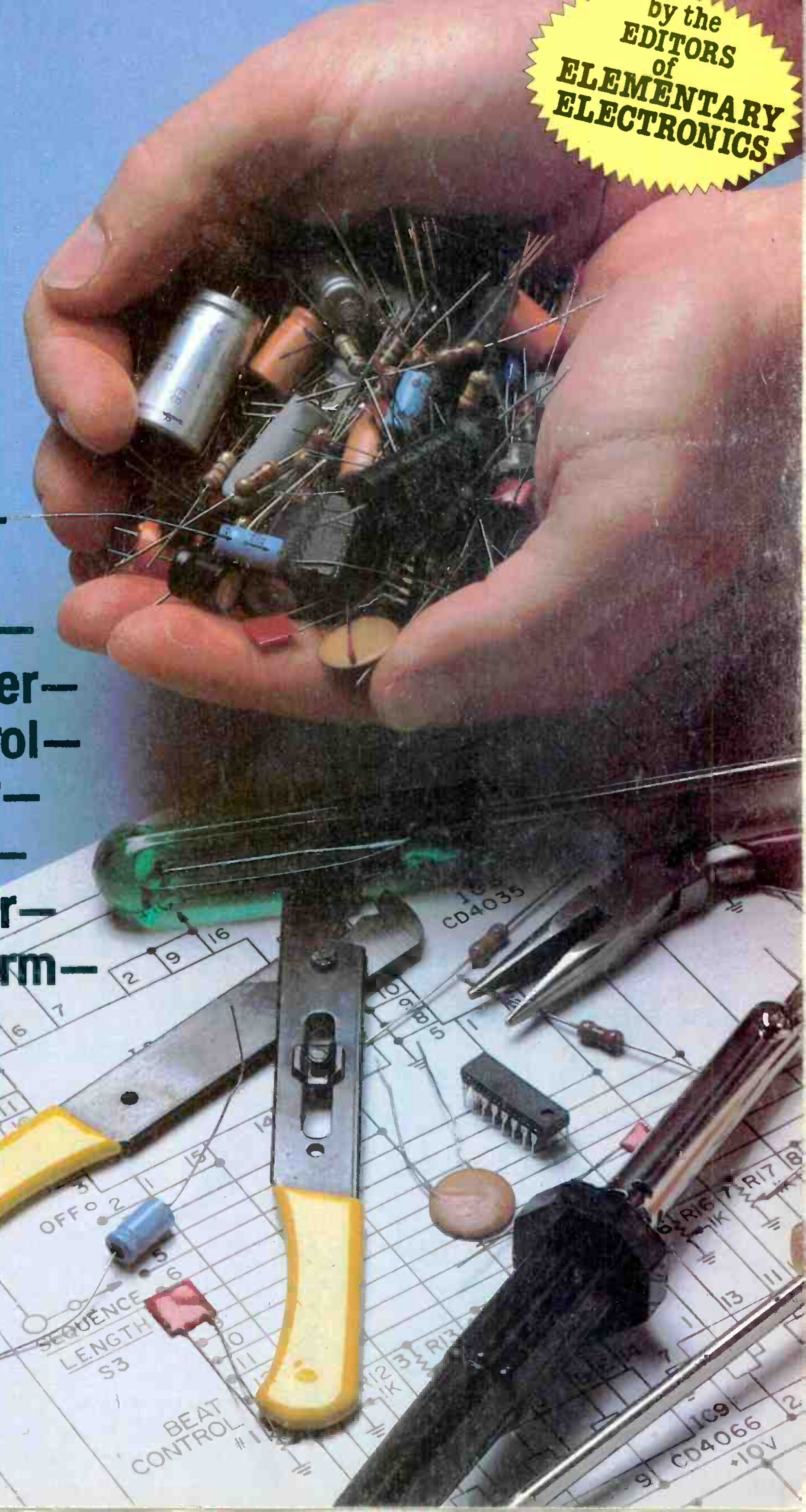
ELECTRONICS HOBBYIST

FALL-WINTER 1979 $1.75 02396

by the EDITORS of ELEMENTARY ELECTRONICS

33 WINNERS YOU CAN BUILD

IC SW RF preamplifier—
LSI sound synthesizer—
Digital rocket controller—
Musical octave multiplier—
Acoustical remote control—
Appliance power pulser—
TV Lissajous generator—
Traffic interval computer—
Light differentiating alarm—
Slave strobe trigger—
and much, much more!



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A DAVIS PUBLICATION

ELECTRONICS HOBBYIST

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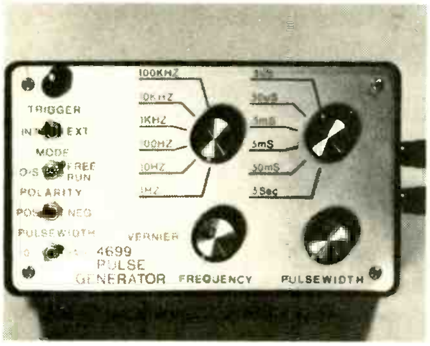
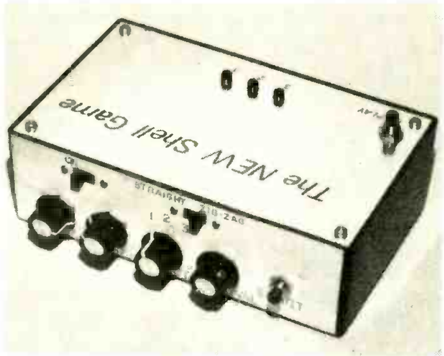


THE HOBBYIST TEST BENCH

As the projects you build become more and more complex, you'll need more and more ways to troubleshoot them. These test bench projects give you a head start in the right direction.

PROJECTS THAT EDUCATE AND ENTERTAIN

From creating original works of art on your TV screen to launching a model rocket or opening your own casino, this grab bag of projects will keep you and your friends fascinated for hours. And if you aren't careful, you may learn some electronics theory in the process!

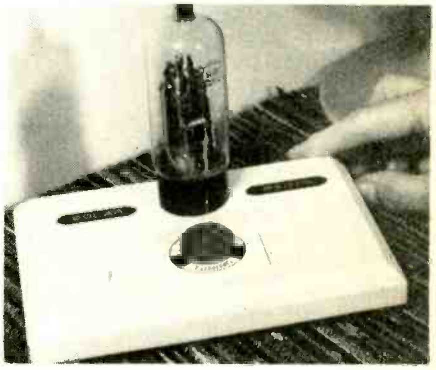


BUILD AN ELECTRONIC ORCHESTRA

For those of you who have trouble tapping your toe to the beat, to those accomplished musicians among you, let our electronic music makers set the tempo for your studies.

ARMING PROJECTS TO KEEP U INFORMED

keeping crooks out of your house, or keeping brother's hands off of your equipment, one ur electronic alarms will surely fill the bill.



RADIOS AND ACCESSORIES FOR EVERY PURPOSE

Here are some ways to give new life to your old radios, and some new radios to give life to parts of the radio world you never even knew existed.

TRICKS AND TIPS FOR THE HOBBYIST

OUR REGULAR DEPARTMENTS

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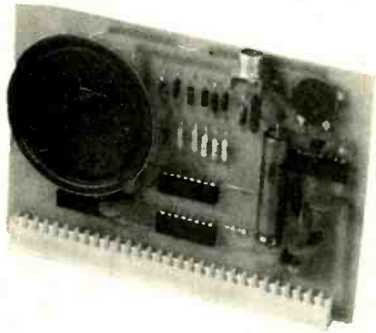
Cover photo by Dave Niedo

New Products

Music Board to SS-50 bus

The Percom Data Company Newtech model 68 Music Board, compatible to the SS-50 bus, produces computer-generated sounds such as melodies and rhythms, computer game sound effects, morse code sounds, audible prompts for interactive computer operation, train sounds for model railroading, play-along sing-along music and sounds for many other applications. The Music Board uses one I/O slot of the Southwest Technical Product's 6800 computer, and

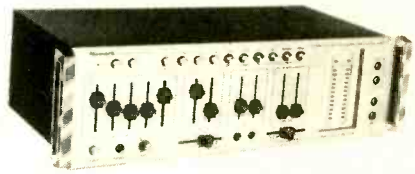


CIRCLE 39 ON READER SERVICE COUPON

is supplied with a comprehensive user's manual that includes a theory of operation, a BASIC program for writing music scores and an assembly language routine for program execution. The cassette version of Americana Plus is compatible with Percom's CIS-30+ cassette/data terminal interface unit and the SWTP AC-30 unit. The disk version runs on Percom's LFD-400 system using MINIDOS-PLUSX. The Americana Plus programs are in machine language and do not require an assembler or interpreter program. The Music Board sells for $59.95 assembled and tested. The cassette version of Americana Plus (MC-1SW) is priced at $15.95. The disk version (MD-1PC) is $19.95. Orders may be placed by dialing Percom's toll-free number, 1-800-527-1592, and may be paid by check or money order or charged to a Visa or Master Charge account. For more information, write to Percom Data Company, Inc., 211 N. Kirby, Garland, TX 75042.

Disco-Electronics

The new Numark Studio Amplifier, Mixer, Equalizer, MA4000 combines essential features in one package for disco application—portable or permanent. The amplifier section features 50 watts RMS per channel at less than 0.1% THD, 20 Hz to 20,000 Hz, along with 12 level LED display for accurate monitoring. The unit also features a five-band equalizer with range of ±12 dB. The mixing section provides for two phono, two line, and two mike inputs. Other features include fader and cue control, phone level adjustment,



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and talk-over switch. Unit features a bridging circuit that allows any power amplifier to be tied into the MA4000 for unlimited versatility. Suggested retail is $580.00. For all the facts, write to Numark Electronics Corp., 503 Raritan Center, Edison, NJ 08817.

Vise Clamp

A new Vise Base Clamp and D-Vise/Clamp Combination has just been introduced by Dremel. Both are designed for the do-it-yourselfer hobbyist, craftsman, model maker and technician who needs that "extra hand" a vise provides. The new Vise Clamp can be easily placed over the Dremel D-Vise and allows it to be clamped to any flat surface. No screws are needed to mount the D-Vise with the use of the new Vise Clamp. The D-Vise offers 180° tilt and 360° swivel for optimum positioning of a work piece.

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Precision machined slide rods assure parallel jaw alignment and equalized work pressure. Unlike other vises, the

(Continued on page 4

New Products

(Continued from page 2)

guide bars of the D-Vise are firmly supported at three major points to provide "wobble free" operation. The new D-Vise/Clamp Combination No. 2221 features one D-Vise and one No. 2218 Base Clamp, and sells for only $28.00. The new No. 2218 Vise Base Clamp has a list price of $4.95. Both are made of sturdy die cast metal and are available wherever Dremel creative Power Tools are sold. Further information can be obtained by contacting Dremel, a Division of Emerson Electric Co., 4915 Twenty First St., Racine, WI 53406.

Voice Synthesizer

Now your computer can actually talk back to you in electronically generated speech using the new TRS-80 Voice Synthesizer just introduced by Radio Shack. The Voice Synthesizer is an accessory for the TRS-80 Microcomputer System. It translates the computers' output into recognizable, intelligible speech. The synthesizer includes a volume control, built-in speaker and cable assembly that permits easy plug-in connection to TRS-80 systems. Programming the TRS-80 for speech is done in BASIC, the simplified computer language used by the microcomputer. About 60

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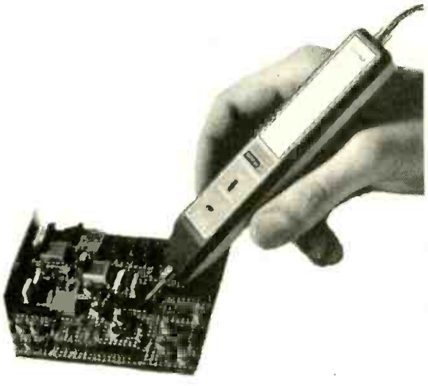
"phonemes," representing units of speech, can be entered via the computer keyboard. According to Radio Shack, this will even enable the computer to speak in foreign languages or with an accent by integrating the various phonemes to produce the desired sounds. The voice synthesizer is said to be especially useful in the field of education where it is used to supplement the displayed video information in a variety of learning situations, such as spelling, reading, language arts, and mathematics. The Radio Shack TRS-80 Voice Synthesizer, priced at $399.00 comes complete with detailed instruction manual and demonstration cassette, and may be ordered through participating Radio Shack stores and dealers, nationwide.

Digital Pulser Probe

The B&K-Precision new digital pulser probe, designated as Model DP-100, is designed as an aid to fast analysis and debugging of integrated circuit logic systems. The DP-100 generates a single pulse in the "one shot" mode or a 5 Hz



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pulse train in the continuous output mode. Simple to operate, the DP-100 can be used alone, or in conjunction with a logic probe or oscilloscope. When the probe output is applied to a circuit, it will automatically pull an existing logic low to a high state or an existing high state to a low. By observing the change in circuit output, the user can isolate faulty circuits and components. Applied test energy is limited to only 0.33% of the normal power dissipation of a good device. The DP-100 is now available for immediate delivery at local B&K-Precision distributors. The user net is $80. For additional information, write to B&K-Precision, Dynascan Corporation, 6460 West Cortland Street, Chicago, IL 60635.

Computer Price Cut

Apple Computer, Inc., has reduced the price of its large memory configured (32K and 48K) Apple II computer sys-

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tems. Previously priced at $1495 for the 32K system and $1795 for the 48K system, the units now sell for $1345 and $1495 respectively. The price of a 16K RAM increment was also lowered from $300 to $160, reflecting the continually declining cost of LSI memory. Get all the facts on Apple computers by writing to Apple Computer, Inc., 10260 Bandley Drive, Cupertino, CA 95014.

Slimline Scientific Calculator

A low-cost scientific calculator with Constant Memory feature has been introduced by Texas Instruments. The new Slimline TI-35 calculator includes a four-key Constant Memory which can store, recall, sum to memory, and exchange memory with the display, while retaining data even when the unit is turned off. The TI-35, a 54-function slide rule calculator, has the following commonly used scientific functions: roots, powers, reciprocals, common and natural logarithms, and trigonometric functions in degrees, radians, or grads. In addition,

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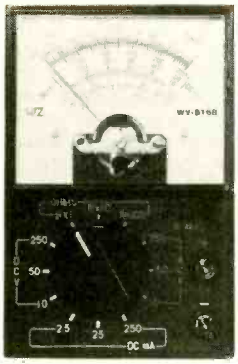
it has special functions such as pi, factorial, and constant which help speed calculations in complex problem-solving. Scientific notation extends the useful range of calculations. The TI-35 also has powerful, built-in statistical capabilities with mean and standard deviation for both sample and population data. The easy-to-read liquid crystal display (LCD) shows eight digits or a five-digit mantissa with two-digit exponent in scientific notation. The TI-35 has a suggested retail price of $25.00 and is available at retailers nationwide. For more facts on the TI-35, write to Texas Instruments Inc., Consumer Relations, P.O. Box 53 Lubbock, TX 79408 (Attn: TI-35).

5-Function Volt-Ohm Milliammeter

Only 4⅝-inches long, this new VOM fits comfortably in the hand for convenient on-the-job use. Housed in a high-impact plastic case, the instrument is ideal for engineers, technicians and hobbyists. Known as the Model WV-651B VOM and made by VIZ Mfg., the instrument can be used to measure DC and AC volts up to 250 V, resistance up to 500,000 Ohms, current up to 250 mA and decibels from —20 to +22. Each function has three ranges which are easily selectable by means of a rotary panel switch with three color coded function indications. Sensitivity is 2000 ohms-per-volt and accuracy is 3% DC and 4% AC. The instrument comes complete with battery (for resistance function) and standard banana plug test leads. It sells for $19.95. For additional information, write to VIZ Mfg. Co., 335 E. Price St., Philadelphia, PA 19144.



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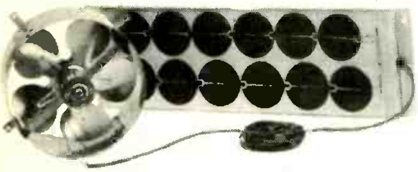
New Products

Solar Power Vent Fan

Edmund Scientific is offering a new, Solarvent Ventilating Fan that costs nothing to operate. Powered by a photovoltaic panel, it has been designed to circulate 250 cubic feet of air per minute without adding a penny to one's electric bill. Requiring no connection to 110-volt wiring and using no fuel, it operates whenever the sun is shining. The motor and panel are ideally matched so that peak efficiency can be obtained. The panel comprises 12 solar cells mounted on a weatherproofed substrate and encapsulated in specially formulated, clear silicone rubber. Self-cleaning, it generates six watts in full sun. Enough power will be provided to start the fan in 15 percent of full sun (early morning or an overcast day). The new Solarvent Ventilating Fan (stock no. 80,295) priced at $299.95, can be ordered by mail from Edmund Scientific Co., 7782 Edscorp Bldg., Barrington, NJ 08007. A free Edmund Catalog can be obtained by writing to the same address.



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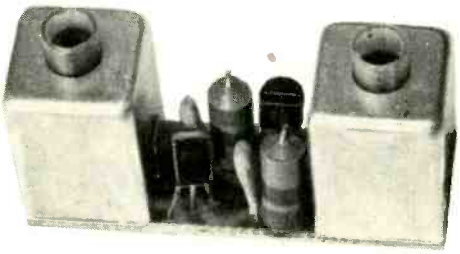
Sound Booster

Robins Industries new entry into the auto sound market is the Car Stereo Sound Expander/Amplifier Power Booster. The unit packs 50 watts RMS (25 watts-per-channel). The unit has a frequency response of 60 Hz to 15,000 Hz, output impedance 4-8 ohm, push-button in-out boost by-pass switch and LED pilot lamp. It also includes an eight-wire, color-coded wiring harness, fuse protection and mounting brackets. Voltage requirements is nominal 12 volt, negative ground common in cars. The Robins Car Sound Expander/Amplifier Power Booster, catalog #47-700, carries a list price of $63.70. For further information, write to Robins Industries Corp., 75 Austin Blvd., Commack, NY 11725.

CIRCLE 42 ON READER SERVICE COUPON

Little Big Amp

Hamtronics' model P8 miniature preamp kit is designed to be tucked away in a corner of your receiver's chassis, but not forgotten. The dual j-FET cascode circuit provides 20 to 25 dB gain, with a nominal noise figure of 2.5 dB, operating inside a bandwidth of 6 dB. It is available in three frequency ranges; 20 to 83 MHz, 83 to 190 MHz, and 220 to 230 MHz. Its small size — ½-inch by 2⅜-inches, allows it to be fitted to handy talkies, scanner/monitors, mobile CBs, and of course, any ham receiver. Installation is a breeze, since it need only be inserted into the coax at the receiver's antenna input, and its two coils peaked for maximum sensitivity. No neutralization is required. The kit version sells for $10.95, and the wired and tested version for $21.95. For more information, write directly to Hamtronics, Incorporated, 65 Moul Road, Hilton, NY, 14468



CIRCLE 43 ON READER SERVICE COUPON

For Mini Mariners

A new battery-operated VHF radiotelephone designed for short-distance use aboard small craft with no power supply is available from Apelco Marine Electronics. The Apelco AF-6 six-channel transceiver is a compact, hand-held unit weighing only two pounds. It operates on eight penlight batteries or an optional nickel-cadmium power pack which delivers 14 hours of operation per charge. Maximum range of the AF-6 is one to five miles depending on weather conditions. Other features include an internal telescoping antenna, an external antenna jack and a meter for measuring transmitting voltage and signal strength. List price of the AF-6 is $299 including crystals for Channels 6 and 16. Optional accessories in addition to the Ni-Cad battery pack, include a 110-volt AC recharger, case with belt loop, waterproof case and a short rubber flexible antenna. Specifications and other information can be obtained from Apelco Marine Electronics, 676 Island Pond Road, Manchester, NH 01303.

CIRCLE 44 ON READER SERVICE COUPON

Fingertip Volume Control

Fingertip convenience is now added to the world's finest microphones. Urban Engineering manufactures a Fingertip Volume Control for use on all Astatic TUG8, TUG9, and TUP9 style D104 microphones, including the Golden Eagle and Silver Eagle. The unit replaces the stock bottom plate and requires no drilling or modifications of any kind. No-scratch feet protect fine furniture, while the large easy-to-read dial gives complete 0-100% volume adjustment at the touch of a finger. Shipped complete with all hardware and instructions, the unit retails for $7.95 and is available at finer radio shops everywhere, or send $7.95 plus 80¢ postage to Urban Engineering, Inc., P.O. Box 5701052, Miami, Florida 33157. NOTE: Prices in Canada and overseas are slightly higher. ■

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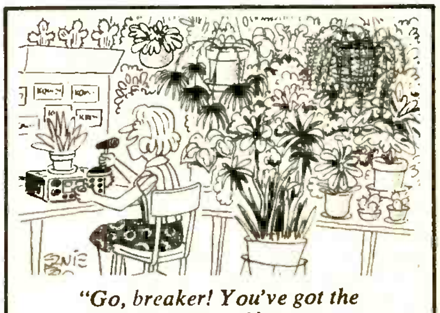


"Go, breaker! You've got the 'Green Thumb' here!"

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
ELECTRONICS HOBBYIST
380 Lexington Avenue
New York, NY 10017

VTR History

I say video tape recorders are fairly new. Discounting lab built units, I claim video recorders are all about ten years old. My father says they are about 20 years old. Who is right?

—D.J., Providence, NJ

Your Dad! Video tape recorders first came into regular use in 1954, 25 years ago, in TV studios. The "instant replay" type is fairly new; maybe that is why you are confused. The first home type that met with consumer success was the Sony Betamax back in 1976. There were several false starts before 1976, but I believe the Sony product made the big breakthrough.

FM DXing

Hank, I've done some serious FM broadcast band DXing. It is amazing what could be done with a good hi-fi receiver, FM antenna and rotator. In fact, I'm into meteor skip and have a few contacts over 2000 miles. What I can use is a good tunable FM booster. Who has one?

—D.R., Collierville, TN

What you may want to use is the Magnum FM Power Sleuth which is a tunable FM antenna power amplifier. It's primarily designed for fringe area AM reception. It sells for about $150.00. I suggest you write to Audio Marketing by Von, 11 Royal Crest Drive, North Andover, MA 01845.

Down With Dust

No matter how hard I try to clean my records, the dust piles up. I've purchased an electrostatic gun. It works for about a minute—then the dust starts to accumulate. What should I do?

—W.D., Buena Park, CA

Try Permostat, sold by Stanton, available at most audio salons where Stanton and Pickering cartridges are sold. A few squirts of Permostat to clean record surface eliminates static-dust pickup. I've tried it, and the only dust on the record in 24 hours was precipitated by gravity. Other discs were loaded because their static charges pulled the dust to the surface. I don't know how it works, but Permostat removes the latent static charges almost indefinitely. Permostat, like most other record care items, does not work well on peanut butter stains and the like.

Untouchable Tones

I suggested to a friend that he use the tone in his Touch-Tone phone as a signal source. Can you tell me what they are?

—K.L., Duluth, MN

The new Touch-Tone phones send tones to the central office. Each time you press a button on the phone, a *pair* of very accurately controlled tones are produced. Pairs of tones are used so that the detector in the central office will accept the signal only if both tones are present simultaneously. Because tones are in the voice frequency range, dual tones are used so that the central office can distinguish the difference between actual signaling and voice noise. Two sets of tones are used: the low group tones are 697, 770, 852 and 941 Hz; and the high group tones are 1209, 1336 and 1477. Here are the tone pairs for the twelve buttons on your touch-tone phone:

Digit	Low-Tone	High-Tone
0	941	1336
1	697	1209
2	697	1336
3	697	1477
4	770	1209
5	770	1336
6	770	1477
7	852	1209
8	852	1336
9	852	1477
*	941	1209
#	941	1477

The tones provided by buttons "*" and "#" are included to avoid future obsolescence. So you see, it's not as simple as you think. If you need audio tones for testing, buy a signal generator.

Here's an Assist

Every time I tune up the car, I need someone to kick the motor over, or position the distributor cam. Can I add a starting button under the hood?

—J.P., Louisville, KY

Check the starter assist relay under the hood. By connecting a button between the hot terminal on the battery and the correct terminal on the starting assist relay, you can crank your engine from under the hood. Now since this is dangerous for novices to do, I suggest you have a friend assist.

Getting Started

Why must I turn off my lights, A/C and radio when I start my car's motor? My battery is kept in good shape and can take the load.

—S.K., Waco, TX

The heaviest load you can place on your car's battery is during the starting period. So why not give it a break. Turn off your lights! You'd be surprised how much current headlamps take. Your A/C is automatically disconnected by the key switch when the starter is powered. But at the instant the motor catches, you remove the starter power and load down the engine with the A/C load—it doesn't make sense. Get the motor started, running smooth, and then turn on the A/C. As for the car radio, I leave mine on all the time. The load is too small to affect the system.

White Noise Generator

How would I go about building a white noise generator?

—L.D., Teaneck, NJ

A Zener diode operating under normal conditions is a perfect white noise generator. Just connect a battery supply in series with a current limiting resistor and Zener diode. Ground one terminal of the diode, and the other terminal will be the signal source. For most troubleshooting instances, a large disc capacitor can be used for coupling without attenuating the high audio frequencies.

Forward & Reverse

What is forward current and reverse current in diode specs?

—L. N., Sunnyvale, CA

First let me define conventional current flow as that mythical flow of electronic current from the positive DC source to a negative DC source. Shades of ol' Ben Franklin! Now, the diode symbol of an arrow striking a cathode has meaning because the arrow points in the direction of ol' Ben's conventional current flow (just the opposite of electron flow). Forward current (If) is the amount of conventional current flowing from the *anode* to *cathode* for a given forward voltage imposed on the diode. In this instance, the anode is positive and the cathode is negative. We should expect the diode's internal resistance to be very low. Reverse current (Ir) is the amount of conventional current flowing from the cathode to the anode when a given reverse voltage is imposed on the diode. That's to say that the cathode of the diode is positive with respect to the diode's anode. Now the only problem remaining is identifying the anode and cathode leads on a diode. Easy—the banded end, a strip of black or red color usually, denotes the cathode side of the terminal.

Hot Up There

I need a remote thermometer to monitor the attic heat during the summer. This way, I'll know when to turn on and off my attic fan. Got any ideas?

—M. M., Globe, AZ

What you need is a thermostatically controlled switch in the attic to turn on the attic fan whenever the temperature is 105°F (who knows from Celcius). Nutone makes one which is placed in line with the

(Continued on page 110)

the 3rd Ear

by Walter Sikonowiz

This electronic servant will jump at the snap of your fingers

FOR MANY CREATURES on this earth, two ears are the norm. The two-eared arrangement does more than allow listening to your mother-in-law and wife at the same time. Thanks to some special neural circuitry (which, among other things, performs phase and magnitude comparisons between left and right ear signals) a two-eared individual can quite accurately tell where a sound is coming from. You know how marvelously well the present system works, but think of the possibilities afforded by a third ear.

Wait a second now, no one is advocating surgery as a hobby (à la Frankenstein). The *Third Ear* in this instance is a versatile, electronic, sound-actuated control system. It can spy on your friends, mind the phone, babysit, thwart would-be burglars and much more. Later on, the *Third Ear's* applications will be explored in detail, but first let's examine its circuit.

The Circuit. The heart (better yet, the eardrum) of the *Third Ear* is a tiny module, the ETCO S-210U sound trigger. This little device originally formed the nervous system of an electronic turtle. The species is now extinct, unfortunately, but its innards are available as a great surplus bargain. As you can see from the schematic, the S-210U contains a crystal microphone, a transistor amplifier, and an SCR. The module's black lead goes to the minus side of a battery, while the red and green leads will be shorted together in this application. The shorted leads connect to one side of a low-resistance load (like a relay), and the opposite end of the load goes to battery positive. Sound picked up by the microphone is amplified by the transistor and fed to the SCR's gate. If the sound is sufficiently loud, the SCR latches in a conducting state, thus drawing a relatively large current through the connected load. Power must be removed in order to turn off the device again.

A more versatile system should operate in either of two modes, latch or pulse. After the first triggering impulse of sound, the latch-mode system remains active. A pulse-mode system, on the other hand, remains active only for some pre-determined time interval after triggering. It then returns to its inactive state, where it rests until re-triggering occurs. Then, the process repeats itself.

Construction. Adding pulse-mode capability to the S-210U is a simple matter. All it takes is some auxiliary circuitry to sense the latching of the SCR and to unlatch it again after a user-selected time delay. Unlatching an SCR can be accomplished by opening a switch in series with the anode or closing a switch to short the anode and cathode together. The latter method is the one used in the Third Ear, but before getting any further into that, there are a few easy modifications that must first be made to the S-210U.

The pictorial diagram shows the four necessary modifications in detail. First, remove the 5000-ohm trimmer by unsoldering it. This device is unusual in that it has two mounting pins, not three. Wire a 2500-ohm potentiometer in series with a 680-ohm resistor so that the net resistance is a minimum (680 ohms) when the pot is fully clockwise. The two wires from the pot/resistor combination should be soldered into the holes vacated by the 5000-ohm trimmer. This new pot will function as the Third Ear's sensitivity control (with maximum sensitivity in the clockwise position).

The second modification requires that the 0.1-uF disc capacitor in the upper left-hand corner of the S-210U be unsoldered. In the holes vacated by the capacitor, install and solder a jumper of bare, solid hookup wire.

The third step is to cut the red wire

3rd EAR

in the lower lefthand corner completely off at the point where it joins the PC board.

Finally, unsolder the 32-uF electrolytic capacitor from the board, and replace it with a similar unit having a higher working voltage; 16 VDC or higher. In general, your replacement may have a value anywhere between 22 and 47-uF, with 33-uF being about optimum. Remember that since you are dealing with electrolytic devices, the orientation must be correct. In the pictorial you can see that capacitor positive (+) must be pointing upward.

Now, let's see how the modified S-210U mates with the rest of the circuitry in our *Third Ear*. As the schematic diagram shows, the green and black leads of the module are its only connections to the external circuitry. Capacitor C2 bypasses the module's supply leads in order to keep the sensitivity high, while R1 isolates C2 to reduce its effects on the performance of the rest of the circuit. Whenever the module's SCR latches into conduction (due to sonic triggering), current will be drawn through relay K1 and the LED1/R2 combination. As a result, the normally open relay contacts will close, and the LED will light simultaneously. These two conditions will persist as long as the SCR remains latched.

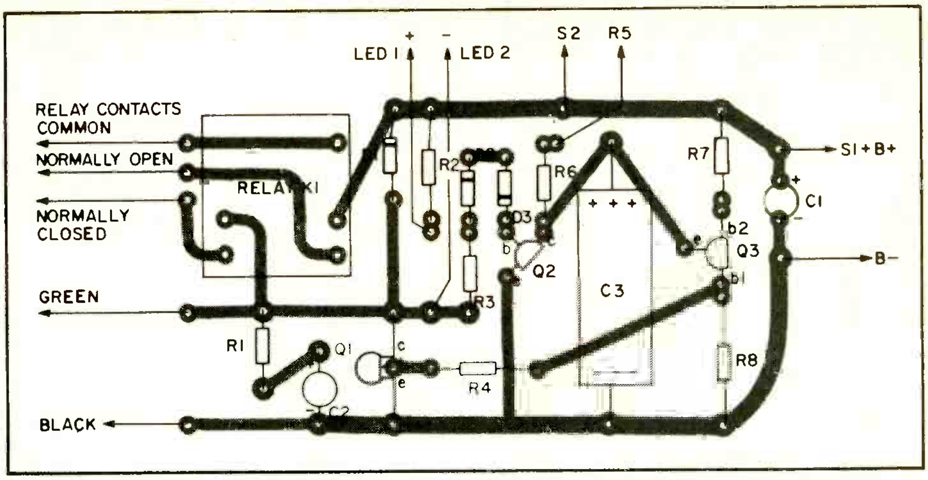
Note how switch S3 selects either the normally open (N.O.) or normally closed (N.C.) contacts of K1. This allows a load to be turned on or off, respectively, when the circuit is activated. Diode D1, connected across K1's coil, is normally reverse-biased (not conducting). When the SCR is forced to unlatch, however, K1's coil generates an inductive kickback voltage which could cause trouble if D1 were not there to clip it.

In order to see how unlatching is accomplished, let's assume that the SCR in the module is initially unlatched, and that mode switch S2 is closed in its "pulse" position. Since the SCR is not conducting, the voltage at the green lead of the module must be high (about 7 volts above ground). This potential drives sufficient current through R3, D2 and D3 into the base of transistor Q2 to ensure that Q2's collector is conducting current heavily. This prevents the voltage on C3 from rising, and nothing of interest happens.

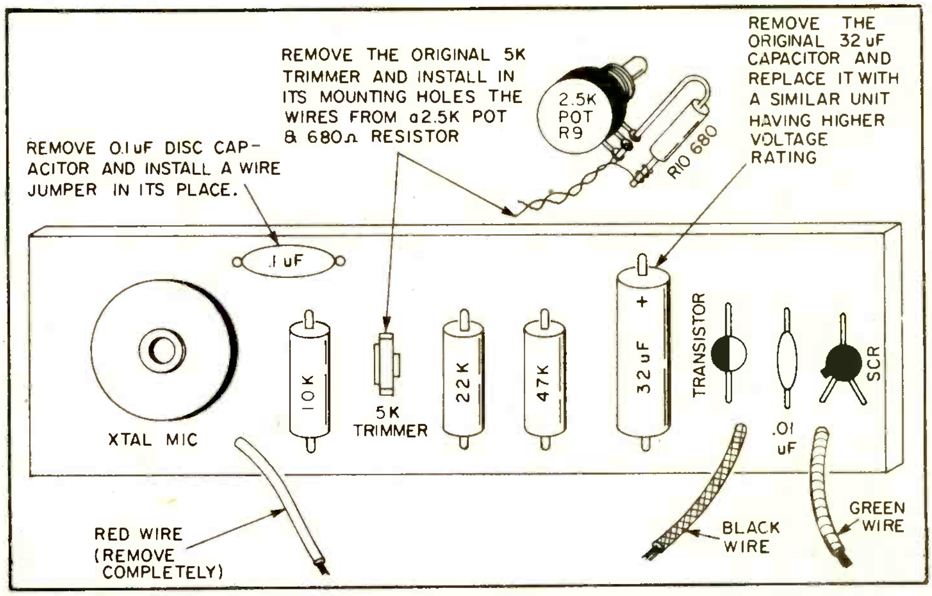
Suppose, however, that a sound triggers the module into conduction. The potential of the green lead drops to less than one volt, which is less than the 2-volt minimum needed to turn on the D2/D3/Q2 combination. Consequently, Q2's collector no longer conducts current, and the potential across capacitor C3 rises as charging occurs through R5 and R6. The rate of ascent is controlled by potentiometer R5; higher resistance causes the potential on C3 to climb more. Eventually, the voltage on C3 will reach a critical level, at which point unijunction transistor Q3's emitter-to-base 1 impedance will break down to a very low level. This rapidly discharges C3 and causes the appearance of a voltage spike across resistor R8.

This voltage spike drives current through R4 into the base of transistor Q1. As a result, Q1's collector conducts current heavily, thus shorting the module's green and black leads together. This deprives the SCR of anode current, causing it to unlatch. Because the voltage spike lasts only a brief instant, less than 0.1 second, Q1 soon loses base drive and ceases to conduct. When this happens, current can no longer activate K1 or LED1, and both will remain off until another sound triggers the module. As you can see, the circuit has returned to the state it was in at the beginning of this discussion.

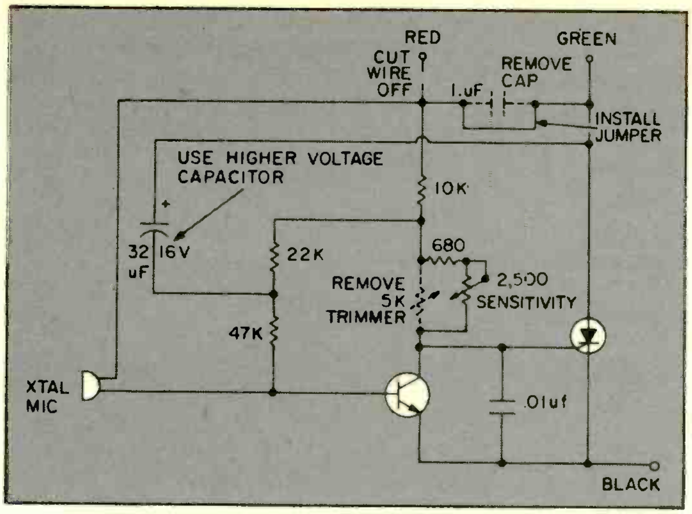
If mode switch S2 had been opened to its "latch" position, no current would have been able to flow through R5 and R6 to charge C3. Since the charging of C3 is an essential part of the unlatching process, it is clear that the module would have remained latched indefinitely. In fact, in the latch mode, the only way to reset the circuit to its inactive state is by opening power switch S1 for at least five seconds.



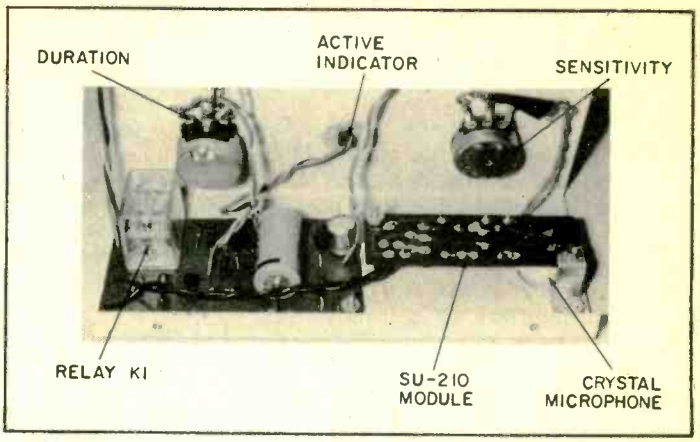
This is the component-side view of the main printed circuit board. The foil pattern is on the reverse side. If your K1 relay has mounting tabs you may have to make some holes.



This pictorial diagram shows all the modifications that are needed on the S-210U module. The 32 uF capacitor should be replaced by one with a 16-VDC or higher voltage capacity.



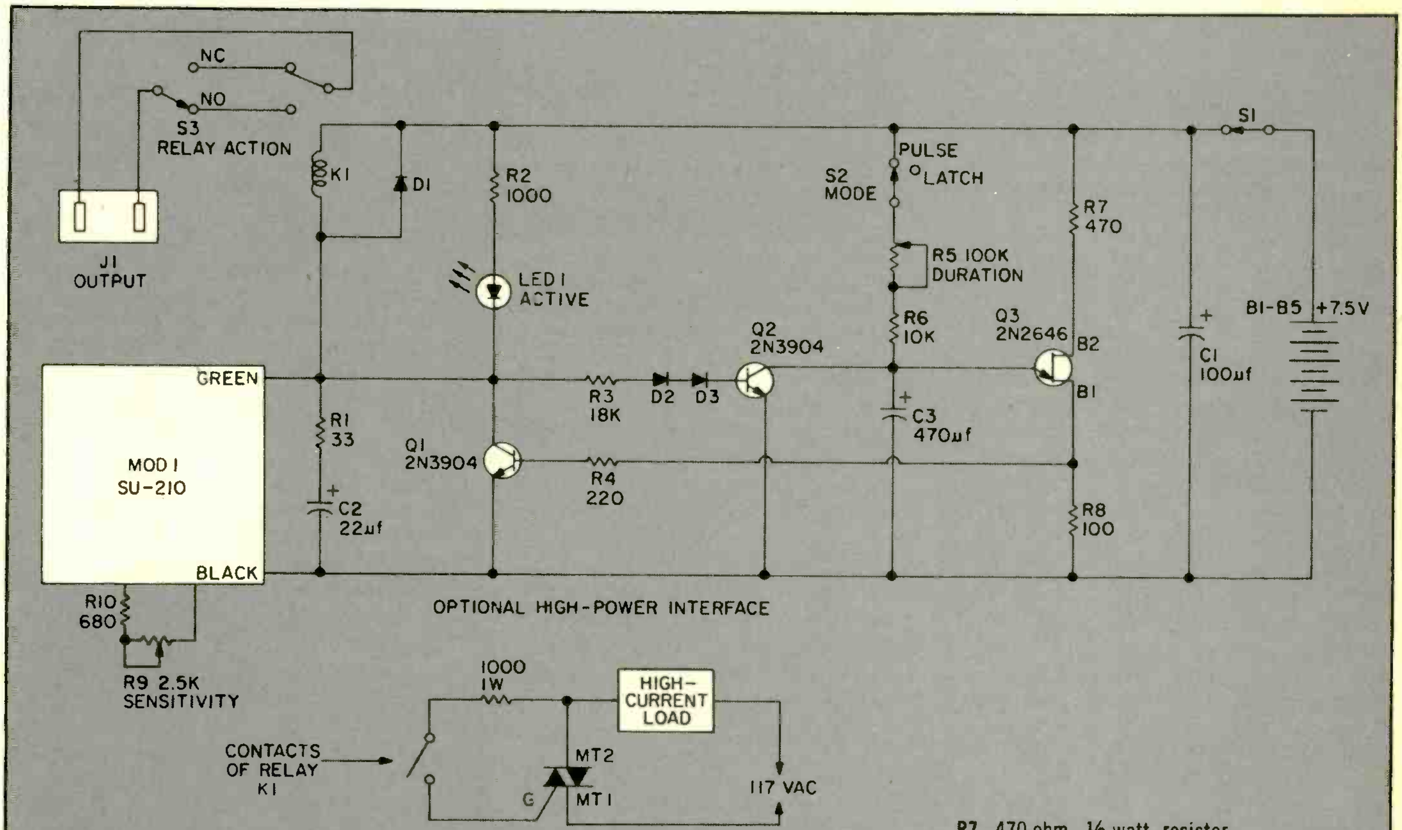
The above schematic shows the circuit of the S-210U. The module can be obtained from the company listed in the parts list.



This shows internal arrangement of The Third Ear. Note how the S-210U crystal microphone is mounted over the hole in the front panel of the case. Using a large, factory built case such as the one shown here makes assembly of a project like this a snap. The batteries mount in the other half of the cabinet.

This gives the various capacitors time to discharge completely, thus ensuring that the circuit will be inactive when S1 is again closed. Similarly, should you wish to manually unlatch the module in the pulse mode before the time delay elapses, the same procedure applies.

In the prototype's pulse mode, duration control R5 was able to produce time delays between 9 and 130 seconds. The actual control range obtained in your model is likely to be somewhat different because of variations in the characteristics of Q3 and C3. Fur-



PARTS LIST FOR THE THIRD EAR

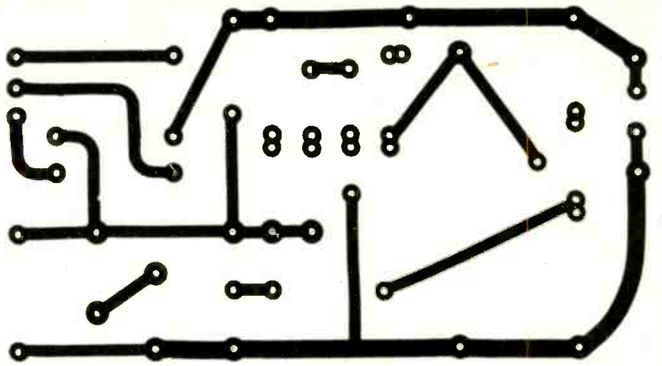
C1—100-uF electrolytic capacitor, 16 VDC
C2—22-uF electrolytic capacitor, 16 VDC
C3—470-uF electrolytic capacitor, 16 VDC
D1, D2, D3—1N914 diode
J1—panel mount AC socket
K1—relay w/6 VDC coil; one set normally open contacts, and one set normally closed contacts
LED1—small red LED
MOD1—ETCO SU-210 sound trigger module
Q1, Q2—2N3904 NPN transistor
Q3—2N2646 unijunction transistor
R1—33-ohm, ½-watt resistor
R2—1,000-ohm, ½-watt resistor
R3—18,000-ohm, ½-watt resistor
R4—220-ohm, ½-watt resistor
R5—100,000-ohm linear-taper potentiometer
R6—10,000-ohm, ½-watt resistor
R7—470-ohm, ½-watt resistor
R8—100-ohm, ½-watt resistor
R9—2500-ohm, linear-taper potentiometer
R10—680-ohm, ½-watt resistor
S1—SPST slide switch
S2, S3—SPDT slide switches
Misc.—case, battery holders, batteries, knobs, hookup wire, etc.

Note: S210U is available from ETCO Electronics, Dept. K, Old Country Shopping Ctr., Plattsburgh, NY 12901 thermore, any leakage within C3 will exert yet another influence on the time delay; the leakier the capacitor, the longer the charging time. With this in mind, it is wise to use a new, high-quality electrolytic capacitor for C3.

Power Supply. Power for the *Third Ear* comes from five "D" cells in series, yielding 7.5 volts. Electrolytic capacitor C1 keeps the power supply's impedance low. Inactive, the *Third Ear* draws only 2 milliamps, but current consumption jumps to 22 mA when the circuit is active. At these small rates of discharge, "D" cells will last a long time. Some readers might prefer to see the *Third Ear* powered by an AC supply; however, transformers hum at 60 Hz, and the Third Ear is sensitive enough to be triggered if a transformer is mounted inside its case. If you want to use an AC supply, a 6- to 9-volt DC unit will work well, but it *must not* be mounted inside the *Third Ear's* case.

Construction. Construction is easy because you don't need to worry about the layout; anything will do. A PC board is not absolutely necessary, but if you like to give your projects that professional look, use the PC patterns provided.

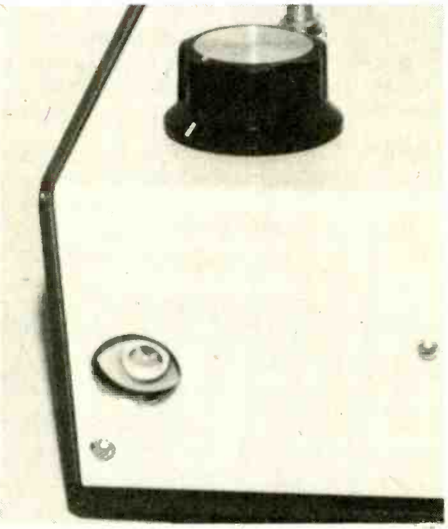
The printed circuit board for The Third Ear is easy to make. You can use this template for a photographic copy or just duplicate the pattern with a resist pen.



You should test LED1's sensitivity before wiring it into the circuit. Bargain LEDs especially may not be sensitive enough to be used here. Hook your LED in series with a 1000-ohm resistor, and connect the combination to a 7.5 VDC source. (Get the polarities right.) If you do not obtain an easily visible red glow, try another LED. Red LEDs are more sensitive than green or yellow ones, so stick with red.

When wiring duration control R5, make sure you obtain maximum resistance in the fully clockwise position. This will then give you a maximum time delay.

When building your Third Ear, you would be better off with slide switches. When a toggle is snapped quickly, the click of the switch can activate your system, regardless of the sensitivity setting. Slide switches require very little operating force and are practically silent.



Make a three-quarter-inch diameter hole in the front panel of the cabinet or wherever you want to put the microphone. Adjust the sensitivity so that it triggers correctly.

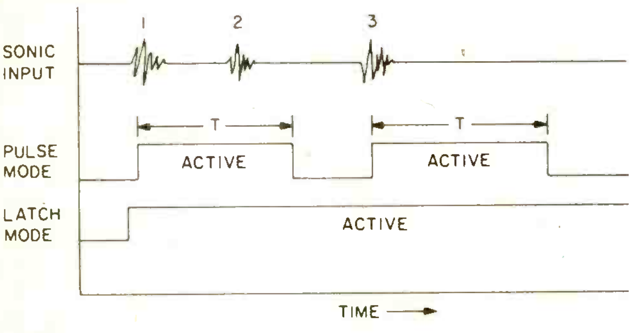
The contacts of relay K1 are rated for a load of up to one ampere, which is more than adequate for most applications. Sometimes, however, you may wish to control a high-power load, such as a flood lamp. One method of doing this would be to substitute a relay with a higher contact rating for K1, but high-current, good-quality relays are expensive. Besides that, all relays arc, especially with high-power loads, so a relay's lifetime under such conditions is limited. A cheaper, better solution is the high-power interface. Note that the triac controls the AC load, but the relay contacts control the triac. In this way, the relay contacts carry only the small gate current of the triac, and your *Third Ear* remains isolated from the AC line (and shock hazards) by the relay. Choose a triac with a current rating high enough for your load, and heat sink it. Mount the triac and heat sink in a well-ventilated *plastic* case to prevent accidental shocks.

Checking it Out. After construction is complete, you should check out the operation of your project. Set your *Third Ear* into the pulse mode, with R5 set for a minimum duration, and sensitivity control R9 placed at the mid-point of its range of rotation. Now, turn on power switch S1. LED1 should flash momentarily as power is applied. Snap your fingers directly in front of the microphone, and note the length of time that LED1 remains lit.

Next, rotate the duration control to maximum. Snap your fingers, and again make a note of how long LED1 stays illuminated.

Finally, turn the power switch off, and flip S2 to the latch mode. After five seconds, re-apply power. Snapping your fingers should now cause the LED to light and stay lit for as long as power is applied. You can do some experimenting with the sensitivity control, too. In the prototype, operation at maximum sensitivity was impossible because even the faintest ambient noise would trigger the circuit.

The applications for the Third Ear are only limited to the uses your imagination can find, and with its switching flexibility, it can control almost anything you may wish to operate around the home or office. ■



The Third Ear can be adjusted so that it triggers and holds, or so that it triggers and resets. This chart shows how the output level varies with incoming sound pulses.

This tailgating gauge helps you to keep your distance.

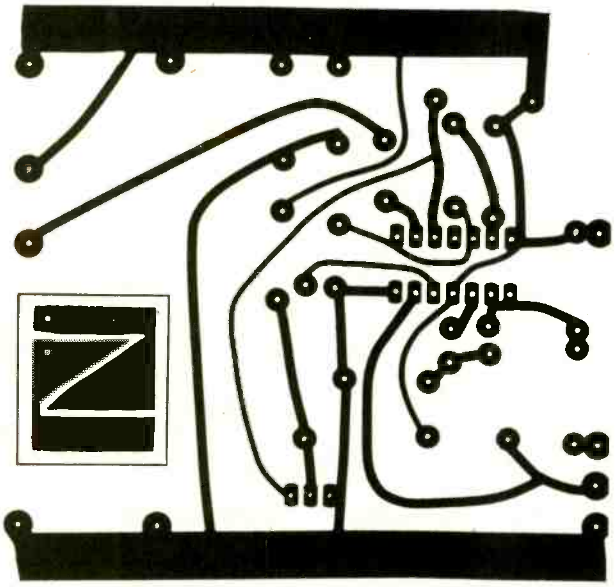
Space Cushion Timer

by Thomas R. Fox

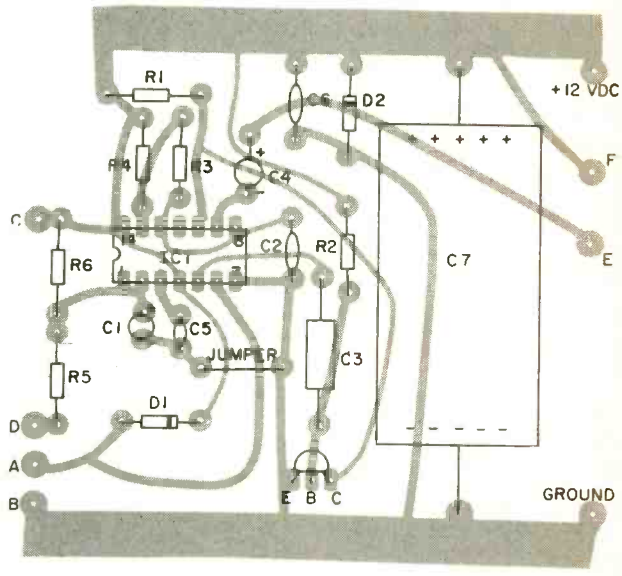
MOST OF US WHO DRIVE the highways these days have become witness, at one time or another, to the gruesome sight of a high speed, rear-end collision. With today's cars becoming smaller and lighter, the only way the auto makers can provide a margin of collision safety for the occupants is to design the cars to crumple on impact, thus absorbing the shock and hopefully leaving the passengers uninjured.

The drawback to this method is that while you and your loved ones may manage to avoid serious injury, your car is likely to be suited for use as nothing more than junkyard scenery.

The Principle. To help you avoid these unpleasant consequences, we suggest you build the Space Cushion Timer. This device works on the "two-second rule." The rule simply says that if a two-second interval is kept between cars at all speeds, ample braking distance will be provided for safe stops. In practice, you would fix a landmark at the side of the road, such as a light pole. When the car in front of yours passes the pole, two seconds should elapse before your car reaches that same spot. With our timer, you merely trip the touch plate, and 2.1 seconds later, a pleasant tone sounds. If you're at the landmark, then you are a safe dis-



Separate the template for the touchplate and make an individual printed circuit board for it. Make both PC boards very carefully.



The components all mount on the side opposite the foil pattern. Be sure to double check the polarities of electrolytic capacitors.

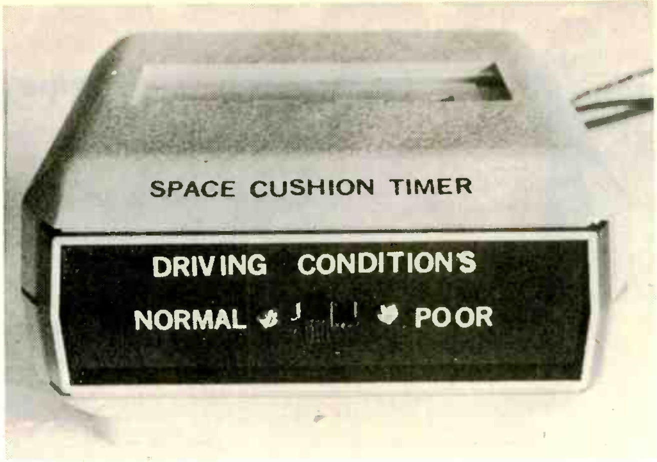
tance behind. If not, then adjust your speed accordingly.

Construction. Best results will be obtained by constructing the timer on a PC board. We have provided a template which you can use for etching your own board. All components, except for the speaker, switches, and the touch plate, are mounted on the PC board. The polarity protection circuit may be wired point-to-point on a small chunk of perfboard, and mounted on or near the car's fuse box, in order to save space within the timer's cabinet.

Instead of using a cabinet, especially if your car has a bit of room behind the dash, you may wish to mount the timer's PC board right inside, and have the touch plate and the switches mounted flush on the dash, in order to give the project that "built-in" look.

How it Works. IC1 consists of two 555 timers, one operating in a monostable mode, and the other in an astable mode. The monostable multivibrator is triggered when your finger contacts the touch plate. It has a pulse length of 2.1 seconds when S1 is in the *normal*, or closed position, and about 5.2 seconds in the *poor*, or open position. The output of this circuit goes to the base of Q1, which serves as a differentiator / inverter, shaping the pulse into a positive sawtooth, with a duration of 0.25 seconds. The reshaped pulse is then fed to the *reset* side of the astable oscillator which operates at 600 Hz. This oscillator will only produce an output when the *reset* input is held above ground potential (minimum of 0.4 volts). Therefore the oscillator will produce a 600-Hz tone for 0.25 seconds, which is fed into the speaker as the audible warning.

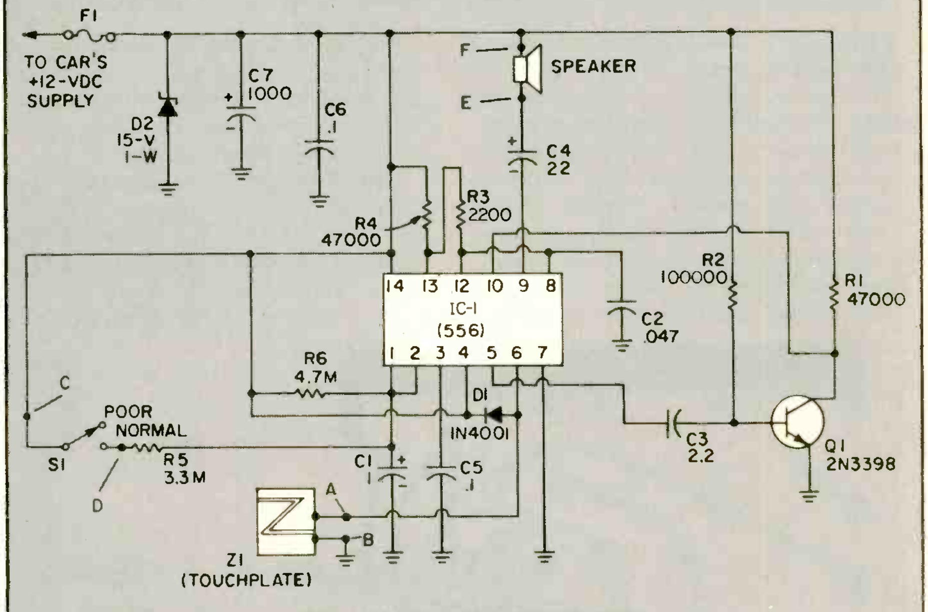
Operation. After connecting the protection circuit to the fuse box and the timer, you're ready for the safest driving you've ever done. Consult the table for the proper setting for the road conditions and the prevailing speed of traffic. The *look-ahead* feature of switch S3 allows you to set a considerably greater safety margin for conservative driving. You may wish to clip the table from the page and fasten it to the underside of your sun visor where it will be handy when you need it. *Remember!* The Space Cushion Timer will not prevent accidents if you don't use it, and even when you do use it, it's not intended as a substitute for seat belts and common sense. ■



While almost any case can be used for the space cushion timer, this Radio Shack clock case seems ideal. This unit can be mounted at almost any convenient spot on the dashboard of your car.

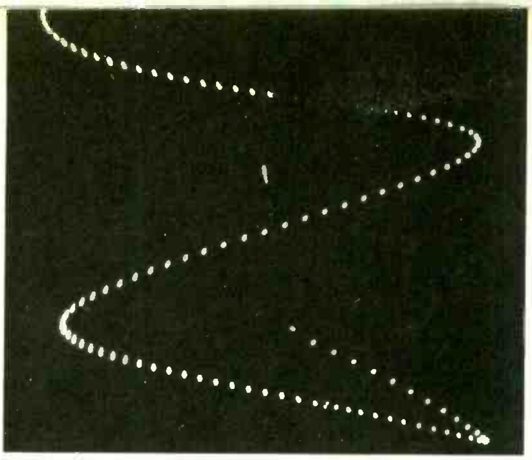
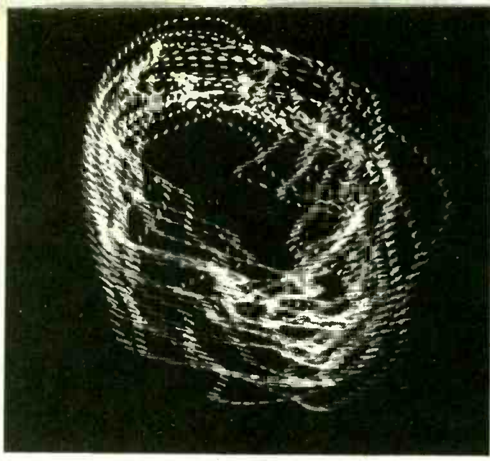
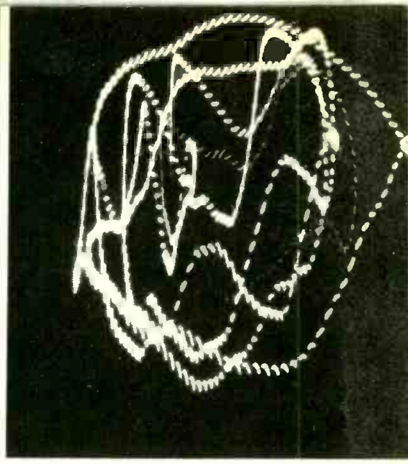
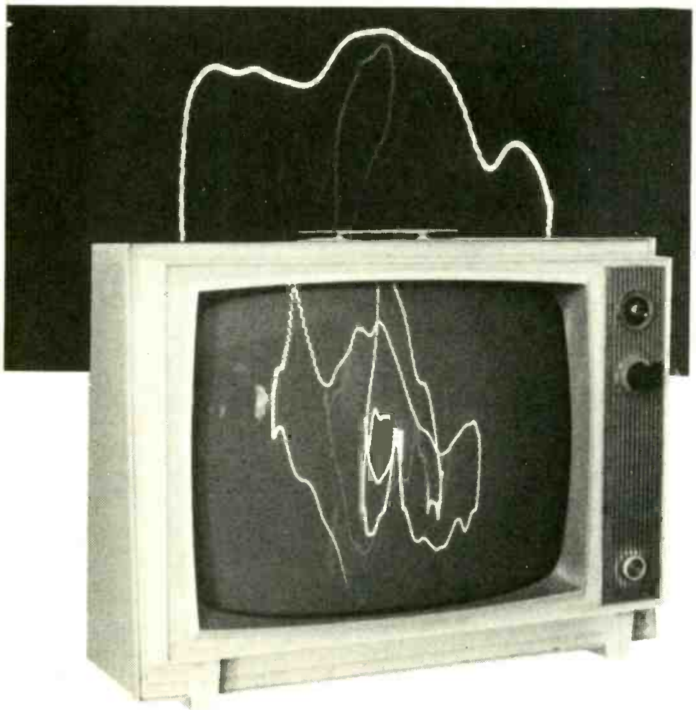
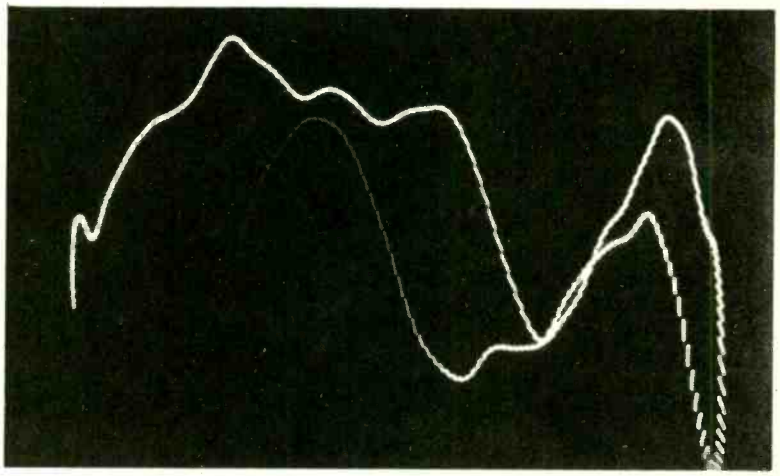
Rationale For Two Seconds Following Distance

Car Speed	Feet Car Will Travel In 1 Second	At 1 Car Length For Each 10 M.P.H. You Will Be (based on 20 ft. vehicle)	2 Second Safety Rule You Will Be
30 =	44.4	60 ft. back	88.8 ft. back
40 =	58.6	80 ft. back	117.2 ft. back
50 =	73.3	100 ft. back	146.6 ft. back
60 =	88.0	120 ft. back	176.0 ft. back



PARTS LIST FOR SPACE CUSHION TIMER

C1—2.2-uF tantalum capacitor, 25-volt or greater
C2—0.047-uF ceramic disc capacitor, 25-volts
C3—2.2-uF non-polarized electrolytic capacitor, 25-volts
C4—22-uF electrolytic capacitor, 25-volts
C5, C6—0.1-uF ceramic disc capacitor, 25-volts
C7—1,000-uF electrolytic capacitor, 25-volts
D1—1N4001 diode
D2—1N4744 zener diode, 15-volts
F1—0.25-amp quick-acting fuse
IC1—556 dual 555 timer
Q1—2N3398 NPN transistor or equivalent
R1, R4—47,000-ohm, ¼-watt resistor
R2—100,000-ohm, ¼-watt resistor
R3—2,200-ohm, ¼-watt resistor
R5—3,300,000-ohm, ¼-watt resistor
R6—4,700,000-ohm, ¼-watt resistor
S1, —sub-miniature SPST slide switch
SPKR—8-ohm miniature speaker
Z1—touch plate (requires 1 square inch of PC board stock)
Misc.—cabinet, perfboard, hookup wire, etc.

LISSY, THE TV LIGHT PEN

Lissajous patterns on your old TV add excitement to stereo.

by Dean Hock

☐ Are you an avid stereo enthusiast looking for a new way to experience your favorite music? Have you tried conventional "color organs" and found them fun for a few minutes, but dull as dishwater thereafter? Have you perhaps seen an oscilloscope hooked up with a microphone on its input and watched in fascination as the sound waves dance on the screen in perfect synchronism with your voice?

If you'd like something new to stretch your visual sense and expand the aural connection with your eyes, look no further. *Lissy*, the adapter which turns any beat-up old TV set into an oscilloscope for stereo sound, displays myriad sound patterns on the receiver screen. Its *Lissajous* patterns respond to both right and left-hand stereo signals—although it can also work with just one channel—providing an infinitely-variable light/sound display for your friend's pleasure and amazement.

What's a Lissajous? Let's go back to basics for just a minute, and review what a Lissajous figure is. Those of you who read our Basic Course in the March/April issue (*Using the Oscilloscope,* pages 83-88) will recall that Lissajous figures are 'scope displays of *two* signal inputs to the display screen —not just the usual vertical input signal which we use when we want to measure the amplitude of a voltage or watch how its amplitude changes with respect to time (the most common use of the oscilloscope).

With signals going to both the vertical *and* the horizontal inputs of an oscilloscope we can measure the relationship with respect to time (it's called *phase*) between the two signals.

For example, if a known signal is applied to the horizontal input and an unknown signal is applied to the vertical input, the resulting Lissajous pattern shows the phase relationship of the two signals.

Lissajous patterns can also be used to measure frequency. A known frequency is applied to the horizontal amplifier and an unknown frequency is applied to the vertical. By counting the number of tangency points at the top and at one side, a ratio of unknown-to-known frequency can be obtained. By multiplying the ratio times the known frequency, you can determine the frequency of the unknown.

A Simple Pattern. The drawing shows a Lissajous pattern for two sine waves. Numbers have been assigned to corresponding voltage points on the two signals. Extensions of these points are brought to the screen. The intersection of corresponding numbered lines is the position of the electron beam at that instant of time. In this case the two sine waves are in phase.

In the figure below, voltage/time relationships are different; corresponding voltage points are 45° apart. Therefore the waveforms are 45° out of phase.

