1967

POPULAR ELECTRONICS

ELECTRONIC EXPERIMENTER'S HANDBOOK

SPRING EDITION

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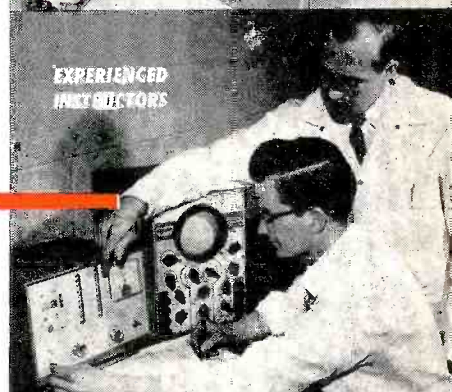

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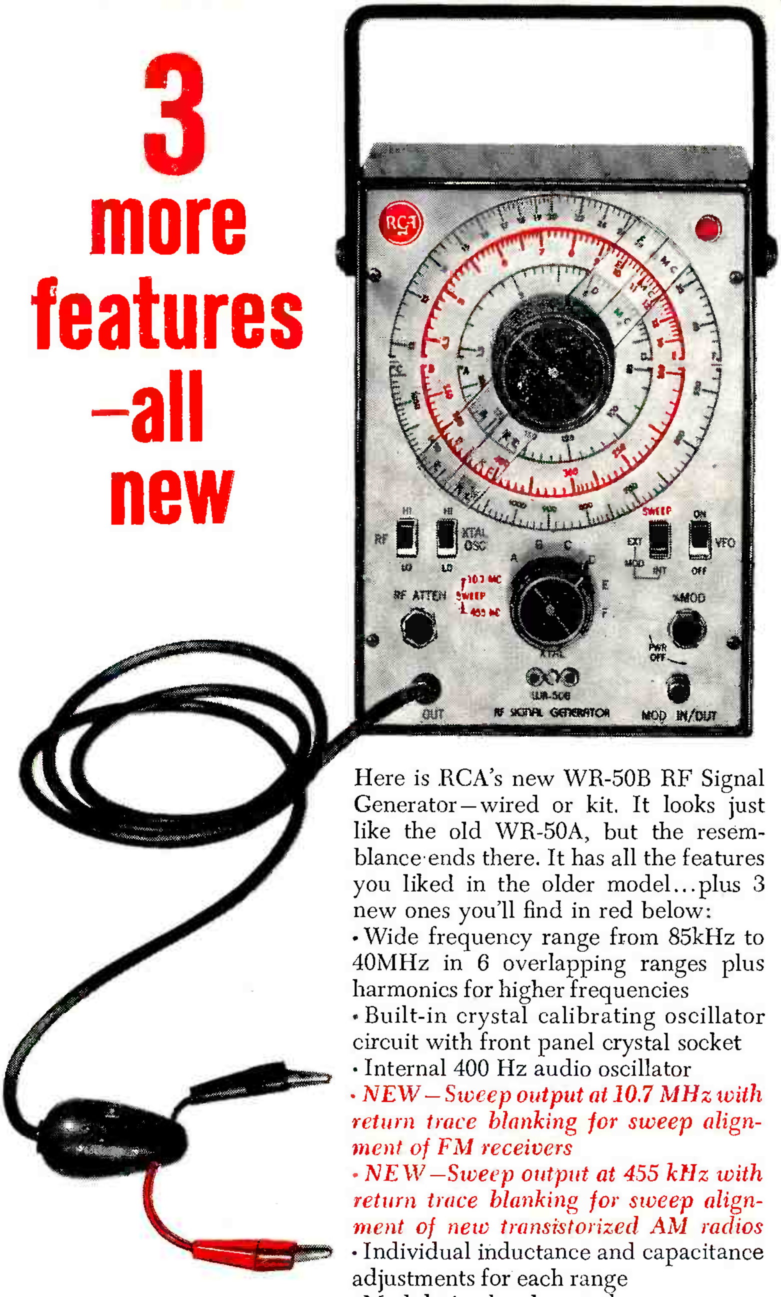

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SPRING EDITION 1967 POPULAR ELECTRONICS ELECTRONIC EXPERIMENTER'S HANDBOOK

