
T1—1000;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

4 Cigar Lighter Power

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

PARTS LIST FOR CIGAR LIGHTER POWER

C1—100-uF capacitor
D1—Zener diode, 9.1 V at ¼-watt
Q1—NPN transistor, 2N2222 or equiv.
R1—560-ohm resistor, ½-watt



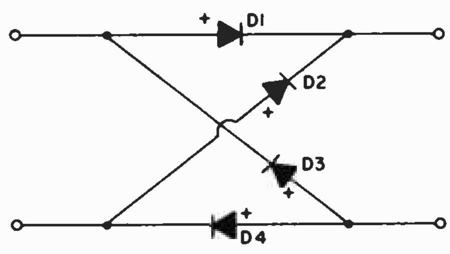
2N3055. With either device, unless the equipment you are driving is very low power, use a heat sink.

There are two easy ways to determine how much current your transistor radio or whatever draws (more to the point, whether or not the amount of current it draws will necessitate heat sinking). One is to connect your VOM in series between one of the battery posts and its associated clip connector. You will want to check the *maximum* amount of current drawn. Another way is to connect this circuit for only a few seconds and touch Q1 with your finger. If it gets too hot to hold your finger on, use a heat sink. You may want to use a heat sink in any case. You may also want to include a small fuse (try ½ amp).

5 Wrong-Way Battery Protector

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

Here, it makes sure that no matter which way you connect the battery, the positive and negative supply terminals in your equipment get the right polarity voltage. Remember, since the forward bias of two diodes are introduced, your equipment will be getting about a volt less than your battery is delivering. And remember, choose your diodes so they're rated for all the current your circuit will draw.

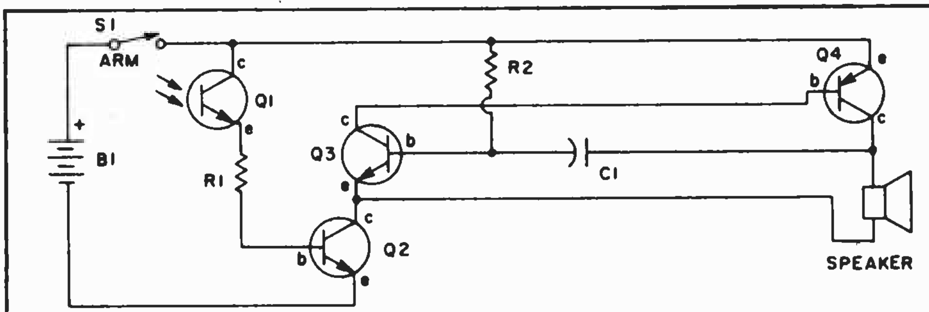


PARTS LIST FOR WRONG-WAY BATTERY PROTECTOR

D1, D2, D3, D4—Diode, 1N914 or equiv.

6 Attache Alarm

☐ Who knows what evils lurk, ready to pilfer the Twinkies out of your attache case when you're not looking? This squealer does. Because when you arm the alarm by turning on S1, the lightest touch will set it off. More accurately, the touch of light. Light striking Q1 turns on transistor switch Q2, which energizes oscillator Q3-Q4. And that blows the whistle.



PARTS LIST FOR ATTACHE ALARM

B1—9 VDC battery
C1—.01-uF capacitor
Q1—Photoelectric transistor, FPT 100 or equiv.
Q2—NPN transistor, 2N2222 or equiv.
Q3—NPN transistor, 2N3904 or equiv.
Q4—PNP transistor, 2N3906 or equiv.
R1—2200-ohm resistor, ½-watt
R2—100,00-ohm resistor, ½-watt
S1—SPST switch
SPKR—8-ohm speaker

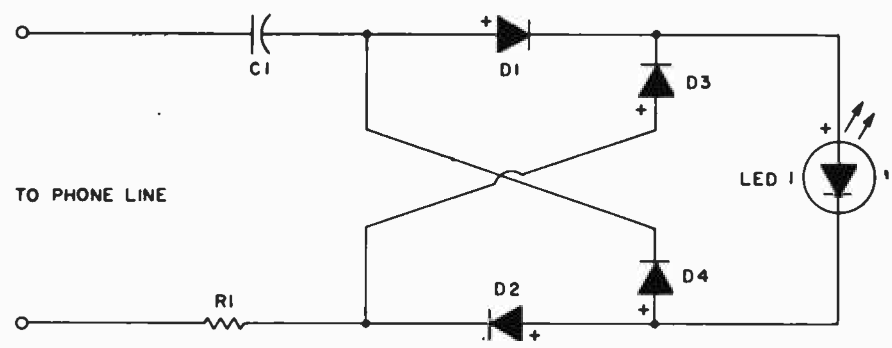
7 LED Telephone Ring Indicator

☐ Know what makes your phone ring? A 20 Hertz AC signal at anywhere from 60 to 120 Volts, depending on your phone company. That same bell-ringing signal can be used to light an LED with the circuit shown here, without significantly loading the telephone line. C1 provides DC isolation to help foolproof this project. The .1 value shown works, but you may want to increase it to .5 microfarads. Use a mylar capacitor (like the Sprague "Orange Drop" series) rated at 250-450 working volts or more.

Why so high? The telephone company keeps its lines clear of ice and trouble by daily sweeping a pulse of high voltage throughout the system. Too low a working voltage could mean trouble for them, and that is absolutely the last thing you want to cause. We might even suggest connecting to the telephone lines only temporarily to verify circuit operation. This will help avoid accidents and trouble. D1 through D4 act as a full wave bridge to deliver the AC ringing voltage as DC to LED1. R1 limits the current through the circuit.

PARTS LIST FOR LED TELEPHONE RING INDICATOR

C1—.1-uF capacitor
D1, D2, D3, D4—Diode, 1N914 or equiv.
LED1—Light emitting diode
R1—82,000-ohm resistor, ½-watt



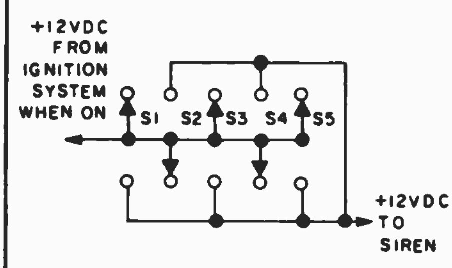
8 Auto Ignition Maze

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

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

Tracing the circuit will show that only if switches S2 and S4 are down is the siren disabled. The siren sounds if any other switch is down or if S2 or S4 is up when the ignition is turned on. A simple wiring change lets you set any combination.

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



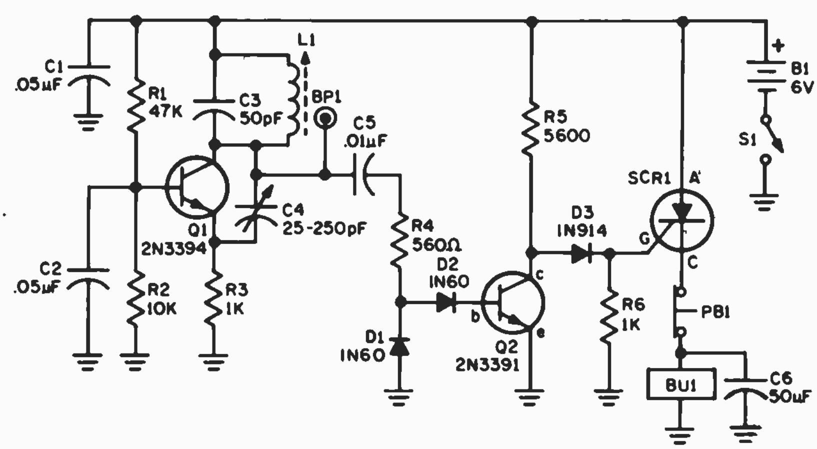
9 Doorknob Security Alarm

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

Transistor circuit Q1 is an oscillator with a connection through binding post BP1 to the doorknob. As long as Q1 oscillates, its rectified output is applied to Q2 which holds the SCR1 gate almost at ground poten-

PARTS LIST FOR DOORKNOB SECURITY ALARM

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



L1—15-uH adjustable RF coil (Miller 4205, or equiv.)
PB1—Pushbutton switch (reset)
Q1—2N3394
Q2—2N3391
R1—47,000-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor
R3, R6—1000-ohm, ½-watt resistor
R4—560-ohm, ½-watt resistor
R5—5600-ohm, ½-watt resistor
S1—Switch, spst (on-off)
SCR1—800-mA/30-V silicon controlled rectifier, HEP R1001

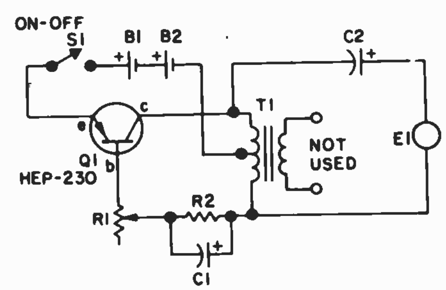
tial. When someone touches the doorknob, hand capacitance "kills" the oscillator, thereby removing that cutoff (holding) bias from the SCR1 gate; the SCR conducts and sounds alarm buzzer BU1. The alarm can only be turned off by opening reset switch PB1.

The alarm should be assembled in a small metal cabinet with insulated binding post BP1 at the top. A small wire loop attached to BP1 secures the alarm to the doorknob—the alarm actually hangs on the knob. To adjust, carefully set C4 in small increments until touching your finger to BP1 causes the buzzer to sound. If C4 is overadjusted, hand capacitance will not "kill" the oscillator. Best operation is obtained if the door is made of wood.

10 Angler's Bite Booster

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

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



PARTS LIST FOR ANGLER'S BITE BOOSTER

B1, B2—1.5-V AAA battery
C1, C2—50-uF, 12-VDC electrolytic capacitor
E1—Crystal earphone
Q1—Motorola HEP-230 pnp transistor
R1—5000-ohm pot
R2—27,000-ohm, ¼-watt resistor
S1—Spst switch, part of R1
T1—Subminiature transistor output transformer; 500-ohm center tapped primary to 8-ohm secondary

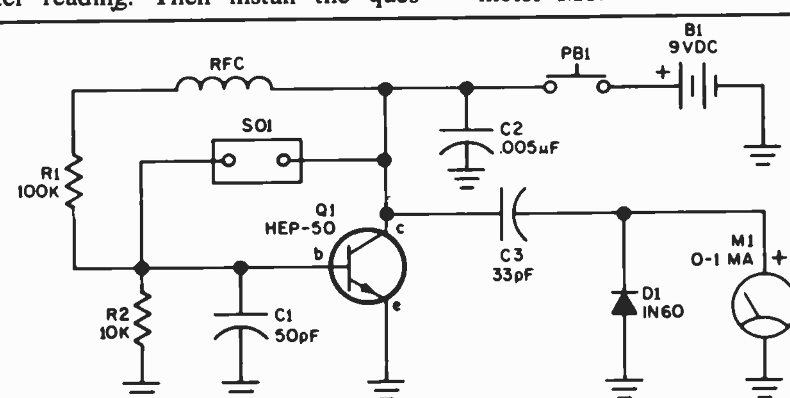
11 Crystal Checker

☐ A fast way to see if the crystal from your transmitter or receiver is properly "active" is to compare its output against that of a known good crystal. This crystal checker will handle both fundamental and overtone type crystals. Socket SO1 should match the pins on your crystals. If you use more than one type of crystal, install two (or more) sockets in parallel. The unit can be assembled in any type of cabinet.

To test a crystal's activity, first plug in a known good crystal, depress push button switch PB1 and note the meter reading. Then install the questionable crystal, press PB1 and note its meter reading; if it's good its output should approximate that of the reference crystal. Take care that you don't compare apples with oranges; the reference crystal should be the exact same type as the crystal to be tested. If good crystals drive the meter off scale, install a 1000-ohm, ½-watt, 10 percent resistor in series with meter M1.

PARTS LIST FOR CRYSTAL ACTIVITY CHECKER

B1—9-volt transistor radio battery
C1—50-pF disc capacitor, 100 VDC or better
C2—0.005-uF disc capacitor, 25 VDC or better
C3—33-pF disc or mica capacitor, 100 VDC or better
D1—Diode, 1N60
M1—Meter, 0-1 mA DC
PB1—Normally open push button switch
Q1—NPN transistor, HEP-50 (Radio Shack 276-2009)
R1—100,000-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor
RFC—2.5-mH RF choke
SO1—Socket to match crystals, see text



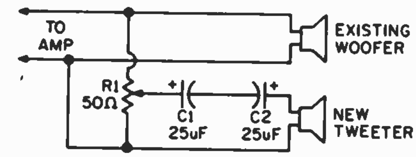
12 Add-A-Tweeter

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

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

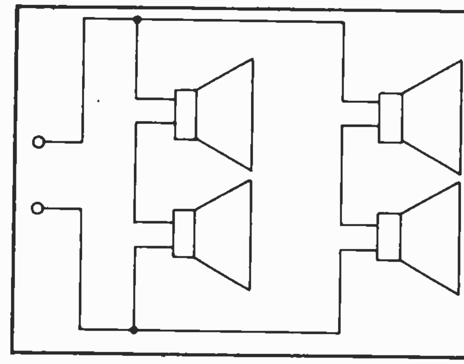
PARTS LIST FOR ADD-A-TWEETER

C1, C2—22-uF electrolytic capacitor, 50 VDC
R1—50-ohm wirebound potentiometer, 1 or 2 watts.
Misc.—Cone type tweeters are suitable for use with this circuit.



13 Speaker System Expander

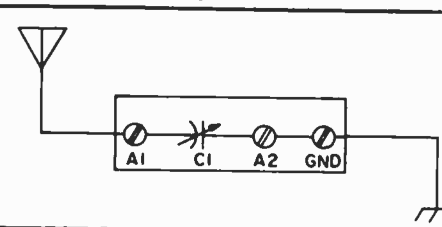
☐ This neat arrangement lets you connect multiple speakers to your system's speaker terminals without upsetting the impedance match. This series-parallel arrangement of speakers exhibits the same impedance as a single speaker, assuming all speakers are of equal impedance and individually match the rating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



14 Add An Antenna Trimmer

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

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



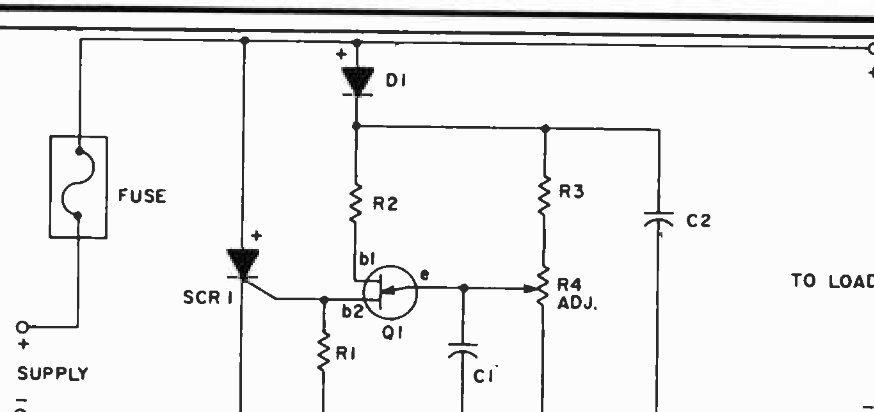
PARTS LIST FOR ADD AN ANTENNA TRIMMER

C1—60-pf trimmer

15 Adjustable Crowbar

PARTS LIST FOR ADJUSTABLE CROWBAR

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



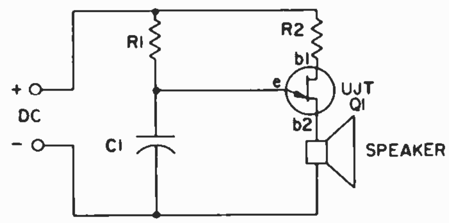
□ This crowbar circuit takes advantage of the electrically well-defined switching point of UJT (unijunction transistor) Q1. Q1's actual trip point voltage is set by trimmer R4. The Q1 circuit is isolated from the load by D1. When Q1 conducts, it triggers SCR1, shorting the supply and blowing the fuse.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

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

16 Voltage Controlled Audio Oscillator

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

For a slightly stranger effect, connect a large value capacitor (say 50-100 uF with a voltage rating larger than the voltages you intend to apply). You'll hear a swooping effect. Many different components can be placed across the input for different effects when voltage is applied. Experiment and have fun.



PARTS LIST FOR VOLTAGE CONTROLLED OSCILLATOR

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

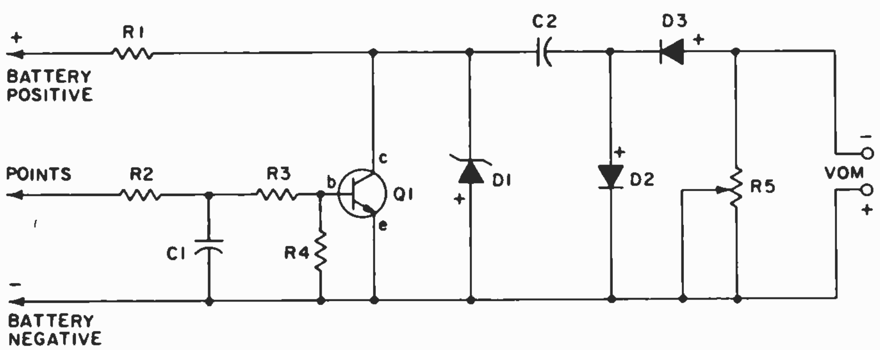
17 Make Your VOM a Tachometer

□ Most of us don't need dashboard tachometers to drive by. But a tachometer can be invaluable as a tune-up aid. And it's a lot handier to have under the hood when you need it there than behind the wheel where you can't see it.

But is a tach worth the investment? With this arrangement, there isn't enough investment to worry about.

Pulses from the distributor points are amplified by Q1, limited by D1, coupled by C2, rectified by D2 and D3, and impressed as a voltage across R5. You could use R5 to calibrate this circuit to one of your VOM's voltage ranges, but that often isn't necessary. Much of the time, we are looking more for *changes* in engine speed than for a *specific* engine speed. If you do need to know specific speeds, of course, you can always borrow a known-good tach and calibrate with R5.

This same circuit can also be applied as a frequency to voltage converter for many other purposes.



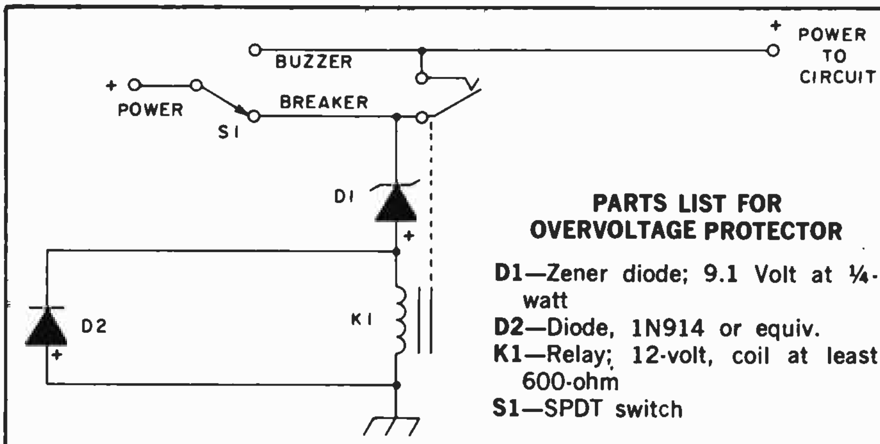
PARTS LIST FOR VOM INTO TACHOMETER

C1—2.2-uF capacitor
C2—.47-uF capacitor
D1—Zener Diode, 9.1V at ¼-watt
D2, D3—Diodes, 1N914 or equiv.
Q1—NPN transistor, 2N3904 or equiv.
R1—390-ohm resistor, ½-watt
R2, R3—220-ohm resistor
R4—1800-ohm resistor, ½-watt
R5—1000-ohm potentiometer

18 Overvoltage Protector

□ Too high a voltage can damage any number of electronic components. Many other components can withstand high voltages, but only for a limited time. This circuit provides either protection against too much voltage in much the same way a circuit breaker protects against too much current, or a warning that an-overvoltage condition is occurring.

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



PARTS LIST FOR OVERVOLTAGE PROTECTOR

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

19 Flash Tester

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

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

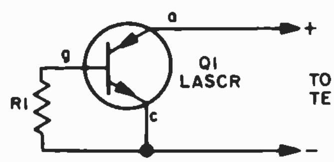
To operate, provide a 6-in. length of stiff wire for the anode and cathode connections and terminate the wires in a polarized power plug that matches the sync terminals on your electronic flashgun (strobelight). Make certain the anode lead connects to the *positive* sync terminal.

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

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

PARTS LIST FOR REMOTE FLASH TRIGGER

Q1—200-V light-activated silicon-controlled rectifier (LASCR)
R1—47,000-ohm, ½-watt resistor



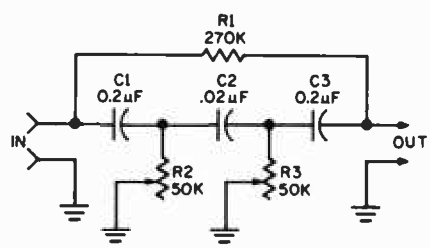
20 Record Restorer

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

The Record Restorer should be assembled in a metal cabinet to prevent hum pickup. Connect the output of your phonograph to the restorer input. Connect the output of the restorer to your tape recorder. Set potentiometer R2 to maximum resistance and adjust potentiometer R3 for the most pleasing sound. If R3's adjustment is too little, or too much as evidenced by a "hole" in the sound quality, trim the restorer with R2 until you get the optimum equalization.

PARTS LIST FOR RECORD RESTORER

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



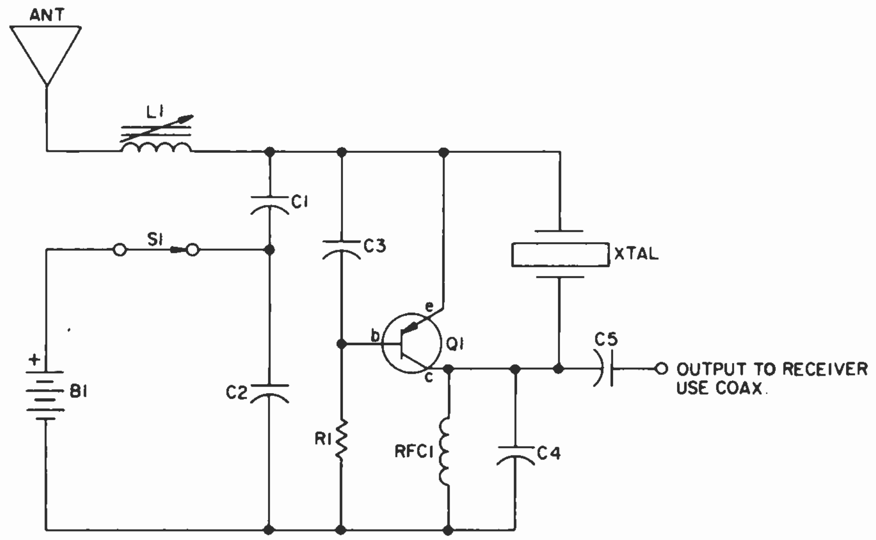
21 SWL's Low Band Converter

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

Q1 acts as a 3.5 MHz crystal oscillator, mixing the crystal frequency with the long wave input from the antenna and forwarding the mix to your receiver.

L1 is a standard broadcast loopstick antenna coil. The crystal is available from many companies by mail order, or is likely to be at a ham radio store near you. You could also use a 3.58 MHz TV color crystal.

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



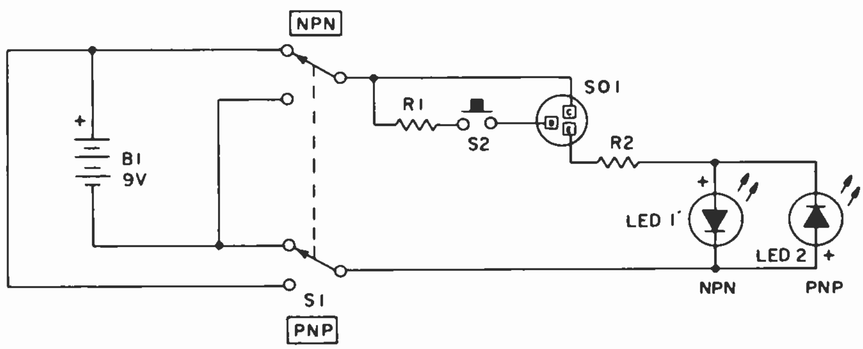
PARTS LIST FOR SWL'S LOW BAND CONVERTER

B1—9VDC battery
C1, C4—470-pf capacitor
C2—.1-uF capacitor
C3—.001-uF capacitor
C5—50-pf capacitor
L1—Loopstick coil
Q1—PNP transistor, 2N3906 or equiv.
R1—470,000-ohm resistor, ½-watt
RFC—2.5 mH choke
S1—SPST switch
XTAL—3.5 MHz crystal

22 Transistor Checker

PARTS LIST FOR TRANSISTOR CHECKER

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



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

Don't know the type? That's okay. Plug it in and try both S1 switch positions while you watch for the appropriate LED to light. You can even test diodes using the collector-emitter leads on the socket. The collector-emitter leads can also be used to check continuity.

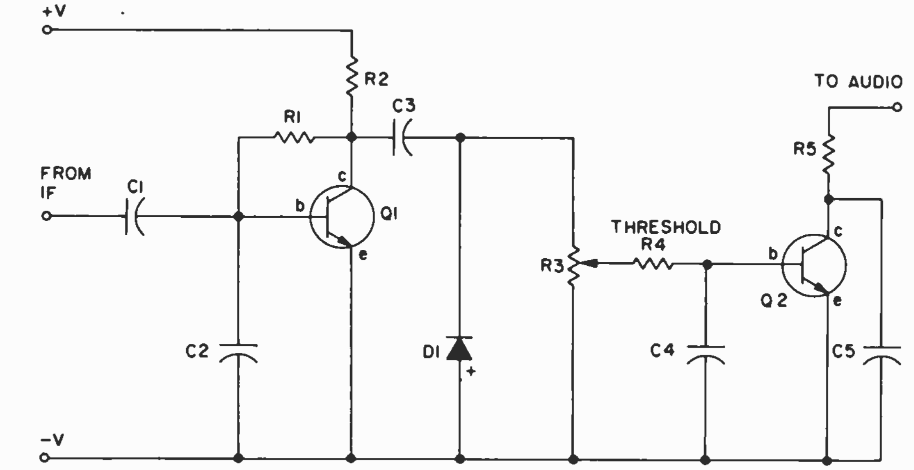
23 Transistor Squelch

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

Transistor Q1 acts as a noise amplifier, operating on signals from the receiver IF. The noise signal is amplified, then detected by D1. The resultant voltage appears across R3, which acts as a voltage divider at the input of switch Q2. When enough signal-derived voltage reaches Q2's base, it turns on, switching off the receiver audio output.

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

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



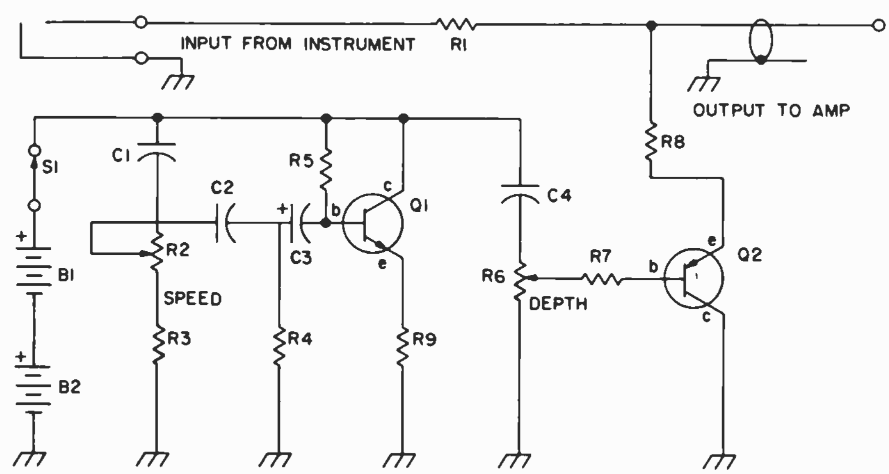
PARTS LIST FOR TRANSISTOR SQUELCH

C1, C3—.1-uF capacitor
C2—.01-uF capacitor
C4—33-uF capacitor
C5—47-uF capacitor
D1—Diode, 1N914 or equiv.
Q1, Q2—NPN transistor, 2N3904 or equiv.
R1—180,000-ohm resistor, ½-watt
R2, R3—10,000-ohm resistor, ½-watt
R4—680-ohm potentiometer
R5—330-ohm resistor, ½-watt

24 Super Vibrato

☐ This professional-sounding circuit adds vibrato to almost any electronic musical instrument. Now you can play all the vibrato effects the big, Top 40 groups have been using on their albums and singles for years. Q1, R2-5, and C1-3 form a phase shift oscillator. Speed control R2 varies its output frequency, which is coupled through C4, R6 and R7 to Q2. Q2 and R8 then amplitude modulate the signal in the line between the instrument and the amplifier. The amount of modulation applied is varied by Depth control R6.

You may also want to try this circuit out between a mike and your tape recorder to experiment with strange vocal effects. If driven hard enough, it can even make you sound as if you're talking under water. If the range of R6 doesn't permit this, try either adding a third battery or reducing the value of R8. You may decide to make S1 a momentary or push-push foot pedal switch and build this entire circuit into the foot pedal housing.