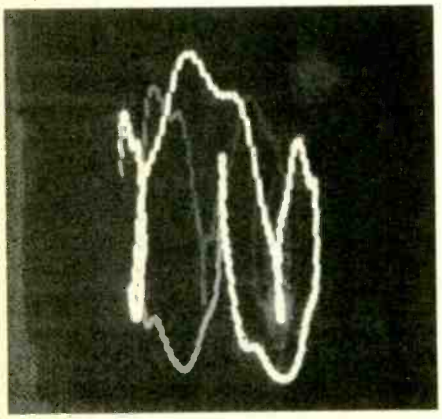
Lissy's Pictures. A continually shifting Lissajous pattern results when the phase relationship between the two input signals is constantly changing. The more complex the pattern (resulting from a frequency ratio having large numbers, such as 17/13) the harder it is to interpret. But since were not trying to *analyze* Lissy's pictures, we can just lean back and enjoy. *(Please turn page)*

LISSY TV LIGHT

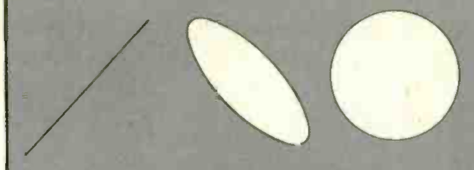
How Lissy Does It. By connecting the parts of an old TV set so that the output from one channel of a stereo set (for example, the left) drives the electron beam of TV tube vertically, and the output of the stereo set's right channel drives the beam horizontally, we can use the TV set to display Lissajous figures created by the signals from the two stereo channels. What we do is make the old TV set/stereo amplifier combination into an uncalibrated oscilloscope. Then we feed it the two signals without worrying what they mean.

Putting It Together. Begin with an old television set. You can use one in which the tuner, IF, and sound sections do not work since they will not be used. You'll also need an extra deflection yoke from another old set. Most of the older tube-type black and white sets have yokes the same size. As long as the extra yoke will fit over the neck of the set's picture tube it can be used. A junked TV is the best place to look. You must also have a stereo set with amplifiers capable of producing 12-15 watts of output power per channel. Even better is a spare (second) stereo set. This will insure better results and will also allow you to adjust the tone, volume and balance controls to the TV set without upsetting your listening pleasure, by changing the volume setting while you listen.

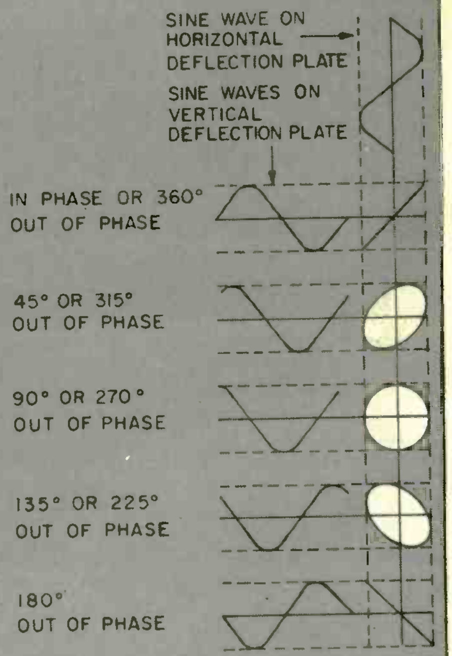
Begin by removing the back from the old TV set. Disconnect the socket from the rear of the picture tube. Loosen the clamps holding the deflection yoke and slide it off the neck of the tube. Do not disconnect any of the wires from the



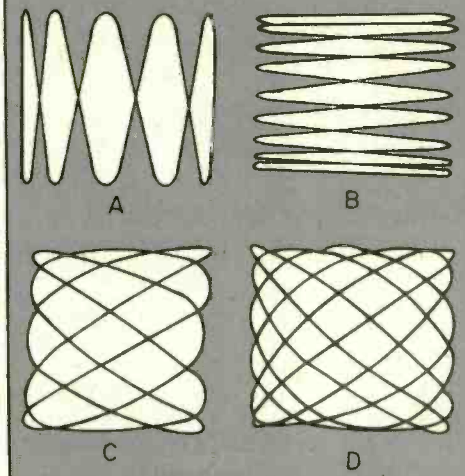
These patterns appear from moment to moment on the TV screen when it's being driven by signals from music. To see what they really look like you'd have to have motion pictures.



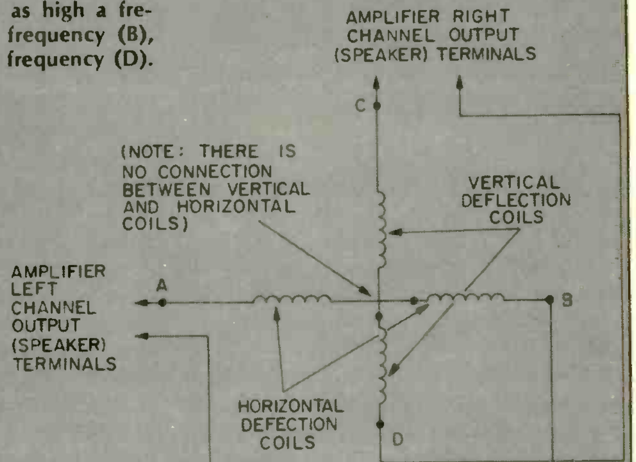
Simple Lissajous figures like these result from putting the same (or almost same) signal voltages on horizontal input and vertical input of oscilloscope (or TV picture tube).



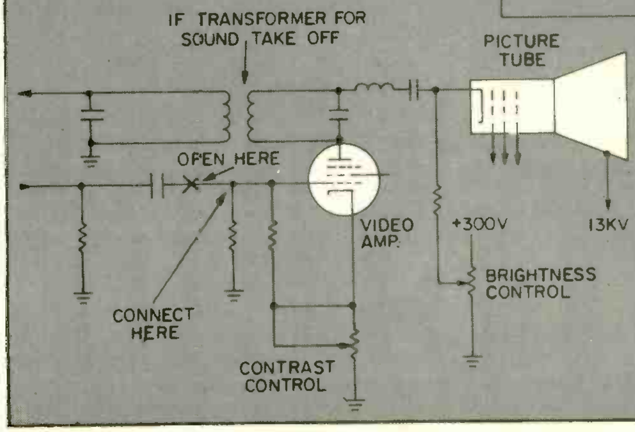
If your two stereo channels put out exactly the same signals (or you put a mono signal into both) you should get a straight (diagonal) line on the screen. If not, adjust gain of one channel. Other Lissajous patterns like these will result from out-of-phase signals. Music waveforms are extremely complex compared to the signals used to derive simple patterns shown here.



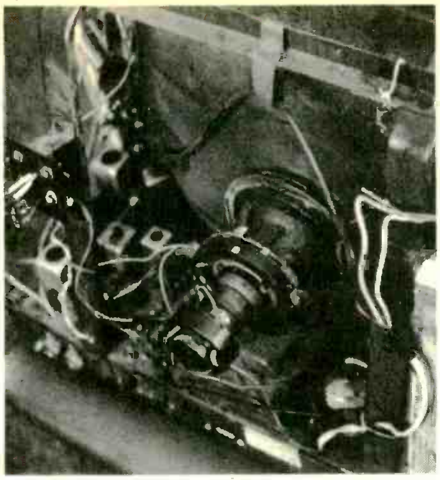
These more-complex Lissajous patterns are created by feeding a simple sine wave to the horizontal input of a scope and sine waves of exactly five times as high a frequency (A), one-ninth the frequency (B), 3/5 frequency (C), and 5/6 frequency (D).



The added deflection yoke from second TV set is connected as shown above to the two stereo channels of an amplifier or receiver. Using a separate amp (from the one you listen to) is recommended, but not essential.

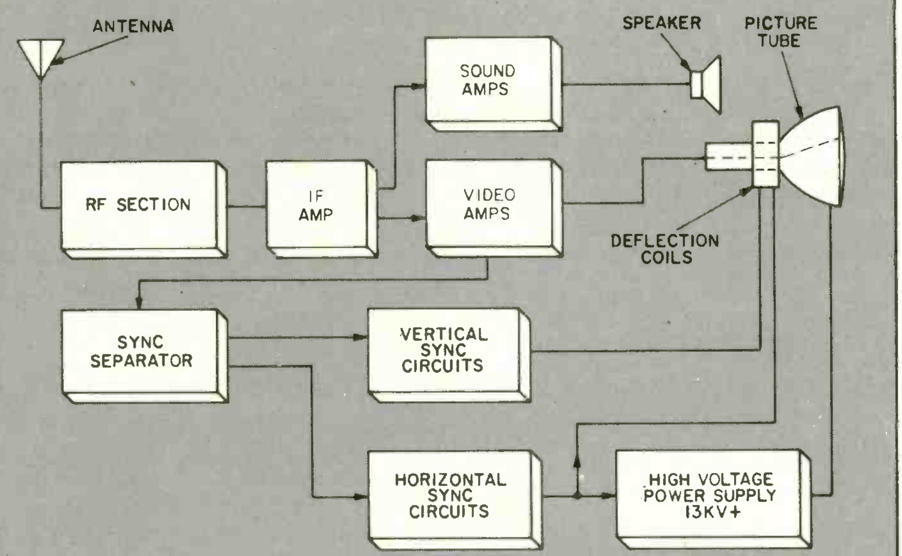


This schematic shows a typical video amplifier tube for TV sets six to 15 years old. Disconnect the video input signal on the grid side of the grid-coupling capacitor and connect your Lissy oscillator at the same point to make Lissy do extra tricks.

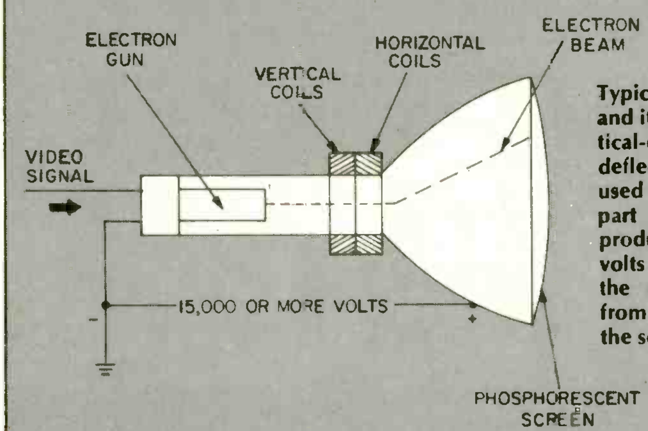


Here's how the back of author's set looks with the new picture tube yoke (deflection coils) on neck of picture tube. Original deflection yoke is removed from tube but kept hooked up because it's also used in the circuit which generates high voltage for picture tube. It's tied out of way at upper right, atop high voltage cage.

Closeup of picture tube neck shows large circular positioning magnet which some sets have behind yoke. Be sure to replace any magnets your set had into their original position after you replace the yoke.



Simplified block diagram of TV set shows how vertical and horizontal sweep currents are derived from the synchronizing signals sent from the transmitter. Vertical and horizontal sweeps feed vertical and horizontal deflection coils.



Typical TV picture tube and its horizontal and vertical-deflecting coils. Old deflection yoke is still used in Lissy because it's part of the circuit which produces thousands of volts required to attract the stream of electrons from the electron gun to the screen.

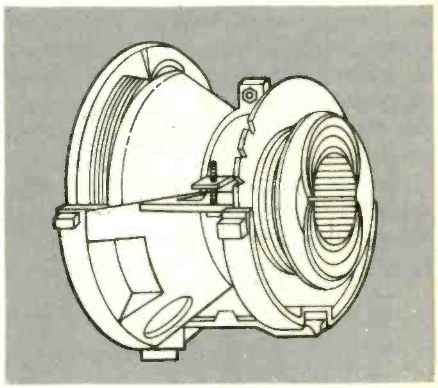
yoke since it is part of the circuit for putting the beam on the screen. Secure the old yoke to the chasis of the TV somewhere out of the way, taking care in seeing that it does not short circuit.

Preparing the Deflection Yoke. There are two coils in the deflection yoke of a TV set. One is called the horizontal and one the vertical.

Each of these two coils is divided into two sections, and we must eliminate any extra parts such as a small resistor or capacitor which are often connected to one or both of the yokes. They are usually connected to the midpoint of the horizontal coil or vertical coil. Simply remove any resistor or capacitor connected to any parts of the yoke, and if this separates the two sectional parts of either the horizontal or vertical coil, put a jumper between the two sections. Check with a voltmeter to be sure which terminals are connected (through the two coils) together. Mark them in some way so that you'll know which two leads of each coil are connected together (through each coil). Solder 2 three-foot lengths of speaker wire to the terminals of the vertical and horizontal coils.

Putting It Together. Take the yoke and slide it on to the neck of the picture tube securing it with a clamp. Return the socket to the back of the tube along with any magnets that may have been removed. Put the magnets back exactly where they were. (Adjust to center beam, later.) Route the speaker wire out the back of the TV set as you put the cover back on. Run wires from the speaker outputs on your stereo to the TV set and connect the two sets of wires together using a terminal strip.

You are now ready to test out Lissy. Leave your stereo off and turn on the TV set. After warmup a small dot should be visible in the middle of the screen. Adjust the magnets, if any, to



Most old TV sets have deflection yokes which look like this. Large end (left here) goes snug up against the flare of the picture tube. May require loosening of screw which secures clamp around coils.

LISSY TV LIGHT

center the beam. If necessary turn the brightness control up or down. Now turn on the stereo set and turn up the volume slowly until you start to notice the dot moving. By adjusting the balance control you should be able to make the dot move about an equal amount horizontally and vertically. It may be necessary to disconnect the speakers in order to move the beam enough. Adjust the brightness for a pleasing light level without burning the screen phosphor. Low bass notes will show up as rotating circles. Each tone has its own pattern which intensifies with the volume.

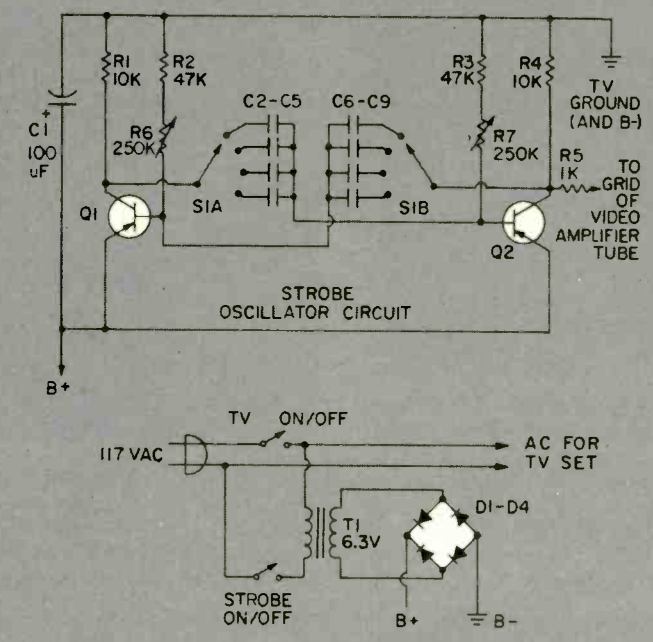
Now that you are finished sit back and enjoy the added dimension of the music TV in a dark room. It will provide you with many hours of listening and viewing pleasure.

More Fun With Lissy. Once your Lissy is working you may want to add an extra circuit which will strobe the moving pattern on and off, making a more unusual and interesting light display. By connecting the output of an oscillator to the grid of the TV set's video amplifier tube you can turn on and off the electron beam in the picture tube. This will produce dots and dashes as the beam is moved around on the screen. The effect is quite pleasing. A stop-action type of display (called "strobe"), is only one interesting improvement you'll see.

The added circuit is a simple two-transistor oscillator. The switches and potentiometers allow you to select different dot line lengths and frequencies. By connecting the output of the oscillator to the grid of the video amplifier you force the tube alternately into conduction and cutoff.

The oscillator and power supply are not critical and can be constructed any way that is convenient, as long as safe construction practices are used. The circuit in the prototype was built on a terminal strip using point-to-point wiring and then mounted inside the TV. Almost any general purpose PNP transistors can be used for Q1 and Q2.

If you can't get a schematic of the TV set you are using the best way to locate the video amplifier tube is to look at the tube placement chart (usually on the side or back of the TV) and find the tube which is labeled *Video Amp.* If the video amp tube also contains other elements in the glass envelope you will have to trace down that part of the tube which has its plate connected to the sound trap transformer



PART LIST FOR LISSY—THE TV LIGHT ORGAN

TV receiver—which has light (raster) on the picture tube. It need not have a working tuner or IF section, nor sound.
Picture tube deflection yoke—in working condition. (Most are—this is a part that rarely fails in TV sets.)
Speaker wire—8-10 ft.
Stereo amplifier or receiver—preferably 12-15 watts or more per channel.
Misc.—Solder, wire, switches, etc.

PARTS LIST FOR STROBE CIRCUIT FOR LISSY

C1—100-uF, 16-VDC electrolytic capacitor
C2, 6—.002 or .22-uF capacitor
C3, 7—.01-uF capacitor
C4, 8—.1-uF capacitor
C5, 9—1-uF capacitor
D1, 2, 3, 4—rectifier diodes, 30 PIV or better, any amperage
R1, 4—10,000-ohm, ¼-watt resistor
R2, 3—47,000-uF, ¼-watt resistor
R5—1000-ohm, ¼-watt resistor
R6, 7—250,000-ohm potentiometer (or 500,000 if 250,000 not available)
S1—Single-pole, 4-position (or more) rotary switch
Q1, 2—General-purpose PNP silicon transistors, HEP-242 or similar
T1—Power transformer, 117 VAC primary, 6.3 VAC secondary, any amperage

You can call Lissy's designs Lissajous patterns, but your friends will call them "out-of-sight"! The twisting, convoluted, ever-changing, swirling designs are truly a visually exciting wonder which can't fail to draw the viewer's eye into almost hypnotic attention. You can convert almost any old television from a boob tube to a groove tube with just a little effort, and at almost no cost at all. Just an evening's work, and your place will be jumping like never before.

(usually a metal can type) and its cathode connected to the contrast control. This may vary slightly in your set.

Once you have found the video amplifier cut one of the leads of the capacitor going to the grid and replace it by connecting the oscillator output to the tube in its place, (see the schematic). Connect the negative lead on the oscillator's power supply to the TV common ground.

Fire Her Up. Now you are ready to test the circuit. Look it over for any wiring errors. Set the potentiometers to maximum resistance and set the rotary switches at the .01 uF capacitors. Turn on the TV set and allow it to warm up. Get a music display on the screen. Turn down the brightness control until you can no longer see the raster (white lines). Turn on the strobe oscillator and adjust the brightness control as needed. The display should be chopped up into little line segments. By adjusting the controls you can get different line lengths and frequencies—anything from star-like dots to a pulsating array of stopped action traces.

Now you can lean back and enjoy your Lissy—the TV light organ which will amuse and amaze your friends for many evenings ahead. ■

DISCO KING

Drum up a storm with this percussive project!

DISCO MUSIC ENJOYS a phenomenal popularity, as evidenced by many of today's most popular records and movies. This popularity is due, in part, to the uniquely identifiable Disco percussion pattern which is basically identical in all songs. *Disco King* is a low cost rhythm unit which produces the standard Disco pattern plus three variations (selected by moving the "Pattern Select" jumper wire). The King also doubles as a base drum synthesizer which is triggered by means of a standard footswitch.

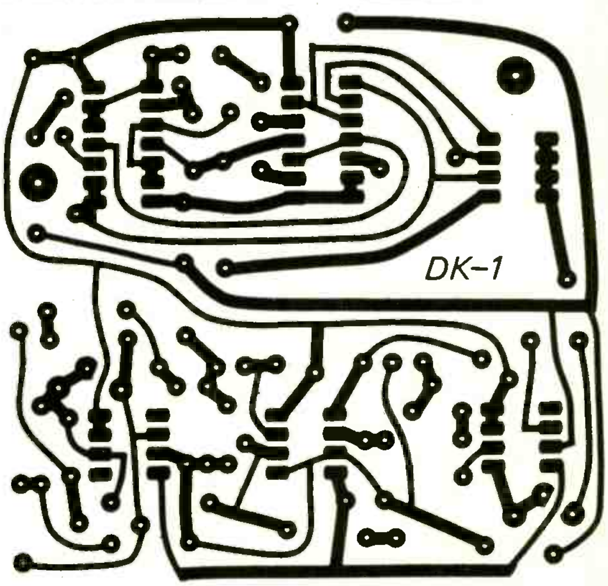
Disco King is simple to construct, uses readily available CMOS and analog active devices and is powered by two 9 volt batteries, Construction cost for the basic unit should be less than $20.00 (see parts list for kit availability).

How It Drums. As indicated in the schematic diagram, CMOS NAND gates IC1A and IC1B form a gated oscillator which serves as the clock for the unit. The clock output frequency (set with *Tempo* control R2) is divided by two in D Flip Flop IC2B and again by two in D Flip Flop IC2A. Either the clock output, the Q output of IC2A or B or the Q output of IC2A can be used as the cymbal trigger signal.

Transistor Q1 generates a continuous white noise signal which is A.C.-coupled through C9, amplified in IC3A and provided to IC4, a transconductance Operational Amplifier. The trigger signal selected is A.C. coupled through (and differentiated by) C7 and used to Amplitude Modulate the white noise signal in IC4. In this way, a repeating pattern of cymbal sounds is generated. Initially, R20 is adjusted to set the decay portion of the differentiated trigger pulses to create the characteristic amplitude envelope of a high hat cymbal. A portion of the IC4 output signal is tapped off *Cymbal Level* control R16 and provided to IC3B, where it is further amplified and summed with the synthesized base drum.

The Q output of IC2A is differentiated by C4 and R5 to produce a narrow trigger pulse. D1 eliminates the negative portion of the differentiated pulse. The Q output signal is also inverted in IC1C which drives LED 1 to indicate the start of the pattern (in musical terms, the start of the *bar*). In lieu of the Q output, a switch may be connected to J1. When depressed, the switch will manually generate a trigger pulse. In this manual mode, C3 and R4 eliminate switch bounce which would cause undesirable multiple trig-

The beat goes on . . . and on . . . and on . . . when you build our Disco King. It's really simple to put together, as it uses readily available CMOS and analog integrated circuit devices. The full-size printed circuit template is shown here, and it is easily duplicated by using one of the popular kits on the market today. For all of you would-be DJs, the Disco King is an excellent device for running mixes!



DISCO

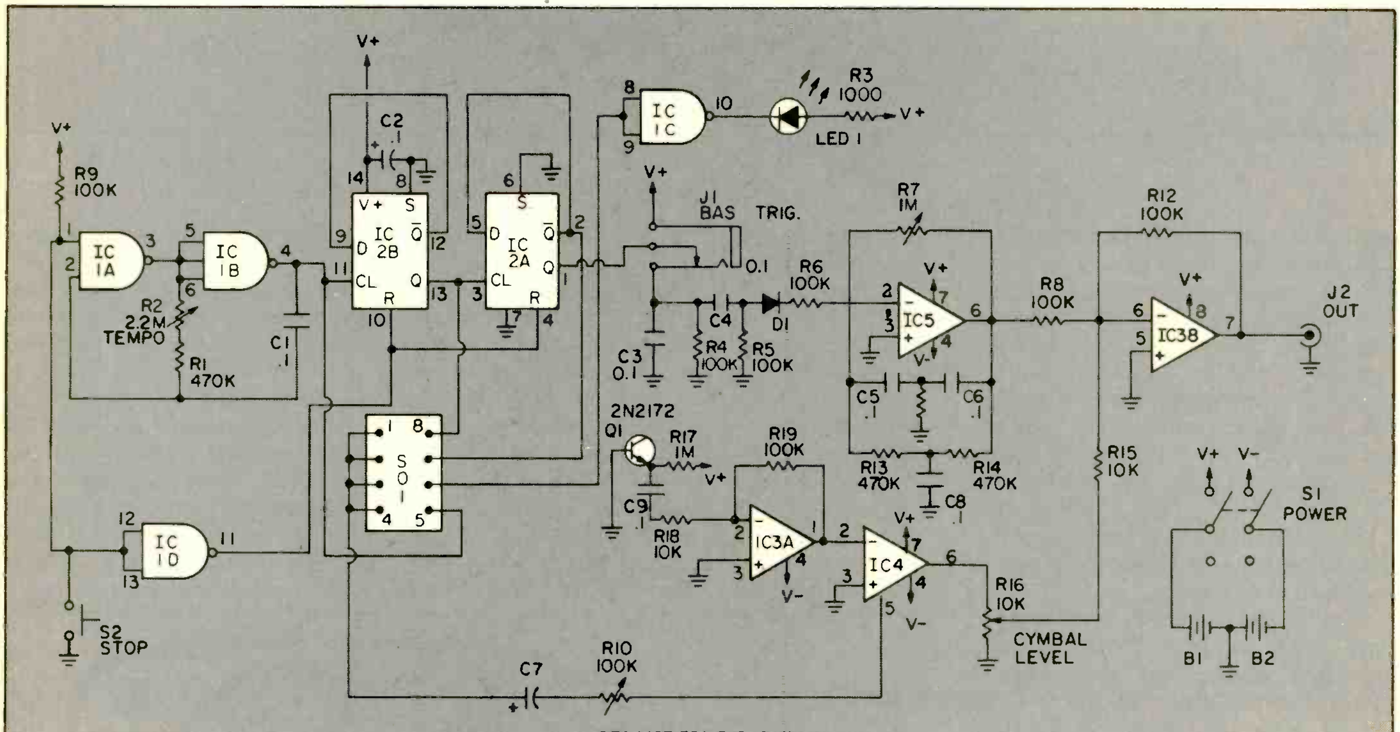
gering. In either the manual or automatic mode, the resultant pulse triggers the base drum generator.

C5, C6, C8, R11, R13 and R14 form a Twin-T notch filter tuned to the base drum frequency and make up one of two feedback loops for Op Amp IC5. If this were the only feedback loop, IC5 would simply oscillate at the notch frequency. Feedback loop R7, however, provides sufficient negative feedback to suppress continuous oscillation. The positive going trigger pulse momentarily overcomes the feedback through R7 and generates a damped sine wave output. The setting of R7 determines the amount of feedback and how long the oscillation lasts.

With S2 open, operation is as described above. Closing S2 (*stop*) grounds the input to pin 1 of IC1A, stopping the clock and resetting both Flip Flops with the high output of inverter IC1D. When S2 is released, the clock restarts and the sequence restarts at the beginning of the bar with the base drum sound. Power (±9 volts) is supplied by two 9 volt batteries.

Construction. Although not absolutely necessary, a PC Board is recommended as the means of construction. A PC pattern and components placement guide are provided. Observe standard precautions when handling and soldering CMOS ICs 1 and 2. Sockets may be used if desired. The CA3080 IC in the TO-5 can is available in two different lead configurations. The "S" configuration has the leads preformed in an 8 pin DIP (Dual Inline Package) pattern, where the "plain" configuration does not. If necessary, form the leads in an 8 pin DIP pattern prior to insertion. After all components are installed, perform final wiring.

Any suitable case may be used to house the project (although a case is not actually necessary). The case may be marked as shown in the photo using transfer lettering or other similar marking methods. A suitable holder for the two 9 volt batteries can be formed from a 1" by 3" strip of aluminum. Drill a 3/16" hole in the center of the strip and form it into a stubby "U" shape, the two shorter sides being 3/8" each. Drill a 3/16" hole in the bottom of the case and pass a #6-32 x 1" machine screw through the hole, between the two batteries and on through the

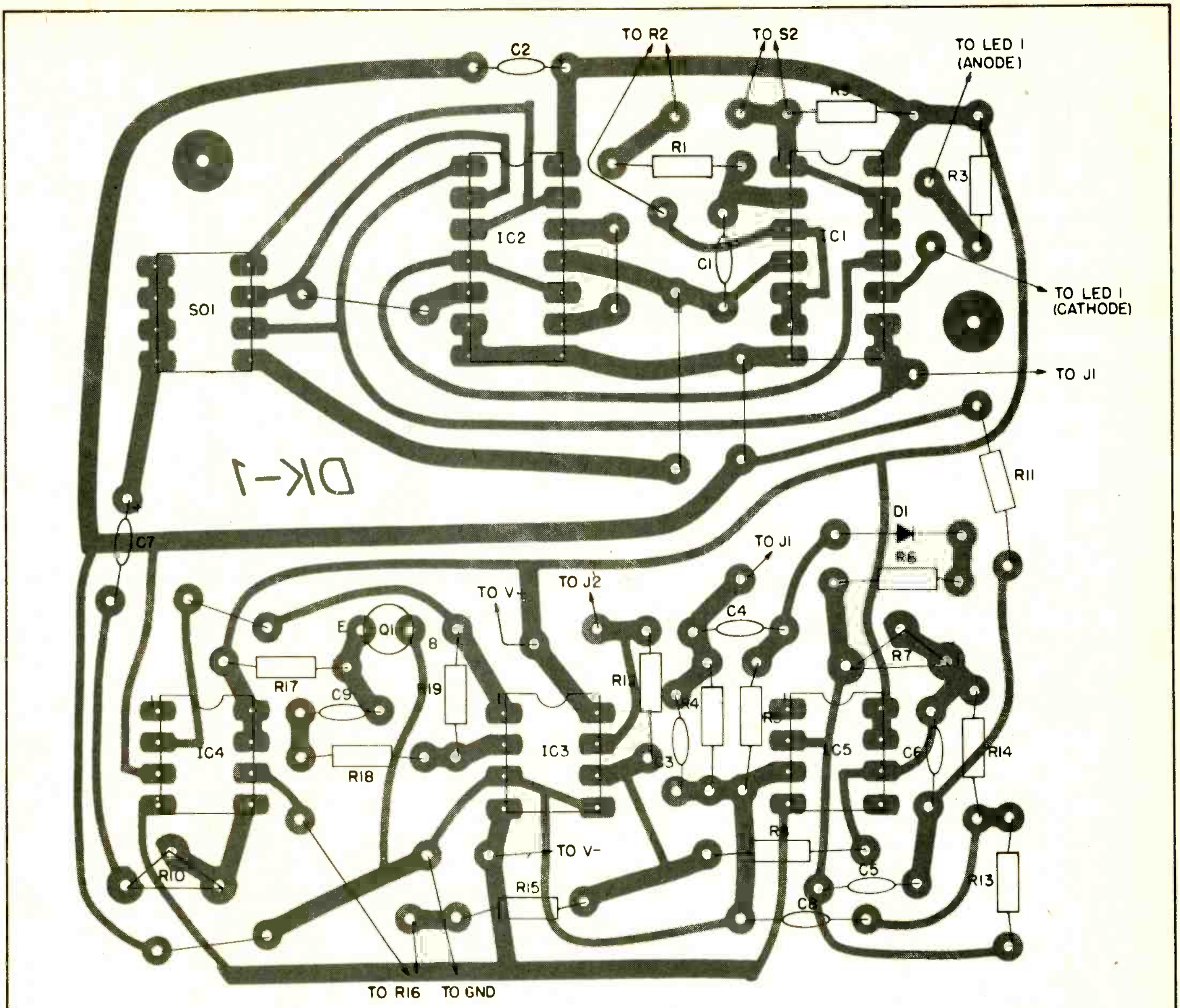


PARTS LIST FOR DISCO KING

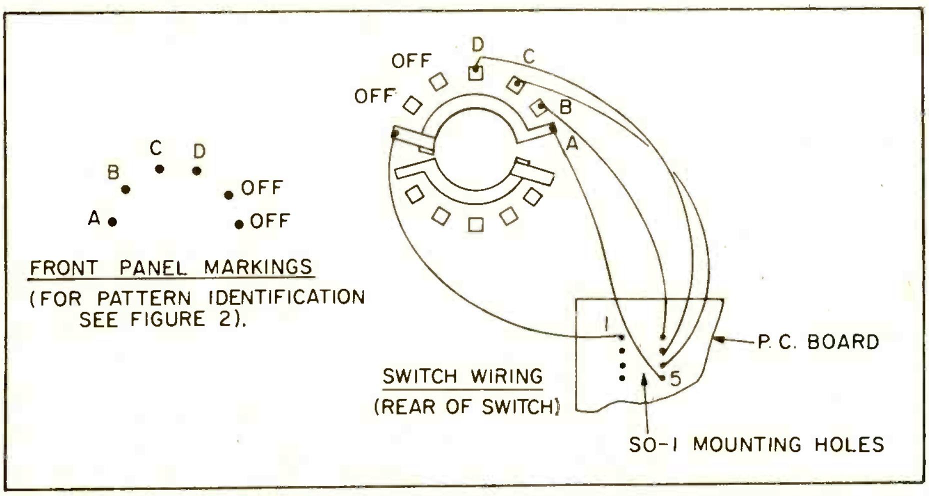
B1, B2—9-volt battery
C1, C3, C4, C5, C6, C8, C9—.1-uF capacitor, disk ceramic, 25VDC
C2, C7—1.0-uF electrolytic capacitor (radial leads), 10VDC
D1—1N4148 or 1N914 diode
IC1—4011 Quad 2-input CMOS NAND Gate
IC2—4013 Dual CMOS D Flip Flop
IC3—Dual 8-pin Op Amp (5558, LM1458 or similar)
IC4—Transconductance Op Amp (CA3080 or CA3080S or similar)
IC5—741 Op Amp (8-pin DIP)
J1—Phono jack, closed circuit, ¼-inch
J2—Phono jack, open circuit, ¼-inch
LED 1—Light Emitting Diode, type NSL5053, TIL32 or similar
Q1—2N2712 transistor
R1, R13, R14—470,000-ohm resistor, ¼-watt
R2—2.2 Megohm linear taper potentiometer, ½-watt
R3—470-ohm resistor, ¼-watt
R4, R5, R6, R8, R9, R12, R19—100,000-ohm resistor, ¼-watt
R7—1 Megohm trim potentiometer, ¼-watt
R10—100,000-ohm trim potentiometer, ¼-watt
R11—4700-ohm resistor, ¼-watt
R15, R18—10,000-ohm resistor, ¼-watt
R16—10,000-ohm linear taper potentiometer, ½-watt
R17—1 Megohm resistor, ¼-watt
SO-1—8-pin DIP socket
S1—DPST slide switch
S2—Momentary pushbutton switch, N/O (normally open)
Misc.—Suitable enclosure, aluminum strip, knobs, wire, solder, hardware, etc.

Note: The following are available from BNB Kits, RD #1, Box 241H, Tennent Road, Englishtown, N.J. 07726; Parts Kit (DK-1) consisting of all electronic parts, controls, switches, jacks, wire and etched and drilled P.C. Board at $18.95. Etched and drilled P.C. Board alone (DK-1PC) at $5.95. Prices include handling and U.S. Postage. Canadian residents please add $1. U.S. Funds only. Please allow 3 to 6 weeks for delivery.

Note: Blank case as shown in photo available from Continental Specialties Corporation, 44 Kendall Street, P.O. Box 1942, New Haven, CT 06509 (DMC-2). Write for current price.



The overlay, shown above, provides you with the placement of all on-board components, as well as the wiring connections for the switches and jacks. Take care to observe correct polarity for diode D1. This view of the board is foil side down, with the parts on top.



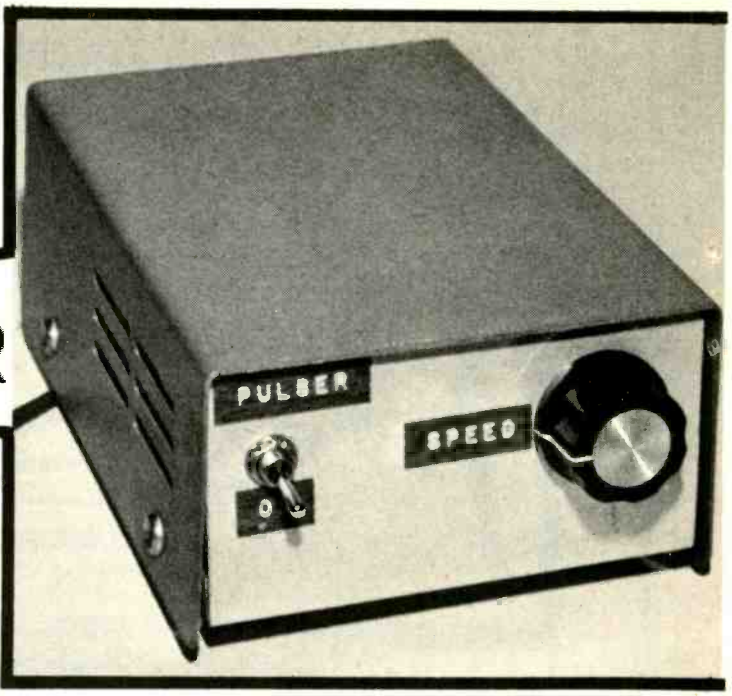
Here's an easy modification to our Disco King! Our own unit uses jumper wires in the SO-1 socket to change the beat but if you'd like a rotary switch could be installed.

hole in the holder. Secure the holder with a #6-32 nut.

Initial Adjustment and Checkout. Set Trim Potentiometers R7 and R10 and controls R2(*Tempo*) and R16 (*Cymbal Level*) to mid position. Connect the output of the unit to a music amplifier or hi-fi. When power is applied, you will hear a repeating base drum sound. Adjust R7 for a non-boomy, short duration "thud" sound. Form a jumper from a short length of #20 or #22 solid wire and insert it into pins 4 and 5 of socket SO-1. Set R2 for medium speed and adjust R10 for a short duration cymbal sound. This completes the adjustments required. To insure the unit is performing properly, check the following. Note

(Continued on page 111)

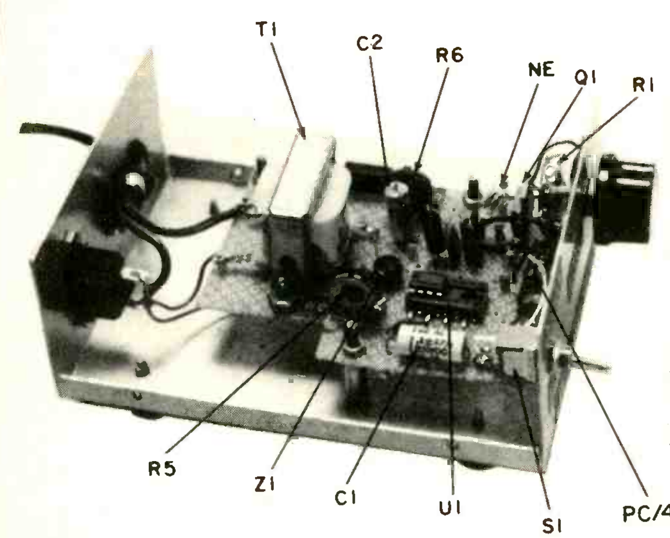
KITCHEN KONTROLLER



Add a new dimension to your culinary artistry—let our electronic chef command your appliances

by Cass Lewart

Here is an inexpensive project—the cost of parts is under $10—which will make many of your kitchen appliances perform better then they were originally designed to. It is a motor speed control combined with an optional automatic on-off-on-off cycling pulser/interruptor. The pulsing feature is particularly important for kitchen blenders, mixers and food processors. The short pause, during which the appliance stops, allows you to see the progress of the food preparation. You can then stop before your food processor grinds and mashes everything to bits. Modern kitchen appliances frequently operate at such high speeds, that a few seconds difference in running time can transform an exquisite meal into meat loaf. Many appliances such as blenders also mix the food better when operating with an on-off cycle, which prevents the food from sticking to one side of the bowl. It should be noted that the duration of both the "on" cycle and the "off" cycle in the Kitchen Helper can be adjusted separately. The continuously variable speed/dimmer control used in conjunction with the pulser adds another desirable feature to many of your appliances. The pulsing/interrupting feature can also be bypassed by flipping a switch, and the Kitchen Helper becomes a regular variable-speed or light dimmer control for your power tools, Christmas lights, Halloween pumpkins, etc. In fact, you may have trouble deciding between the kitchen and the work bench, as to where it should be kept. Don't fret too much, build a pair!



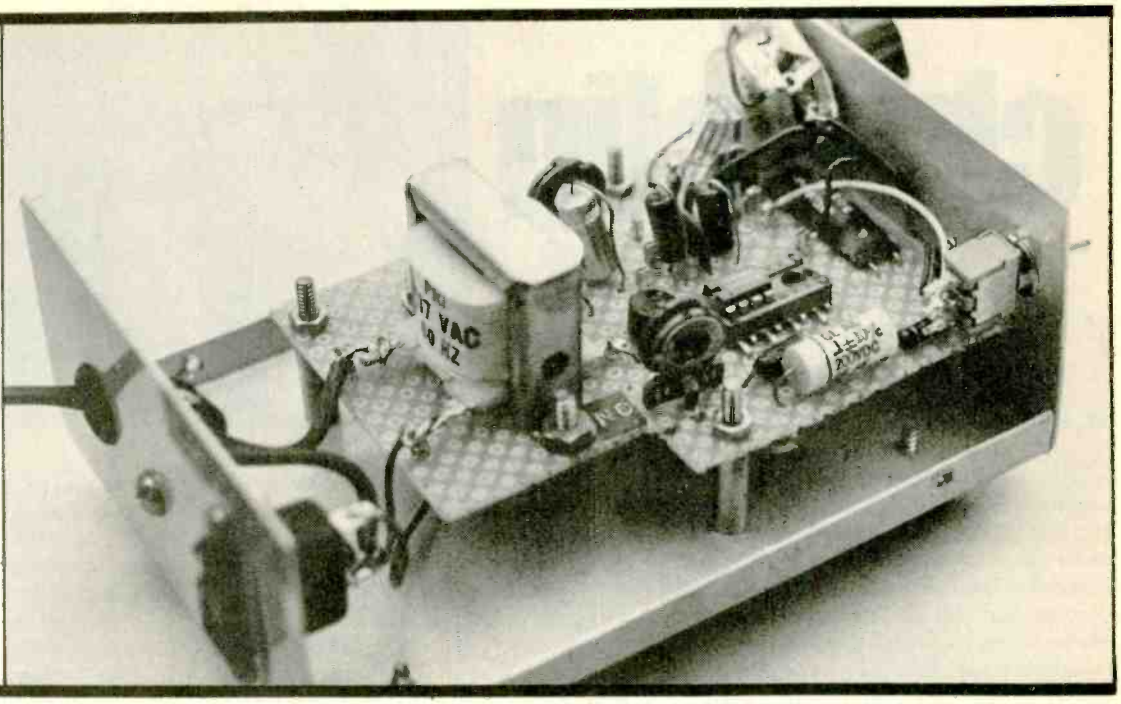
Perfboard construction is the preferred method for building the Kitchen Kontroller, because some components vary in size depending on working voltage and manufacturer style. An IC socket is recommended to prevent damage to the IC from soldering. Be sure to isolate the circuit board from the cabinet.

How It Works. The schematic diagram consists of two distinct sections: The low-voltage on-off pulser with a heart made out of our old friend—the 555 timer (IC1), and the high-voltage section, consisting of a 600-watt/110-volt Triac speed control. A small lamp (L1) and a photocell (PC) tied together, act as a light coupler by separating the high and low voltage sections. When the timing circuit puts a voltage across the lamp (L1), it lights up, the resistance of the photocell decreases, and the Triac conducts. Potentiometers R5 and R6 control independently the "on" and "off" cycles of the timer, with time on—1.1xC4xR5, and time off—1.1xC6xR6. With the values chosen for resistors and capacitors, the "on" and "off" cycles can be set between 0 and 5 seconds. Switch S1, when closed, bypasses the timing section of the circuit. Power for the low-voltage section is provided by transformer T1 with the associated rectifier bridge (Z1) and capacitor C3.

The high-voltage section of the circuit is a standard Triac motor speed/dimmer control for lights and appliances up to 600-watts. Capacitors C1 and C2, resistors R1, R2, R3 and the photocell resistance, set the firing point of the Triac, and vary its duty cycle for conduction. Potentiometer R1 is used as the speed/dimmer control, and neon light NE provides the hysteresis required by the speed control circuit for smooth operation.

Construction. The circuit can be built easily on a 2½ by 3½-inch perf-

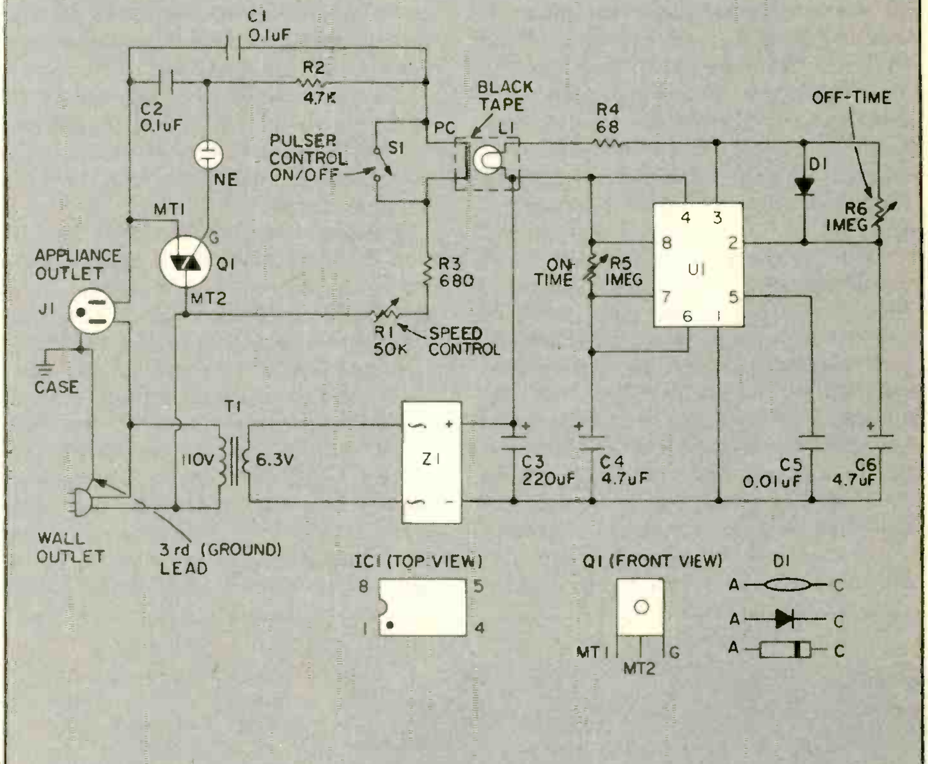
If you decide to put together more than one Kitchen Kontroller, it might be a wise idea to investigate the bulk prices for components offered in the HOBBY MART section at the back of the magazine. The dimmer feature, coupled with the slow pulse timer can be a real bulb-saver with photo-flood lamps, and other high-wattage / high-priced lamps. Be sure not to exceed the load rating of your Triac in use.



board, using point-to-point wiring. No special wiring precautions are necessary, except for the section of the circuit which carries AC voltage. It should be well-insulated, and kept away from the rest of the circuit and the cabinet. We strongly recommend using a 3-prong cable and jack, with the ground wire connected to the cabinet. The light coupler consists of the photocell and the lamp tied together with black electrical tape. Make sure that the active side of the photocell faces the lamp, and that the photocell pins do not touch the lamp wires.

The "on" and "off" controls, R5 and R6, can be mounted externally on the case, or internally on the perfboard. Mounting them inside makes for neater appearance, but changing the timing becomes a chore. We found that 3-seconds "on" and 2-seconds "off" were optimum for most applications.

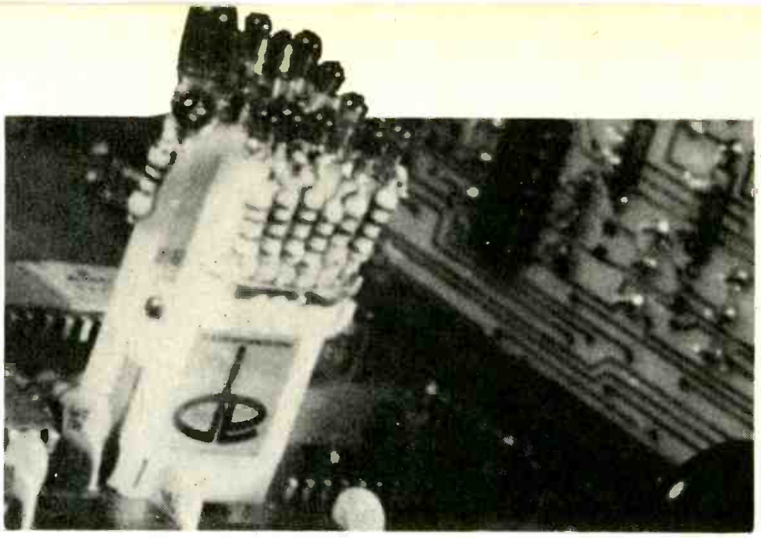
Operation. Operation of the Kitchen Helper is very simple. Plug it into an AC outlet, and plug your appliance into jack J1 on the case of the Kitchen Helper. You can vary the speed or brightness—if you use it as a dimmer—with R1. If you don't need the pulsing feature flip switch S1. That's all there is to it! Bon apetit! ■



PARTS LIST FOR KITCHEN KONTROLLER

C1, C2—0.1-μF, 200-VDC tubular capacitor
C3—220-μF, 25-VDC electrolytic capacitor
C4, C6—4.7-μF, 35-VDC electrolytic capacitor
C5—0.01-μF, 35-VDC mylar capacitor
D1—1N4000 diode
J1—3-prong AC appliance receptacle
L1—6-volt pilot lamp, low current-type
NE—NE-2 neon lamp
PC—CdS photocell (Radio Shack #276-116 or equiv.)
Q1—Triac rated @ 200-volts @ 6-Amperes (GE-X12 or equiv.)
R1—50,000-ohm, linear taper potentiometer
R2—4,700-ohm, ½-watt resistor
R3—680-ohm, ½-watt resistor
R4—68-ohm, ½-watt resistor
R5, R6—1,000,000-ohm, linear taper potentiometer
S1—SPST switch
T1—transformer with primary rated @ 110-VAC/secondary @ 6.3-VAC @ 300 mA.
U1—555 timer
Z1—full-wave bridge rectifier; 200 PIV @ 4-Amperes
MISC.—cabinet, perfboard, hookup wire, solder, knob, AC plug and line cord combo., etc.

Chip-clip



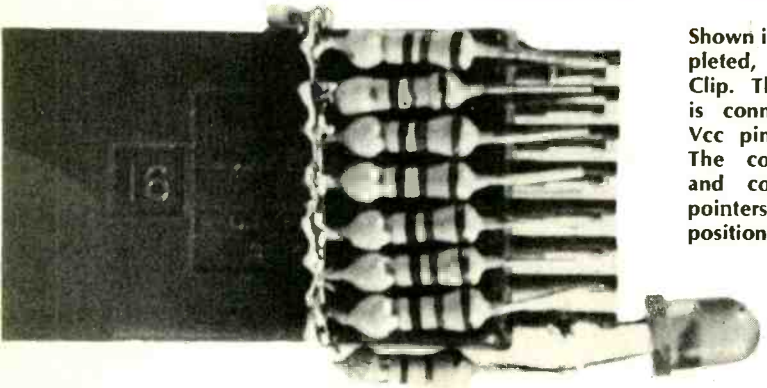
IC testing got you flipping? Don't give up, try Clip-Chipping!

by James Gupton

☐The dual-inline-package (DIP) integrated circuit (IC) is not a really new electronics device; it's been around for more than ten years. While it was the microprocessor and mini-computer revolution that focused attention on this device, even those of us not involved in computers use ICs. For example, tape decks, radios, and television receivers now use them. Unfortunately, ICs are not infallible, and do on occasion breakdown. Due to the compact size of the IC, working space between devices is scant, to say the least. The need for an IC tester becomes apparent when one tries to follow a schematic diagram, manhandle two snake-like probes, and keep one eye on a meter and the other on an IC pin at the same time. That's where our deluxe *Chip-Clip* becomes a necessity.

Most frequently, repairmen come across digital ICs. In digital logic circuits there are only two input and output values (called states), low or high, corresponding to off or on. Most digital logic ICs use a voltage of +5 volts DC for the high state and 0 volts for the low state. We use the low or high voltage to turn off or on a light emitting diode (LED) and let a number of LEDs tell us what the present state is at every IC pin simultaneously. Chip-Clip will close on the small, tightly spaced is high on either or both NAND outputs, there are eight close-quarter voltage measurements that you must make. Imagine how difficult it would be to keep your meter probe in the right spot without wandering and shorting between pins! We have also diagrammed the 7404 hex inverter logic IC. Here we have not two logic devices but six independent inverting circuits. In operation, if a high voltage appears on the input pin, the output drops to a low voltage. Should the input go low, the output goes high. By taking advantage of the high and low voltage states, we can observe the on or off condition of the LEDs and see the status of all six inverters simultaneously. Here, too, the Clip-Chip will prove an invaluable aid.

Building the Chip-Clip. The foundation of the Chip Clip is the standard 14 pin or 16 pin IC test clip available at any Radio Shack store or from any number of electronic mail order firms. To the IC test clip we add subminiature LEDs and a current limiting resistor between each logic test-clip pin and the IC ground pin. As mentioned previously, when low voltage is present on the IC pin, the LED does not light. When +5 volts appears on the logic input pin, the LED turns on. In addition, Chip-Clip has a different color LED on the Vcc connection (pin 14 or 16) to confirm the presence of Vcc IC pins without shorting adjacent pins. Equally important, it can be attached to an IC when there is only a quarter of an inch of space between circuit components.



Shown is a nearly completed, 16-pin Chip-Clip. The green LED is connected to the Vcc pin, number 16. The contrasting size and color serve as pointers to the correct positioning.

To further illustrate the utility of our Chip-Clip, lets take a look at two types of logic ICs. We have illustrated a 7420, quad input, positive, NAND gate. It actually contains two separate four-input NAND gates, one on each side of the DIP. In either circuit, the output voltage will be high if a low voltage appears on any of the four input pins. When all four input voltages are high, the output voltage goes low. Therefore, to find out why the output voltage. The contrasting LED color prevents confusing Vcc indication with a logic indication.

The assembly drawing illustrates the necessary connections for the 14 pin Chip-Clip. If you are building a 16 pin unit, two additional LEDs and resistors are needed for the two extra test points. The IC ground changes to pin 8 and Vcc input changes to pin 16. The additional LEDs are connected to pins 7 and 15. No other changes are necessary.

The ground pin is connected to a common ground wire loop. It consists of two rectangular loops fashioned from 20 gauge solid wire. One of these loops is placed around each edge of the test clip one-half inch down from the top of the plastic. Four 0.028 holes are drilled to anchor the ground bus to the test clip. Since there is one ground bus loop on each half of the test clip, they must be connected together with a short piece of #20 flexible stranded wire to allow free movement of the test clip's sections and enable the test clip to clamp onto the IC DIP pins.

On the 14 pin test clips, six 150 ohm, quarter watt resistors are soldered to the ground bus loop on each side of the test clip and are positioned vertically. The body of the resistors should not stand above the top of Chip-Clip's frame and the resistor leads should be trimmed to the level of the metering pins. The resistor for the Vcc pin is positioned at the same level as the rest of the resistors but instead of being positioned on the side of the test clip, it is placed at the end of the clip next to the Vcc pin.

Finishing Touches Installing the LEDs is only a matter of soldering the cathode LED lead to a resistor and the anode lead to one of the test clip's metering pins. The cathode lead can be identified by its knotch or flat side. Remember, no LED goes to the test clip's pin 7 on a 14 pin Chip-Clip, or pin 8 on a 16 pin one. All oher test clip metering pins have a LED and resistor attached. It should be noted that the specified LEDs have a forward voltage rating of 1.6 volts d.c. and a maximum current rating of 20 mA. For voltages greater than 5 volts at Vcc, a new value of current limiting resistance must be used. (See accompanying box.)

Determining Limiting Resistance

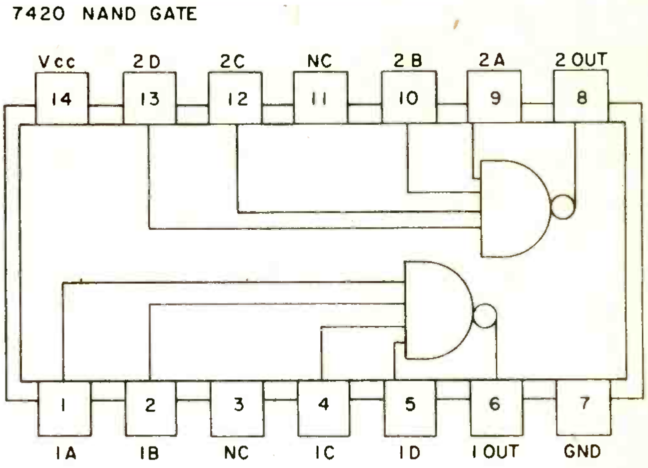
The simplest way to determine the value of current limiting resistance for any value Vcc is by the formula:

$$R = \frac{Vcc - 1.6}{.020}$$

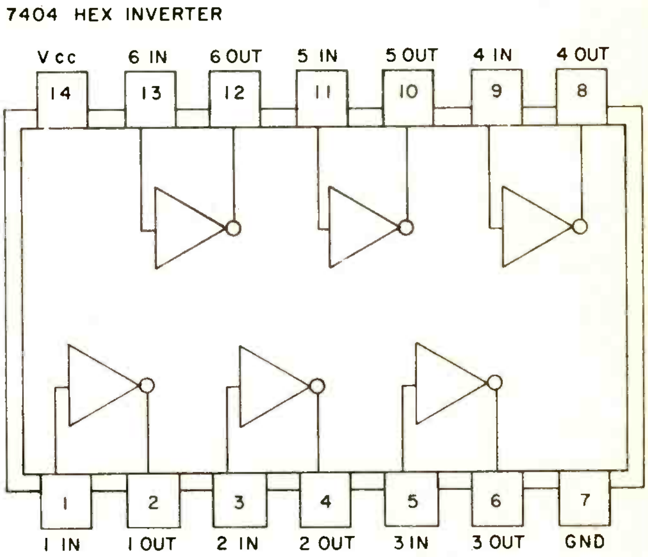
Vcc = voltage greater than + 5 volts.
1.6 = forward voltage of LED
.020 = maximum LED current
R = the new resistance

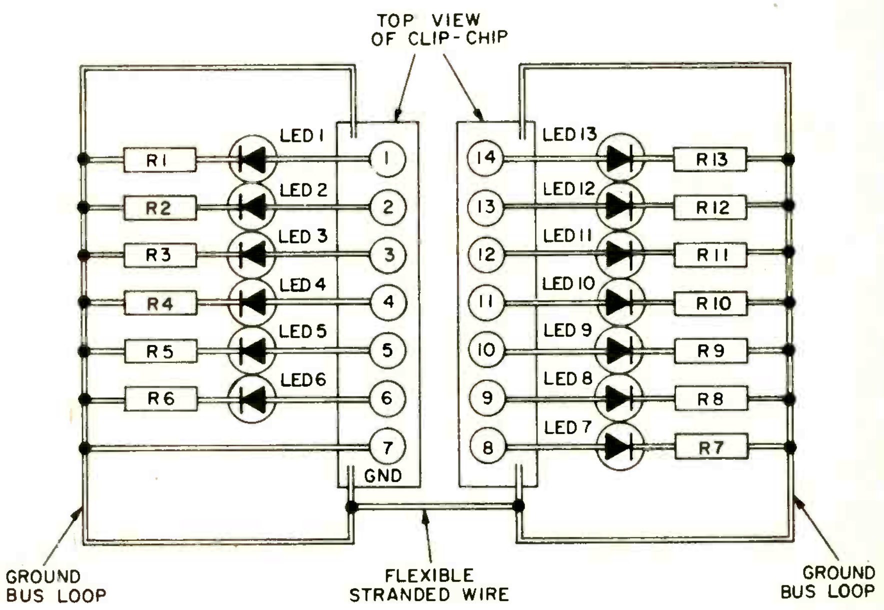
While almost any size LED can be used, the subminiature LED is recommended because of the limited space across the side of the IC test clip. In the author's model, a green emitting LED, jumbo size, was used to indicate the presence of Vcc voltages. The contrasting color prevents mistaking the lit LED as a logic function and serves as a pointer to the correct positioning of the test clip on the IC under test since the Vcc indicator is on pin 14 or 16.

Final Checkout. There are two things to be sure of. Be certain that the LEDs polarities are observed. Also, identify pins 1 and 14 on the 14 pin test clip or 1 and 16 on the 16 pin test clip and always be sure that these numbers always point towards the IC identifying notch, dot, or indenture on the top of the IC case. Final note, while these logic status test clips have been designed only for logic type ICs, it may be possible to employ them for other 14 or 16 pin ICs providing your schematic diagram confirms pins 7 or 8 as ground and pins 14 or 16 as Vcc. If in doubt, *don't use the Chip-Clip.* ■



A NAND unit's output is low only if all inputs are high. If any inputs are low, the output must be high. The 7420 is actually two separate NAND logic units housed in the same package and powered from the same source. An inverter's function is to convert a high signal into a low signal, or vice-versa. The 7404 Hex inverter contains six independent units. Like the 7420, the only interfaces are common packages and Vcc inputs.





Composite wiring-component placement drawing for 14 pin Chip-Clip. The LEDs are shown connected to the test clip's metering pins. They are attached to the current limiting resistors which are in turn all fastened to the ground bus loops. The ground bus loops must be firmly anchored to the test clip. Flexible wire connects both loops electrically making them into a common ground wire loop which is wired to pin 7.

★ PULSTAR

Here's the universal digital clocking source you always needed but couldn't afford

by John Rasmussen

IF YOU HAVE BEEN INVOLVED in designing and building digital circuits, you have undoubtedly found a constant need for a handy clock signal source of some kind. There are several ways of satisfying this need. One way is to build a simple R/C oscillator whenever you need one. Another way is to build a fixed-frequency crystal oscillator, and divide the output frequency down to whatever frequency you want. Any of these methods will do the job in most cases, but it invariably involves building something special for each particular case, and tearing it down again when it is no longer needed. Of course, you could also buy one of the commercially available pulse generators if your budget can stand the price tag of $150.00 and up.

We have another solution for you—a simple pulse generator based on two CMOS ICs. It covers a frequency range of 1 Hz to 1 MHz, and has a pulsewidth variable between 0.5-seconds and 0.5-microseconds. It features three modes of operation: Free running, Gated oscillator, and Single Shot, with either external or internal triggering.

The unique thing about this design is that it is powered from the same power supply as the circuit it is driving. This means that you can use the pulse generator to drive both CMOS and TTL circuits, as the drive level will always match the circuit you are testing. It also saves you the cost of a separate power supply for the pulse generator.

The Circuit. Referring to the schematic diagram, it can be seen that the basic pulse generator consists of U2 and U3, which are both 4047s, a low-power CMOS Astable/Monostable multivibrator.

U2 and associated circuitry form an oscillator circuit with a 50% duty-cycle in the free running mode. In the monostable mode, it is a one-shot oscillator which may be triggered either from an external source or from the internal pushbutton.

S4 controls the mode of operation. In the free running mode, it grounds pin 8 and pin 9 of U1, thereby keeping pin 6 of U2 high, and pin 8 of U2 low. This enables the astable mode of U2. Neither the trigger input or the pushbutton have an effect on the circuit operation in this mode, because pin 5 of U1 is held high.

When S4 is in the free running position, pin 5 of U2 may be pulled low by a low input on GATE IN. This allows U2 to operate as a gated oscillator. When GATE IN is pulled low, the operation of U2 is inhibited.

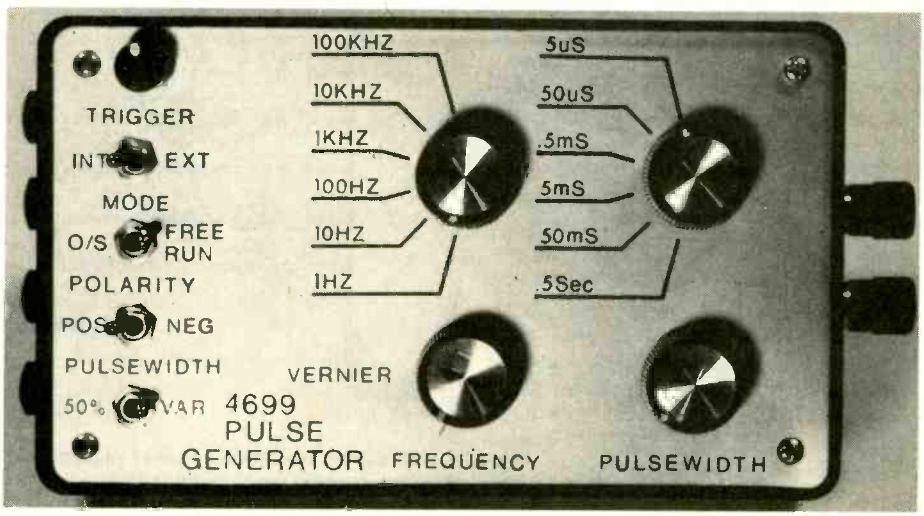
With S4 in the one-shot position, U2 operates as a one-shot oscillator. In this mode, U2 is triggered by a low-going signal at pin 6 of U1. This low-going signal may originate from an external source (if S3 is in the EXT TRIG mode) or from the de-bounced pushbutton switch, if S3 is in the INT TRIG mode. Two sections of U1 are used to de-bounce the push button switch.

The components which determine the operating frequency of U2 are capacitors C1 through C6, and resistors R6 and R8. S1 allows frequency adjustment in decade steps while R8 is a vernier control allowing adjustment of the output to the exact frequency required.

U3 operates continuously in the astable mode. It is used to generate an output signal with a variable pulsewidth, and is triggered on the rising edge of the waveform output of U2. The components which determine U3's pulsewidth are C7 through C12, and R7 and R9.

S5 allows a choice of either a positive or negative-going output pulse. S6 allows a choice between an output signal with a 50% duty-cycle, or one with a variable pulsewidth (adjusted by R9).

The output signal is buffered by U4. Only one section of the six buffers contained in the chip is shown on the schematic, although all the buffer sections can be driven in parallel to provide as many as 12 (each buffer can drive 2 TTL or DTL circuits) outputs. Check the wiring diagram provided

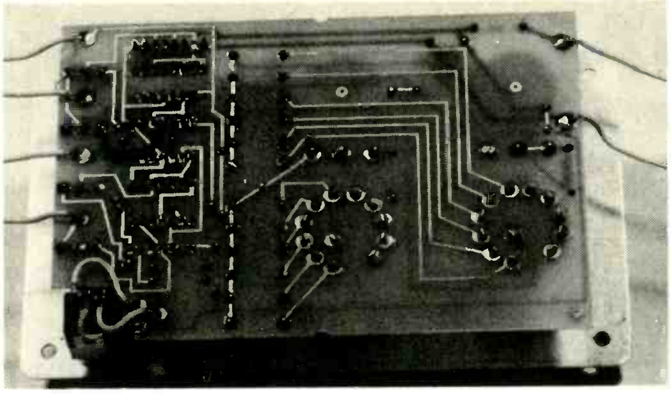


This professional-looking finished product was completed with the aid of a dry lettering transfer kit, which is available in most art supply stores for a usually very low price.

with the chip for the pin numbers of the additional buffers.

Construction. Assuming that you will utilize a PC board for assembly of the pulse generator's circuitry (and we suggest that you do), take note of the fact that the PC board that must be used for this project is a double-sided one, with copper foil on both sides of the board. We have provided two templates for this purpose. Template "A" is to be used to create the foil pattern on the underside of the board (the side opposite the component side). Template "B" is to be used to create the foil pattern on the component side of the board. Depending upon what etching method you use, you may have to etch one side, and then repeat the process for the other side, or you may be able to etch both sides in one single process. Check the directions with your etching kit before proceeding with the etching process.