AS I STARTED TO WRITE THIS INTRODUCTORY NOTE TO THE 13TH EDITION OF OUR SEMI-ANNUAL **ELECTRONIC EXPERIMENTER'S HANDBOOK**, IT OCCURRED TO ME THAT THESE HANDBOOKS ARE A "BARGAIN" FOR THE ELECTRONICS HOBBYIST. THE AVERAGE COST TO THE READER PER SET OF PROJECT PLANS IS LESS THAN FOUR CENTS—WHO SAYS THAT COSTS ARE RISING? WHILE SPEAKING ABOUT MONEY, IT MAY BE OF INTEREST TO SOME READERS TO LEARN THAT ALL OF THE CONSTRUCTION PROJECTS APPEARING IN THIS HANDBOOK WERE PREPARED BY FREE-LANCE AUTHORS, DESIGNERS, ENGINEERS, AND TECHNICIANS WORKING IN COOPERATION WITH THE EDITORIAL STAFF. THE AUTHORS RECEIVE A LIBERAL COMPENSATION FOR THEIR WORK—WHICH IN THIS ISSUE TOTALS ABOUT $7400.00. FROM THIS INVESTMENT IN PRIME CONSTRUCTION PROJECTS, YOU CAN FIND ANOTHER REASON FOR CONTINUING TO BUY AND ENJOY THE TWICE-YEARLY EDITIONS OF THE OFTEN IMITATED—BUT NEVER DUPLICATED—**ELECTRONIC EXPERIMENTER'S HANDBOOK.**

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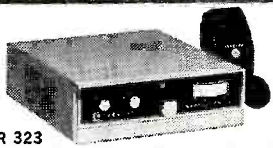

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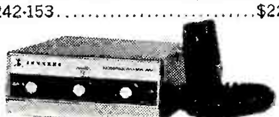

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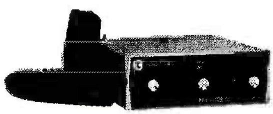

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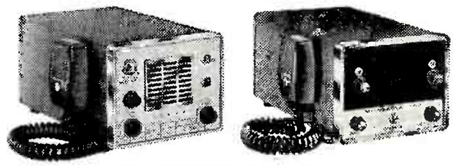

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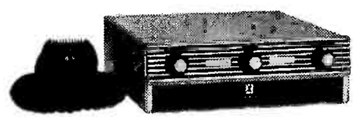

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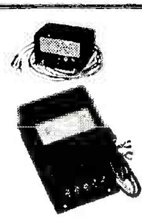

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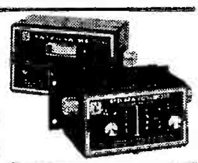