PARTS LIST FOR SUPER VIBRATO

B1, B2—9VDC battery
C1—.5-uF capacitor
C2—2.3-uF capacitor
C3—5-uF, 25VDC electrolytic capacitor
C4—.05-uF capacitor
Q1 — NPN transistor, 2N2222, 2N3904, or equiv.
Q2—PNP transistor, 2N3906 or equiv.
R1, R8—100,000-ohm resistor, ½-watt
R2—10,000-ohm potentiometer
R3—2700-ohm resistor, ½-watt
R4—3300-ohm resistor, ½-watt
R5—560,000-ohm resistor, ½-watt
R6—500,000-ohm potentiometer
R7—470-ohm resistor, ½-watt
R9—4700-ohm resistor, ½-watt
S1—SPST switch

25 Stereo Beat Filter

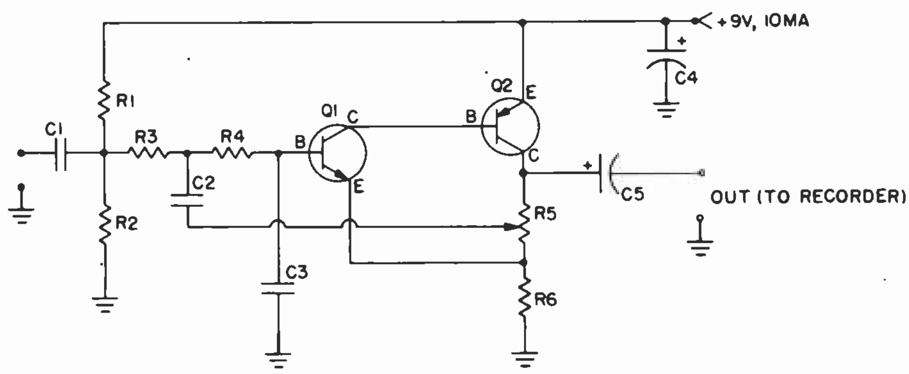
☐ Many early stereo tuners, and quite a number of modern budget priced stereo tuners, have considerable output at 19 kHz and 38 kHz from the stereo pilot system. While these frequencies aren't heard, they can raise havoc if they leak through to a Dolby noise reduction encoder, or if the frequencies beat with a tape recorder's bias frequency or its harmonics. Normally, Dolby-equipped units have a 19 kHz filter specifically to avoid the problem of pilot leakage from the tuner, but often the pilot interference is so high it still gets through.

This filter, which can be powered by an ordinary transistor radio type battery, is connected to the output of the FM stereo tuner, and provides approximately 12 to 15 dB additional attenuation at 19 kHz and about 25 dB attenuation at 38 kHz. It has virtually no effect on the frequency response below 15 kHz, the upper limit of frequencies broadcast by FM stations.

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

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

The input signal should be in the range of 0.1 to 1 volt—typical level from a tuner's tape output jack.



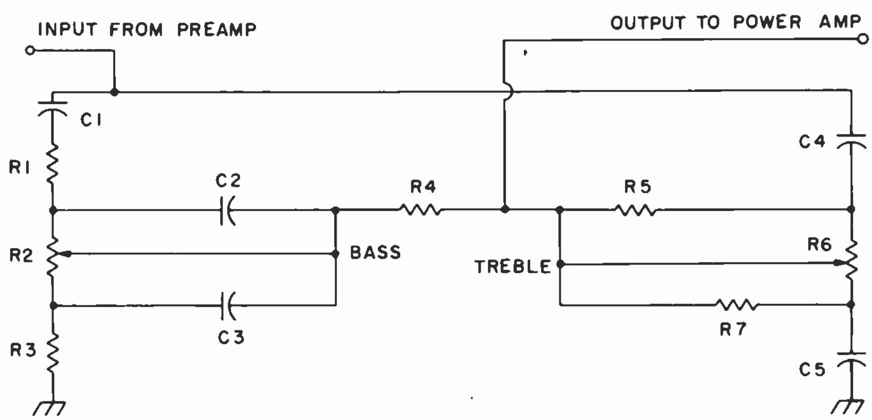
PARTS LIST FOR STEREO BEAT FILTER

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

26 Tone Control Network

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

Once you have learned, by experimenting with the effects of various component values, just how you can alter the characteristics of these networks, you may want to construct your own graphic equalizer. Just include more stages similar to the two basic types of filters you see here: R1, R2, R3, R4, C1, C2 and C3 form one of the filters, the rest of the components the other. Just remember, the more stages of passive filtering you add, the more loss you introduce into your system. For that reason, most commercial graphic equalizers include built-in amplifiers. And, of course, you will have to duplicate your filter(s) for each channel if you're working in four or more tracks.



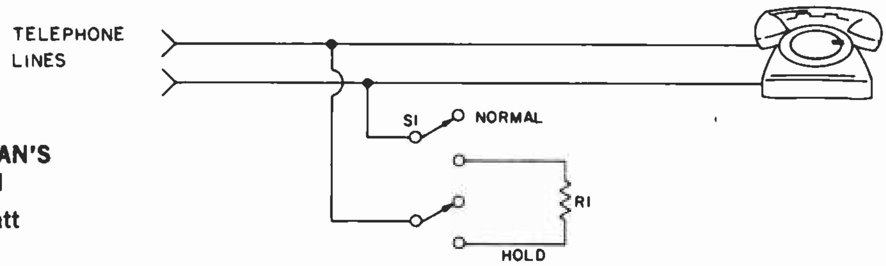
PARTS LIST FOR TONE CONTROL NETWORK

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

27 Poor Man's Hold Switch

☐ This is just one step more sophisticated than holding your hand over the telephone mouthpiece. We all find occasions when we would like to discuss something with the people in the room without sharing it with the party on the phone. This circuit provides dc continuity for the phone line to keep from losing a call when you hang the phone up. There is some danger, though, of putting the phone on "terminal hold," if you forget. Because as long as you are switched to hold, it's just like leaving a phone off the hook: no one can call in, you can't call out.

Only two of the lines that reach your telephone are really part of the phone line, and these are most often the red and green wires that are in the cable between your phone and the wall. Other wires in the cable may carry power for lighting your phone, or may carry nothing. Check carefully. Also understand that if you make a connection to the phone line that inhibits the phone company's ability to provide service, they have the right to disconnect you for as long as they like. This is a proven, simple circuit that should cause no difficulty. But be careful.



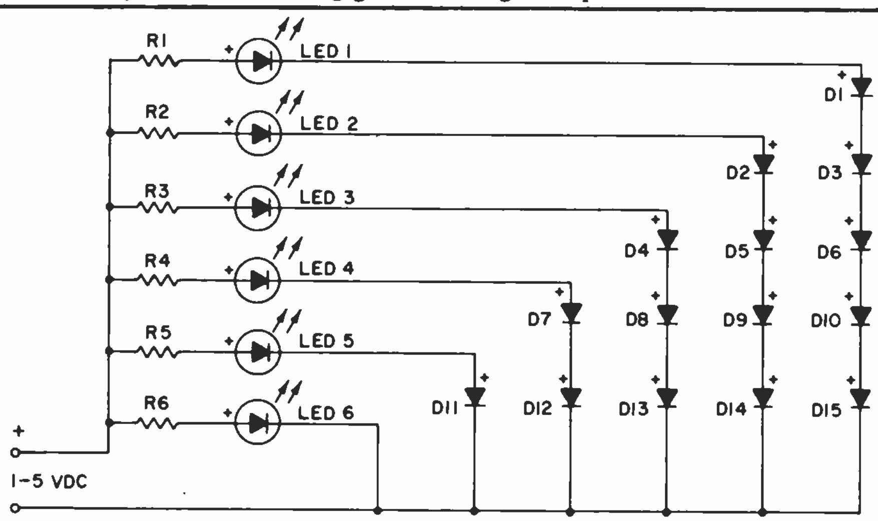
PARTS LIST FOR POOR MAN'S PHONE HOLD SWITCH

R1—650-ohm resistor, ½-watt
S1—DPDT switch

28 LED Bar Graph Display

☐ This circuit takes advantage of the forward voltage drop exhibited by silicon diodes. Each leg of the circuit shows a light emitting diode in series with a current limiting resistor and a different number of diode voltage drops, from 0 to 5. You may use any kind of diode you wish, including germanium, silicon, even expensive hot carrier types (although they won't exhibit quite as much drop, they're very expensive, and too large a current could burn them out).

Depending on the diodes you choose, each will exhibit a forward voltage drop between 0.3 and 0.7 volts. For consistency, stay with diodes of the same type, or at least the same family. Those twenty-for-a-dollar "computer" diodes will do just fine. To expand the range of this LED "meter," use two resistors as a voltage divider at the input. Connect one across the + and – terminals, the



PARTS LIST FOR LED BAR GRAPH DISPLAY

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

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

The voltage across the input equals the resistance across the output, divided by the sum of the resistances and multiplied by the voltage being measured. Or:

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

29 Pulsing CB Saver

☐ If there's anything that will attract attention better than a honking car horn, it's an intermittently honking car horn. This circuit is an adaptation of the CB Saver that interrupts the horn relay contact with a flasher cartridge. Make sure you get the multiple-load flasher, as others require too much current to operate.

Notice there is no hidden defeat switch. There are two ways to defeat

(Continued on page 118)

Las Vegas LED

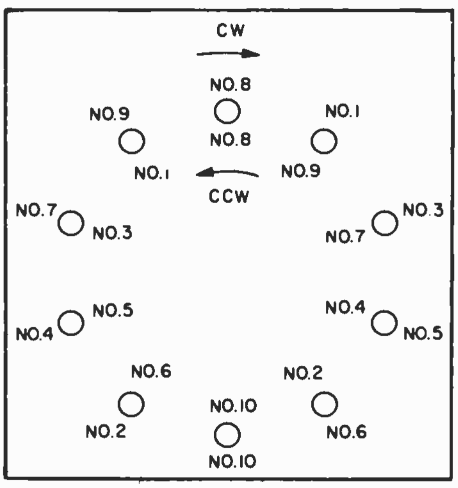
Win a bundle of fun with this electronic casino game!

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 ap-

Las Vegas LED

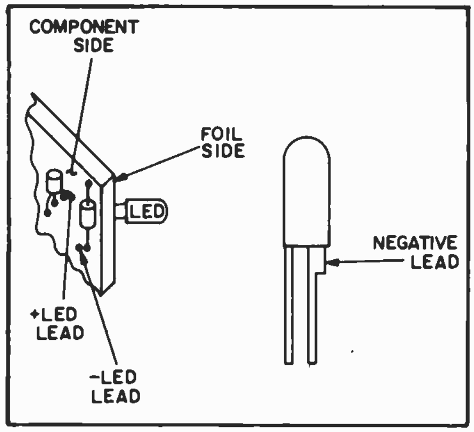
parent revolution of a dot of light by using an integrated circuit known as a decade counter. One essential characteristic of such an IC is that it has ten outputs, and at any given instant of time, nine of these outputs will be at a low potential, while the tenth will be high. The second important feature 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 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.

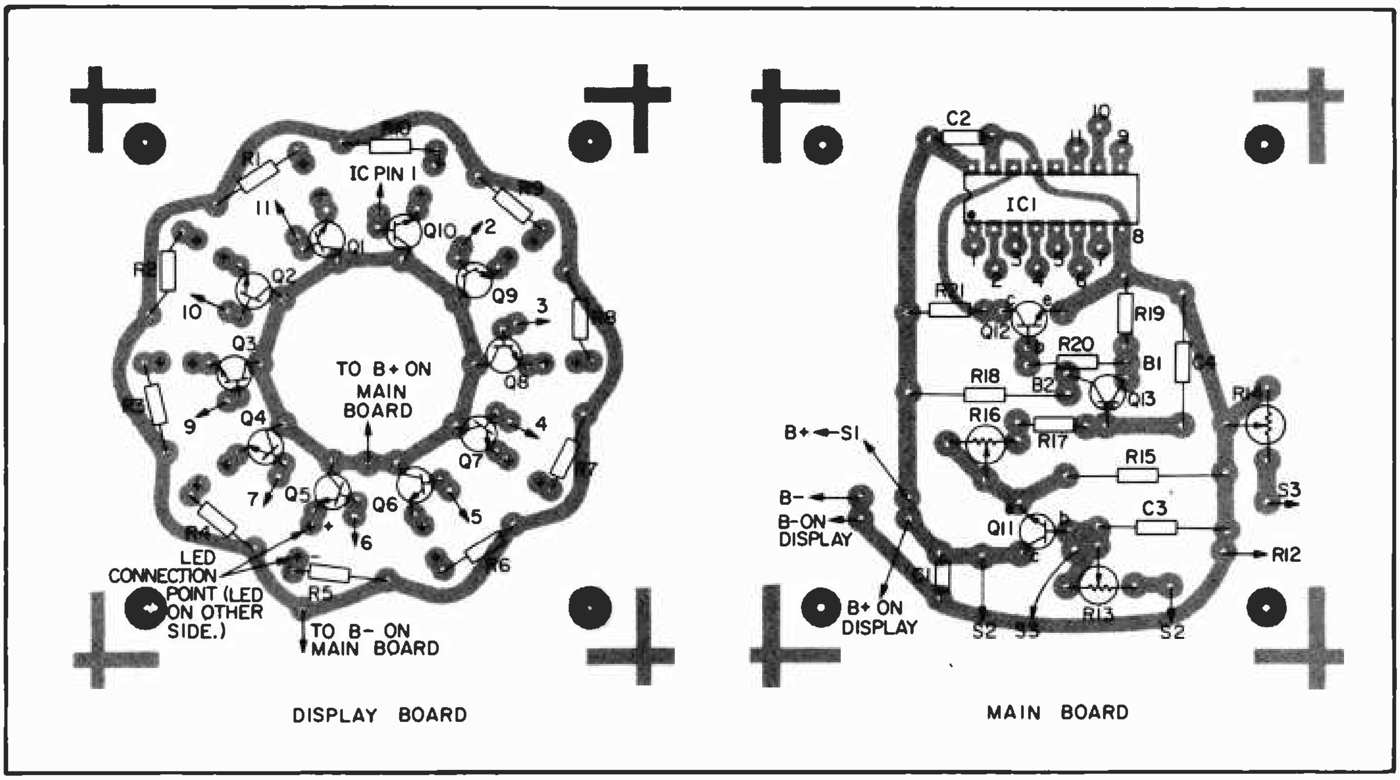
We arrange these LED's in a circle so that as we progress in a clockwise direction, starting at the LED associated with output #1, we encounter, *in proper consecutive order*, those LEDs associated with output #2 through output #10. When we feed an input signal to our IC, we see the LEDs fire sequentially 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 constructio 1 is by drilling your 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



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.



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.

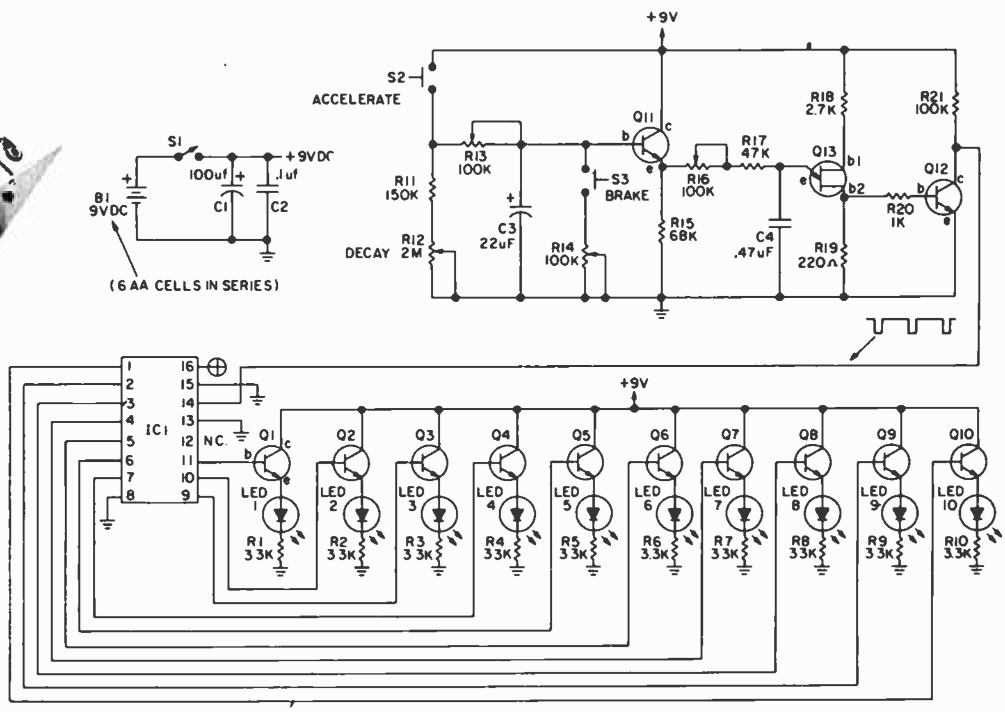
When installing components on the display board, follow the dimensional details in the accompanying drawings. Note that Q1 through Q10, and R1 through R10 mount on the component side of the board. LED1 through LED10 mount on the opposite foil side, with leads of such a length that the tops of the LEDs 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

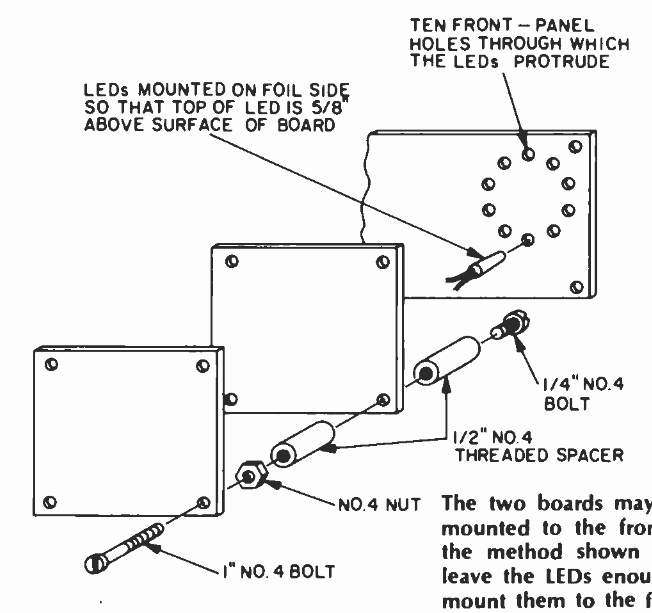
- **B1**—Six AA (penlight cells) 1.5 VDC
- **C1**—100-uF, 16-VDC capacitor
- **C2**—.1-uF capacitor
- **C3**—22-uF, 16-VDC tantalum capacitor
- **C4**—.47-uF, capacitor
- **IC1**—Decade Counter/Divider CD4017
- **LED1-LED10**—Light Emitting Diodes
- **Q1-Q12**—2N3904 transistors
- **Q13**—Unijunction 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.



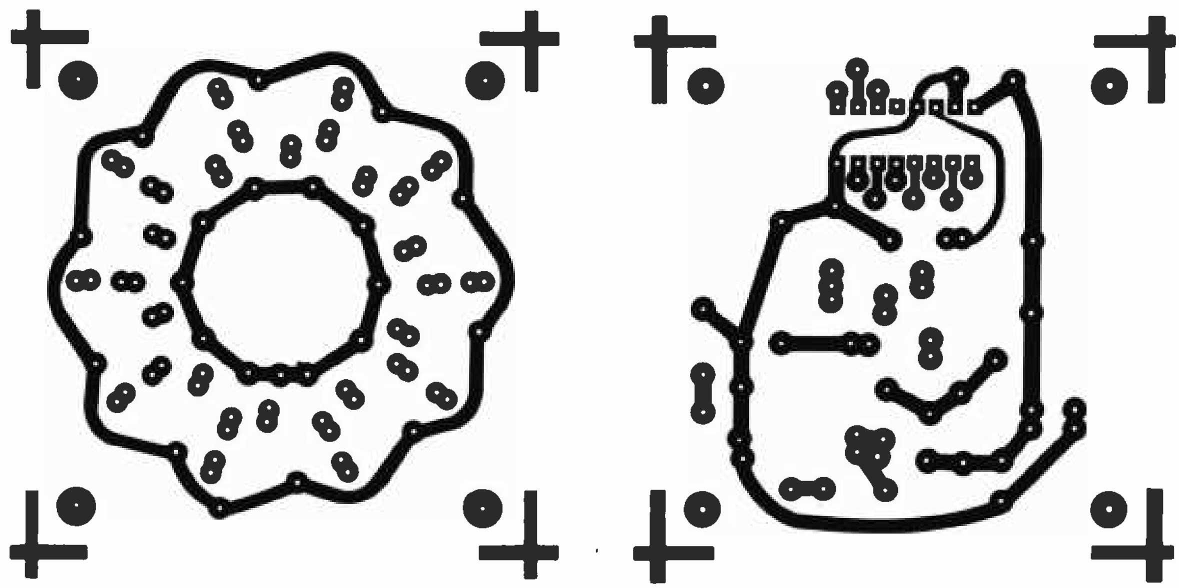
The two boards may be easily and neatly mounted to the front panel by following the method shown here. Make sure you leave the LEDs enough lead, and that you mount them to the foil side of the display board.

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.

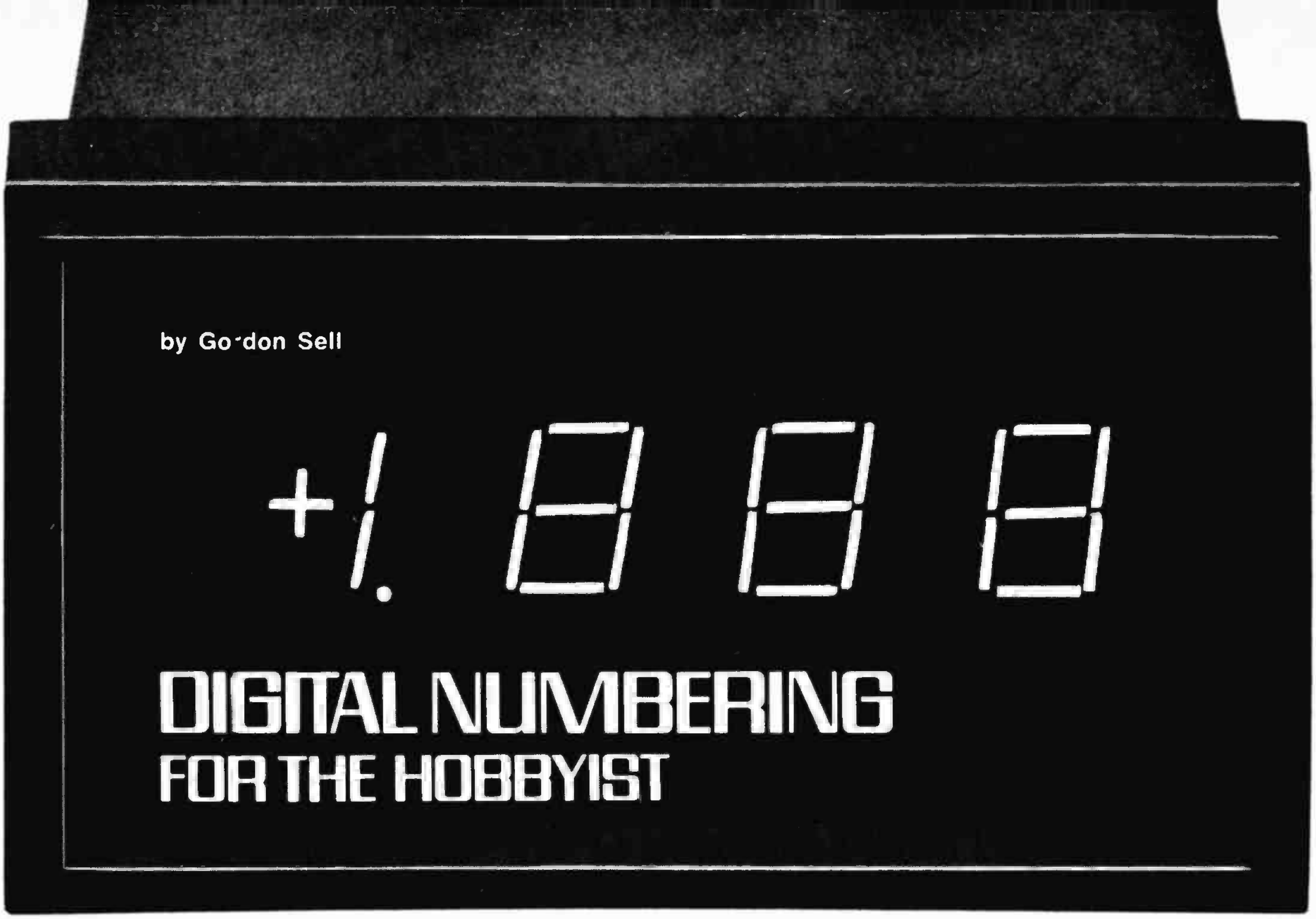
Release the *accelerate* button, and the velocity of the light will diminish rapidly. Press *accelerate* again, and then release it, repeating the cycle sever.! times, and at the same time adjust R13 to get an acceleration response that you like. In general, the best position for R13 will be somewhere 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.



by Gordon Sell

DIGITAL NUMBERING FOR THE HOBBYIST

Teach your projects to talk back digitally.

DIGITAL NUMBERS — they are everywhere! The entire electronics world has been caught-up in the digital revolution — watches, radios, TVs, VOMs, frequency counters — the list is almost endless. But, have your construction projects been a part of the revolution or are you still back in the hobbyist stone age of meters and light bulbs? Do your projects look like 20th Century state-of-the-art or do they look more like a turn-of-the-century patent application?

If you think it is time to go digital but feel that the technology is beyond your grasp you are not alone. There is a mumbo jumbo that has grown up around digital electronics that makes people think they have to learn all about computers before they can do any kind of digital project. If you have ever made the mistake of asking a "computer know-it-all" how digital number displays work, you are sure to have received a two-hour lecture on binary numbers, Boolean algebra and assorted flip flops, and come away knowing less than when you started.

Learn Backwards. All this hassle is unnecessary, however, if you learn digital electronics *backwards!!* Start with the familiar end result, a decimal number display, and work backwards into the circuitry that makes it possible.

Digital displays come in a number of different forms but all the circuits discussed here will use a common cathode, seven-segment LED (Light Emitting Diode) numeric display. These are cheap, easily obtainable and the circuitry can be adapted to other types—especially the liquid crystal type displays. The best way to learn about numeric displays is to put one together so you can physically see how it works and how the various components interact.

To simplify construction of the demonstration circuit accompanying this article a Continental Specialties Corporation PB-203 solderless breadboard was used. It allowed almost infinite experimentation with various circuit arrangements — experimentation that would have otherwise consumed a prohibitive amount of time. All parts mentioned in the parts list and article are easily obtainable through mail-order houses (see the HOBBY MART in the back of this issue) or from most electronics parts distributors. The parts in the article are referred to by their common name since many parts with different numbers can perform the same tasks. The parts used in the demonstration circuit are identified by their generic part number—most parts distributors will have a cross-reference from this number to the manufacturer's part number.

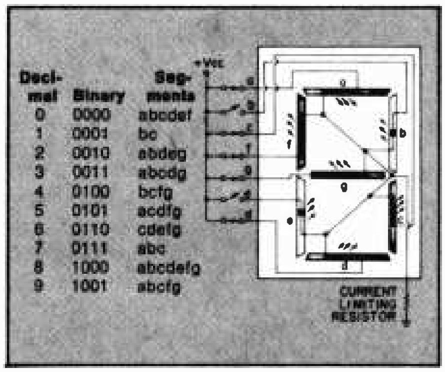
Translating. As you can see in the diagram of the seven-segment display, any digit from zero to nine can be represented by a certain combination of lit LED segments. Each of these segments is an individual LED with its cathode tied to a common ground; hence the name common cathode (some have common anodes). Each segment can now be activated by a switch between the anode and a power source. Switching on segments a, c, d, f and g, for example will cause the digit five to be lit. (As a practical consideration be sure to use a current limiting resistor—110 ohms in the circuit shown.)

We can now represent any digit by various combinations of "on" or "off" of the seven switches. There is a potential for 49 different character displays with this set-up—well beyond the needs of a numeric display.

So, by using a common integrated circuit chip we can reduce the number of switches to four. The internal circuitry of the BCD to seven-segment decoder (the name will make more sense later), as the chip is called, takes the

NUMBERING

combinations of the four "ons" and "offs" and applies power to the appropriate LED segments. This representation of a digit by four combinations of "on" and "off" is called Binary Coded Decimal or BCD for short. A binary number uses only zero and one rather than zero through nine. The one can be represented electronically by a high level voltage and the zero by a low level voltage. The following chart shows decimal numbers, their BCD equivalent and the segments that are lit on a numeric display:



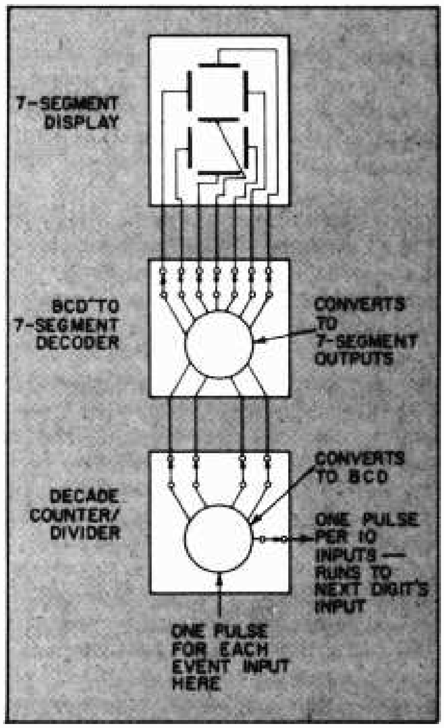
Decimal	Binary	Segments
0	0000	abcdef
1	0001	bc
2	0010	abdeg
3	0011	abcdg
4	0100	bcfg
5	0101	acdfg
6	0110	cdefg
7	0111	abc
8	1000	abcdefg
9	1001	abcfg

We now have a circuit that can translate "computerese" BCD numbering into the decimal numbers we have used all our lives.