Once the board is completed (and after you have visually inspected it for accuracy and compliance with the original template) solder all of the components (except the ICs) to the "B" side, following the component layout diagram we have provided. We strongly suggest that you utilize IC sockets, especially for CMOS chips, since they are susceptible to damage from static charges emanating from your body, as well as stray AC from a soldering iron.



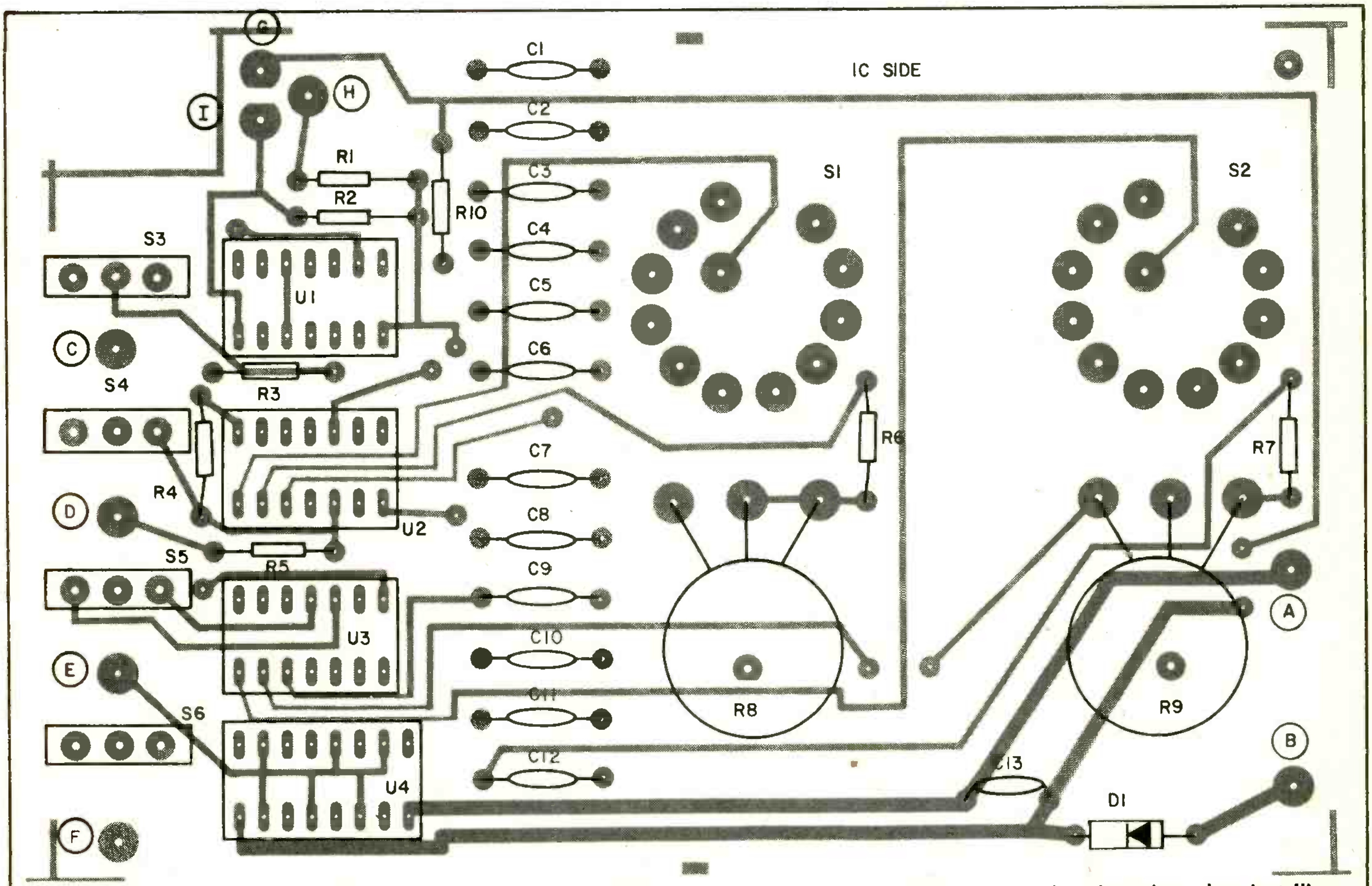
This photograph shows the foil pattern of the PC board. Use the template on the next page to obtain similar results in building your own PULSTAR.

The only component which is not mounted on the board is switch S7. As you can see in the photograph, S7 is connected to the board by three jumper wires to points G, H and I.

In order to mount switches S1 and S2 on the PC board, the wiper and the topmost terminal of the unused second sections must be cut away. In addition, the wiper of the section that *is* to be used must be bent down slightly to accommodate the holes drilled in the PC board.

Applications. This pulse generator may be used to check out all kinds of digital circuits. Its wide frequency range and operating voltage make it very adaptable. The variable pulse-width feature enables you to check a circuit for sensitivity to variation in clock pulse width.

Let's say a circuit using CMOS ICs with long counting chains, and both positive and negative edge-triggered flip-flops was to be tested. Such a circuit, due to the relatively high propagation delays in the CMOS ICs, may



This is the component placement guide for the printed circuit board. Be certain that you observe correct pin orientation when installing the integrated circuit sockets. Switches S1 and S2 can be mounted directly on the PC board. Refer to the text for mounting instructions.

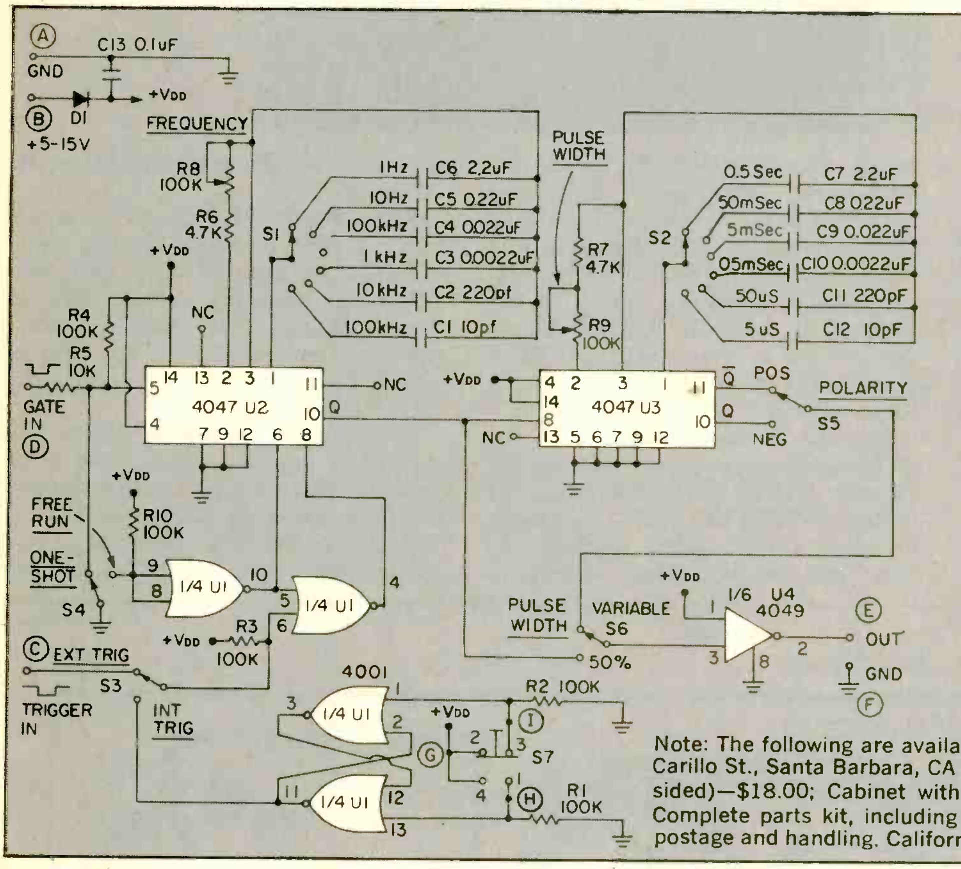
PULSTAR

be sensitive to clock pulsewidth variations. With this pulse generator, you will be able to check the operating margins of such a circuit.

If you wish to drive a TTL circuit at 1MHz with this pulse generator, it may be done by operating the pulse generator from a voltage source between 10-volts and 15-volts and by using an external type 4050 IC to level-shift the output pulse to the TTL level. The 4050 would be powered from a 5-volt source.

The pulse generator is not calibrated per se. The component values are chosen so that the ranges are overlapping on both ends of the vernier control. It was designed so, in order to accommodate the changes in the operating frequency and pulsewidth associated with different supply voltages. It is suggested that either a scope or a

(Continued on page 114)

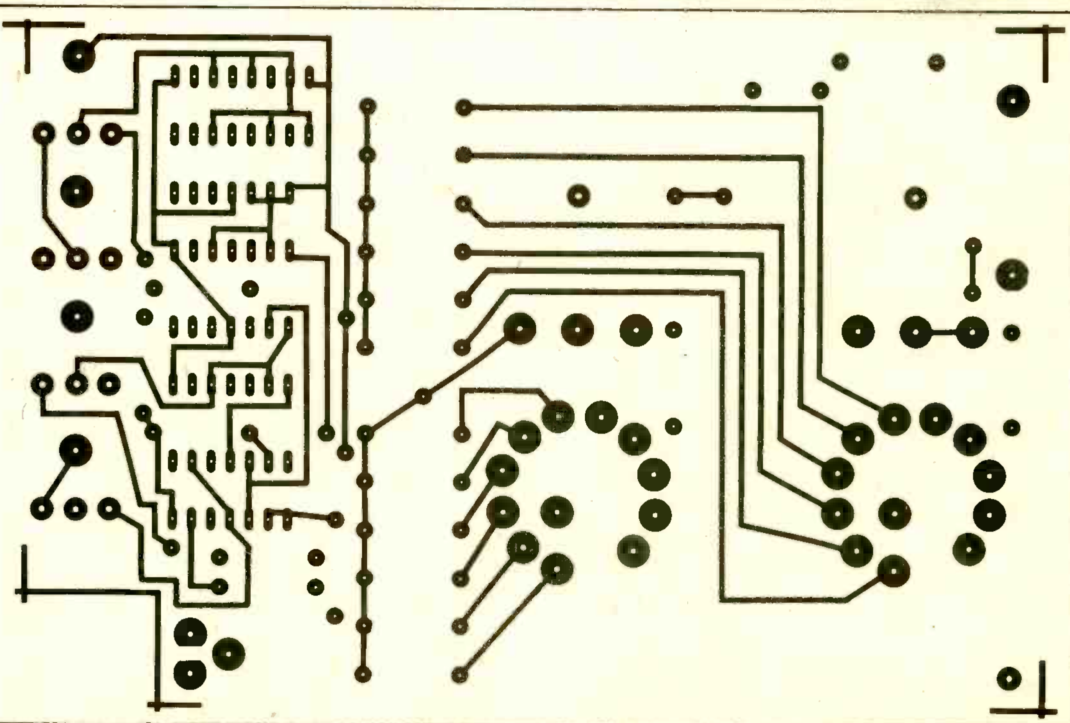


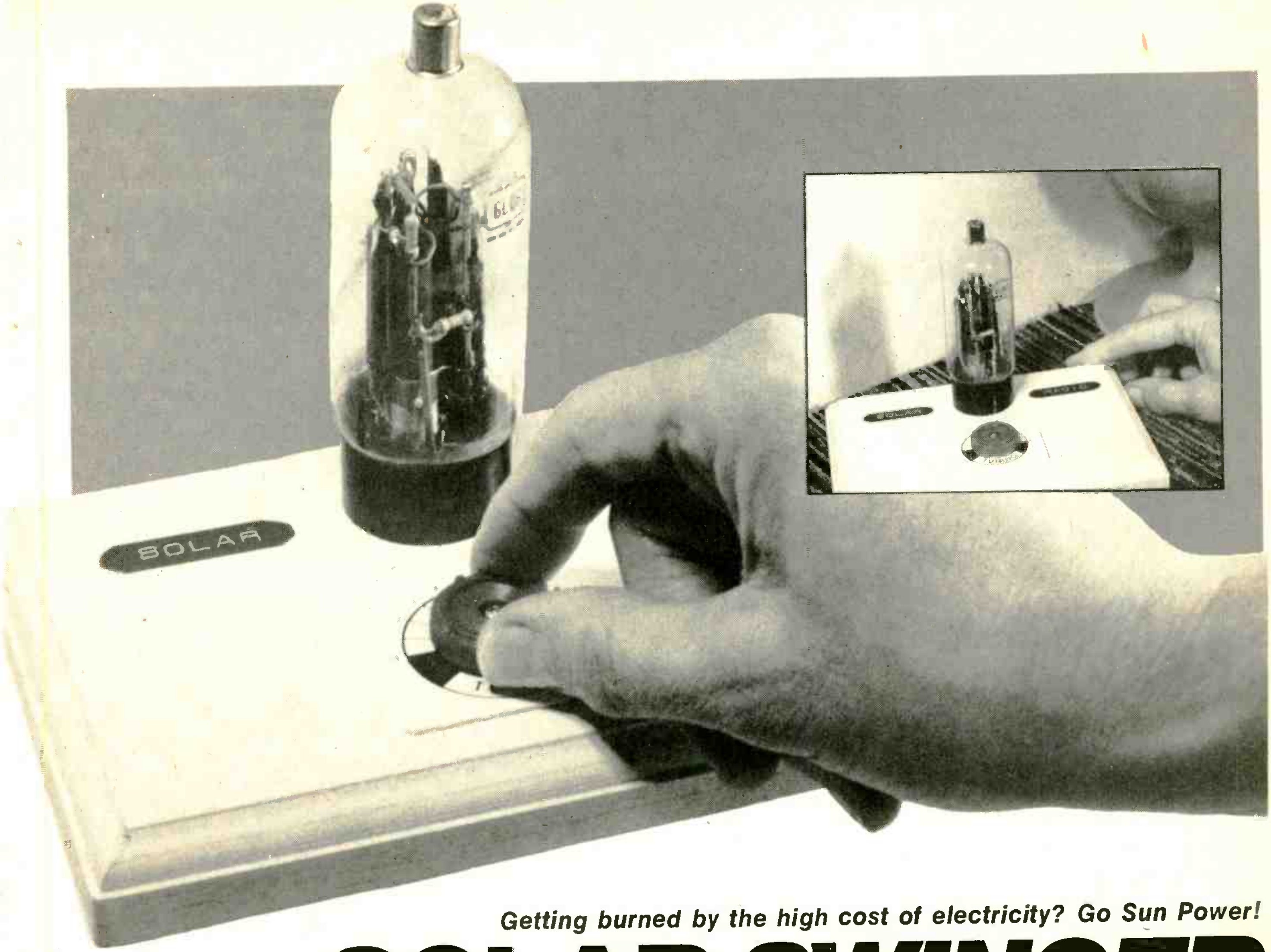
PARTS LIST FOR PULSTAR

- C1, C12—10-pF ceramic disc capacitor, 100-VDC
- C2, C11—220-pF ceramic disc capacitor, 100-VDC
- C3, C10—0.0022-uF mylar capacitor, 100-VDC
- C4, C9—0.022-uF mylar capacitor, 100-VDC
- C5, C8—0.22-uF mylar capacitor, 100-VDC
- C6, C7—2.2-uF tantalum capacitor, 25-VDC
- C13—0.1-uF ceramic disc capacitor, 100-VDC
- D1—1N4148 diode
- R1 to R4, R10—100,000-ohm, ¼-watt resistor
- R6, R7—4,700-ohm, ¼-watt resistor
- R5—10,000-ohm, ¼-watt resistor
- R8, R9—100,000-ohm, linear-taper potentiometer
- S1, S2—2-pole, 6-position, non-shorting rotary switch (Radio Shack #275-1386)
- S3 to S6—SPDT toggle switch
- S7 — SPDT momentary-contact pushbutton switch
- U1—CD4001 quad NOR gate
- U2—CD4047 astable/monostable multivibrator
- U3—CD4047 astable/monostable multivibrator
- U4—CD4049 inverting hex buffer
- U5—optional CD4050 non-inverting hex buffer (see text)
- MISC: binding posts, knobs, plastic case, IC sockets (three 14-pin DIP, one 16-pin DIP), dry letter transfer kit for faceplate lettering, etc.

Note: The following are available from Engineering Resources, 221 W. Carillo St., Santa Barbara, CA 93101: Screen-printed PC board (double-sided)—$18.00; Cabinet with front panel drilled and labled—$15.00; Complete parts kit, including all of the above—$65.00 plus $3.25 for postage and handling. California residents add 6% sales tax. No CODs.

This is the full-scale circuit board template for PULSTAR. Check your finished board for unwanted foil bridges and continuity of the long foil paths before attempting to assemble the project. This precaution can save a lot of headaches later on.





Getting burned by the high cost of electricity? Go Sun Power!

SOLAR SWINGER

Homer L. Davidson

HAVE YOU EVER seen a model ship inside a bottle? The next logical step is to build a small radio inside of a radio or TV vacuum tube! We call it the *Solar Swinger* and it has no on/off switch, batteries or power supply. If you want to turn the Solar Swinger off, just place a cap or hood over the tube. You may want to let it play all the time—it doesn't hurt a thing. No need to worry about batteries running down, for the little radio is solar powered. It will operate in the sun, shaded daylight or under a desk lamp in the evening. Of course, the radio won't blast your ear drums with music, but you can listen to local AM broadcast stations with ease.

Tube Preparation. Select a defective radio or TV tube with a bakelite base. The larger the glass tube, the greater building area for the small radio components. An antique radio tube is ideal, but not necessary. If you can't find one in the junk box, check with your local Radio-TV shop—they may throw out several hundred of these old tubes every year.

There are many old power output tubes available, such as 6L6G, 6C6G and 5U4G. Don't select a 6BK4 type as you cannot remove the top metal anode from inside the glass envelope. You may use a large tube (6LQ6) with a glass base and then mount it on top of a black tube base. Pickup five or six old tubes to practice on.

Before attempting to remove the bakelite base from the tube, let air into the bottom of it. All radio and TV tubes operate with an internal vacuum —the air having been pumped out. A small glass seal is located at the bottom of the tube.

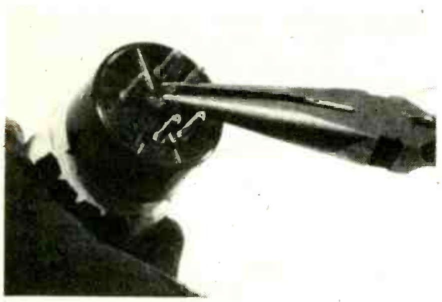
Always wear a pair of gloves when working around glass or warm components.

Now you want to let air back inside the tube. Break off the black bakelite center key locator between the tube side the tube. Break off the black bakelite center key located between the tube prongs. You should see the pointed glass seal. Take a pair of long nose pliers and break off the glass tip. You may hear a rush of air, or see a couple of white areas form near the bottom of the tube envelope.

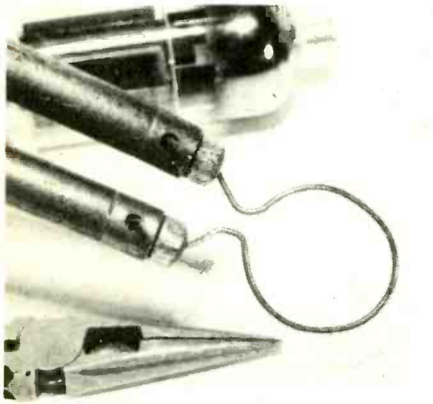
To prevent glass pieces or excess solder from falling on the floor or work bench, do all of the glass preparation inside of a large pasteboard box.

Next remove the soldering iron tip from a 150 or 250 watt soldering gun. Take a six-inch piece of number 14 copper wire, (you can remove the insulation from a piece of number 14 romex or a single conductor electrical wire for this purpose) and form a loop shaped soldering element. Wrap the bare wire around the base of the tube next to the bakelite base area and insert about one inch into the gun tip and bend over. Tighten down the soldering iron nuts—real tight. After cutting a couple of glass bases you may want to snug up the soldering iron nuts for a greater transfer of heat. Keep the copper loop close to the gun tips so

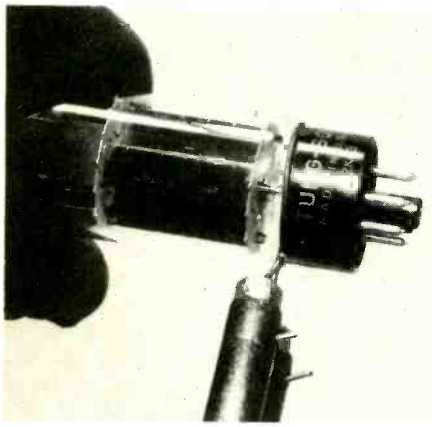
SOLAR SWINGER



Break off the black tube-locator pin and the glass tip with some long nose pliers.



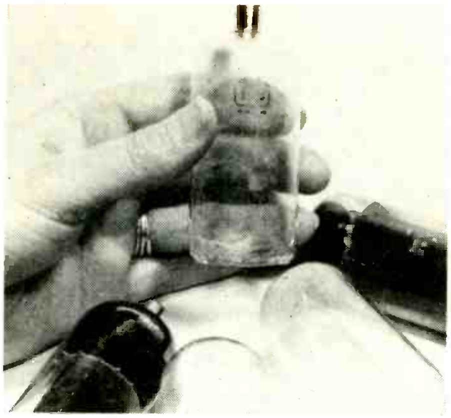
Form a loop of copper wire that fits snug around the tube and into a soldering gun.



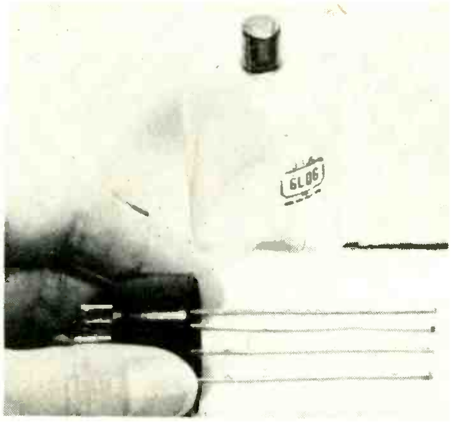
Put the loop over the part of the tube you wish to cut and hold the tube firmly. Wear gloves to keep from burning yourself on the hot glass. Next apply heat to the loop and rotate the tube until the glass cracks.

the loop will heat up faster. Pinch it close together, and snug, clear around the tube with a pair of long nose pliers. You have now constructed a copper wire loop to replace the soldering iron tip.

Slip the wire loop over the end of the tube base and press the loop together at the ends—but not so close as



Note the clean easy cuts this technique produces. Make sure you have a back-up tube.



The four copper support wires are soldered into the pin bases. The components are soldered and glued to these supports.

to touch. Now hold the tube in the left hand and soldering gun in the right. Very slowly turn the vacuum tube inside the heated loop. Within a few minutes you will hear the glass crack and break in a perfect cut at the base of the tube. Some glass tubes take longer to break than others. In the meantime you may smell a hot bakelite odor from the wire loop, which is normal. Often the glass will crack clear around and just a tap on the end of the bakelite base separates the two pieces.

If you have selected a tube with a metal cap on top, turn the inside components until the connecting wire breaks off. Be careful not to break the remaining glass envelope, which is very brittle. It's best to cut off the wires connecting the tube elements to the base with a small pair of side cutters. In case the tube elements and mica insulators will not pull through the small opening, use a pocket knife to cut out sections of the insulators. You may have to crush or remove the tube elements in sections. Again, proceed slowly to prevent breaking the glass envelope. If you break or crack the tube envelope, start on another one—one out of three is not a bad average.

If you choose a TV tube with a glass base (6LQ6), press the copper loop around the prongs and against the glass bottom of the tube. Break off the small glass seal between the prongs and let air into the tube. Heat up the soldering gun and rotate the tube until the glass cracks in a round circle. Now break and crush the glass base with the wire tube prongs into little pieces. Be very careful in removing the tube elements, they must be reduced in size until all parts fit through the small opening. You may want to cut and remove each element piece individually until all parts are removed from the tube envelope. Later on, you can glue this glass envelope over a separate bakelite tube base.

It's best to cut out three or four tube envelopes. After removing the tube elements, choose the best one. If the glass edge is a little irregular, don't worry; when placed upon the black base the area will be covered with rubber silicone cement and will look like it belonged there all along. Now wash out the white and dark areas inside the glass envelope.

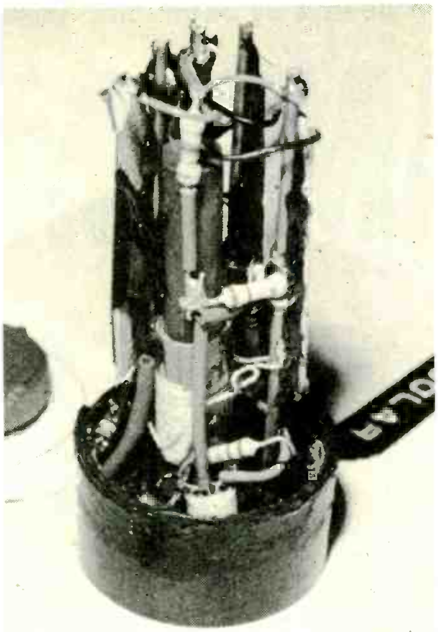
Tube Base Preparation. To remove the remaining glass and connecting wires from the tube base, each tube prong must be unsoldered. Hold the tube base upright and over a pasteboard box. Apply heat from the soldering iron against each prong. Let the excess solder begin to boil and then fling the tube base downward and the excess solder will fall into the bottom of the pasteboard box. Use this method on each tube prong a couple of times to remove all of the solder. After the excess solder has been removed, pull the connecting wires out of the tube base area. You may have to break the glass in several pieces to remove some stubborn connections. Clean out the excess glass cement with a pocket knife and place the tube base with the glass envelope for safe keeping.

Tube Base Construction. Cut four pieces three inches long, of number 14 or smaller copper wire. These four support wires will become tie-in circuit and mounting supports for the small components. You may use any stiff wire for these supports as long as the wire itself can be soldered. Number 14 copper wire will just fit inside the tube pins and solder should be fed up from the bottom terminal. Also, you may solder the wire supports from the top side, down inside the tube base. Place support wires in terminals 1, 2, 6 and 8. Look at the bottom of the bakelite socket and start with Pin #1, to the left of the center pin. (Although the tube locator pin is broken off you still can see where it was located.)

After all support wires are soldered into position, clean excess solder from each wire with a pocket knife. Scrape off rosin and excess solder down inside the base, next to the support wires.

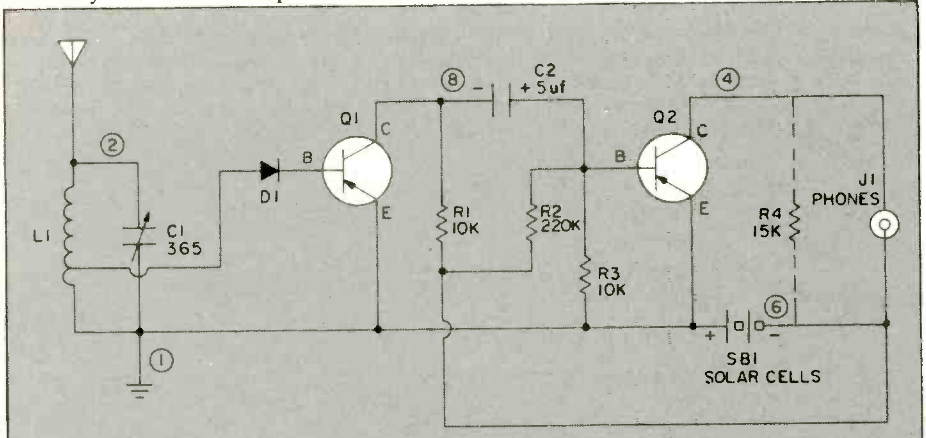
Place a 6-32 ¾ inch machine screw and washer in the center hole of the tube socket. Slip a nut on the outside of the screw to hold it in position until the socket can be bolted to the wooden base. Temporarily, slip the glass envelope over the support wires to see if they will clear the top area. You may use longer support wires if the glass envelope is a lot longer in length. This may help string out the parts and keep them from shorting against each other. A cut glass envelope from a 5U4GT tube runs about three inches long.

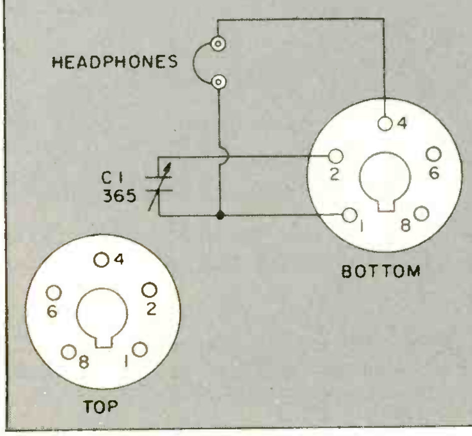
A tube's pin terminal connections (bottom view) are shown. Remember the tie-wire supports are reversed when the tube socket is upright. Scratch a line straight up from the tube locator pin, along the side of the socket, with a pocket knife. Now place a piece of masking tape around it and mark the support wires. You can now solder to your heart's desire. The four supports will be used for component tie points and they are marked upon the sche-



The photo cells are mounted on two sides of the frame. The loop stick fits neatly in the middle of all the components. The transistors are in the base of the tube.

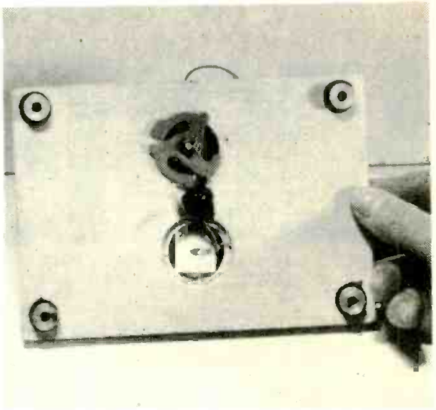
matic. Wire support number 8 is used only as a wiring tie-point for the small components. All other support terminals will be tied into the circuit after the tube socket is bolted to the wooden base.





PARTS LIST FOR SOLAR SWINGER

C1—365-uF variable capacitor
C2—5-uF electrolytic capacitor, 15-volts
D1—1N34A germanium diode
J1—any jack to fit headphones
L1—ferrite antenna coil (Radio Shack 270-1430 or equiv.)
Q1, Q2—2SA52 transistor (RCA SK-3003, GE-2, Radio Shack 276-2004)
R1, R3—10,000-ohm resistor, ¼-watt
R2—220,000-ohm resistor, ¼-watt
R4—15,000-ohm resistor, ¼-watt
SB1—two solar cells (Radio Shack 276-120 or equiv.)
Misc.—headphones of 1000-2000-ohms; ¾ bolt and nut; tube base; old tubes; wooden plate; etc.



The only wood work needed is to make two large holes in the base. One for the tube and one for the tuning capacitor. A bolt through the base holds the tube in place.

Wiring in the Parts. Mount the antenna coil (L1) in the center of the support wires since it is the largest component. Solder the top wire to pin 2 and the bottom terminal to pin 1. Leave it loose until all parts are soldered and then use a dab of silicone cement to hold it in place. Solder the collector terminal of Q1 and negative terminal of C2 to support wire number 2. Keep the leads fairly short and place a pair of long nose pliers next to the transistor body as a heat sink. The emitter terminals from each transistor will tie to terminal support number 1.

Now solder in all small components to their correct support wire terminals. Place a piece of spaghetti over the collector wire of Q2 and solder into pin terminal 4. if it is long enough. If not, lengthen the terminal wire with a piece of hookup wire. Connect the small diode between the coil tap (L1) and the base terminal of Q1. Slip a piece of spaghetti over the wiring to prevent touching of other components.

Mount the solar cells last—inside the tube area. Be careful to observe correct wire polarity. The positive terminal will solder to terminal 1 and the negative wire to 6. After all wiring has been completed inside the tube socket, double check each component and tie wire before bolting to the wooden base. Now tack the antenna coil (L1) and solar cell into position with a dab of silicone cement.

Base Layout. You may pick up a wooden base mounting plate at any novelty or hobby store. Ours was 6¾ by 4½ and cost .99 cents. They may come in many sizes and shapes with a higher or lower price tag. Mark the parts layout on the bottom side of the wooden base. The tube socket may be mounted 1½" from the rear and in the center of the base plate. Place a

(Continued on page 111)

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:

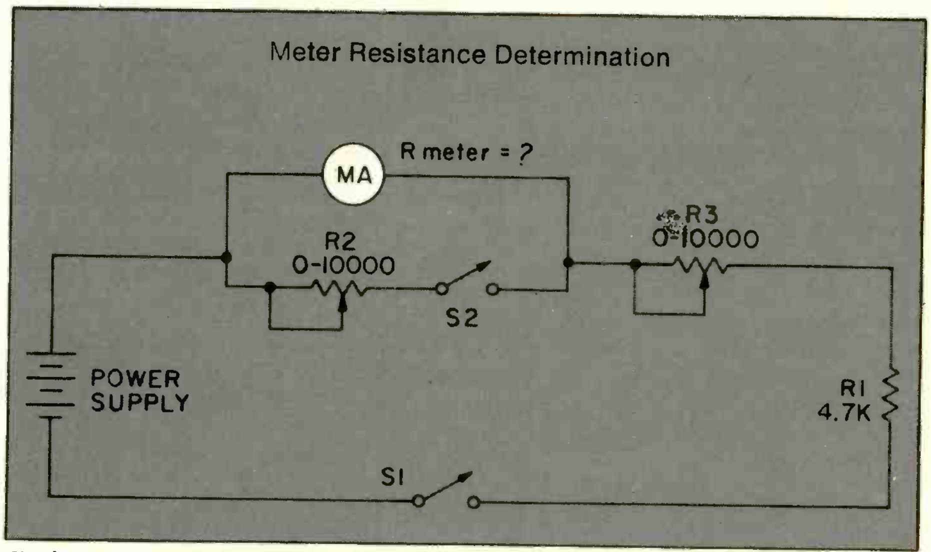
$$E = (\text{Current}) \times (\text{Resistance})$$
$$= (0.01 \text{ amps}) \times (100 \text{ ohms})$$
$$= 1 \text{ volt}$$

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

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

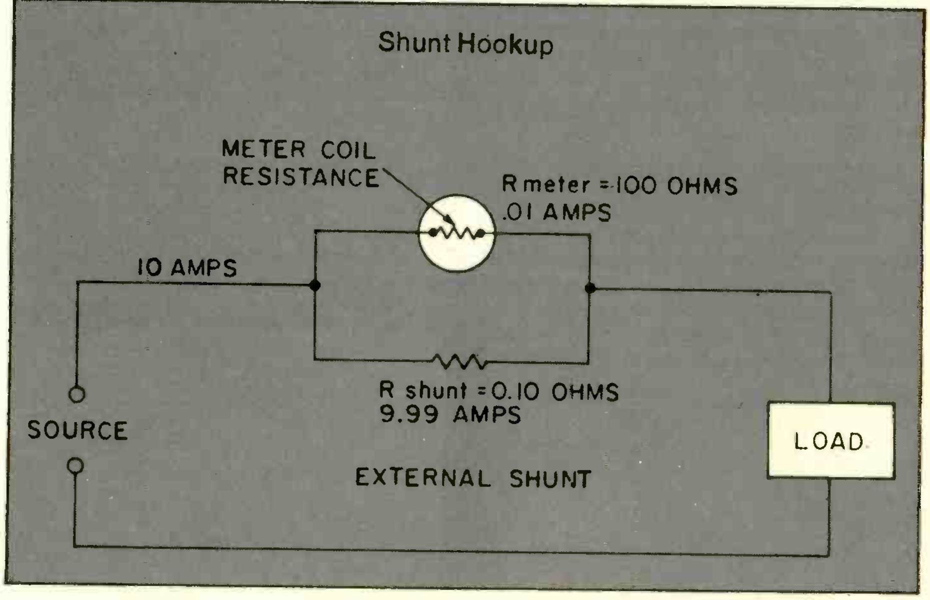
In this case the milliammeter would be capable of giving a readout directly in amperes.

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.



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DIAGONAL

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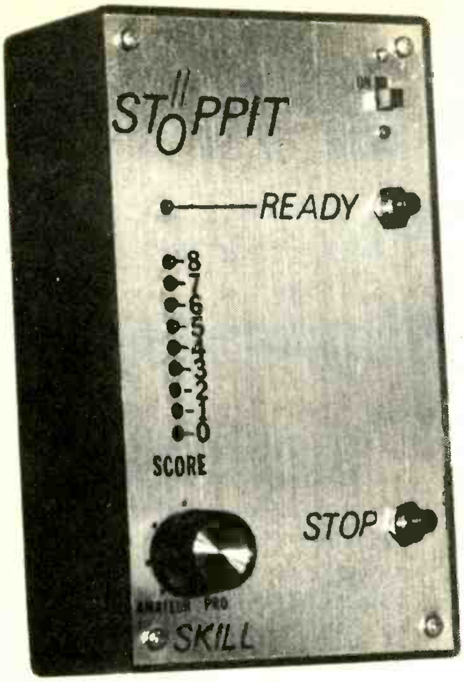


STOPPIT!

Are your reflexes faster than a speeding LED?

by James J. Barbarello

HOW FAST CAN YOU REACT? One way to find out is by playing our LED game, named *Stoppit.* Start by pressing and holding the *ready* button. The ready LED will light and remain on for an unspecified time. Then the light will begin "falling" at a speed determined by the *skill* control (the illuminated light will extinguish and the one below it will go on, and so forth). If the zero position is reached, this light will remain on until the game is reset by pressing the *ready* button.

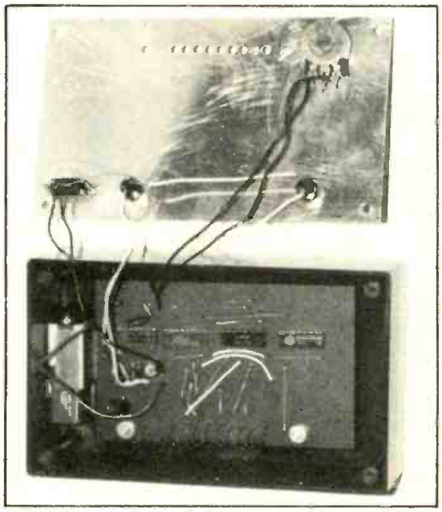
The object of the game is to stop the action as quickly as possible (thus earning a high score) by momentarily depressing the *stop* button. Since the *ready* button must be held down until the action starts, you must be quick to reach the *stop* button and obtain a high score.

Stoppit uses readily available CMOS devices, is powered by a single 9 volt battery and can be built for between $15 and $20.

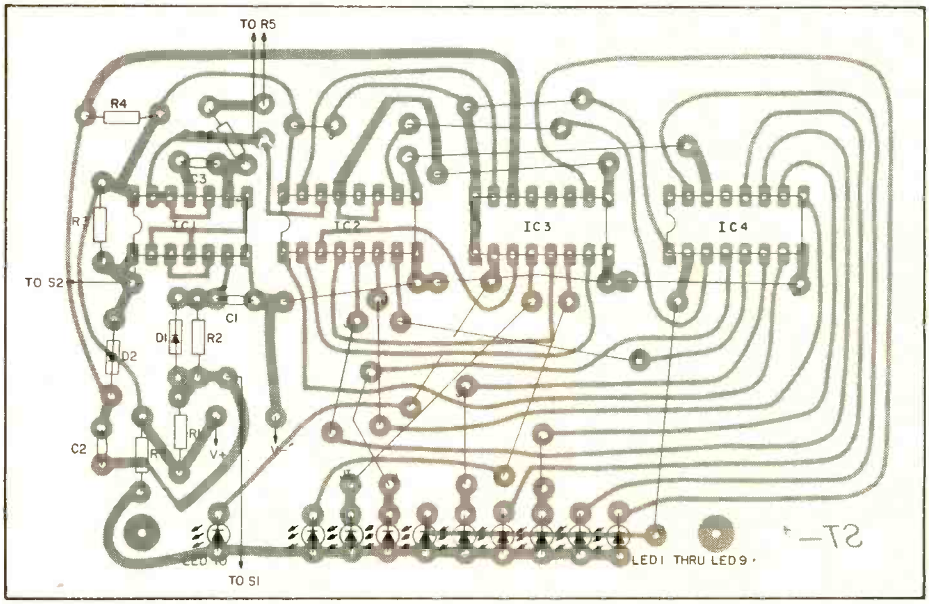
How It Works. The "heart" of Stoppit is a 4017 CMOS Decade Counter with decoded outputs. It contains 10 output pins that are sequentially energized (count from 1 to 10) with each input clock pulse. Only one output at a time is high. A high input to reset pin 15 will set the count to 1. A high input to enable pin 13 will stop the counting.

As seen in the schematic diagram, the decade counter's (IC2) outputs drive 10 inverting buffers. When any one of the counter outputs goes high, the corresponding buffer output goes low and sinks sufficient current to allow the associated LED to light. R7 limits the current drawn by the LED. The last output (pin 11) is also connected to the *enable* pin. This output is low until the last count, allowing IC2 to sequence. At the last count, pin 11 goes high, energizing L1 and disabling IC2.

Another way of stopping the count is by stopping the input clock signals. IC1, a Quad 2-input NAND gate serves two purposes. It is used to form a gated clock oscillator (IC1C and D) and an R/S (Reset/Set) Flip Flop (IC1A and B). When S1 is closed, a negative pulse is transmitted through C2 which resets the R/S Flip Flop through D2. This causes the "Q" output (Pin 4 of IC1B) to go low and the "Q" output (Pin 3 of IC1A) to go high. The negative pulse is also inverted in IC3F and resets IC2. At the same time, C1 begins to discharge



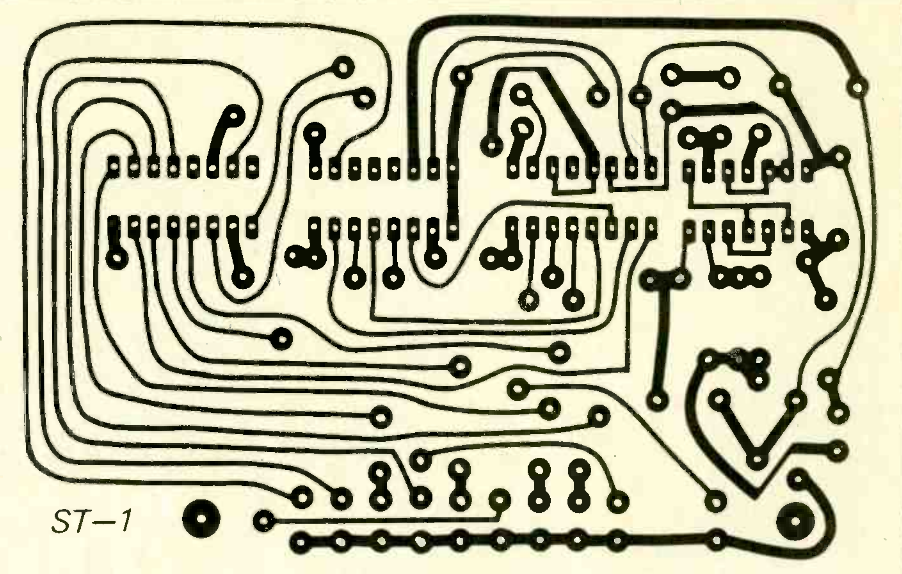
The LEDs are mounted carefully on the PC board so that they just fit through the holes in the front panel. You may have to fiddle around with the spacing between the PC board and project box. The diagram below shows how the various components fit on the PC board.



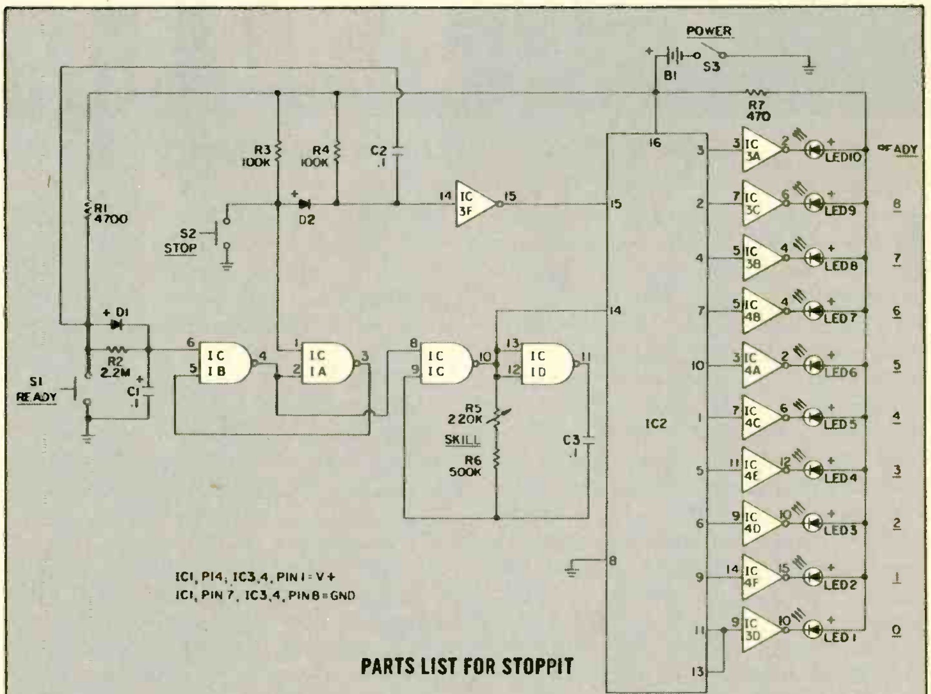
through R2 and S1 to ground. When the voltage across C1 decays to the CMOS low level (½V+), the R/S Flip Flop is set, forcing the "Q" output high and the "Q" output low. The high "Q" output enables the clock oscillator and allows IC2 to begin counting at a rate determined by R5 (Skill), R6 and C3. R6 limits the upper frequency of the clock oscillator. Closing S2 (Stop) resets the R/S Flip Flop, disabling the clock and stopping the count. Since the set pin of the Flip Flop must be high before it can be reset, S1 must be released to allow C1 to recharge through R1 and D1 before S2 has any affect. Since R1 is relatively small, C1 recharges "instantaneously." Thus, in operation, S1 is depressed until the counting begins. S1 is then released and S2 is quickly closed to stop the count. Power is supplied by a 9 volt battery.

Construction. Stoppit can most easily be assembled using our PC Board layout and components placement. In this way, all components except for the switches and *skill* control are mounted directly on the board. Note that there are 18 jumpers, 3 of which are insulated. Standard handling precautions should be observed for the CMOS devices and I.C. sockets may be used. To be compatible with the PC Board layout, ⅛" diameter LEDs should be used. The leads should be long enough so that, when mounted, the top of the LED is at least ¾" above the PC Board. Mount the LEDs so that they form a straight line and are of uniform height. The finished unit can be mounted in any convenient case. A simple battery holder can be made from a ¾" x 1¾" piece of aluminum stock by forming it into a "Z," the vertical portion of the "Z" being the dimension of the wider side of the battery. A hole can then be drilled in the lower horizontal portion of the "Z" so that it can be anchored to the bottom of the case with a machine screw and nut.

Playing The Game. When the unit is first turned on, the lights will sequence and stop on the *zero* position. Place the *skill* control near the *amateur* position. Depress and hold the *ready* button. After a few seconds, the *ready* LED will extinguish and the numbered LEDs begin to sequence. As soon as this happens, release the *ready* button and momentarily depress the *stop* button. Repeat this process five times, noting your score each time. Your total score is then the sum of the five individual scores. As your proficiency increases (as noted by an increased total score), advance the *skill* control. You may wish to challenge your family or friends in a test of quick reactions. ■



You can use the above, PC board template to build your own or order one from the supplier listed below. If you do it yourself watch for those pesky PC-board short circuits.



PARTS LIST FOR STOPPIT

C1—1-uf, 10 volt electrolytic capacitor
C2, C3—0.1-uf, 25 volt disk capacitor
D1, D2—1N4148 or 1N914 diode
—4011 Quad 2-Input NAND Gate (CMOS)
—4017 Decade Counter with Decoded Outputs (CMOS)
4—4049 Hex Inverting Buffer (CMOS)
LED 1—LED 10—⅛" dia. LED (Such as Continental Specialties Corp. LD-12)
R1—4700-ohm, ¼ watt resistor
R2—2.2 Megohm, ¼ watt resistor
R3, R4—100,000-ohm, ¼ watt resistor
R5—220,000-ohm, ¼ watt resistor
R7—470 ohm, ¼ watt resistor
R6—470,000 or 500,000-ohm, ½ watt potentiometer (Audio Taper)
S1, S2—Pushbutton Switch, normally open
S3—SPST slide switch
Misc—9 volt battery and battery clip; suitable case (such as Radio Shack 270-627); one knob; two #6-32 x 1¼" machine screws and nuts; one #6-32 x ½" machine screw and nut, wire, etc.

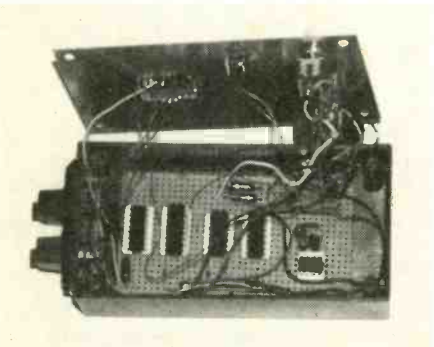
Note—The following are available from BNB Kits, R.D. #1, Box 241 H, Tennent Road, Englishtown, N.J. 07726: Kit containing all parts and P.C. board (less case and mounting hardware) (STOPPIT) at $17.50; P.C. Board only (STOPPIT-PC) at $6.00. Prices include postage and handling. Canadian residents pleasse add $1.00. U.S. Funds only. N.J. residents add 5% sales tax. Please allow 3 to 6 weeks for delivery.

10 SECONDS.... AND COUNTING!

Send your model rocket to the stars with our launch computer

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.

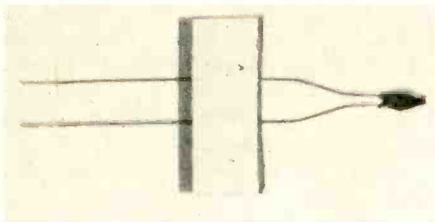


You can use perfboard construction to build your controller, as shown here. Parts layout is not critical, nor are any dimensions.

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 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 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



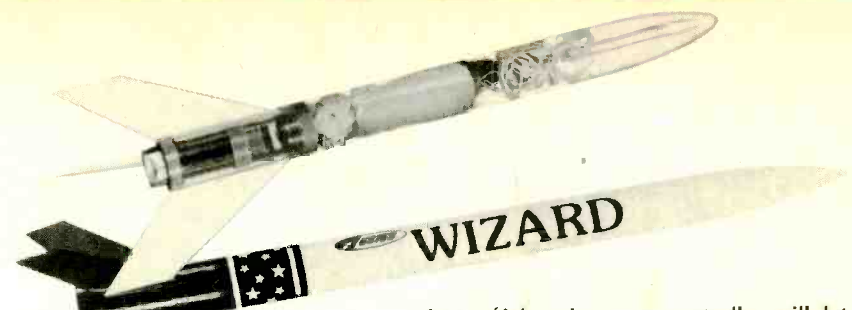
This igniter wire fits into the back of a model rocket engine. Once fired by our rocket computer it burns with the intensity of a match. This sets off the engine.

(*off/on*) to the *on* position. LED 1 should light, and the display should show a 9. If the display did not light, or if it didn't show a 9, then recheck the wiring from IC3, and correct the problem. 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.)

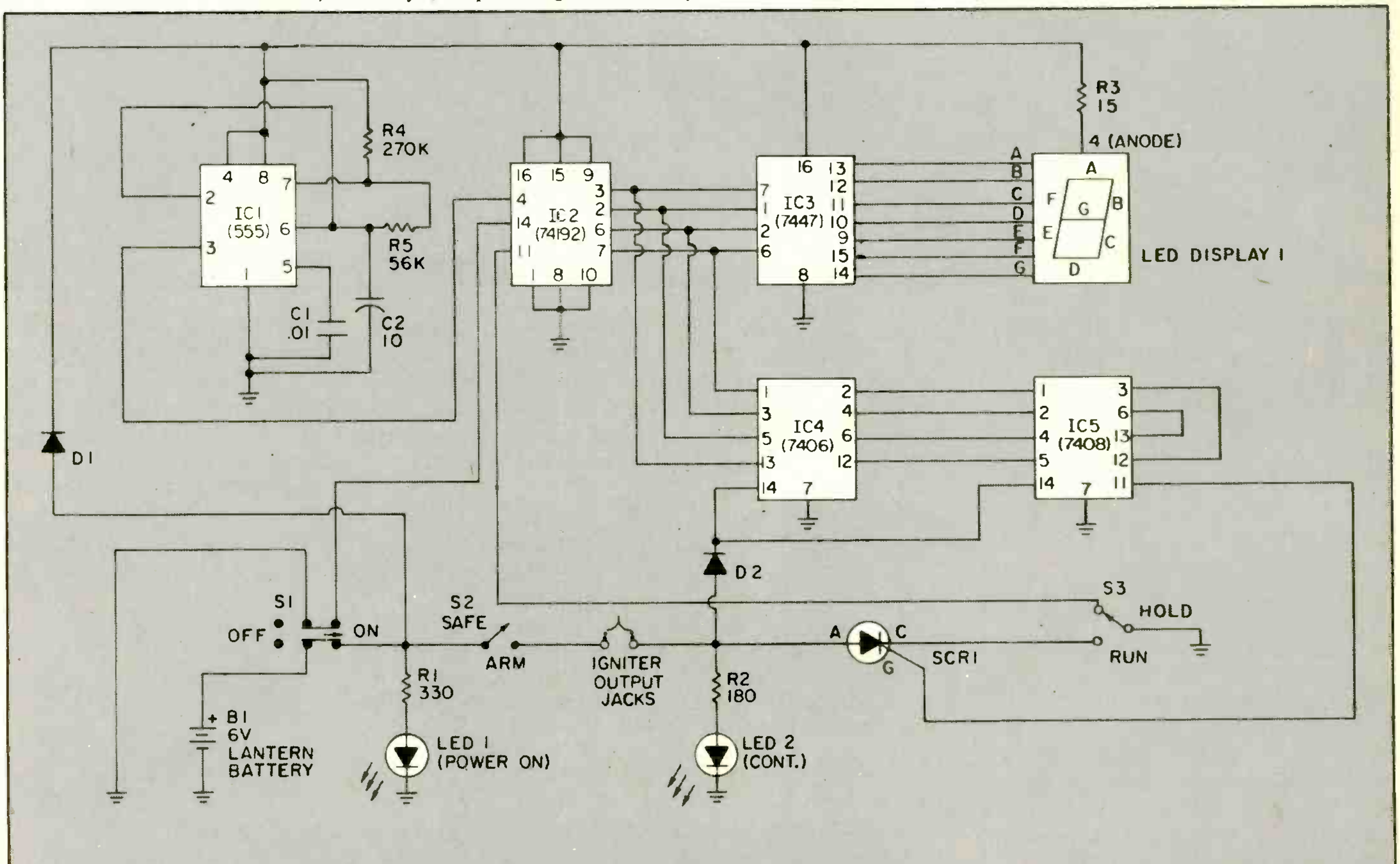
Now see if the unit can fire an igniter (not in an engine yet!!!) on your bench. Move the igniter away from anything inflammable as the igniter usually burns for a second at about the intensity of a match. Throw switch S3 (*hold/run*) to *run*. The display should count slowly down, and—get ready—at zero, 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 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 shows us the numbers as they are understand—decimal. The LED display counted. IC 7406 and IC 7408 "watch" the count and when they sense a zero, they send a pulse to the SCR, triggering it into conduction and thus firing the igniter. ■



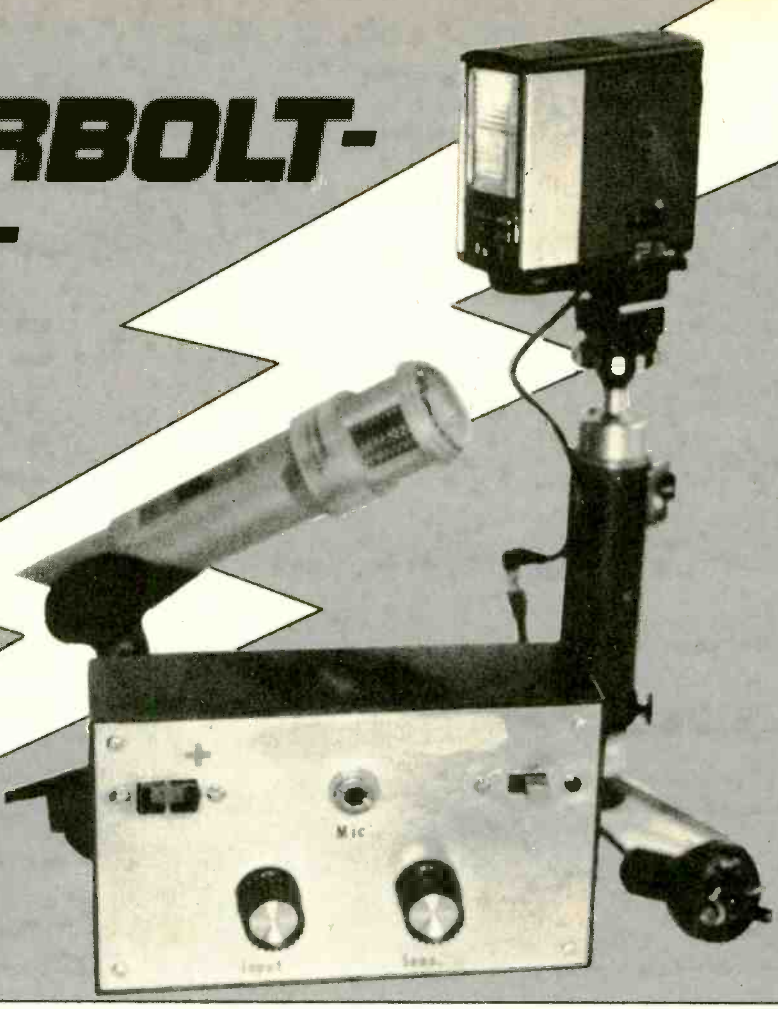
The model rockets our controller will let you launch are fun kits in themselves. Most have a parachute for a colorful "re-entry" and you can get everything from nearly exact scale models of the V2 and Saturn V, to some far-out spaceships of the future.



PARTS LIST FOR THE ROCKET COMPUTER

B1—6-volt lantern battery, Mallory F918 or equivalent
C1—0.01-uF ceramic disc capacitor, 15 VDC
C2—10-uF electrolytic capacitor, 15 VDC
D1, D2—1N4148 diode
IC1—555 timer, 8-pin IC
IC2—74192 binary counter, 16-pin IC
IC3—7447 BCD-to-decimal decoder, 16-pin IC
IC4—7406 hex inverter, 14-pin IC
IC5—7408 AND gate, 14-pin IC
LED1—large red LED
LED2—large green LED
LED Display 1—7-segment, common-anode LED display
R1—330-ohm, ½-watt resistor
R2—180-ohm, ½-watt resistor
R3—15-ohm, ½-watt resistor
R4—270,000-ohm, ½-watt resistor
R5—56,000-ohm, ½-watt resistor
S1—DPDT slide switch
S2—SPST toggle switch
S3—SPDT toggle switch
SCR1—Silicon controlled rectifier, 50-volt/2-amp or better
Misc:—Input and output jacks, IC sockets, wire, solder, suitable enclosure, igniter (Estes #2301), etc.

THUNDERBOLT-For Stop-Action Photos



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

by Frank I. Gilpin

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

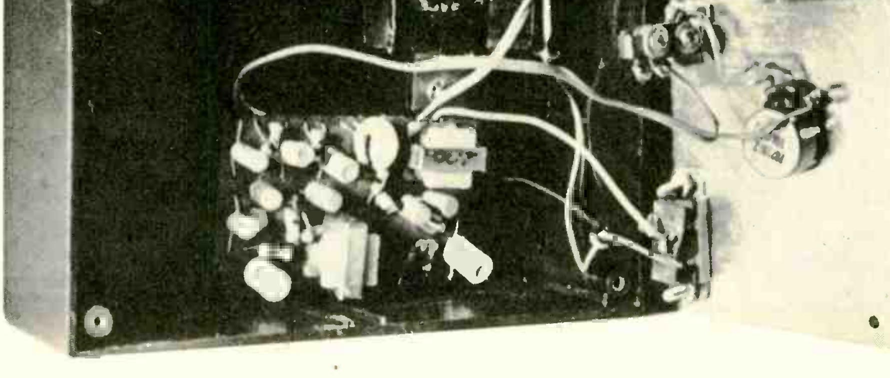
Sound-activated switches have been around a long time. The first one I built 18 years ago weighed 25 pounds and would have cost nearly $100 if I hadn't cannibalized some old radios for the parts and tubes . . . remember tubes? When I built Thunderbolt a few months ago it cost five dollars and weighed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

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

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

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

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



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

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

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

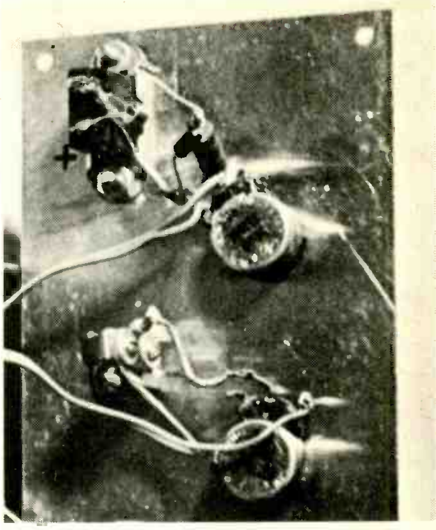
Putting Thunderbolt together is easy, because the most complicated part—the amplifier—is a module, ready to wire into a circuit with just a few simple connections and a handful of other parts.

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

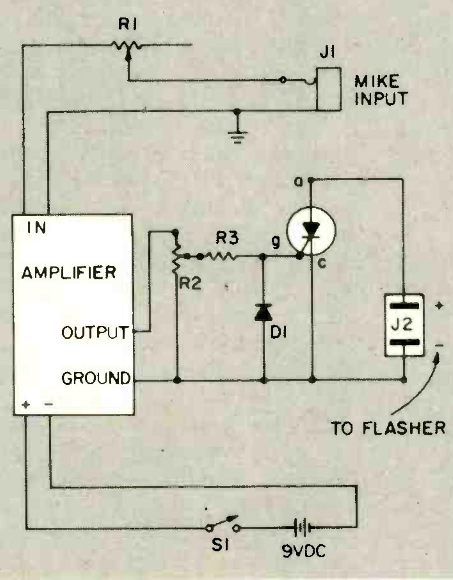
The cabinet I show in the parts list will accommodate almost any transistor amp you select. You could even get ambitious and build a simple transistor amp. Most any old tube amp will also work fine, though it'll be quite bulky.

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

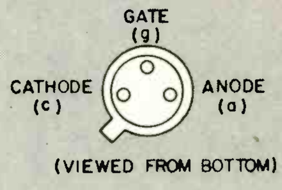
Hookup To Flashgun. After making all the connections, double check your work. Be sure you have connected the SCR's three leads correctly and check the polarity of D1. When you are sure everything is in order, you'll need to make a connector cord for your flash unit. Insert the PC plug of your flash extension cord into the flash unit's sync cord. Both ends of some brands of extension cords look almost alike and you don't want to cut off the wrong end. With one end plugged into your flash unit to make sure, cut off the other end close to the plug. Strip off the insulation and carefully separate the braided



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



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



PARTS LIST FOR THUNDERBOLT

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

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

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

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

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

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

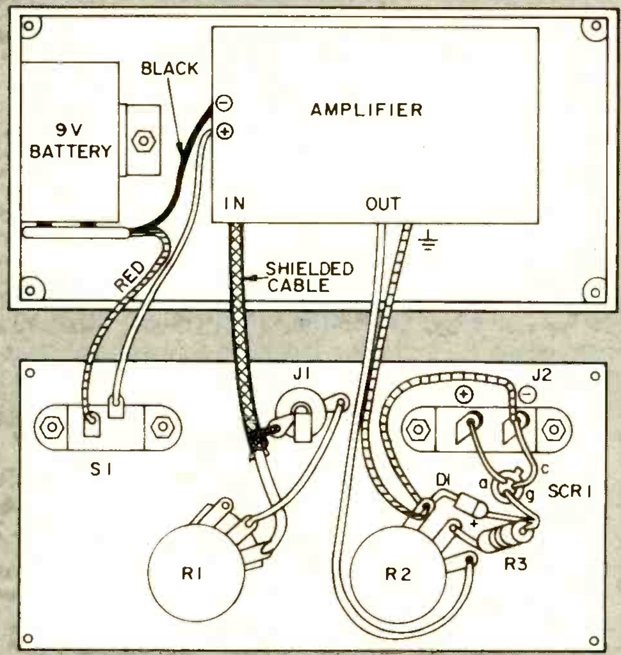


Diagram of the parts layout for Thunderbolt. The components are pretty evenly distributed between the front panel and the box, and connected by a few hookup wires and some shielded cable. Make sure that the wires and the cable are long enough and flexible so that there wont be any trouble as you close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

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

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

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

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

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

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

OCTAVIZER

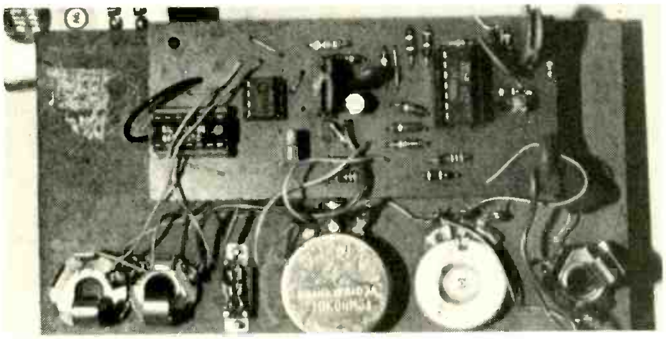
A new dimension in sound for the hobbyist and musician

CONNECT ANY ELCTRIFIED or electronic musical instrument to OctaVizer and your instrument's single frequency output is expanded threefold. In addition to the single frequency input signal, square waves at fifty-percent of the frequency and one at twenty-five-percent of the frequency are available at OctaVizer's output. All three signals can be mixed in any proportion desired, using the *blend* and *prime* controls. The composite output signal can be used immediately, or further processed using filters or other such devices.

The *blend* control adjusts the relative magnitude of the two square wave signals, while the *prime* control adjusts the amount of input signal which is fed through to the output. The footswitch-operated cancel function disables the square wave outputs when activated.

OctaVizer uses readily available linear and CMOS digital integrated circuits, is powered by a single 9-volt battery, and can be built for less than $15.00.