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CHAPTER

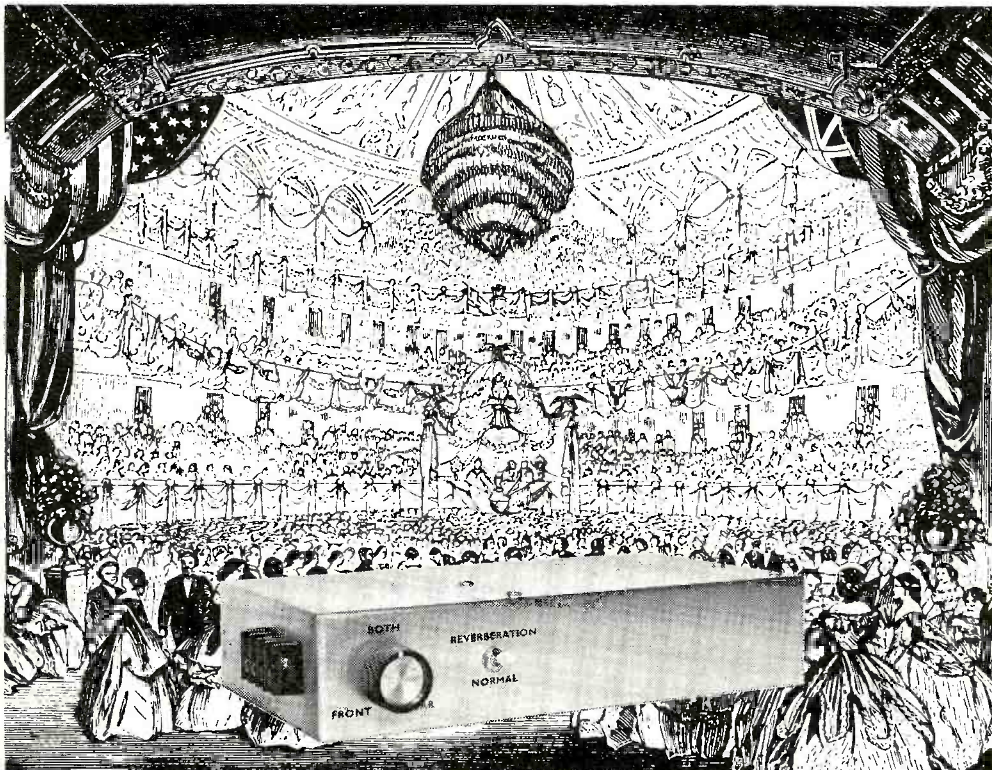
1

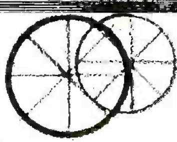
USEFUL PROJECTS

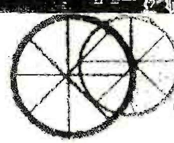
To provide a desirable "mix" of projects for this chapter of the ELECTRONIC EXPERIMENTER'S HANDBOOK, your editors screened 70 eligible articles and settled on the 10 projects listed below. All of these projects have been carefully double-checked by the individual authors and the editorial staff. You can build any one of them with complete assurance that if you follow the instructions the project will work "first time out."

Due to the continued interest in automotive electronics, four of the articles in this chapter pertain to improving the operation of your car, or increasing your driving enjoyment on long trips. The reverberation article (page 8) is a very desirable construction project—one that has been satisfactorily duplicated by hundreds of electronics hobbyists. The "Auto-Light Minder" (page 41) is another favorite and needs to work only once to repay its construction cost.

Two different theft alarm systems are described—one essentially for home or travel (page 44) and one for business or office (page 13). The time-signal receiver (page 19) is a project that was developed for POPULAR ELECTRONICS and is now in use in many laboratories and offices, as well as ham shacks and workshops.







By DANIEL MEYER

Reverb for your car

Concert hall on wheels

HAVE you ever noticed the difference between the sound of music indoors and the sound of music out in the open air? This difference is due to the presence and absence, respectively, of reverberation. In an enclosed space, we hear the direct sounds from the performing instruments, and the sounds that are reflected from the walls, ceiling, floor, furniture, and other surfaces.

These reflected sounds reach our ears later and slightly weaker than the direct sound because they have traveled a greater distance. The larger the room, the greater the reverb time, and the greater the decay. If the direct sound is loud enough, it will usually cause more than one reflection . . . each subsequent reflection arriving with greater delay and greater decay.

Reverberation time, as small as it might be, is quite critical. If it is too long, there is a severe echo effect, and if it is too short, the music will sound flat and lifeless, as it would normally sound in a very small room. So important is this reverb time that some concert halls have added electronic reverberation to optimize the natural reverberation characteristics of the auditorium.

For less than $20 plus a little time, you can assemble the reverberation setup to be described here for your car radio or your hi-fi set at home. With it, you will be able to electronically enlarge your listening area to concert-hall proportions.

How It Works. A patented Hammond organ reverberation unit, an electromechanical device, is used to delay and decay a portion of the sound. A transducer at one end of the reverberation unit acts like a speaker. It picks up the audio signal from the output transformer in a car radio, converts this electrical energy into mechanical energy, and "excites" a couple of sets of springs which are attached to it. (See Fig. 1.)

The signal, now in mechanical form, travels along the springs and energizes an output transducer attached to the other end of the springs. The output transducer acts like a microphone and reconverts the mechanical energy back into electrical energy. It takes approximately 25 milliseconds for the sound to travel down the springs, but not all of the signal gets past the output transducer the first time. Some of the signal "bounces" back and forth from transducer to transducer, through the springs, one or more times. (This feature is purposely designed into the springs to simulate multiple reflections in a room). The delay line has approximately 40 to 50 db insertion loss and so the reverb signal must be amplified to bring its output signal level back up to the original input level.