Learning to Count. Now we need to teach our circuit to count from zero to nine. We can do this by adding an integrated circuit chip called a decade counter. This integrated circuit has one input line and four outputs. The outputs, as you have probably guessed, are connected to the four input lines of the BCD to seven-segment decoder. The outputs are all at zero until a single pulse appears on the input line. Then one of the outputs changes to a "one" so that the BCD to Seven-Segment decoder receives the number 0001 and lights segments b and c. On the second pulse the decade counter sends out the number 0010 and a 2 lights up on the display. This continues until the decade counter gets to nine; it then recycles to zero.

You should congratulate yourself—you now have a practical event counter that will total (up to nine) the number of pulses generated by the occurrence of some event. A switch on a refrigerator door that will turn on once each time the door is opened might allow you to record how many times it has been opened. Unfortunately there is a phenomenon of mechanical switches called contact bounce, where one switch-closing can trigger 3 or 4 pulses. This can be eliminated by adding a one-shot multivibrator, or similar circuit, to clean up the unwanted pulses. For the demonstration circuit the event pulses were obtained from a free-running multivibrator signal generator for simplicity and freedom from unwanted pulses.

Extra Digits. Now it is time to add a few more digits. After all, how many useful things can be measured by a single digit. To do this we must add a second set of the three components already mentioned: a numeric display, a BCD to Seven-Segment Decoder and a Decade Counter. Everything is wired the same way except that the input for the second decade counter is attached to the "carry out" pin of the first counter. This pin gives off an output pulse each time the counter resets from nine to zero. So, after the first display gets to nine and then resets the second display counts one so that the display reads ten. When the decade counter resets a second time the display clicks to 20. An almost infinite number of digits could be added that would count once each time the preceeding stage reset to zero.

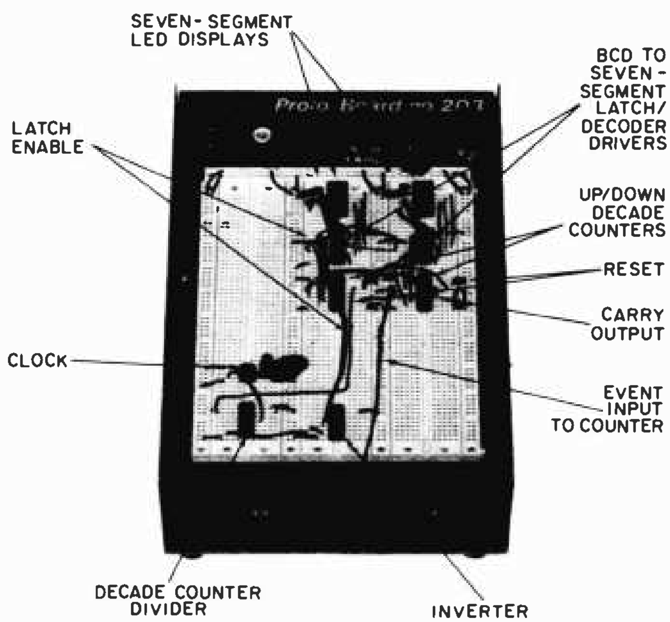


This block diagram shows how the sequence of pulses at the input are first translated to BCD and then to seven-segment coding.

A counter such as this could be used for any sort of tallying operation where you have to keep a record of how many events have taken place. Most digital applications, however, involve rate operations — cycles-per-second, miles-per-hour, gallons-per-day or even dollars-per-week.

Rate Measurements. For the above counter to be converted to measure the number of events per unit of time a few additions have to be made. The first of these is called a clock. A clock gives you the seconds of miles-per-second or the hour of inches-per-hour. It sets the interval over which the number of events is counted. This is achieved by adding a simple freerunning multivibrator. In the case of the circuit shown it puts out five volts with momentary negative going pulses at regular intervals. Once calibrated to the proper rate this multivibrator remains at a constant frequency.

The clock has two main jobs: It must



This photo shows the layout used in the demonstration model. The event input was from a 555-based code practice oscillator. Even better would be an AF/RF Signal generator with a variable square wave output jack.

reset the entire counter circuit to zero at the appropriate time and it must freeze the display at the appropriate part of the counting cycle so that it is a readable and meaningful number rather than a blur of speeding digits.

This last task requires a device known as a latch. A latch is a circuit that freezes on whatever BCD number is in its register when a high voltage is applied to the "latch enable" pin. If your circuit is counting from zero to 1000 every 10 seconds and you put a high voltage on the "latch enable" pin at 6 seconds the display will hold at 600. If it is grounded at seven seconds the display will resume the count at 700. So the count doesn't stop—it is only the display that freezes. In the circuit shown on these pages the latch is incorporated in the BCD to Seven-segment decoder IC chip.

By carefully coordinating the counter "reset-to-zero" pulse and the latch pulse so that the latch freezes the count display a moment before the counter resets, we have a event per unit time display.

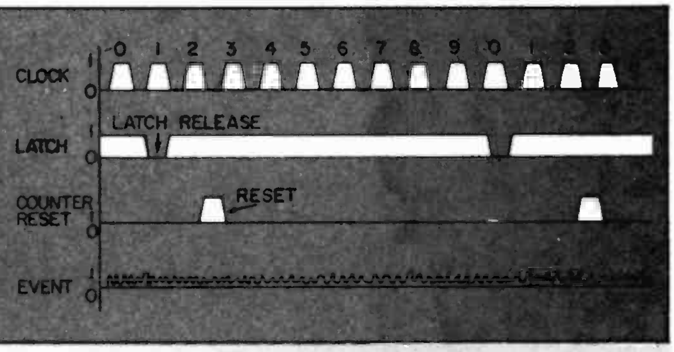
Synchronizing. To get this proper synchronization of clock, latch and reset, a Johnson counter or decade counter/divider is used. In this chip there are 10 output pins that go high (puts out a 5-volt pulse) in a repeating sequence. So for every 10 input pulses each pin goes high once, one after the other. If we control the latch with the pin that goes high on the first input pulse to the counter and then reset with the pin that goes high on the third input pulse we can control the display so that it will latch and reset at the proper time. The pin that goes high on the second pulse isn't used because of pulse overlapping.

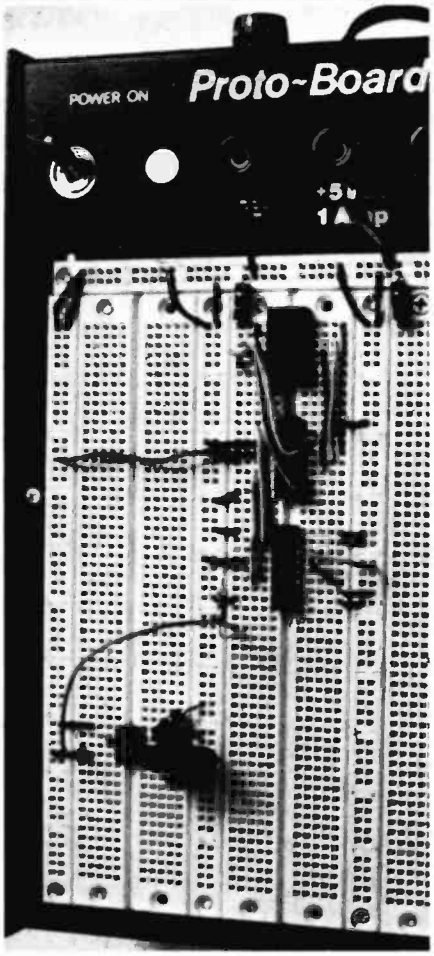
One slight problem with the output to the latch is that it needs to be inverted. This is accomplished by sending the pulse by way of an inverter. You can use a common inverter. An inverter is a device that produces a high output with a low input and a low output from a high input.

Putting It All to Work. You have now finished your basic rate measuring device. Now it's up to you to incorporate all of this into your pet project. All you have tc do is convert your project's output into series' of pulses of high and low voltage—high being about five volts and low about zero volts. A high-frequency of pulses will give a high numeric readout and a low frequency of pulses a low readout.

If your project gives a variable voltage readout you can buy a chip called a analog to digital converter—this puts out a higher frequency of pulses in

The clock sets the timing of the latch and reset. In this circuit the latch holds the count eight clock pulses after the clock has reset so that the number on the display is only proportional to the number of events per cycle rather than a total of the events.





This is a simple one digit event counter. It will count from zero to nine, recycle to zero and start the count again. The resistor added between the clock on the lower left and the decade counter is to lower the level of the input voltage peaks. 220 ohms is fine.

The CSC Proto-Board made experimentation a snap. Connections could be swapped around without muss or fuss. Hang on to the data sheets that come with IC chips, they are an invaluable reference source. Some, like the Radio Shack/Archer ones shown here, have lots of ideas for future experimentation and circuit design modifications.

NUMBERING

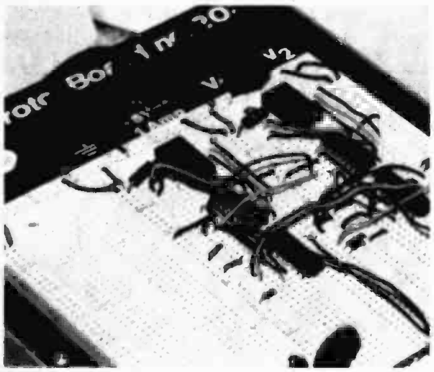
proportion to an increase in voltage.

The chips used in this article were referred to by their general name rather than number since the attached schematic is only an example of a typical digital numbering circuit. There are hundreds of other combinations of similar integrated circuit chips. After you have worked with these circuits for a while you will begin to understand the system better and will find yourself designing more and more complex circuits.

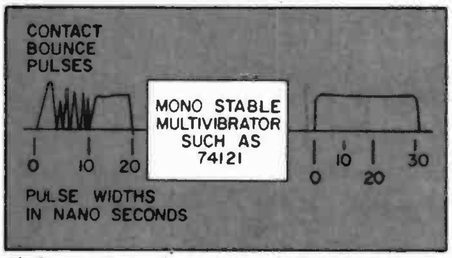
If you want to extend the number of digits much beyond two or three this technique starts to get very expensive and you should consider multiplexing the circuitry, but that is another article altogether. To describe it as simply as possible, multiplexing is the running of many displays off a single BCD to seven-segment decoder. Power goes to the display digit only when that digit is being decoded. Multiple digits are decoded in sequence so rapidly that they appear to be all lit at once.

More Help. Two books which were extremely helpful in putting this circuit together are: *CMOS Databook* by Bill Hunter and published by TAB Books/No. 984, $6.95; and Radio Shack's *Archer Semiconductor Reference Handbook* (276-4002) $1.95.

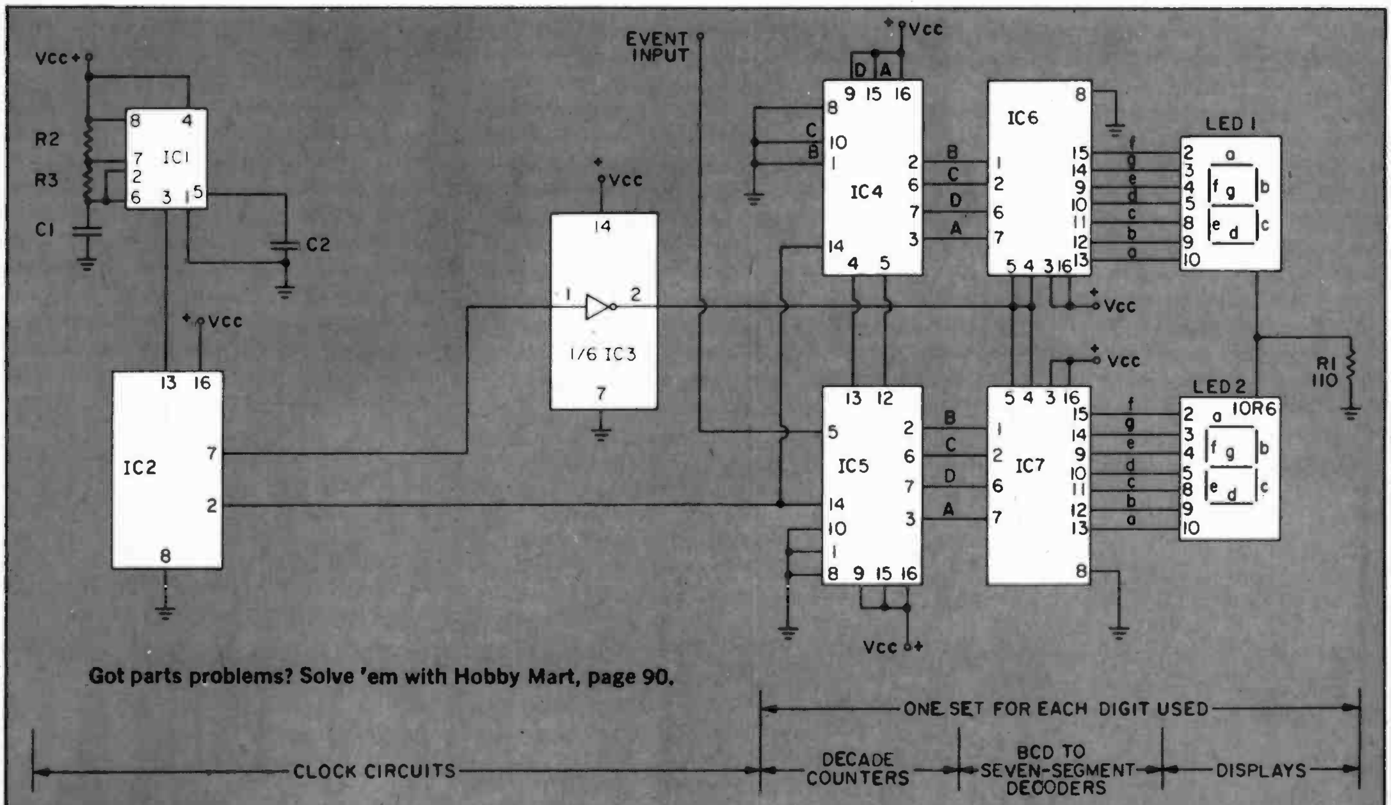
You can learn a lot from these and other books, but nothing takes the place of actually putting one of these circuits together. It is only by trial and error that you learn how to use these basic digital building blocks—learn how to get all the parts ticking over in the proper sequence and humming along to the beat of the clock, the way a good orchestra plays to the rhythm of the conductors batton. ■



The connections appear complicated but once you understand the principles involved they all will make sense. Note the despiking capacitor added to stabilize the circuit.



If the output of a mechanical switch were put straight into a counter, each one of the contact-bounce pulses would trigger a cycle of the counter. The monostable multivibrator triggers as the pulse first goes high. The output remains high for a time longer than any continuation of bounce pulses so the unit only counts once. The pulse widths are typically measured in nanoseconds.



Got parts problems? Solve 'em with Hobby Mart, page 90.

PARTS IN DIGITAL DEMONSTRATION CIRCUIT

C1—0.1-μF capacitor
C2—.01-μF capacitor
IC1—555 timer
IC2—4017 Decade Counter/Divider
IC3—7404 Hex Inverter
IC4, IC5—74192 Up/Down Decade Counter
IC6, IC7—4511 BCD to Seven-Segment Latch/Decoder/Driver
LED1, LED2—Common Cathode Seven-Segment LED display
R1—110-ohm, ½-watt resistor
R2—1-megohm, ¼-watt resistor
R3—500,000-ohm, ¼-watt resistor
Misc.—CSC PB-203 Solderless Breadboard, jumper wires, and a variable frequency, 5-volt peak-to-peak, square wave signal generator or equivalent free running multivibrator.

"Bad SCR" LEDIT Said It

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

☐ 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.

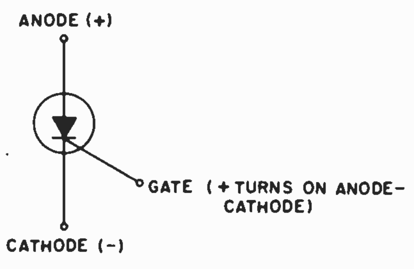
The problem with trying to check most common, small-size SCRs with an ohmmeter is that the minimum gate current and minimum holding current are naturally provided by the ohmmeter. All but the cathode-to-gate path may check "open," making it impossible to identify the leads on an unmarked SCR. What LEDIT 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.

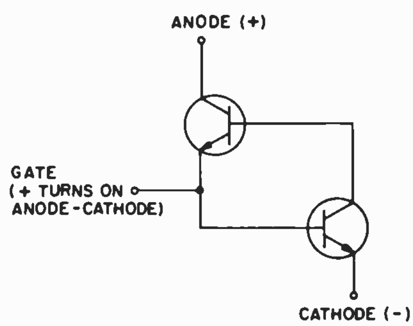
Checking SCRs. There are five ways to misconnect an SCR to the three posts, and one correct way. None of the incorrect ways will damage a good SCR among the vast majority of those around today. The correct connection, when identified, provides for short tests between gate and cathode, cathode and anode,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

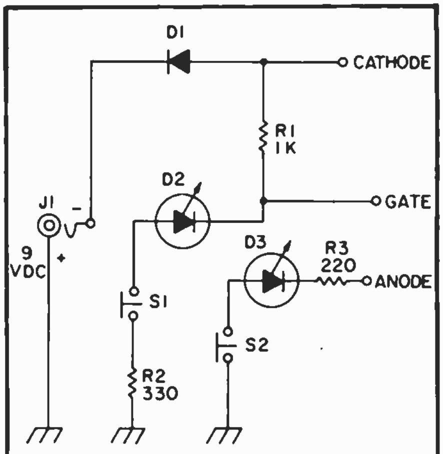
If the gate is either normal or shorted, D2 will emit red light. But only if the gate is normal will D3, the anode current indicator, come on with a clear light. Letting up on S1 should let D2 go out and leave D3 on. If it does not, then the SCR either cannot remain on with a 10 mA anode current (which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

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

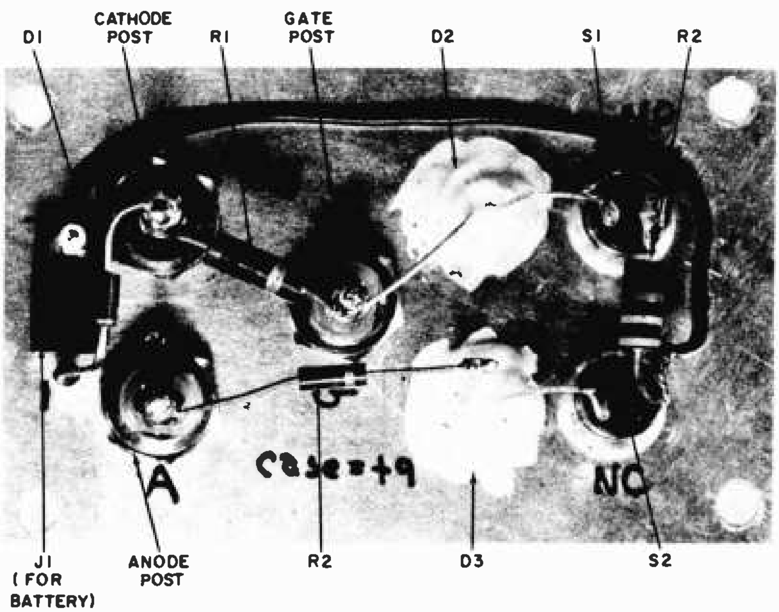
(Continued on page 116)



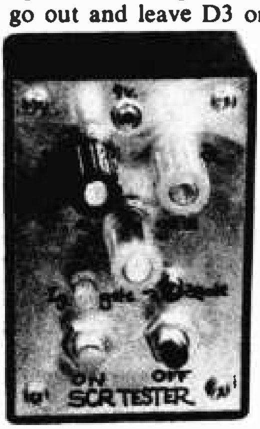
PARTS LIST FOR LEDIT SCR TESTER

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.

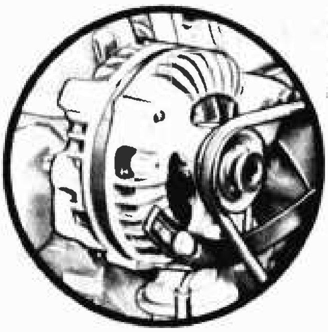
The circuit used in LEDIT is extremely simple and should take little time to assemble. The parts, with the possible exception of the two LEDs, will probably be in your junk box. Mount the panel on an old plastic box—perhaps from a broken midget volt/ohm meter that's seen better days or been canibalized 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.



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!



ALTERNATOR TESTER

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

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

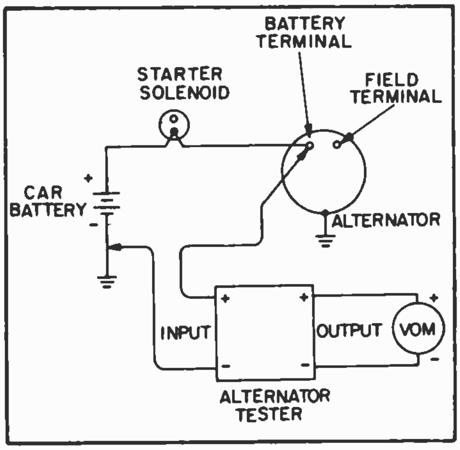
Alternator Tester completed and installed in its compact metal cabinet, shown with its test leads.

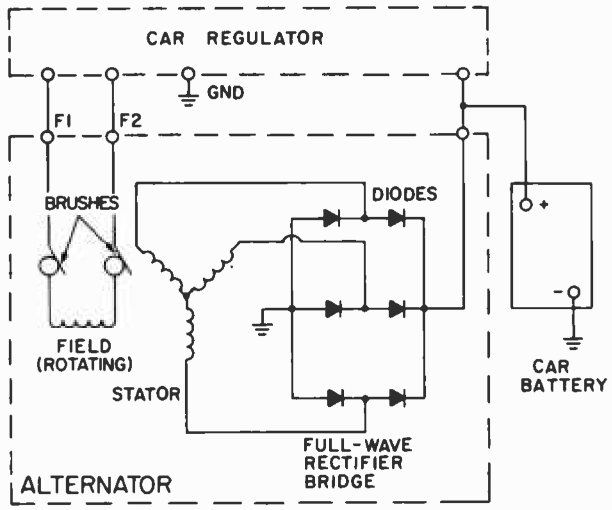
ALTERNATOR TESTER

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

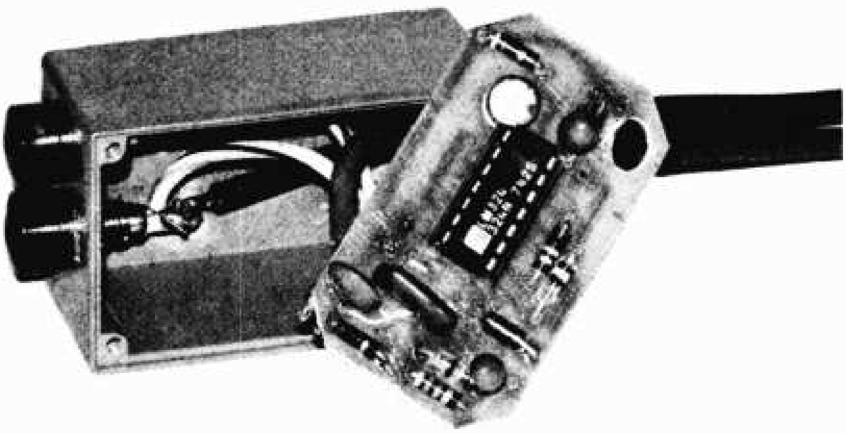
About the Circuit. The Alternator Tester is basically a peak detector circuit which responds to the peak-to-peak value of an AC voltage fed to its input terminal. Power to operate the circuit is derived from the output of the alternator on the same lead which feeds the ripple voltage to the input of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

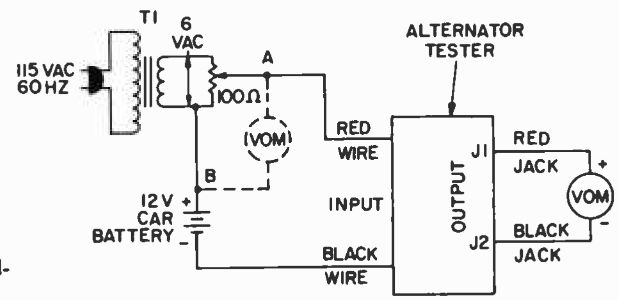




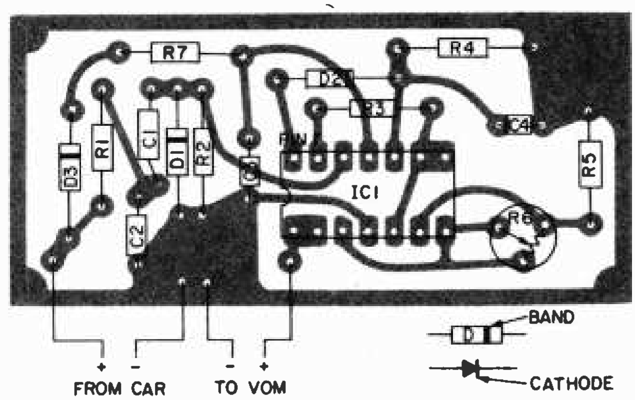
Typical automotive charging circuit. Latest model alternators have solid-state regulator circuit built into alternator frame.



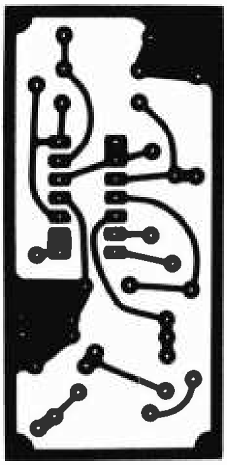
Alternator Tester opened, showing printed circuit board. Comparison with this early version of printed circuit board reveals improvements made by the editors.



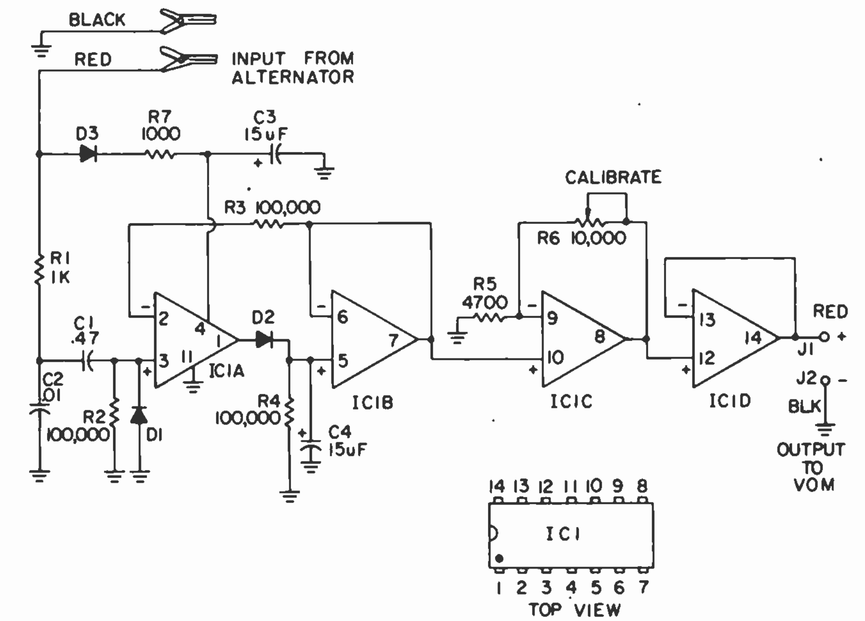
Calibration of the Alternator Tester.



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 114)

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 into your listening post like they were right next door.

SHORTWAVE SUPERCHARGER

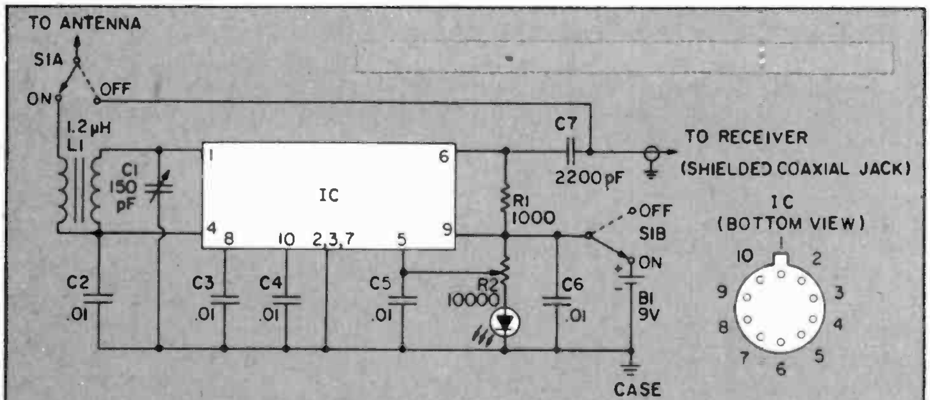
Turn your old SW clunker into a high-band hot-rod.

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.