How It Works. As shown in the schematic diagram, the input signal is AC coupled through C1 and C6 to a low-pass filter and a level control (R23) respectively. R4 and C2 form the low pass filter with a –3 dB point of about 350 Hz, which filters higher order harmonics that might otherwise be detected in later stages and cause false triggering. The filtered signal is amplified in IC1D along with the DC level set by R2. The output of IC1D is further processed in IC1A where it is squared up and clipped. The output of IC1A is AC coupled through C3 and added to the variable DC level set by R12 in the R11, R12, R13 voltage divider. This composite signal is used to trigger a monostable multivibrator (one shot) formed from IC2, R14, R15 and C4. If pin 4 of IC2 is held low by grounding J2, the output remains low regardless of the input. If J2 is not grounded, pin 4 of IC2 is held high by R16 and the pin 3 output is a pulse train of the same frequency as the input signal. This pulse train is used to clock two divide-by-2 flip-flops (IC3B and IC3A) which próduce square waves at one-half and one-quarter the frequency of the input pulse train. The two flip-flop outputs are attenuated in the two variable voltage dividers formed by R17, R18 and R19. With R19 set at midrange, two equal voltage dividers are formed which attenuate the 9-volt square wave outputs to about 95-millivolts each (a level similar to that of the input signal). As the wiper is moved toward one side, that divider's signal level is decreased while the other's is increased. Therefore, *blend* control R19 can select either signal alone, or any ratio of the two. The level of the input signal provided to IC1B is selected by the *prime* control (R23). This signal, along with the out-



As you can see from this almost full-scale photograph, the circuit board is rather compact. It would be a relatively easy matter to build it into an existing pre-amp.

OCTAVIZER

put of the two voltage dividers, is added in unity gain summer IC1B. Since the output of IC1B has a DC component, it is coupled by C5 to output jack J3.

Construction. OctaVizer can be constructed using any standard technique. Standard CMOS handling precautions should be observed when handling IC3. IC sockets may be used if desired. Assemble all components onto the board, being sure to observe polarity for the ICs, D1, and C5. Note that C6 is not mounted on the PC board, but is wired directly between J1 and R23. Interconnect the completed PC board with all jacks and controls. Any suitable case may be used to house the project.

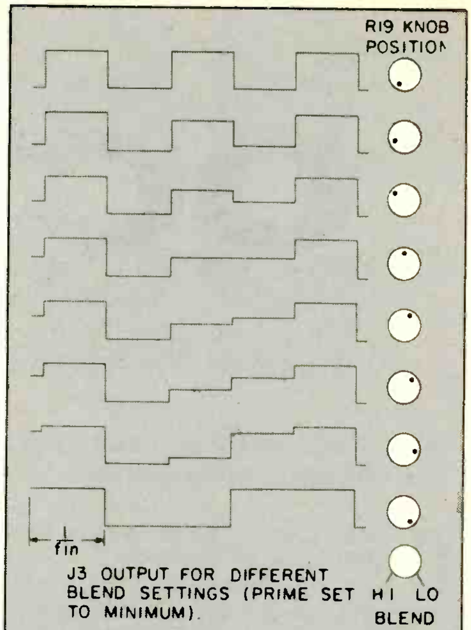
Alignment. If the input to OctaVizer was always a pure, mono-frequency signal, no alignment would be necessary. However, many electrified musical instruments' outputs are generated by a non-linear electromagnetic device (such as a magnetic pickup) and, as such, contain non-sinusoidal and/or harmonically related components. These components can be detected and cause false triggering. The alignment procedure outlined below will minimize the effects of these components while maximizing the overall response of the unit.

Begin by setting the wiper of R2 to ground, and the wipers of R12 and R15 to midposition. Connect the input device you will be using, and patch the output to an amplifier. Turn the unit on and rotate the wiper of R12 towards ground until you hear oscillation begin. Now turn the wiper of R12 slightly past the point where the oscillations stop (If a VOM is handy, set the voltage on the wiper to about 3¼-volts). Set R23 (*prime*) to minimum and R19 (*blend*) to high. As you play the instrument, rotate the wiper of R2 until an output is obtained. If the output is not half the frequency of the input (as determined aurally), back off R12 very slightly. You will notice that when the proper frequency output is obtained, its duration may be short. To increase the duration, adjust R2 slightly in the direction that produces oscillation. Next, play the highest note you will intend to play. The output will either be correct, very static sounding, or much lower in frequency than anticipated. If the output is correct, no adjustment is required. If the output is static sounding or lower than anticipated, rotate R15 until the proper output is obtained.

The final step is a fine adjustment which will maximize how long the signal lasts while minimizing false triggering. This adjustment consists of alternately adjusting R12 and R2 until you are satisfied you have obtained maximum duration and minimum (if any) false triggering.

Use. OctaVizer can be used over a 3-octave range. As with any new device, it is best to experiment with all controls to determine the effects that can be obtained. A standard guitar can be used with OctaVizer to create a raspy bass guitar effect by setting *blend* to "Hi" and *prime* to "Min." An interesting effect is created with *blend* to midvalue and *prime* set so both output components are of equal loudness. By striking the strings forcefully, you can create high amplitude harmonics that will false trigger the unit and raise the square wave outputs in frequency by an octave. Thus, by varying your striking

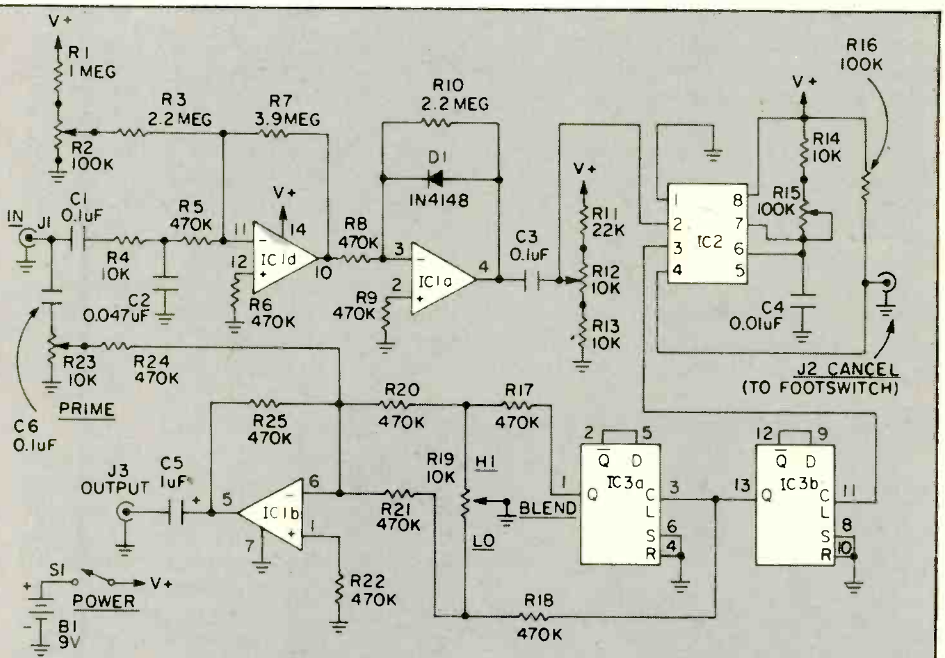
(Continued on page 113)



Here is the chart of the various waveform configurations made possible by varying settings on the "blend" and "prime" controls. Although designed for use through a three-octave range, if used with an electric guitar, false harmonics can be generated by forceful strumming, thus raising the outputs by one full octave automatically.

PARTS LIST FOR OCTAVIZER

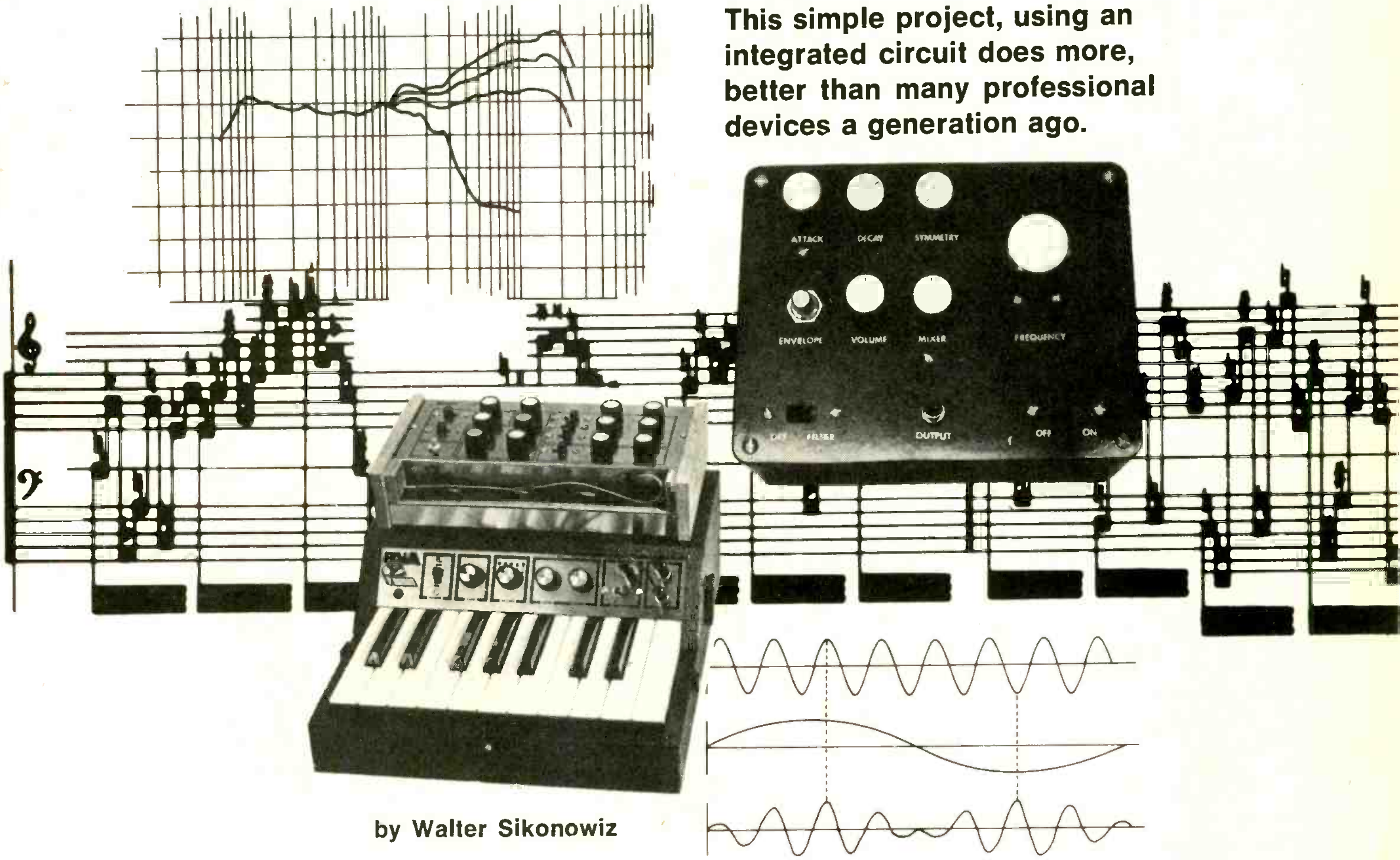
- B1—9-volt transistor battery
- C1, C3, C6—0.1-μF, 25-VDC disc capacitor
- C2—0.047-μF, 25-VDC disc capacitor
- C4—0.01-μF, 25-VDC disc capacitor
- C5—1.0-μF, 16-VDC electrolytic capacitor
- D1—1N4148 diode
- IC1—LM3900 quad op amp
- IC2—555 timer
- IC3—CD4013 dual flip-flop
- J1, J2, J3—standard 2-conductor phone jack
- R1—1,000,000-ohm, ¼-watt resistor
- R2, R15—100,000-ohm, ¼-watt vertical-mount trimmer potentiometer
- R3, R10—2,200,000-ohm, ¼-watt resistor
- R4, R13, R14—10,000-ohm, ¼-watt resistor
- R5, R6, R8, R9,
- R17, R18, R20,
- R21, R22, R24, R25—470,000-ohm, ¼-watt resistor
- R7—3,900,000-ohm, ¼-watt resistor
- R11—22,000-ohm, ¼-watt resistor
- R12—10,000-ohm, ¼-watt vertical-mount trimmer potentiometer
- R19, R23—10,000-ohm, ¼-watt linear-taper potentiometer
- S1—SPST slide switch
- Misc.—cabinet, hookup wire, knobs, etc.



Note: A complete parts kit is available from: BNB Kits, R.D. #1, Box 241H, Tennent Road, Englishtown, NJ 07726, for $18.95. The PC board alone is $6.00 from BNB also.

SIMPLE-SYN, THE MUSIC MACHINE

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



by Walter Sikonowiz

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

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

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

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

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

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

SIMPLE-SYN

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

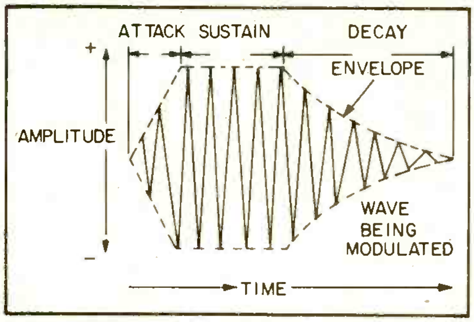
Timbre. This is the quality of sound that differentiates a trumpet from a violin when both are playing the same frequency. The timbre is the result of "secondary" frequencies (harmonics—also called "overtones") being present in the sound of the respective instruments. If there are many harmonics present,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

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

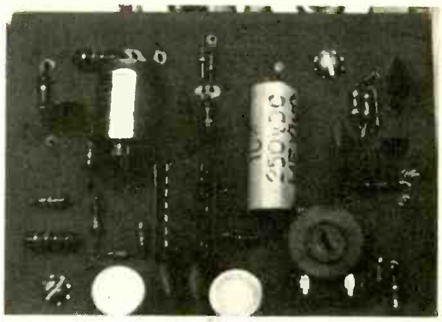
Assume both the violin and clarinet are playing the same pitch, A440. Then A440 would be called the fundamental. The first overtone has a pitch of 880 cycles per second (2x440); the second overtone has a frequency of 1320 cycles a second (3x440); the third overtone has 1760 cps (4x440) and so on.

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

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



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



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

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

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

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

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

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

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

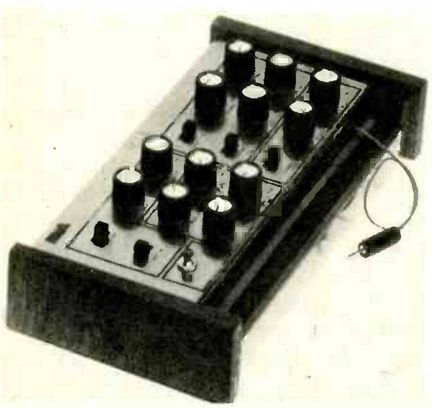
1. Attack time—the time period from silence to when the sound reaches its maximum loudness.
2. Sustain time—the period during which the sound is maintained at some loudness level.
3. Decay time—the period during which the sound fades away to silence.

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

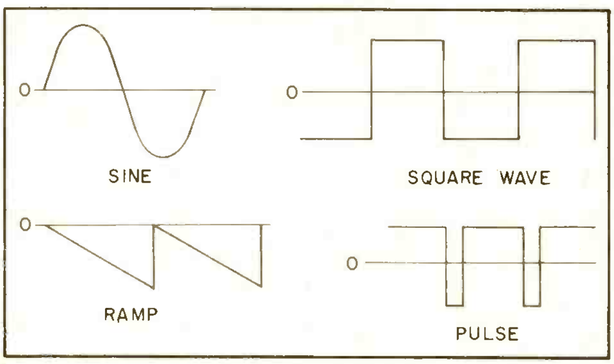
A graph of the variations in loudness in a typical sound is shown.

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

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



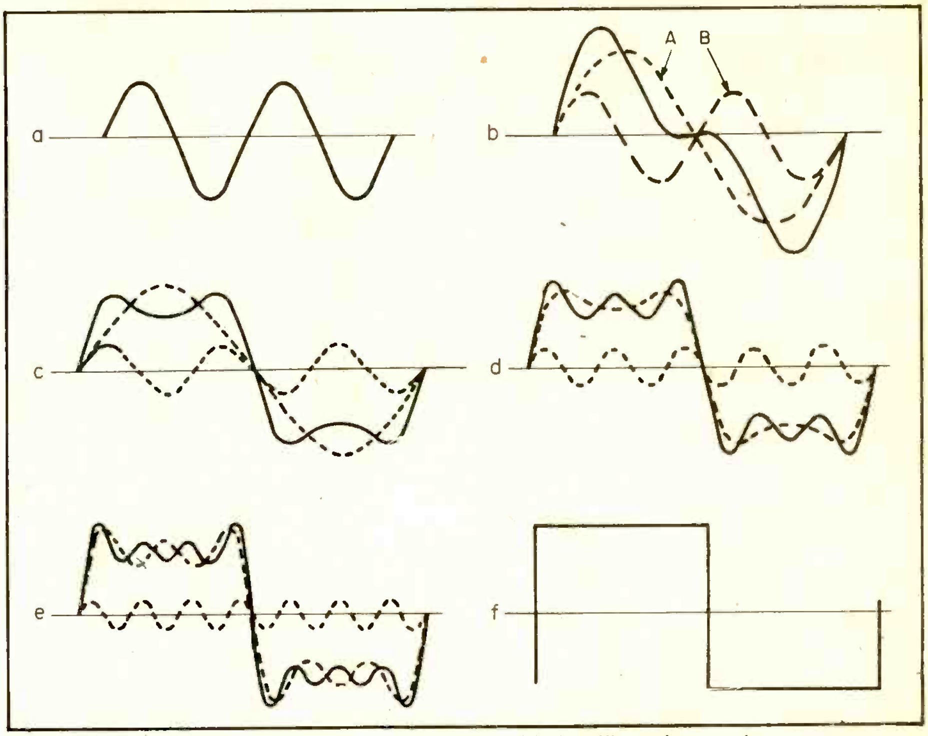
Small electronic musical instruments may be built from kits like this one from PAIA Electronics (address at end of article)



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

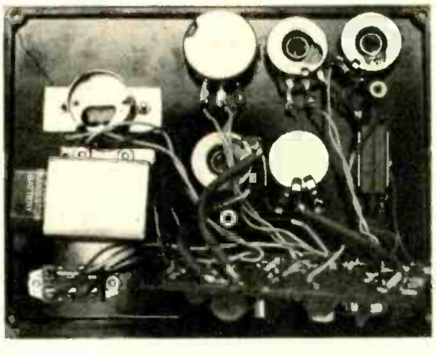
either A or B it has the same frequency (and consequently pitch) as the fundamental frequency A. If third, fourth, fifth and higher order harmonics were added into this wave the result would continue to change shape but the frequency would remain the same.

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



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

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


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

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

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

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

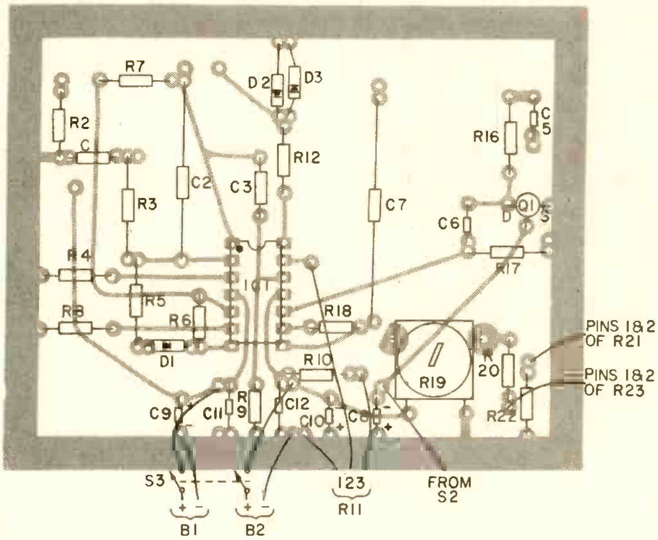
Shown here is a diagram of a burst of sound. The time interval during which the sound's volume builds from zero to some reference level is called the *Attack* time, while the interval during which the sound remains at the reference level is called the *Sustain* time. Finally, the period during which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

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

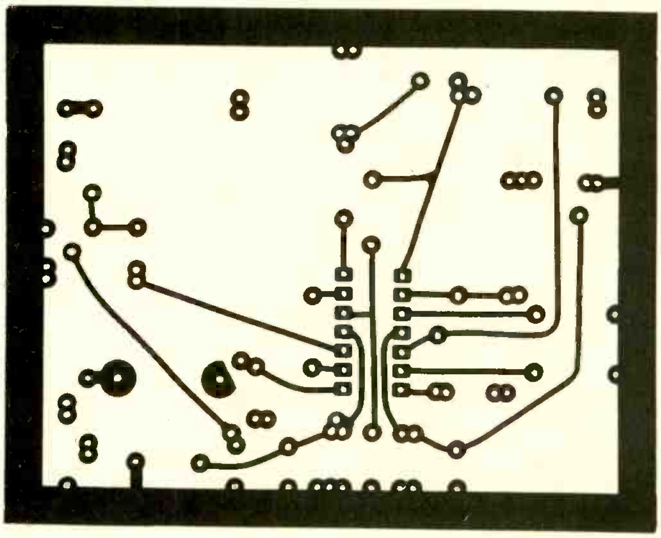
An important characteristic of natural sound generators is that they filter the waveshapes of the sounds they generate. For example, the body of a violin and the horn of a trumpet are natural resonators which reinforce some frequencies, and attenuate others. The overall shape of a waveform is correlated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

How the Circuit Works. Now let's turn

SIMPLE-SYN



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



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

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

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

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

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

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

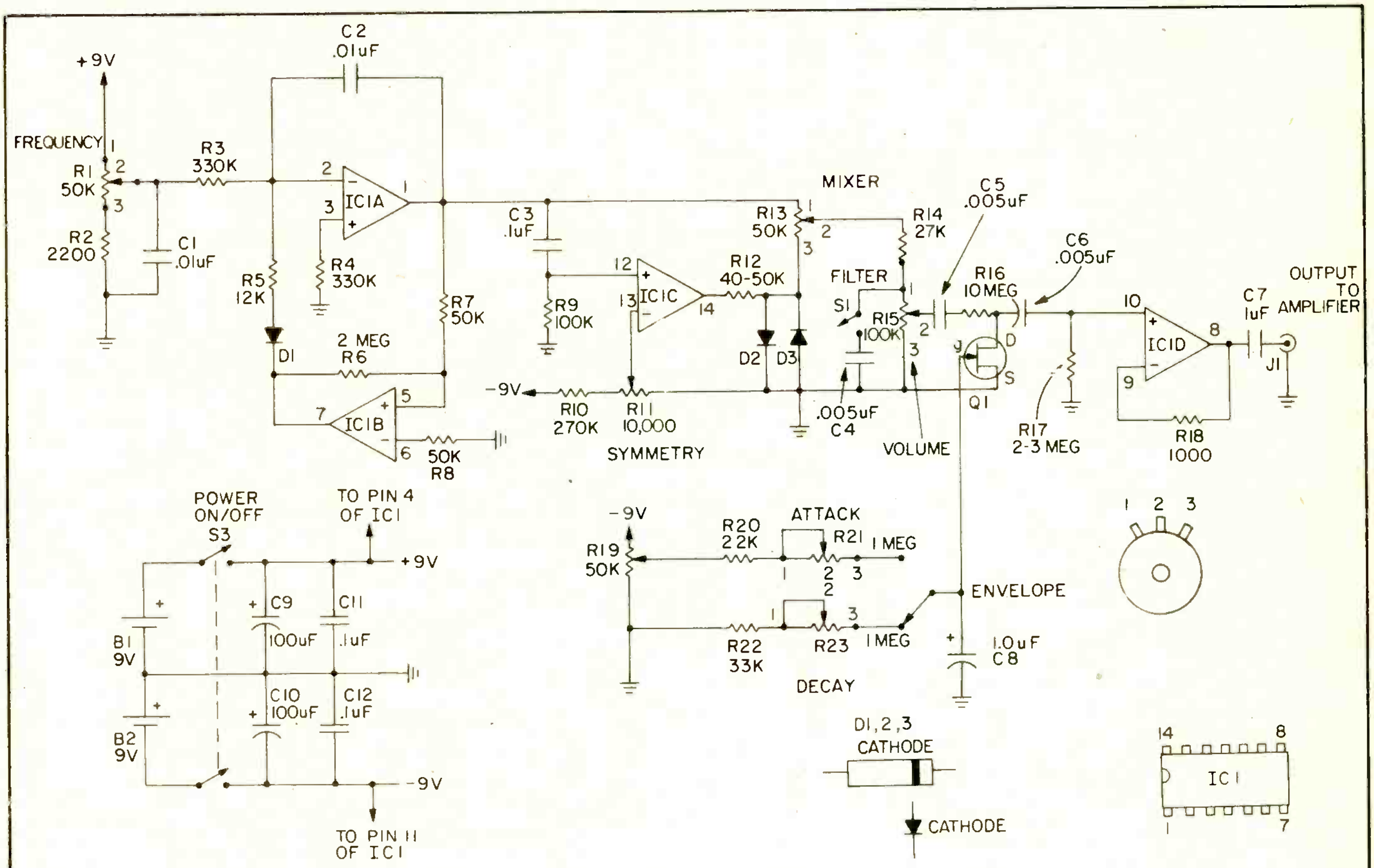
Try to copy the construction of Simple-Syn's prototype cabinet as closely as possible. *Frequency control* R1 mounts in the upper-right-hand quad-

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

rant and is actuated by the largest knob. Directly below that pot is an aluminum bracket holding B1 and B2. Right below the bracket is *Power* switch S3.

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

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



PARTS LIST FOR SIMPLE-SYN TONE SYNTHESIZER

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

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

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

SIMPLE-SYN

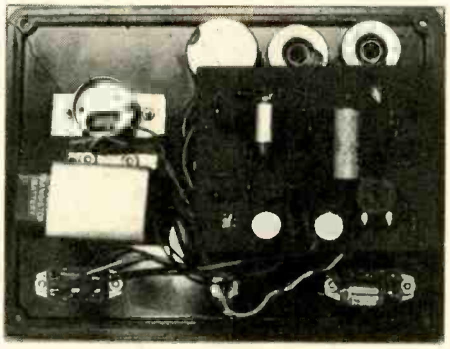
circuit board—it mounts point-to-point between lug #2 of R14 and lug #1 of R15. Likewise, C4 is off the board, wired between S1 and R15 as the schematic indicates.

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

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

Using Simple-Syn. If you make tape recordings, Simple-Syn can be used to imitate foghorns, train whistles, sirens, musical instruments, insect buzzes and hums, as well as surreal science-fiction-movie sounds. In conjunction with a small amp and loudspeaker it can provide realistic horn and whistle effects for a model railroad. You might use it to replace your humdrum doorbell with some really wild sounds. Finally, Simple-Syn can be used as a musical instrument. All that is necessary is that you calibrate the frequency control, perhaps using a pointer affixed to the frequency knob and a scale with the positions of the various notes marked on it. Simple-Syn spans more than three octaves, so the larger scale you use, the easier it will be to calibrate. Calibration is easiest with a frequency counter, but you can also tune it by ear, using a piano as reference. In addition, you can replace the 9V. batteries with 8.6V. mercury cells, since the frequency of the ramp generator is voltage-sensitive. Your calibration with mercury cells will stay accurate because, unlike zinc-carbon cells whose voltage decreases with age, a mercury cell's voltage remains quite constant throughout its useful life.

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



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

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

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

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

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

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

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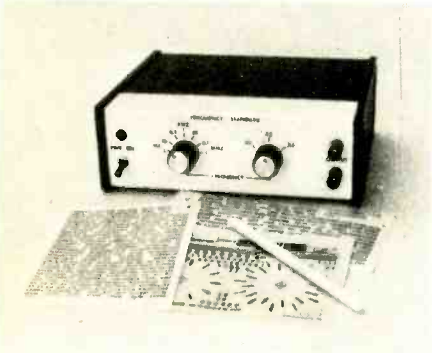
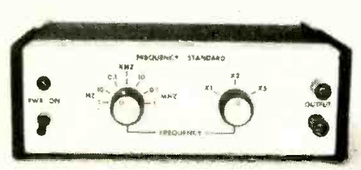
LOVE THAT

Press-on decals will turn

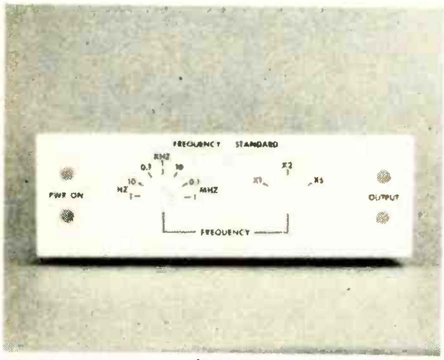
by Randall



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

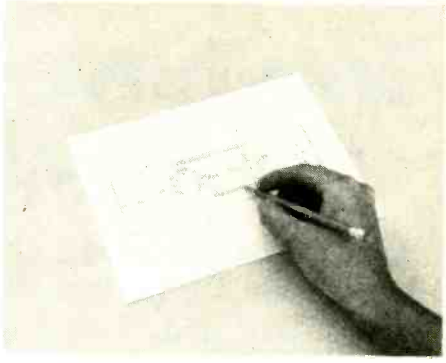


14. And now—the finished project, a delight to the eye! Once you try this method on one of your projects you'll never go back to ugly again. You don't have to be an artist, and it does not add much to the cost. Electronics can be beautiful!



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

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



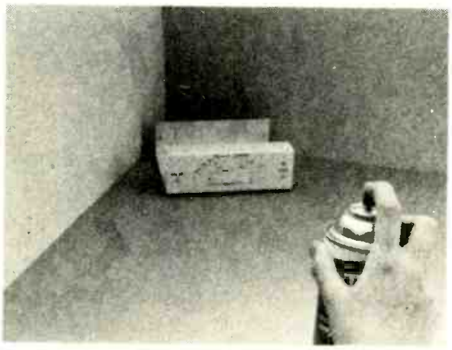
3. You can't fashion it if you have never seen it before—at least seen it on paper. First, make a sketch and work on the arrangement until you are quite satisfied with it. Using the quadrille paper, as pictured here, makes the job easier.

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

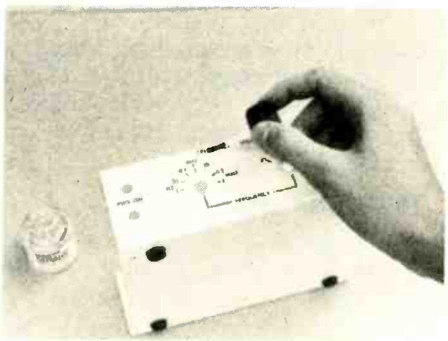
Rub-on lettering is available in various sizes and colors (black and white are the most common). Sets may contain complete words, individual letters or numbers, or a combination of these. Sets consisting of index marks and other designs for rotary switches and dials are also available.

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

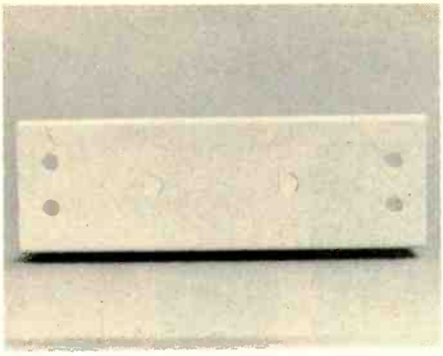
In addition to the lettering and a few household items (cellophane or plastic



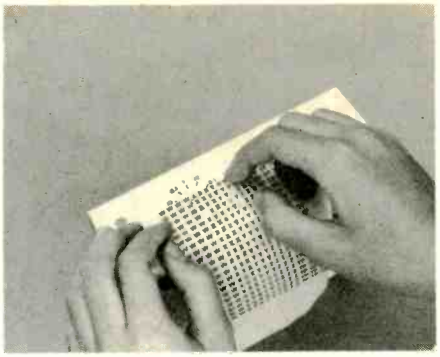
12. You can also buy spray overcoating as pictured here. Spray is more even than the brush-on, but the brush-on can be applied thicker. This method too requires that you carefully check for the compatibility of the overcoat with both letters and panel.



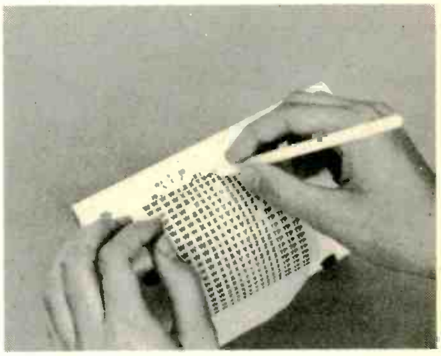
11. You'll want to protect that final panel, and there are two methods you can use. Here we show the brush-on method of overcoating. First, check on a scrap or hidden area for compatibility with both rub-on lettering and the panel finish.



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



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



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

LETTERING

projects into works of art

Kirschman

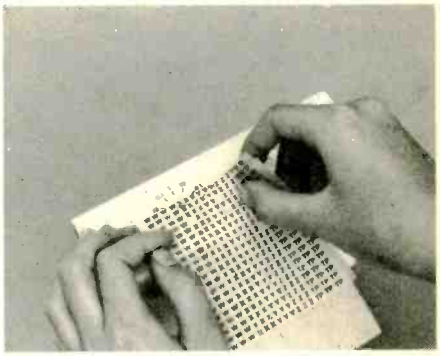
tape, ruler, paper, etc.), you will need a blunt-pointed tool to burnish the letters into place. Tools for this purpose can be obtained where art supplies are sold, or you may be able to find something around the house that will serve the purpose. However, a pencil or ballpoint pen tends to be too sharp, and may also obscure the lettering. The burnishing tool shown in the photos was made from 1/4-inch diameter plastic rod sanded round on one end and tapered and rounded to about 1/8-inch diameter on the other end. It could also have been made from a wood dowel.

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

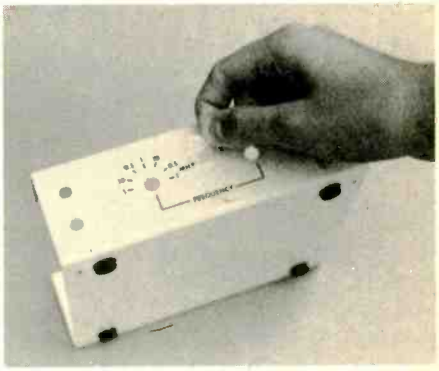
If you use solvents or other chemicals be sure to follow the manufacturer's directions and particularly observe the appropriate safety precautions. Spend a little extra time and effort to be safe and minimize the possibility of injury.

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

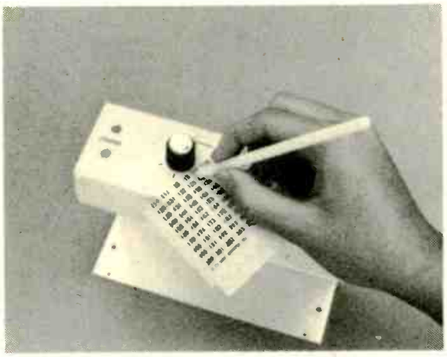
(Continued on page 113)



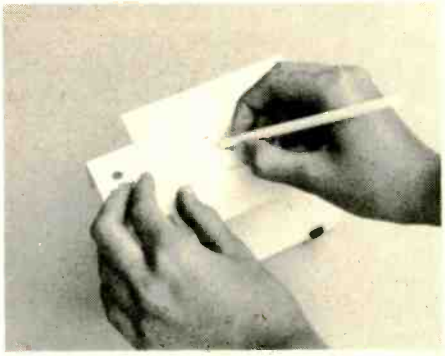
7. Peel the carrier sheet away from the panel, starting from one end and holding the other end in position against the panel. Check that the letter has completely transferred. If it has not, all you have to do is lay the sheet back down and burnish over.



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



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



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

SHORTWAVE SUPERCHARGER

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

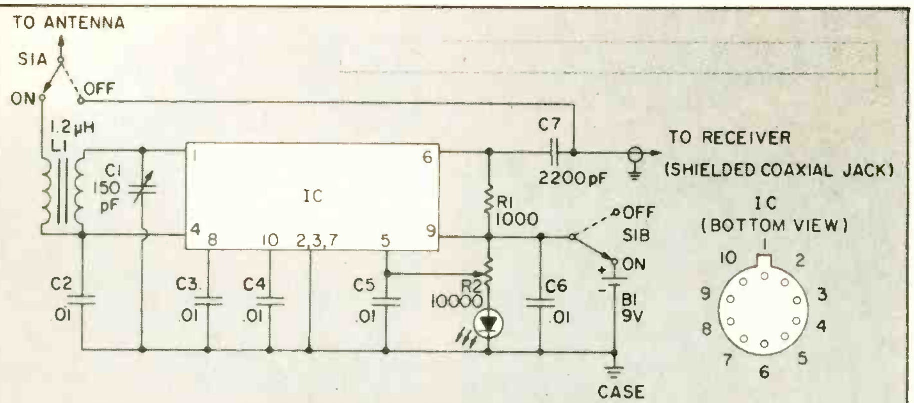
SOME BIG CHANGES are on the way for the SWL, especially in the upper shortwave bands from the 25-meter band on up to 30 MHz and beyond. The Sun is now entering one of its periods of increased sunspot activity after a 20-year period of relative calm. This will make short range communications unreliable 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.

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

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

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

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

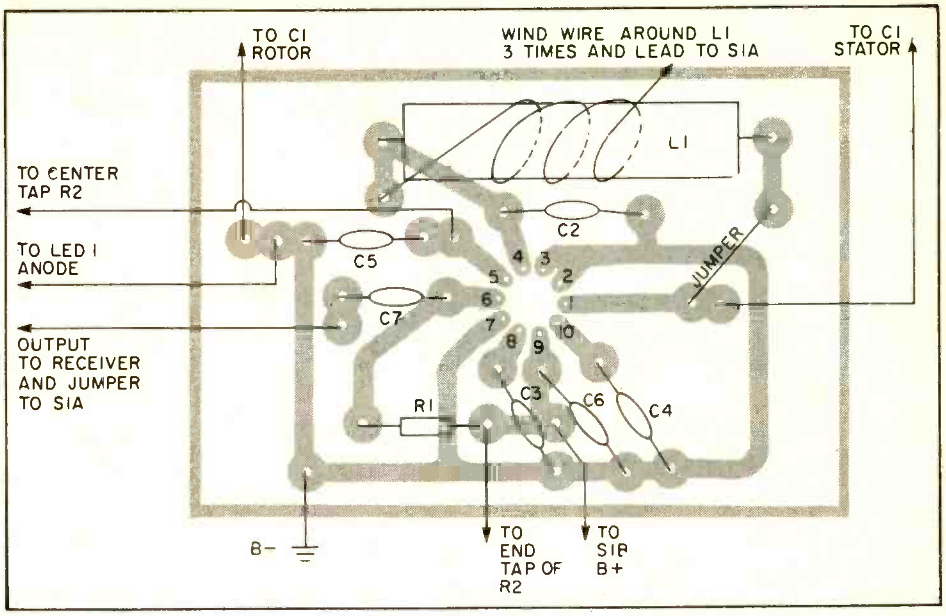


PARTS LIST FOR SHORTWAVE SUPERCHARGER

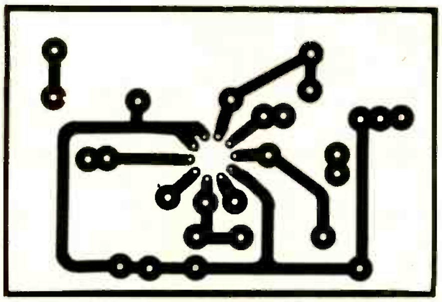
B1—9V transistor radio battery
C1—150-pF variable capacitor
C2, C3, C4, C5, C6—0.01 uF capacitor
C7—2200-pF capacitor
R1—1000-ohm ¼-watt resistor
R2—10,000-ohm variable resistor
IC—Motorola MC1550, HEP 590 or HEP C6091
LED—Red LED indicator
L1—Miller 4502, 1.1-1.5-microhenry coil (for winding your own,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

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.



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.



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

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.

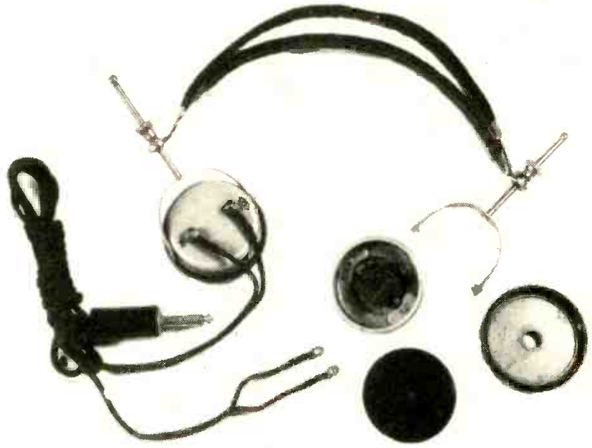
If you find that the circuit "whistles" at certain frequencies (this may easily happen if you do not use a PC board or your connections are too long), the simplest cure is to thread a few small ferrite cores through pins 1 and 4 of the IC. Such cores can be purchased from many electronic surplus dealers.

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.

LOW-COST FILTER IMPROVES CODE RECEPTION



A few snips of aluminum and an old reed make headphones into high quality filter.

Amateur radio operators and short wave listeners often find CW (continuous-wave code) reception difficult, if not impossible, when several radiotelegraph stations are transmitting on, or near, the same frequency. Such interference can be eliminated, or at least greatly reduced, by a narrow band electronic filter circuit that can be installed in the radio receiver or transceiver. However, this extra equipment can cost up to $150.

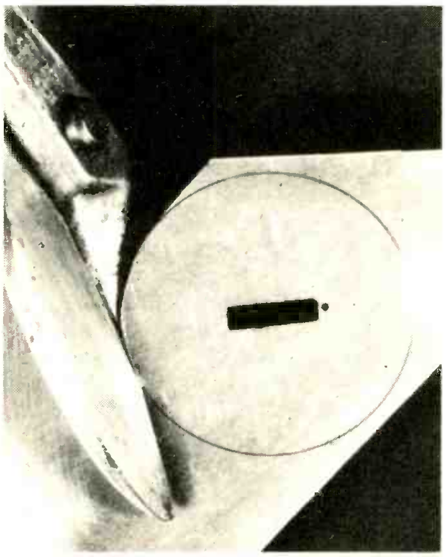
What You Need. A mechanical filter that will do the job can be built for $15, or less. In fact, should you already own a pair of earphones—the old-fashioned kind with metal diaphragms—and have access to a music store that will sell a used steel reed removed from an accordion (the writer was given his at no cost by such a store) you can build this effective filter for practically nothing.

A low-frequency reed should be used. A 440-Hertz (A) reed will work well. In fact, anything from about 300 to 1000 Hertz will be ok.

Should you have access to a steel (not brass) reed from an old harmonica, that could be used, too.

The removed reed is installed in one earphone of the headset so that it vibrates only when an incoming CW signal sets up a beat note at the reed's resonant frequency. All other interfering signals will automatically be eliminated since they will be of a different beat frequency, and the reed will not respond (audibly) to them.

To Get More Volume. Should you wish to have both earphones of the headset operate in this manner, the *matching* reed of the same length (they come in pairs in the instrument) must be installed in the second earphone.



A thin piece of aluminum is cut to same size disc as the original iron diaphragm of the 'phones. Rectangular center opening is for the iron frequency-resonant instrument reed. Small hole at right of rectangle is for rivet (or nut and bolt) to secure reed.

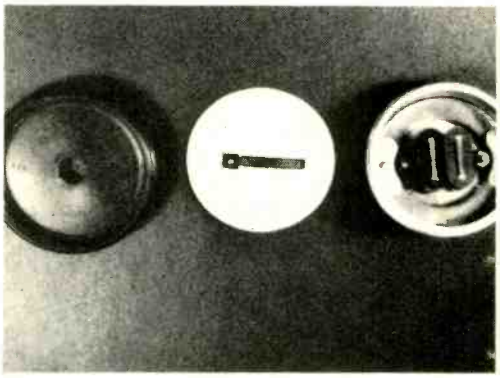
Here's how it's done: Use a pair of tin snips to cut from a thin sheet of aluminum (about 1/32-inch thick) a disc that will replace the earphone diaphragm. At the center of the aluminum diaphragm make an elongated hole that will permit the reed to vibrate freely (see picture) when it is riveted fast at one end of the opening.

In installing the reed it is important that the little strip of steel extend into its opening for the *same* vibrating distance that it did when it was in the musical instrument.

The operation is simple. The aluminum diaphragm, being non-ferrous metal, will not be influenced by the magnets in the earphone. Only the reed will vibrate, instead. In use, only the desired CW signal will be heard loudly as the receiver or transceiver is tuned. The resulting silence can be uncanny!

PARTS LIST FOR CW FILTER
Communications-type headphones, 1000-ohms or more. (**Not** stereo headphones, which are all wrong for this project).
Steel reed(s) from accordion or harmonica.
One (or two) small rivets of the same size as were used to hold the reed in place in the instrument.

Use These Tools. You'll need a pair of tin snips or metal cutting shears. An electric (or hand) drill, with bits the right size for drilling out the rivet(s) which secure the reed(s) in the instrument will be needed, and you'll find a small square-edge (or triangular) file good for dressing the opening in the aluminum disc. ■



Original hard rubber cap (left), original magnet and coil assembly (right) and new aluminum diaphragm (center) with steel reed in place.

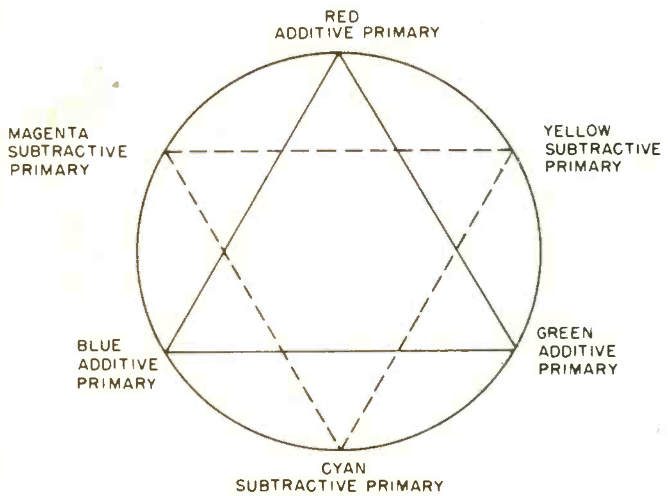
Darkroom Color Analyzer

by Herb Friedman

It's easy to make quality, bright color prints at home with modern color chemistry and this electronic color analyzer!

ONE OF THE SHUTTERBUG'S most satisfying accomplishments is producing his own color prints. For years the time spent on and the cost of making color prints were discouraging, but with modern color chemistry, such as the Beseler system, you can turn out quality color prints *in less time than for black and white* (about 3 minutes), and the prints will be far superior to anything you're likely to get from a color lab.

One thing that takes the drudgery out of color work—besides the chemistry—is a color analyzer, a device that gives you the correct filter pack and exposure time at the very first crack. Most often, the very first print made with the analyzer will be *good.* At most, it will take perhaps 0.10 or 0.20 change of filtration for a *superb* print. This is a lot less expensive and time-consuming than making test print after test print. In fact, it's really the color analyzer that puts the fun into making your own color prints!



Any one of the primary colors on this circle is composed of its immediately adjacent colors in equal amounts. Each primary color is also complementary to the color directly across the center of the circle. Complementary colors added together form neutral densities. It is the balancing of additive primary colors of photographic light sources and subtractive-type color filters that provides control in color print photography.

Color Analyzers Are Not Cheap. A decent one costs well over $100, and a good one runs well over $200. But if you've got even a half-filled junk box you can make your own color analyzer for just the junk parts and perhaps $10 to $15 worth of new components.

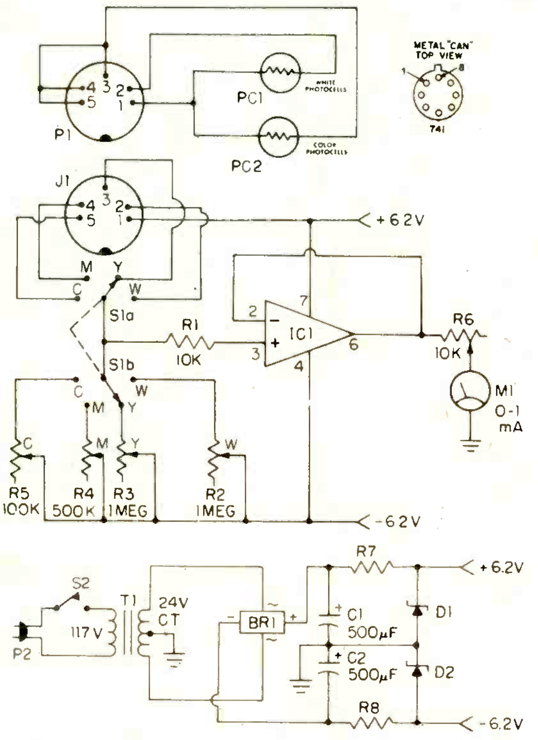
A color analyzer is basically a miniature computer. You make a "perfect" print the hard way—by trial and error—and then calibrate the analyzer to your filter pack and exposure time. As long as you use the same box of paper and similar negatives, all you need to do to make a good color print is focus the negative, adjust the filter pack and exposure so the analyzer reads "zero," and hit the enlarger's timer switch. Even if you switch to a completely different type of negative, the analyzer will put you well inside the ballpark, so your second print is a winner. (And even if

COLOR ANALYZER

the filtration is off, the exposure will probably be right on the nose.)

Construction. The color analyzer shown was specifically designed for the readers of this magazine—essentially an electronics hobbyist with an interest in photography. All components are readily available in local parts stores or as junk box parts. Several protection devices have been designed into the circuit so accidental shorts won't produce a catastrophe. The printed circuit board template has foils for both incandescent and neon meter lamps, as well as extra terminals so you can use either a socket and plug or hard wiring for the color comparator and exposure sensor. In short, you can make a lot of changes to suit your individual needs.

The template for IC1 uses a half-minidip, Signetics V-type package lead arrangement. However, you can also use an IC with a round (TO-5) configuration. If anything is wrong with the IC you can get the TO-5 out easily. The half-minidip removal might result in destruction of the PC board. We'll explain how to install the TO-5 IC on the PC board later.



PARTS LIST FOR COLOR ANALYZER

- **BR1**—50-PIV, 0.5-amp or higher silicon bridge rectifier
- **C1, C2**—500-uF, 10-VDC or better electrolytic capacitor
- **D1, D2**—6.2-volt, 1-watt zener diode
- **IC1**—type 741C operational amplifier, see text
- **J1**—5-pin socket, DIN-type (optional, see text)
- **M1**—0 to 1-mA DC meter, see text
- **P1**—5-pin plug, DIN-type (optional, see text)
- **PC1, PC2**—Clairex CL5M5L photocell, **do not substitute**
- **R1**—10,000-ohm, ½-watt resistor
- **R2, R3**—1-megohm potentiometer, see text
- **R4**—500,000-ohm potentiometer, see text
- **R5**—100,000-ohm potentiometer, see text
- **R6**—10,000-ohm trimmer potentiometer (Mallory MTC-14L4 for exact fit on PC board)
- **R7, R8**—820-ohm, ½-watt resistor
- **R9**—100,000-ohm, ½-watt resistor
- **S1**—2-pole, 4-position rotary switch (Allied Electronics 747-2003; adjust stops for 4 positions)
- **S2**—spst switch
- **T1**—117-volt primary, 24 to 26.6-volt secondary transformer, see text for point-to-point wiring (Note: you can also use two less expensive 12-volt transformers with secondary windings connected in series-aiding, if you have the space.)

The printed circuit board for the Color Analyzer is available direct from Electronics Hobby Shop, Box 192, Brooklyn, NY 11235 for only $5.60. US orders add $2.00 for postage and handling; Canadian orders add $3.50. No foreign orders, please. Postal money orders will speed delivery; otherwise allow 6-8 weeks for delivery.

If you cannot obtain the Clairex Type CL5M5L photocell locally, write to Electronics Hobby Shop at the above address, enclosing $5.00 for each photocell. U.S. orders add $2.00 for postage and handling. Canadian order add $3.50. No foreign orders, please. New York State residents add sales tax. Postal money orders speed delivery; otherwise allow 6-8 weeks for delivery.

- **Misc.**—cabinet, pilot lamp for meter, 2-in. or 3-in. size Kodak Wratten filters #70, #98, and #99 (available from photo supply dealers), calibrated knobs, wire, solder, hardware, etc.

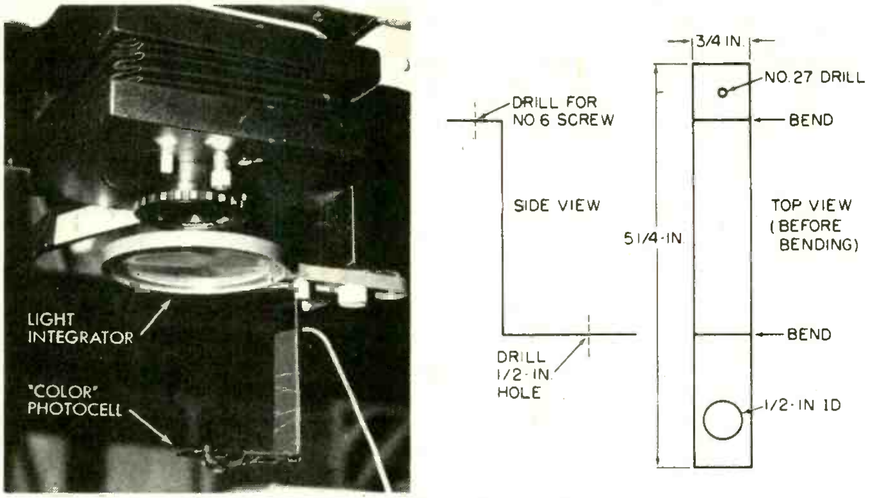
You can either buy or make the printed circuit board (see parts list). Either way, the first step is to prepare the printed circuit board. If you do it yourself, make it any way you like, using free-hand or template resist. Nothing is critical, but be certain there are no copper shorts between the terminals for IC1. Use a #56 bit for all holes. Then use a larger bit for transformer T1's mounting screws (#4 or #6 screws), a ¼-in. bit for resistor R6, and a #30 to 40 bit for the linecord connections (any bit that will allow the linecord wires to pass through the board).

Assemble the power supply and check it out before any other components are installed. Install transformer T1 first. Any 24-volt or 25.2-volt center-tapped transformer that will fit on the board will be fine. Get something small, like 100 milliamperes. A Wescom 81PK-100 is a perfect fit.

Bridge rectifier BR1 is the low cost "surplus" found in many distributors. This type has the positive and negative outputs at opposite ends of a diamond. The AC connections are the remaining opposite ends. Note that BR1 is installed in such a manner that its negative output is farthest from transformer T1 while the positive output is nearest to T1. Make certain your bridge rectifier has the same lead configuration; if it is different, modify the printed circuit template to conform to the rectifier you're using. Get it right the first time.

Finally, install C1 and C2, R7 and R8, and zener diodes D1 and D2. Take care that the capacitors and zener diodes are installed with the polarity correct. If the capacitors have their negative leads marked with an arrow or line, these markings face the *opposite edges* of the PC board (negative to the outside). The zener diodes are installed so that their cathodes (the banded ends) face each other towards the center of the board.

Initial PC Checkout. When the power supply is completed, temporarily connect a linecord. Connect the negative lead of a meter rated 10 volts DC or higher to the foil between T1's mounting screws (that's ground). Connect the meter's positive lead to the junction of R7 and D1, which is in the center of the board; the meter should indicate approximately +6.2 volts DC. Then connect the positive meter lead to the R8 and D2 junction, which is near the edge of the board. You should get approximately −6.2 volts DC. If the voltages



The color comparator photocell Z-bracket is installed under a light integrator. If your enlarger has a filter holder under the lens, attach the Z-bracket to the holder.

are far apart in value, or if the polarity is wrong, make certain you find the mistake *before* installing IC1.

Disconnect the linecord and complete the PC assembly. If you use a 24 or 28-volt pilot lamp to illuminate the meter you connect to the holes adjacent to T1's secondary (24-V) leads. If you plan to use a neon illuminator, install a 100,000-ohm resistor (R9) on the PC board and connect the lamp to the holes marked "neon." The lamp must have as little illumination as possible. Incandescent 24 or 28-volt lamps must be the miniature or "grain of wheat" type rated approximately 30 to 60 mA; the lamps come with attached leads. Do not use pilot lamps of the 100 to 500 mA variety. The excessive light will confuse the analyzer.

To install IC1 when it is the metal can TO5 type, fan out the #1 to 4 leads and #5 to 8 leads so they form two straight lines. Note that the lead opposite the tab on a TO5 package is #8. Insert the leads into the board leaving about ¼ inch between the IC and the board. The IC is correctly installed if the tab faces *away* from the transformer towards the nearest edge of the PC board. Solder IC1 and cut off the excess lead length.

The edge of the PC board nearest IC1 has four sets of paired foil terminals. These are provided as mounting terminals if you connect the photocell comparator and sensor without the use of a plug and jack. However, we strongly suggest the use of the specified DIN-type connectors as they allow for easy repairs if the connecting wires break. (The connectors aren't *that* costly).

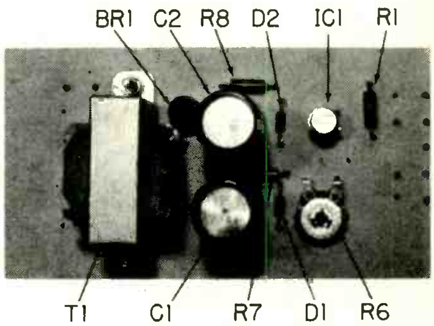
Potentiometers R2 through R5 can be linear or audio taper, though audio taper gives a slightly smoother adjustment; use whatever you have in stock.

The analyzer shown is built in a Bud 7-inch AC-1613 Universal Sloping Cabinet. This is the least critical item and you can substitute whatever cabinet you prefer. Just be certain the cabinet will accommodate the type of meter you use.

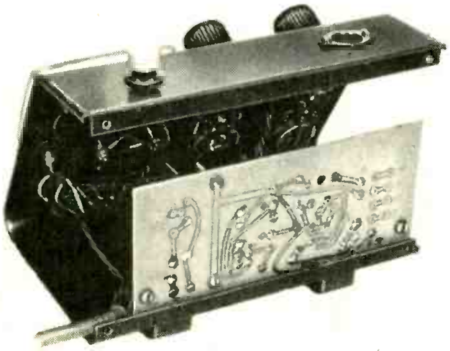
Meter M1 should be 0-1 mA with a zero-center scale. But these are expensive, so you can substitute any standard 1-mA meter you want. You will simply calibrate the instrument for zero-center.

If you use a neon pilot lamp mount it directly above the meter and shield the forward brilliance with a piece of black tape; the lamp should radiate straight down onto the meter scale. If you use the meter in the parts list, remove the front cover by pulling it forward. Then remove the meter scale. As shown in the photographs, place a black dot approximately 3/16-inch wide at the center of the scale. If you want, you can also modify the meter for the incandescent lamp. Drill a ¼-inch hole in the lower right of the meter *from the rear*. Position the meter in the cabinet and mark the location of the meter hole on the panel. Remove the meter and drill a ⅜-inch hole in the panel. When the meter is installed you can pass a "grain of wheat" lamp through the panel into the meter. Reassemble the meter and complete assembly.

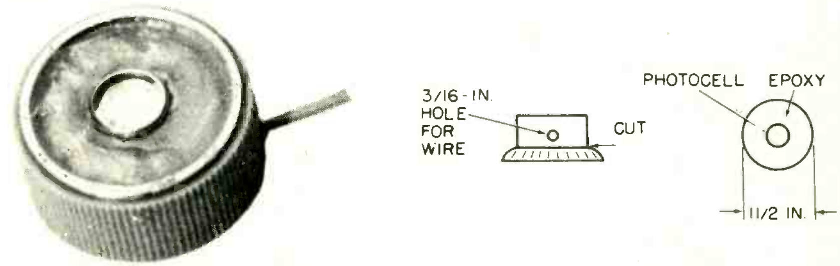
The Comparator. The photocells used for the comparator and exposure sensor, P1 and P2, must be Clairex type CL5M5L. Make no substitutions. From a piece of scrap aluminum ¾ to 1 inch wide, fashion a Z-bracket to the dimensions shown. Drill a ½-inch hole close to the end of the longer Z-leg. Fasten the other end of the Z-leg to your enlarger's under-lens filter holder. If your enlarger does not have a filter



This is the parts location when our PC board is used. To get a free template of the PC board, send a Self-Addressed Stamped Envelope to: Davis Publications, Dept. T, 229 Park Ave. South, New York, NY 10003.



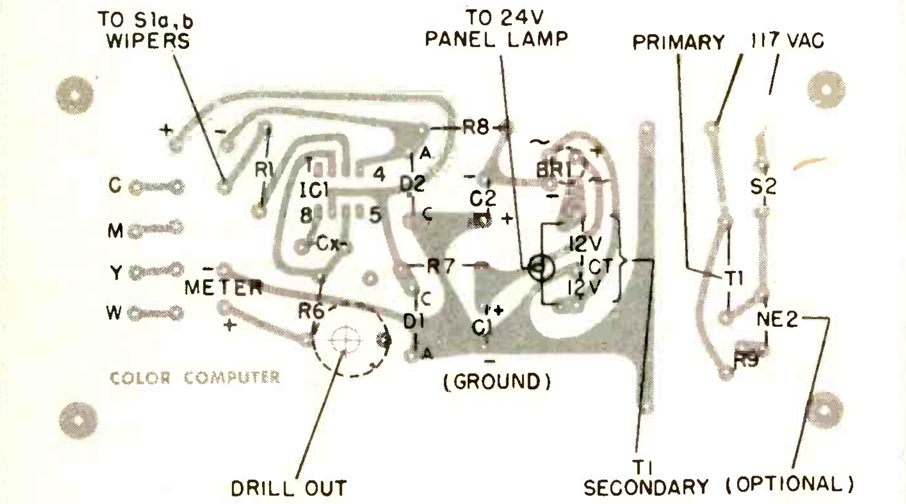
Rear view of author's color analyzer shows vertical mounting of the circuit board.



The exposure sensor photocell is mounted in anything that will keep it in place on the easel. This example was epoxy-cemented into a large control knob after the outside dial section was ground off. In typical operation, the sensor is placed under the lens with the light integrator or filters.

COLOR ANALYZER

holder, or if it has a permanent swing-away red filter under the lens, mount a Paterson swing-away light integrator (available from local photo shops) under the lens. Fasten the short leg of the Z-bracket to the integrator—which has pre-drilled holes—so that the ½-inch hole is on the optical center of the lens. Then cement photocell P2



There are few parts on the PC board and nothing is critical. Modify the board if you wish. Trimmer potentiometer R6 should be a flat mount, so it can be adjusted through a hole in the cabinet.

in the hole and attach the connecting wires; these can be extra-thin zip cord such as used for short-length speaker connections. (This whole bit reads a lot more complicated than it is. Use the photographs as a guide.)

Photocell P1, which measures the exposure light, can be mounted in anything heavy enough to hold it in place on the easel. The photographs show the photocell epoxy-cemented in an oversize control knob.

When the complete analyzer is assembled, attach oversize calibrated knobs such as the Calectro E2-715 to R2 through R5. The knob calibrations are important so they should run out to the very edge of the knob skirt. If the calibrations don't run to the edge you won't be able to preset the controls with any reasonable degree of accuracy. Place a fine line or other indicator directly above each knob.

Checkout. Connect the photocells to the control unit and apply power. Don't worry if the meter pins at either end of the scale. Set switch S1 to the extreme clockwise position and adjust R2 through R5 until you find the control that changes the meter reading. Mark the switch and the control "C" for cyan. (We suggest you paint the cyan knob insert a blue-green. Also paint the other knobs the appropriate color.) Advance S1 one position clockwise, find the correct knob and label both "M" for magenta. Advance the switch another position clockwise, find the knob and label both "Y" for yellow. The last switch position and knob is labeled "W" for white (white light exposure). Make certain the C, M, and Y controls are reading P2, the color comparator mounted under the enlarger lens.

Set S1 to any position, set all other controls to their mid-position, and turn on bright room lights. If the meter pins out or approaches full scale deflection, adjust trimmer control R6 so the meter pointer just pins (don't be afraid to pin the meter). Depending on the amount of light the meter pointer will pin right (for bright light) and left (for

Close-up of meter face showing a small scale-illumination lamp in lower right corner. This lamp should not be operated at full voltage to avoid fogging the film.

dark or very low light). This is normal and there will be no damage to the circuit or the meter. (Note: If you use a zero-center meter the pointer will barely pin on both sides.)

Install the Z-bracket under the lens. If your enlarger uses a filter holder under the lens insert a diffusion screen or glass, or a Beseler Light Integrator or similar ground glass in the filter holder. You are now ready to make color prints.

The first thing you need to make fine quality color prints is a high speed chemistry, such as the two-step Beseler system which can produce a finished print in two minutes. The second item you need is the electronic color analyzer for which we've already given you the plans.

Color Variables. Color materials such as the negative, printing paper, enlarger lamp, and even color correction filters vary in their sensitivity to light colors from batch to batch, roll to roll, and time to time. Even the enlarger's optical system can have a color cast. For this reason it is generally impossible to place a negative in your enlarger, expose the paper, and develop a good—let alone decent—color print.

To avoid upsetting a control setting while groping for the on-off switch in the darkroom, mount switch S2 as far as possible from the controls.

Provides a wealth of worthwhile info for photographers interested in the color print techniques available from Kodak or your photo dealer. Their publication No. E-66.

One way we can correct for these variables is through an *additive* exposure, exposing the paper through blue, green, and red filters for differing lengths of time. Since blue, green, and red create all the colors in additive printing, any correction can be obtained by controlling the precise timing of each exposure. The additive system is a pain in the neck for the hobbyist, for the slightest desired change in the color rendition or saturation (exposure) can involve changes in the exposure through all three filters.

A printing system that's easier to use and more favored by hobbyists is the *subtractive* exposure. A single filter pack made up of two of the filters known as YELLOW, MAGENTA, and CYAN makes all the color corrections at the same time. This filter pack is placed between the enlarger lamp and the negative; virtually all modern enlargers have a drawer in the lamphouse to accommodate a filter pack. A single exposure through the filter pack is all that's required to make a color print. Some of the more expensive enlargers have what is termed a "dichroic head" with variable filters as part of the light system; the exact value of filtration is simply dialed by the user. Again, all the color correction is provided at one time by the dichroic head so only a single exposure is needed.

More Info. A full and complete treatment of both types of color printing is contained in the Kodak publication *Printing Color Negatives;* this book is a required reference for anyone who wants to make quality color prints. The book also gives the most convenient operating procedures for electronic color analyzers.