Almost any audio amplifier could be used to beef up the output of the reverberation unit and feed the signal to the rear-seat speaker in a car, or to a second speaker in the home. But you can build the amplifier shown here and mount it and the reverb unit in a 5" x 9½" x 2" case.

In the transformerless amplifier in Fig. 2, the signal from the reverberation unit is applied between the base of *Q1* and the sliding contact on potentiometer *R4*, which acts as a stabilizing emitter resistor and level control. This unbypassed resistance introduces degenerative feedback to reduce distortion. Distortion is less than 1% at 3 watts output.

The amplified signal from the collector of *Q1* is capacitively coupled to the base of *Q2*. Transistor *Q2* amplifies the signal and feeds it to the complementary driver transistors (*Q3* and *Q4*). Transistor *Q3* conducts on positive half cycles, and *Q4* conducts on negative half cycles, and drives output transistors *Q5* and *Q6* in a push-pull manner. The voltage drop across *D1* and *D2* forward-biases the driver transistors slightly to prevent

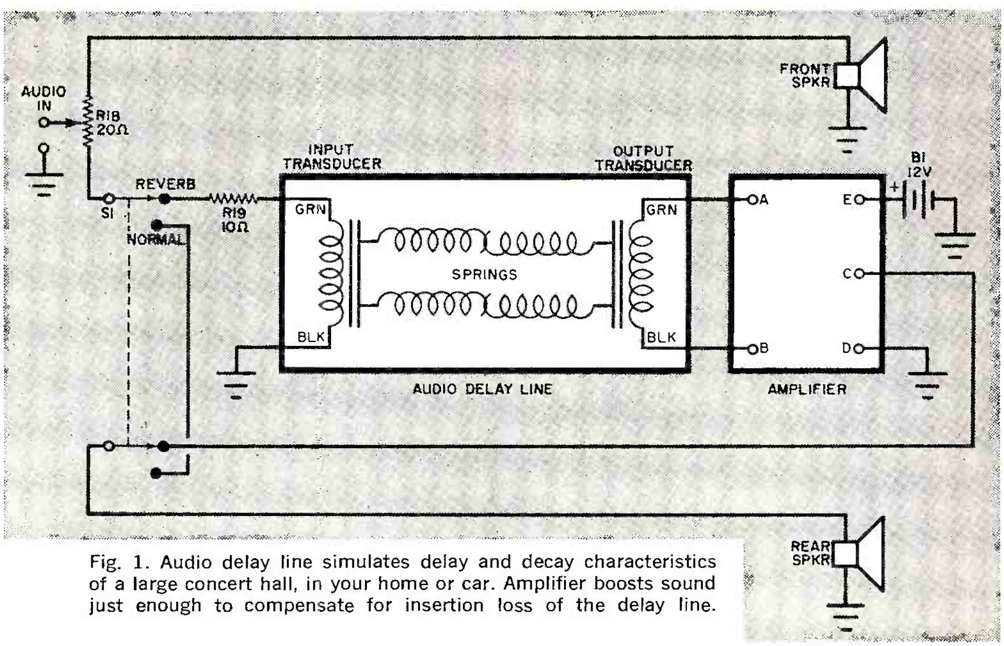


Fig. 1. Audio delay line simulates delay and decay characteristics of a large concert hall, in your home or car. Amplifier boosts sound just enough to compensate for insertion loss of the delay line.