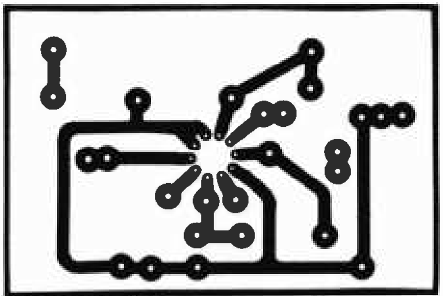
This unit will boost selectively the RF signal by 20-30 dB and it will compensate for many deficiencies of your set. It will not only improve the gain of the shortwave receiver but will also improve its selectivity and the image frequency rejection. Simple, single conversion superhet SW sets have the 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 $20 + (2 \times 0.455) = 20.910$ 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-

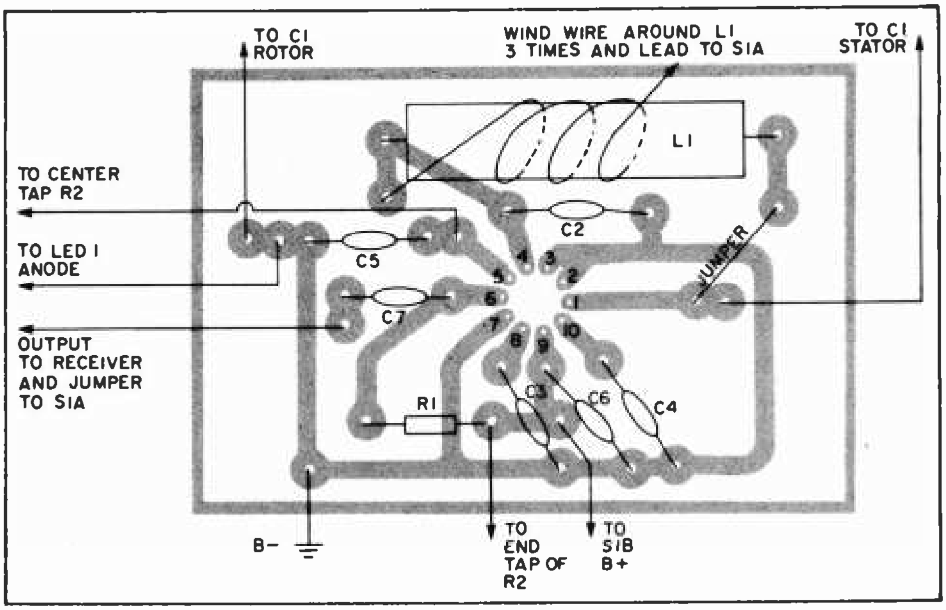


PARTS LIST FOR SHORTWAVE SUPERCHARGER

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.

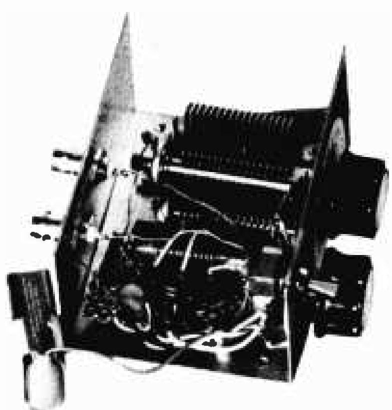
Mount the Shortwave Supercharger inside a metal case which you can find in most electronic supply stores. Use shielded cable between the supercharger and your receiver otherwise the connecting wire will behave like an antenna and some of the features of your supercharger will be lost. The final job is 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.



Keep up with current events by expanding your meter's amp-ability

HIGH-AMP METERS

WITH THE RISING COST of test equipment it is advantageous to be able to perform several operations with one meter. For instance a DC milliammeter can be converted to read higher values of current by adding a shunt to bypass the bulk of the current around the delicate meter. By following a few simple steps a milliammeter can be converted to read 10 to 20 amps or more. The first step is to determine the internal resistance of the meter. From this you can calculate the shunt resistance needed and the type of material to be used.

To find the internal resistance of the meter, construct the test circuit illustrated here. The 4700 ohm resistor is used to limit current and serves no other purpose. Start with the power supply set to zero volts, leaving S2 open and S1 closed. Slowly increase the current flow by varying R3 until the meter needle moves to full-scale deflection. Without touching the setting of R3, close S2 and adjust R2 until the meter reads half of full scale. According to Ohm's Law the resistance of the meter and of R2 are now equal. Open switch S2 and measure the resistance across R2. This value will be equal to the internal resistance of the meter.

Shunt. Precise shunt resistance is important for accurate current readings and must be chosen carefully. With the shunt connected across the meter, most of the current is diverted past the meter. This is the theory behind a small meter being able to read high currents. The shunt can be a wire, steel or copper bar, or almost any material that will offer the proper resistance. To determine the needed shunt resistance we will consider an example. If we want a 0 to 10 milliammeter to be able to read full-scale for a current of 10 amps. Therefore 10 mA will flow through the meter when 9.990 Amps are diverted through the shunt. If the meter resistance was 100 ohms, using Ohm's Law the voltage across this parallel circuit is found by using the following equation:

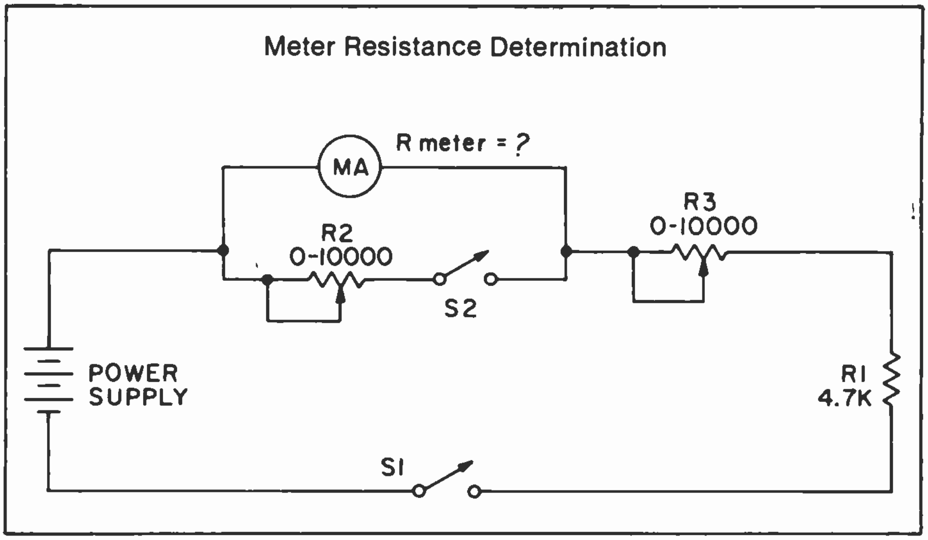
E=(Current) (Resistance)
 =(10^{-3}) (100 ohms)
 =1 Volt

Using the calculated voltage and solving Ohm's Law for resistance the proper shunt can be found. This derivation is shown below:

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}} = \frac{1\ \text{Volt}}{9.990\ \text{Amps}} = .1001\ \text{Ohms}$$

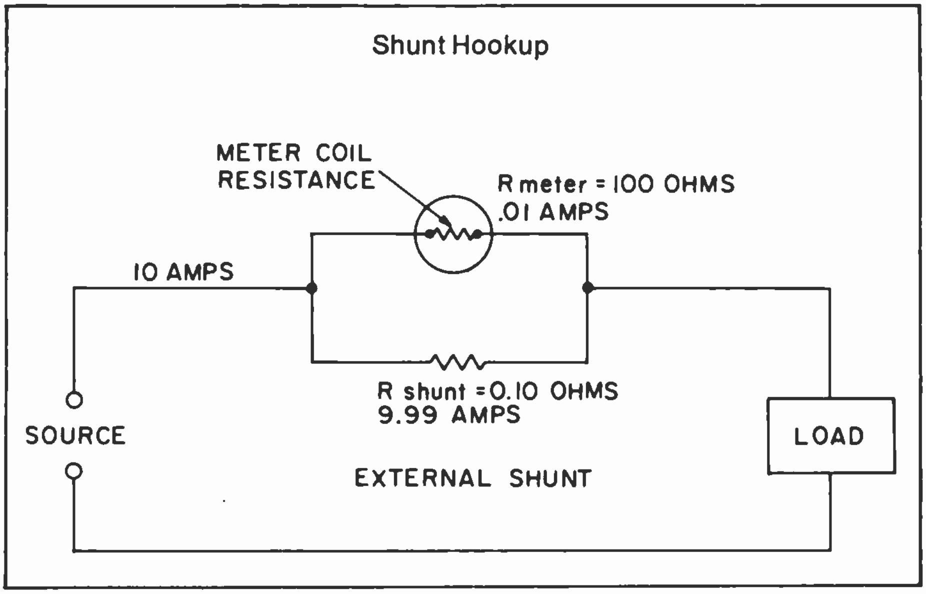
In this case the milliammeter would be capable of giving a readout directly in amperes.

By following these few simple steps you will greatly expand the versatility of your test equipment. It will increase your ability to handle a greater variety of test and trouble shooting situations. ■



To determine the internal resistance of a meter construct a circuit like the one illustrated above. If you don't have the parts in your junk box then check an electronics surplus outlet.

A shunt resistor bypasses the bulk of the current around the meter while allowing a regulated amount to pass through the meter's coil and give an accurate reading. A shunt can be a resistor or a measured length of wire. Make sure it will handle the current.



MACK THE TACH

Our phototachometer travels in the best of circles!

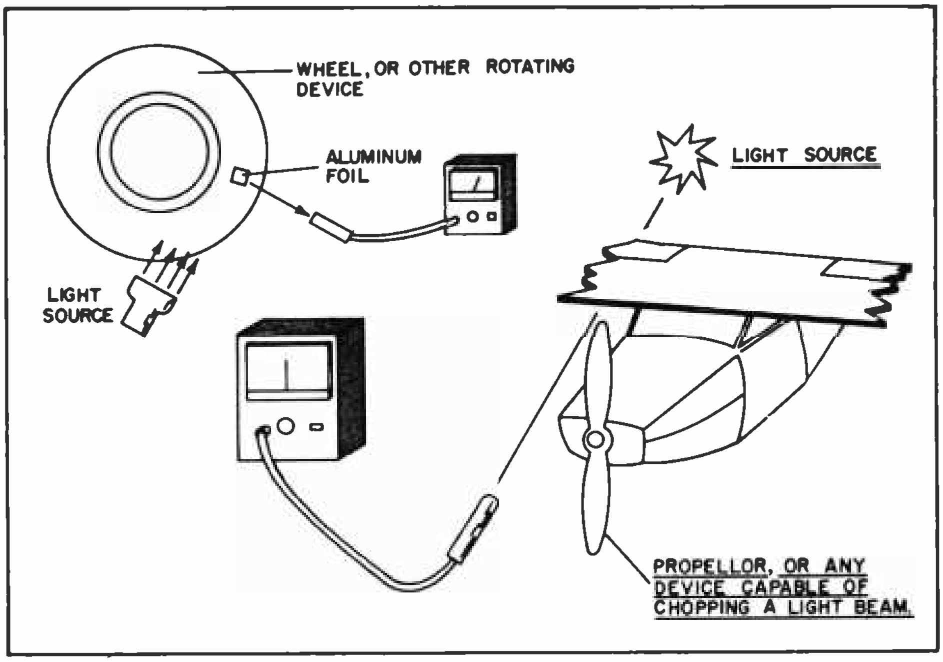
LIKE MOST PEOPLE you probably own a variety of motor-driven appliances and devices; autos, boats, washing machines, lawn mowers, power tools, model airplanes, movie projectors, tape recorders, and so forth. Again like most people, you probably never give a thought to the proper maintenance of these items until they break down. One of the surest indications of an upcoming breakdown is improper motor speed, and for about $35 you can make a tachometer to measure it.

A good tachometer is an absolute necessity for the proper maintenance and tuning of motor-driven devices, and we here present *Mack the Tach,* every bit the equal of commercial units costing around $200. Motor speed can be measured on four ranges from 1000 RPM full-scale to 30,000 RPM full-scale. Accuracy is an excellent ±2½% of full-scale on the 10,000 RPM range, and ±3½% of full-scale on all other ranges. Furthermore, because this tachometer is optically coupled, no extra load is placed on a rotating device while it is being tested. The result is better accuracy, especially with small, light-duty motors.

Seeing the Light. As you probably know, RPM measurements are just frequency measurements. In order to obtain an RPM reading on an analog meter, we need a frequency-to-voltage converter circuit. Such a circuit is detailed in the block diagram. Assume that we have arranged things so that every time the motor rotates, one pulse of light falls on the photo-transistor. This causes the photo-transistor to conduct and trigger the monostable circuit that follows. Each time the monostable is triggered, its output (point A) rises to a high potential for a fixed time interval T, then drops low again, remaining low until re-triggered. The monostable output next feeds into an averaging circuit, whose output (point B) is ideally a D.C. voltage that drives a meter.

Operation of Mack the Tach is explained more clearly by the voltage diagrams. At low RPM, the monostable's output pulses are spaced fairly well apart. Consequently, the average value of the output is low, as indicated by the D.C. level dashed-in on the diagram. Since the average value is low, the meter will only deflect a little bit. Now, at higher RPM, the monostable gets triggered more frequently. The monostable's output spends proportionately more time at a high potential than at a low potential. The average value of the monostable's output is now higher, and this results in a correspondingly higher reading on the meter. In both the high- and low-RPM cases, the monostable's output rises to the same high potential for the same time interval (T); higher RPM decreases the time between pulses, and this alone results in a higher average voltage at the monostable's output.

Let's next examine Mack's schematic diagram. Diodes D2 and D3 full-wave rectify the A.C. voltage from transformer T1. This rectified current splits



Mack the Tach may be used to measure the rotational speed of just about any object that can "chop" a light beam simply by using it as shown in the lower right. If you wish to measure rotational speed of something such as a wheel then use the aluminum foil as shown, reflecting light off it into Mach's home-built, light-sensitive probe.

two ways: to D1 and to R3. Consider first the path through R3, D4, C4, and R2. The purpose of this four-component network is to provide a 120 Hz., clipped, full-wave-rectified sine wave, available whenever S2 is fully clockwise. This signal is used to trigger monostable IC1 during calibration.

Now let's consider the alternative path of the rectified current through D1 to C1 and IC2. C1 smoothes out the rectified A.C., while D1 isolates the R3-C4-D4-R2 network from the smoothing action of C1. Voltage regulator IC2 transforms the unregulated D.C. voltage across C1 into a regulated 5-volt potential at its output (pin 3). Capacitors C2 and C3 bypass the 5-volt supply and stabilize the circuit.

Transistor Q1 is the photo-transistor, and it connects to the rest of the circuit through a piece of coaxial cable terminated in P1. Plug P1 connects to jack J1.

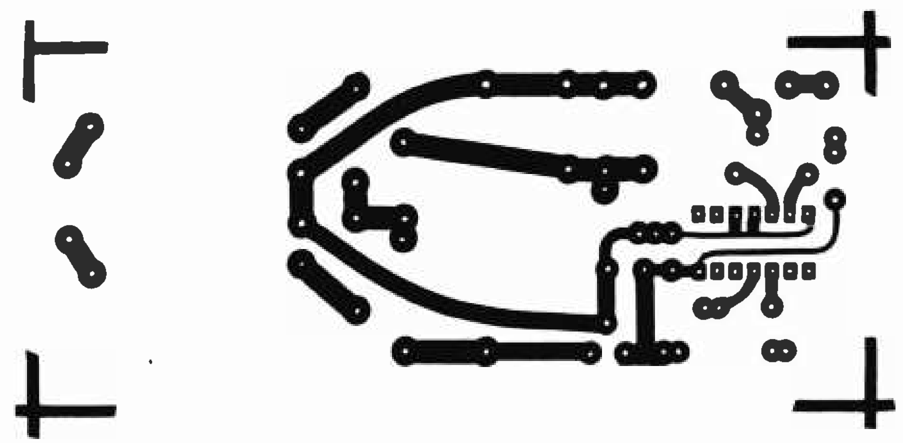
So long as *Range Selector* S2 is not in the *Cal.* position (extreme clockwise), the trigger input (pin 5) of IC1 will be connected to photo-transistor Q1's collector through S2a.

Changes in the intensity of the light incident on Q1 produce changes in Q1's collector potential, thus triggering IC1. The duration of the output pulse available from monostable IC1 is controlled by C6 together with either R4, R5, R6, or R7. Switch S2b selects the resistor appropriate to the RPM range in use.

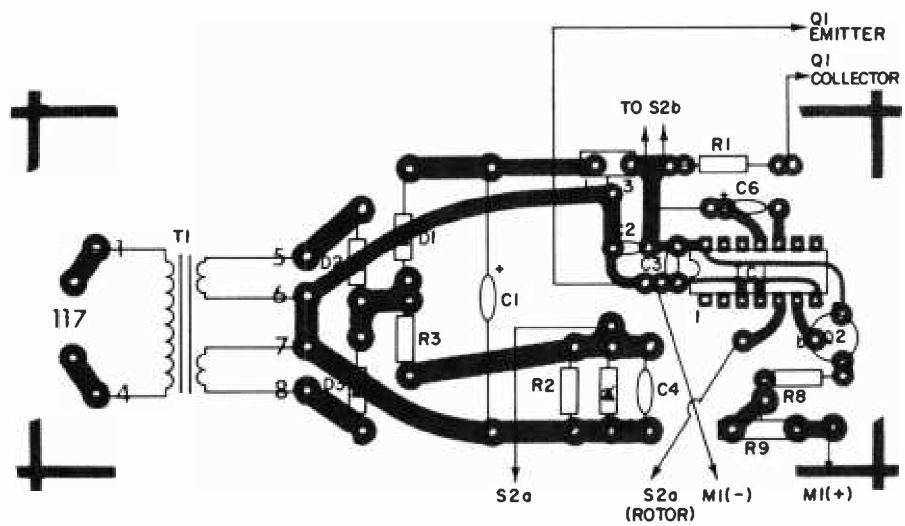
IC1's output (pin 6) drives transistor Q2, which then drives meter M1 through R8 and R9. Q2 provides some current gain, and it also ensures that all current to the meter gets cut off when pin 6 drops to its low level (a few tenths of a volt). The averaging in this circuit is performed to some extent by meter M1 itself because the inertia of the meter's needle causes the deflection to be proportional to the average current.

At low RPM, however, the meter needle would vibrate perceptibly, so capacitor C5 assists in averaging the pulses. Even so, you may still notice a little vibration when reading very low RPM; this is normal and not a cause for concern.

Light and Easy. Construction of the tachometer is particularly simple. Though a printed circuit board is optional, it does make construction even easier—transformer T1 is especially made for PC mounting. Instead of the usual solder lugs, this transformer's lead wires are brought out as pins,



Above is a foil-side pattern for making your own Mack the Tach PC board. As you can see, this circuit is simple enough to allow use of a resist pen to make the board if you do not have photographic means at your disposal. Beneath is a component-side view of old Mack. Make the board, plug in and solder the components and what a spin you'll be in!

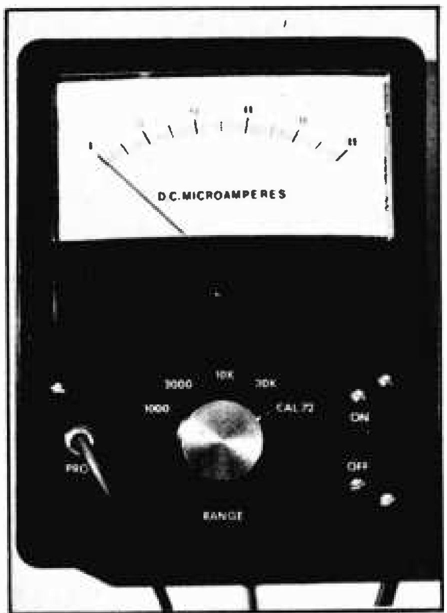


which then are soldered directly to the circuit board. The Signal Transformer Co. will supply you with one of these units for just $4.90 plus postage. See the parts list for their address. Incidentally, while you're ordering the transformer, be sure to request a copy of their catalog. It contains a tremendous variety of reasonably priced and often hard-to-get transformers.

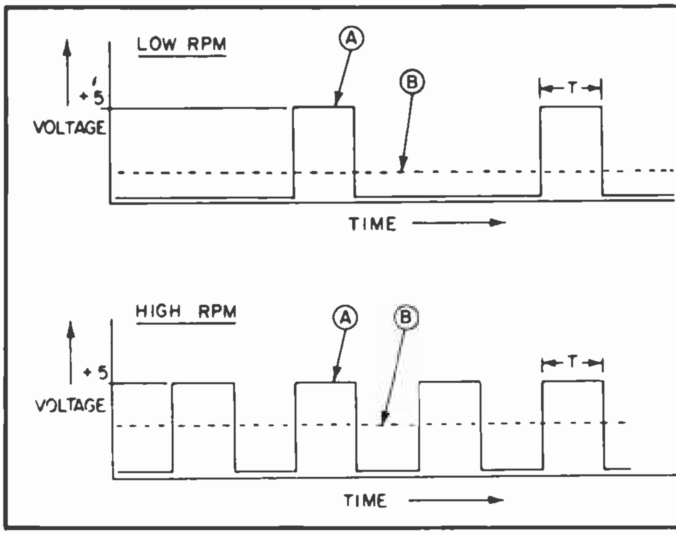
Parts layout within our Mack the Tach is not critical, so you may use any convenient arrangement. The photographs which accompany this article show how the prototype was built into a 6 x 5 x 2½-inch plastic cabinet. As you can see, there was room to spare. When drilling your cabinet, provide an access hole for R9 as this will allow you to calibrate the circuit without removing the front cover every time.

Meter M1 is a 0-100 microamp D.C. unit, and while any similar meter will do, the Mouser #39LK417 is both accurate and reasonably priced ($10.95 plus $3.00 handling). You'll find Mouser's address in the parts list. Incidentally, if you happen to have a 0-100 microamp meter at hand, you can use it, but remember that the accuracy of the meter will determine the overall accuracy of your tachometer.

A few further comments on some of the other components are in order. Note that resistor R3 should be a 150-ohm, 1-watt unit. If you don't have a 1-watt resistor, two 330-ohm, ½-watt resistors in parallel can be used instead. Almost any phototransistor can be used for Q1. Fairchild FPT-110s and FPT-100s (Radio Shack #276-130) were used with success. As noted in the parts list, resistors R4, R5, R6, and R7 were 1% units in the prototype. You can get by with 5% units which will leave the accuracy at about ±2½% of full-scale on



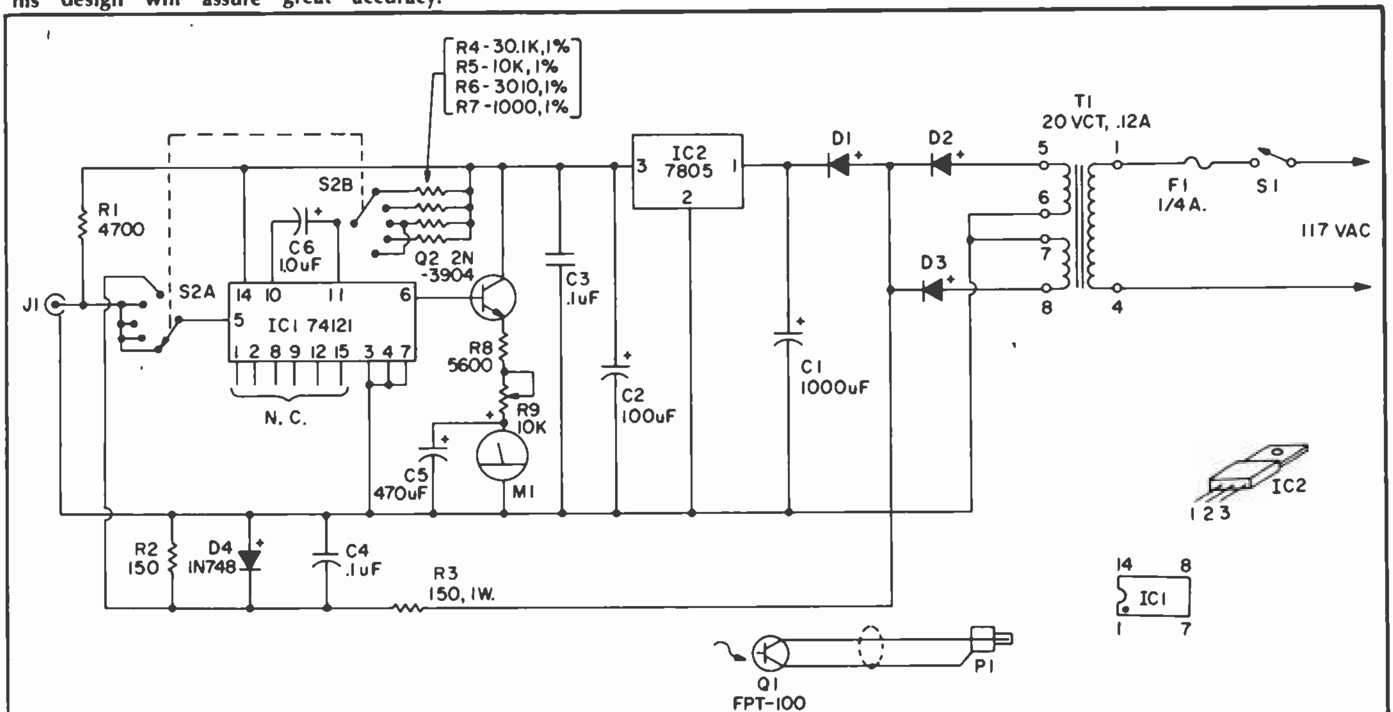
Why spend anywhere from one to two hundred dollars for a tachometer when you can build our Mack the Tach? He's quite functional, and will only set you back about $35 to get it all together. Optically coupled, his design will assure great accuracy.



At low RPMs, the voltage pulses from the monostable output are far apart in time and this lowers the average voltage level. As the RPMs increase, these pulses become closer and the voltage rises as read on the meter.

the 10,000 RPM range; however, accuracy on all other ranges will now be less than or equal to ±7½% of full-scale.

Timing capacitor C6 is a 1.0-uF electrolytic, but be sure to use a tantalum device, not an aluminum capacitor. With this capacitor you must be sure to get the proper orientation when installing it into the circuit. The same caution applies to all the semiconductors, meter M1, and capacitors C1, C2, and C5. As an added precaution, use a socket for IC1. In this way the IC can easily be removed if by chance it should

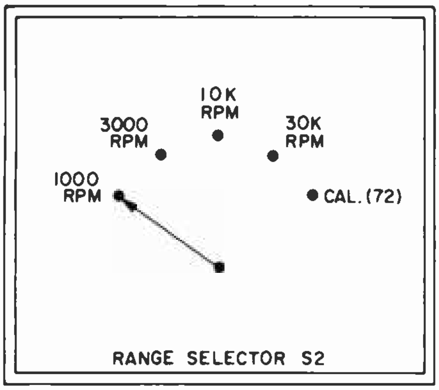


PARTS LIST FOR MACK THE TACH

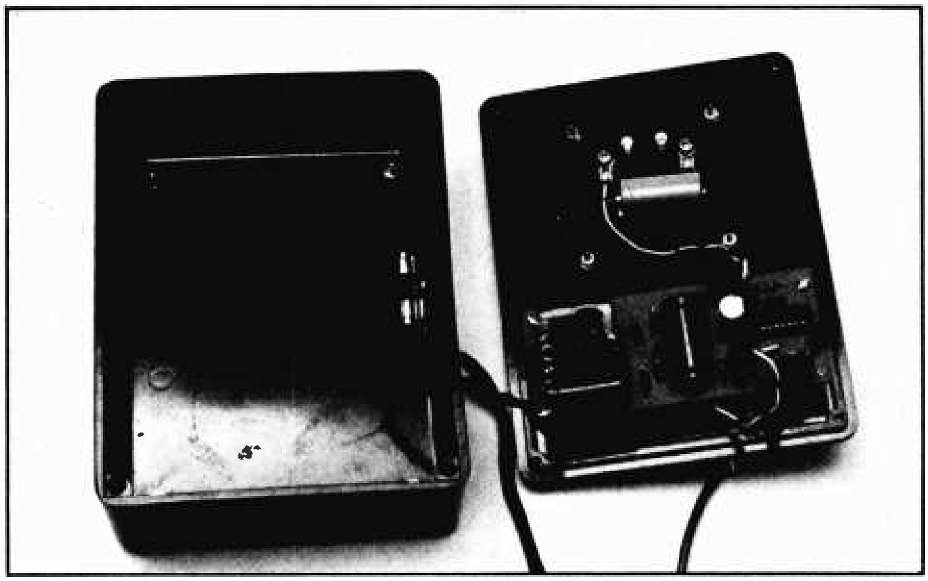
C1—1000 uF, 25V. electrolytic capacitor
C2—100 uF, 16V. electrolytic capacitor
C3, C4—.1 uF ceramic capacitor
C5—470 uF, 35V. electrolytic capacitor
C6—1.0 uF, 35V. tantalum capacitor
D1, D2, D3—1A., 200 PIV rectifiers
D4—1N748A, 3.9 volt, ½ watt zener diode
F.1—¼ amp. fuse
IC1—type 74121 TTL monostable vibrator
IC2—type 7805 5V. voltage regulator
J1—phono jack
P1—phono plug
M1—0-100 microamp. D.C., 2½% panel meter (Mouser #39LK417)
Q1—Fairchild FPT-100 photo transistor
Q2—2N3904
ALL RESISTORS ½-WATT, 10%, UNLESS SPECIFIED OTHERWISE
R1—4700-ohm
R2—150-ohm
R3—150-ohm, 1 Watt
R4—30.1K, 1%
R5—10,000-ohm, 1%
R6—3010-ohm, 1%
R7—1000-ohm, 1%
R8—5600-ohm
R9—10K trimmer pot
S1—SPST slide switch
S2—DP5pos. rotary switch
T1—20 VCT, 120 mA., PC-mount transformer (Signal #ST-3-20; $4.90)
misc.—fuseholder, pen barrel, plastic case, line cord, knob, coax IC socket.