The subtractive printing procedure is particularly well adapted for use with a color analyzer, is the easiest method for the amateur, and is exceptionally fast-handling, so the illustrations to follow will refer to the subtractive system.

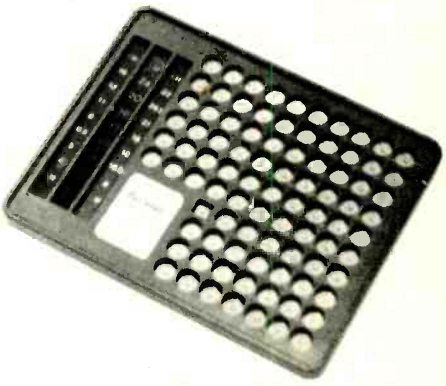
An electronic color analyzer basically consists of a photocell (vacuum tube photomultiplier or photoresistor) positioned under the lens, blue, green, and red filters mechanically positioned over the photocell (or positioned over the cell by hand) and a meter that indicates the amount of light falling on the cell. The meter is connected to the photocell through independent potentiometers as shown in the figure. Color analyzer readings will be accurate for most negatives and lighting situations as long as the same box of printing paper is used. The system needs to be recalibrated only when the printing paper is changed (so purchase boxes of at least 100 sheets to avoid extra work).

The first step is to make a really fine print from a decent negative. You can do it the hard way, one print at a time, or use a Beseler Subtractive Calculator which puts you inside the ball park on the first try. When you have made a print with satisfactory flesh tones and color saturation don't disturb the enlarger or timer controls.

To Continue. . . . Place the color analyzer's probe on the easel or swing it under the lens (if it is mounted on the enlarger). Install a light integrator—which is nothing more than a piece of ground glass or its equal—under the lens, between the lens and the analyzer's probe. The light integrator scrambles the picture into a diffused "white light" which contains all the color elements of your negatives and the filter pack. Place a blue filter (Kodak Wratten No. 98) on top of the light integrator. (Note that most hobbyist analyzers have a selector switch that also mechanically positions the correct filter over the photocell.) Turn on the enlarger and adjust the analyzer's *yellow* control for a convenient reference meter reading. (Usually, center-scale or "null" is used as the reference reading, but any meter reading can be used as a null.)

Remove the blue filter, install a green filter (Kodak Wratten No. 99), switch the analyzer to MAGENTA and adjust the *magenta* control for a null meter reading. Remove the green filter, install a red filter (Kodak Wratten No. 70), switch the analyzer to CYAN and adjust the *cyan* control for a null meter reading (the color controls yellow, magenta, and cyan refer to the color of the subtractive filters in the filter pack). Finally, remove all filters from under the lens, switch the analyzer to WHITE and adjust the *white* control (exposure control) for a null meter reading.

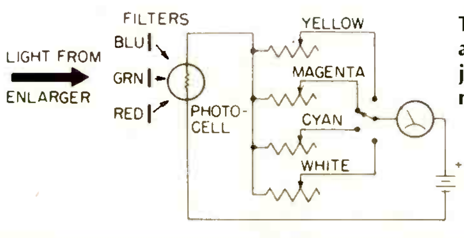
(The color analyzer in this project uses a separate photocell for the exposure. If you look at the easel you'll see a shadow cast by the Z-bracket holding the color comparator cell. Position the exposure cell on the easel so it is just off the edge of the shadow. If you prefer, you can place several thicknesses of opaque paper over the color comparator cell and use it for the white measurement, though we suggest you use the separate cell.)



Modern color print chemistry techniques from Beseler include this subtractive color calculator to aid filter selection.

When all the controls are adjusted you have programmed the color characteristics and exposure of your "reference" print into the analyzer, and you should note the control settings and exposure time for future use.

Down to Business. Now assume you want to make a print from another negative. Put the new negative in the enlarger. Then set the degree of enlargement and focus, leaving the lens wide open. Place the analyzer's probe under the lens, install the light integrator and set the analyzer's switch to CYAN. Install the red filter on top of the light integrator and adjust the lens aperture until the meter indicates null. Switch the analyzer to MAGENTA, install the green-reading filter and note the meter reading. If it is not at null, add or remove magenta filters (from the filter pack) until the meter shows a null. Then switch the analyzer to YELLOW, install the blue-reading filter and

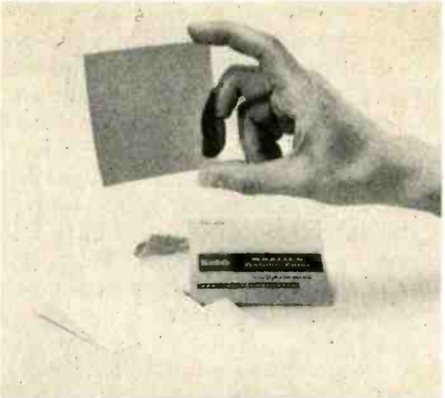


The basic color analyzer. Once controls are matched to a "standard" negative, just select filters for a null on the meter for each individual color and white.

modify the yellow filtration in the filter pack until the meter shows a null. Finally, set the analyzer to WHITE, remove all reading filters and adjust the lens aperture for a null indication.

Through the color analyzer you have now established a new filter pack and exposure for the new negative. If the new negative uses similar lighting to the reference negative the print should be perfect. If the lighting was considerably different the print will be good–acceptable to most people, but requiring just a slight filter pack modification for a great print.

Swinging Filters. In the previous example the filter pack would wind up with magenta and yellow filters–which is what is generally needed. Some Kodacolor negatives, however, might require cyan lters plus magenta *or* yellow (but never all three). This information will have been programmed into the color analyzer, so you will have no difficulty if you make a slight modification in procedure. The first meter reading, the one where you adjust the lens's aperture, should be made for the filter you are *not* using in the filter pack. For example, if your basic filter pack has cyan and magenta, switch the analyzer to YELLOW, place the blue-reading filter in position on the light integrator, and close down the lens for a null indication. Then proceed with the other readings. If your reference negative did not require cyan in the filter pack, if it had yellow, magenta, or both, and you find a new negative just can't be pulled in for null meter readings with yellow and magenta filters, it indicates the new negative requires cyan filtration, so start with the assumption that yellow is not required. If you still can't null the meter, it means magenta should *not* be in the filter pack.



Kodak color printing filters. Typical filter designation CP20Y means color filter with a .20 density; the color is yellow.

As we mentioned, a more thorough discussion and procedure for using a color analyzer is found in Kodak's *Printing Color Negatives*.

Most, but not all, commercial color analyzers use photomultiplier tubes which have no light memory, nor are they confused by infrared from the enlarger lamp. These units are, as you would expect, relatively expensive. Low cost models use photoresistors.

More Data. Photoresistors are infrared-sensitive and they have a light memory, both of which can confuse the meter. The infrared is easily handled by installing a heat or infrared filter glass in your enlarger (it should be there to protect the negative anyway). The light memory is handled by using a consistent measurement procedure. The best way is to turn the enlarger off, install the reading filter and the light integrator, turn off the bright room lights, count to five, and then turn the enlarger *on*. Take the meter reading, or adjust the appropriate color control, slide the new reading filter in place before withdrawing the old one, switch the analyzer, and make the new meter reading. Repeat this for the third reading filter. You'll note that this procedure keeps bright white light from falling on the photocell between meter readings. If you want to change filters under room lights, make certain there are about five seconds of darkness between turning the room lights out and turning the enlarger on.

The whole bit might sound somewhat complicated, but after you've run through the procedure once or twice to get the hang of things it shouldn't take you more than a minute or so for a full color analysis of a new negative.

The Kodak Wratten filters needed are available from professional camera shops. For the construction project, color analyzer 2-in. or 3-in. Kodak Wratten filters Nos. 98 (blue), 99 (green), and 70 (red) are recommended. If you have difficulty obtaining these specific filters you can make the following substitutions, through the analyzer's precision will be slightly reduced: 47B (blue), 61 (green), and 92 (red).

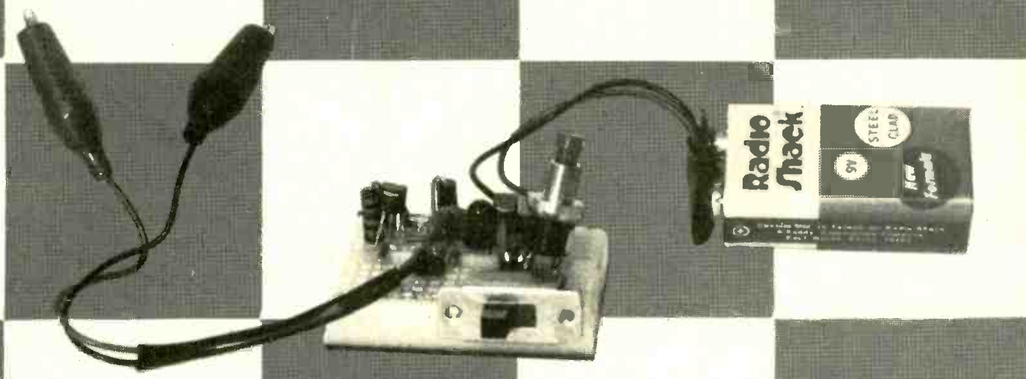
The Pro Shop. We could not close without some words on commercially processed color prints such as you might order from a drugstore or camera shop. Commercial color labs have as high (if not higher) a remake rate than the amateur if *quality* color prints are desired. As a general rule, it takes two tries to get a decent color print, so the hobbyist with a color analyzer is way ahead of the game because he can turn out, at worst, two *good* prints for each three first tries. The average is even higher than this as the hobbyist gets skilled in the use of a color analyzer.

Commercial labs come close to a hobbyist's results only when they are equipped with a video analyzer such as the Kodak Video Color Negative Analyzer Model 1-K; and Kodak only claims a 75%+ first try acceptance rate for their analyzer. The video analyzer is a 5-in. x 5-in. TV display. The operator views the color negative as a positive color TV image, and adjusts the TV's controls for proper color balance and brightness (saturation). The control settings are translated to the printing equipment's filter adjustments so that the final print is similar to the image displayed on the TV.

The video analyzer is a fast and easy way to get good color prints on the first try, but since video analyzers cost in the thousands, the color analyzer is the best thing going for the hobbyist. ■


Professional equipment used by color labs includes this Kodak Video Color Negative Analyzer. It uses a 5-in. color TV screen to assist an operator in selecting the correct filter.

BUILD CHECKERBOARD FOR QUICK TESTING



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

by Martin Weinstein

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

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

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

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

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

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

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

And that's how Checker Board checks crystals.

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

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

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

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

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

CHECKERBOARD

their leads to the bare wires.

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

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

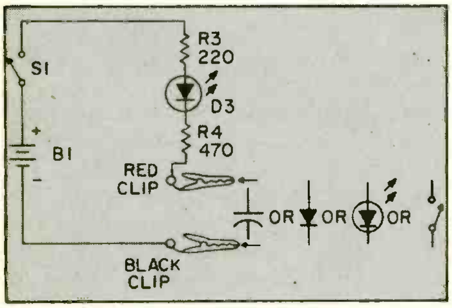
There are 17 rows of five holes each on each side of the center of the breadboard, a total of 34 rows in all. Underneath each row of five holes is a connecting spring clip. The clip holds onto whatever lead you push through the hole. And all the leads you've inserted in any one row (on each side of center,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

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

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

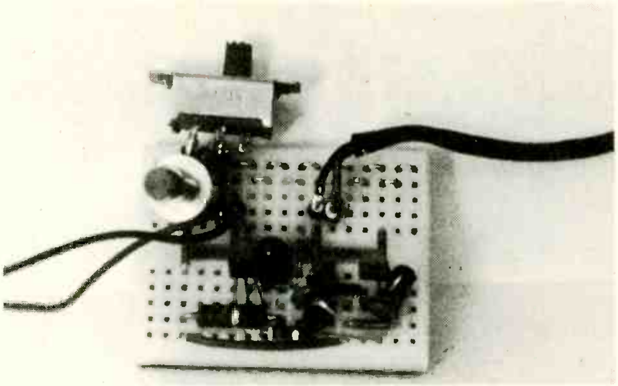
Using Checker Board. Follow the instructions below as you test each component. Generally, components can either be clipped-to with the alligator clips, plugged directly into the solder-

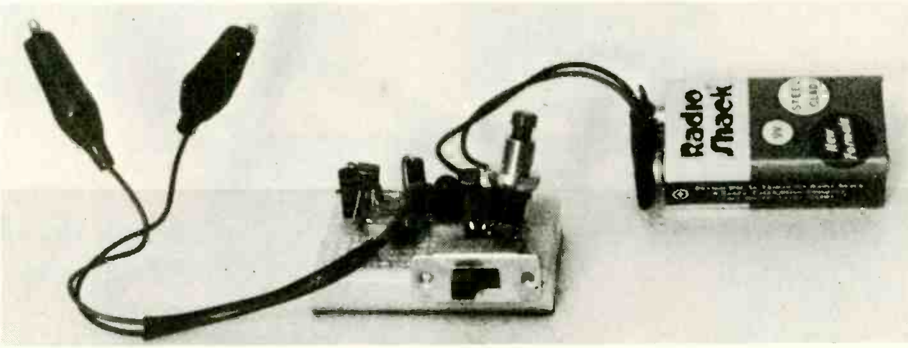
(Continued on page 118)



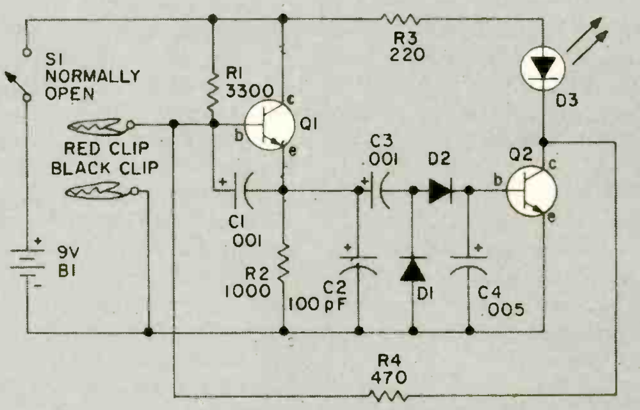
If you use Checkerboard circuit to test capacitors (electrolytics, tantalums, etc.) or diodes, LEDs, or switches, here's the actual working circuit, simplified from the complete Checkerboard circuit, which can check crystals.

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





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



PARTS LIST FOR CHECKER BOARD

C1, 3—.001-uF capacitor
C2—100-pF capacitor
C4—.005-uF capacitor
D1, 2—1N914 or other general-purpose, rapid-response silicon diode
D3—LED (light-emitting diode)
Q1, 2—General-purpose, small-signal NPN transistor, 2N3904 or similar
R1—3300-ohm, ½-watt resistor
R2—1000-ohm, ½-watt resistor
R3—220-ohm, ½-watt resistor
R4—470-ohm, ½-watt resistor
S1—SPST toggle switch, or normally-open pushbutton. Use either, or both in parallel, as desired.
Misc.—Solderless breadboard (AP Products, Inc. distribution strip part number 923273-for AP dealer see end of Parts List); headers (AP Products), alligator clips with pastic covers, 9-V battery connector, 9-VDC transistor radio battery, hookup wire, solder, etc.
For name of dealer nearest you who carries AP Products telephone 800-321-9668 toll free.

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

Las Vegas LED

Always win on the red with electronic roulette

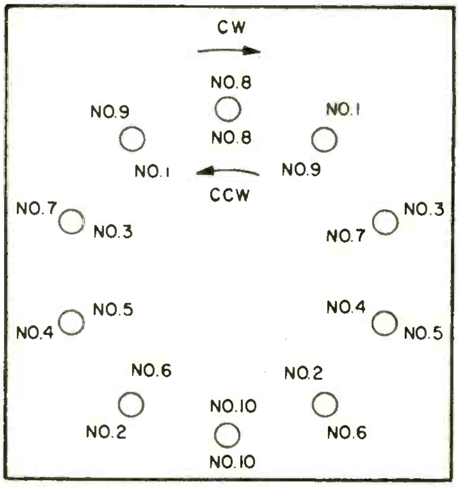
by Walter Sikonwiz

PEOPLE HAVE ALWAYS BEEN fascinated by games of chance, as diversions and obsessions. Inveterate gambler or not, chances are you'll really like *Las Vegas LED*, our version of that old favorite, Roulette. Here's more good news—you won't have to drop a bundle to cash in on the fun.

Las Vegas LED's spinning wheel of fate is a revolving dot of light, provided by a ring of ten LEDs. A glance at the photographs will show you that play is governed by three controls: *Accelerate, brake,* and *decay*. You start by pressing the *accelerate* button, which causes a red dot of light to revolve at an ever-increasing rate until a terminal velocity is reached. If you release *accelerate,* the spinning light will gradually coast to a standstill. The rate of deceleration is determined by the *decay* control. Pressing *brake* while the light is coasting causes a more rapid, but not instantaneous, halt to the spinning.

At least two games are possible, with this control format. Using a little imagination, you can probably devise more. The first possibility is similar to standard Roulette. A player presses *accelerate,* then releases it, and hopes that the number he has predicted beforehand will be the one at which the light ultimately comes to rest. Alternatively, the player starts the light into motion; then, upon the release of *accelerate,* he tries to stop the light on a number designated by his opponent, using only one pulse of the *brake* switch for this purpose. This second variation is quite a frustrating game; particularly so if various decay times are used. Decay times from about 1.5 to 15 seconds can be selected via the *decay* potentiometer.

How It Works. Before discussing construction, let's delve into the theory behind our Roulette game. We start with a very simple voltage-controlled oscillator. We then devise some means for converting the oscillation of our VCO into the apparent revolution of a spot of light (this might seem hard, but we'll see how simple it is later); the velocity of the light will be directly proportional to the VCO's frequency. The VCO's frequency, however, is proportional to the control voltage applied to it. We can produce acceleration of the revolving light if we cause the VCO's control voltage to gradually rise while the *accelerate* button is depressed. Conversely, deceleration of the light is synonymous with a gradual reduction in control voltage. How do we produce a control voltage that behaves in such a manner? We can charge and discharge a capacitor through resistors, and use the voltage across the capacitor as our control voltage.



Mount the LEDs in one of the two orders shown here, which one depending on whether you wish your wheel to "rotate" clock-wise (cw) or counter-clockwise (ccw).

Take a look at the schematic diagram. The voltage across capacitor C3 is our control voltage, and you can see how pressing S2, the *accelerate* button, charges the capacitor through R13. Once S2 is released, charge accumulated on C3 drains away through R13, R11, and *decay* control R12. Setting R12 to its maximum resistance produces the slowest rate of capacitor discharge; hence, as we'll see later, the revolving light will take a maximum amount of time to come to rest.

Brake switch S3 also discharges C3, this time through R14. Since the resistance of R14 is set to a relatively small value, the rate of discharge is quite rapid, and produces a quick cut in the speed of the light. It is the voltage on C3 that is to be our control voltage. Transistor Q11, functioning here as an emitter follower, reads C3's voltage; and because the emitter follower configuration is used, Q11 will not significantly contribute to the discharge of capacitor C3. At Q11's emitter we now have a voltage proportional to that on C3, which is used to drive our VCO.

Unijunction transistor Q13, along with R16, R17, R18, R19, and C4, comprise a relaxation oscillator, the frequency of which is proportional to the input voltage present on the left-hand end of R16. We don't have the nice, linear, voltage-to-frequency conversion of fancier VCOs, but what we have serves our purpose well enough. The output signal of our VCO appears across R19, and is a series of short-duration spikes with an amplitude of a volt or two. Such a signal won't be acceptable to the circuitry that follows, so we first feed it to transistor Q12, set up so that only a small input signal saturates it fully. The resultant output signal, available at Q12's collector, is a well-defined series of negative-going pulses, approximately 9 volts in amplitude.

Now we convert the variable-frequency pulses from Q12 into the ap-

Las Vegas LED

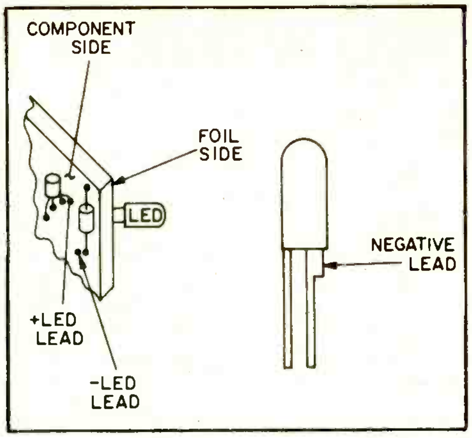
parent revolution of a dot of light by using an integrated circuit known as a decade counter. One essential characteristic of such an IC is that it has ten outputs, and at any given instant of time, nine of these outputs will be at a low potential, while the tenth will be high. The second important feature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

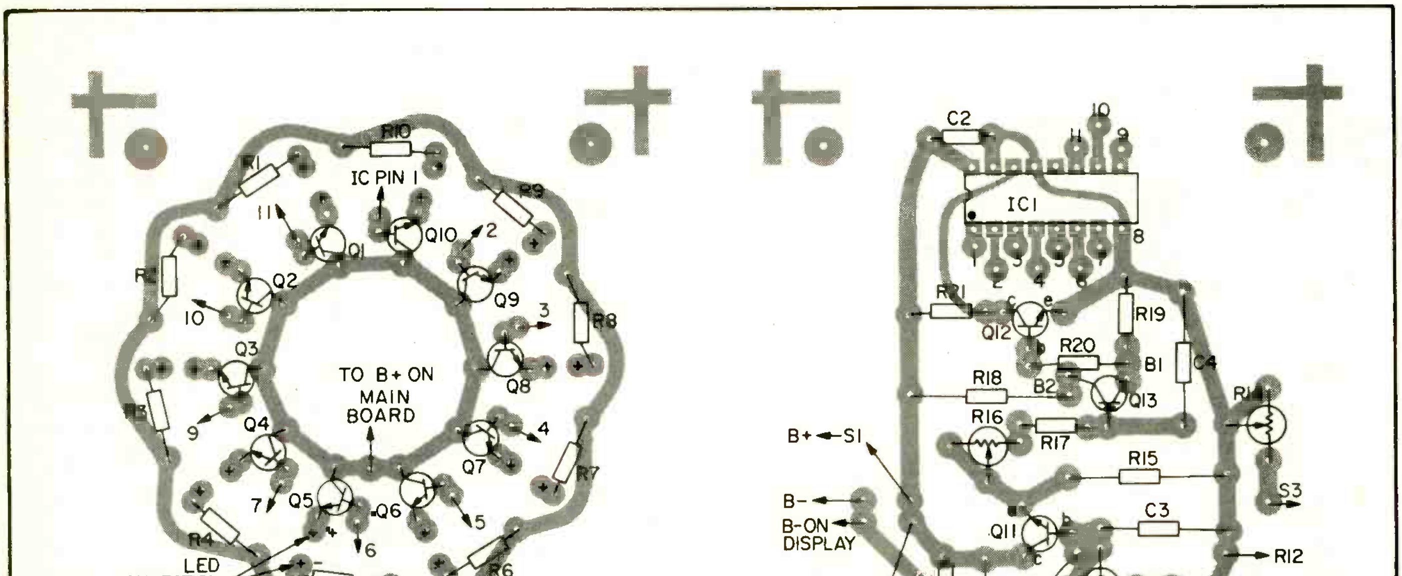
Let's review what we have: 1) the frequency of our VCO is controlled by the gradual charge and discharge of a capacitor; 2) the variable-frequency signal from the VCO feeds a decade counter, which drives ten LEDs; and 3) proper LED arrangement results in the apparent revolution of a single dot of light, 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 construction is by drilling your



LEDs are to be wired to the foil side, with their leads left long enough that their heads poke through the front cabinet (see text). Observe polarity; the negative leads of the LEDs are notched, as shown, and should be connected as both the pictorials and the schematic indicate.

cabinet to accept the ten LEDs. With a compass, lay out a small circle on a sheet of paper. If you intend copying the PC layout provided, the circle's radius should be exactly .9 inch. With a protractor centered at the circle's center, divide the circle into arcs at 36-degree intervals. Trim away any excess paper, leaving just the circle and a small border around it. Position the circle conveniently on your cabinet, and tape it down. With a fine, sharp awl make



The component sides of the main and display boards are shown in this pictorial view. Make certain that the main board's IC pins are all interconnected properly to the solder-points on the display board, as labeled. Connect, for example, IC pin 1 to Q10. Don't forget about R11 which is not shown and is wired point-to-point between R12 and S2.

slight indentations in the cabinet at the points where the circle is subdivided into arcs. Remove the circle, and at each indentation drill holes through which the LEDs can protrude.

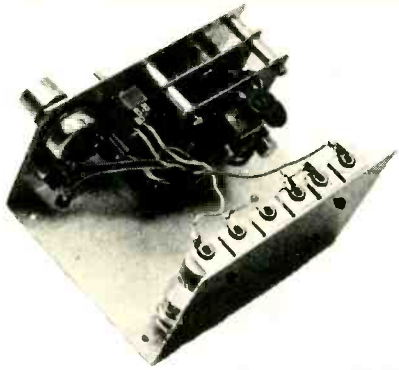
The drawing given shows the order of mounting of LEDs for both clockwise and counterclockwise revolution. The PC layout supplied for the display board provides counterclockwise revolution of the light.

The majority of the components mount on two circuit boards—either the main board or the display board. Even if you decide not to use a PC board, the PC layout provided for the display board may be helpful to you. Note that the arrangement is particularly simple, even though a good many parts are involved, because a radially symmetric pattern is employed instead of the usual rectilinear layout.

When installing components on the display board, follow the dimensional details in the accompanying drawings. Note that Q1 through Q10, and R1 through R10 mount on the component side of the board. LED1 through LED10 mount on the opposite foil side, with leads of such a length that the tops of the LEDs extend beyond the spacers and through the cabinet's panel. The semiconductors that mount on the display board are not especially fragile, but as is the case with all solid-state devices, excess heat can be damaging. Solder all connections quickly, using a 25-watt iron and fine, rosin-core solder. Twelve wires will run between the display board and the main board; ground, +, and the ten counter output leads.

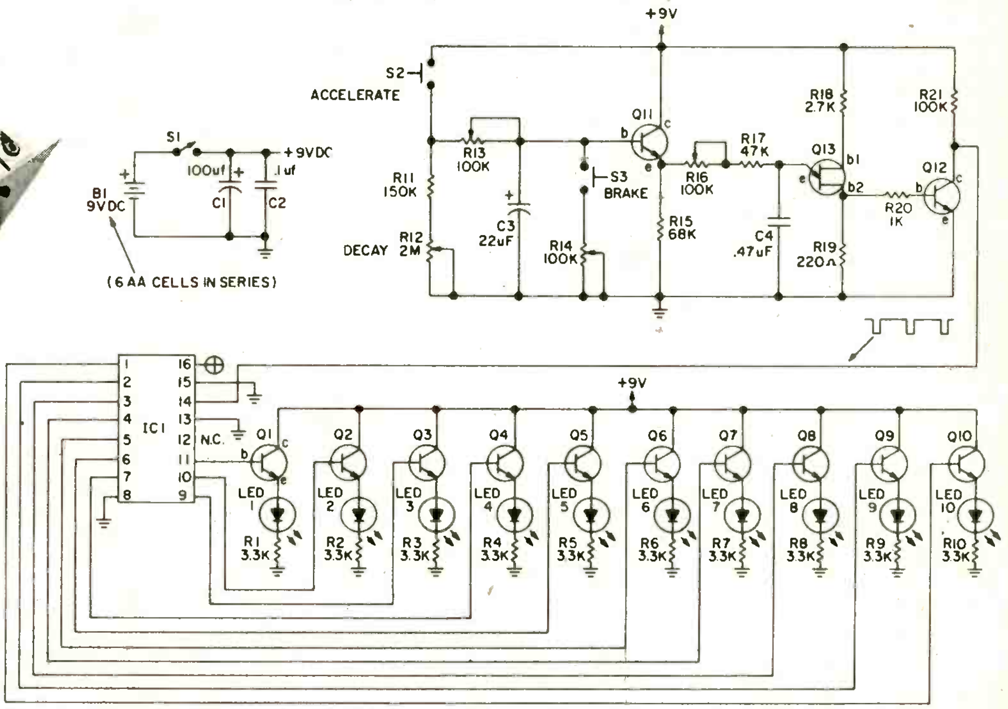
The main board contains the rest of the components. Note that if the PC patterns supplied are copied, the main board may be stacked right behind the display board. This makes for a very dense packing arrangement, but if you have ample space, the boards may be mounted in any manner you like. R11 does not appear on either circuit board; instead, it is wired point-to-point between R12 and S2. Be sure to use a 16-pin socket for IC1. This IC is a CMOS unit, and should be inserted into its socket only after all soldering is finished. If, in checking out your unit, you should find an error that requires re-wiring, remove IC1 before applying a soldering iron to the board.

In assembling the circuit, pay atten-



Inside view of Vegas LED showing stacking of PC boards.

Completed Vegas shown fully assembled, and installed in case.



PARTS LIST FOR LAS VEGAS LED

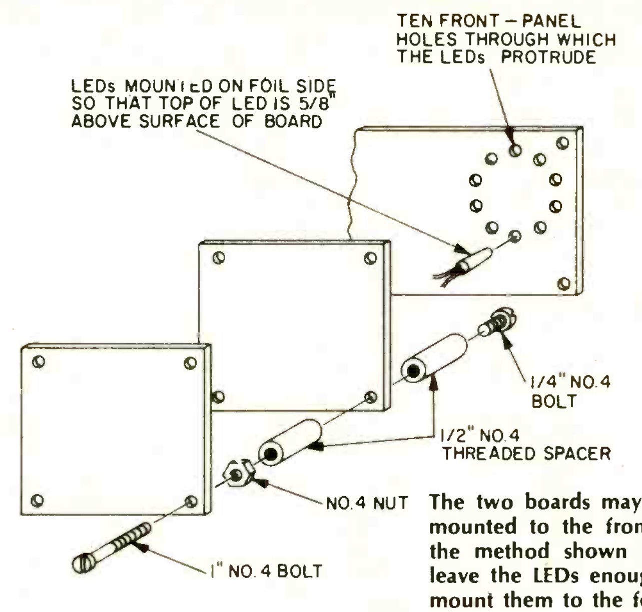
B1—Six AA (penlight cells) 1.5 VDC
C1—100-uF, 16-VDC capacitor
C2—.1-uF capacitor
C3—22-uF, 16-VDC tantalum capacitor
C4—.47-uF, capacitor
IC1—Decade Counter/Divider CD4017
LED1-LED10—Light Emitting Diodes
Q1-Q12—2N3904 transistors
Q13—Unijunction transistor
R1-R10—3300-ohm resistor
R11—150,000-ohm resistor
R12—2-Megohm potentiometer
R13, R14, R16—100,000-ohm trimmer
R15—68,000-ohm resistor
R17—47,000-ohm resistor
R18—2700-ohm resistor
R19—220-ohm resistor
R20—1000-ohm resistor
R21—100,000-ohm resistor
S1—SPST toggle switch
S2, S3—SPST pushbutton switches, normally open
Misc.—Battery clips, IC socket, aluminum spacers, wire, solder, hardware, etc.

You might not be able to afford a trip to Vegas; but Las Vegas LED will bring the glittering, gambling glamor of that city right into your own home town. When you assemble the circuit, just pay strict attention to the orientation of C3 and C1. It also pays to doublecheck the positions of all ICs and transistors; you'd be surprised how often a simple positioning error can lead to hours of fruitless trouble-shooting. The boards may be mounted in any way you like within the cabinet, but remember to leave room for the batteries to fit into later on. Finally, make absolutely sure you have positioned the LEDs properly depending on whether you want clockwise or counter-clockwise rotation of your "wheel." Follow the diagram on the first page very exactly. Once it's all together just get your bet down and start Las Vegas LED spinning around.

Las Vegas LED

tion to the orientation of C3 and C1. Likewise, make sure the transistors and IC are correctly positioned. The LEDs must also be properly oriented. The leads of all these devices are identified on the packages in which they are sold. Because of the circuit's low power consumption, six 1.5-volt penlite cells in series will power it for a long, long time. A single 9-volt transistor battery could also be used.

Because this is not a finicky circuit, the operating controls and circuit boards can be mounted in any convenient way inside your cabinet, but be certain to allow sufficient room to accommodate the batteries. When you've completed cutting and drilling the cabinet, finish off the front panel with press-on decals. As shown in the photographs, LED1 through LED10 should be identified with numerals applied in a random order.



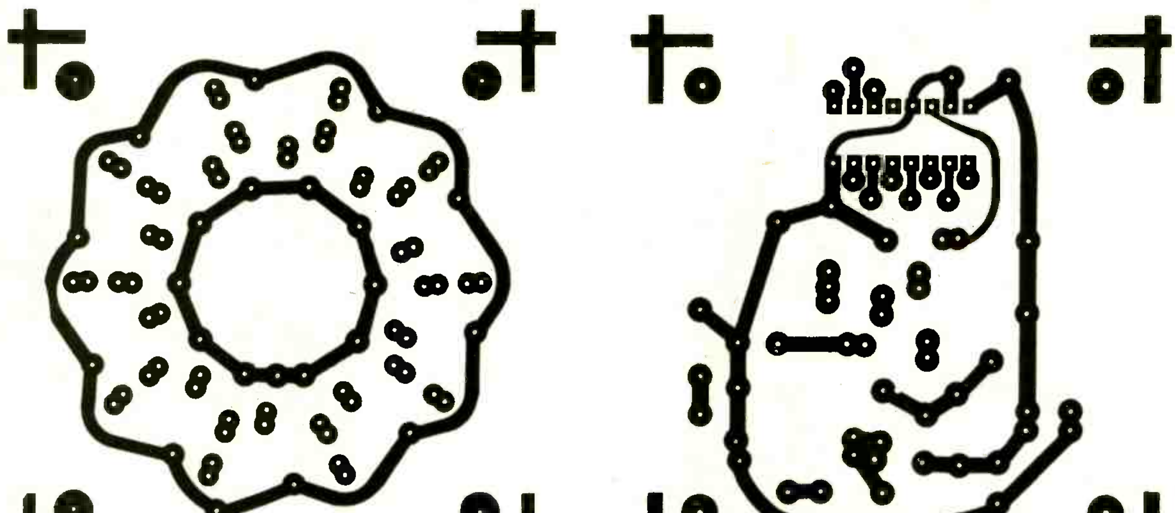
The two boards may be easily and neatly mounted to the front panel by following the method shown here. Make sure you leave the LEDs enough lead, and that you mount them to the foil side of the display board.

Final Calibration. After assembly is complete, only a few simple adjustments are necessary to put the circuit into operation. Turn R12 so that its resistance is at a minimum. Set R13, R14, and R16 to the midpoints of their ranges of rotation. Apply power, and depress the *accelerate* button. Within several seconds you should see a spinning dot of light. Adjust R16 for the desired maximum velocity. Too high a maximum speed blurs the image and spoils the effect, whereas a slow-poke display is equally undesirable.

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

Turn R12 so that its resistance (and the decay time) is a maximum. Press the *accelerate* button until the display reaches maximum velocity, then release it, and press *brake*. Note the rate at which the display is slowed down. Adjust R14 while alternately pressing *accelerate* and *brake* until you obtain a rate of deceleration that you like. A very rapid braking action is undesirable; the brake should diminish the velocity, not halt motion instantaneously.

The game may be used as already described in the opening paragraphs. However, just as dice can be found as constituent parts of many other games, so too can Las Vegas LED be adapted to games of your design. ■



Las Vegas LED uses two compact PC boards to keep its "wheel" spinning. The display board, on the left, takes advantage of a repetitious circuit to achieve a neat, clean symmetry of design. The main board, on the right, is also simple to etch and wire. Use these two full-size patterns as templates for your own Las Vegas LED.

The *Smart* Power Supply

by Bob Powers

Keeps tabs automatically on current and voltage levels

When working with various electronic projects, it's easy to get carried away with too many current-eating components, which can overload a power supply. Our Smart Power Supply solves this problem with its built-in LED ammeter, which always tells you what the current draw is.

The supply delivers a regulated 5 and 8-volt output at up to 1-amp, and you'll never be in the dark as to how much current is being drawn. 4 LEDs display the amount of current being utilized by the load. Each LED lights respectively to show the level of current being drawn. For example, if ¾ of an amp (.75) is being used, the first three LEDs (".25", ".50", and ".75") will all glow to show that a current of at least ¾ of an amp is flowing. Best of all, the current measuring resistance is an unprecedented 0.1-ohm! What's more, the cost for the ammeter portion of the circuit is only about $5. That's way less than you'd pay for a good mechanical meter.

The 5-volt output is ideal for all of your TTL IC projects, while the 8-volt output may be selected for CMOS circuits, and other, higher-power requirements. The total cost for the whole supply, including the bargraph ammeter, is about $15-20, depending on your buying habits, and choice of parts suppliers.

How it Works. IC4 is supplied by an accurate reference voltage of 5-volts by IC3. IC4 is a quad op amp used in a quad comparator configuration.

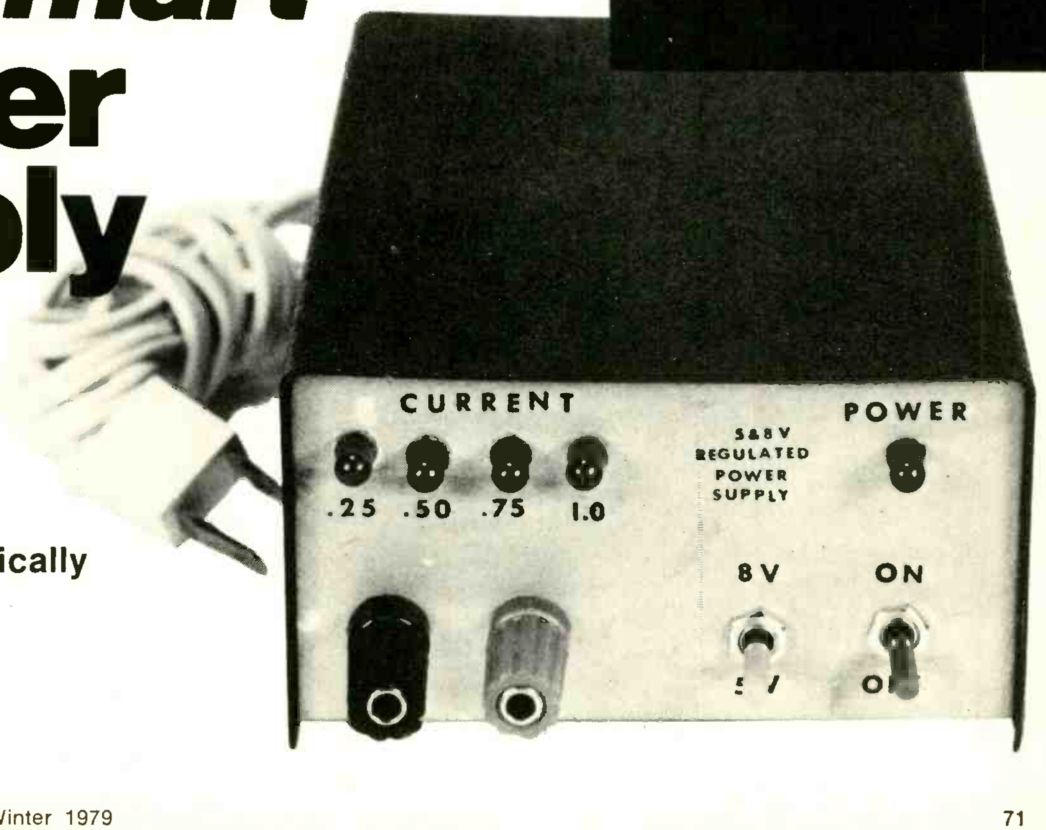
The 4 op amps (comparators) in IC4 are each fed a separate reference voltage by the divider network made up of R1-R4 and R5-R8. These comparators in IC 4 are very sensitive, and they can detect extremely small voltage differences and compare them.

Let's take the first op amp comparator as an example. Its inputs are pins 2 and 3, and its output is pin 1. The reference voltage appearing at pin 3 is compared to the voltage coming into the first comparator at pin 2. When ¼ of an amp or more is flowing thru R10, .025-volts or more (0.1-ohms times 0.25A = .025V) appears across R10, which is enough voltage to equal pin 3's reference voltage, thus turning on the first op am. The output of this op amp is at pin 1, so LED1 turns on to signify that at least ¼ of an amp is being drawn. In a like manner, the other LEDs turn on or off with the changing current. The rest of the circuitry makes up a basic voltage-regulated power supply.

Construction. All of the circuitry, except ICs 1 and 2, can be mounted on a small piece of perfboard. These two ICs must be mounted to the cabinet. In operation, IC1 and IC2 will get hot when the supply is run at higher currents, and they may shut down if the heat is not carried away. The back of the cabinet is the best place to mount ICs 1 and 2, for it allows a large heat dissipating area, while keeping the rest of the cabinet cool to the touch. When mounting ICs 1 and 2, smear heatsink grease between the IC cases and the cabinet, then bolt the ICs down tightly. Connect three long wires to IC1 and 2. These will be connected to the main circuit board later.

If the transformer that you wish to use has a center tap, cut it off or tuck it away. You won't need it. Bolt T1 down to the cabinet. Use heavy gauge (#16) wire for all line voltage connections, and carefully wrap all AC line connections with electrical tape. Use a

As you can see, our proto type was assembled on breadboard, with plenty of room for the components. The parts layout isn't critical.



Smart Power

grommet around the line cord exit holė in the chassis to protect the cord from the heat that will be there due to ICs 1 and 2. Tie a knot in the line cord just inside the cabinet hole to prevent it from being pulled out.

IC3, unlike ICs 1 and 2, can be mounted on the perf-board because it will not get hot in operation. You should use a 14-pin socket for IC4. Install IC4 only after all of your wiring to the socket is complete.

Be careful not to make any solder "bridges" between socket pins, as they are close together. When you install IC 4 in its socket, make sure that you observe the correct orientation with regard to pin 1.

After you've installed the circuit board, attach the wires from ICs 1 and 2 to their proper places on the board. Connect the wires to the display LEDs last, and make sure that you observe polarity on each LED. Be careful not to let the LED leads short against the metal cabinet.

Operation. Carefully inspect your wiring on the circuit board, especially the wiring to IC4's pins. This is a very important step, as one misplaced wire here can produce some real odd-ball systems. If everything appears to be in order, turn the unit on. The "power" LED (LED5) should glow.

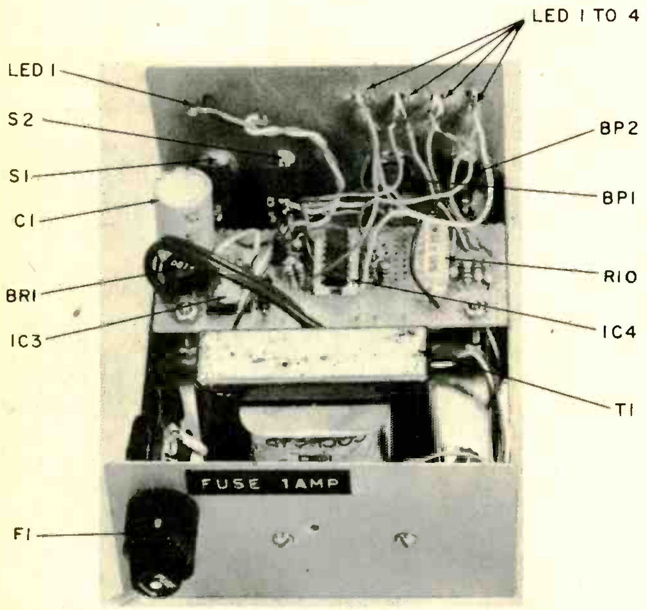
Connect a voltmeter to the output jacks. Depending on what position switch S2 is in, the voltmeter will read 5 or 8 volts. Throwing S2 to its other position should cause the voltmeter to read the other of the two voltages that the supply delivers.

To test the ammeter section, connect a circuit to the output jacks. With the supply set for 5-volts, a TTL IC circuit would be good for this test.

If the circuit that you hooked up draws more than ¼ amp, then one or more of the display LEDs will go on to show you how much current is being drawn.

Conclusion. You shouldn't worry about overloading the power supply, as fuse F1 will limit current draw to a peak of about 1.3-amps momentarily, before acting, and we deliberately overloaded several times in a row, with no damage occurring to the circuitry.

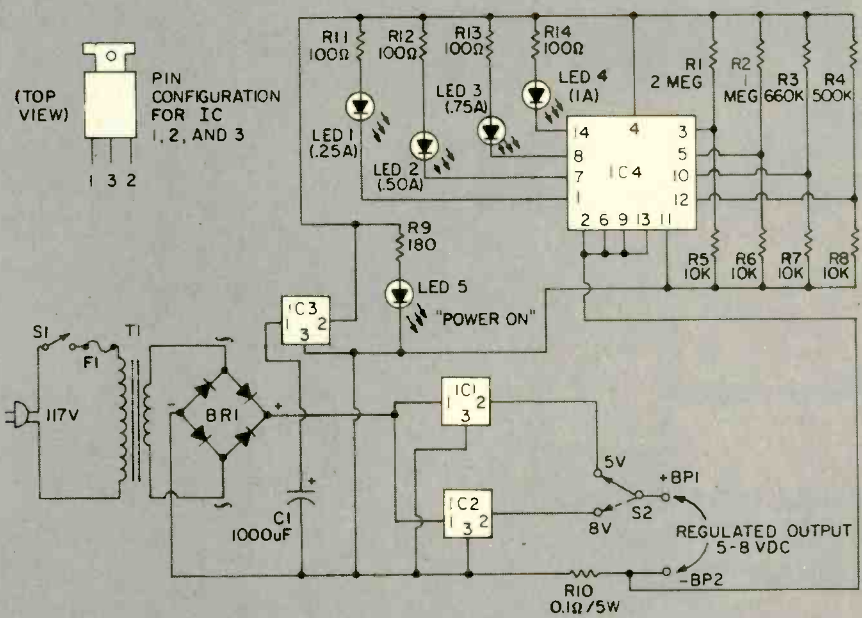
You might wish to attach a solderless breadboard to the top of the cabinet, to act as a permanently-powered breadboard for your experiments, or to construct an output voltage switcher for powering several projects alternately. ■

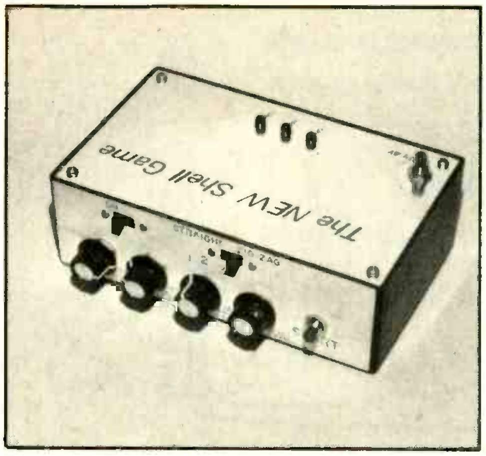


Again, parts layout is not critical in this power supply, but feel free to use our idea of where things should go. It's always a good general design idea to keep the power transformer as far away from the rest of the circuitry as cabinet size or practicality permits. Suspend the board above chassis.

PARTS LIST FOR THE SMART POWER SUPPLY

- **BP1, BP2**—5-way insulated binding post
- **BR1**—bridge rectifier rated @ 50 PIV 2-Amperes
- **C1**—1,000-µF, 24-VDC electrolytic capacitor
- **F1**—3AG 1-Amp fuse
- **IC1,IC3**—7805 linear voltage regulator
- **IC2**—7808 linear voltage regulator
- **IC4**—LM324N quad op amp
- **LED1 through LED5**—large, red LED rated @ 20 mA.
- **R1**—2,000,000-ohm, ¼-watt resistor
- **R2**—1,000,000-ohm, ¼-watt resistor
- **R3**—660,000-ohm, ¼-watt resistor
- **R4**—500,000-ohm, ¼-watt resistor
- **R5, R6, R7, R8**—10,000-ohm ¼-watt resistor
- **R9**—180-ohm, ¼-watt resistor
- **R10**—0.1-ohm, 5-watt resistor (Radio Shack #271-128)
- **R11, R12, R13, R14**—100-ohm, ¼-watt resistor
- **S1**—SPST switch
- **S2**—SPDT switch
- **T1**—transformer with primary rated @ 120-VAC/secondary @ 12.6-VAC, 2-Amperes





the new Shell Game

James J. Barbarello

Step right up and build this semiconductor con game

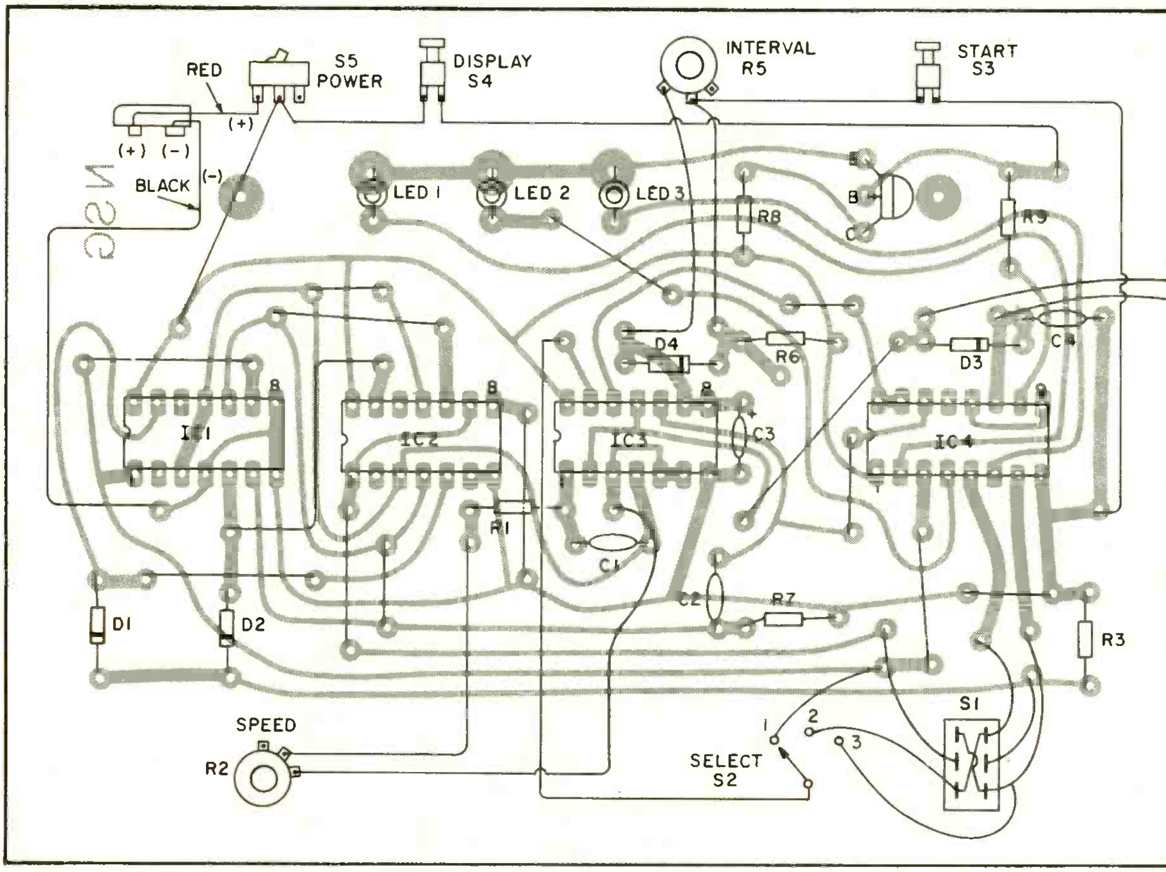
YOU WILL HAVE to be alert to win at *The New Shell Game*. In this electronic version of the famous carnival shell game, the electronic "pea" is manipulated in full view, rather than hidden under one of three walnut shells. As the game starts, the three light emitting diodes (LEDs) are dark. The operator presses the *start* button, a single LED lights and then moves back and forth in a straight or zig-zag pattern. After a time, the light goes out. The player's job is to follow the light's movement in an effort to determine which one was on last.

How fast the light moves, the total time of the manipulation, which light is on last, and for how long, are all controlled by the operator. The operator also selects either the straight or zig-zag sequencing pattern. The controls allow a full range of settings, from one that is fully obvious, to one that is totally misleading.

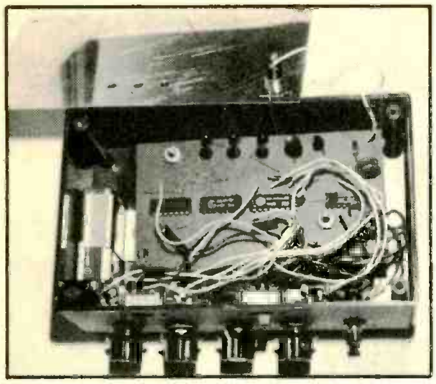
The skill of the player is pitted against that of the operator in this project that uses readily available CMOS devices, is powered by a single 9 volt battery, and can be built for about $20.00.

How it Works. As shown in the schematic diagram, flip-flops IC1 and IC2 form a four stage shift register. When *start* switch S3 is depressed, a logic "1" is loaded into IC1a through the *set* input, while all other stages are set to zero. As the shift register is clocked, the "1" bit continually circulates like a standard ring counter. Outputs 2 (IC1b), and 4 (IC2b) are combined in the discrete OR gate made up of D1, D2, and R3. The 1, 2 (or 4) and 3 outputs drive LEDs 1, 2, and 3 respectively.

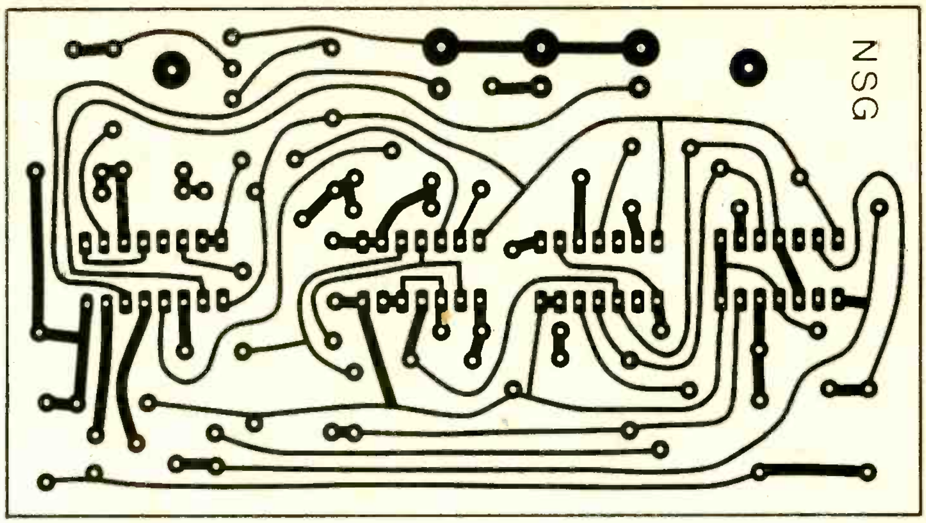
NAND gate IC3 and associated components form a one-shot (monostable) multivibrator. When S3 is depressed, C3 discharges rapidly through D4, and drives the IC3c gate output high. When S3 is released, C3 charges through R5 and R6 with a time constant proportional to [C3 × (R5+R6)]. When the voltage across C3 reaches 4.5V (the CMOS logic level), the output of IC3c



Wiring the printed circuit board is a snap if you follow this parts location diagram carefully. The two, large non-electrically connected holes in the upper left and right corners of the P.C. board are for the mounting bolts. Make sure you use the correct polarity on the 9-volt battery connector. Red positive, black negative.



The three LEDs must be carefully soldered to the PC board so that they will just fit through the holes in the project faceplate.

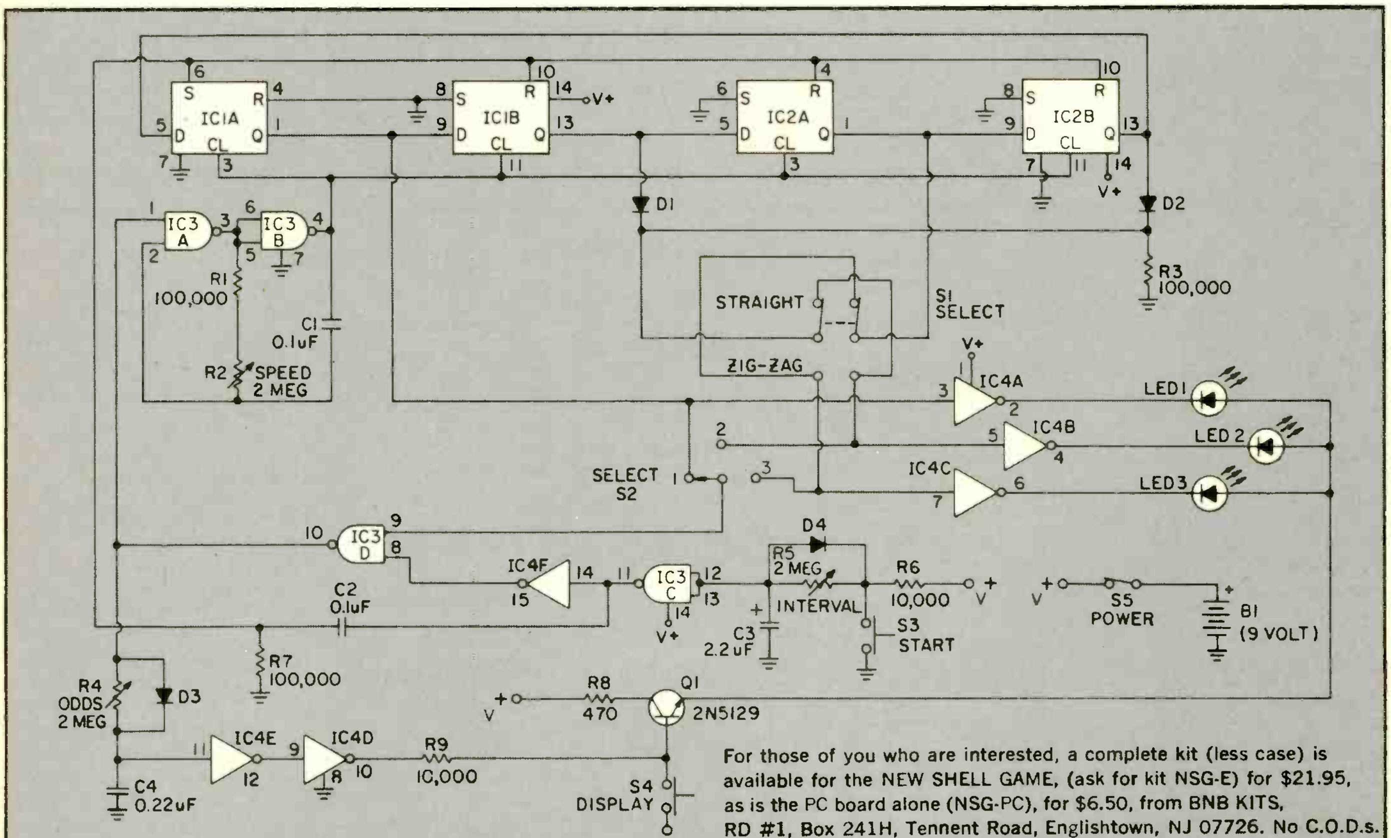


To the right is the full-sized printed circuit board template for New Shell Game.

returns to the low level. The positive portion of the IC3c output is differentiated by the C2, R7 combination which provides a *set* pulse to IC1a and a *reset* pulse to the other flip-flops. The output of IC3c is also inverted in IC4f and provided to IC3d. The other input to IC3d is one of the three shift register outputs routed through *select* switch S2. Thus, when S3 is depressed, the output of IC3d goes high, enabling the clock. The clock is simply an oscillator (made up of IC3a and B, R1, R2, and C1) which is controlled by the output of IC3d. Aside from turning on the clock, the output of IC3d also charges C4 through D3. When the voltage across C4 reaches 4.5V, the output of IC4d goes high, and turns on driver transistor Q1. This furnishes power to the LEDs, allowing them to light when driven by either IC4a, IC4b or IC4c.

At the end of the one-shot interval,

(Continued on page 112)

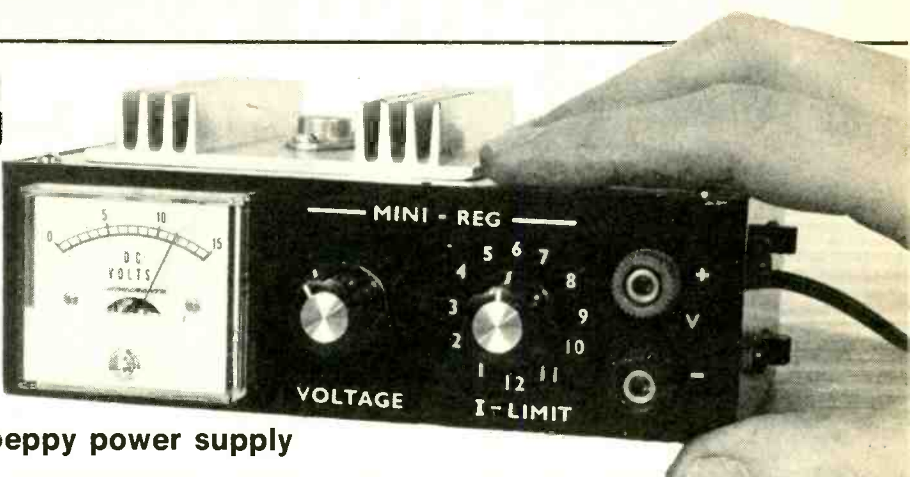


For those of you who are interested, a complete kit (less case) is available for the NEW SHELL GAME, (ask for kit NSG-E) for $21.95, as is the PC board alone (NSG-PC), for $6.50, from BNB KITS, RD #1, Box 241H, Tennent Road, Englishtown, NJ 07726. No C.O.D.s.

PARTS LIST FOR THE NEW SHELL GAME

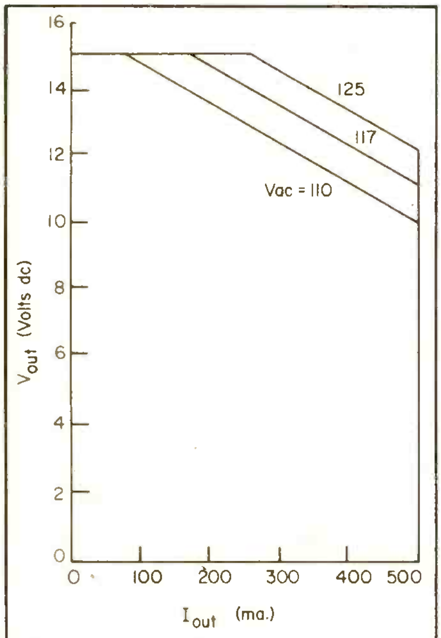
C1, C2—0.1-uF ceramic disc capacitor, 10 VDC
C3—2.2-uF electrolytic capacitor, 10 VDC
C4—0.22-uF ceramic capacitor, 10 VDC
D1, D2, D3, D4—1N4148 or 1N914 diode
IC1, IC2—4013 dual flip-flop
IC3—4011 quad NAND gate
IC4—4049 hex inverter w/buffer
LED1, LED2, LED3—small, red LED
Q1—2N5129 transistor
R1, R3, R7—100,000-ohm, ¼-watt resistor
R2, R4, R5—2,000,000-ohm, linear-taper potentiometer
R6, R9—10,000-ohm, ¼-watt resistor
R8—470-ohm, ¼-watt resistor
S1—DPDT slide switch
S2—1-pole, 3-position rotary switch
S3, S4—SPST momentary-contact pushbutton switch
S5—SPST slide switch
Misc.—battery clip, mounting case, hookup wire, knobs, etc.

MINI-REG
the regulated IC Power Supply



Keep your projects cool, calm and under control with this peppy power supply

HERE'S A LOW-COST precision regulated DC power supply which is sure to be a welcome addition to any workbench—provided some family member doesn't appropriate the power supply for use as a universal AC adaptor! Compactly assembled in an eye-catching low profile, the Mini-Reg is continuously adjustable from 3.4 volts to 15 volts DC and delivers up to 500 milliamperes, enough for just about any job. Using the HEP C6049R precision monolithic IC regulator, the Mini-Reg effects 0.01% regulation with line voltage variations, 0.05% regulation for load variations, and its output impedance is a mere 35 milliohms. Short-circuit proofed, the Mini-Reg also features adjustable current limiting which greatly reduces the chances of damaging valuable components in the circuits you are working on. You can also use the Mini-Reg as a constant-current source and recharge nicad batteries.



This chart shows the operating range of the Mini-Reg at various line voltages. The full 15 VDC is only available at lower currents, but few IC projects ever require that much voltage or current supply.

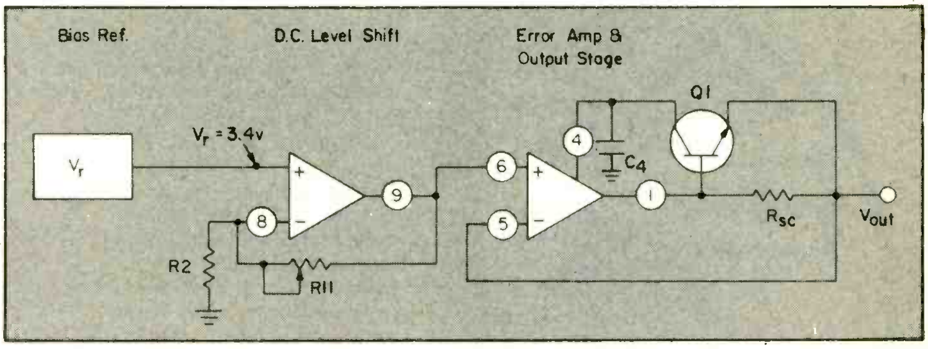
Circuit Operation. The HEP C6049R is actually a DC regulator within a regulator which accounts for its high performance. As shown in the block diagram, a very stable reference voltage (Vr) is applied to the non-inverting or voltage follower input of an op-amp which serves as the first regulator and DC level shift amplifier. The output voltage of this stage can be varied from 3.4 volts to 15 volts by varying pot R11. This voltage is applied to the non-inverting input of the second op-amp which is capable of supplying up to 5000 milliamperes current to the load. This stage has unity voltage gain wherein V-out follows the input voltage to this stage. This double regulator arrangement fully isolates the DC level shift amplifier and results in very close regulation. Capacitor C4 provides frequency compensation and precludes possible circuit oscillation.

External components consisting of transistor Q1 and selectable resistor Rsc provide constant-current limiting should the supply be short-circuited. When the load current passing through Rsc becomes sufficiently high, the base of Q1 becomes forward biased causing Q1 to conduct. When Q1 conducts, the voltage regulator delivers an essentially constant current to the load at a level depending on the value of Rsc. In the schematic diagram, resistor R3 places a minimum load on the regulator. Switch S3 selects the desired current limit. Jacks J1 and J2 permit insertion of a milliammeter to read load current but without impairing regulation. Diode D2 provides meter protection and diode D1 provides reverse voltage protection.