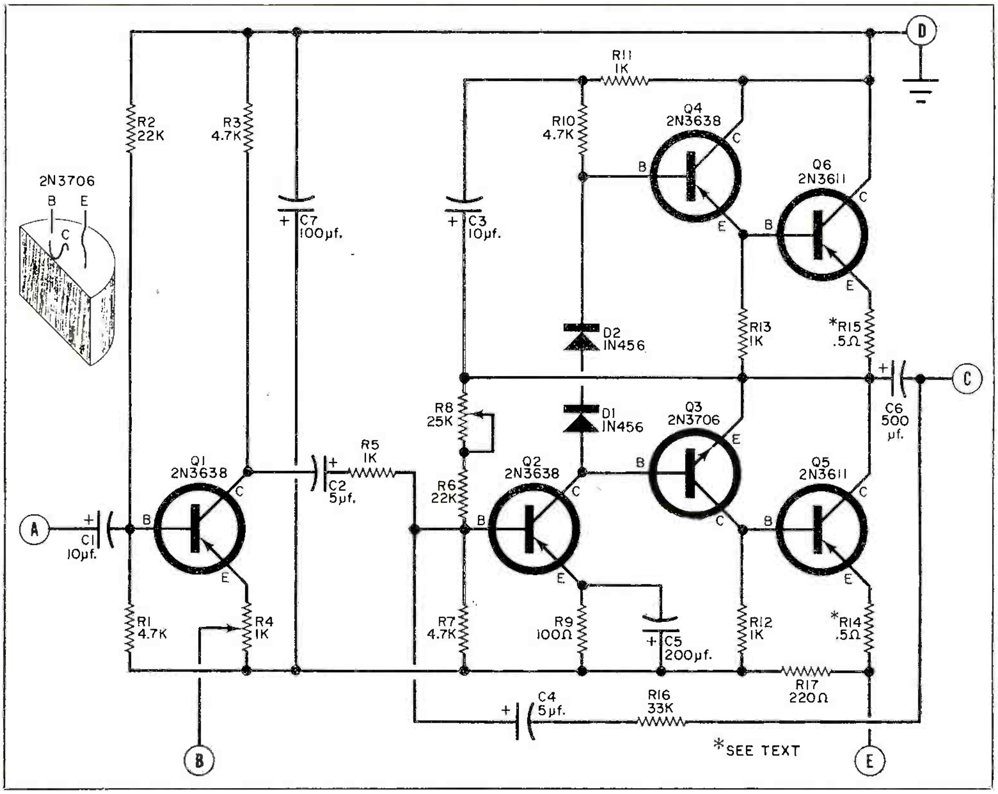


Fig. 2. Signal from the delay line is applied to points A and B, then amplified and fed out to a speaker connected to C and D. Level control R4 is adjusted to obtain equal levels of direct and indirect signals. Amplifier distortion is less than 1% at 3 watts output. Class B operation accounts for high efficiency.

crossover distortion. The diodes also provide temperature compensation.

When reverb is desired, *S1* switches in the second speaker and the fader control (*R18*) controls the percentage or mix of direct and "reflected" sound. When *S1* is in the normal position, the fader control feeds more or less direct signal to either speaker as desired.

Silicon transistors in all but the output stages make the amplifier temperature-stable. The specified output transistors should be used if at all possible; they are inexpensive and have superior leakage and frequency response characteristics.

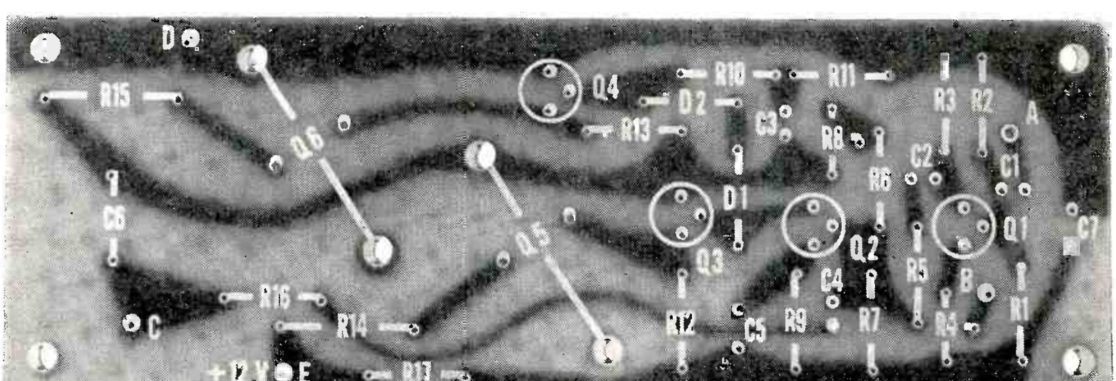


Fig. 3. Non-conductive paint is used on component side of printed circuit board to show location of parts.