You may obtain the special parts at the following places. Mouser Electronics, 11511 Woodside Ave., Lakeside, Calif, 92040 and Signal Transformer Co., 500 Bayview Ave., Inwood, N.Y. 11696.

MACK THE TACH



Design your front panel as this diagram shows. The RPM full-scale readings can be calculated using the table of RPM Full Scale vs. Mult. Factor, given in the article.



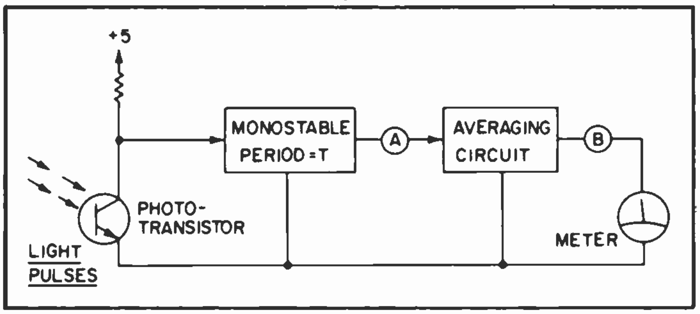
Construction can be made roomy, as it was here in the author's model. One thing the photo does not show is the access hole for R9. It's a good idea to drill one; it can save you all sorts of time whenever you want to recalibrate the circuit. Meter M1 is a 0-100 u-Amp DC unit. We used a Mouser #39LK417 and you will find that company's address and other information in the parts list. Any good phototransistor can be used to give Mack the eye. You'll find that construction will be straightforward and fun too!

turn out to be defective. Finally, note that voltage regulator IC2 is simply soldered to the circuit board. No heat-sinking of this IC is required because only a small amount of supply current is consumed by the circuit.

In order to protect Q1, a photo-probe assembly will have to be constructed, which we have illustrated. Start by threading one end of a small-diameter coaxial cable (Belden 8417 or the equivalent) completely through the plastic barrel from an old pen. Now, grasp photo-transistor Q1, and cut its base lead completely off. Solder the central conductor of the coax cable to Q1's collector, and then solder the coax's shilde to Q1's emitter. Pull on the coax so as to retract Q1 far enough into the pen barrel so that its light-sensitive face is recessed one-half inch. Carefully secure Q1 and the coax to the pen barrel using epoxy cement. Finish up by attaching plug P1 to the far end of the coaxial cable.

Once you've completed construction of Mack, only calibration remains. Adjust R9 so that its resistance is maximum. Turn on the power, and put S2 into its *Cal.* position. Now adjust R9 for a reading of exactly 72 on M1. This completes the calibration. In the future you may re-check the calibration simply by repeating the above procedure. For most applications Mack the Tach as originally designed has adequate sensitivity. In fact, it is desirable for a photo-tachometer to have a minimum practical amount of sensitivity; in this way, ambient lighting conditions rarely affect a measurement. If added sensitivity is desired, however, the easiest course (besides going to a more powerful light source) is to replace Q1 with a photo-Darlington transistor, which must be NPN. One good choice is a type 2N5777, available from Poly-Paks as stock number 92CU2649. Other types may be used as well. Hookup is identical to that of a standard photo-transistor.

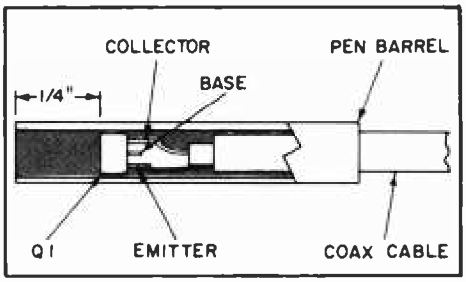
When a light pulse falls on the phototransistor, the transistor conducts and triggers the monostable circuit which follows. When triggered, this circuit's output goes high, then returns low. The output is fed into an averaging circuit and the meter.



Let's now discuss the use of the tach. To begin with, you should place range switch S2 so that full-scale deflection is well above the motor's estimated RPM. After the first reading, drop down to a lower range if necessary. You'll notice in the photos of the prototype that meter M1's scale was left with its original markings: 0 to 100. It's then easy to apply a multiplication factor appropriate to the given range, as shown below.

RPM FULL SCALE	MULT. FACTOR
1000	X10
3000	X30
10,000	X100
30,000	X300

When setting up a measurement, it is important that the ratio of maximum to minimum illumination of Q1 be as high as possible. So far as the maximum illumination is concerned, a 100-watt bulb can saturate (fully turn on) Q1 from as far away as 5 feet, approximately. This assumes that the bulb is in a suitable reflector. If not, Q1 will have to be nearer to the lamp (about a foot away). The minimum light intensity on Q1 should be as low as possible. Recessing the photo-transistor helps in this respect, since stray illumination is thus eliminated *Try to avoid fluorescent lights* as sources of illumination for your Mack the Tach; incandescent bulbs

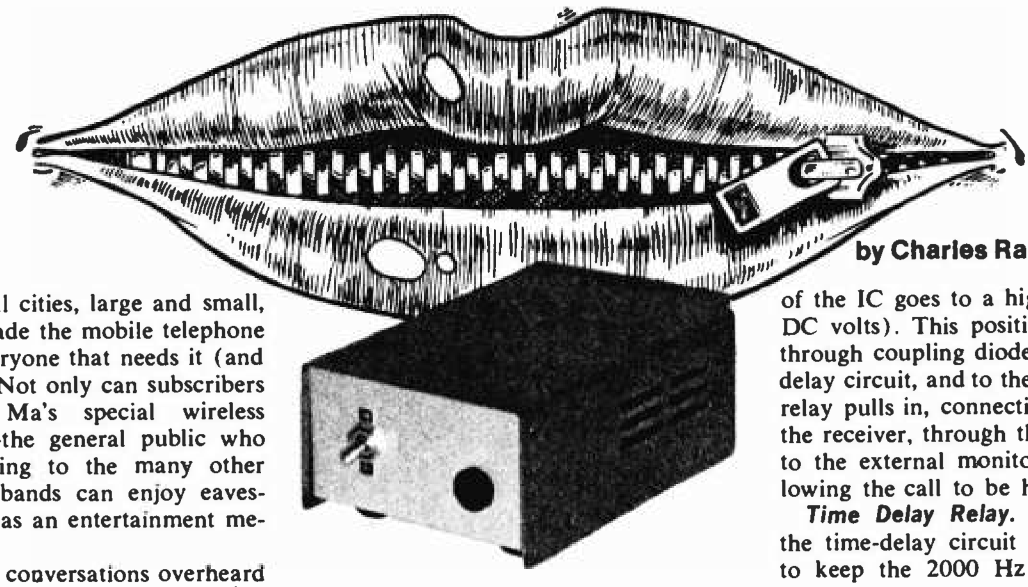


Not only is the pen mightier than the sword but an old pen barrel can show you the light! Build Mack's unique, light-sensitive probe—a pen to house the phototransistor.

(Continued on page 118)

MA BELL'S MOBILE-TEL LIP-ZIPPER

Easi-build silencer lets you listen in on land-mobile phone talk with any regular communications set.



by Charles Rakes

☐ In almost all cities, large and small, Ma Bell has made the mobile telephone available to everyone that needs it (and can afford it). Not only can subscribers benefit from Ma's special wireless phone service—the general public who are now listening to the many other public service bands can enjoy eavesdropping on it as an entertainment medium.

Many of the conversations overheard on Ma Bell's mobile phone frequencies would make a person blush, even in these loose and liberal times, because most users don't have the foggiest idea that their phone conversations can be overheard, and on an ordinary multiband receiver. For the majority of us, who no longer have the advantage of the old party-line telephone system it's a great way to once again catch up on the latest gossip with the no-holds-barred *MBMT Lip-Zipper*. That is, *Ma Bell's Mobile Telephone*, Lip-Zipper.

Who Needs Lip-Zipper? You Do! Now hold it just a second. Why can't you just tune in on the public service band and sit back and enjoy listening to the gossip? Well, you can. This part of the operation is just that simple, but the problem is what happens when no one is using the mobile phone radio channel. Good old Ma Bell places an *idle tone* of 2000 Hz on the channel during this *non-busy period*, and holds it there until the system becomes busy again. This audio tone is transmitted so that the subscriber's receiver can tell when the radio channel is open for use. This is all well and good for the complex mobile telephone system, but it is darn annoying to sit and listen to a continuous 2000 Hz tone while impatiently waiting for the next juicy call to come in. (Ed Note: Maybe that's why Ma chose that frequency. It could just as easily have been one above the limits of the audio range.)

We Lick the Problem. Our handy-dandy MBMT Lip-Zipper shuts Ma's mouth during the tone period. During this time our Lip-Zipper disconnects the speaker from the receiver, giving us peace and quiet, and when the channel is put back in use the audio is routed to the speaker so we don't miss anything.

How Lip-Zipper Zips. The heart of the Zipper is a 567 phase-locked loop (PLL) IC tone decoder tuned to respond to the 2000 Hz idle-tone frequency. The output of the 567 IC (pin 8) is direct coupled to a time-delay relay driver transistor, Q1. When a 2000 Hz tone signal is present at the input of the PLL (pin 3), the DC output (pin 8) of the IC is low—near zero volts. During this time no DC bias is present at the base of Q1, and the relay is not operated. The relay remains in this condition as long as the tone is present at the input of the IC.

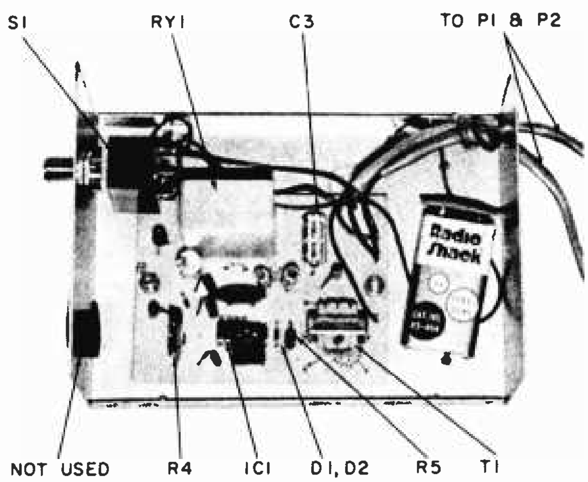
At the instant the channel goes into use the tone is removed and the output of the IC goes to a high state (positive DC volts). This positive voltage is fed through coupling diode D3 to the time-delay circuit, and to the base of Q1. The relay pulls in, connecting the output of the receiver, through the relay contacts, to the external monitoring speaker, allowing the call to be heard.

Time Delay Relay. The function of the time-delay circuit (C6 and R6) is to keep the 2000 Hz audio-frequency components that are present in normal speech from causing the relay to chatter. Without this delay circuit the relay would cut in and out, badly interrupting normal voice conversations.

The input of the Zipper is matched to the receiver's audio output by transformer T1. The audio signal level at the secondary of T1, is limited by diodes D1 & D2 to maintain a near constant level at the input of the PLL.

A DPDT toggle switch is included to allow the receiver's audio to pass directly to the monitor speaker when the Zipper is turned off, and it places Zipper's mouth-shutting circuit into operation when the switch is in the *On* position.

Putting Zipper Together. Construction of Lip-Zipper is simple and straightforward. It can be built either on perfboard or on a printed-circuit



Interior view of completed Lip-Zipper showing major parts locations. Consult parts layout for location of small components.

board. The choice is yours because the layout isn't at all critical, and the circuit will perform in almost any physical configuration.

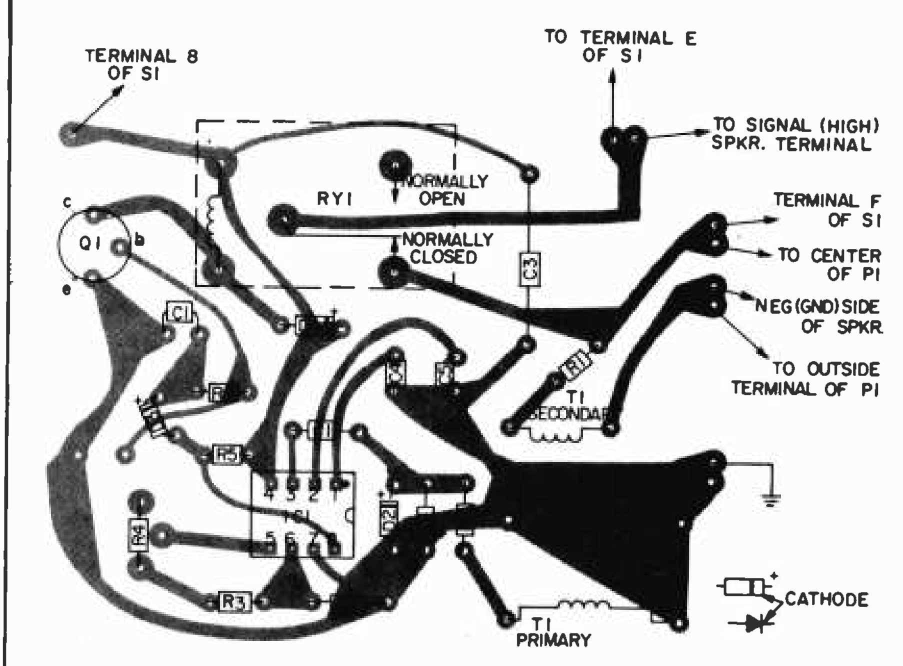
To Use a Circuit Board. If a printed-circuit board is used, you can copy my layout and cut your construction time to the minimum. Take great care when soldering the semiconductors in place, and use a socket for the PLL IC. Zipper can be housed in a metal cabinet 4-in. wide x 2⅜-in. high x 5⅜-in. deep without crowding, as shown here.

The printed-circuit board should be mounted so that trim pot R4 may be adjusted either through the front or the side of the cabinet.

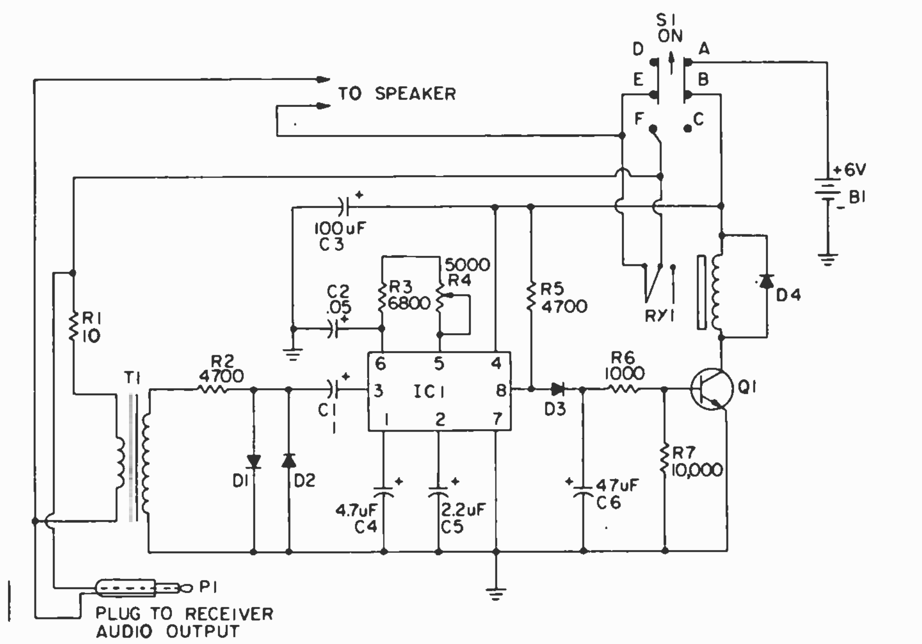
Using Lip-Zipper. Plug P1 into the monitor receiver's audio-output jack, and connect P2 to an external speaker. For added enjoyment try using a good-quality enclosed speaker.

With the toggle switch in the *Off* position the audio should be coming

(Continued on page 116)



Parts placement on printed circuit board is shown above. Note the polarity of the four diodes. The striped end is the cathode. Parts may also be mounted on perf board, if desired (viewed from foil side).



The Lip Zipper's circuit will kill that unwanted 2,000 Hz audio tone that Ma Bell puts on its mobile telephone carrier when the frequencies are not in use. The 567 phase-locked loop (PLL) IC chip is the base of the system. This will respond to the 2000 Hz idle tone and drive a relay that will shut off the speaker. To keep the relay from turning off and on every time 2000 Hz appears in normal speech there is a time-delay circuit added to the output of the IC (pin 8). This time-delay circuit, made up of resistor R6 (1000 ohms and capacitor C6 (47uF), will keep the relay from chattering during a normal conversation. The time-constant need not be very large since no voice tone would remain on 2000 Hz for more than a fraction of a second.

PARTS LIST FOR LIP ZIPPER

- B1—Four AA (penlight) cells 1.5 VDC
- C1—.1 uF, 100-VDC capacitor
- C2—.05-uF, 200-VDC capacitor
- C3—100-uF, 16-VDC capacitor
- C4—4.7-uF, 16-VDC capacitor
- C5—2.2-uF, 16-VDC capacitor
- C6—47-uF, 16-VDC capacitor
- D1, 2, 3—1N914 signal diode, silicon only, not germanium
- D4—1A (or more), 25-V silicon diode, 1N4000 series
- IC1—Phase-locked loop (PLL) integrated circuit (Radio Shack 276-1721 or equiv.)
- Q1—NPN medium power amplifier/switching transistor, silicon, 2N2924 or similar
- R1—10-ohm, ½-watt resistor
- R2, 5—4700-ohm, ½-watt resistor
- R3—6800-ohm, ½-watt resistor
- R4—5000-ohm, printed circuit board mounting potentiometer
- R6—1000-ohm, ½-watt resistor
- R7—10,000-ohm, ½-watt resistor
- RY1—6 VDC relay, coil 300-ohms or higher (not lower)
- S1—DPDT toggle switch
- T1—1000-ohm to 8- or 16-ohm audio output transformer

Misc.—Cabinet, IC socket, battery holder, plug to match receiver output (and speaker, if required) wire, solder, etc.

Printed circuit board for this project, with holes drilled, ready for installation of components may be ordered for $3.75 postpaid from Krystal Kits, Box 445, Bentonville, Arkansas 72712.

Build this long range microphone and...

Bug Mother Nature

by F. J. Bauer

With a parabolic mike offering sonic and electronic amplification you're in tune with Helix Aspera to Yellow-bellied Sapsuckers!

ENGLISHMAN George Riley lives in Kent, works in London, and goes home to an unusual hobby.

"It all started about a couple of years ago when I borrowed a friend's parabolic directional microphone dish. This type of equipment is hyper-sensitive and can be pinpointed to record a sound without external noise interference. I was using it to record the sound of crickets when I suddenly heard a strange 'slurping crunching' sound. This turned out to be a large snail making the most of some hard grass. From then on I was hooked," says George.

Experts such as zoologist Donald J. Borror have used the parabolic microphone technique to produce 33⅓ rpm records that sonically illustrate ornithology books and booklets.*

After stumbling over a couple of radar antenna dishes a few years ago, I finally decided to put one of them to work. Since I was no microwave expert, I decided to try an acoustic application. After all, I reasoned, a parabolic dish is a parabolic dish whether it is used for reflecting and focusing microwaves or sound waves. The result is the parabolic microphone described in this article.

If you want to go all out for added gain, look over the surplus dealers' list for an 18-inch or larger aluminum model. As nearly as I can tell with the test equipment available, the 18-inch reflector adds about 10-dB gain to the microphone.

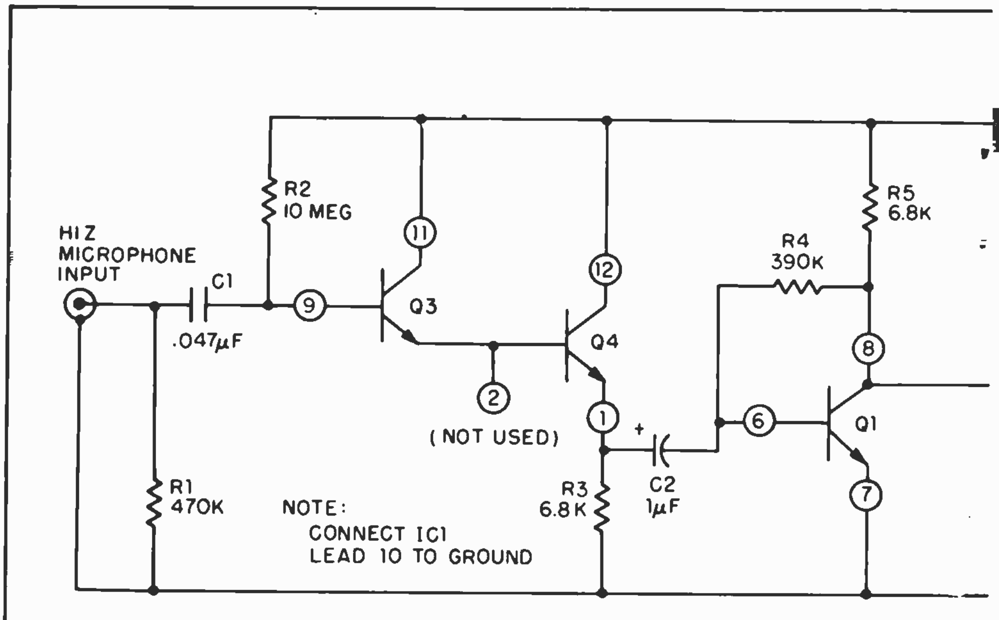
Construction. It's simple enough as reference to the photos will reveal. The mount for the dish is made of wood and masonite. The dish is held in place by three threaded rods which also serve as the microphone support. Almost any kind of rod material will do, as long as it is or can be threaded. I happened to have some odd pieces of 9-gauge aluminum clothesline which threaded easily with a 10-32 die. Make the rod length about 7½ inches to allow sufficient leeway for adjusting the microphone for optimum focus. A small bracket or block may be added where the dish touches the wooden base to add rigidity, and a hole in the center of the base will make it convenient to mount the whole assembly on a camera tripod.

Any low-priced ceramic or crystal microphone cartridge will work well with this reflector. The one shown in the photograph happens to be out of a pre-WW II hearing aid!

Mount the microphone cartridge on the rods with rubber bands. The exact method of attaching the rubber bands to the microphone cartridge is left to the ingenuity of the builder, since this will largely depend upon the physical configuration of the microphone.

Next route a 16-inch piece of shielded microphone cable from the microphone along one of the rods, through the dish (but inside the back plate), and terminate the cable in a phono plug. The cable should have sufficient slack so that it may be easily plugged into the amplifier box. Also, be sure to allow sufficient lead slack at the microphone end of the cable so that the shock mount effect of the rubber bands is not nullified. This will complete the microphone reflector assembly, which should be set aside until the amplifier is built.

Electronics. The amplifier is a three stage affair using an RCA CA3018 integrated circuit. Transistors Q3 and Q4



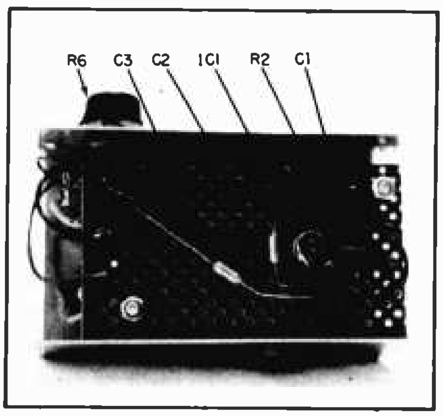
PARTS LIST FOR A PARABOLIC MICROPHONE

B1, B2—2U6-type 9-volt battery
C1—0.047-uF disc or tubular capacitor
C2, C3, C5, C6—1-uF electrolytic (observe polarity) or tubular capacitor, 35 volts or better
C4—0.01-uF ceramic disc capacitor
IC1—3018 integrated circuit (RCA CA3018), available from Circuit Specialists Co., Box 3047 Scottsdale, AZ 85257; $2.00 postpaid
R1—470,000-ohm, ¼-watt resistor
R2—10-megohm, ½-watt resistor
R3, R5, R8—6800-ohm, ¼-watt resistor

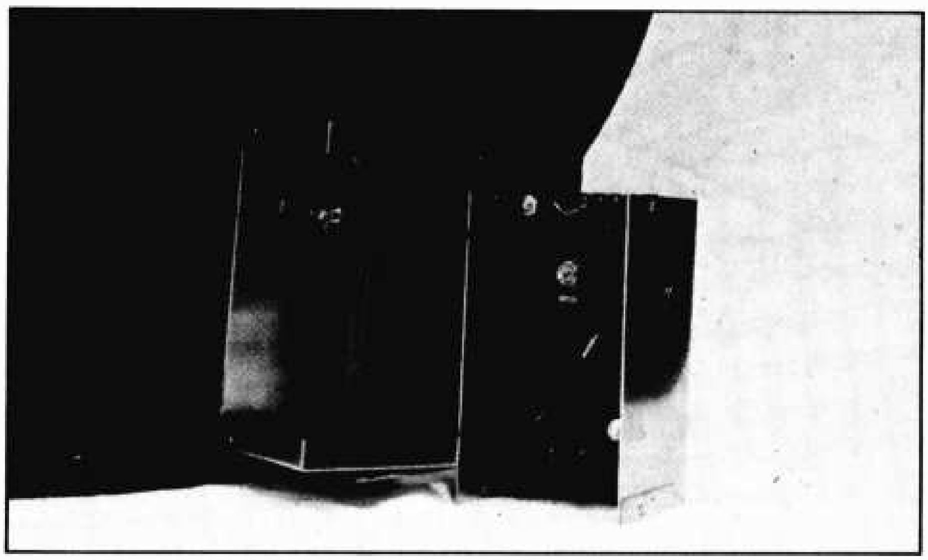
are used as a Darlington pair in an emitter-follower circuit in the first stage. This provides the necessary high input impedance required by the crystal microphone. The two following stages utilize Q1 and Q2 respectively as conventional common emitter amplifiers. The average gain per stage is about 38 dB.

Capacitor C4 across audio gain control R6 provides a 3-dB roll-off at 15 kHz, thus limiting amplifier frequency response to the desired audio range. In addition to limiting the frequency response, this capacitor also reduces the tendency of the amplifier to oscillate at higher frequencies, which could result in instability and low output. The 3-dB point at the low frequency end is about 70 Hz, sufficient for this application.

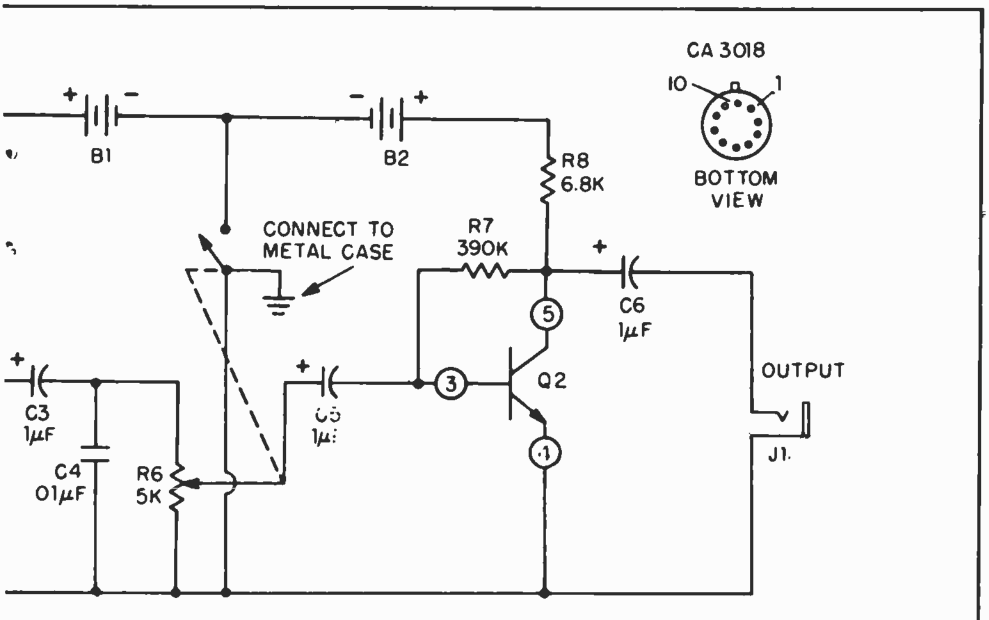
Two 9-volt transistor batteries are used to power the amplifier; not because of high current drain, but, to avoid common coupling between the output stage



Place components above and below the raised perf board. High impedance circuit makes it necessary to shield the amp in a metal box.



Suspend the microphone you use from rubber bands that extend to the support rods. Or, a clamp wrapped in foam packing material holds Riley's microphone securely.



R4, R7—390,000-ohm, ¼-watt resistor
R6—5,000-ohm audio taper potentiometer with spst switch
Misc.—Aluminum case, 2 x 4-in. perf board, plugs, jacks, hardware, push-in terminals, microphone (high impedance crystal, see text), wire, solder, etc.
Note: ETCO lists a 22-in. parabolic reflector for $19.95 plus $3.80 for shipping. ETCO Electronics USA Corp., North Country Shopping Center, Rt. 9 North, Plattsburg, NY 12901.

and earlier stages of the amplifier. An RC decoupling network could, of course, be used instead of two batteries, but it was found that oscillation would occur in spite of the decoupling network after the batteries had been in service for awhile. Two batteries absolutely guarantee against amplifier instability during the useful life of the batteries. The total current drain of the amplifier, by the way, is only 1.5 mA.