Construction. Assemble the Mini-Reg in an aluminum case or in a plastic case with aluminum cover plate. Select a case which will accommodate the particular meter and transformer you plan to use. Plan the layout allowing room for the PC board assembly when the cover plate is secured.

Begin by laying out and drilling mounting holes for IC1 in the heatsink. Drill a 7/16-inch-diameter hole in the heatsink to pass the lead wires of IC1. File off drill burrs and ridges so that IC1 mates perfectly on the heatsink. Drill matching holes in the cover plate. For ventilation, drill a number of holes in the cover plate and on the bottom of the case.

Make the PC board using the circuit pattern shown, taking care to locate



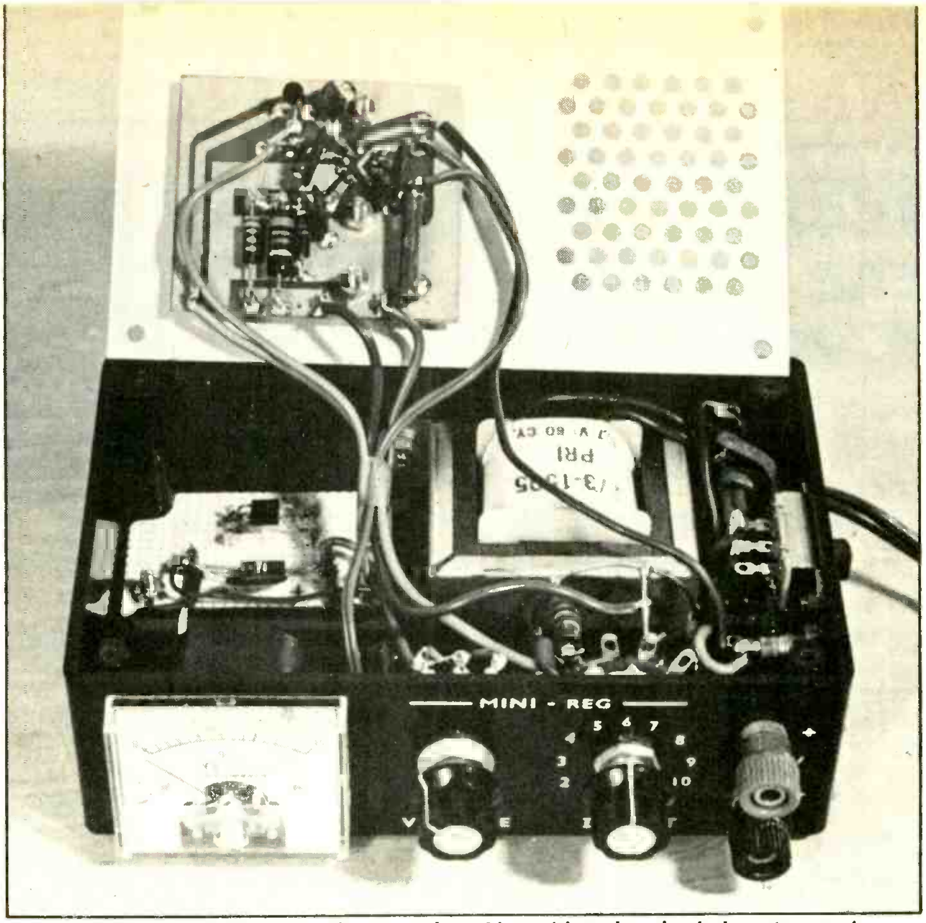
This is a simplified block diagram of the C6049R regulator chip—the heart of the Mini-Reg power supply. Thanks to such ICs construction projects are easy to build.

MINI-REG

pads for IC1 just right. Push IC1 into the drilled board and mark and drill the mounting holes. For easier mating, countersink the lead holes for IC1 on the insulation side of the board by twirling a small drill bit.

Install and solder the jumper on the insulation side of the board and install and solder T42-1 micro-clips (Vector) on the copper side at all resistor and board take-off terminals. Clip a small heatsink (Radio Shack 276-001) on the leads of Q1 when soldering. Install remaining circuit board components excepting trim resistor R5. Using 6-32 machine screws, bolt IC1 and the heatsink to the cover plate. Place a lock washer and two 6-32 nuts on each mounting bolt. *Omit the mica washer between IC1 and the heatsink* and apply a bit of silicone heatsink grease between IC1 and the heatsink. Coil a ¼- by 1½-inch strip of fishpaper insulation and slip it down into the hole in the cover plate around the IC lead wires. Push the PC board assembly down on the mounting screws and mate with the protruding IC leads and secure. If you can't install the assembly, look for bent pins or reversed installation of IC1.

Install switches S1 and S2 along with jacks J1 and J2 on the left side of the case. Install diode D2 and capacitor C7 on switches S2. Secure two solder lugs on each binding post and install diode D1 and capacitor C6 on the binding posts. Pass the AC line cord through the left side of the case and knot the cord for strain relief. Install resistors R6 thru R10 on switch S1. Depending on the base-emitter characteristics of Q1, the specified values of current limit resistors R6 through R10 may differ somewhat in your power supply. This is why trim resistor R5 was included to properly trim the 500 mA current



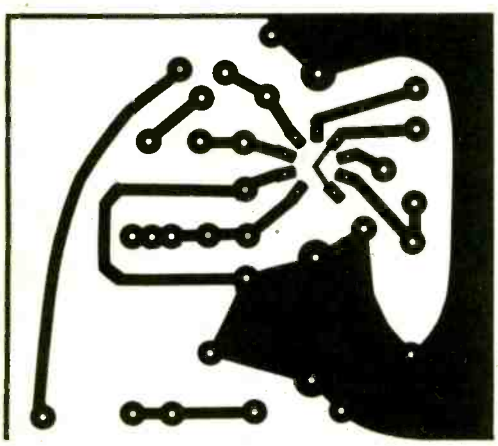
Internal view of the Mini-Reg. The circuit board is positioned so that it doesn't come in contact with the meter and transformer. The case is perforated for ventilation. You can see the tiny, square HEP 176 rectifier on the small circuit board in the bottom of the case.

limit. For this reason, you may defer installation of resistors R6 thru R9 but *do* install resistor R10.

Place RECT-1, R1, C5, and C8 on a small piece of perfboard and situate this sub-assembly behind the meter. Connect meter M1 directly to binding posts BP1 and BP2. Use #20 stranded wire for connections to the PC board. Connect a wire from board pin G to BP2. Run a wire from board pin E to the rotor lug of S3. Connect a wire from board pin D to resistors on S3. Run a wire from board pin F directly to BP1. Run a pair of wires from pot R11 to board pins B and C. Connect a wire from *V-in minus* directly to BP2. Do not make the connection from *V-in plus* to board pin A at this time. You may omit the double-fused plug and provide but one fuse in the primary side of transformer T1. Carefully check all wiring and solder connections.

Checking It Out. We intentionally deferred installation of several components and some wiring, so that you can perform a few simple tests which preclude damage to circuit components. Connect a voltmeter across R1 and verify that V-in plus is nineteen volts DC. Connect a milliammeter and 100-ohm resistor in series from V-in plus to board pin A. Set S3 to pick up R10 and set R11 to minimum resistance. Turn S1 on and observe about five milliamperes current on the milliammeter and 3.4 volts on meter M1. Advance R11 and observe a voltage increase up to fifteen volts DC. If the output voltage is less than fifteen volts, the value of R11 may be too small or R2 may be too large. Having verified the above, you may now install the wire from V-in plus to PC board pin A.

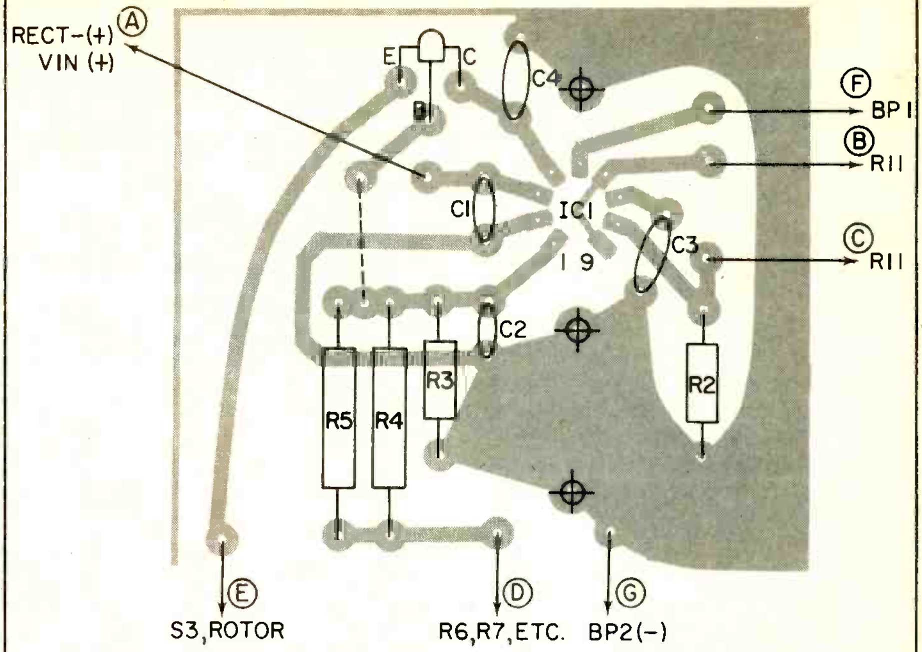
Plug the milliammeter into jacks J1 and J2 and open S2 (Meter In). Adjust R11 for ten volts output and set S3 to ten milliamperes current limit. Then, connect a 500-ohm ½-watt resistor across the output terminals. If current limiting action is taking place, the milliammeter should indicate roughly ten milliamperes and the output voltage



This is an exact-scale printed circuit board pattern showing the foil side of the board. This side contrary to normal, is, where the components are to be mounted. Only the jumper and the IC chip are mounted on the other side. Be careful to keep the foil-side component bodies off the metal surface to avoid shorts. Be especially careful with resistors R4 and R5 and capacitor C3.

should drop to about five volts. If much higher values are observed, current limiting is not taking place. Look for a defective or improperly installed Q1. If your current limit is, say, seven milliamperes, you can bring it up to ten by using a smaller value for R10 or by connecting a suitably larger value resistor across R10.

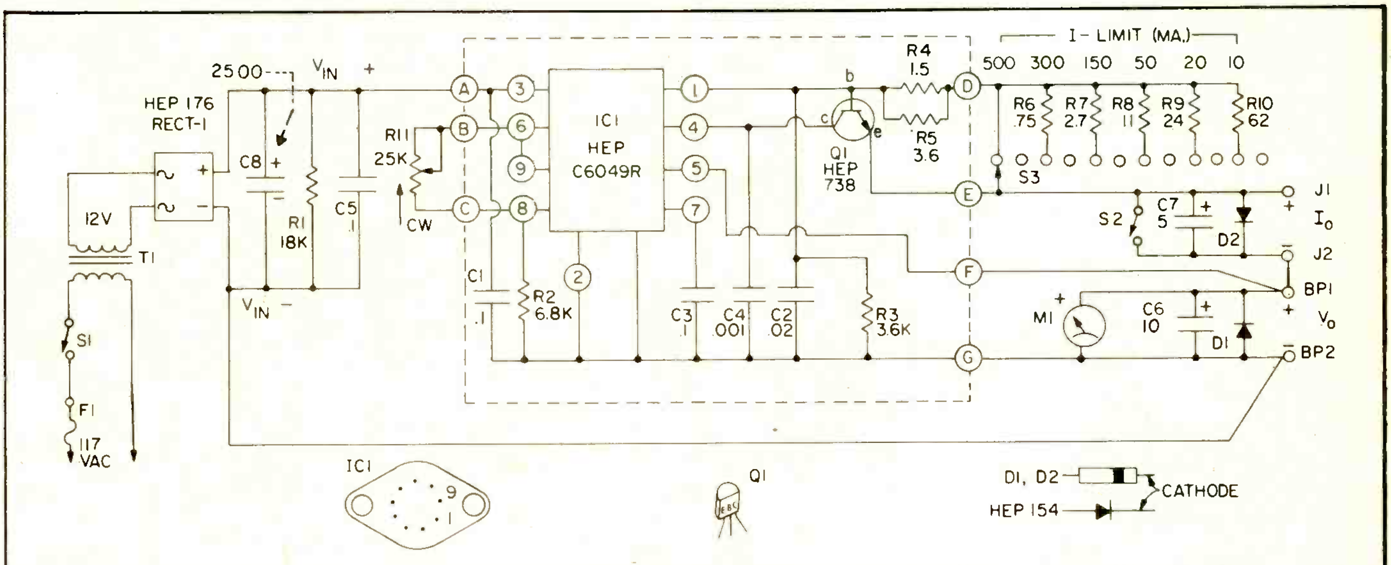
Only after you have verified current limiting action at low current, set S3 to pick up R4 (500 ma setting) and set the VOM accordingly. You will need either a 50-ohm 10-watt rheostat or adjustable power resistor to gradually load the supply. Or, you can use a number of small-valued power resistors. Set the rheostat to maximum resistance and connect it across the output terminals. Gradually reduce load resistance while observing output voltage and current. Current limiting should occur at below 500 ma. To increase the limit to 500 milliamperes, select and install a suitable resistor for R5. Proceed similarly to size or trim resistors R6 thru R10. You can easily include other current limits in the spare positions on S3 to match the charging currents of your nicad batteries. Do not exceed 500 milliamperes or IC1 will be damaged.



The parts should be placed according to this diagram. Note the location of the three drill holes for securing the IC and the board to the chassis. Locate the IC mounting holes very carefully so that everything mates snugly. This will help keep the chip cool.

Application. The operating range of the Mini-Reg for several line voltages is shown. The supply "drop-out" shown in the upper right hand corner of this chart is due to an insufficient difference between V-in plus and V-out which in turn depends on transformer T1 voltage. When you are not using a meter at jacks J1 and J2, close S2.

The adjustable current limiting feature of the Mini-Reg greatly reduces the chances of damaging circuit components of the circuit powered by the supply.



PARTS LIST FOR MINI-REG

BP1, BP2—binding posts, red, black
C1, C3, C5—0.1-uF 25-VDC capacitor, ceramic
C2—0.02-uF 25-VDC capacitor, ceramic
C4—0.001-uF 25-VDC capacitor, ceramic
C6—10-uF 25-VDC electrolytic capacitor
C7—5-uF 25-VDC electrolytic capacitor
C8—2500-uF 25-VDC electrolytic capacitor
D1, D2—1-Amp 50 PIV silicon rectifier diode, HEP 154
F1—½-Amp fuse
IC1—HEP C6049R voltage regulator
J1, J2—insulated phone tip jacks, red, black
M1—0-15 VDC miniature DC voltmeter
Q1—HEP 738 transistor
R1—18,000-ohm, ½-watt resistor
R2—6800-ohm, ½-watt resistor
R3—3600-ohm, ½-watt resistor
R4—1.5-ohm, 2-watt wire-wound resistor, IRC type BWH
R5—3.6-ohm, ½-watt resistor
R6—0.75-ohm, 2-watt wire-wound resistor, IRC type BWH
R7—2.7-ohm, 2-watt wire-wound resistor, IRC type BWH
R8—11-ohm, 1-watt resistor
R9—24-ohm, 1-watt resistor
R10—62-ohm, 1-watt resistor
R11—25,000-ohm linear taper potentiometer
RECT-1—HEP 176 1-amp, 200-PIV bridge rectifier.
S1, S2—SPST slide switch
S3—1-pole, 12-position switch, non-shorting (Mallory 32112J or equiv.)
T1—12-volt, 1.2-ampere filament transformer

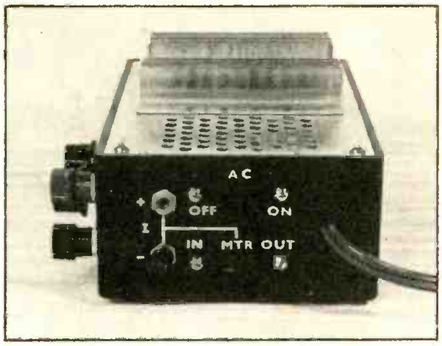
Misc.—Plastic case with aluminum top, 6¼ x 3¾ x 2 inches; heat sink, 3 x 3½ inches, (Allied Electronics 957-2840 or equiv.); T42-1 micro-clips (Vector); AC line cord; fused cord plug or fuseholder; perforated board; copper clad board; rubber feet (4); hardware, etc.

MINI-REG

Suppose you are experimenting with a transistorized circuit drawing five milliamperes at five volts. You would then set S2 to ten milliamperes. At these settings, the maximum power the supply can deliver is but a mere fifty milliwatts.

If you plug a transistor in backwards, the most it can draw is fifty milliwatts, probably much less; hence, the device will survive the error. However, certain semiconductors can be damaged with but microwatts of power. Nevertheless, you are far better off using current limiting supplies. If your experimental circuit draws 400 milliamperes at five volts, set S3 to 500 milliamperes limiting the power to 2.5 watts. This power level is more than enough to zap many devices if you make an error. If you have another five volt supply, split the circuit supply lines and protect those devices you cannot spare with the Mini-Reg.

Almost any circuit operating off three volts can safely operate at 3.4 volts. The output voltage can be further reduced by connecting a low-voltage zener diode in series with the plus lead to the load and monitoring the load voltage with a voltmeter. In this case, load voltage regulation now depends on zener diode characteristics.



The AC line switch, current jacks and current meter switch are on the end of the case.

When recharging batteries with the Mini-Reg, connect a silicon rectifier diode in series with the plus lead going to the battery. This eliminates "backleak" when the supply is turned off with battery yet connected. Observe battery polarity when making connections. Circuits using op-amps usually require a dual or split supply. To provide a dual six-volt supply, set the output voltage to fifteen volts, set S3 to 100 milliamperes, and connect two six-volt zener diodes in series across the output terminals. Then, connect a 100 uF 25V electrolytic capacitor across each zener diode.

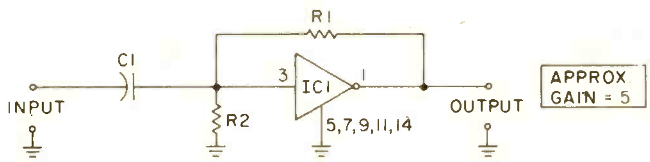
The Mini-Reg handily checks and sorts zener diodes of fifteen volts or less. Set R11 for fifteen volts output and set S3 to ten milliamperes. Connect the diode across the output terminals with plus lead wire to BP1. Observe zener diode voltage on M1. Advance S3 to high currents but do not exceed rated current of the diode. The better the quality of the diode, the less increase in voltage observed on M1.

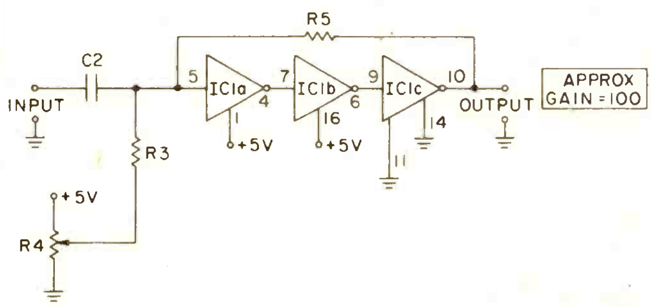
When you operate radio or audio equipment from the Mini-Reg, set S3 to a current level which supplies peak currents on audio peaks. Otherwise, you will notice audio distortion on audio peaks. With some radio and audio equipment, operations off an AC adaptor or the Mini-Reg may introduce an AC hum. Reversing the AC plug usually remedies the problem. If not, connect a ground wire to either the plus or minus terminal of the Mini-Reg, whichever proves most effective. In addition to its use as a universal AC adaptor, the Mini-Reg serves as an excellent power supply when servicing battery operated transistorized equipment. You'll wonder how you ever solved your power supply problems before you discovered Mini-Reg! ■

CONSTRUCTION QUICKIE

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

THE JUNK BOX SPECIAL

Power your projects, spend pennies for parts.

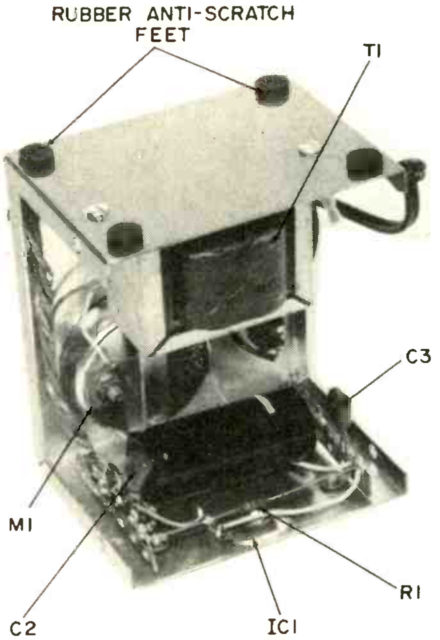
by Herb Friedman

Between 555 timers, TTL, CMOS, opamps and run of the mill transistor projects, the average experimenter is often faced with the need for a regulated power supply with a range of about 5 to 15 volts—just to try out a breadboard project. If you've priced any regulated supplies lately you know they don't come cheap. Maybe, just maybe, you might get one for \$30 or \$35.

With a little careful shopping, a reasonably stocked junk box and one or two "brand new" components you can throw together a regulated supply costing less than \$10 that will handle most of your experimenter power supply requirements. One of these Junk Box Specials is shown in the photographs and schematic. The range of this model is 5 to 15 volts DC at currents up to 1 ampere. One of the common, 3-terminal regulators which are now flooding the surplus market provides everything in the way of regulation. Depending on the source, the regulator will cost you from \$1 to \$2.50; the higher prices often include an insulated mounting kit (worth about 25-cents).

5 to 15 volts from one 3-terminal regulator? Correct. If regulator IC1's collector terminal is connected to a voltage divider across the output—R1 and R2—the output voltage will be that at the junction plus the volage rating of the regulator, which in this instance is 5 volts. So, when potentiometer R2 is adjusted so its wiper is grounded the power supply's output is that of the regulator, 5 volts—perfect for TTL projects. As R2 is advanced, increasing the resistance from IC1's collector to ground, the voltage output increases.

Getting the parts. There are plenty of parts around to build this supply for under \$10. If you go out and round up "all new" components the cost is likely to go well over \$30, so forget about new parts. Power transformer T1 can be 18 volts at 1 ampere (or rated at higher current, though the supply's maximum output is 1 ampere), or 36 volts center-tapped at 1 ampere or more. Both the 18 volt and 36 volt transformers are glutting the surplus market. If you get an 18 volt transformer use the bridge rectifier shown in the schematic. If you get a 36 volt C.T. transformer use the full-wave rectifier shown below the schematic. The diode rectifiers SR1 through SR4, are type 1N4001, 1N4002, 1N4003, or 1N4004, which are also glutting the surplus market. Just to show you the savings possible, at the time this article is being prepared you can buy fifteen surplus 1N4001s for \$1. Just one single "general replacement" for the 1N4001 from a national supplier is selling for over 40-cents. Get the idea how to save costs on this project?



To prevent scratching your workbench apply rubber anti-scratch feet or bumpers on the bottom of the cabinet. They are available in most hardware and houseware stores.

Capacitor C1 can be anything from 2000 to 4000 uF at 25 volts or higher. Look for an outfit selling surplus computer capacitors. If worse comes to worse you can get the value specified in the parts list in a Radio Shack store.

The 3-terminal, 5 volt regulator is another item easily found on the surplus market. With an adequate heat sink—such as the cabinet itself—the device can safely deliver 1 ampere. The unit shown in the photographs is a Motorola MC7805 (though you can substitute any similar type) obtained for \$2.50 from Circuit Specialists. We have seen similar devices from other manufacturers selling for \$1. The terminals B, C and E are indicated directly on the device or on the terminals—where they join the case. The collector (C) lead is connected to the IC's metal tab, and is normally grounded. Note that in this project, however, the collector terminal, and therefore the tab, is not grounded. You must use an insulated mounting kit consisting of a mica insulator and a shoulder washer. Place the insulator between the IC's body and the cabinet, or the tab and cabinet, and slip the shoulder washer into the opening (hole) in the body or tab. Pass the mounting screw from outside the cabinet through the mica washer, through the IC, and

JUNK BOX

through the shoulder washer. Secure with a ¼-inch (or smaller, not larger) nut hand-tightened against the shoulder washer. Before going any further check with an ohmmeter to be certain the collector terminal is insulated from the cabinet.

Connecting wires are soldered directly to IC1's terminal leads; use a heat sink such as an alligator clip on each terminal if you have a large (greater than 40 watts) iron. Since the layout is not important, we suggest the arrangement shown, with IC1 positioned between two mounting strips so R1 can span across the strips and be soldered to IC1's collector terminal.

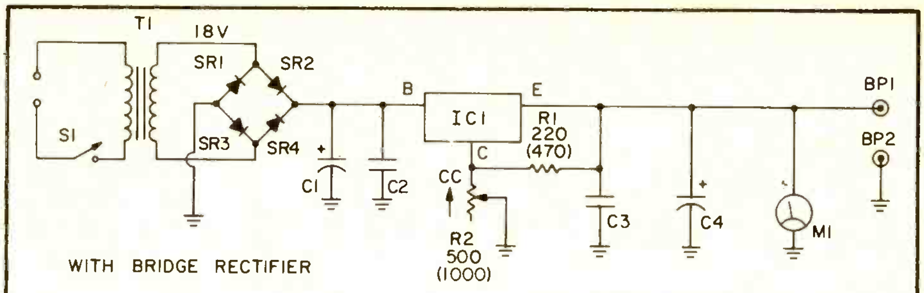
Finally, we come to the meter, a device that has become slightly more expensive than a barrel of Arabian oil. Any meter that can indicate at least the range of 0 to 15 VDC is adequate. The EMICO 0-30 VDC meter shown in the photographs was selling in one local store for $7.95, while we bought ours almost down the block as "surplus" for $2.99. A good source for surplus meters is Fair Radio Sales. You might not end up with a meter case that looks suitable for NASA, but the output voltage doesn't care two hoots whether the meter is a modern $25 dollar model or a surplus-special for a buck ninety-nine.

Power switch S1 can be a separate SPST as shown in our project, or it can be part of R2. But keep in mind that a separate S1 allows you to turn the supply on and off without affecting voltage control R2's adjustment.

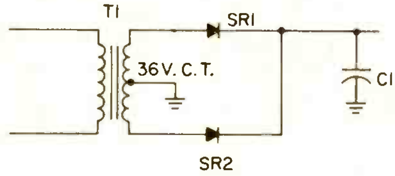
Finally, we come to R1 and R2. You will note that the schematic shows two values for each. One value for each resistor is in brackets (parenthesis). You can use either set of values as long as they are matched. If R2 is 500 ohms R1 is 220 ohms; if R2 is 1000 ohms R1 is 470 ohms. The reason we show both sets of values is because 500 and 1000 ohm potentiometers appear on the surplus market from time to time, but usually not together. This way, you can use whatever is available at low cost.

CHECKOUT. Set potentiometer R2 so the wiper shorts to the end connected to IC1's collector terminal, thereby connecting the collector directly to ground.

(Continued on page 110)



WITH BRIDGE RECTIFIER

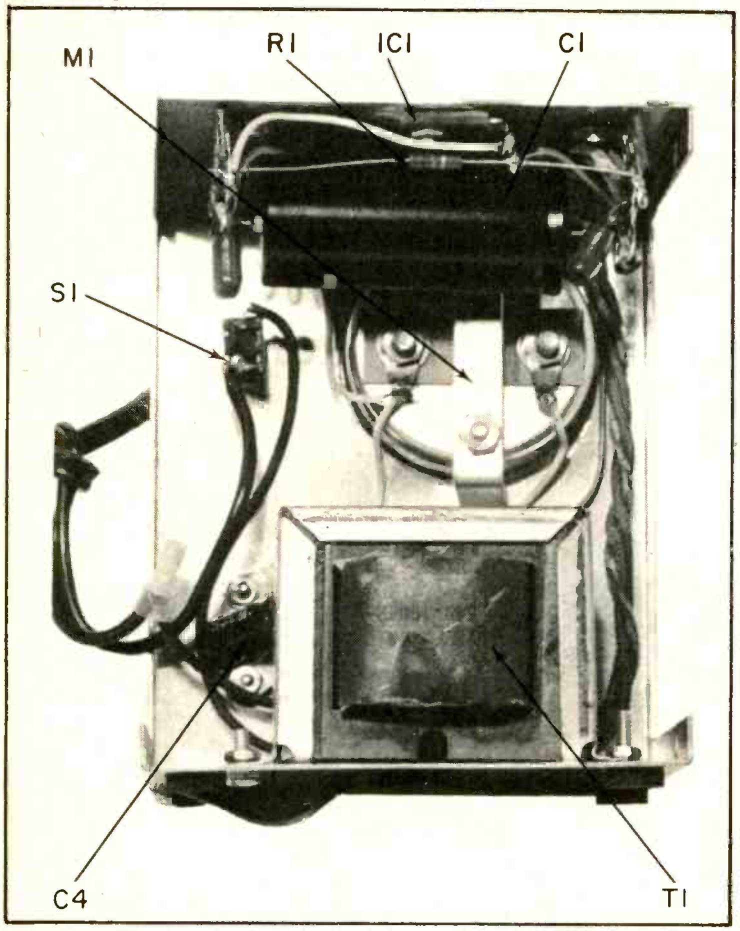


ALTERNATE FULL-WAVE RECTIFIER

Virtually any DC voltmeter that can display the range of 0 to 15 volts can be used. The surplus market is loaded with less-than-$5 meters that are suitable if you don't mind a little extra scale coverage.

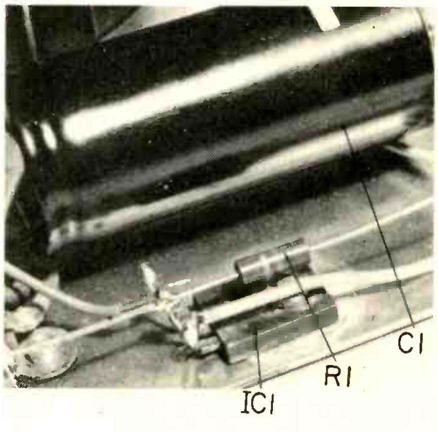
PARTS LIST FOR JUNK BOX SPECIAL

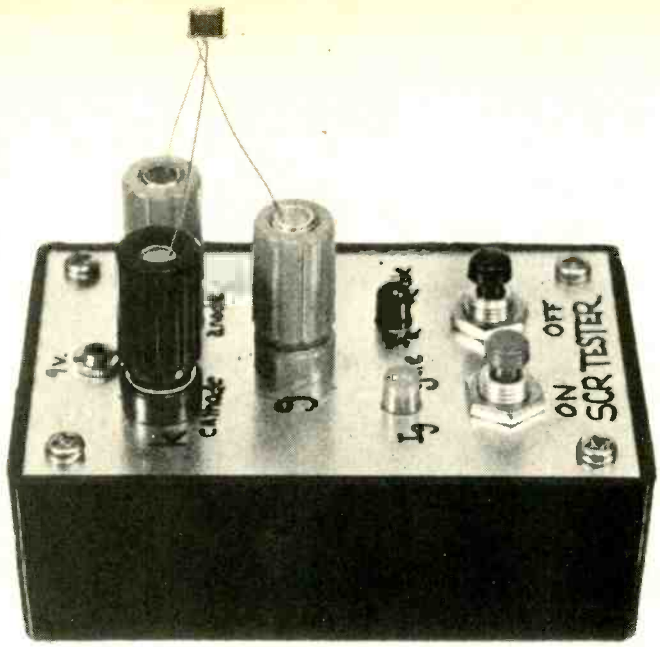
R1—220 or 470-ohms, ½ watt, 10% (see text)
R2—Potentiometer, 500 or 1000-ohms (see text)
C1—3300-uF, 35 VDC (see text) (Radio Shack 272-1021 or equivalent)
C2, C3—0.1 uF Mylar
C4—25-uF, 25 VDC or higher
M1—DC voltmeter (see text)
IC1—Motorola MC7805, 5 volt 3-terminal regulator (see text)
T1—Power transformer, secondary 1 ampere at 18 volts or 36 volts C.T. (see text)
SR1, SR2, SR3, SR4—Silicon rectifiers (see text)
S1—SPST switch
BP1, BP2—5-way binding posts
Misc.—Cabinet, terminals strips, etc.



If you've had experience with assembly in tight quarters, you can shoehorn the power supply into a standard 3 x 4 x 5-inch Minibox. If your soldering iron is so big it burns adjacent wires when you make a connection, use a larger size cabinet.

In order to handle a full ampere, the IC regulator must be heat sinked to the cabinet. Make certain the collector and its attached sink tab (the back of the package) is insulated from the cabinet. Use silicon grease to insure heat transfer from the IC to the cabinet.





"Bad SCR" LEDIT Said It

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

by David R. Corbin

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

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

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

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

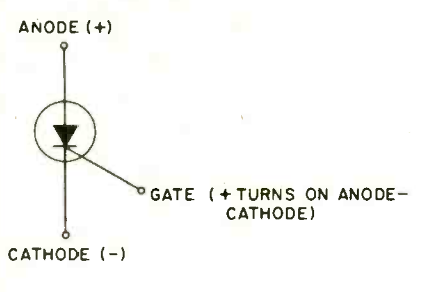
The problem with trying to check most common, small-size SCRs with an ohmmeter is that the minimum gate current and minimum holding current are naturally provided by the ohmmeter. All but the cathode-to-gate path may check "open," making it impossible to identify the leads on an unmarked SCR. What LEDIT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

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

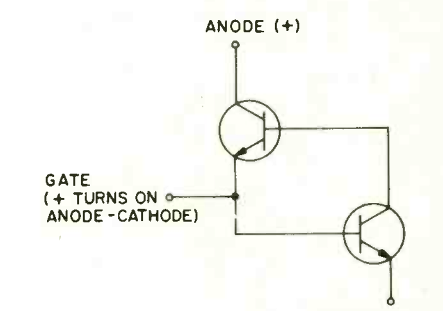
Checking SCRs. There are five ways to misconnect an SCR to the three posts, and one correct way. None of the incorrect ways will damage a good SCR among the vast majority of those around today. The correct connection, when identified, provides for short tests between gate and cathode, cathode and anode,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

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

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



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



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

LEDIT Said

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

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

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

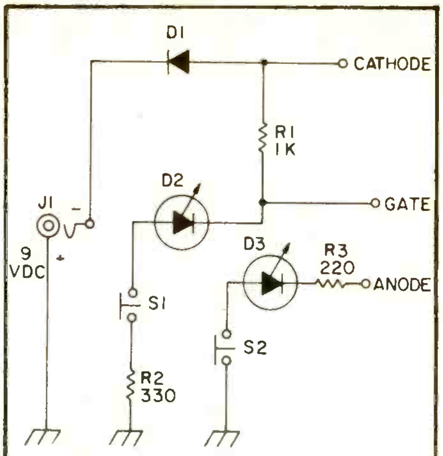
If the gate is either normal or shorted, D2 will emit red light. But only if the gate is normal will D3, the anode current indicator, come on with a clear light. Letting up on S1 should let D2 go out and leave D3 on. If it does not, then the SCR either cannot remain on with a 10 mA anode current (which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

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

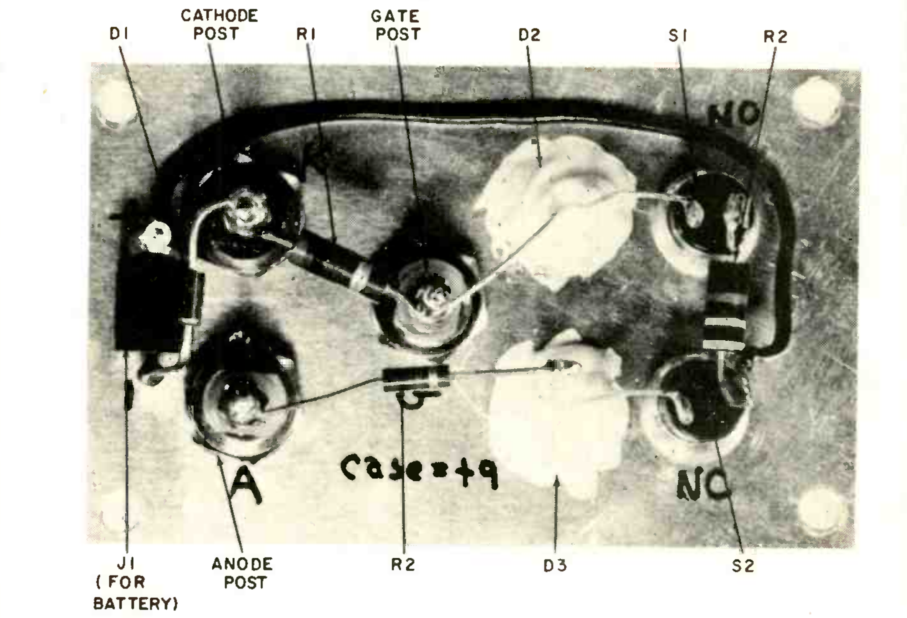
(Continued on page 113)



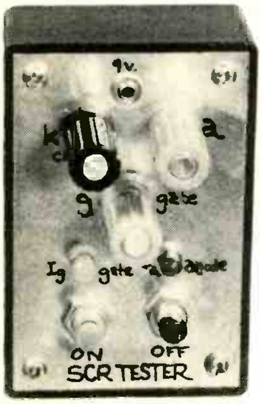
PARTS LIST FOR LEDIT SCR TESTER

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.

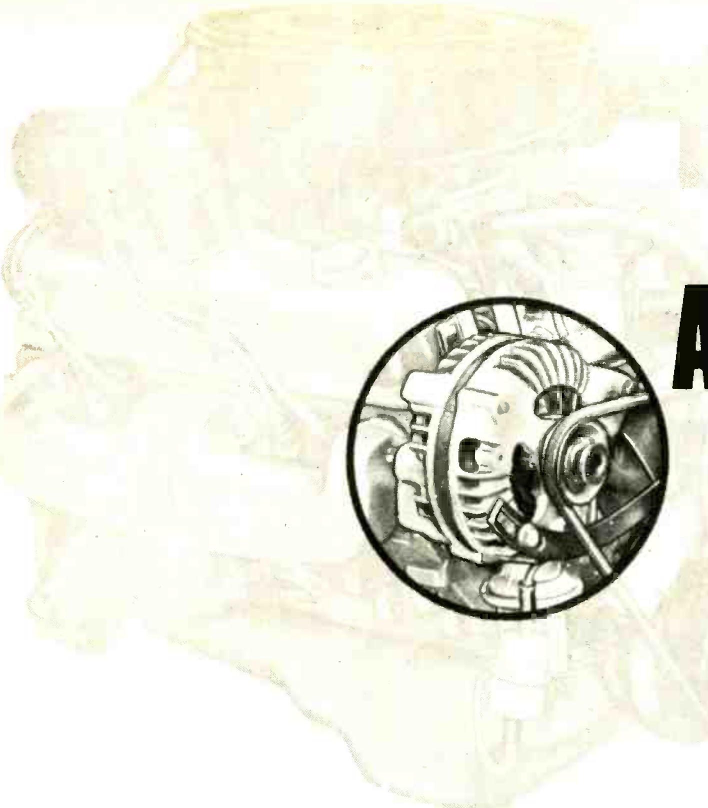
The circuit used in LEDIT is extremely simple and should take little time to assemble. The parts, with the possible exception of the two LEDs, will probably be in your junk box. Mount the panel on an old plastic box—perhaps from a broken midget volt/ohm meter that's seen better days or been canibalized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

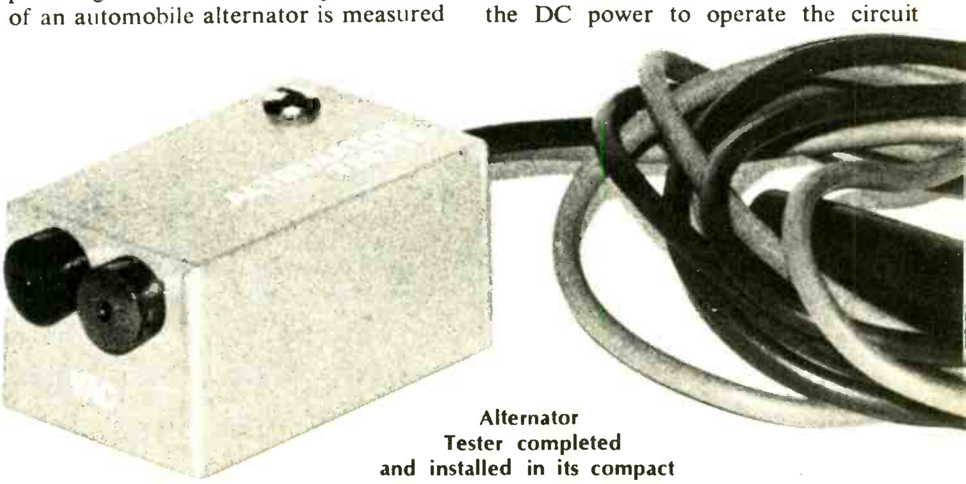
by Anthony Caristi

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

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

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

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



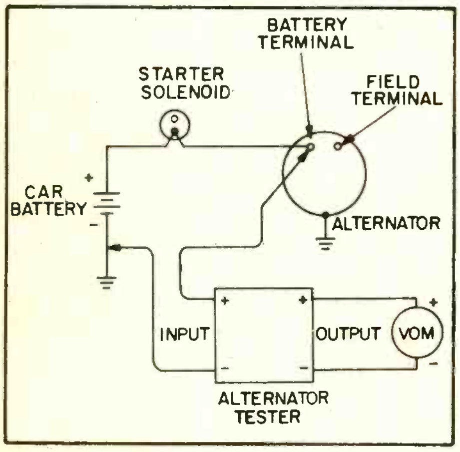
Alternator Tester completed and installed in its compact metal cabinet, shown with its test leads.

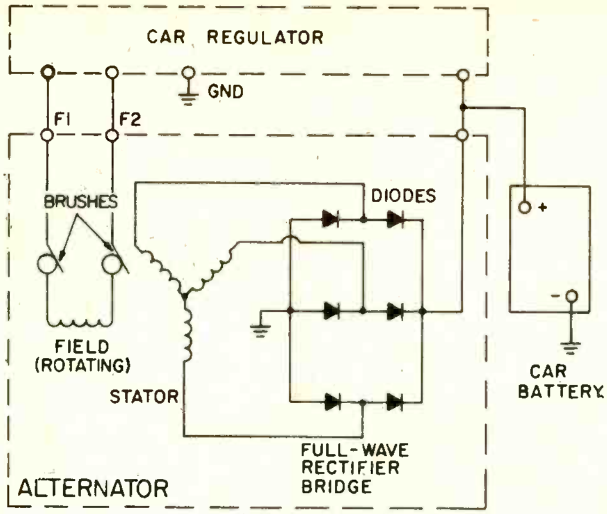
ALTERNATOR TESTER

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

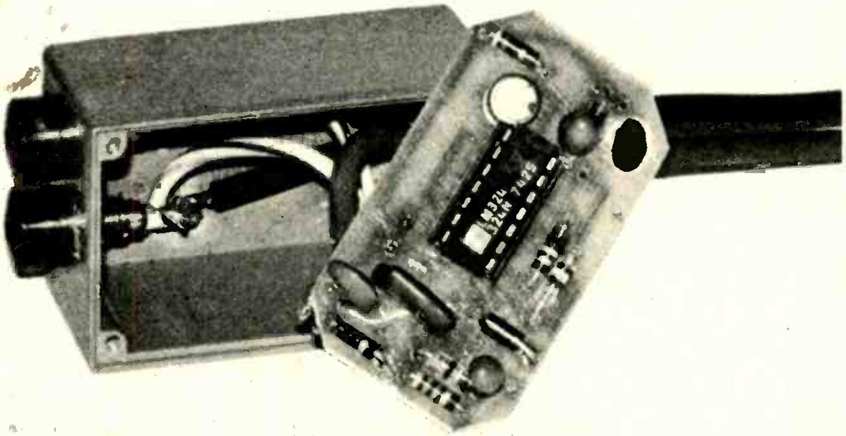
About the Circuit. The Alternator Tester is basically a peak detector circuit which responds to the peak-to-peak value of an AC voltage fed to its input terminal. Power to operate the circuit is derived from the output of the alternator on the same lead which feeds the ripple voltage to the input of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

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

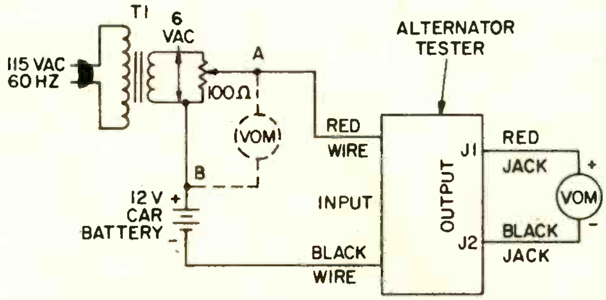




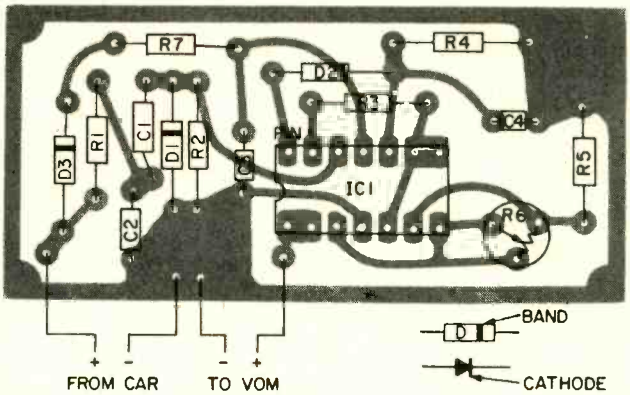
Typical automotive charging circuit. Latest model alternators have solid-state regulator circuit built into alternator frame.



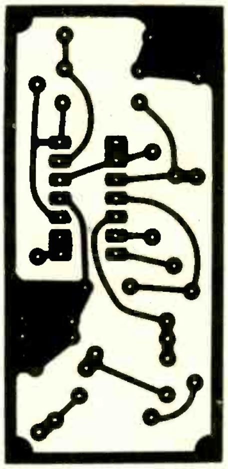
Alternator Tester opened, showing printed circuit board. Comparison with this early version of printed circuit board reveals improvements made by the editors.



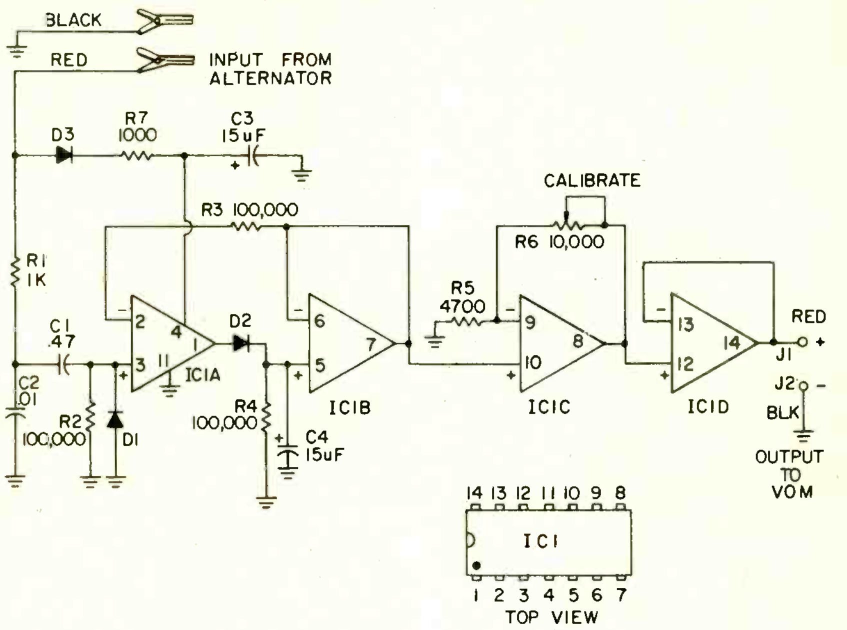
Calibration of the Alternator Tester.



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



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



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

PARTS LIST FOR ALTERNATOR TESTER

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

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

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

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

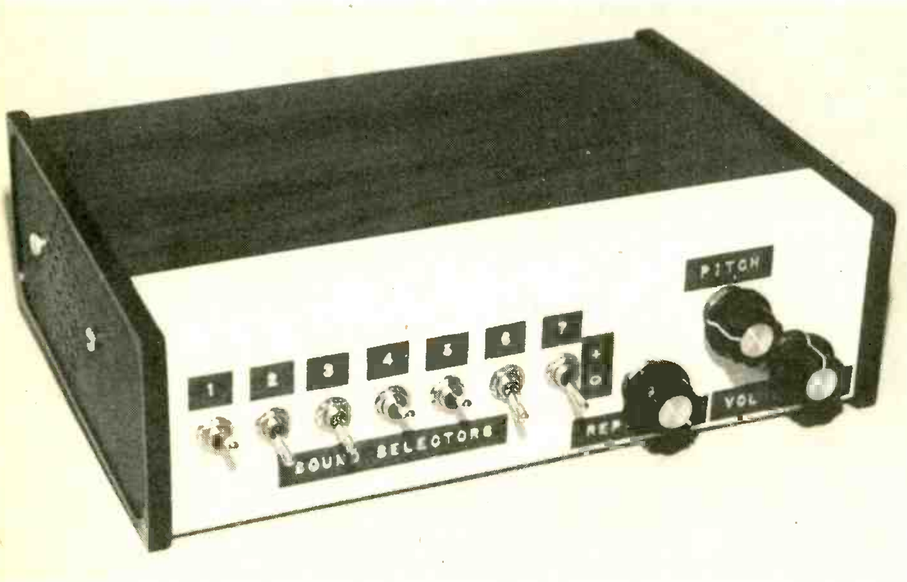
The alternator output test requires the use of only the VOM which is set to read DC volts on a 0 to 15 volts or greater scale. Connect the VOM directly across the battery, observing correct polarity. Start the engine and turn on the headlights (high beam), windshield wiper, blower motor (high speed),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

(Continued on page 118)

Super Sound Effects Synthesizer

Bring way out sound effects right into your home

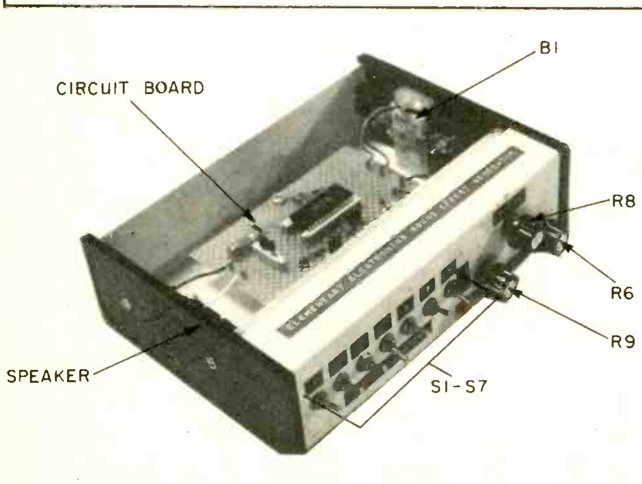
by Cass R. Lewart



The table at right shows some of the more popular effects made possible by our synthesizer. More combinations can be had by experimenting at random with the switch positions. If you feed the synthesizer through your stereo system, the tone controls can also be used to vary the sound effects.

TABLE OF SWITCH POSITIONS

1	2	3	4	5	6	7	Sound Effect
+	+	+	+	+	0	0	Siren
0	0	0	0	+	+	0	Locomotive
+	+	+	0	+	+	0	Tweeting bird
0	+	0	0	0	+	0	Phaser gun
0	+	+	0	+	+	0	Phaser gun
0	0	+	0	0	+	0	White noise (sea sound)
+	+	0	+	0	+	+	Different siren
0	0	0	0	0	+	0	Steady organ sound
+	+	0	+	0	+	0	Ticking clock
0	0	0	+	0	+	+	Alternating tones
0	0	+	0	+	+	0	Interrupted tone

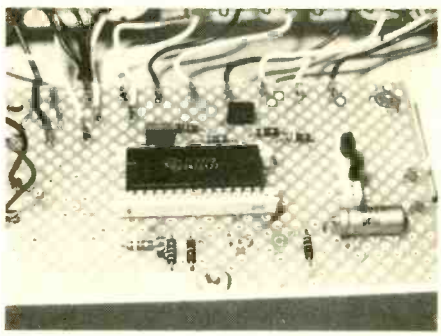


The arrangement of parts on the perfboard is not at all critical. Wire the switches and potentiometers to the circuit board before mounting them to the front of the cabinet. You may wish to purchase a larger cabinet to accomodate a larger speaker. This will definitely add depth to the sound quality of the Super Sound Synthesizer.

IF YOUR IDEA OF FUN is a locomotive in your bedroom, or a siren announcing breakfast, then we have the right kind of project for you! This simple-to-build sound effect generator will produce a variety of sounds resembling a ticking clock, a locomotive puffing away, a police siren, a ray gun straight out of a science fiction movie or a tweeting bird. The sound generator can be used to add a "living" sound to electronic games, or it can be a part of a futuristic bell chime.

How It Works. The guts of the sound generator—a newly developed integrated circuit—consist of thousands of transistors. The main building blocks of this IC are a noise generator, an audio pitch generator and a Super Low Frequency (SLF) generator. The SLF generator controls the changing pitch and the repetition rate of the audio generator by, for example, producing a slowly rising and falling pitch of a siren. The SLF generator can also turn the other two generators on and off at a slow rate. A puffing locomotive sound will result when the SLF generator controls the noise generator.

Several pins on the integrated circuit control the mixing mode of the three generators. Seven of these control pins are brought out to switches S1 through S7. The frequency of the SLF generator and of the audio pitch generator is controlled by the potentiometers R10 and R8, respectively. Transistors Q1 and Q2 drive a small speaker while potentiometer R6 adjusts the volume. Switch



Make sure to follow the proper pin orientation for the IC. See the text for details.

S8 ganged with the volume control turns the unit on and off.

Construction. The sound generator operates at audio frequencies, therefore no special wiring precautions are necessary. We assembled our prototype on regular breadboard stock with point-to-point wiring techniques, and encountered no difficulties. Caution is advised when handling the IC. It is highly sensitive to static electricity discharges passed from the body, and can be destroyed before you are aware that you've done the damage. During construction, do not remove the IC from its packing until you are ready to install it in its socket, which should be fully connected to the rest of the circuit.

Take care that you have followed the correct pin orientation in wiring the socket. The pin connections are supplied with the IC, and pin number one is marked on the IC's body. Make a small mark on the IC socket to indicate pin number one, and wire the pins in consecutive order to avoid confusion and possible errors.

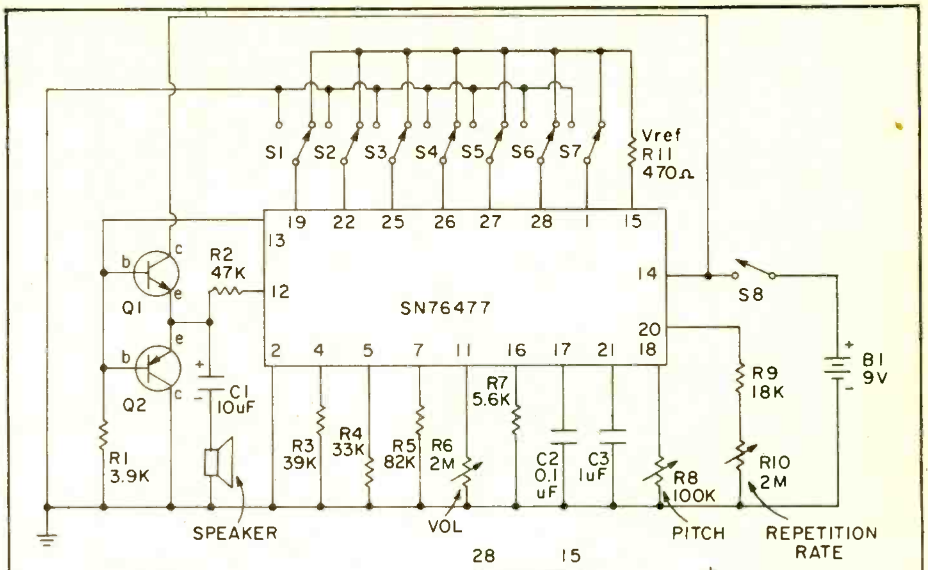
After assembly, you may find that the small, built-in speaker does not provide sufficient sound for the purposes which you intend the synthesizer's use. To provide for direct input to your home stereo system, or to a tape deck, simply wire a 22-ohm, ½-watt resistor across the leads running to the built-in speaker (you must disconnect the speaker for this purpose), and run the synthesizer directly into your system.

Of course, these are only some of the many combinations and effects available. With a little experimentation, many more are available. If you are using a guitar amplifier with the synthesizer, the reverb, vibrato, and accessory controls, such as "fuzz" can also enhance the effects which are generated. Even the tone controls on your stereo can cause dramatic changes in the synthesizer's effects.

One note of caution: Your stereo speakers may not be able to handle sustained high-level output when being driven by the synthesizer. Watch your levels!

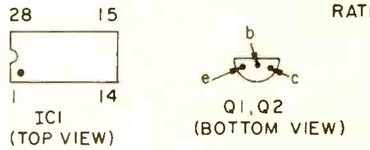
Operation. You can control the sound coming out of the sound generator by setting switches S1 through S7 and by adjusting the pitch and the repetition rate with potentiometers R8 and R10.

Shown are some representative switch positions and the corresponding sounds. A "+" in the Table means that the switch is connected to Vreg, a "0" means that it's connected to ground. ■

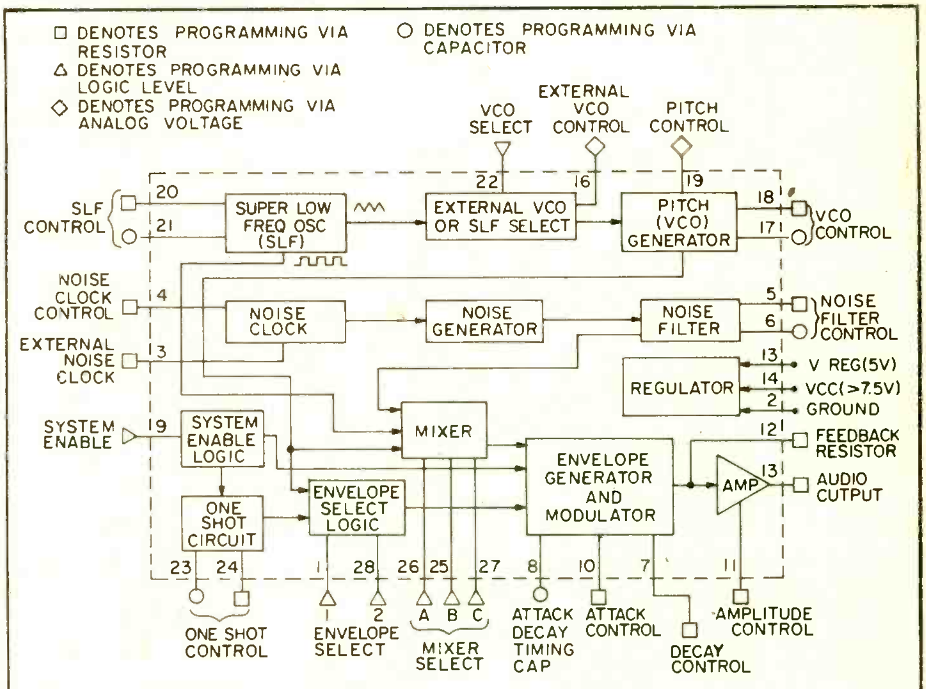


PARTS LIST FOR SOUND SYNTHESIZER

B1—9-volt transistor radio battery
C1—10-μF, 35-volt electrolytic capacitor
C2—0.1-μF, 35-volt mylar capacitor
C3—1-μF, 35-volt electrolytic capacitor
IC1—SN76477 (Radio Shack #276-1765)
Q1—general purpose NPN transistor
Q2—general purpose PNP transistor
R1—3,900-ohm, ½-watt resistor
R2—47,000-ohm, ½-watt resistor
R3—39,000-ohm, ½-watt resistor
R4—33,000-ohm, ½-watt resistor
R5—82,000-ohm, ½-watt resistor
R6—2,000,000-ohm audio taper potentiometer with SPST switch attached (S8)
R7—5,600-ohm, ½-watt resistor



R8—100,000-ohm linear taper potentiometer
R9—18,000-ohm, ½-watt resistor
R10—2,000,000-ohm linear taper potentiometer
R11—470,000-ohm, ½-watt resistor
S1 through S7—SPDT toggle switches
S8—SPST switch, part of R6
SPKR—8-ohm miniature PM speaker
Misc.—cabinet, 28-pin IC socket, battery holder and clip, knobs, hookup wire, etc.



Here's a flow chart of the inner workings of the SN76477 chip. As you can see, there's an immense amount of circuitry. An actual schematic would fill up three full pages.

CB BATTERY CHARGER SAVES $$$

Low-cost project charges inexpensive nickel-cadmium cells to keep you on the air for pennies an hour.

by Herb Friedman W2ZLF

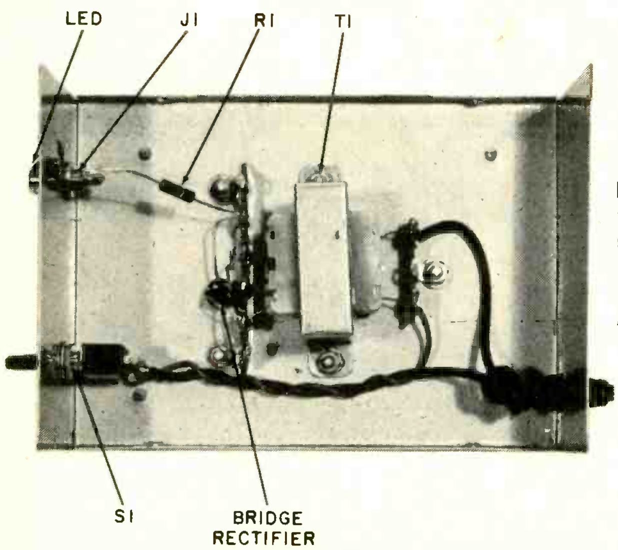
☐ If you're a typical user of one of those high-power hand-held CB walkie talkies rated between 3- and 5-watts input, you know that batteries don't come cheap. And if the cost of the batteries doesn't get you, their leakage will. Leave the power switch on overnight by accident and it's a good bet by next morning the hand-held set will be dripping battery *gook*.

But there is a way to beat the problems of high battery upkeep and leakage, and also to insure maximum RF output at the same time. The answer? Switch to nickel-cadmium (NiCad) penlight batteries (AA size). Are they expensive? Not any more. A NiCad should cost about the price of two alkaline batteries, or even less, and the NiCad can be recharged hundreds, possibly a thousand times. If you use a hand-held transceiver you'll break even on the second or third recharge.

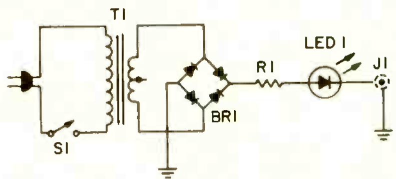
Hold on, don't go running to the parts catalog to look up the price of NiCads, you probably can't afford them at catalog prices. What you need is a surplus dealer. You see, today everyone is in a hurry and most people can't wait the usual overnight period to recharge NiCads—they demand a *fast-charge* battery. So hundreds of thousands of the overnight (or *trickle* charge) NiCads were dumped on the surplus market, and you can buy them for as little as a buck a piece, no higher than $1.50. And you get a tremendous advantage with the trickle-charge NiCads: they hold their charge much longer than the fast-charge type. Charge 'em up, stash the transceiver in the closet, or the trunk of your car, and a week or two later they will deliver almost full power. Fast charge NiCads can't hold a charge that long.

You Can Refrigerate 'Em. Speaking of car trunks, if you leave a hand-held CB set in the trunk and the temperature plunges down near freezing ordinary penlight batteries aren't going to deliver much operating time. But NiCads will still be going like gangbusters in cold weather long after standard batteries are too pooped to pop.

Can your hand-held use NiCads? Simply look inside to tell. If your hand-held uses penlight (AA) size batteries there is probably room for twelve cells though only ten are used; a filler takes up the space of two cells. Since the standard battery delivers voltage of 1.5,



Inside view of author's prototype charger. Parts layout is uncritical. Using terminal strip lugs as shown makes things secure. Bridge rectifier can be made up from four junk box diodes.



This simple circuit will allow you to take advantage of recharging your batteries and saving a bundle of cash. Using surplus parts also keeps costs low.

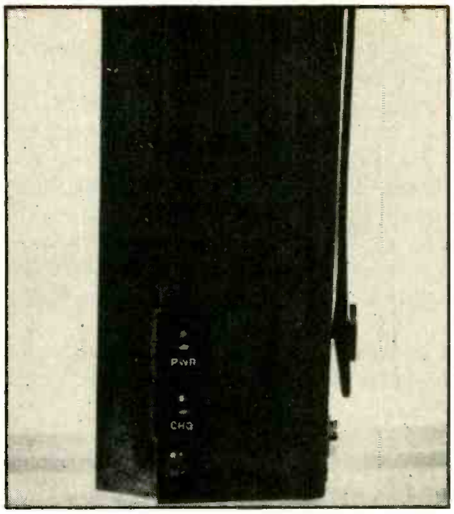
PARTS LIST FOR CB-BATTERY CHARGER

R1—220-ohm, ½-watt resistor
T1—24-28-VAC power transformer rated 100 mA.
BR1—Bridge rectifier, 50 PIV, 100 mA.
LED1—50 mA.
J1—Phono jack
PL1—Phono plug (see J1, above)
PL2—Plug to match transceiver power input receptacle
S1—Switch, SPST
Misc.—Cabinet, terminal strips, wire, solder, etc.

ten batteries equals a fresh power pack of 15 VDC. But NiCads only deliver 1.2 volts, so twelve batteries are required to produce 15 VDC. The two "extra" NiCads fit in place of the filler. So in order to use NiCads your set must provide room for twelve, rather than ten cells. There must also be a jack on the side of the transceiver to which a charger can be connected. If you have both these conditions (space for twelve cells, and a charger jack) you can use NiCads. The only exception to this rule is a few models which cannot accept NiCads because some NiCads are very slightly longer than a standard penlight AA battery, or the CB set manufacturer did not allow for the extra size even though he provided a charger connection. Make certain your hand-held set will accept NiCads before you buy them.

Really Low-Cost. Finally, you need a NiCad charger, and that's where you can spend real money, but really! One of the top instrument companies charges $30 for a NiCad charger you can build for less than $8. They get this exorbitant price because they manufacture one of the very few chargers that can handle all twelve batteries at the same time. Most chargers handle only four to eight cells at a time, taking two to three days to recharge a complete set of NiCads. If you can recharge all twelve cells at once you plug it in in the evening, and you're ready to go the following morning.