PARTS LIST

C1, C3—10-μf., 15-volt electrolytic capacitor
C2, C4—5-μf., 15-volt electrolytic capacitor
C5—200-μf., 6-volt electrolytic capacitor
C6—500-μf., 25-volt electrolytic capacitor
C7—100-μf., 15-volt electrolytic capacitor
C8, C9—1000-μf., 25-volt electrolytic capacitor
D1, D2—1N456 silicon diode
D3, D4—1N1692 diode (50 volts PIV, or better)
Q1, Q2, Q4—2N3638 transistor
Q3—2N3706 transistor
Q5, Q6—2N3611 transistor
R1, R3, R7, R10—4700-ohm, ½-watt resistor
R2, R6—22,000-ohm, ½-watt resistor
R4—1000-ohm printed circuit board type trimmer resistor
R5, R11, R12, R13—1000-ohm, ½-watt resistor
R8—25,000-ohm, printed circuit board type trimmer resistor
R9—100-ohm, ½-watt resistor
R14, R15—½-ohm, ½-watt resistor—see text
R16—33,000-ohm, ½-watt resistor
R17—220-ohm resistor
R18—20-ohm potentiometer
R19—10-ohm, ½-watt resistor
R20—10-ohm, 5-watt resistor
S1—D.p.d.t. switch
T1—Low-voltage rectifier transformer; 117-volt primary, 20-volt secondary with CT (Allied 64 U 733, or equivalent)
*1—Reverberation unit; 8 ohms input, 2000 ohms output (Gibbs Type 5G)**
*1—Printed circuit board, or other suitable wiring board**
1—5" x 9½" x 2" aluminum case (Bud AC-403 or equivalent)
Misc.—Terminal strip, ½" standoffs, nuts, bolts, wire, solder, etc.

*The following parts can be purchased from DEMCO, Box 16297, San Antonio, Texas 78216: reverberation unit, $7; epoxy fiberglass printed circuit board, $2.50; kit, including reverberation unit, printed circuit board and all components for amplifier, except case and external a.c. power supply, $15.00.

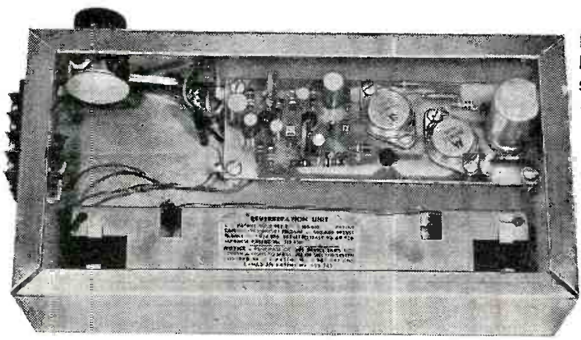
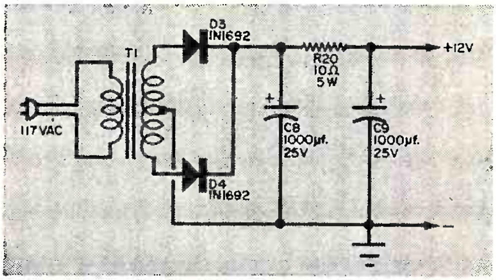


Fig. 4. Bottom view. Reverberation unit (audio delay line) is shock-mounted and hangs from four small springs when the chassis is top side up. Chassis can be mounted under dashboard near the driver.

Fig. 5. For use in the home, a 12-volt power source is needed. If it is not available from existing equipment, you can build this full-wave power supply.