No trouble should be experienced with the amplifier if the original layout is followed. All amplifier components are mounted and wired on the perf board as shown. The volume control, capacitor C4, and the earphone jack are mounted on the part of the minibox that serves as a cover and battery holder. All connecting wires are soldered to push-in terminals on the perf board, and the perf board is mounted above the batteries with small bolts and spacers. After assembly, connect the microphone to the amplifier input with a short piece of cable.

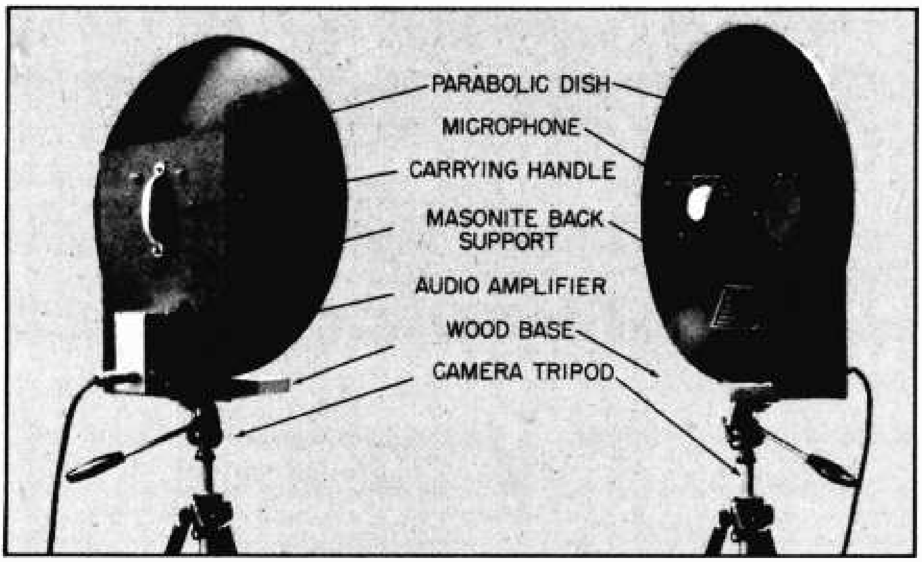
Check Out. When testing the amplifier on the bench, either have the microphone connected to the input terminals or substitute a half-megohm resistor for the microphone input. If you have a hum problem it is probably caused by nearby AC wiring. (I had to turn off power to the workbench whenever I tested the amplifier out of its case.) Alternatively, you may find a place in the house that is hum free; make your tests there. With the amplifier completely enclosed in its case, there is absolutely no hum pickup problem.

When you are satisfied that the amplifier is stable and working properly, solder the short microphone cable to the input terminals and mount the amplifier in its case. You are now ready to set up the microphone for maximum gain. To do this, you will need a code practice oscillator or other source of audio signal and an AC voltmeter with a ten-volt range connected to the amplifier output.

Set the equipment up in a clear area. Enable the CPA and adjust the audio gain so that the voltmeter reads two volts or less. Next move the microphone cartridge towards and away from the center of the dish to find the microphone position giving the greatest output. Do not let the voltmeter reading go above three volts because overloading the amplifier will make it difficult to find the point of maximum gain. After finding the best position for the microphone, secure the rubber bands on the support rods with dabs of cement.

The parabolic snooper may be used in several ways. As a portable field instrument, just plug in a set of 2000-ohm earphones and be on your way through the woods. The unit will also work as a combination microphone-preamplifier with any amplifier or tape recorder. However, if you are using a speaker for monitoring outside noises, be sure to have sufficient acoustic isolation between the microphone and speaker, such as closed doors and windows. If you don't, all the world will know by your feedback howl that you are listening. When using the unit with an audio power amplifier it is best to run the gain quite high on the amplifier and adjust the system gain as needed with the preamp gain control.

Now you're ready for a new world of close-up sound. ■



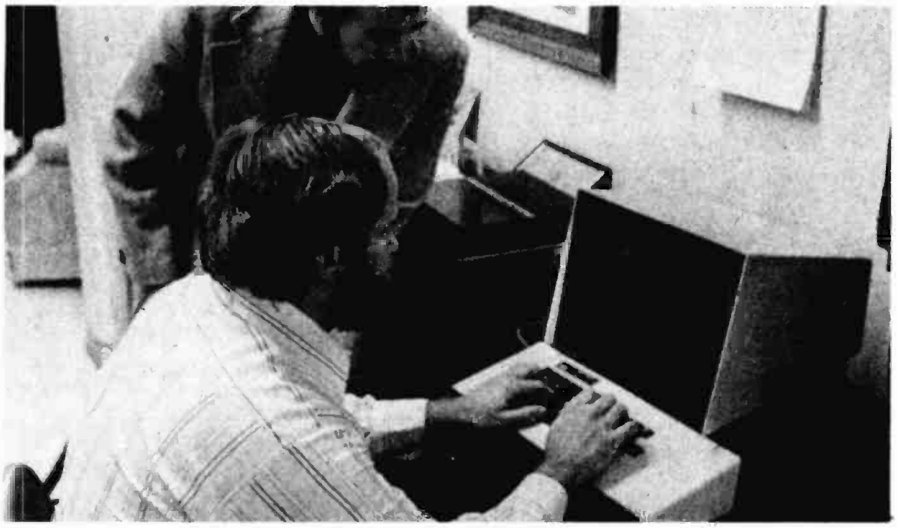
The audio amplifier cabinet cover is secured to the Masonite back support permitting snap removal of amplifier chassis for inspection.

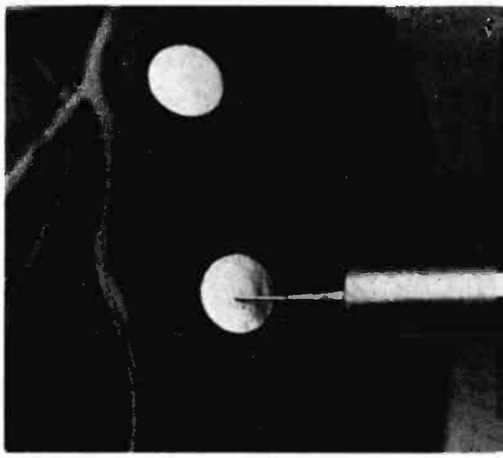
******Common Bird Songs*, **the title of a booklet and record by Borror, is available from Dover Publications, 180 Varick Street, New York 10014 for $3.50 postpaid; order number 21829-5. It provides songs of sixty species such as the Robin, Cardinal, Bluejay, Bobolink, and Tufted Titmouse!**

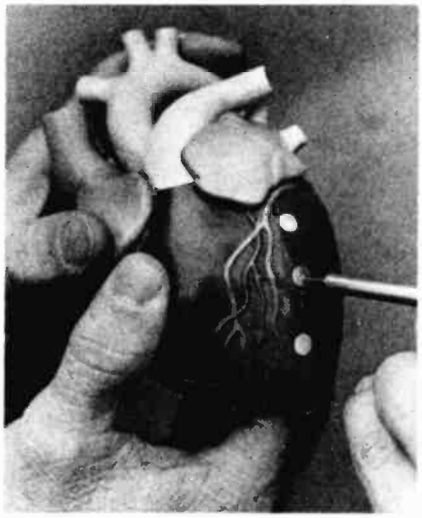
LEONARDO'S IDEA

Doctors team-up with Leonardo da Vinci and a computer to track the heart.

by Mike DeMuccio







Small metal discs are placed on the surface of the heart. These have no effect on the heart's operation but they can be seen by an X-ray video recorder. Their motion is computed to tell how well the heart is pumping, how much blood is moving through it, the contraction time of the heart muscles and the heart's growth.

□ Doctors in California have developed a new method of monitoring heart activity by combining an old idea from Leonardo da Vinci with modern computer technology. The technique has proven invaluable for post-operative checks of heart surgery patients.

The proceedure was "rediscovered" when bio-engineer Neil Ingles, Ph.D., was reading about Leonardo da Vinci and his many inventions. He noted that the great man had attempted to study the motion of the hearts of pigs by placing small pins in the muscle and observing their motion. Over 460 years later at the Palo Alto Medical Research Foundation this old idea has been put into practice.

X-Rays on Video-Disks. The modern technique involves the implanting of small coils at strategic points in the patient's heart during an operation. The motion of these coils, as the heart moves, is then monitored by an X-Ray video-disk machine which records a sequence of pictures in which the coils show up easily.

The X-Ray sequences are transmitted to CRT where the coils are marked with a light pen to develop the "X" and "Y" coordinates in a Hewlett Packard 2115. This machine communicates via a modem over telephone lines with a Control Data 6400. The computer processes the sequence of coil movements into readouts of the heart's motion. Ingles and his research partner George Daughters can determine, within an hour, just how well different sections of the heart are working, how much blood the heart contains, how much blood it is pumping, the contraction time of the muscles, if part of the heart isn't getting enough blood and how much each section is contracting.

By comparing X-Ray sequences taken over a period of days, the doctors can tell if a heart is getting larger or smaller, or, in transplant cases when the new heart appears to be being rejected, how fast is the deterioration or improvement taking place.

It only takes two minutes to implant the seven coils and they can be left in the patient for a lifetime without danger. By implanting them in the wall of the heart, not on it, they truly delineate the movement of the muscles.

Thus, another of Leonardo da Vinci's supposedly way-out ideas has come to fruition—with the help of modern medical science and, of course, the computer. ■

10 SECONDS.... AND COUNTING!

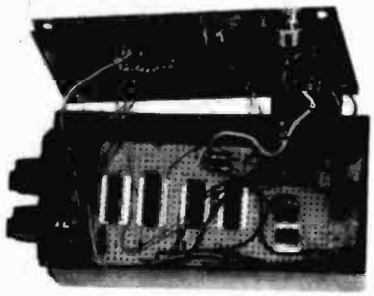
Send your model rocket to the stars

FOR YEARS, THOUSANDS of people have been building and launching small scale model rockets that propel themselves with miniature solid-core propellent engines. But no matter how much time, money, and effort a person put into his (or her) rocket, the launch has always been pretty much the same; a switch, a battery, and perhaps a light bulb to check continuity.

A Breakthrough! Thanks to lower Integrated Circuit (IC) prices, a hand-held, computer-like launch controller is new practical even for a "model rocketeer" on a budget. The Rocket Computer consists of a display that—when ordered—counts down from 9 to 0 and then, thanks to a SCR (Silicon Controlled Rectifier), fires current through an igniter to start the propellent engine. Two LED's tell you if power is on and also give continuity verification. It's simple to operate with only three switches. The whole project can be assembled, even at retail prices, for only $5 or $20, less case.

Construction. The circuit is quite stable, so any method of construction can be used. IC sockets should be used to protect the "chips" from soldering heat, and facilitate easy replacement—if necessary.

I built my Rocket Computer on perfboard, with IC sockets, and a wire-wrapping tool was used to wire it up. But, soldering the project with point-to-point wiring is just as easy and effective. Take care not to make any solder "bridges" between socket pins, as they are usually spaced pretty close together. The LED display pins must correspond with IC 3's output pins. Most manufacturers of these displays give sufficient data to make this an easy task; simply match the A-G lines together. A 15-ohm resistor on the common anode lead should be rated at least at a half watt. (The common anode lead is easily identified on the LED display data also.) In the parts list, I recommend a Radio Shack RS-1020 SCR, but any SCR that can handle 2 amps or more of current with a low gate voltage can be used. Use spring clip terminals like I did to make igniter hook-up quick and easy. I mounted my terminals for the igniter on top of the case. Then, I mounted the power input jacks on the side. Once again, use spring clip or



You can use perfboard construction to build your controller, as shown here. Parts layout is not critical, nor are any dimensions.

screw type connectors here. It is an excellent idea to use jacks for the power input and igniter output that do *not* look similiar. This will avoid mistakes and possible damage. Finally, be sure to note polarity when wiring the input power jacks.

Testing and Blastoff! Give the circuit a complete bench test before taking it out to your "launch pad". Use only a 6 volt lantern-type battery on this circuit. Only a small or large lantern battery can insure that there will

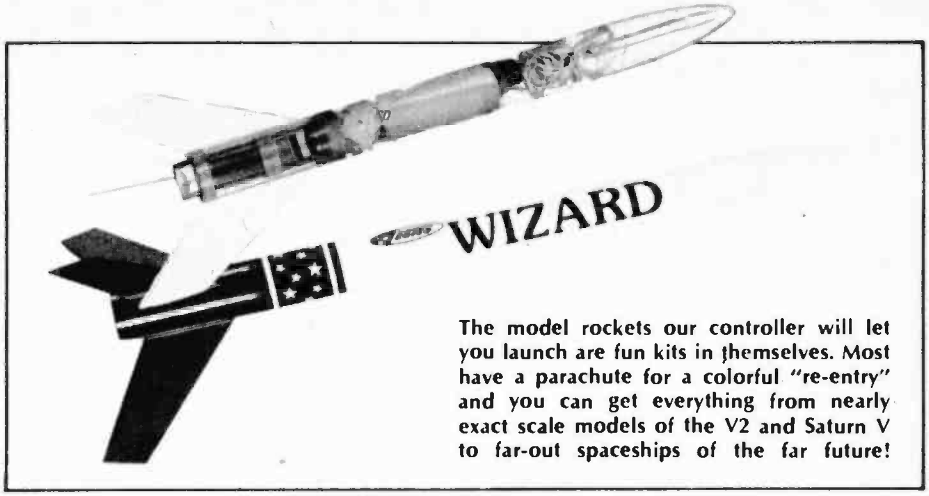
10 SECONDS....

be plenty of current available to drive both the circuitry and igniter. Test the circuit first *without* using an igniter hooked up. Attach your battery to the proper jacks. Now, turn switch S1 (*off/on*) to the *on* position. LED 1 should light. So should the display light up a 9. If the display did not light or a 9 is not observed, correct the error before going on. Everything OK? If so, continue. Turn S2 (*safety/arm*) up to *arm*. LED 2 will not light yet because no igniter is in. Now, take a low current igniter (Estes #2301) and hook it up to the igniter output jacks. LED 2 should now glow, proving continuiny. (Polarity is not observed on an igniter.)

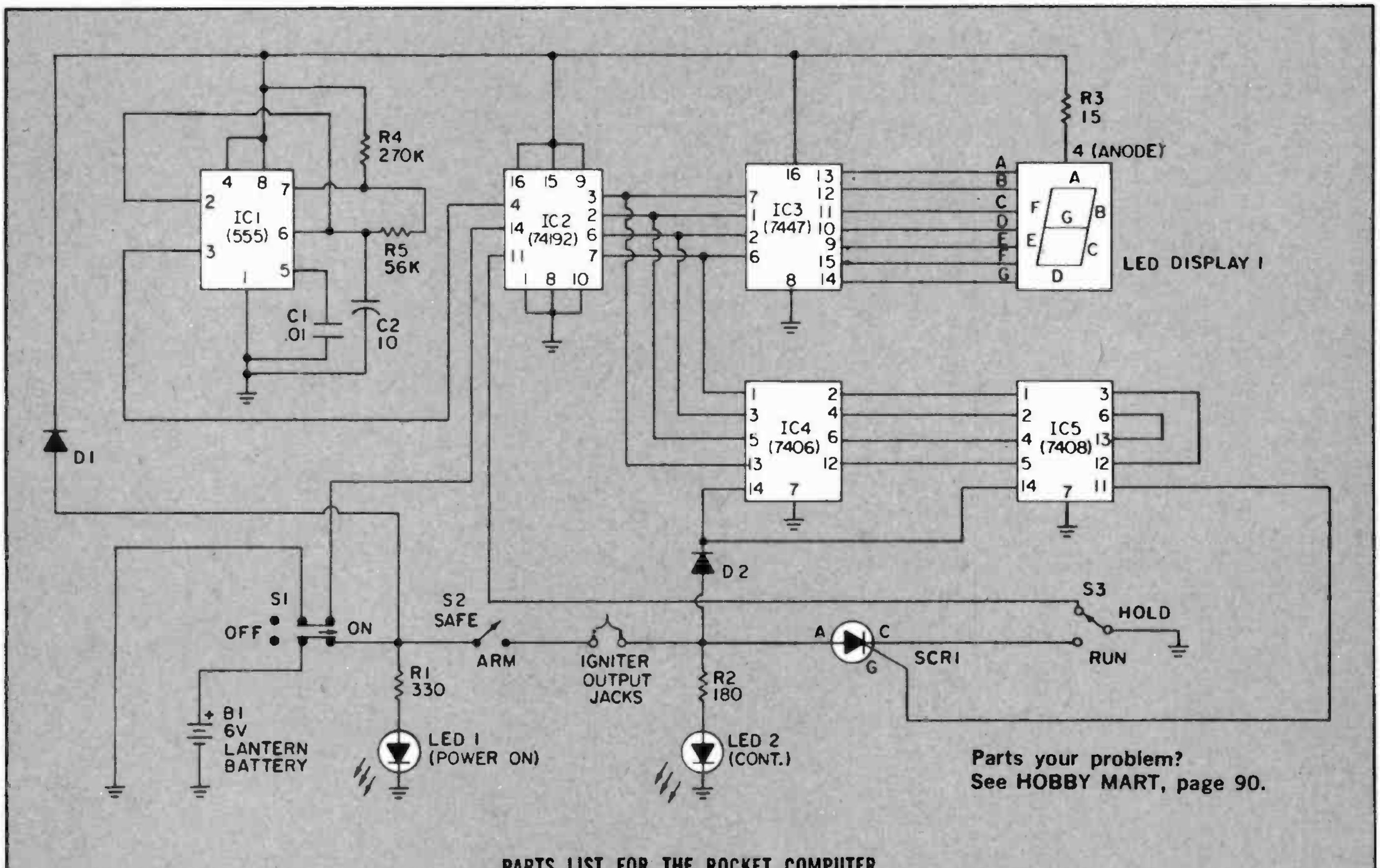
Now see if the unit can fire an igniter (not in an engine yet!!!) on your bench. Move the igniter away from anything inflammable as the igniter usually burns for a second at about the intensity of a match. Throw switch S3 (*hold/run*) to *run*. The display should count slowly down, and—get ready—at zero, the igniter should fire.

At all times, when using this unit, start your launching procedure with all switches in their "off", "safety", "HOLD" positions respectively. After

(Continued on page 116)

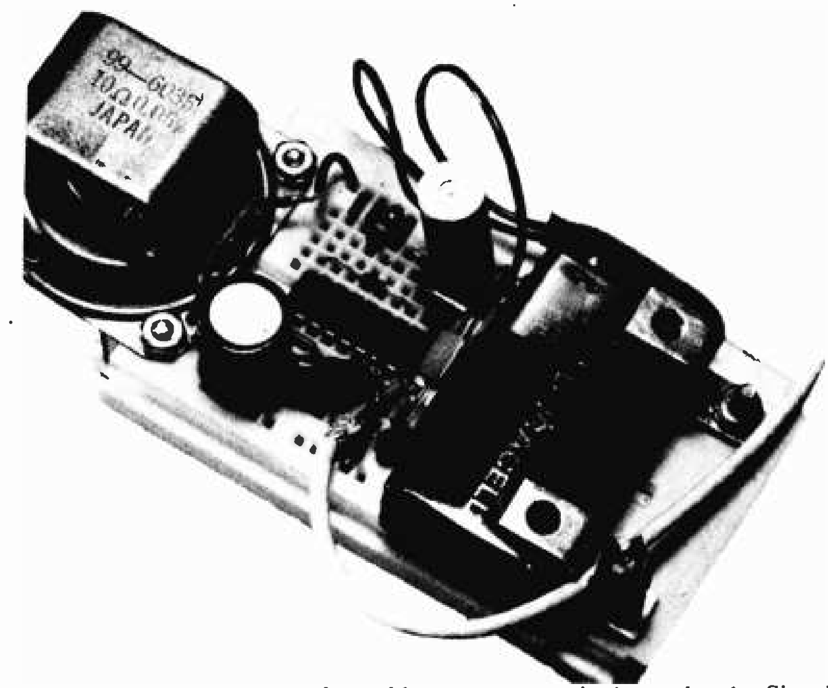


The model rockets our controller will let you launch are fun kits in themselves. Most have a parachute for a colorful "re-entry" and you can get everything from nearly exact scale models of the V2 and Saturn V to far-out spaceships of the far future!



PARTS LIST FOR THE ROCKET COMPUTER

B—6 volt lantern battery, Mallory F918 or equivalent.
C1- 01-uF Disc capacitor
C2—10-uF capacitor Electrolytic (10 VDC or better)
D1, D2—Diode, IN4148
LED1—LED (red)
LED2—LED (green)
IC1—555 Timer, 8 pin chip
IC2—74192 counter, 16 pin chip
IC3—7447 BCD to decimal decoder, 16 pin chip
IC4—7406 Hex inverter, 14 pin chip
IC5—7408 and Gate, 14 pin chip
LED Display 1—7 segment common anode display
R1—330-ohm resistor, ½ watt
R2—180-ohm resistor, ½ watt
R3—15-ohm resistor, ½ watt
R4—270,000-ohm resistor, ½ watt
R5—56,000-ohm resistor, ½ watt
S1—DPDT switch
S2—SPST switch
S3—SPDT switch
SCR1—Silicon controlled rectifier, 50 volt, 2A or better. (Radio Shack 276-1020 or similar)
Misc.—Input and output jacks, I.C. sockets, suitable enclosure, wire, solder, igniter (Estes #2301), etc.



SIGNAL CHASER

Save on repair dollars with this pennywise project.

by Martin Weinstein
WB8LBV

ONE OF THE SECRETS of trouble-shooting is to start at those circuit areas where there is no trouble, then to back your way through the circuit until you've reached the point where it isn't working. The same trick can work frontwards, letting you trace a signal through a circuit until you reach the point where it disappears.

Here's a handy aid for troubleshooting in the frontwards fashion, a signal tracer with a great deal of input sensitivity called Signal Chaser.

Built-in Demodulator. An ordinary amplifier could help you find signals in the AF (audio frequency) range, but the Signal Chaser can do more. D1, a 1N914 diode, acts as a demodulator, much like the diode in a simple crystal-set-style radio, to demodulate AM (amplitude modulated), RF and IF signals directly to audio (or whatever the carrier is modulated with). On FM and PM (frequency modulated and phase modulated) signals, the diode acts as a slope detector, giving a suitable, if low-fidelity, audio output.

High Impedance Input. The one feature of this circuit that really makes it shine when compared to most signal tracers is its high impedance input. The input impedance of the Signal Chaser is close to 10-Megohms. This is due to the use of a JFET (Junction Field Effect Transistor) for Q1. Q1, a Siliconix 2N5458 or similar P-channel JFET, is configured as a high-to-low impedance converter with an input impedance determined mostly by the value of R2, 10-Megohms. Capacitor C1 blocks DC but passes AF, RF and IF signals. Resistor R1 limits the input current to Q1.

A high input impedance means that for a given signal voltage, very little current is drawn by the Signal Chaser. This means that under almost all conditions, the Signal Chaser cannot load down the circuit you are troubleshooting.

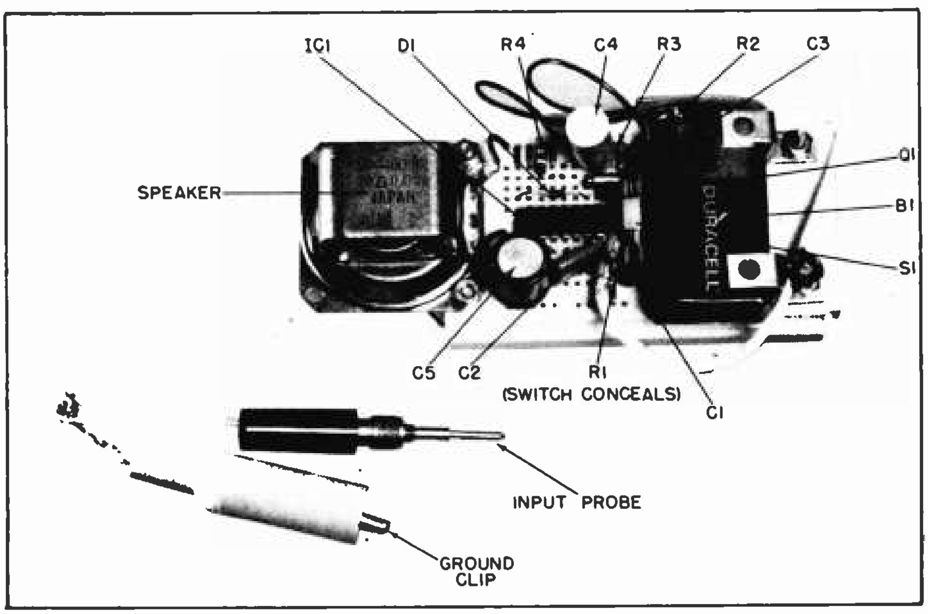
Speaker Size Output. The output of Q1 alone would be enough to drive a high impedance earphone, but keeping one in your ear while busy probing a suspect circuit can be, to say the least, inconvenient.

Instead, the output of Q1 (after demodulation) is coupled to the input of IC1, an LM38ON audio amplifier. IC1 provides enough drive to power even low-impedance speakers, around 8-ohms, to a good, healthy volume.

Capacitor C5 provides DC decoupling between the speaker and the output of IC1.

Breadboard-Easy Consruction. The entire circuit can be built up on a small solderless breadboard like the one shown (a Continental Specialties Corporation "Experimentor Socket," model EXP350, about $5.50) almost in less time than it takes to tell about it.

I've used three tricks here I would especially like to share. For one, I used a pair of zig-zag mounting brack-

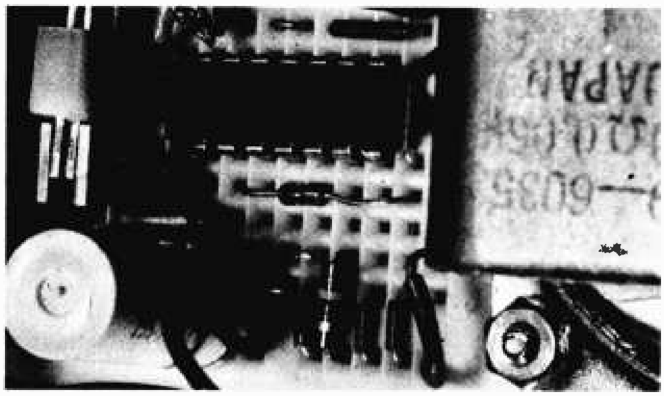


Our Signal Chaser was built using a solderless breadboard and, as you can see, it made for a neat component arrangement. If you follow this photo, be certain you don't forget about R1, which connects to the Gate of Q1 and to C1—it's really there, it's just hard to make out in the picture! Signal Chaser should go together quite quickly, so if you start it after lunch you should be chasing your first signals before the dinner bell.

CHASER

ets (from the local Radio Shack) as battery hold-down clips. The mounting holes in the CSC EXP350 helped make this especially easy. At the far side of the breadboard, the mounting holes there happened to match exactly the holes on a small speaker I had on hand, and I was quick to take advantage of it. My third trick was to solder stiff wire (resistor leads I cut off some of the resistors in the circuit) to the breadboard end of the shielded probe cable. You may also want to use "headers," available from several sources and many parts stores for under a dollar a strip.

Signal Chaser has a high impedance input that is close to 10-Megohms. It will draw very little current and so will not usually load down the circuit under test.



The rest of the assembly is fairly straightforward. Follow the lead of my layout, as shown in the photograph, when you lay out your own Signal Chaser—whether on solderless breadboard, a PC board or whatever method you use.

Understanding Solderless Breadboards. In case you haven't tried solderless breadboards before, you may not know how easy they are to work with. The holes in the face of the breadboard are arranged on .1" centers (1/10th of an inch apart), which happens to be the lead spacing on standard DIP (dual inline package) integrated circuits and most other modern components.

The center channel (.3" wide) is just right for IC's to straddle. On each side of the center channel are groups of five holes (columns, if you view the breadboard as widest on the horizontal, with the center channel running left to right). Behind each group of five holes is a spring clip with slits between the hole positions to allow a lead inserted into any one hole to be grasped firmly and independently, and interconnected with anything grasped at any other position in the group.

Each five-position terminal can be interconnected with any other by simply using hookup-wire jumpers.

The separate rows (at the top and bottom) are connected across their entire lengths and can be used for power or signal busses. I use them to carry the battery plus and minus lines.

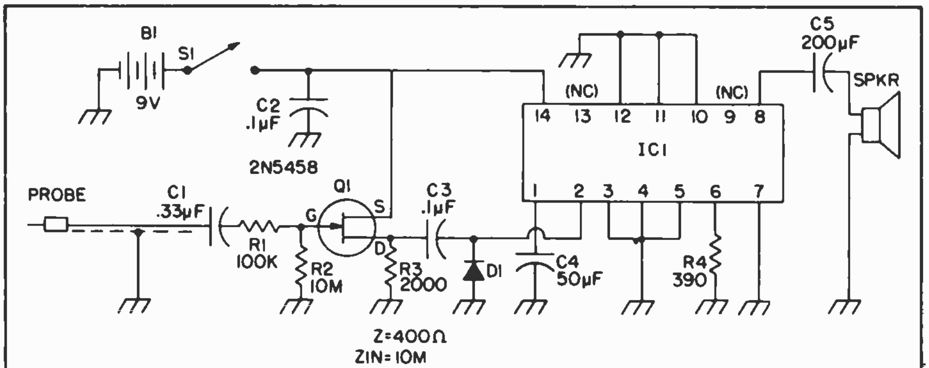
Using the Signal Chaser. For most run-of-the-mill signal tracing, clip the probe cable shield to a circuit ground near the area you're testing and touch the probe to each side of the signal path near each active or passive device in the signal path. Start at the front end and work your way to the output, if you like—but skipping a few stages on the chance they'll work can also help you localize a problem.