The diagram shows a simple but effective charger circuit that will handle up to twelve cells simultaneously. It needs no regulation or control because it trickle-charges *any* type of NiCad. You can even leave it plugged in continuously without fear of damage to the cells, thereby insuring the NiCads are always in a state of full charge. The charging current is 40 to 50mA regardless of the number of cells (in case some become defective), or their state



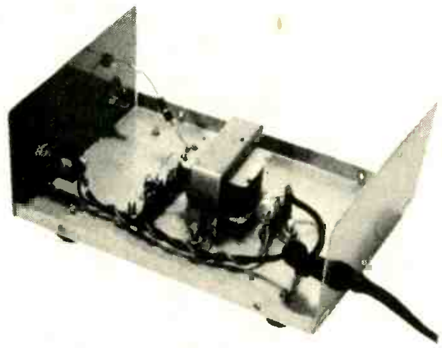
Side view of author's CB transceiver shows two inputs, one for charging internally-contained Nicad batteries.

of discharge. From full-discharged to fully-charged the charging current is always a safe 40 to 50mA.

Use These Parts. Excepting the cabinet, if you select surplus components the whole thing will cost less than $8. If you buy all new, you'll run up unnecessary expense, which have no effect bearing on the performance.

Transformer T1 is 24-to-28 VDC at no less than 100 mA. It doesn't have to be more than 100 mA. Don't waste your money on a high current filament transformer. If you use a 28-volt transformer increase R1's value to 270 ohms. BR1 is a 50 PIV bridge rectifier rated 100 mA or better. Use the least expensive type you can get. If you have four discrete silicon diodes lying about simply connect them as the bridge circuit.

LED 1 serves as both a pilot light and *Charge* indicator. If the LED doesn't light the batteries aren't being charged. The LED also serves as a fuse. If the rectifier and R1 short out the NiCads will attempt to discharge through the diodes and the



Completed charger chassis shows neat layout of parts. Note knot in AC power cord just to the left (inside) of the rubber pass-through grommet in the chassis. Knot prevents power cord from pulling through grommet accidentally.

high discharge current could cause considerable damage. But the LED will burn up almost instantly, thereby opening the circuit to the batteries.

The LED is the only critical component, in the sense you must be certain it is rated for a *maximum* of at least 50 mA. We suggest a diffused LED be used as its light can be seen from the sides. These are usually not too hard to obtain.

To mount the LED simply push it through a hole in the front panel of whatever you use for the cabinet. If you connect R1 between the LED and a terminal strip as shown in the photographs the LED will be held in position without need for glue or a lamp mounting kit. The cabinet can be plastic or metal; the one shown is a store-bought metal cabinet.

How To Connect It. The charger's output is through phono jack J1 rather than a direct cable. In this way different patch cords can be connected to accommodate the several styles of plugs required for transceivers charging jacks. Just make certain you get the charger plug polarity correct. Before PL2 is wired, insert it in the transceiver's charging jack and measure the voltage across the jack noting the plug's polarity. Normally the shield is ground (–) and the tip (center conductor) is positive, but it can sometimes be the other way round. Make certain the charger's positive output connects to PL2's positive terminal. You can damage the NiCads badly if you get it reversed.

Note that most transceivers are disconnected when the charger plug is inserted, so don't expect to operate the transceiver while charging the batteries.

Using The Charger. Resistor R1 limits the charger's output to 40-50 mA even if the output jack is shorted, so the charger can be used with hand-held transceivers that use ten, rather than the usual twelve NiCad batteries. Regardless of the number of batteries the charging current remains a safe 40 to 50 mA. Normally 14 to 16 hours will be required for a full charge, so this can be done overnight. If you want the batteries maintained fully charged and ready for use at any time you can keep them on continuous-trickle charge.

The only caution is not to try and charge two or more hand-helds at the same time. Don't make up a "Y" adaptor that connects two or more hand-held battery packs in parallel because one pack will discharge into the other, and if there is a weak cell in one pack the other pack will discharge with excessive output current. Charge only one set at a time. ■

IT IS A LITTLE KNOWN FACT, but the simple act of using jumper cables to start (boost) a car with a dead battery can lead to severe personal injury. It's true!

A good Samaritan in California was helping his neighbor start his car by jumping the battery. The battery exploded and our hero got a face full of sulfuric acid for his trouble. A man in Pennsylvania noticed another charging his batteryincorrectly. When he attempted to rearrange the cables from the charger there was some sparking, and the battery exploded.

The reason for both of these accidents, and many others, is the fact that a battery being charged produces hydrogen gas, a very combustible and explosive element. The longer a battery is charged the greater the accumulation of hydrogen, and the greater the danger of a serious explosion. All that is required is a single spark as one connects either of the jumper cables to a battery post.

How does one avoid such an occurrence? Simple. Just follow the step-by-step procedure given below whenever you need to jump one battery to another.

10 steps to safe battery boosting

By Thomas R. Sear

1. Ensure that the ignition switches and all electric accessories, including the lights, are turned off in both cars.

2. Verify that both batteries are rated for the same voltage. Most automotive-type batteries are 12-volt models these days; but many older cars, as well as some of the smaller models, may have a 6-volt battery.

3. Remove the dustcaps from each cell of both batteries, and make certain that the electrolyte reaches the FULL-mark. If not, ordinary tap water can be used to top-off each cell if distilled water is not available. If the dead battery is to be recharged, the dustcaps should be left off to prevent any buildup of pressure due to the rapid release of hydrogen gas from the battery fluid.

4. Cover the battery openings to prevent any splashing acid from reaching your skin or clothing. Your handkerchief will suffice.

5. Attach only one jumper cable at a time. Connect one end of the *red* jumper cable to the positive terminal of the good battery first. This is the terminal marked with a +, a P, or POS. Then connect the other end to the positive terminal of the dead battery.

6. Connect one end of the *black* jumper cable to the negative terminal of the good battery. This is the terminal marked with a –, an N, or NEG. Then connect the other end to a point on the frame of the car with the dead battery at least 18 inches from the battery.

7. Start the engine of the car with the good battery. Allow the car to warm up for a few minutes, holding engine speed to a fast idle.

8. Start the engine of the car with the dead battery. If the engine starts, proceed to Step 9. If it doesn't, turn off the ignition and wait several minutes. Don't flood the engine with too much gasoline. If the battery is completely dead, wait about half an hour so the battery may be charged by the running car. Try to start the dead car again. Now, if successful, proceed to Step 9. If the car cannot be started, see a mechanic.

9. Disconnect the jumper cables by reversing the order in which they were connected. Keep the car with the bad battery running at a fast idle until it is warmed up. The chance of stalling is thus greatly reduced.

10. Replace the dustcaps on the dead battery.

Some final notes: It's always best to determine why the car didn't start in the first place and have the car adjusted or repaired. Repeated battery boosts are unwise and unsafe. Also, because of the hydrogen gas present when batteries are involved, *never* smoke a cigarette near a battery that is being charged. ■

CYCLOPS

Sleep for 1001 peaceful nights with this electronic genie standing faithful guard

by Anthony J. Caristi

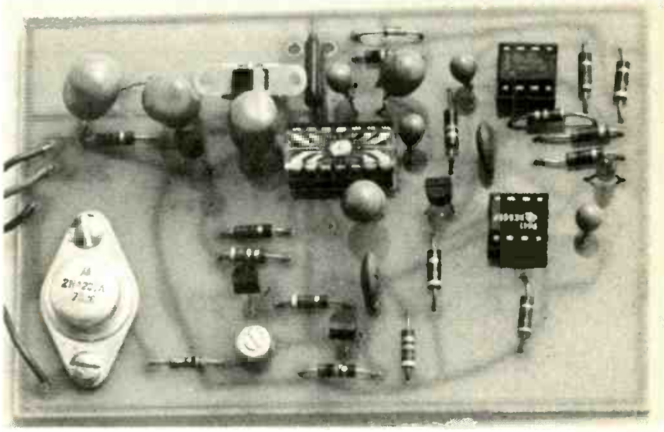
BUILD CYCLOPS. With his space age magic eye he will stand guard over your house or property and sound a musical alarm if an intrusion should occur. He does this without the use of any special light source by monitoring the ambient light intensity falling on his eye. Cyclops performs his guard duty with a very meager appetite for power, consuming only ½ watt while he is on duty. If an intrusion should occur, Cyclops responds by sounding an attention getting alarm, and automatically resets himself after a specified time delay selected by you.

You can also take advantage of Cyclops' unfailing eye by using him as an automatic doorbell. When someone approaches the door of your house and casts a shadow, the resulting change in light intensity falling upon Cyclops will cause him to sound a short and pleasant series of musical notes. You can extend his detection range by placing him in your driveway or garage to announce the arrival of an automobile at night, when he sees the headlights of a car.

Versatility. Cyclops is quite versatile and can be used for purposes other than an intrusion alarm or automatic doorbell. For example, you can construct an electronic rifle range by placing Cyclops' eye at the center of a bull's eye and shooting with a beam of light from a home-made ray gun. Each time the bull's eye is hit, a series of musical tones will sound. An electronic ray gun or rifle can be constructed by modifying a small flashlight which emits a narrow beam so that the light rays are concentrated. In order to produce a "shot," the circuit shown can be used. This will drive the light bulb from a charged capacitor and result in a pulse of light. Use a spring loaded SPDT switch.

Cyclops' built-in musical ability can be used as the basis for a "Close Encounters" sound generator accompanied by a flashing light, or you can even place Cyclops in your car and have an unique musical horn. This and all the other features of Cyclops can be performed by a single electronic assembly which can be constructed at low cost. Simple modifications of the circuit will permit you to use Cyclops for whatever purpose you desire.

About the Circuit. The eye and heart of Cyclops is a specialized integrated circuit which is the result of a marriage between a photodiode and a digital and linear circuit on a single chip. Such a device is called an Optolinear and is available to you from the source specified in the parts list for Cyclops. This is the 14-pin IC chip shown in the photograph of the Cyclops PC board.

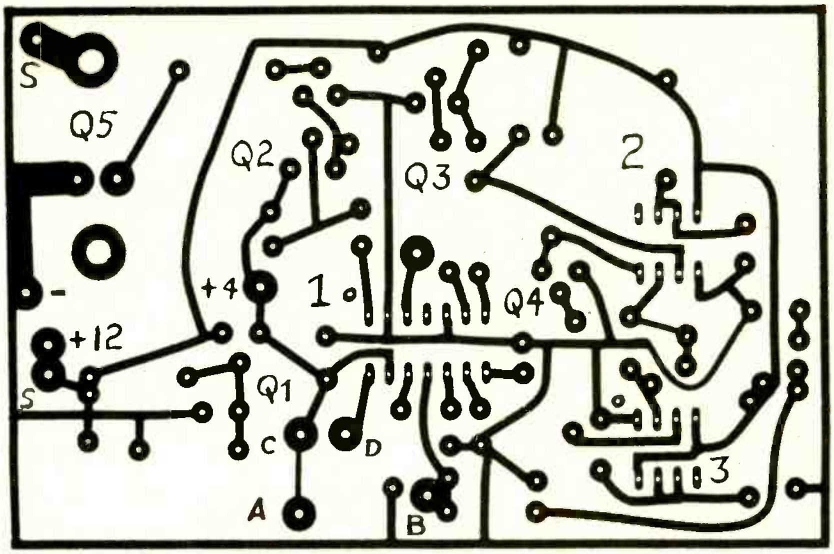


The Optolinear IC chip is the eye of Cyclops. This nifty little package detects small changes in the ambient lighting conditions and triggers the alarm. You can use this handy device as a burglar alarm or as a household remote controller.

IC1 is an integrated circuit motion detector which monitors the ambient light intensity falling on the built-in photodiode. When a change in light intensity occurs, a circuit is triggered which produces a series of pulses of varying frequency in the audio range. A digital counter within the chip permits a specified number of pulses to be generated, and then resets the circuit back to a standby mode to await the next change in light intensity falling upon the photodiode. The series of audio pulses produced, when amplified and fed to a loudspeaker, is a simulation of the familiar whooping sound which is characteristic of some alarms. C4 determines the rate at which the circuit changes from one tone to the next, and can be changed to suit individual tastes. IC1 has an additional digital circuit which produces a second set of random musical tones which might be described as "Close Encounters" music. When the chip is in this mode of operation, it is also capable of flashing a 6 volt light bulb in time with the music.

Control of the operation of IC1 is accomplished by feeding a positive voltage to either or both control input terminals, pins 11 and 14. When terminals C and D of the printed circuit are connected together and terminals A and B are open, the circuit is set to perform as an intrusion alarm. Opening the circuit between terminals C and D, and A and B, programs the circuit for "Close Encounters" music. Automatic control of terminals A and B of the circuit is provided by IC2 and IC3, and manual control of terminals C and D is provided by a single pole silde switch mounted directly on the printed circuit board.

CYCLOPS



Use this full-sized printed circuit board template to make your own Cyclops. You might try out one of the new PC kits from Vector that lifts the pattern from a magazine page.

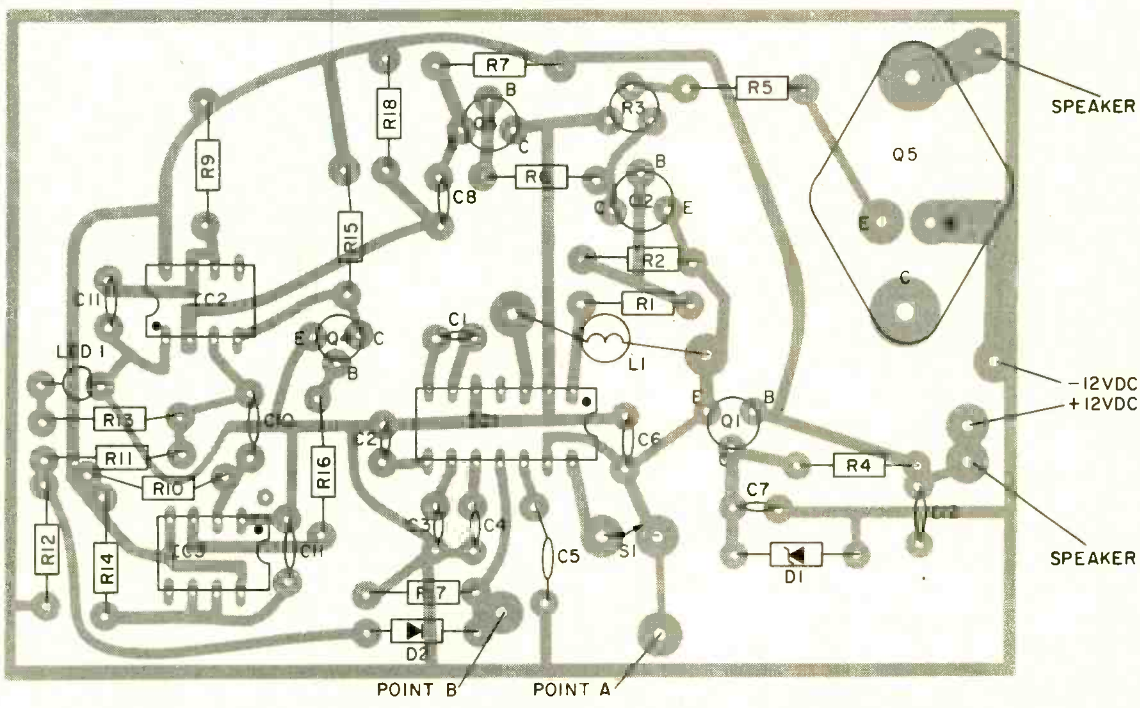
Power to drive a loudspeaker is provided by Q2 and Q5 which amplify the low voltage output pulses of IC1 and deliver peak currents of up to 1 ampere into the speaker. When IC1 is in standby mode, the voltage at the output terminal, pin 1, is about 4 volts. This cuts off both Q2 and Q5 so that current in the loudspeaker is zero. When IC1 is activated, Q2 conducts current and provides base drive to Q5 through R3 which acts as a volume control. When the circuit is set for maximum volume, Q5 acts as a switching transistor, driving the loudspeaker with pulses of about 12 volts. The circuit will drive loudspeakers of any impedance. Greatest volume will be obtained with a 3.2 ohm speaker, since this will draw the highest load current from Q5. Peak power delivered to a 3.2 ohm speaker can be as high as 40 watts when the volume control is set to maximum. Average power will be much less than this since the circuit delivers pulses with a duty cycle of less than 50%.

Construction. Cyclops can be constucted on a single sided printed circuit board measuring 2⅞ by 4¼ inches. This includes all the necessary circuitry with the exception of the 12 volt power source. If an AC operated power supply is desired, it can be added to the circuit at the option of the builder. A typical power supply circuit is shown with the schematic on the next page.

The printed circuit layout in this article is shown full size as seen from the copper side of the printed circuit board. The component layout is also shown. If possible, make photocopies of the printed circuit, component layout, and schematic diagram and work from these copies. This will avoid wear and tear on the originals which you will want to keep in good condition for future reference.

After etching the printed circuit, go over it with a magnifying glass to pick up any shorts or opens which may exist. This will help avoid problems when the circuit is first placed in operation. For a slight additional cost, it is strongly recommended that sockets be used for the integrated circuits. Their value in a printed circuit assembly cannot be overemphasized. The use of sockets give you the ability to troubleshoot the circuit, should a problem exist, in much less time than if the IC's were soldered in place. It is extremely difficult to remove a multi-pin IC which has been soldered into a printed circuit without destroying the IC or printed circuit. Do not mount the integrated

This parts location diagram will help you get everything in the right place. This view is of the component side with the parts facing up. The foil PC pattern is on the underside. Building this project is a snap even if you are a beginner.



circuits until instructed to do so in the checkout procedure.

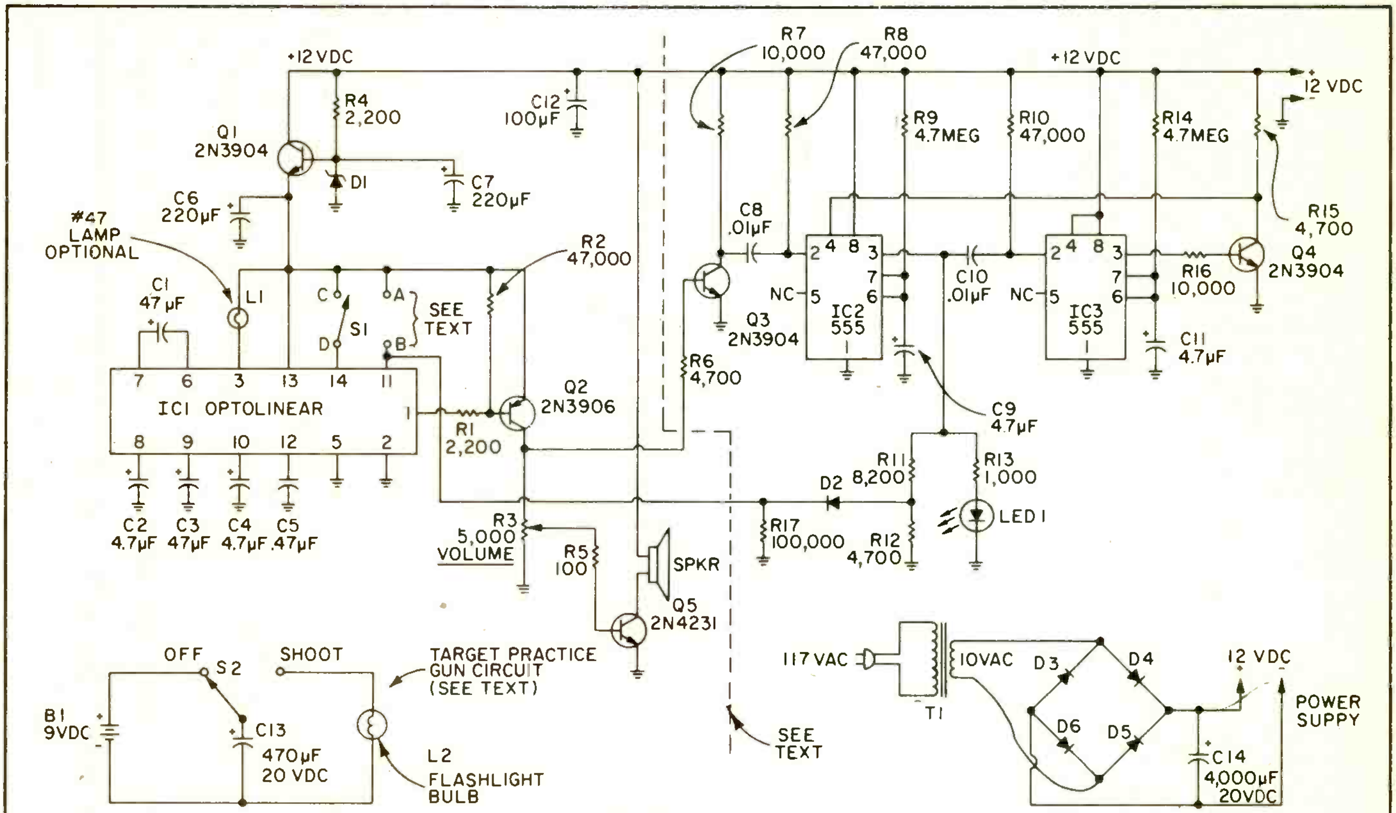
The component layout shows control switch S1 and volume control R3 mounted directly to the printed circuit board. You may want to mount the printed circuit board in a small cabinet with these components accessible from the outside. If you are going to use the lamp with the circuit, be sure to place it so that its light will not fall upon IC1. Should this happen, the additional feedback signal from the lamp may cause a circuit malfunction, although no damage will occur.

You will note that the power output transistor, Q5, is mounted to the printed circuit board with no heat sink. None is required since this transistor operates as a switch at high current levels, and therefore dissipates very little heat. Mount Q5 to the printed circuit board with two 4-40 screws and nuts. Make them tight but not overtight.

Checkout Procedure. The printed circuit assembly should be checked with power applied before installing any of the integrated circuits in place. This will avoid damaged components in the event of possible short circuits or miswiring. Apply 12 VDC power to the circuit using a battery or AC operated power supply, observing correct polarity. Measure the voltage at pin 13 of IC1 using the negative side of the DC power supply as the meter reference. This should be between +3.5 and +4.5 volts DC. If the voltage is not within this range, check zener diode D1 for a voltage drop of 4.2 to 5.2 volts. Check also that D1 is mounted

(Continued on page 112)

If Cyclops really appeals to you as a useful gadget, but you don't have the time or experience to put it together, then you might consider ordering Delta Electronics' Motion Detector. It uses the same IC as Cyclops. It sells for $24.50 in kit form or $69.50 fully assembled with NiCad batteries and charger. Delta's address is in the parts list of this article.



PARTS LIST FOR CYCLOPS

B1—9-volt battery
C1, C3—47-uF electrolytic capacitor, 10 VDC
C2, C4—4.7-uF electrolytic capacitor, 10 VDC
C5—0.47-uF ceramic disc capacitor, 10 VDC
C6, C7—220-uF electrolytic capacitor, 20 VDC
C8, C10—0.01-uF ceramic capacitor, 10 VDC
C9, C11—4.7-uF electrolytic capacitor, 20 VDC
C12—100-uF electrolytic capacitor, 20 VDC
C13—470-uF electrolytic capacitor, 20 VDC
C14—4,000-uF electrolytic capacitor, 20 VDC
D1—1N5230 4.7 volt zener diode
D2—1N4148 silicon diode
D3, D4, D5, D6—1N2069 silicon diode
IC1—Optolinear IC (see text for explanation)
IC2—555 timer
IC3—555 timer
L1—#47 lamp
L2—flashlight bulb
LED1—light emitting diode
Q1, Q3, Q4—2N3904 NPN silicon transistor
Q2—2N3906 PNP silicon transistor
Q5—2N4231 NPN silicon transistor
R1, R4—2,200-ohm, ¼-watt resistor
R2, R8, R10—47,000-ohm, ¼-watt resistor
R3—5,000-ohm trimmer potentiometer (PC board mounting type)
R5—100-ohm, ¼-watt resistor
R6, R12, R15—4,700-ohm, ¼-watt resistor
R7, R16—10,000-ohm, ¼-watt resistor
R9, R14—4,700,00-ohm, ¼-watt resistor
R11—8,200-ohm, ¼-watt resistor
R13—1,000-ohm, ¼-watt resistor
R17—100,000-ohm, ¼-watt resistor
SPKR—3.2-ohm PM type speaker
S1—SPST miniature slide switch
S2—SPDT momentary-on switch
T1—10-volt, 1.2 amp transformer
Misc.—large plastic cabinet (8 in. by 4 in. by 4 in.) screws, spacers, wire, AC plug and zip cord, etc.

Note: IC1 is available from:
Delta Electronics
7 Oakland St.
P.O. Box 2
Amesbury, Mass. 01913
Catalog #1072W
Price: $8.95

Lure hard-to-get DX like grandad used to do with this hot receiver

Spider Web Receiver

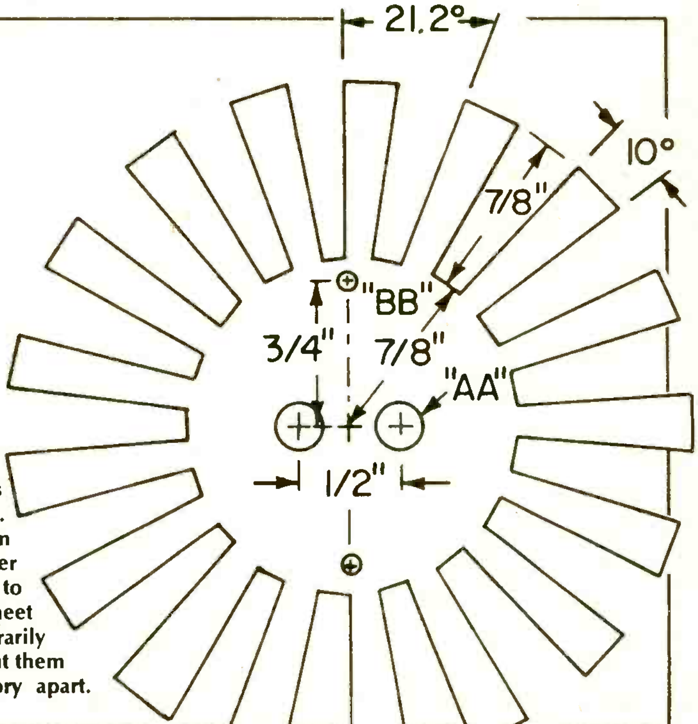
IN THE OLD DAYS OF RADIO, back when grandpa was building his first one tube radio, the spiderweb coil was the "cat's pajamas." This type of tuning coil was very popular with the home-constructors, and with good reason; the spiderweb coil is a high Q type, wound with interleaved turns for minimum residual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

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

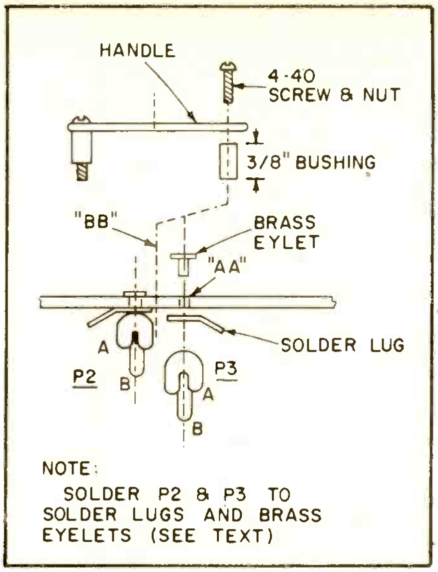
The Spiderweb Coil Receiver Circuit. Signals from the antenna are coupled through J1 and C1 to L1 and the tuning capacitor C3. The bandspread capacitor C2 is used to fine-tune crowded SW bands and the resultant signals are fed via C4 to the gate-leak R2 and the gate of FET Q1. The RF signals are detected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

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

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



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



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

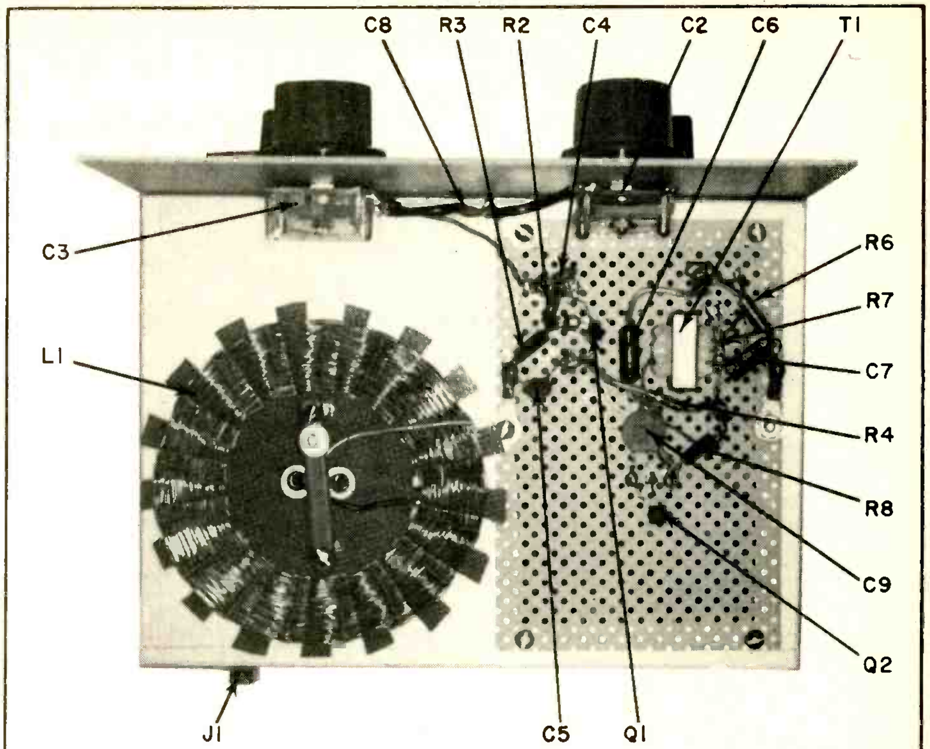
frequencies. L1 A tunes from 7 MHz to 14 MHz, L1 B tunes from 1.7 MHz to 5 MHz, and L1 C tunes from .55 MHz to 1.6 MHz.

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

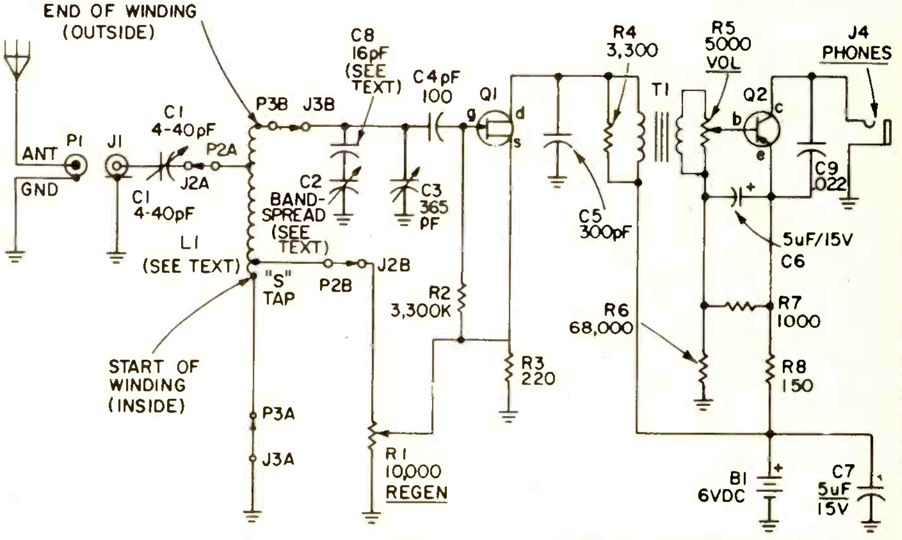
The easiest way to start construction of the coil forms, is to trace the outline of the spiderweb coil form drawing and temporarily cement the tracing onto a sheet of plastic. Then cut out the coil form with a hack saw. If desired, three sheets of plastic can be temporarily cemented together with rubber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

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

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



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



PARTS LIST FOR SPIDERWEB RECEIVER

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

Spider Web

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

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

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

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

SPIDERWEB COIL WINDING TABLE

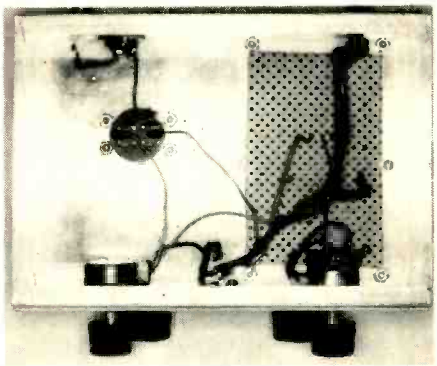
	WIRE SIZE	TOTAL TURNS	ANT TAP (P2A)	"S" TAP (P2B)
BAND A 7 MHz to 14 MHz	#18 Enam.	4	½-Turn from end	1-turn from start
BAND B 1.7 MHz to 5 MHz	#24 Enam.	17	1½-turns from end	2-turns from start
BAND C .55 MHz to 1.6 MHz	#28 Enam.	52	10-turns from end	1-turn from start

mounting screws, as shown in the photo.

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

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

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



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

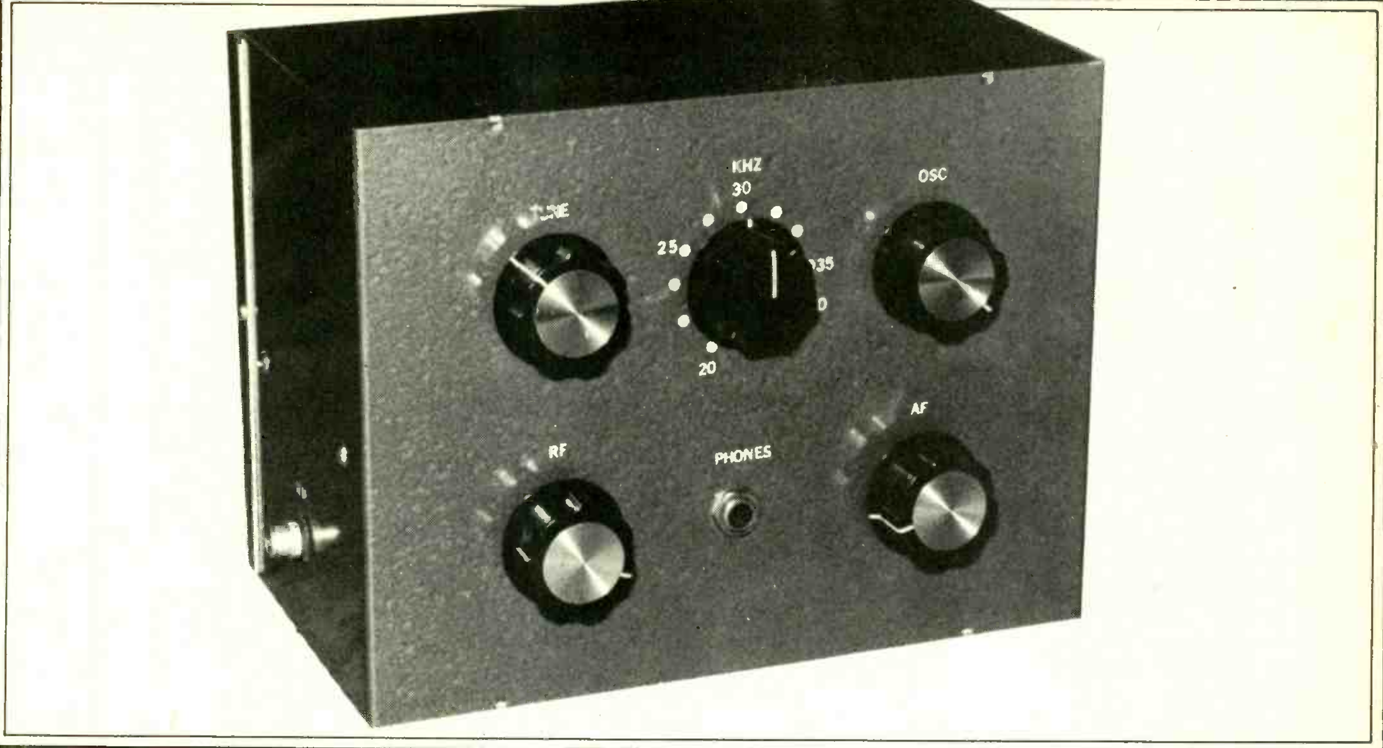
mmf (as on the model shown in the photo).

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

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

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

(Continued on page 114)



SUB-BASEMENT RADIO

EXPERIMENTER'S DELUXE FET/IC VLF RECEIVER

JUST AS MANY of the "cliff dwellers" in modern multi-story apartment buildings have little-known basements and sub-basements, the radio spectrum has a "basement" LF (low frequency) band and a mysterious "sub-basement" VLF (very low frequency) band, little known to many electronics hobbyists and experimenters. The LF band goes from 300 kHz down to 30 kHz, and the VLF band from 30 kHz down to 3 kHz.

The lower portion of the LF band, from about 60 kHz to the upper portion of the VLF band (about 18 kHz), is used by the National Bureau of Standards to transmit coded, standard-frequency signals (similar to WWV). Special receivers are used for proper reception of these signals, which automatically adjust electronic laboratory generators to coincide with the standard frequencies. The U.S. Navy has found that the VLF band signals will penetrate into salt water and has established giant high powered transmitting stations that communicate with submerged submarines anywhere in the world.

Other nations maintain transmitting stations in the LF/VLF region for scientific and navigational purposes. These stations are subject to changes in frequency, power, and time of broadcast since there is still considerable experimentation. The stations usually transmit their call signs in CW at periodic intervals for identification.

Receivers for the LF/VLF "basement" transmissions are usually quite complex, but you can sample the activity in this portion of the rf spectrum with our simplified receiver project which covers the most popular portion of the bands from 20 to 50 kHz. This frequency coverage can be changed by using different values of inductances than specified in our plans. Plans are also included for a VLF-style loop antenna to be used with the receiver instead of the usual outdoor dipole antenna used in the higher frequencies. Inasmuch as VLF wavelengths are many miles long, a half wave antenna dipole is impractical at these frequencies.

The receiver uses two ICs and three FETs in a simplified regen detector circuit with a two-stage rf amplifier. Good audio volume is provided for earphone reception, and the receiver is housed in a compact metal utility box. Perf board style construction is used for ease in building the receiver.

The Circuit. Very low frequency signals picked up by the loop antenna are fed through coax cable to the input of IC1, the rf amplifier stage. The amplified signals are fed through C3 to the coil L1 and the second rf amplifier stage, IC2. L1 and the input capacity of IC2 act as a broadly tuned circuit for VLF signals: R2 controls the rf amplification.

Capacitor C6 couples the amplified rf signals to the oscillating detector stage of FET Q1. These signals are tuned by L2 and the S1 switch-selected capacitors of C8 to C18. Variable capacitor C7A/B acts as a fine tuning control for the VLF signals, and R5 controls the oscillation point and, therefore, the sensitivity of the detector stage.

The detected audio signals are fed through the low pass filter R7/C20 and coupling capacitor C21, to the audio gain control R8 and audio amplifier stage Q2. The amplified audio signals are coupled via the L3/C23 peak filter to the second audio amplifier stage of FET Q3. The peak filter is tuned to approximately 800 Hz to provide better receiver selectivity of the

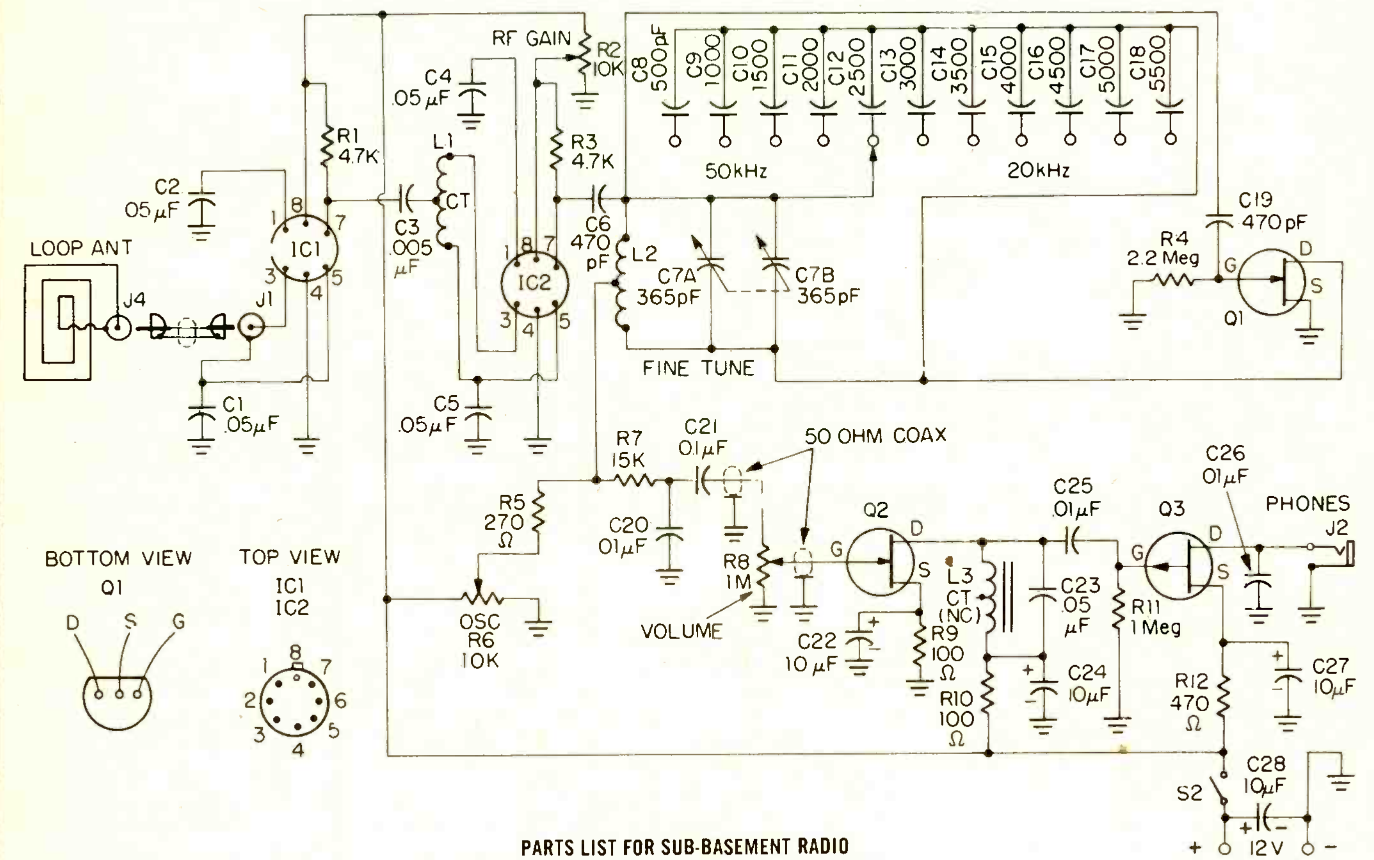
SUB-BASEMENT RADIO

VLF signals. The amplified signals are fed from the drain circuit of Q3 to J2 and can drive high impedance earphones (2000-ohm type).

Field effect transistors Q2 and Q3 form the audio amplifier stages. Q3 is a P-channel FET and therefore requires a relatively negative potential on its "drain" terminal. This is accomplished by grounding the drain through the earphone and returning the "source" to the positive power supply terminal.

Construction. Coils L1 and L2 are made from miniature transistor audio transformers by removing the laminated iron core. We used 10,000-ohm to 2,000-ohm center-tapped transformers for the coils in our receiver. The connections are made to the 2,000-ohm center-tapped winding only; the leads to the 10,000-ohm winding should be cut off close to the coil form. Coil L3 is a 1,000-ohm CT to 8-ohm miniature output transformer and is used *with* its iron core intact. The 1,000-ohm winding is used (no connection is made to the center tap), and the 8-ohm and center tap leads should be cut off close to the coil form.

The receiver operation is at low rf frequencies, but the wiring of the receiver should still be carefully done. For best results, follow our component layout as shown in the photos. Your best way to start construction is to cut a 4¼ x 7⅞-in. section of perf board and install it approximately halfway up the LMB-146 aluminum box. We used two 4¼-in. lengths of sheet aluminum



PARTS LIST FOR SUB-BASEMENT RADIO

C1, C2, C4, C5, C23—0.05-uF capacitor, 12-VDC or better
C3—0.05-uF capacitor, 12-VDC or better
C6, C19—470-pF capacitor
C7A/B—dual-gang 365-pF variable capacitor (TRW 273 or equiv.)
Note—A dual-gang 365-pF variable capacitor may be difficult to obtain. You can go the same route as pioneer radio builders by using two single-gang 365-pF variable capacitors and operate them in tandem (turn each knob the same amount).
All capacitors 15-VDC or better
C8—500-pF (see text for all capacitors, C8 to C18)
C9—1000-pF
C10—1500-pF
C11—2000-pF
C12—2500-pF
C13—3000-pF
C14—3500-pF
C15—4000-pF
C16—4500-pF
C17—5000-pF
C18—5500-pF
C20, C21, C25, C26—0.01-uF capacitor
C22, C24, C27, C28—10-uF electrolytic capacitor, 16-VDC
IC1, IC2—703-type integrated circuit
J1, J3—insulated phono jack, RCA type (see text)
J2—two-conductor phone jack
L1, L2—inductors made from small 10k to 2k audio driver transformers
L3—inductor made from small 1k to 8-ohm audio output transformer (see text)
Q1—N-channel FET, HEP-802 (Motorola)
Q2—N-channel FET HEP-F0015
Q3—P-channel FET HEP-F1035
R1, R3—4700-ohm, ½-watt resistor
R2, R6—10,000-ohm potentiometer, linear taper
R4—2.2 meg, ½-watt resistor
R5—270-ohm, ½-watt resistor
R7—15,000-ohm, ½-watt resistor
R8—1 meg potentiometer, audio taper
R9, R10—100-ohm, ½-watt resistor
R11—1 meg, ½-watt resistor
R12—4700-ohm, ½-watt resistor
S1—single pole, 11 position rotary switch (Calectro E2-161 or equiv.)

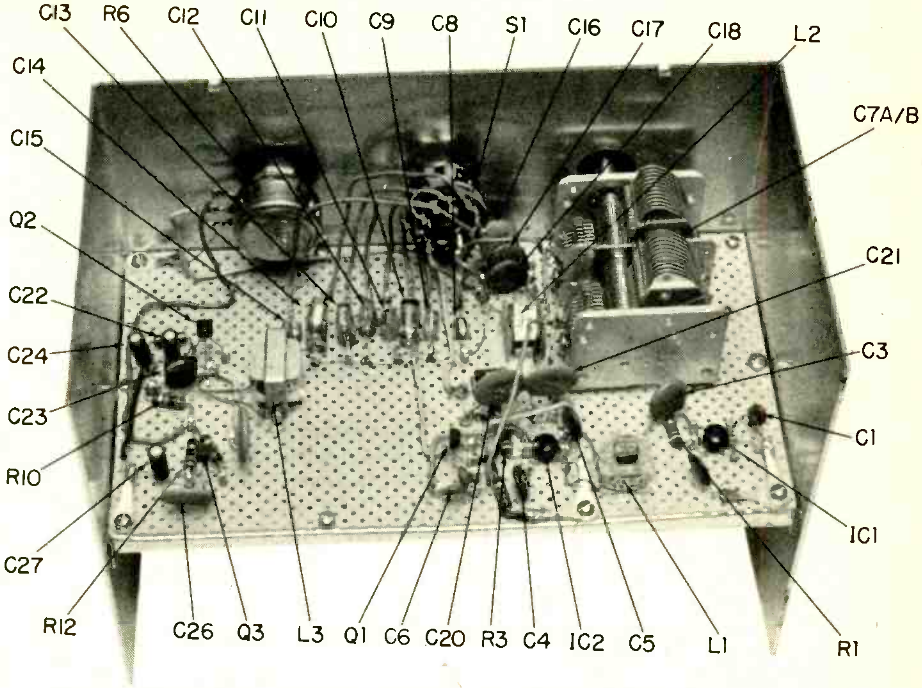
Note: values for bias resistors R9 and R12 may be changed for optimum performance.

Misc.—aluminum cabinet 8-in. x 6-in. x 4½-in. (Author used LMB 146), perf board, push-in clips, 50-ohm coaxial cable, knobs, hook-up wire, No. 28 enameled wire, plastic tape, solder, etc.

bent into brackets with sides approximately ¼ x ½-in. (½-in. side mounted to the box wall, and the ¼-in. side mounted to the perf board). Additional lengths of ¼-in. wide sheet metal stiffeners were added to the side of the perf board to increase the rigidity of the board. This may not be necessary in your unit.

More Mechanics. Locate C7A/B on the front panel as shown in the photos, and then cut a ½-in. or larger hole for the shaft. This will allow the frame of C7A/B to be mounted to the perf board and allow the shaft to protrude through the front panel without touching the metal panel. Note that the shaft *must be* insulated from the panel, or it will short the B+ at the detector circuit. If necessary, you can use an insulated coupling for the shaft. Make sure that you use a plastic tuning knob to minimize the possibility of short circuits.

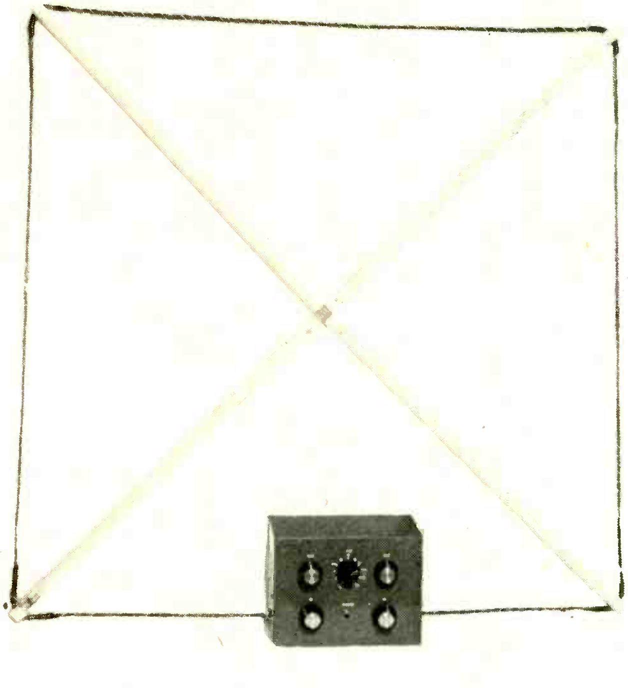
Locate and install the remainder of the front and side panel controls and components as shown in the photos. Make sure that you install serrated washers between the control bushings and the inside of the panels to prevent accidental disturbance of the position of the controls. Also, use insulating washers for J1 to keep the jack body from electrical contact with the box panel and electrical ground.

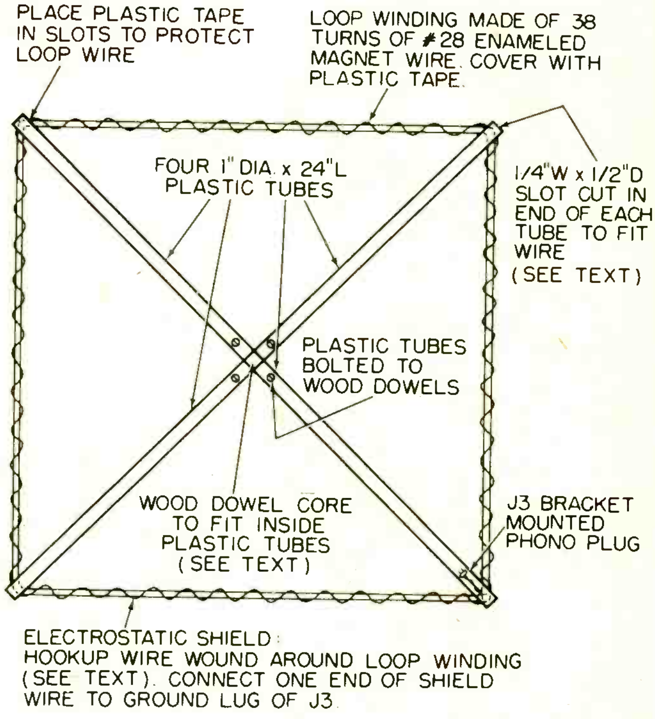


These are the major parts locations for the perf board. Note dual-gang cap C7A/B.

Most of the components on the perf board are connected to push-in clips. Keep the component leads as short as possible and group them around their particular IC or FET as shown in the photos. Wire the components as indicated in the schematic drawing and position the leads as shown in the board photo.

Coil forms L1 and L2 can be either cemented to the top of the perf board, or (as in our unit) held with an application of hot plastic glue from an electric glue gun. Use short lengths of coax or shielded wire to connect R8 to the perf board components as shown in the

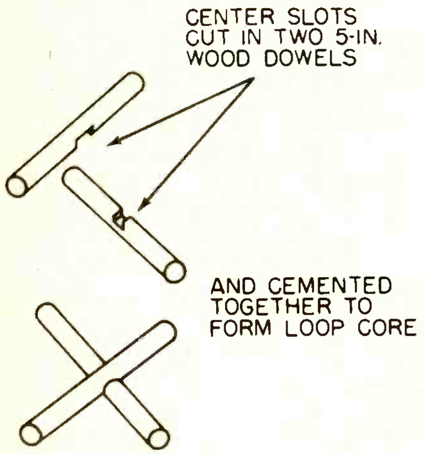




Reinforced PVC tubes available from building supply outlets are lighter and easier to work with than dowel sticks when building an open air antenna support frame. The RCA-type phono connector makes a convenient way to use standard audio cable.

photo. Connect ground lugs at the board corners and on the C7A/B mounting screws for the necessary electrical circuit connections.

Capacitors C8 to C18 should have as accurate a capacity value as possible (select them on a capacitor bridge if possible), and they can be either ceramic or polystyrene types. Mount them with short leads around S1 and connect them with straight direct leads to the S1 lugs. If necessary, you can parallel capacitors to make up the required capacity values. Connect the remainder of the front and side panel controls and jacks to the board circuits, and position the leads as shown in the photos.



Dowel sticks for this assembly are available from lumber yards, hardware store and hobby shops. Notch with a wood chisel or a keyhole saw or whittle with a pocket knife.

The Loop Antenna. As shown in the drawing, the loop antenna is composed of four 1-in. diameter x 24-in. long plastic tubes. We used polyvinyl chloride (PVC) tubes that can be obtained from a building supply store. Or any type of plastic tube can be used as well. The plastic tubes are fitted over a wood-dowel center core as shown in the drawing, and the loop antenna wires are wound over the slots in the tube ends.

Begin construction of the loop antenna by cutting center slots in two 5-in. long wood dowels (of a diameter to fit snugly into the plastic tubes), and cement them together as shown in the drawing. Wood screws can be used in place of cement, or hot glue from an electric glue gun can be used as we did in our model.

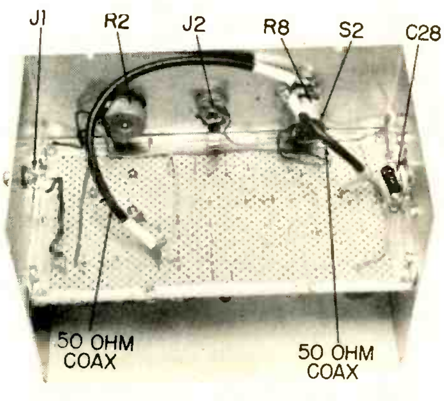
Cut the plastic tubes to size and then cut a ¼-in. x ½-in. deep slot on one end of each tube. Then mount the tubes to the wood dowel core with the slotted ends outward and parallel to allow the loop antenna wires to be wound around the ends as shown in the drawing.

The front panel control knob "osc" sets the regenerative feedback point of the detector FET Q1 (it sets the audible "plop" point!). That "tune" knob is actually a fine-tune of the bandswitch-like "kHz" (course) control.

Place plastic tape in the tube slots to prevent the wire from being abraded, and wind the loop with 38 turns of #28 enameled magnet wire, and cover the wires with a layer of plastic tape. Connect the loop leads to a phono jack (J4) mounted on the end of one of the plastic tubes.

To minimize noise pickup, wind an electrostatic shield composed of a spiral winding of hookup wire around the antenna loop. Leave about 1-in. spacing between the electrostatic shield wire turns, and connect one end of the wire to the "low" side (shell) of J4. The other end of the electrostatic shield wire should be taped so that it will not cause any accidental short circuits.

A length of good quality phono or coax can be used to connect the loop antenna to the receiver. Make sure that the "low" sides of P4 and J1 are connected together (the outside shells of the jacks).



Experimenters should use a short length of 50-ohm coaxial cable for vol. control R8 connections (mini-type RG-174U or RG-58 U).

Range and Panel Markings. We used rub-on decals for the panel markings for our receiver model, but neatly drawn pen and ink markings on white tape can be used as well.

The receiver does not require any calibration for exploratory operation on the VLF band, and you can designate the approximate frequency of the S1 kHz switch as follows: 20 kHz (C18=5500 pF), 25 kHz (C15=4000 pF), 30 kHz (C13=3000 pF), 35 kHz (C10=1500 pF), 40 kHz (C9=1000 pF), 45 kHz (C8=500 pF).

For more accurate calibration with the transformers you used for L1 and L2, connect an audio oscillator to J1 through an isolating audio transformer.

Testing and Operation. The loop antenna can be suspended with a length of cord from one of the plastic tubes for easy rotation and operation indoors. Or the loop can be placed on a wooden chair for temporary operation. Note, however, that the loop should be away from AC appliances for best performance.

Set all controls to the extreme counter-clockwise position, and connect the receiver to a 12 volt DC power supply or battery. Connect the loop antenna to J1 with either coax or a length of good quality phono cable, and plug in a set of high impedance earphones at J2.

Adjust the *audio gain* (R8), *rf gain* (R2) and *fine tune* (C7A/B) controls to mid-range. Adjust the *osc* control (R5) clockwise until the detector circuit (Q1) is oscillating. There will be a "click" or "plopping" sound in your earphones when the detector stage first falls into an oscillating condition. Keep adjusting the *osc* control (R5) near this point for best sensitivity when tuning for signals. Adjust R8 and R2 for best reception of signals.

Adjust the *fine tuning* control (C7A/B) for each setting of S1 as you listen in on the VLF band from 20 kHz to 50 kHz. Reposition the loop antenna as necessary for best reception of signals. Practice is required to obtain the proper "feel" for operating the receiver controls. You can also try different loop antenna assemblies with different turns of wire for best results in VLF reception over different portions of the band. You can experiment with the tuning range by changing the values of L1 and L2.

Remember, this is an experimenter's project exploring the little-known, little-tuned very low frequencies. It's a good first-step project into VLF; why not "kick in" right now! ■

Rhythm & Blues Box

Boogie to the sound of this electronic drummer

by Randall Kirschman

RHYTHM IS THE TIME-PATTERN of sounds that enables us to distinguish a march from a mazurka, and it is one of music's basic ingredients. It could also earn a stack of votes from both beginner and veteran musician alike as one of the most troublesome. But help can be close at hand if you build the rhythm synthesizer described here.

Use our Rhythm and Blues Box (R&B Box), while practicing on an instrument, to analyze or demonstrate rhythms, or even for learning dances. It can also be connected to a percussion generator to provide simple accompaniments, or it can serve as a programmable controller for musical synthesizers. Whatever your particular involvement with rhythm, you'll find the R&B Box a valuable companion.

A metronome is the traditional aid for timing in music, but it falls short in the rhythm department because the clicks it produces are all identical. In music, rhythm comes about when each beat does *not* receive identical emphasis. With the R&B Box you can overcome metronomic monotony by giving each click in a sequence a different emphasis to produce musical rhythms.

A notable feature of this rhythm synthesizer is that it is not limited to standard or preset rhythms, but can be set up to generate thousands of rhythms of all kinds. Furthermore, each rhythm is precise to the microsecond.

Let's find out how the Rhythm and Blues Box accomplishes its feat by taking a tour of the circuit. Even at second glance the circuit may seem formidable, but it can be understood by tackling it a section at a time. Each section is a basic building block which you may meet in other circuits also—the multivibrator, shift register, flip-flop, latch, analog switch, and multiplexer.

Good Vibes! We'll begin our tour with IC2, a 555 timer, and its associated components. These form an astable (free-running) multivibrator that generates a continuous train of pulses to drive the rest of the circuitry. The tempo of the rhythm is controlled by *Tempo* control R3.

The pulses from IC2 (pin 3) go to IC3A. IC3A and IC3B, both NOR gates, are connected as a monostable (one-shot) multivibrator, which puts out a pulse each time it is triggered by a pulse from IC2. This pulse is then fed to NOR gates IC3C and IC3D to improve its shape and to generate both an inverted (negative-going) pulse (from pin 3 of IC3C) and a positive-going pulse (from pin 4 of IC3D). As we'll see, these pulses serve as *clocking* (or simply *clock*) pulses for the flip-flops in the synthesizer. They occur at the same rate as the tempo pulses from IC2, but are narrower.

Shift Into High. The next section on our itinerary is a *shift register*. Basically, a shift register is a string of flip-flops connected in cascade. The output of each flip-flop is connected to the input of the next and all are clocked by the same clock pulse. Thus, at each clock pulse, the *high* or *low* bit held in each flip-flop is shifted to the next flip-flop (except at the ends). This mode of operation of the shift register, where the bits play follow-the-leader, is called the *serial* mode. Some shift registers, like the one in the Rhythm Synthesizer, can also operate in the *parallel* mode. In this mode the inputs of the flip-flops are disconnected from the outputs so that all the flip-flops can be *loaded* simultaneously from outside during a single clock pulse.

In the R&B Box, IC's 5, 6, and 7, each a four-bit shift register, are cascaded to form a 12-bit shift register.

Blues Box

The Rhythm and Blues Box can be used as a simple metronome for piano practice. Just as easily, the rhythm shown on the score can be dialed in directly, so you can keep your feet on the pedals, your mind on dynamics.

As described later, to start a rhythmic pattern the shift register is loaded in the parallel mode with a *high* in stage 1 and *lows* in the remaining 11 stages. The shift register is then put into the serial mode and clocked by the positive clock pulses from pin 4 of IC3D, which shift the single *high* from stage to stage (left-to-right in the circuit diagram). Thus the otuput of each stage goes *high* in sequence. This continues until the *high* reaches the stage selected by the *Sequence Length* switch, S3. S3 then feeds the *high* to the input of a *D-type* flip-flop (pin 9 of IC4).

A D-type flip-flop has the characteristic that the logic level (*high* or *low*) present at its input before it is clocked will be assumed by its output after it is clocked. However, note that the clock input (pin 11 of IC4) of the D flip-flop is fed the inverted clock pulse from pin 3 of IC3C. So when the shift register is being clocked by the rising edge of the positive clock pulse, and the *high* is fed to the D flip-flop input, the D flip-flop sees the falling edge of the inverted clock pulse and just sits there with its output still *low*. A few milliseconds later, at the end of the clock pulse, the D flip-flop is clocked and then the *high* is transferred to its output (pin 13 of IC4), which connects to the load enable input of the shift register (pin 7 of IC5, 6, and 7). This puts the shift register into the parallel mode. Nothing happens until the next clock pulse, at the beginning of which the shift register is loaded with a *high* in stage 1 and *lows* in the other stages, and at the end of which the output of the D flip-flop goes low, putting the shift register back into the serial mode. The situation is now the same as it was when we began our analysis, and the whole sequence repeats.

Here we have been assuming that S3 is set to a number (2–12), causing the shift register to keep reloading automatically as described, so that the sequence repeats indefinitely. However, if *Sequence Length* is set to *off*, the *high* in the shift register is shifted through all 12 stages and out the end without being fed to the D flip-flop, so the shift register is not automatically re-loaded. Thus the sequence only occurs once, after which the R&B Box quiets down. To start the action again, it must be loaded manually.

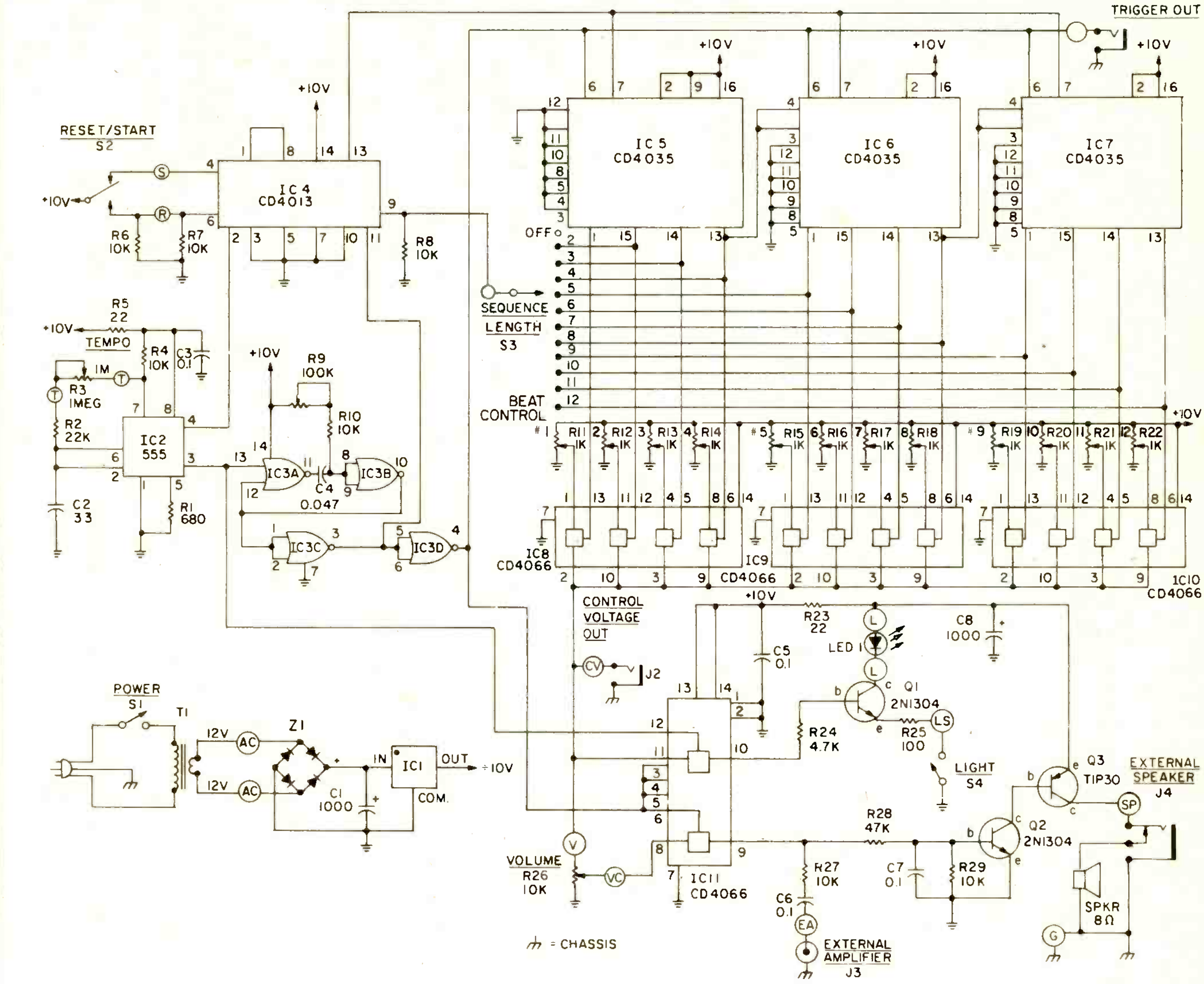
The shift register is loaded manually by means of the *Reset/Start* pushbutton, switch S2, and the other half of IC4. This half of IC4 is also a D-type flip-flop but is used here as a *set-reset* flip-flop or *bistable latch* to eliminate the effects of switch bounce from S2. Pushing S2 makes pin 6 of IC4 *high*, *setting* the latch. This in turn sets the other flip-flop (via pin 1 to pin 8) in IC4, which puts a *high* on the load enable input of the shift register (pin 7 of IC5, 6, and 7), putting it into the parallel mode. At the same time, the latch makes pin 4 of IC2 *low*, stopping the tempo pulse to keep the synthesizer silent.