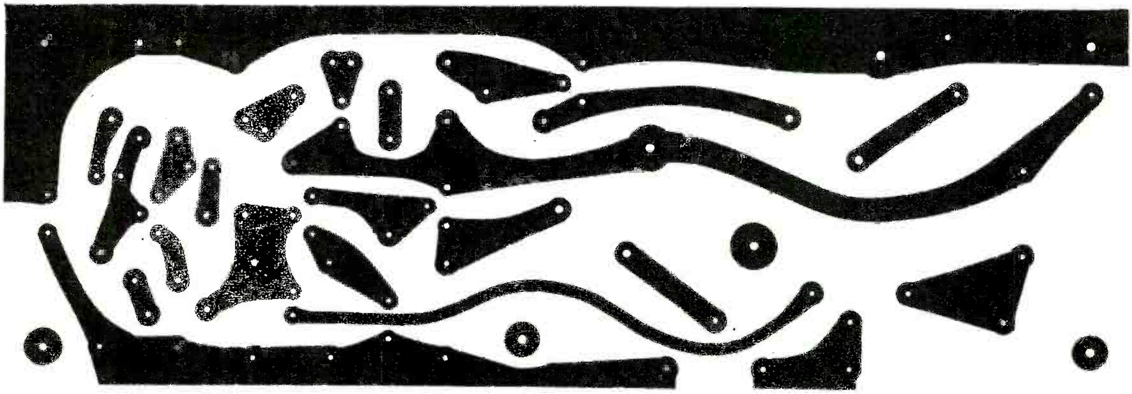


Fig. 6. Foil side of board is shown actual size to help you make your own; however, wiring isn't critical.

Since the power amplifier operates class B, standby or low-level operation causes little power drain. Only at full output is the maximum 0.5 to 1.0 ampere of current required. For use in installations other than in cars, the a.c. supply shown in Fig. 3 can be used to power the amplifier. It is best to build the power supply in a separate case to avoid hum pickup.

Construction. To simplify matters, a printed circuit board is used for the amplifier, as shown in Fig. 6. It is shown actual size in case you decide to make your own.

Note the lead arrangement for *Q3* (the 2N3706). If bent properly and installed as shown, the flat side of the case will face resistor *R12*. If you cannot locate any proper size 0.5-ohm resistors for *R14* and *R15*, you can make them by winding 15 inches of #36 magnet wire on a resistor body and soldering the ends of the wire to the resistor leads; use at least a 1000-ohm resistor.

The delay line assembly must be shock-mounted to prevent car movements and road bumps from activating the springs. To do this, suspend the reverberation unit from the top of the case with four springs, one in each corner. Allow sufficient clearance between the unit and the case to prevent contact even when you hit the brakes hard.

To mount the springs, drill two small (#60) holes about ⅛″ apart for each spring. Start from the inside of the chassis and thread the end of the spring through one of the holes, and then back through the other hole into the case. Do not shorten the leads from the reverberation unit; they must be long enough to allow free movement.

Mount the unit in the case, the open side facing in, as shown in Fig. 4. Dress all the leads from the unit to extend past the output end. The output end of the delay line is the end with the shielded transducer.

Installation. In automotive installations, the fader control and switch can be mounted on a separate panel and located within easy reach of the driver. The leads can then be run to the reverberation amplifier, which can be mounted in the trunk or other convenient place.

Disconnect the speaker from the car radio's output transformer and connect it to the fader control. Then install a rear-seat speaker and connect it to the fader control. This will allow you to select either direct output to both front and rear speakers, or direct output to the front speaker and reverberation output to the rear speaker. Of course, if your car is already equipped with a fader control and a front and rear speaker setup, you're that much ahead of the game—all you need add is the d.p.d.t. switch (*S1*).

To adjust the amplifier for proper operation, connect it to a 12-volt power supply. It's a good idea to install a 1-ampere fuse in the + lead. Measure the voltage at the collector of *Q5* (it can normally range from 4 to 8 volts) and adjust trimmer resistor *R8* to obtain a 6-volt reading. The purpose of this adjustment is to obtain symmetrical operation.

After you install the amplifier, tune in your favorite program—and enjoy your concert hall on wheels.

Using the Reverb At Home. The reverberation amplifier can be used on a stereo system in your home by feeding a combined signal to the input transducer. Only one reverberation system is needed since there is no such thing as stereo separation in reflected sounds.

The combined signal can be obtained by connecting 22- to 47-ohm, 1-watt resistors from the signal lead of each speaker to the input of the reverb unit. Start with 47-ohm resistors and reduce the value if the volume output is insufficient. But *do NOT* use the fader (*R18*) or the load resistor (*R19*) in your home installation—drive the reverb directly from the combined signal takeoff point.