The high impedance of the Signal Chaser input means high sensitivity, which lends it to some useful applications.

You can attach a coil of wire or a magnetic tape head to the input to inductively probe circuits and devices. You can "listen" to the magnetic stripe on the back of your credit cards, amplify a telephone conversation or pick off the signal on your transmitter's modulation transformer.

Or attach a photocell to the input and listen to the sounds of light bulbs, LED readouts, the sun, street lights and then some.

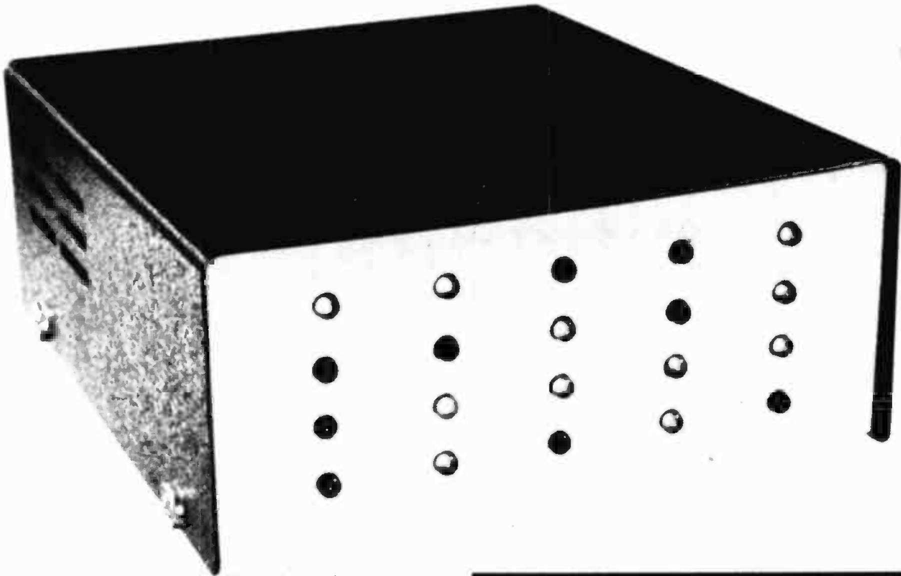
Signal Chaser—not only a good introduction to solderless breadboarding, but once it's built you may find it to be one of the handiest gadgets in your electronic bag of tricks-of-the-trade. Have fun and chase those signals—and those problems—down! ■



PARTS LIST FOR SIGNAL CHASER

B1—9-VDC battery
C1—.33-uF capacitor
C2—.1-uF capacitor
C3—1-uF capacitor
C4—50-uF capacitor
C5—200-uF capacitor
D1—1N914 diode
IC1—LM380N audio amplifier
Q1—2N5458 JFET (Juntion Field Effect Transistor)
R1—100,000-ohm resistor, ¼-watt
R2—10-Megohm resistor, ¼-watt
R3—2000-ohm resistor, ¼-watt
R4—390-ohm resistor, ¼-watt
S1—SPST switch
SPKR—8-10-ohm speaker
MISC—Breadboard (Continental Specialties model EXP350 or similar) or other method such as PC board; probe; insulated clip; battery holder/clip; wire; etc.

Solderless breadboard materials is arranged with the holes about 1/10 inch apart. As you can see, this just fits the spacing of the IC's leads and of most modern components.



Friendly Flasher

Solid state circuits make your livingroom look like a computer center.

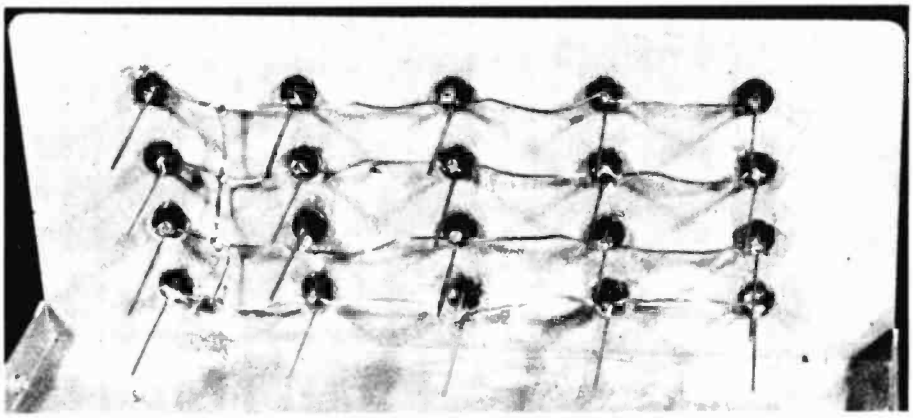
FOR MANY YEARS I've heard rumors that the banks of blinking lights seen on the front panels of many computers are just to impress the computer's owner. It must be admitted that the sight of several square feet of flashing lights acting under the control of unseen forces can exert a powerful pull on almost anyone. Certainly a display of this sort is much more fascinating than a painted metal panel even though they often convey the same amount of useful information.

The Old way. While it's fine for a businessman to have a large computer merrily blinking away, the average electronics enthusiast must find other, less expensive ways to have a decent set of flashing lights. One simple approach that has been used for many years is based on small neon-filled tubes.

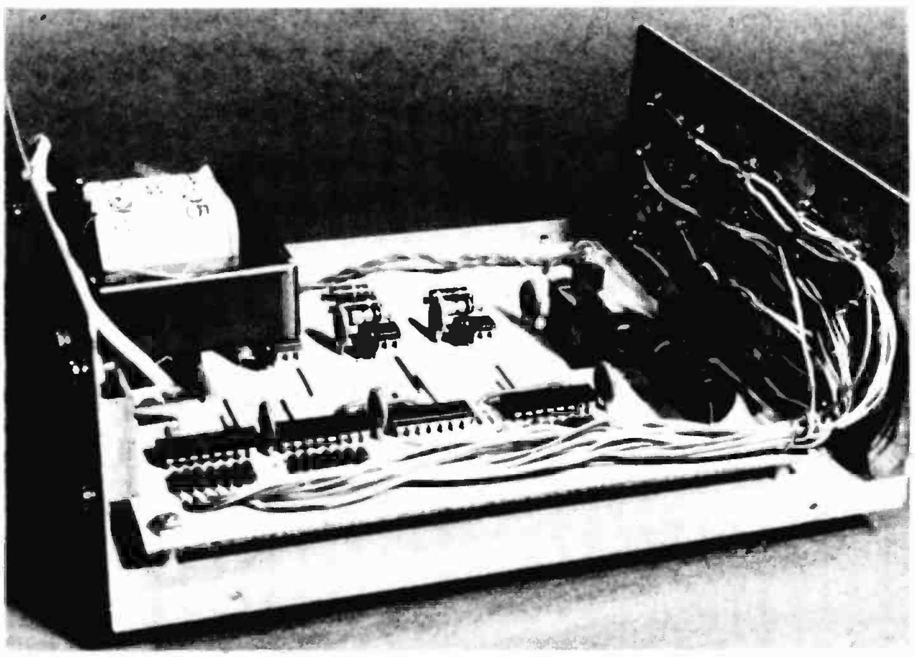
Experimenters take several of these circuits, hook them up in parallel and feed them off a ninety volt battery. Variations in values of the resistors and capacitors keep all the lights from coming on and going off at the same time and the total current drain is so low that battery life is measured in months of continuous use.

Over the years, I've built several versions of the neon tube Idiot Box. Recently, I decided to see if I couldn't design and build a modern, solid-state box of blinking lights. I had so much fun in the process that the things I learned from necessity were a real pleasure. The design I evolved is fairly simple but offers several instructive pointers, especially in the area of combining standard circuits in novel ways. And to keep things as simple as possible, I only used parts available from local electronics supply stores, which means anyone should be able to obtain them.

How it works. In order to get an over-



This view of the back of the flasher front panel shows how the LEDs are connected to the five-volt DC power source. On a more complex panel design it would be a good idea to use insulated wire. The design of your flasher is up to you.



An interior view of the completed flasher gives a good perspective of how the project is laid-out and how the wiring is routed to keep the chassis neat and professional looking. This project is a good one for those interested in learning more about digital integrated circuits, how they are interconnected and designed.

Flasher

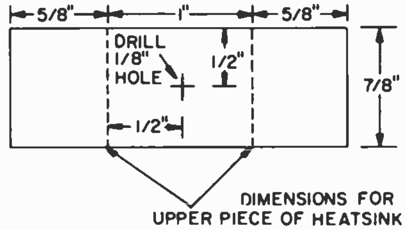
all idea of how the circuit works, we can begin by studying the inputs and outputs of a 7447 integrated circuit. This particular circuit is designed to decode Binary Coded Decimal inputs in order to turn on the correct outputs which are used to drive a seven segment readout. For now, it is enough to know that by applying one of the sixteen possible combinations of inputs to the chip, we get a unique combination of output lines turned on. We can replace the seven segment readout with seven individual light emitting diodes (LEDs). If we can devise a scheme to turn the inputs of a 7447 on and off at different times, we have a solid basis for a modern box of flashing lights.

This turns out to be relatively easy to accomplish. We can use a standard multivibrator circuit built around the 555 timer chip to provide repeating cycles of on and off signals. If we build four of these multivibrators and cause each one to have a different period of oscillation, we can then connect the output of each multivibrator to one of the input pins of the 7447 decoder/driver.

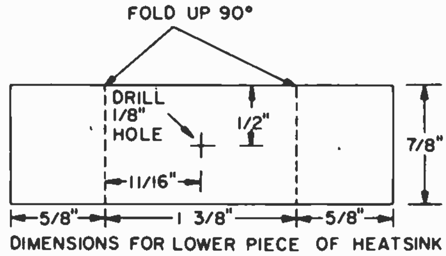
The output of each 555 multivibrator is connected to only one input of the 7447. Each time any of them changes from low to high or from high to low, the overall combination of inputs to the 7447 is changed and this in turn causes a new pattern of output lamps to turn on.

So far we have used a total of five integrated circuits to control seven lamps. This poor ratio of chips to lights can be greatly improved if we care to add more lights. It only takes one additional 7447 to handle each further group of seven lamps. We can share the outputs of the existing 555 multivibrators among the inputs of these additional 7447 decoder/drivers. By thoroughly scrambling the order in which we connect the multivibrators to the inputs of the new 7447s, we can keep the output pattern from each 7447 from being the same.

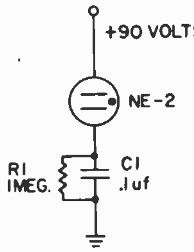
The next step in this progression is to simultaneously apply the output of one multivibrator to three different input lines of three separate 7447s. In this case, we are applying the same output to the A input of the first chip, the C input of the second and the D input of the third. Because of the way 7447s decode the various input lines, the same signal being applied to different inputs on each 7447 has a completely different effect on the output pattern from each of these chips. By similarly scrambling



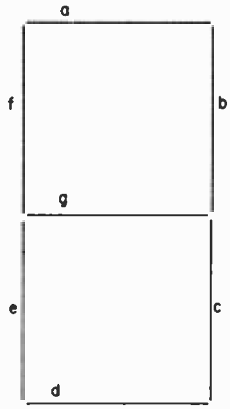
DIMENSIONS FOR UPPER PIECE OF HEATSINK



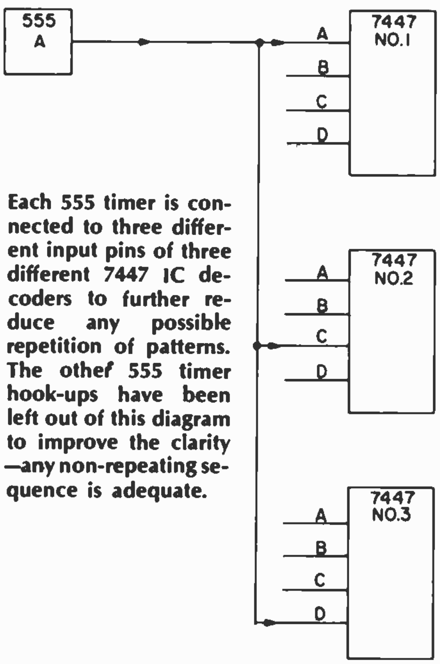
DIMENSIONS FOR LOWER PIECE OF HEATSINK



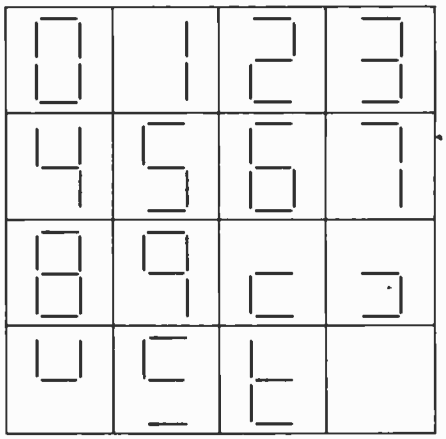
The old-time flasher was a neon tube hooked to a 90-volt DC potential. This would cause the gas to ionize and glow until the R/C circuit charged up and lowered the potential.

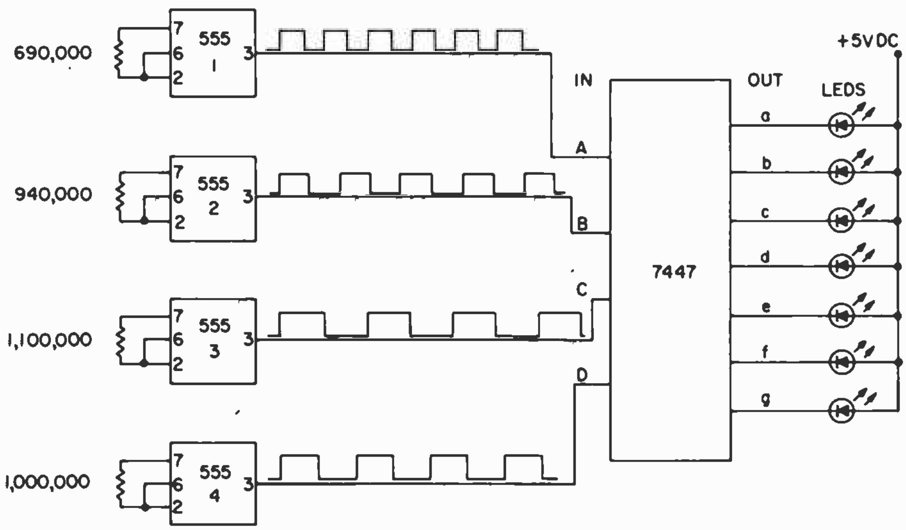


When the 7447 allows pins a, b and c to conduct the corresponding lines on the seven-segment readout are lit and the number "7" appears. Below are the 16 possible combitions of lines.



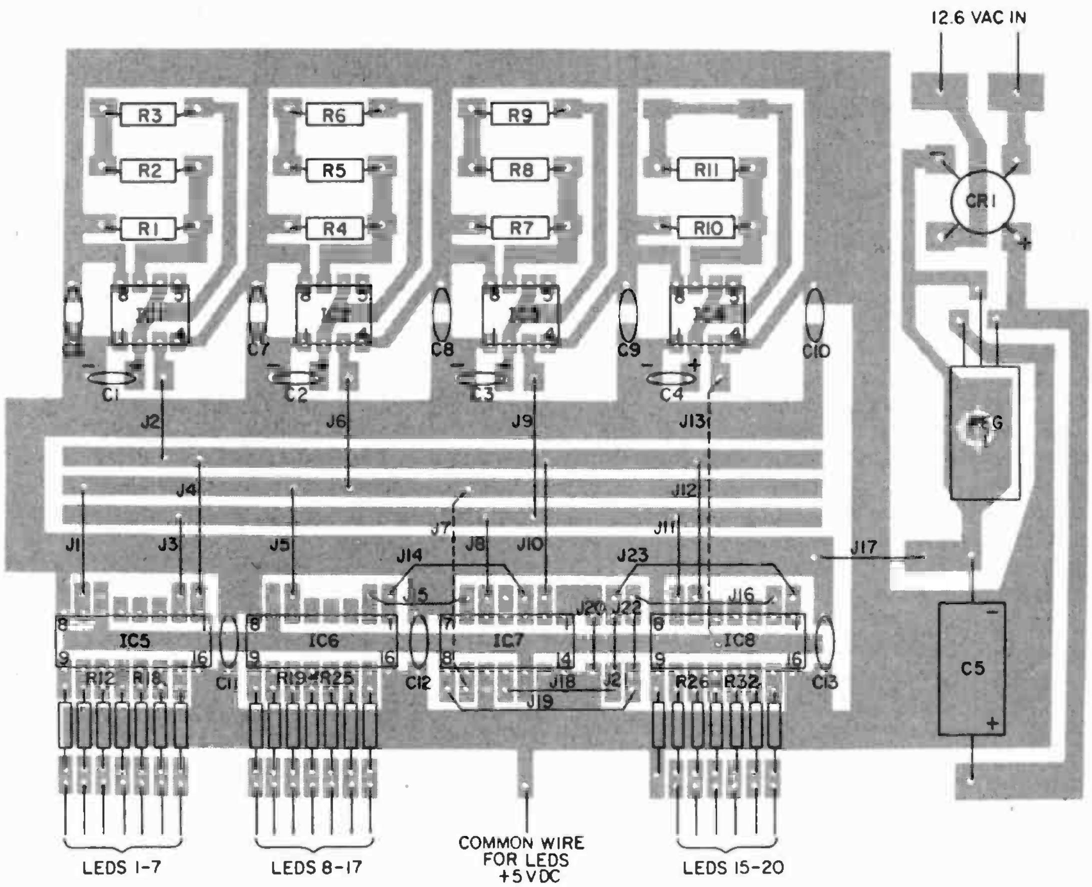
Each 555 timer is connected to three different input pins of three different 7447 IC decoders to further reduce any possible repetition of patterns. The other 555 timer hook-ups have been left out of this diagram to improve the clarity —any non-repeating sequence is adequate.

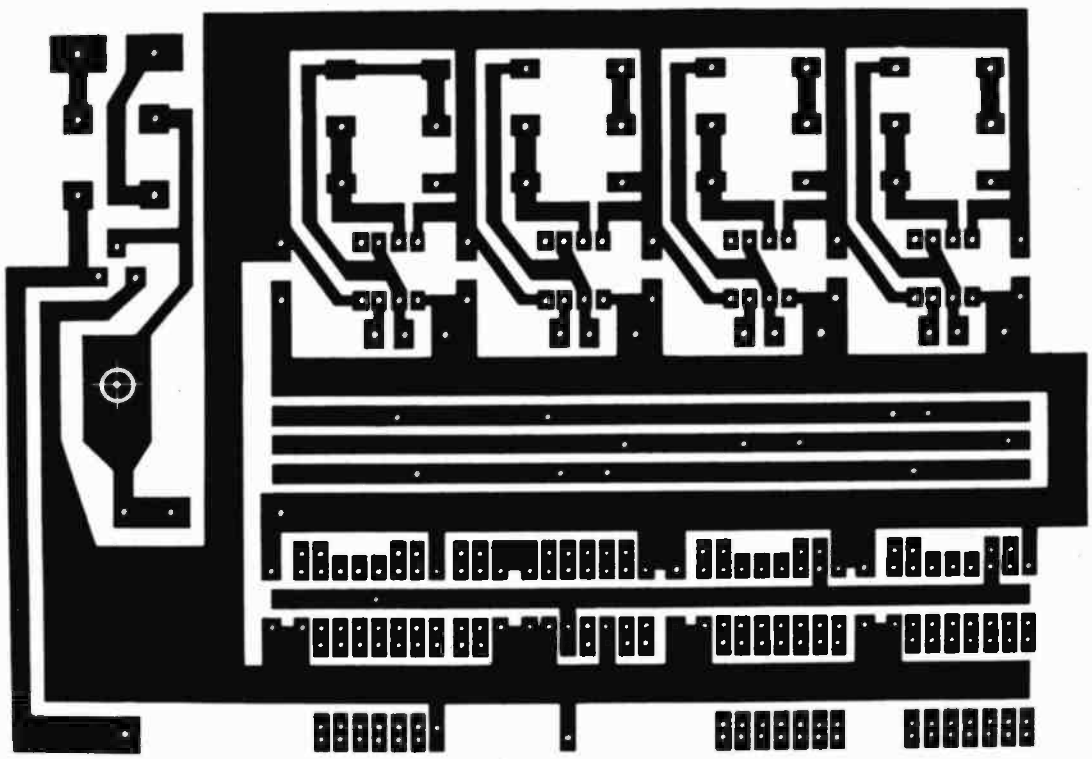




By varying the resistance between pin 7 and pins 2 and 6 of the 555 timers the timing of each IC is slightly different. Initially all four will give a pulse at the same time but after that they will change state, with respect to each other, at random intervals. Each change-of-state at the inputs of the 7447 causes a new binary number to be sent into the decoder and therefore a different combination of outputs to the LEDs.

This is the parts location diagram for the friendly flasher. Note the author's liberal use of despiking capacitors (C6 through C13). If a 21st LED is desired, cut the foil pattern to separate the outside end of resistor R26 from the body of the circuit board. Then run a wire from the resistor connection to the LED then back the 5VDC common. Be careful to use insulated jumpers on the bottom side of the circuit board and where one jumper crosses another. Elsewhere in this article is a chart which explains what type of jumpers should go where. Use IC sockets for all the IC chips. This will simplify assembly, testing and, if needed, repair.





Here is a full-sized template of the circuit board pattern. A photo etching procedure would be ideal for such a complex circuit, or else one of the new kits that enable you to lift a pattern straight off a magazine page. What ever technique you use, be very careful that you don't get any bridges between sections of the board. Don't be put-off by the apparent complexity of this project—once you figure it out it is really quite simple and straightforward, especially after you have a completed printed circuit board. Making the printed circuit board is, after all, part of the fun of building any project.

Flasher

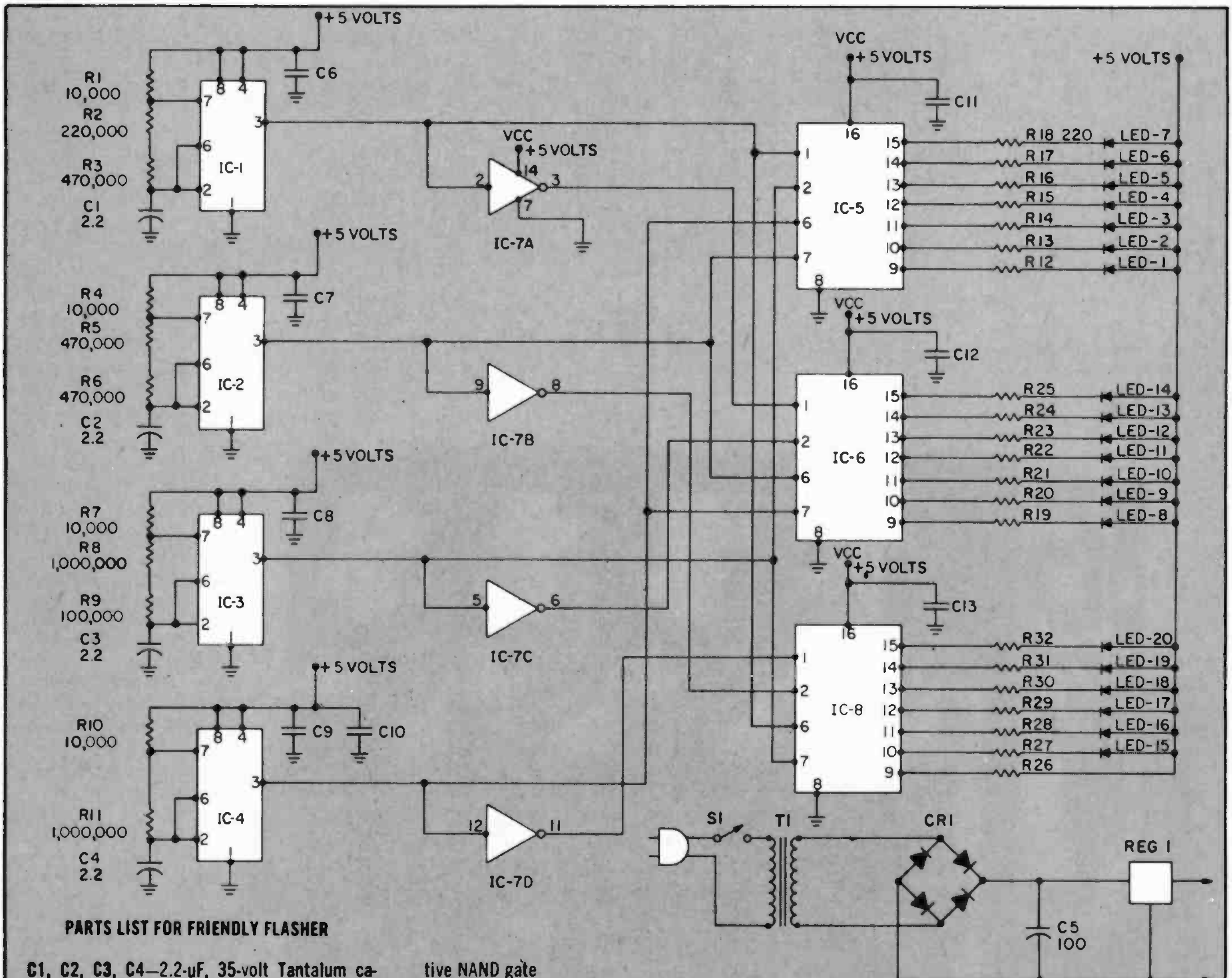
the outputs of the remaining multivibrators among the other inputs of the 7447s, we can obtain a well mixed final set of patterns.

The six-percent solution. As I mentioned earlier, the 7447 integrated circuit is normally used to decode Binary Coded Decimal inputs and then turn on the correct segments of a seven segment display. The individual segments of such a display combine to create sixteen possible output combinations. One of the combinations of inputs results in all seven outputs being turned off.

Any time all four of the 555 multivibrators happen to have their outputs high, all inputs of the 7447s will be high and this will cause all output lamps to be turned off. This occurs each time power is first applied to the circuit (the capacitors are charging) and roughly six percent of the time during normal operation.

I was so horrified when I first saw all the lamps turn off in my breadboard version of this circuit that I added an extra integrated circuit to correct this situation. In essence, I allowed the output of each 555 multivibrator to go directly to an input on two of the 7447s. Before I allowed this output to reach an input of the third 7447, I inverted it. This meant that anytime all the outputs of the 555s went high, some of the inputs of the 7447s would have lows (inverted highs). This would prevent all four inputs of any given 7447 from simultaneously going high.

While I could have used a 7404 Hex Inverter (six inverters on one chip), I chose the common 7400. By tying one of the two inputs of each gate to +5 volts, each gate acts as an inverter. The reason I selected this method of invert-



PARTS LIST FOR FRIENDLY FLASHER

C1, C2, C3, C4—2.2-uF, 35-volt Tantalum capacitor
C5—100-uF, 50-volt electrolytic capacitor
C6, C7, C8, C9, C10, C11, C12, C13—0.1-uF, 10-volt disc capacitor
CR-1—Full-wave bridge rectifier, 1.5-amp, 50-volts
IC-1, IC-2, IC-3, IC-4—555 Timer
IC-5, IC-6, IC-8—7447 BCD to seven segment decoder/driver
IC-7—7400 (A package) quadruple 2-input positive NAND gate
LED-1 through LED-20—select on basis of color, size and price
REG-1—Type 7800, 5-volt, 1-ampere regulator
R1, R4, R7, R10—10,000-ohm, ½-watt resistor
R2—220,000-ohm, ½-watt resistor
R3, R5, R6—470,000-ohm, ½-watt resistor
R8, R11—1-megohm, ½-watt-resistor
R9—100,000-ohm, ½-watt resistor
R12 through R32—220-ohm, ½-watt-resistor
S-1—SPST slide switch
T1—Small 12.6-VAC filament transformer
Misc—Cabinet 6¼ in. by 2¾ in. by 7¼ in. assorted machine nuts and screws; wire caps; power cord; scrap metal for heatsink; grommet; circuit board standoffs and paint.

ing the multivibrator outputs lies in the fact that there are exactly four gates available on a 7400 chip. This allowed me to use one gate for each multivibrator output and not have any left over.

Power supply. The power supply shown is quite straightforward. An ordinary filament transformer changes the line voltage to 12.6VAC which is then rectified and filtered to 12.6VDC. I then used an inexpensive 5-volt regulator to produce a stable smooth 5VDC output. Avoid 6.3 VAC filament transformers since the regulator becomes unstable with an input of less than seven volts.

One of the nice features of the 5 volt regulator is the fact that it will automatically shut itself off if its temperature approaches dangerous levels. The higher the voltage we apply to the regulater, the more power it must dissipate in order to maintain a constant output. This wasted power can heat up the regulator and cause it to shut off.

One final comment and we will have covered the entire circuit. Based on personal experience, I added a small despiking capacitor between the +5 volt inputs and ground on each integrated circuit. While those who like to design for a minimum number of components will feel that this is a wasteful practice, I believe the cost of these capacitors is so low in relation to the amount of trouble they can prevent that I always include a generous number of them in any digital project I'm building.