Releasing S2 makes pin 4 of IC4 *high*, which *resets* the latch, and IC2 and IC3 start producing pulses. The initial pulse first clocks the shift register, loading it, and then clocks the D flip-flop so its output goes *low*, putting the shift register into the serial mode. After that the *high* in the shift register is clocked from stage to stage as described previously.

Move To Multiplexing. Let's move on to the next section of the circuit to see why the *high* is being shifted around. The output of each stage of the shift register is fed to the control input of an *analog switch* (in IC8, 9, and 10). An analog switch is a solid state version of a relay; when the control input is *high* the two signal lines are connected together with a low resistance; when it is *low* they are disconnected. An analog switch differs from a logic gate in that a logic gate deals only in *highs* and *lows*, whereas an analog switch passes any voltage level (within limits), and passes it in either direction.

At the beginning of a rhythmic sequence, the *high* in stage 1 of the shift register turns on the first analog switch (pins 1 and 2 of IC8 are connected), while the remaining switches are off. At this time the common output line of the analog switches (pins 2, 10, 3, and 9 of each of the chips—IC8, 9, and 10) is connected only to the wiper of beat control #1 (R11), and assumes the voltage level set by R11. At the next

Just by properly setting the controls, you can program our Rhythm and Blues Box for any kind of beat you wish. Any sequence of one to twelve beats, with any of them emphasized, is readily obtainable. The Tempo control sets overall speed.



PARTS LIST FOR RHYTHM AND BLUES BOX

C1, C8—1000-uF, 25-VDC electrolytic capacitor with radial leads (Sprague QV1-185, or equiv.)
C2—3.3-uF, 16-VDC tantalum capacitor
C3, C5, C6, C7—0.1-uF, 16-VDC disc ceramic capacitor
C4—.047-uF, 16-VDC disc ceramic capacitor
IC1—Positive 10-volt regulator in TO-220 package (National LM340T-10, UA7810 or equiv. See note.)
IC2—555 timer
IC3—CD4001 CMOS quad NOR gate
IC4—CD4013 dual D-type flip flop
IC5, IC6, IC7—CD4035 CMOS 4-stage shift register
IC8, IC9, IC10, IC11—CD4066 (preferred) or CD4016 CMOS quad bilateral switch
J1, J2—miniature phone jack, or to suit
J3—phono jack
J4—miniature phone jack with NC switch (Switchcraft 42AP2 or equiv.)
LED1—Jumbo red LED, 70-mA (Radio Shack 276-041 or equiv.)
Q1, Q2—General-purpose NPN germanium transistor (2N1304 or equiv.)
Q3—PNP silicon power transistor in TO-220 package (TIP30 or equiv.)
R1—680-ohm, ¼-watt resistor
R2—22,000-ohm, ¼-watt resistor
R3—1-megohm, linear-taper potentiometer
R4, R6, R7, R8, R10, R27, R29—10,000-ohm, ¼-watt resistor
R5—22-ohm, ¼-watt resistor
R9—100,000-ohm PC-mount trimpot
R11-R22—1,000-ohm miniature linear-taper potentiometer (Mallory MLC13L or equiv.)
R23—22-ohm, ½-watt resistor
R24—4,700-ohm, ¼-watt resistor
R25—100-ohm, ½-watt resistor
R26—10,000-ohm, linear-taper potentiometer
R28—47,000-ohm, ¼-watt resistor (see text)
S1, S4—SPST miniature toggle switch
S2—SPDT, break before make, miniature push-button switch (Switchcraft 953 or 963 or equiv.) or two NO SPST pushbutton switches
S3—single pole, 12-position, non-shorting rotary switch (Calectro E2-161, modified as explained in text, or equiv.)
SPKR—8-ohm speaker, size to suit (author used 4-in. diam.)
T1—12-VAC, 150-mA or greater power transformer (Triad F-113X or equiv.)
Z1—Full-wave bridge rectifier, 50-PIV, 200-mA or greater (Radio Shack 276-1151 or equiv.)
Misc:—Cabinet, knobs, line cord, IC sockets (3 16-pin, 6 14-pin), heat sinks, PC board, solder, wire, hardware, etc.

Note—IC1, TH7 LM340T-10 IS AVAILABLE FOR $1.25 FROM DIGI-KEY, P.O. BOX 677, THIEF RIVER FALLS, MN 56801.

Blues Box

clock pulse, the *high* shifts to stage 2 of the shift register, which turns on the second analog switch, while all others are off. The output line is now connected to the wiper of beat control #2 (R12), and so on down the line. As the shift register goes through its sequence, a series of voltage levels that correspond to the settings of the beat controls appears on the common line.

This type of circuit, where a common line is connected to a series of inputs (or outputs) one at a time in sequence is called a *multiplexer*.

On To The Output. The last stop on our tour is the output section, where the voltage levels from the multiplexer are converted into loudness levels of audible clicks and into brightnss levels of LED flashes. The voltage levels are gated through two more analog switches (in IC11), one for the clicks, one for the flashes. We'll see how the clicks are produced first.

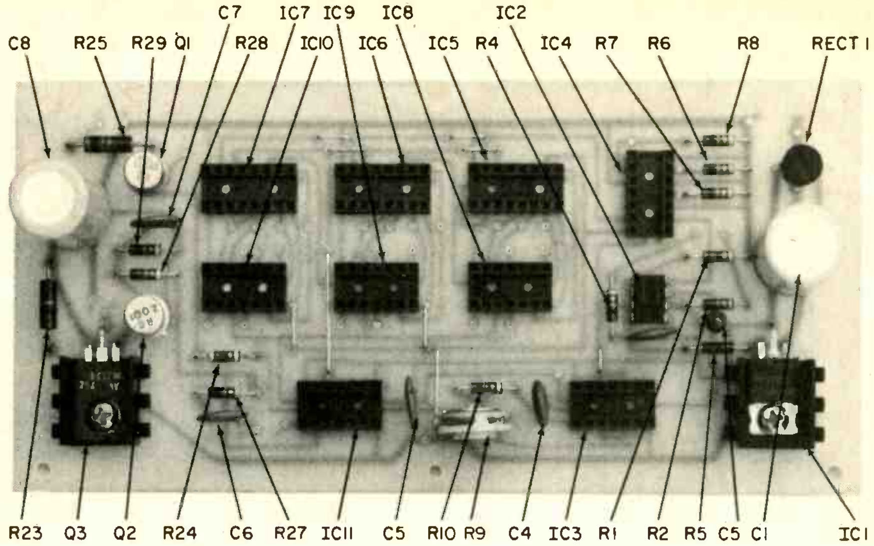
The sequence of voltage levels is fed into a signal input of one of the switches (pin 8 of IC11). This switch is turned on briefly during each voltage level by the clock pulses from pin 4 of IC3D. Coming out of the switch (pin 9 of IC11) is a sequence of short pulses whose amplitudes are the same as the voltage levels from the multiplexer, which in turn correspond to the settings of the beat controls. An amplifier consisting of Q2, Q3, and associated components, gives the pulses sufficient current to drive the speaker, producing a click. The loudness of each click corresponds to its beat control setting, thereby creating emphasis.

A similar arrangement is used to drive the LED, with another analog switch (pins 10, 11, and 12 of IC11) and Q1. In this case the analog switch is turned on by pulses directly from IC2 (pin 3), which are longer than the clock pulses from IC3. If the shorter clock pulses were used, the LED flashes would be too brief and dim.

Pins from the two unused switches in IC11 (pins 1 to 5 and 13) are tied (as indicated in the schematic) to convenient points to keep them from picking up stray signals.

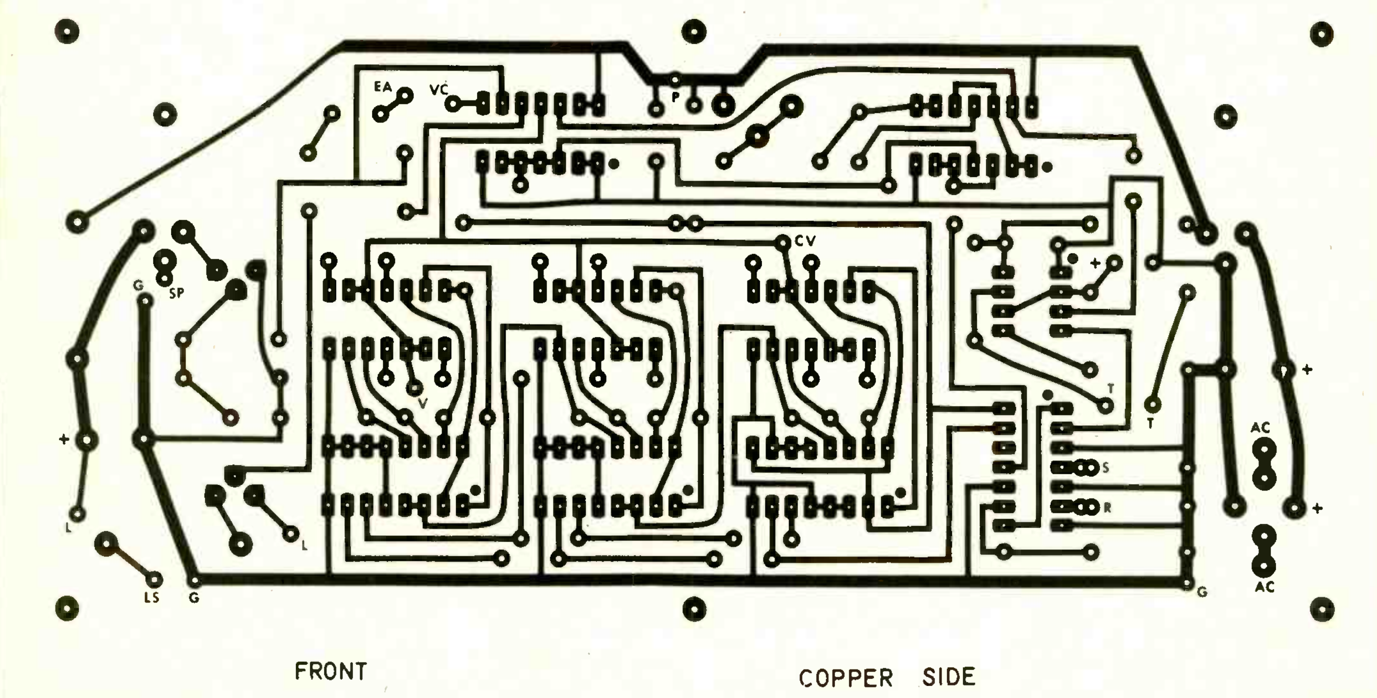
Power for all the above is provided by a regulated power supply of conventional design, consisting of T1, RECT1, C1, and IC1. R5-C3, C5, and R23-C8 isolate the power lines to IC2 and to the output section from the rest of the circuit to prevent undesirable interactions.

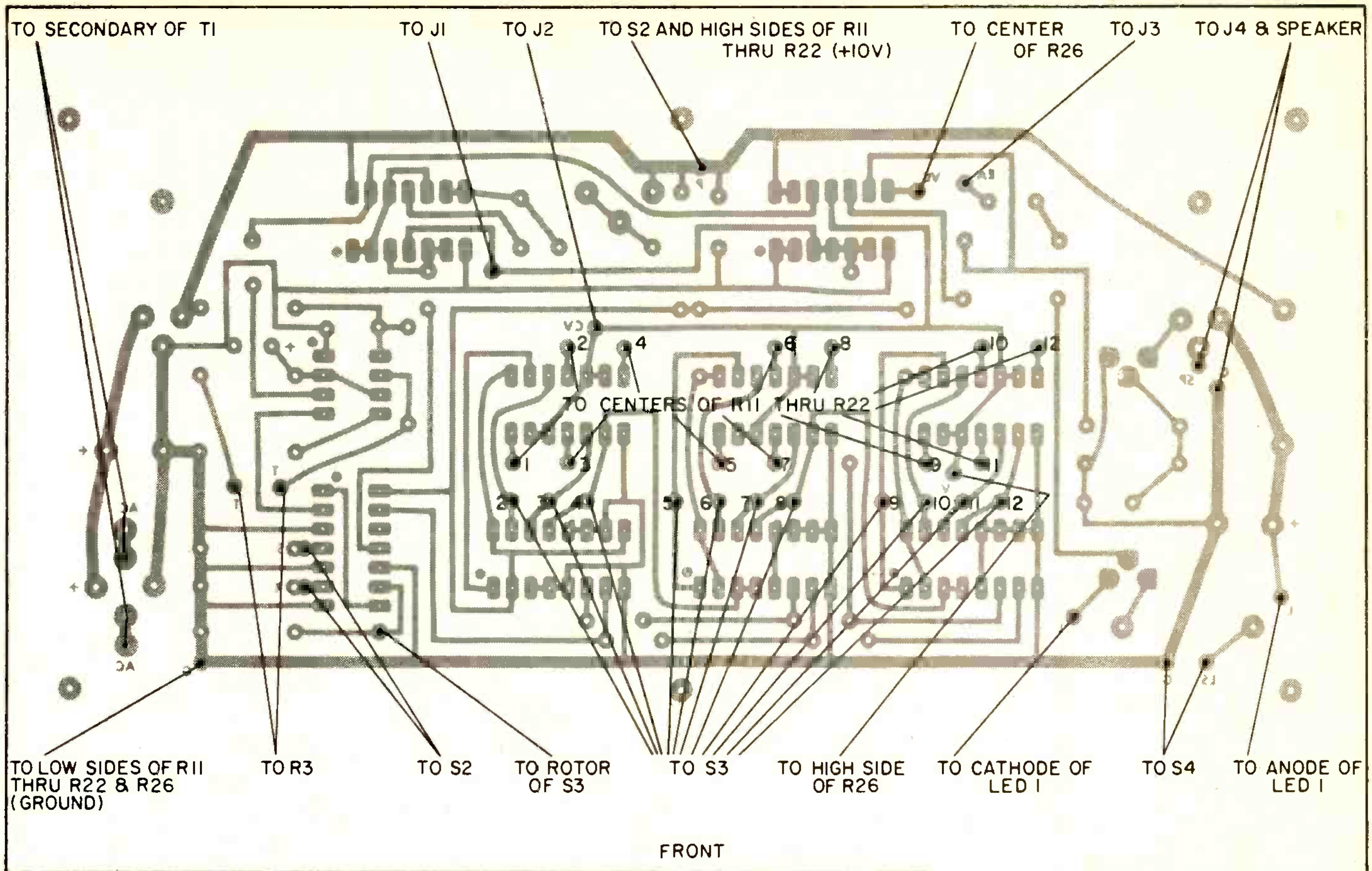
Getting It Together. Although it in-



The neat, clean, professional look of the R&B Box is not hard to come by if you follow our printed circuit template. If you fabricate your own PC board, be sure to make sure that all the leads from the IC pins are properly insulated from each other on the board.

Here's the template for the printed circuit board, shown foil side up. Follow this exactly for a perfect finished product. The dots in the IC pin sections denote pin number 1 orientation to insure that the ICs don't become reversed during the installation process.



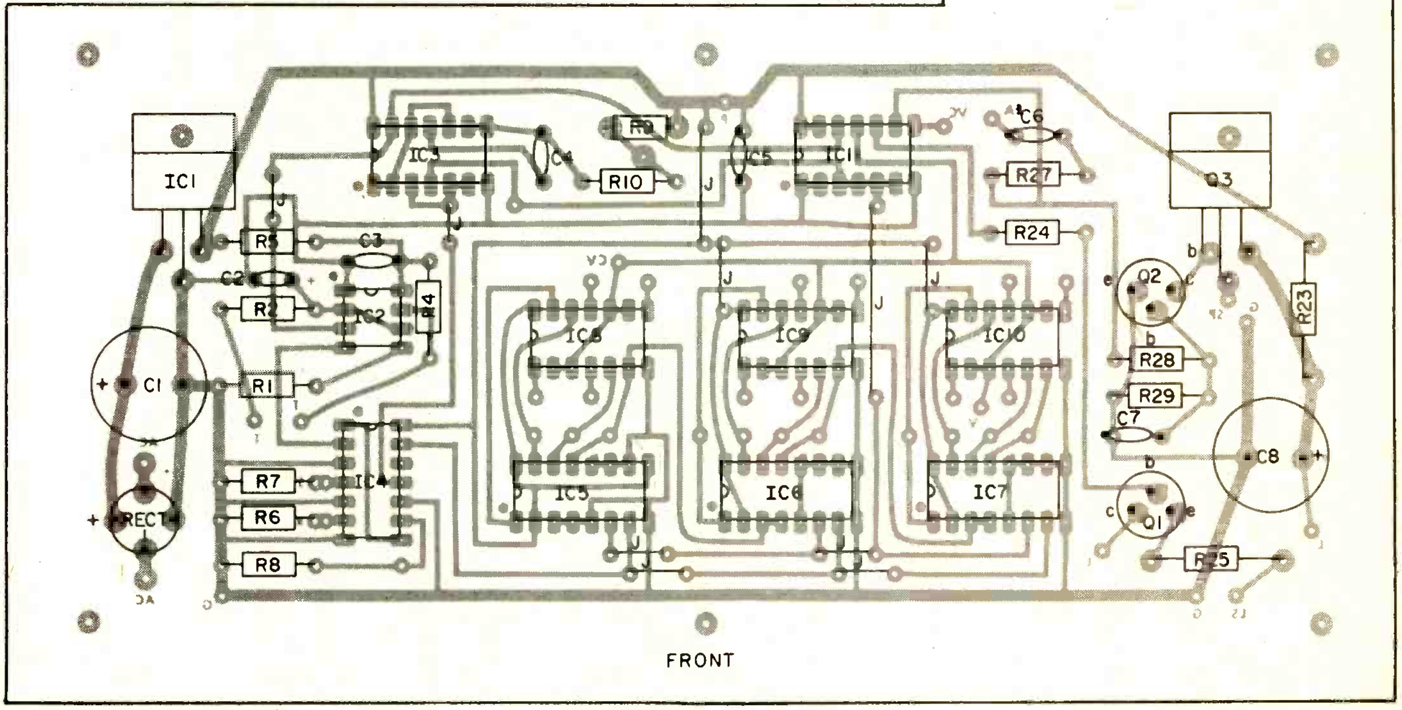


volves a fair amount of wiring, there is nothing particularly difficult about assembling the Rhythm & Blues Box. Follow the directions given here and the diagrams and photos and you shouldn't have any trouble. If this is one of your first projects, enlist the help of someone experienced in electronic construction.

When assembling the rhythm synthesizer, keep in mind that CMOS IC's (IC3 through IC11) can be damaged by static electricity or other excessive voltages, so handle them appropriately. Leave them in their packages until the final steps of construction.

Although the R&B Box could be hand wired, a printed circuit (PC) board will make the job easier and lessen the chance of wiring errors. The

The upper diagram indicates the placement of wires for the components which are not mounted on the PC board, such as the front panel controls. The diagram below shows the placement of components on the PC board. This view of the board is from the top, or unetched surface as you would see it.



Blues Box

finished product neater. An actual-size PC etching guide is provided. Most of the components of the synthesizer mount on the PC board, as shown in the parts placement diagram. Note that ten jumper wires are required (identified by J). These are all inserted from the component side of the board and may be bare wire. Use sockets for the nine CMOS IC's; using a socket for IC2 is optional. Heat sinks are recommended for IC1 and Q3, either commercial or homemade.

The optimum value for R28 depends on the transistors used for Q2 and Q3. Therefore, at this time, temporarily install a 100,000-ohm potentiometer wired in series with a 10,000-ohm fixed resistor, in its place. Set the potentiometer at midrange for starters. This will allow for tailoring the pulse to the speaker.

After assembling the PC board, check carefully for solder bridges, bad connections, etc. The PC board may be mounted to the chassis or cabinet by means of six sets of screws and spacers at the location indicated near its edges.

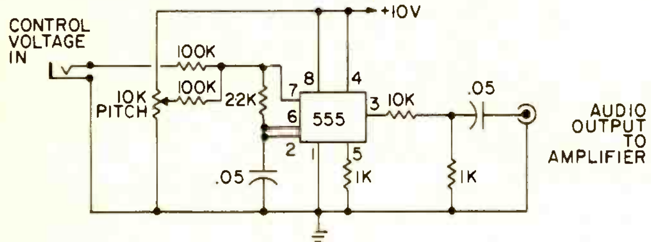
Arrangement of the components off the PC board is not critical. The author's arrangement is shown in the photos. Some of the connections from the PC board to these components are indicated by circles on the schematic diagram. Letters within these circles also appear on the etching guide.

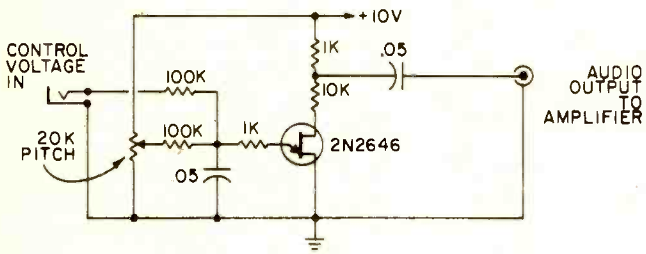
If you use the switch specified in the parts list for S3, you will need to make a simple modification to it. The specified switch has a rotation stop which allows only eleven positions to be indexed. Bend the stop out of the way to allow all twelve positions to be indexed. Note that in the newly-created position the switch rotor does not contact any of the stationary treminals; this position is used as the *off* position. When wiring S3 and the beat controls, take care to connect the wires in the correct order. Please note that switch S3 is wired only to stages 2 through 12 of the shift register. The chassis, panel, and cabinet were custom made for the author's unit, but standard commercial items could be used. The author's cabinet measures 4-in. high by 10½-in. wide by 5-in. deep.

Tuning Up. After you have completed the wiring and assembly, but *before* you insert the CMOS IC's, check out the power supply. Plug the unit in, switch it on, and measure the voltage between the point labeled P and either one of the points labeled G on the PC board. It should be 10 volts (plus or minus 0.1 volt) with P positive. If not, check the power supply (S1, T1, Z1, C1, and IC1) for wiring errors or faulty parts. When the power supply checks out, unplug the R&B Box and insert the IC's, observing their orientations.

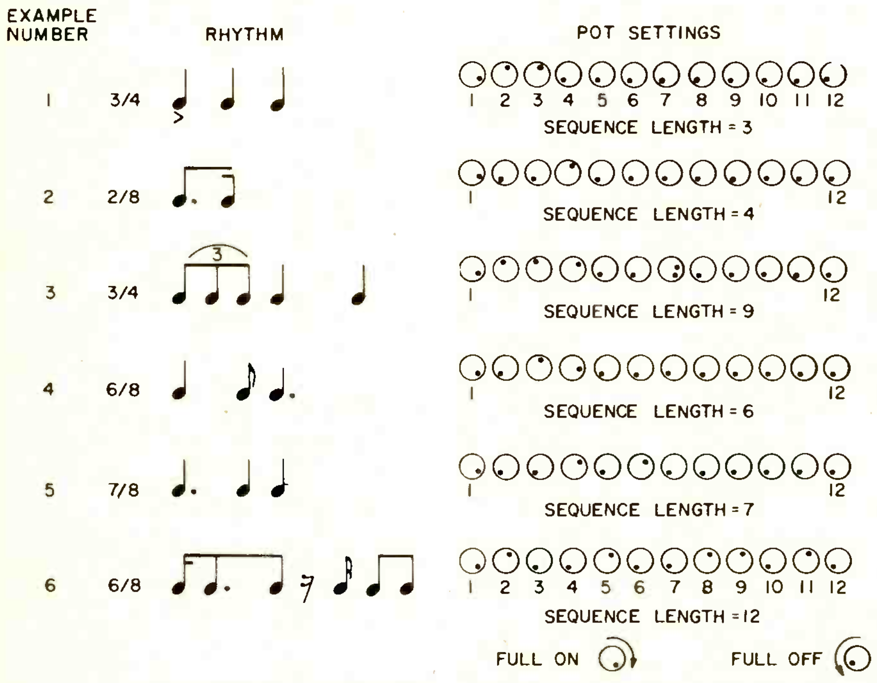
To continue the checkout, set the beat controls (R11-R22) fully clockwise; *Tempo* (R3) about ¾ of the way clockwise; *Sequence Length* (S3) to 12; *Volume* full on, and *Light* to *on*. Turn the power on, and push and release *Reset/Start* (S2). Immediately after it is released, a continuous series of clicks should be heard. The synthesizer may start without pushing S2. The clicks should all be equally loud, occurring at evenly-spaced intervals, and the LED should flash for each click that you hear.

Sour Notes? If your R&B Box doesn't behave as it should, first recheck the PC board and all the wiring. Make sure that the ICs are correctly installed and oriented properly. Next, determine that the clock (IC2 and IC3) is working. Check for a series of 10-volt pulses at the *External Amplifier* jack, which indicates that the shift register (IC5, 6, and 7) and analog switches (IC8, 9, and 10) are work-





To use your R&B Box as a melody generator, construct one of these voltage controlled oscillator circuits, and connect it to jack J2 and to an audio amplifier.



Here are some examples of time signatures and their corresponding setups on the control panel. Remember that not only is tempo controlled, but also emphasis. There aren't many musical notations that the Rhythm and Blues Box can't handle.

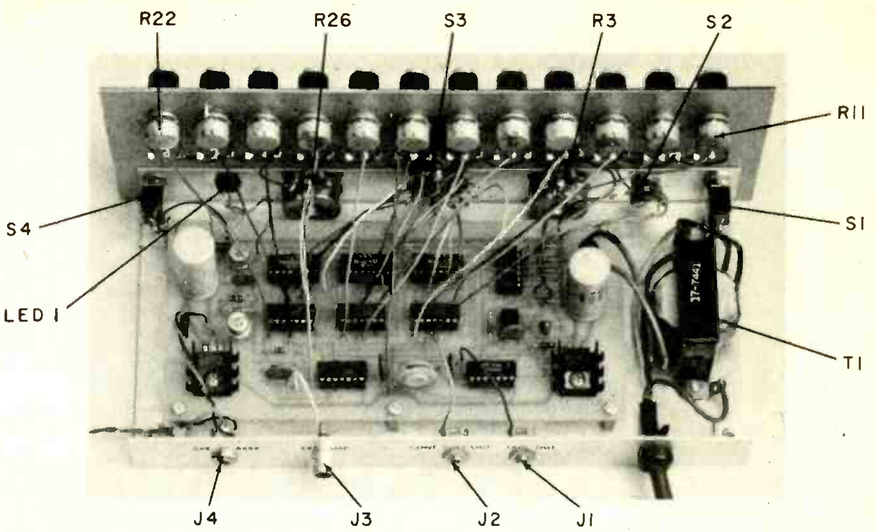
ing. If either the sound or light operates, but not the other, check the appropriate output circuitry. If one of the clicks is weak or absent, look for a problem in the corresponding stage. The troublesome stage can be identified by varying each numbered pot in turn.

Assuming everything is OK, the next step is to determine the optimum value for R28. Verify that all controls are set as specified earlier; be sure that *Volume* is at maximum. If you can get an oscilloscope, connect it across the speaker terminals to observe the pulses; if not, make the adjustment by ear. First, set the potentiometer (temporary R28) to maximum resistance. Turn the synthesizer on, and start it pulsing. Now, slowly decrease the resistance, which should cause the amplitude of the pulses to increase up to a point of saturation, that is when the amplitude no longer increases with decreased resistance on the potentiometer. Back the potentiometer off a bit from this point, unplug the unit, remove IC11, and measure the resistance of the potentiometer and fixed resistor, and replace them with a fixed resistor of the same value, or the closest standard value which you can get.

Reinsert IC11, start the R&B Box again, and continue the checkout by turning all the beat controls, except number one, down to about ⅓. This should result in one loud click (corresponding to beat control number one), followed by eleven softer ones (corresponding to numbers 2 through 12). The intensity of the LED's corresponding flashes should follow the same pattern. Holding the *Reset/Start* button in should stop the clicks. Releasing it should immediately start the sequence of clicks again, beginning with #1, the loudest. Now set *Sequence Length* to 11; a repeating sequence of one loud click followed by ten softer ones should be heard. Similarly check *Sequence Length* settings of 10, 9, 8, etc. When changing the *Sequence Length* setting the pulse may be "lost" from the shift register with the result that the clicks are no longer produced. This is normal, and if it happens, simply push and release *Reset/Start* to restore operation. With *Sequence Length* at *off*, a sequence of twelve clicks should be produced (the first one should be loudest) each time *Reset/Start* is pushed and released.

Check that the loudness of each of the twelve clicks in the sequence can be varied from zero to maximum

Finally, adjust trimmer potentiometer R9 to give the desired sound quality to



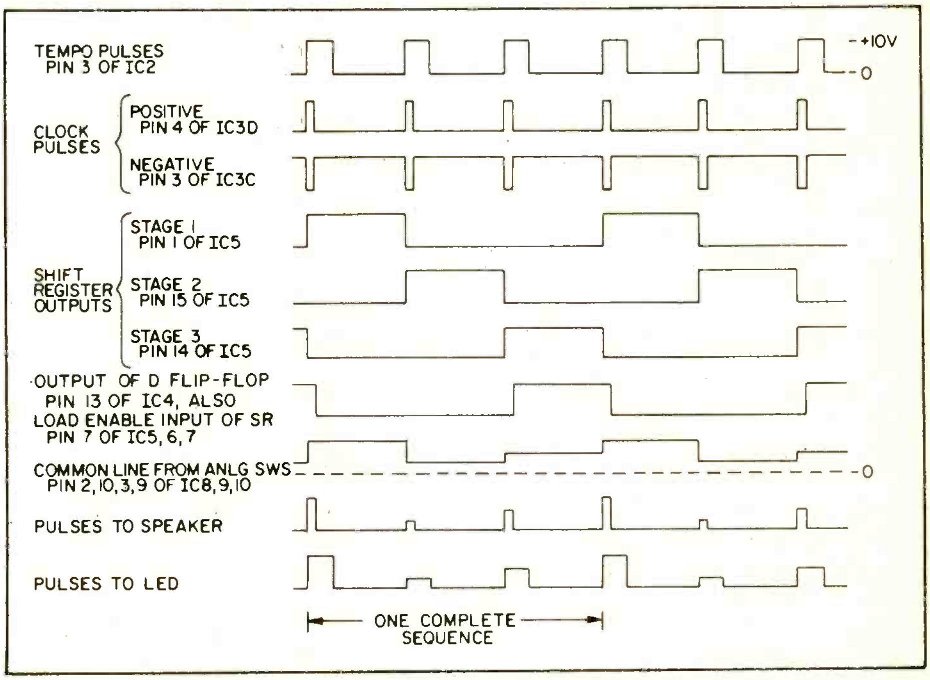
With the cover removed, the placement of all components can be observed. When wiring the beat control potentiometers, it's a good idea to tag the wires from the PC board for easy identification. Install only every other control at first for working room.

the clicks.

Performance. After going through the circuit description and checkout, you should have a general idea of what the synthesizer does. To use it, decide how many beats you need for your rhythm. This will be the *Sequence Length* setting. Turn the appropriate number of beat controls up to emphasize a beat, down to de-emphasize it, or off to delete it. As you have have seen, the R&B Box can operate in two modes: *Single-shot*, or *continuous*.

For *single-shot* operation, set *Sequence Length* (S3) to *off*. In this mode, a single sequence of 12 clicks is produced each time the *Reset/Start* switch (S2) is pushed and released. The sequence always begins from the left with beat control number one. If fewer than 12 beats are required, turn the unused beat controls completely off to silence unwanted clicks.

For the *continuous* mode, set the *Sequence Length* to the number of beats required for your rhythm. The beat control with that number will be the last click in the sequence. The sequence will repeat itself indefinitely in this mode. Since you have preselected the number of beats already, the settings of the unused beat controls are irrelevant. ■



Need an adjustable waveform generator? The Rhythm and Blues Box can handle that too. Simply tap in at the appropriate point, hook up your scope, and you're ready to go.

Ask Hank, He Knows

(Continued from page 7)

power to the fan and at a hot point in the attic. Attic temperatures above 105°F turn the fan on until the temperature goes below 105°. Then the fan is turned off to save power. Nutone also makes a cutoff device in the event there is a fire. The device prevents forced air draft should the temperature exceed 190°F or thereabout. Both devices should be installed. Get all the details from your local Nutone dealer, electrical supplier, or write to Nutone at Madison and Red Bank Roads, Cincinnati, OH 45227 and ask for their attic fan catalog.

Too Old

What devices can be made of old TV sets? For example, can the amplifiers be used for a hi-fi set or a P.A. system? There's gotta be uses for those component circuits.

—*A. W., Danville, CA*

The trouble with old TV sets is the parts have been "baked" too long. I classify parts from old TV sets as junk. I'd throw the old TV out and find a different source for parts and circuits.

Regens a Tickler

I have a shortwave receiver that I built from a kit. It is a Radio Shack Globe Patrol. So far I have not been able to get any DX stations. I have a 70-ft. antenna that is about 35-ft. high. Any circuit that might help, would be appreciated.

—*C. G., Hannibal, MO*

That regenerative rig should pull in the SW biggies from around the world with the antenna you have. Either you are not using your regen set correctly, or you have a problem. Go back to the manual and read carefully.

You'll Laugh Yourself to Death

I get an electric "tickle" from the metal cabinet of my receiver? Is this safe?

—*J. F., Cleveland, TN*

I'd say "No," to that. But check it yourself to be absoultely sure. Use an AC voltmeter having 5000-ohms/volt or more sensitivity in the following manner: Connect a 1500-ohm, 10-watt resistor paralleled by a .15 μF disc capacitor between a known good earth ground (water pipe, conduit, etc.) and the exposed metal parts on the receiver, one at a time. Do this with the receiver plugged into an AC outlet and the receiver turned on. Measure the AC voltage across the combination 1500-ohm resistor and .15-μF capacitor. Reverse the AC plug and repeat the voltage measurements for each exposed metalic part. For receivers manufactured after January 1, 1973, the voltage must not exceed 0.75 VRMS. This corresponds to 0.5 mA AC "tickle" charge and is not excessive or dangerous. If your receiver exceeds this value, look for the fault or short. Sets built prior to 1973 may test high as 7.5 VRMS. Legally, this is okay, but by "current" standards it is unsafe.

Two Can Listen

Hank, I own my own telephone and I would like to add an additional earpiece to it like they have in Europe. This way two of us can listen and only one can talk. How do I do it?

—*J. N., Oklahoma City, OK*

Easy, just parallel a second earpiece across the line after the disconnect switch. One way to do this is to use a handset with the mic removed. Parallel the earpiece to the other handset cable at the point of entry into the telephone base. The results are great, especially on long distance calls and in noisy rooms.

Not Too Much?

What is the difference between a television antenna and a radio or a CB antenna?

—D. B., Ft. Worth, TX

Basically, antennas are all alike except for the frequency for which they are designed. For example, at 400 meters, the middle of the AM band, a quarterwave antenna would be about 390 feet long. A tower that tall is impractical, so AM is horizontally polarized, parallel to the ground. AM stations pump out lots of power, therefore the receiving antenna need not be efficient for good reception. Thus, shorter lengths of wire are okay, and ferrite core antennas can be used. CB antennas all are slightly longer than 100 inches for quarterwave operation and it's easy to mount them vertically for safety. In CB reecption and transmission, the power levels are very low so that the antenna must be tuned exactly to the narrow band for maximum efficiency. A hank of wire will not get your signal out. TV antennas are horizontally polarized, but face a different problem. At TV's high frequencies. signals bounce off buildings. hills, etc. Therefore, a simple antenna will receive all signals, prime signal and reflected ghosts. Thus, engineers added manv elements to the TV antenna to make it highly directional for best reception. What I have said is only scratching the surface. As you study antennas, you'll find that each specialized receiver requires a specially designed antenna.

Solid Ground

What is the most important part of an SWL antenna system?

—*W.M., Billings, MT*

The ground system, and I'm talking about the ground stake for good grounding and lightning protection. Too many of us are eager to climb poles, roofs, trees, whatever, to string wire, never giving a thought to a good ground that makes it all work, and safely.

Lend a Hand

If you need some help that possibly one of our readers could supply, why not write to me, Hank Scott, and I'd happily let our readers know about it. Never can tell, someone out there may be of service.

Here's this issue's list of "Help Wanted."

Δ National Radio Receiver, Model NC-88 (4-band-.55 to 40 MHz); need owner's manual, schematic diagram or any information available; Keith Kessell, 530 Hayes Ave., Hamilton, OH 45015.

Δ Hallicrafters Receiver, Model S-52; urgently needs schematic diagram and/or owner's manual; Neil Trudel, 35 Ontario Ave., Ontario, Canada P6B-1E2.

Δ Globe Champion Transmitter, Model 300; wants to purchase companion receiver and SSB units made by World Radio Labs; Joe Merkler, Rt. 5, Box 152, Sikeston, MO 63801.

Δ Wurlitzer Amplifier, Model 518, schematic diagram needed; Russell Campbell, P.O. Box 141, Thessalon, Ontario, Canada P0R-1L0.

Δ Truetone Model D-705 radio needs help to get it working; Jan Powers, 1726 Brookdale Ave., Cookeville, TN 38501.

Δ Fairchild Channel "F" Video Game, urgently needs schematic diagram; Eric Enock, 220 Pelham Rd., Apt. 1M, New Rochelle, NY 10805.

Δ Eico Oscilloscope, Model 425 and RCA Senior Voltohmyst; needs schematic diagrams and/or operator's manuals; Ken Hillis, BTC K18, Eielson, AK 99702.

Δ Johnson-Viking VFO, Model 122; need assistance in repairing unit—please write; Daniel Plett, 102 11th St., Winona Lake, IN 46590.

Δ Phenomological Systems, Inc., Model 360 Biofeedback Headset; headset in need of repair—can anyone help with information or assistance?; Ron Smyrl, M.D., 75 Manhattan Drive, Suite 2, Boulder, CO 80303.

Δ Webcor Tape Recorder, Model 2110; needs 65P103 oscillator coil or substitute; Marly Jackson, 20 Calfax Ave., Midvale, NJ 07465.

Δ Sharp Portable TV, Model TRP-801; schematic diagram and service manual; Murray Yonkofsky, 2364 Batchelder St., Brooklyn, NY 11229. ■

Junk Box Special

(Continued from page 80)

If you wired R2 correctly it should be full counterclockwise. Then set S1 to *on*. The meter should rise instantly to 5 volts DC. As R2 is adjusted clockwise the output voltage should increase to 15 VDC or slightly higher. If R2 can adjust the output voltage only over the range of approximately 12 to 15 VDC, or 12 to 15+ VDC, IC1 is defective, or has been damaged. ■

Disco King

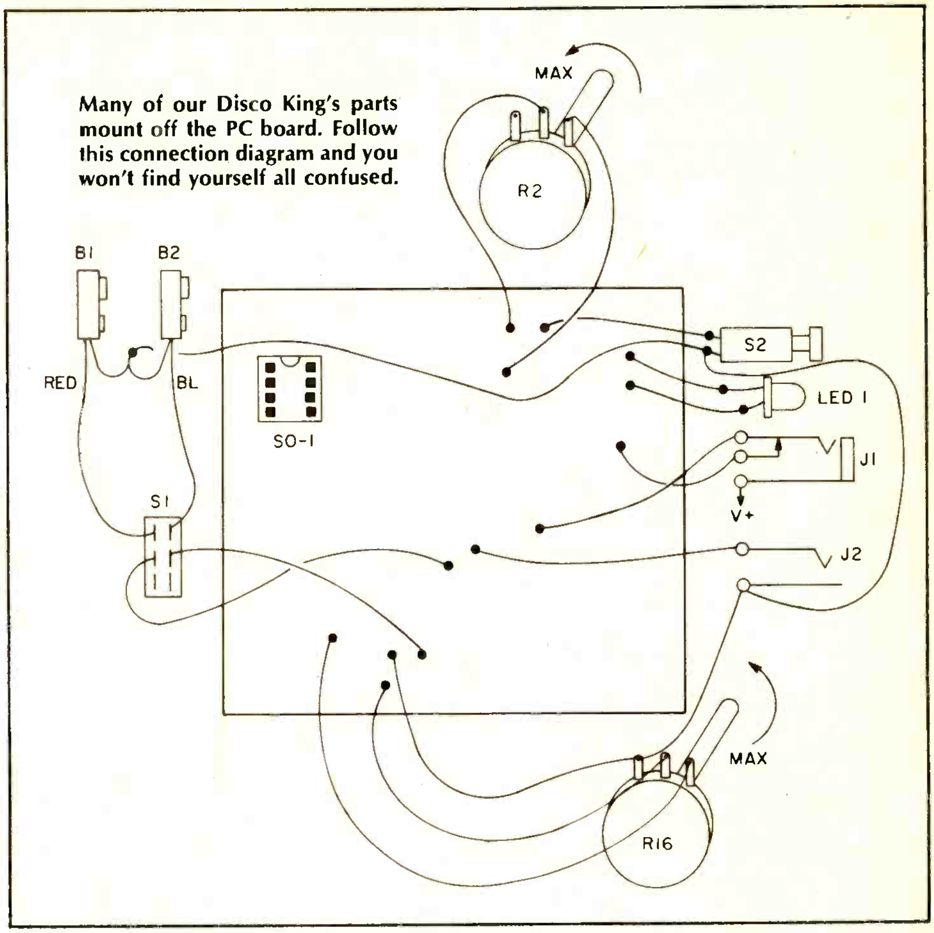
(Continued from page 21)

R2 varies the Tempo from extremely slow to very rapid and that LED 1 lights each time the base drum is heard. Depress and hold S1 and note that the sounds stop. Release S1 and note that the sounds restart with the base drum. If you plan to use the manual base drum triggering facility, you may construct a simple footswitch. Connect the footswitch to J1 (*Base Drum Trigger*) and note that the base drum sound is heard each time the footswitch is pressed.

Drum Up a Storm. Once adjustment and checkout have been completed as indicated above, operation of the unit should be clear. The most common Disco percussion pattern is obtained with the jumper connecting SO-1 pins that R16 can adjust the cymbal volume from full off to maximum. Note that 4 and 5 (note that SO-1 pins 1 through 4 are wired together). The other three pattern variations are obtained by connecting pins 1 & 8, 2 & 7 or 3 & 6. Removing the jumper disables the cymbal generator. To use the unit as an electronic base drum you can either set R16 to minimum or remove the jumper from SO-1. Always turn the unit off when not in use to prolong battery life.

You may wish to substitute a push on-push off switch for the momentary switch S1. This will allow sustained off periods without having to keep S1 depressed. You may also wish to substitute a rotary switch for the socket and jumper method of pattern selecting. A wiring diagram for this substitution is shown.

You'll find that Disco King is quite a conversation piece. All your friends will ask how you fit Ringo Starr into such a small box! ■



Many of our Disco King's parts mount off the PC board. Follow this connection diagram and you won't find yourself all confused.

Solar Swinger

(Continued from page 31)

work cloth under the wooden base to protect the soft wood from scratches and dents.

Cut a 1½" hole about ¼" deep for the tube base. The ¼" indentation will take a large pasteboard washer to bolt the tube socket into position. Finish drilling out the 1-inch hole for the tube prongs to fit comfortably inside. Depending upon the size of the tuning capacitor, lay it upon the bottom area and drill a large hole to enclose the whole body. Do not drill clear through the board but leave about ¼" at the top side for the mounting area of the tuning capacitor.

The tuning capacitor and the headphones are the only components mounted outside of the tube envelope. A small ¼" hole is drilled in the center and at the rear of the base towards the tube socket. The headphone and antenna wire will feed through this area to the tube socket pins. Cut a groove into the wood area between the capacitor and tube socket hole. The capacitor's two small connecting wires will lay flat in this groove.

If needed, sand down the top of the wooden base area with fine sandpaper. Stain, varnish or spray paint the top side. Choose a light color spray paint, such as white or yellow, to give the base and component parts a contrasting appearance. Spray on at least three coats of paint and let it dry between each coat to produce a slick, enamel appearance. Let the wood base dry overnight before mounting any parts.

Final Touchup. After the base appears dry mount the variable capacitor and connect two pieces of hookup wire from it to tie into the tube socket. Next, mount the small tube socket. Temporarily, place a piece of masking tape over the socket and wooden base plate. Lay the base upside down (over a shoebox) to wire up the remaining components. Feed the earphone cable through the rear hole and connect to terminals 4 and 6 of the tube socket. Feed a short piece of hookup wire through the same hole to serve as an external antenna connection. Solder this wire to terminal 2. Now solder the capacitor's two wires to terminals 2 and 1. Once again, check over the entire wiring procedure. Solar Swinger should be ready to roll (and rock).

Connect the antenna wire to the outside antenna—or you can try to pick up local stations with a 12-ft. piece of wire laying around the baseboard of a wall. You should be able to pick up local stations at each end of the broadcast band. If a ferrite, adjustable antenna coil is used, adjust the core until the stations are loudest at each end of the band. Turn Solar Swinger's solar cell toward the sunlight or operate under a table lamp.

After all adjustments are made, spread silicone cement over the tuning capacitor wires. Cut out a large pasteboard or plastic washer and place it

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New Shell Game

(Continued from page 74)

the output of IC4f goes high. IC3d, however, will not go low and turn off the clock until *both* it's inputs are high. When the output selected by S2 goes high, IC3d goes low and stops the clock. C4 discharges through R4 into the near ground potential of the IC3d output with a time constant set by the value of R4. When the voltage across C4 decays to 4.5V, IC4d goes low, which turns off Q1 and removes power from the LEDs.

Switch S1 reverses the stage 2 and 3 connections to provide either a straight (1-2-3-2) or zig-zag (1-3-2-3) lighting sequence. Depressing S4 forward-biases Q1, allowing display of the static contents of the shift register.

With values as specified, the *interval* time can be as long as 3 seconds, the last LED on-time of up to 0.3 seconds, and the clock speed can be varied from 1 Hz to about 40 Hz. Power, which is applied through switch S5, is supplied by a single 9 volt battery.

Construction. While any standard means of construction, such as perf-board or wire wrap, may be used, a PC board is recommended. Solder all components onto the PC board, using as little heat as is required to make a good solder joint. Observe the indicated polarity for all diodes, C3, and the ICs. Be careful when handling the CMOS ICs to prevent static damage. IC sockets may be used if desired. You can use the excess component leads to form the fourteen jumpers identified by "J" in the component layout diagram. After the PC board has been completed, interconnect the controls and switches to it as indicated. Any standard case may be used to house the project. The only restrictions are that the LEDs should be visible to both player and operator, display switch S4 acessible to the player, and all remaining controls visible only to the operator.

Use. A general description of the operation procedure is as follows:

1. Set *select* switch S2 to position 1, 2 or 3.
2. Set S1 to *zig-zag* or *straight*.
3. Adjust *speed* control R2, *odds* control R4, and *interval* control R5 as desired.
4. Press *start* switch S3. As soon as S3 is depressed, the LEDs will sequence, starting with LED1, in the pattern and at the speed selected. The sequence will continue for the interval chosen, whereupon the LED selected will remain on for the time chosen by the setting of the *odds* control.

Initially, the operator should set a slow speed, medium interval and high odds. As the player becomes more confident, the control settings should be changed in an effort to fool the player. The controls can be set so that the last LED to illuminate does not appear to come on at all. With the *odds* control set to minimum, the *speed* and *interval* controls can be set so that on-time of the last LED will be so short that (in a normally lighted room) it will not be seen. The proper settings will cause the interval to end during the low portion of the clock signal. Since this can not be determined without monitoring the internal signals, the operator must develop a "feel" for the controls to obtain the desired effect. This effect should be used sparingly lest the player catch on. Although the game should not be used for gambling, non-monetary betting (with poker chips or the like) makes the game more entertaining. ■

Solar Swinger

(Continued from page 111)

over the tube pins. Use the ¾-inch machine screw and bolt the tube socket into position. To keep the earphone wires from pulling out, apply silicone cement in the small hole. Place four rubber grommets or metal spacers on each corner for feet, and cement in place. Let the radio lay upside down until the silicone cement sets up.

The glass envelope should be mounted last and glued to the tube base with black silicone cement. Place a thin layer of rubber cement around the top, just inside the tube base. Hold the envelope in a straight upright position and set it down in the fresh cement. Now apply rubber silicone mement. Now apply rubber silicone cement to the outside of the glass and base area. Wipe off all surplus with a paper towel and make a neat joint with your fingers. Let the envelope and the base dry overnight.

Many of our Solar Swinger's parts may be found in the junk box. In fact, low priced transistors are used in the directly coupled audio circuit. If you are starting out cold and purchasing all new parts, you may pick up a 2 transistor AM radio kit from Radio-Shack (#28-214) for $6.95. Most all the parts needed for the Solar Swinger can be robbed from this kit.

Solar Swinger—a great conversation piece and a sunny savings over the high cost of batteries! ■

Cyclops

(Continued from page 95)

so that the cathode side is connected to the base of Q1. Do not proceed further until the voltage at pin 13 of IC1 is within the range of +3.5 to 4.5 volts.

Measure the voltage at pins 2, 5, 6, 7, 8, 9, 10, and 12 of IC1. This voltage should be zero. Measure the voltage at pin 8 of IC2 and IC3. This voltage should be about +12 volts. Measure the voltage at pin 1 of IC2 and IC3. This voltage should be zero.

Disconnect the power from the circuit. Very carefully insert the integrated circuits in their sockets, paying strict attention to the proper orientation for pin 1 as shown in the component layout. Pin 1 of the Optolinear IC is indicated by a red dot or "U"-shaped indentation molded into the top of the plastic case at one end.

Be sure the speaker is properly connected to the circuit between the +12 volt bus and the collector of Q5. Set S1 to the ON or closed position. Adjust the volume control about halfway and apply 12-volts of power to the circuit, observing correct polarity. You should hear the whooping sound generated by the circuit, and the LED should light. The LED should remain lit for about 30 seconds, and when it goes out, the sound should continue for a few seconds more. Once the sound stops, you can wave your hand over IC1 and cause the sound to start again. This time the circuit will reset itself after a few seconds, since IC2 is being inhibited by the timed cycle of IC3. After another 30 seconds has passed, the cycle can be repeated.

To generate the "Close Encounters" music sound, throw S1 to the OFF or open position. When you apply power to the circuit, Cyclops will generate the whooping sound for 30 seconds, and then will switch to the "Close Encounters" music for another 30 seconds as IC2 and IC3 switch on and off. This sequence will repeat indefinitely. If you wish to generate only the "Close Encounters" sound, remove IC2.

Applications. Cyclops can be used in many applications depending upon the connections between terminals A, B, C, and D of the circuit and whether or not the timing circuitry of IC2 and IC3 is included in the assembly.

For a short timing interval, such as would be needed for an automatic doorbell or light operated rifle range, the circuit shown on the right of the

(Continued on page 114)

LEDIT

(*Continued from page 82*)

better to be safe than sorry.

In thousands of parts tested I've never had a false indication except in the case of a few rare *dv/dt* turn-ons. When this happens, here's what to do: Just interrupt the power with S2 several times and see if the indicator D3 lights every time, or just part of the time. Part-time turn-on indicates a definite *dv/dt* situation. Full-time turn-on usually indicates a short. That's all there is to it! ■

TERMINAL POST			BUTTON PRESSED			LED ON			INDICATES
Anode	Cath.	Gate	None	On	Off	Red	Clear	None	
a	c	g	x					x	a-c not shorted
a	c	g		x		x			g-c short or a-c open
a	c	g	x				x		a-c short or possible dt/dv
a	c	g		x				x	g-c open
a	c	g		x		x	x		normal turn-on
a	c	g			x			x	normal turn-off
MISCONNECTIONS									
g	c	a	x				x		
g	c	a		x		x	x		
c	a	g	x					x	
c	a	g		x				x	
a	g	c	x					x	
a	g	c		x				x	
c	g	a	x					x	
c	g	a		x				x	
g	a	c	x					x	Clear LED may be on weak
g	a	c		x				x	Clear LED goes out
DIODES									
a	c		x				x		normal
a	c		x					x	open
c	a		x				x		shorted
c	a		x					x	normal

Lettering

(*Continued from page 55*)

with a brush-on spray coating. It's best to use products made for this specific purpose, which should be available from the same sources as the rub-on lettering. Ordinary lacquers, clear fingernail polish, etc., are likely to damage the lettering. Always make a test beforehand or you may end up with an ugly mess.

Here are some additional suggestions:

1) Read the instructions (if any) that accompany the lettering set.
2) If this is your first experience with rub-on lettering, practice on scrap material first to get the feel of it.
3) When applying the lettering, keep a backing sheet beneath the part of the carrier sheet that you are not using. This prevents unwanted letters from transferring and keeps the lettering clean. ■

Octavizer

(*Continued from page 44*)

force, you can play in different octaves.

When viewed on an oscilloscope, the output signal changes shape as shown in the diagram when the *blend* control is rotated. As you can see, at midsetting of the *blend* control, a step approximation to a ramp wave is generated. This signal can be fitted to produce a realistic reed-type sound.

A standard foot switch can be used for the *cancel* control. If not available, one can be made using a push on-push off SPST switch and a length of audio cord.

As you familiarize yourself with this new tool, you will find it an interesting and useful special effects device. ■

Cyclops

(Continued from page 112)

dotted line of the schematic can be deleted. S1 should be set to the ON or closed position and terminals. A and B of the printed circuit board should be connected together. For these applications, as well as using Cyclops for a musical automobile horn, you may want to slow the whooping rate for a more pleasant sound. This can be easily accomplished by changing the value of C4 to 10 microfarads or more.

The circuit can be used as an intrusion alarm with a long timing interval by building the complete circuit as shown in the schematic. Set S1 to the ON or closed position and short terminals A and B.

A combination whooping sound and "Close Encounters" music can be produced by building the entire circuit and setting S1 to the OFF or open position. Delete the timing circuit for continuous "Close Encounters" music. ■

Pulstar

(Continued from page 28)

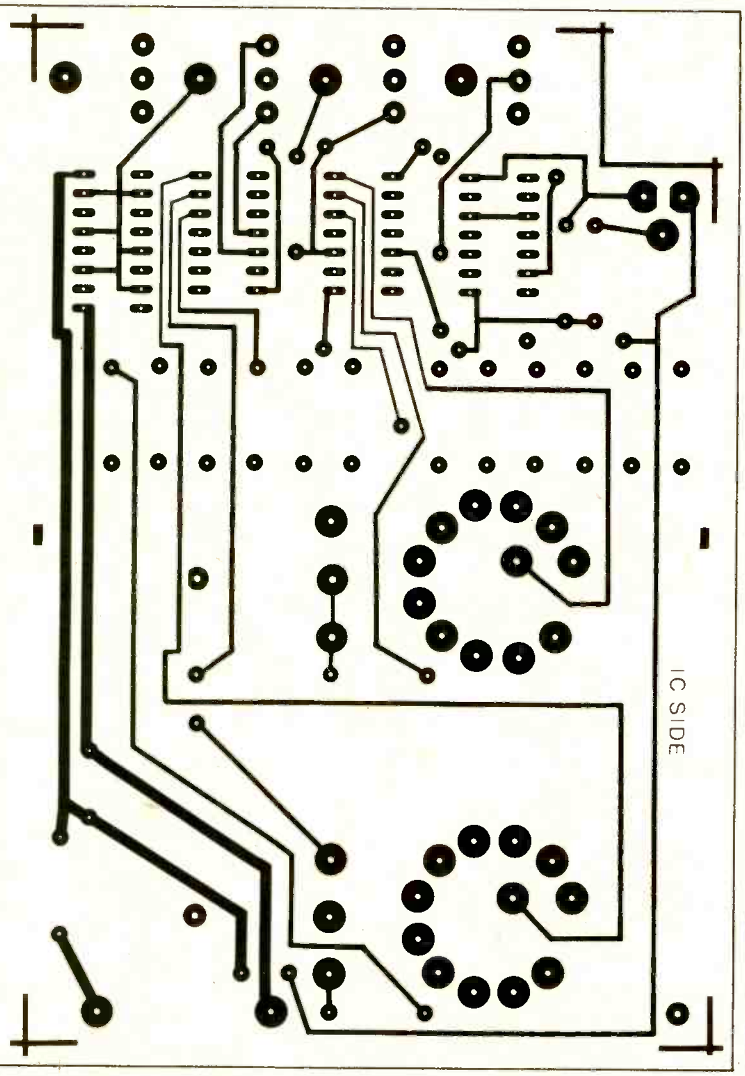
counter is used to monitor the output to determine operating frequency and pulsewidth, if accuracy is required.

The output frequency and pulsewidth will vary with applied supply voltage, mostly on the high range. On that range, the maximum operating frequency at 5-volts is about 600 kHz. At 10-volts and above, it is 1 MHz. This is due to inherent limitations of the 4047 chip.

The gating feature allows you to generate pulse bursts containing a specific number of pulses. This may be accomplished by letting a preset counter count the output pulses and letting the "carry" output of the counter trigger a one-shot. The output of the one-shot would then be used to inhibit the pulse generator by pulling GATE IN low for a specific period of time, determined by the time constant of the one-shot. By changing the preset value of the counter, pulse bursts containing a variable number of pulses may be generated. Such a set-up may be used to check out event counters, staircase generators, and envelope detection demodulators.

The one-shot feature of the pulse generator may be used to manually single-step counters, toggle flip-flops, and trigger one-shots. All in all, it's a great piece of test equipment for checking out your digitital creations. ■

As we mentioned earlier, Pulstar's PC board is a two-sided affair. Here is the etching guide for the foil which appears on the component side of the board. If you use a commercially available etching kit, make sure that you can expose the second side separately after you have etched the first side. Otherwise, you may have to etch both sides at once—no real headache if you have a clear etching tray and can observe the progress on both sides at once.



Spiderweb Receiver

(Continued from page 98)

volt battery to the receiver. Set the Bandspread Capacitor C2 to minimize capacity and the Tuning Capacitor C3 to maximum capacity. Connect a signal generator to J1 and then calibrate the dial with the generator. Adjust the AF Gain R5 and R1 as necessary for a good received signal. Make sure that the signal generator output is kept low enough to prevent overloading of the receiver. Begin with a modulated signal generator frequency of 550 kHz and mark the receiver dial accordingly. Proceed up the dial to 1600 kHz and mark the scale at convenient points. Then replace the "C" with the "B" plug-in coil and calibrate the scale from 1.7 to 5 MHz with the signal generator. Also, calibrate the "A" plug-in coil with a generator from 7 to 14 MHz. If a signal generator is not available, you can calibrate the bands with markings noted from received radio stations of known frequency. The Bandspread dial is not calibrated, but, a set of points can be marked over the range of C2 to aid in tuning the dial.

Operation. For best results a good antenna and ground are required. Also high impedance earphones (2000 ohms or more) are needed. If a DC power supply is used in place of the 6-volt battery, make sure that the supply does not have any hum in the output as this will affect the receiver sensitivity. Tune C3 for a received station, while at the same time adjusting the Regen control R1 for a whistle. If the station is AM, back off R1 until the station is received clearly. If the received station is CW, adjust R1 for a convenient "beat note." Many strong side-band stations can also be received by experimentally tuning R1 and C2 for best reception. Adjust the AF Gain control for good earphone volume. Adjust C1 for best reception for each coil. The position of the "S" tap can be experimented with (moving up or down on L1) for best regeneration over the band. Also, try several FET's as Q1 for maximum sensitivity over the higher SW frequencies. ■

LITERATURE LIBRARY

389. You can't buy a bargain unless you know about it! *Fair Radio Sales'* latest electronics surplus catalog is packed with government and commercial buys.

388. SWLs need *Gilfer's* Shortwave Mail Order Catalog for economy one-stop armchair shopping. From top-notch rigs to reporting pads, Gilfer supplies all your hobby needs.

372. *Olson* continues to amaze hobbyists with their jammed packed 48-page newspaper catalog. It's a bargain buyer's bonanza.

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

362. A new catalog crunched full of military, commercial and industrial surplus electronics for every hobbyist is offered by *B&F Industries*. 44 pages of bargains you've got to see!

366. *Poly Paks* has a special section on solar powered products in their latest catalogue. As a special bonus, they are offering free of charge either two $1.29 items or one $2.49 item with any $20 shipment.

384. *B&K-Precision's* latest general line catalog lists instruments locally stocked at distributors throughout North America. Standard and new products are featured.

310. *NCE (Newman Computer Exchange)* has just issued their Spring/Summer 1979 "Mini-Micro" catalog, and it's full of hard-to-find equipment. Money-saving offers are listed on such items as all Data General and LSI-11 equipment.

322. A new 20-page, full-color TRS-80 Microcomputer Catalog has just been issued by *Radio Shack*. The catalog includes complete, current information on the TRS-80 Microcomputer, its peripherals and accessories with plain-language descriptions.

386. If you're lookng for books on computers, calculators, and games, then get *BITS, Inc* catalog. It includes novel items.

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

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

345. For CBers from *Hy-Gain Electronics Corp.* there is a 50-page, 4-color catalog (base, mobile and marine transceivers, antennas, and accessories). Colorful literature illustrating two models of monitor-scanners is also available.

393. A brand new 60-page catalog listing *Simpson Electric Company's* complete line of stock analog and digital panel meters, meter relays, controllers and test instruments has just come out. Other new products are listed also.

385. Amateur Radio buffs and beginners will want the latest *Ham Radio Communications Bookstore* catalog. It's packed with items for the Ham.

373. 48-page "Electronic Things and Ideas Book" from *ETCO* has the gadgets and goodies not found in stores and elsewhere.

382. Buys by the dozens in *Long's Electronics* super "Ham Radio Buyer's Guide." Good reading if you're in the market for a complete station or spare fuses.

383. If you're a radio communicator, either ham, SWL, scanner buff or CBer, you'll want a copy of *Harrison Radio's* "Communications Catalog 1979." Just what the shack book shelf needs.

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

301. Get into the swing of microcomputer and microprocessor technology with *CREI's* new Program 680. New 56 page catalog describes all programs of electronics advancement.

302. Giant savings are what *Burstein Applebee* has in store in their latest mail order catalog. Everything from CB test equipment to name brand audio wares are advertised. Telephone accessories and pocket calculators too!

305. A new 4-page directional beam CB antenna brochure is available from *Shakespeare*. Gives complete specs and polarization radiation patterns for their new fiberglass directional antennas.

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

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.

306. *Antenna Specialists* has a new 32-page CB and monitor antenna catalog, a new amateur antenna catalog, and a complete accessory catalog.

307. *Atlas* calls their 210X and 215X the perfect amateur mobile rigs. Their 6-page, full-color detailed spec sheet tells all. Yours for the asking.

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

392. The opening of the new Software of the Month Club has been announced by *Creative Discount Software*, which is giving out membership enrollment applications now. The Club plans to have separate branches for users of the Apple II, TRS-80, Ohio Scientific, Exity, Pet and CP/M based systems.

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.

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

390. *Whitehouse & Co.*, your "hard to find parts specialist," offers over a dozen parts and kits in their latest catalogue, featuring an entire section on gunnplexers for Amaeur Radio buffs.

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.

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.

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.

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*.

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

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

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

391. A new software products catalog for the Apple II Computer has just been issued by *Charles Mann & Associates*. The booklet contains business accounting, accounts receivable, inventory, BASIC teaching and other special purpose business applications.

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

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.

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.

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Alternator Tester

(Continued from page 87)

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. ■

Checkerboard

(Continued from page 66)

less breadboard, or placed in contact with the bare wire groups. You can test as you go by using a slide, toggle or rocker switch at S1, or push-to-test with a momentary switch.

Checking Diodes. A properly operating diode will conduct in one direction only, and will not conduct when the leads are reversed. So you can check a diode with just two passes on Checker Board. If it lights the LED no matter which way it's connected, your diode has an internal sort. If it won't light the LED no matter which way it's connected, it's opened up. If it lights the LED only when connected, then you can identify the anode end (the triangular arrowhead on schematic representations) as being connected to the red alligator clip (at the junction of R1, C1 and the base of Q1). The cathode (bar) end is then connected to the black alligator clip (ground).

Checking LEDs. You can follow the instructions for checking diodes to check LEDs, but that's the hard way. The LED you test will light up, too, assuming it's good, when you test it on Checker Board. Make sure you get the polarity right. You can also trace 7-segment and multiple-digit LED displays to see which pin does what.

Checking Electrolytics. The thing that most often goes wrong with electrolytic capacitors is that they short out. And that's the easiest thing to spot with Checker Board. Connect the + lead to the red alligator clip and the – lead to the black, or plug the electrolytic right into the solderless breadboard. This test will be more fun with the momentary switch. Push it and watch the LED. You should see a bright flash that decays into darkness. The bigger the electrolytic, the longer the flash lasts. A shorted electrolytic won't go out—an open one won't flash.

Checking Crystals. Connect the two crystal leads to the alligator clips. If the LED lights brightly, the crystal is good. If it lights dimly, the crystal is good but will not work in all kinds of oscillator circuits. If the LED does not tal is bad. But it *may* means that the light at all, it probably means the crys- crystal is one of the few, obscure types that cannot make Q1 oscillate in the Checker Board circuit. Most crystals, if good, will light the LED brightly.

Checking Switches. With Checker Board connected to any pair of switch contacts, the LED will light whenever there is continuity between the contacts. When there is no continuity, it will not light. With this information, a sheet of paper and a pencil, you can methodically analyze when continuity occurs with each change of setting of an unknown switch. This can tell you what kind of a switch it is. And, of course, when you know what kind of a switch you have, Checker Board can tell you whether or not it's working properly.

Checking Continuity. A closed circuit will light the LED, an open circuit won't. (We're speaking of DC continuity here). With this in mind, you can check cables, connectors, printed circuit paths, relays, light bulbs and many other devices. As long as the testing-path resistance doesn't get too high (just how high is too high depends on your particular LED and what shape your battery is in), anything that needs to maintain continuity in order to work (or discontinuity, in case you're looking for shorts) can be checked on the Checker Board.

Checking Out Checker Board. Yes, Checker Board even checks itself out. Just clip the two alligator clips together. If everything is working, the LED will light up! ■