FRIENDLY FLASHER JUMPERS

Jumper number	Type of wire	Location
1	Bare	Top
2	Bare	Top
3	Bare	Top
4	Bare	Top
5	Bare	Top
6	Bare	Top
7	Insulated	Bottom
8	Bare	Top
9	Bare	Top
10	Bare	Top
11	Bare	Top
12	Bare	Top
13	Insulated	Bottom
14	Insulated	Top
15	Insulated	Top
16	Insulated	Top
17	Bare	Top
18	Bare	Top
19	Insulated	Top
20	Bare	Top
21	Bare	Top
22	Bare	Top
23	Insulated	Top

Construction. Due to the relatively slow speed at which this circuit operates, almost any of the usual construction techniques can be used. The best place to begin construction is with the circuit board. The pattern shown can be used or you can devise your own. Either way, you should start by etching and drilling your board. Then, if you are using my pattern, solder the various jumpers in place. The component layout shows their placement. Once all jumpers are in place, carefully inspect the board for solder bridges. Install the bridge rectifier and 100 mfd filter capacitor in place. Take care to observe the polarity markings on the capacitor and to orient the rectifier correctly. The package the rectifier comes in shows how to identify the leads.

Next, install the 5 volt regulator and its heatsink. The two pieces of the heatsink are placed next to the board and the regulator on top of them. A small screw is then run through the regulator, heatsink and circuit board. When everything is properly aligned (regulator leads in their holes, heatsink not shorting out any leads), fasten everything in place with an appropriate nut. The heatsink can be fashioned from almost any kind of scrap metal.

Now is a good time to install all the resistors and capacitors. This will take care of most of the parts to be installed and at this stage, problems are easy to diagnose. The component layout shows where these parts go. I suggest that you insert and solder one part at a time rather than trying to do them in batches. Be especially careful with the current-limiting resistors along the bottom edge of the board. Watch for solder bridges and solder flowing into the other hole on the pads.

Testing the ICs. Now, taking care to align the pins correctly, insert IC-1 into its holes and solder in place. You may plug the line cord in and use your voltmeter to take a reading on pin 3, the output pin. The voltage here should swing between roughly zero and five volts, remaining at each point about one-half second. If this is the case, the entire circuit of the first multivibrator is working. If it isn't, make sure the IC is really a 555, check for solder bridges, measure the +5 voltage on pins 8 and 4 and recheck the orientation of the pins to make sure the IC isn't installed backwards. As a last resort, remove the chip and substitute another.

Once the first multivibrator is functioning correctly, remove the line plug from the wall and solder in the remaining 555s (IC-2, IC-3 and IC-4) one-at-a-time. After each is soldered in, apply power and verify its operation the same way you did for the first 555. When all the 555s are in place and working, you will have a functioning power supply and four good multivibrators.

You should now solder IC-5 in place. In order to test its operation, an LED can be used to probe each of the outputs. To do this, take an LED and gently spread its leads apart. Then use an ohmmeter to take forward and reverse readings across these leads in order to make sure that you have a good LED. (One reading should be much higher than the other.)

Next, cut about a foot of stranded hookup wire and solder one end to the pad used as a common return for the LEDs. This pad is located along the bottom edge about midway between the first and second groups of current limiting resistors. Then attach either lead of the LED to the other end of this wire. At this point, apply power to the board and briefly touch the free end of the LED to ground.

Should the LED light up when you touch it to ground, kill power to the board and lightly solder the lead attached to the hookup wire. If it failed to light up, reverse the leads of the LED at the stranded wire and again touch the free lead of the LED to ground. This time it should light and after killing power, you should solder the lead attached to the hookup wire.

What you have done is fashion a simple test probe that will light up whenever the free lead of the LED is applied to a point at ground potential. (The power supply must be on.) Since this simple probe has no means of limiting the current flowing through the LED, you can destroy the LED if you touch ground more than a brief instant. However, you can safely probe the output sides of the current limiting resistors already on the board and that is how you will test the outputs of the 7447 lamp drivers.

To proceed, apply power to the board and touch the free end of the LED to each output lead of the current limiting resistors located just below the first 7447 (IC-5). The output lead of these resistors is the one nearest to the bottom edge of the board. As you probe each lead, the LED should flash on and off in an irregular fashion. If everything appears fine at all these outputs, remove power from the circuit and solder in the second 7447 (IC-6). If something isn't working right, follow the general hints I suggested for correcting problems with the multivibrators.

Use the above check-out procedures for the second 7447 (IC-6) and then the third (IC-8). After you have in-

(Continued on page 114)

Friendly Flasher

(Continued from page 113)

stalled all three 7447s and verified correct operation at all twenty outputs, you are ready to install and test the 7400 (IC-7) which will be used as four inverters.

Make sure that power has been removed from the board and solder the 7400 (IC-7) in place. To test the 7400 for correct operation, apply power and use a DC voltmeter on pins 1, 4, 10, 13 and 14. Each of these pins should read a steady five volts. Next, check pins 2, 5, 9 and 12 for inputs swinging back and forth between high and low. Finally, check the output pins 3, 6, 8 and 11 to make sure that they also swing between high and low.

When you have met all these conditions, you may remove power. At this point, you have a working circuit board that you have thoroughly checked out. All that remains is to wire in the LEDs and assemble everything in a suitable enclosure.

The selection of an enclosure for this project is pretty much a matter of individual taste. You may wish to build your own or purchase one ready-made. Rather than give detailed instructions which may not apply to your particular choice, I want to pass along some general hints.

The area requiring the greatest attention to detail is the mounting of the LEDs. Make sure that all the holes are exactly lined-up; the slightest misalignment will make the project look sloppy. Paint the front panel before installing the LEDs and, when you do install them, use one of those super strong, super fast instant glues. Be sure to test the LEDs before installation. Finally, in a random fashion, solder the twenty output wires to the LEDs. Be sure to use a heat-sink each time you solder a wire to an LED.

Before applying power, recheck all LEDs with an ohmmeter and secure any loose wiring. Make a final visual check and then plug in the power cord. Now hit the switch and you should be rewarded with twenty flashing LEDs. Let everything cook for a couple of hours and then put the rest of the cabinet together.

Now you are ready to make your favorite black box look like it is really doing something important. ■

Alternator Tester

(Continued from page 91)

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. ■

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312. *E.D.I. (Electronic Distributors, Inc.)* carries everything from semi-conductors to transformer/relays to video cameras. In prices ranging from 19¢ to $500, products appear from over 125 electronic parts manufacturers. The catalog is updated 3 times a year.

313. Get all the facts on *Progressive Edu-Kits* Home Radio Course. Build 20 radios and electronic circuits; parts, tools, and instructions included.

314. Cover the Ham bands from 80 to 10-meters with one classy rig—*Swan Electronics'* 100-W 100 MX mobile transceiver. Get the details direct from *Swan*.

315. Develop insight into future trends of microcomputers with SYM-1 by *RNB Enterprises*. Large key pad, 1K static RAM, 6502 chip plus I/O for cassette, TV, CRT, and teletype.

316. Get the *Hustler* brochure illustrating their complete line of CB and monitor radio antennas.

318. *GC Electronics* offers an "Electronic Chemical Handbook" for engineers and technicians. It is a "problem solver" with detailed descriptions, uses and applications of 160 chemicals compiled for electronic production and packaging. They are used for all types of electronic equipment.

320. *Edmund Scientific's* new catalog contains over 4500 products that embrace many sciences and fields.

321. *Cornell Electronics'* "Imperial Thrift Tag Sale" Catalog features TV and radio tubes. You can also find almost anything in electronics.

322. *Radio Shack's* 1979 catalog colorfully illustrates their complete range of kit and wired products for electronics enthusiasts—CB, ham, SWL, hi-fi, experimenter kits, batteries, tools, tubes, wire, cable, etc.

323. *Lafayette Radio's* 1979 catalog offers almost everything in hi-fi, CB, ham and many electronic parts. A product index will help you find anything from auto equipment accessories to wire wrapping tools.

327. *Avanti's* new brochure compares the quality difference between an Avanti Racer 27 base loaded mobile antenna and a typical imported base loaded antenna.

328. If you are into audio, ham radio, project building, telephones, CB or any electronics hobby you'll want *McGee's* latest catalog of parts and gadgets. Hard to find parts fill each page, so get a copy of the catalog from *McGee* today!

329. *Semiconductor Supermart* is a new 1979 catalog listing project builders' parts, popular CB gear, and test equipment. It features semiconductors—all from *Circuit Specialists*.

330. There are nearly 400 electronics kits in *Heath's* new catalog. Virtually every do-it-yourself interest is included—TV, radios, stereo and 4-channel, hi-fi, hobby computers, etc.

331. *E. F. Johnson* has a CB 2-way radio catalog to help you select equipment for your vacation, business travel, or normal day-to-day "bucking the mob."

332. If you want courses in assembling your own TV kits, *National Schools* has 10 from which to choose. There is a plan for GIs.

333. Get the new free catalog from *Howard W. Sams*. It describes 100's of books for hobbyists and technicians—books on projects, basic electronics and related subjects.

335. The latest edition of the *TAB BOOKS* catalog describes over 450 books on CB, electronics, broadcasting, do-it-yourself, hobby, radio, TV, hi-fi, and CB and TV servicing.

338. "Break Break," a booklet which came into existence at the request of hundreds of CBers, contains real life stories of incidents taking place on America's highways and byways. Compiled by the *Shakespeare Company*, it is available on a first come, first serve basis.

354. A government FCC License can help you qualify for a career in electronics. Send for information from *Cleveland Institute of Electronics*.

355. New for CBers from *Anixter-Mark* is a colorful 4-page brochure detailing their line of base station and mobile antennas, including 6 models of the famous Mark Heliwhip.

356. Now you can get the "Break-through Book" with its 105 innovations in breadboarding and testing. *Continental Specialties*. The break-through is twofold—products and price!

359. *Electronics Book Club* has literature on how to get up to 3 electronics books (retailing at $58.70) for only 99 cents each . . . plus a sample Club News package.

361. "Solving CB Noise Problems" is published by *Gold Line* and tells you how to reduce the noise and get a clearer signal. In discussion and diagram you can find out about the kinds of noise, their sources, and the remedies.

362. *B&F Enterprises'* Truckload Sale catalog offers 10% off all merchandise: (military or industrial surplus) speaker kits, TV games, computer terminals, tools, TV components, lenses, and more.

364. If you're a component buyer or specifier, you'll want this catalog of surplus bargains: industrial, military, and commercial electronic parts, all from *Allied Action*.

365. *Electronic Supermarket* has a new catalog of almost everything in the field—transformers, semiconductors, tv parts, stereos, speakers, P.C. boards, phones, wire and cable, tools, motors.

366. How about a hybrid 13-watt audio module for $8.88? Or ultrasonic transducer for $1.49? You find these and other exotic parts and products aplenty in *Poly Paks* flyer. Get your copy now!

367. *Optoelectronics'* new catalog features their new Frequency Counter, a 6-digit clock calendar kit, mobile LED clock, biorhythm clock, digit conversion kit, and many others.

371. Your computer system needn't cost a fortune. *Southwest Technical Products* offers their 6800 computer complete at $395 with features that cost you extra with many other systems. Peripheral bargains are included here.

372. See how you can save with *Olson's* "Erector Kit" Computer System; also their factory wired version which includes a 2-volume Bell & Howell instruction course. Send for information.

373. *ETCO* has a Grand Opening Catalog which anyone in the electronics field shouldn't miss. Full of all kinds of products from surplus and warehouse sales, they claim everyone is a bargain.

374. *Radatron's* Catalog 1006 lists many projects from a self-contained portable lab station for an electricity-electronics course to many texts, lab manuals, and applied activities.

375. *Compucolor Corp.* has a personal computer system with an 8-color integral display, a typewriter-like keyboard, and a mass storage device. Programs are ideal for checkbook and income tax figuring.

376. *Sparkomatic* offers all the car sounds for the "travelin' man"—speakers, amplification systems, radios, speaker accessories along with CB antennas, all presented in 4-color pics with descriptions.

377. We can't enumerate all the products in *John Meshna, Jr.'s* catalog of surplus electronic parts: power supplies; computer keyboards; kits for alarms, clocks, speakers; and more.

378. *Delta Electronics* is a complete parts source for electronics experimenters. Discrete parts, modules, boards, subassemblies and complete gadgets. Get *Delta's* 120-page catalog today.

379. There's everything in the area of musical synthesizers for drums, strings, other instruments and full orchestras, as well as audio gear, video display modules, and a computer in *PAIA Electronics'* catalog.

380. If your projects call for transistors and FETS, linear and digital ICs, or special solid-state parts, then look into *AdVa Electronics'* mini-catalog for rock bottom prices.

99 IC PROJECTS
Box 1849, G.P.O.
New York, NY 10001

1979 Edition
Void After May 11, 1979

Please arrange to have the literature whose numbers I have circled below sent to me as soon as possible. I am enclosing 50¢ for each group of 10 to cover handling. (No stamps, please.) Allow 4-6 weeks for delivery.

301	302	303	304	305	306	307	308	309	310	311	312
313	314	315	316	318	320	321	322	323	327	328	329
330	331	332	333	335	338	354	355	356	359	361	362
364	365	366	367	371	372	373	374	375	376	377	378
379	380										

300 ☐ Enter my subscription to ELEMENTARY ELECTRONICS for 9 issues at $5.97. Check enclosed. Add $1.00 for Canada and all other countries. H9A185

NAME (print clearly)

ADDRESS

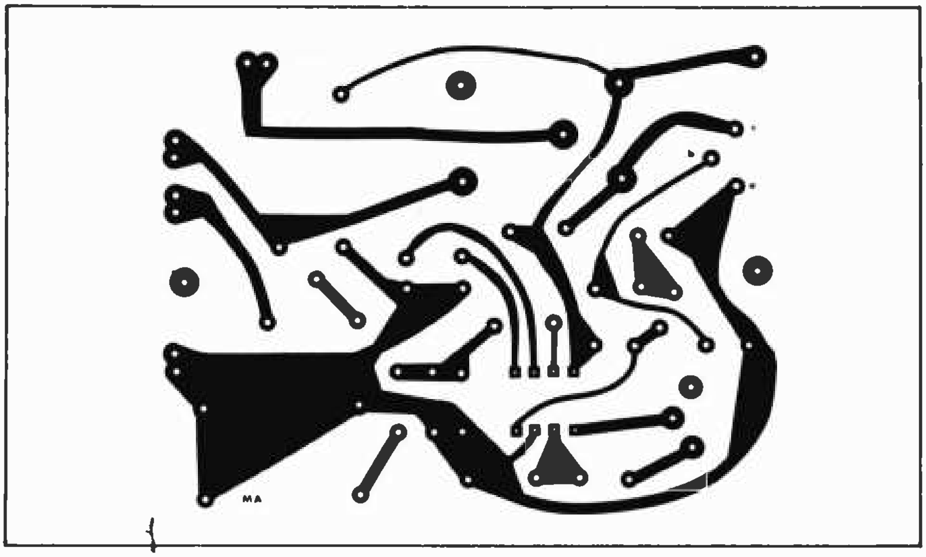
CITY STATE ZIP

Ma Bell's Zipper

(Continued from page 100)

out of the external speaker. Tune in on a local mobile telephone channel. If you have located a mobile channel you will either hear the 2000 Hz tone or someone talking. Once the channel has been located, wait until it is clear and you hear the 2000 Hz tone. Turn Zipper's toggle switch *On*. Adjust trim pot R4 (slowly) until the relay drops out and the tone is no longer coming from the speaker. That's all there is to the adjustment procedure.

Now you can just sit back and enjoy shutting Ma's mouth—automatically, and opening it the same way, when there's mobile-telephone talk to eavesdrop on. Enjoy! ■



Full-size template for the printed circuit board. Note the two rows of four holes each into which the IC-mounting socket is placed.

LEDit

(Continued from page 88)

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. Thats 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

Rocket Countdown

(Continued from page 106)

the launch *always* pull S2 and S3 down to their safety and hold positions. Failure to do so can result in premature liftoff of the next rocket. Remember, safety in rocketry always comes first!

In the Firing Room. The heart of this circuit is the 74192 IC counter. This amazing little chip takes the clock pluses generated by the 555 timer IC and counts them in binary code. The 7447 IC receives the binary numbers and changes them into a form we can understand—decimal. The LED display counted. IC 7406 and IC 7408 "watch" shows us the numbers as they are the count and when they sense a zero, they send a pulse to the SCR, triggering it into conduction and thus firing the igniter. ■

CLASSIFIED MARKET PLACE

99 INTEGRATED CIRCUIT PROJECTS—PUBLISHED ANNUALLY. The rate per word for Classified Ads is $1.00 each insertion, minimum ad $15.00 payable in advance. Capitalized words 40¢ per word additional. To be included in next issue, write to R. S. Wayner, DAVIS PUBLICATIONS, INC., 380 Lexington Ave., N.Y. 10017

ADDITIONAL INCOME

BIG Profits in Mail Order. Stamped self-addressed envelope. Aeschylus, 661 Ellis, Suite 2757, San Francisco, CA 94109.

AGENTS WANTED

DISTRIBUTE FOREIGN AND DOMESTIC PARTS. Leinemann, Box 585, Ocean City, MD 21842.

BLUEPRINTS PATTERNS & PLANS

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1000% PROFIT Bronzing Baby Shoes. Free Literature. NBC, Box 1904-DC, Sebring, FL 33870.

GUARANTEED WEEKLY Income of $178.00 ($35.60 daily working one hour at home). Earnings guaranteed. FAS, Box 13703, San Antonio, Texas 78213.

STAY HOME! EARN BIG MONEY addressing envelopes. Genuine offer 10¢. Lindco, 3636-DA, Peterson, Chicago 60659.

$60 hundred addressing envelopes. Guaranteed earnings. Rasmussen, DP29, 1747 N. 450 E. Ogden, UT 74404.

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$350 weekly mailing letters. Free details. Bronxville House, Box 311-D, Bronxville, NY 10708.

WHOLESALE Rubber Stamp Outfits. Supplies. Catalog $1.00. Martin, 1432D Major, Jefferson City, MO 65101.

$30.00 HUNDRED stuffing our circulars into stamped addressed envelopes. No limit. Beginners Kit $2.00. Colossi, Box 318-DC, Brooklyn, NY 11204.

HOW To Buy and Operate Your Own Motel. Little or No Cash. Free Details. RGC, Box 806-J, Chattanooga, TN 37401.

$45,000.00 GUARANTEED in three weeks. Send stamped addressed envelope: VERNE, Rte. 6 BOX 1293, CONROE, TX 77302.

UNIQUE sales program provides TOP INCOME, EXCITING GIFTS, PRESTIGE. Limited appointments ensure profitability. ACT NOW. Send $2 for details (refundable on appointment) to JACANUS, Box 570361, Miami, FL 33157.

HOMEWORKERS—$1,000 Weekly mailing circulars! Stamped envelope: KV Advertising, Box 13283, Ft. Carson, CO 80913.

BUY IT WHOLESALE

SAVE MONEY! Buy low cost items. 5 catalogs $4.00. World Directory $3.00. International Directory $3. 1001 Things Free $2.00. All (8) $10.00. Winchester Enterprises, Inc., 2807BC Hargrave Street, Phila., PA 19136.

EDUCATION & INSTRUCTION

COLLEGE degree by mail, via resume. Education, 256D South Robertson, Beverly Hills, CA 90211.

GET INTO BROADCASTING. Become DJ, engineer. Start your own station, get free equipment, records. Free details. "Broadcasting," Box 130-G-2E, Paradise, CA 95969.

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AUSTRALIA-New Zealand want you!! Big pay. All occupations. Reports $2.00. AUSTCO, Box 84989-EE, Long Beach, CA 90808.

FARMS, ACREAGE & REAL ESTATE

LAND bargains. Lots—$5. Houses—$50. Send for free details. Boggle Publications, Box 1293, New York, NY 10009.

FORMULAS & TRADE SECRETS

HAVE Roaches? Formula to Get Rid of Them. Send $2.00 to: Darby, 10 Dalton Rd., Hensley, AR 72065.

HOBBIES & COLLECTIONS

"NEW" Electronics Kits for the Hobbyist. $1.00 for Catalog and monthly Kit News. Hobbi Shack, P.O. Box 235, Jersey City, New Jersey 07303.

HYPNOTISM

FREE Fascinating Hypnosis Information! Startling! DLMH, Box 487 Anaheim, CA 92805.

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FREE! 48 page color jewelry catalog. Russo, Box 1106-D, Wayne, NJ 07470.

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BORROW $25,000 "OVERNIGHT." Any purpose. Keep indefinitely! Write: Success Research, Box 29263-SN, Indianapolis, IN 46229.

BORROW $1,000-$50,000 secretly—"overnight." Anyone! Credit unimportant Repay anytime. Incredibly low interest. No interviews, collateral, cosigners. Unique "Financier's Plan." Full information, $2 (refundable). Spectrum, 79 Wall St.-16, NY 10005.

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$300.00 WEEKLY, Mailing Circulars. Write: McGuire, Box 91054, Tacoma, WA 98491.

EXTRA MONEY for Video Cassettes users. Send $1.00 AND Stamped Envelope. VIDEORAMA, Box 3003, Chicago, IL 60654.

$180.00 WEEKLY Mailing Circulars. Start Immediately. Everready, 422 Clermont Ave., Brooklyn, NY 11238.

$200 WEEKLY stuffing envelopes spare time possible. Details, stamped, self-addressed envelope. Mail Sales-I, 8023 Leavenworth Rd., Kansas City, KS 66109.

HOMEWORKERS! Big $$$ stuffing envelopes. Free Details. SayCo, 824-D2 Augusta, Elgin, IL 60120.

$350 WEEKLY Mailing Letters. FREE Details. Karmchell, 628FD Cherry, Albany, GA 31701.

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$500 WEEKLY! FANTASTIC HOME MAILORDER PROFITS! (DEALERS WANTED) GRAHAMCO DPBX, 99371 TACOMA, WA 98499.

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PERSONAL

JAPANESE introductions! Girls' photographs, descriptions, brochure, details. $1.00 INTER-PACIFIC, Box 304-SC, Birmingham, MI 48012.

DATES GALORE! Meet singles-anywhere. Call DATELINE, toll-free (800) 451-3245.

BEAUTIFUL MEXICAN GIRLS! Correspondence. Photos details free! "Latins," Box 1716-DE, Chula Vista, CA 92012.

NEW Luxury Car Without Cost! Free details. CODEX-C Box 6073, Toledo, OH 43614.

JAPANESE Girls Make Wonderful Wives. We have large number of listings. Many interested in marriage. Only $1.00 brings application, photos, names, descriptions, questionnaire, Etc. Japan International, Box 156 AA, Carnelian Bay, CA 95711.

INFORMATIVE HANDBOOK—For people with an interest in electronics and desire to know more. Covers basic electricity, resistors, capacitors, microwaves, facts on frequency, about fuses, circuit breakers, crystals and much more. Send $1.50 for your copy (includes postage) to: Electronics Theory Handbook, 380 Lexington Ave., N.Y., NY 10017.

BEAUTIFUL Mexican-Oriental girls Needing American Boy-Friends. Free Details "actual" photos. World, Box 3876-DC, San Diego, CA 92103.

LONELY? LIKE to meet a mate? Magazine, circulars, $1.00. Merit, Box 74758-C, Los Angeles, CA 9004.

SINGLE? Widowed Divorced? Nationwide introductions! Identity, Box 315-DC, Royal Oak, MI 48068.

FOR anyone who wants the satisfaction and economy of repairing, furnishing and maintaining the furniture in his home. Send $1.50 (includes postage) to FURNITURE, 380 Lexington Ave., New York, NY 10017.

MEET Sexy Swingers Nationwide. Free details. (State age). Gateway, Box 338-DC, Lafayette, CO 80026.

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LINEAR AMPLIFIERS, 25-100 watt solid state. OMNIPOLARIZED BASE ANTENNAS. Portable/mobile/memory/300 MHz FREQUENCY COUNTER. Construction Plans: $3.00 each, 3/$7.50. Specify frequency band! Kits available. Free catalog! PANAXIS, Box 130-G2E, Paradise, CA 95969.

RUBBER STAMPS

RUBBER stamps made. Three lines $3.75. Rubber Stamps, B-1337-E2, Waldo, AR 71770.

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STAMPS COLLECTING for profit! How to start, send $1.50 to ANY'S MERCHANDISING, 611 N.W. 10th St., Miami, FL 33136 M060CS.

SWAP FOR FUN OR PROFIT

TERRIFIC swap offers nationwide! Next 5 issues $2. "Electronics Trader," Box 73-IC, Folly Beach, SC 29439.

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Mack the Tach

(Continued from page 98)

and sunlight are best. The trouble with fluorescents is that their light output is intensity-modulated at 120 Hz., which is equivalent to 7200 RPM. Depending upon the exact characteristics of the fluorescent lamp and its distance from the photo-probe, erroneous readings can result from the use of such sources.

There are basically two different ways of using a photo-tachometer; the choice of method depends on whether or not the rotating object can chop a beam of light. Consider first those devices which can chop a light beam, such as fans, propellors, pulley spokes, and even drive chains. With these you simply place the rotating object between the light source and photo-probe, thus allowing the propellor or whatever to chop the light that falls on Q1. Start with a distance of about six feet between your light source (100-watt lamp plus reflector) and the photo-probe. Decrease the spacing until you obtain a steady indication on M1. Further decrease in distance will not affect this reading. Make note of this working distance for future reference. Of course, if you are using sunlight, the above directions don't apply.

Note that if the propellor has two blades, your reading on M1 will be twice the actual speed of rotation. Likewise, four blades yield a reading that is four times too high, and so on. Do *not* use any backlighting (light coming from probe side of what you're measuring.).

The other mode of operation relies on reflection to supply light pulses to Q1. We have diagrammed a dark-colored wheel, to which a small piece of aluminum foil has been attached. Once every cycle, the foil is in a position that enables it to reflect light from the source onto the photo-probe. Measurements by reflection may tend to be tricky, since you have to set up the angles just right. Nevertheless, a little experimentation is usually all that's necessary to get things working. The total light path—from source to reflector to photo-probe—should be less than or equal to the working distance you determined for the previous case with the propellor. Sometimes stray reflections in this mode can be troublesome, since they may prevent Q1 from cutting off (i.e., ceasing to conduct). A careful elimination of all extraneous sources of reflection will solve this problem.

As a final observation, note that Mack the Tach is a very flexible measuring instrument; its applications are limited only by your own ingenuity. So, when you come upon a measuring task that has not been described here, don't be afraid to experiment! ■

Ask Hank, He Knows

(Continued from page 9)

vacuum-tube type diodes, these ratings may be in the thousands of volts. Also, the solid-state diode cannot stand any overvoltage. It will usually break down and ruin itself, if the reverse voltage is just over the rating. The solid-state diode's advantages are its small size and its ability to conduct large current with low voltage drops. The low voltage internal drop results in very little power loss in the rectifier. ■

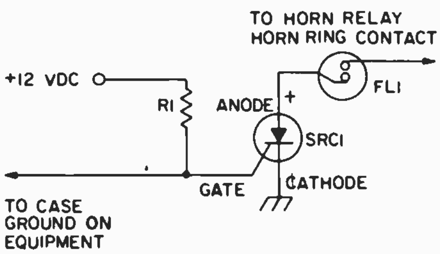
30 Transistor Projects

(Continued from page 78)

this alarm. You can either reground the protection lead, or pull the flasher out of its socket (assuming you use a socket). If you want to protect several pieces of equipment, use separate protection leads, resistors and SCRs for each, and parallel all of the SCR anodes at the SCR end of the flasher.

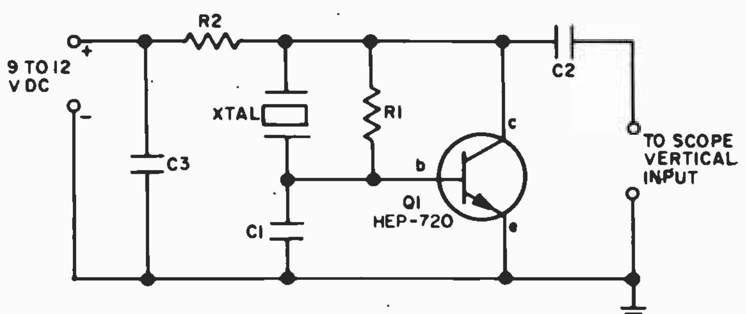
PARTS LIST FOR PULSING CB SAVER

R1—820-1800-ohm resistor, ½-watt
SCR1 — Silicon-controlled-rectifier, 20-volts or more at 1-amp. or more
FL1—Multiple load turn signal flasher cartridge



30 Time Base Reference

☐ Operating on exactly 100 kHz, the Scope Calibrator provides a reference for calibrating the variable time base oscillator of general purpose scopes. If the scope is set, for example, so one cycle of the signal fills exactly 10 graticule divisions, each division represents 1 MHz, or 1 microsecond. If the scope is adjusted for 10 cycles on 10 graticule divisions, or 1 cycle per division, each division represents 100 kHz or 10 microseconds. Now if the scope's time base oscillator is sufficiently stable so it doesn't drift to far off, you can make precise measurements of an unknown pulse width, length and frequency. ■



PARTS LIST FOR TIME BASE REFERENCE

C1, C3—0.01-uF, 25-VDC capacitor
C2—0.002-uF, 25-VDC capacitor
Q1—HEP-720 npn transistor
R1—100,000-ohm, ½-watt resistor
R2—1000-ohm, ½-watt resistor
Xtal—100-kHz crystal

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