A wide-range speaker is not required on the reverb channel since the frequency response of the reverb channel is about 100 to 5000 hertz. The amplifier in the diagram will put out more power (to a 4-ohm speaker) if the input voltage is raised from 12 to 18 volts. The output would then be about 6 watts.

The author is working on the design of a new reverb unit using one of the miniature (?) delay line assemblies, a project scheduled for spring publication in POPULAR ELECTRONICS. -30-

BUILD THE

ULTRASONIC OMNI-ALARM

Fail-safe protection...
silent sound beam
triggers alarm when disturbed

By DANIEL MEYER

YOU CAN'T hear it; you can't see it; you can't feel it; you can't smell it; and you can't taste it; but you can make it work for you. It really isn't mysterious; it just seems that way. What is "it"? The beam in the Ultrasonic Omni-Alarm, an all-purpose, all-sensing, always-ready alarm system. The system can be used as an intruder alarm, fire alarm, or as a counter or controller in an industrial process or production line. It can also be employed to demonstrate the use of ultrasonic sound, and should make a good science project.

The alarm consists of a transmitter that broadcasts an inaudible ultrasonic beam of "sound" and a receiver on the same chassis that detects this "sound." The "sound" is a 25-kc. note, which is about 10 kc. above most people's hearing range. In many respects the system is similar to the common light source and photocell alarm system, but with several important advantages. The ultrasonic beam cannot be "fooled" with a flashlight, nor is it affected by sunlight. Ultrasonics works equally well in pitch darkness and in broad daylight.

Two transducers, one from the trans-

PARTS LIST

*C1, C5—100-µf., 15-volt electrolytic capacitor**
*C2—30-µf., 15-volt electrolytic capacitor**
*C3, C7, C9, C11—0.05-µf., 50-volt ceramic disc capacitor**
*C4—0.003-µf., 5% polystyrene capacitor**
*C6, C8, C10—0.01-µf., 50-volt ceramic disc capacitor**
*C12, C13, C14—5-µf., 15-volt electrolytic capacitor**
*D1, D2—1N34 germanium diode (or equivalent)**
*D3, D4—50-volt PIV, 750-ma. silicon rectifier**
I1—Neon pilot light with built-in resistor
*K1—Printed-circuit-type d.p.d.t. relay (Price Electric 206-14P or equivalent)**
K2, K3—Relay—see text
*L1—15- to 25-mh., variable inductor with 10% tap (DEMCO 3E-027-1)**
M1—0-15 volt d.c. voltmeter (Lafayette 99 G 5047 or equivalent)
*Q1, Q6—2N3706 transistor (Texas Instruments, or equivalent)**
*Q2, Q3, Q4, Q5—2N3708 transistor (Texas Instruments, or equivalent)**
*R1, R4, R6—470-ohm, ½-watt resistor**
*R2—47,000-ohm, ½-watt resistor**
*R3, R19—4700-ohm, ½-watt resistor**
*R5, R18—1000-ohm, ½-watt resistor**
*R7, R11, R15—100,000-ohm, ½-watt resistor**
*R8, R16—10,000-ohm, ½-watt resistor**
*R9, R13—27,000-ohm, ½-watt resistor**
*R10, R14—2200-ohm, ½-watt resistor**
*R12—10,000-ohm trimmer resistor (CTS X-201 or equivalent)**
*R17—15,000-ohm, ½-watt resistor**
R20—Resistor—see text
S1, S2—Miniature s.p.s.t. toggle switch
SO1—2-prong socket (optional)
T1—Low-voltage transformer: 110- to 120-volt primary; 20-volt CT secondary (Stancor TP-2 or equivalent)
1—Chassis (Bud CU-465 or equivalent)
*1—Circuit board (DEMCO #128)**
*2—25-kc. ultrasonic transducers (DEMCO E-25)**
Misc.—Wire, solder, nuts, bolts, connectors, spacers, etc.

NOTE: Most of the parts listed above are standard and should be available from your local dealer. If you have any difficulty in obtaining them, you can contact DEMCO, Box 16297, San Antonio, Texas 78216 for the following: a kit of all the parts marked with an asterisk for $20; an etched and drilled fiberglass circuit board like that shown in the photo for $3.50; any of the parts used—price list available from DEMCO on request.

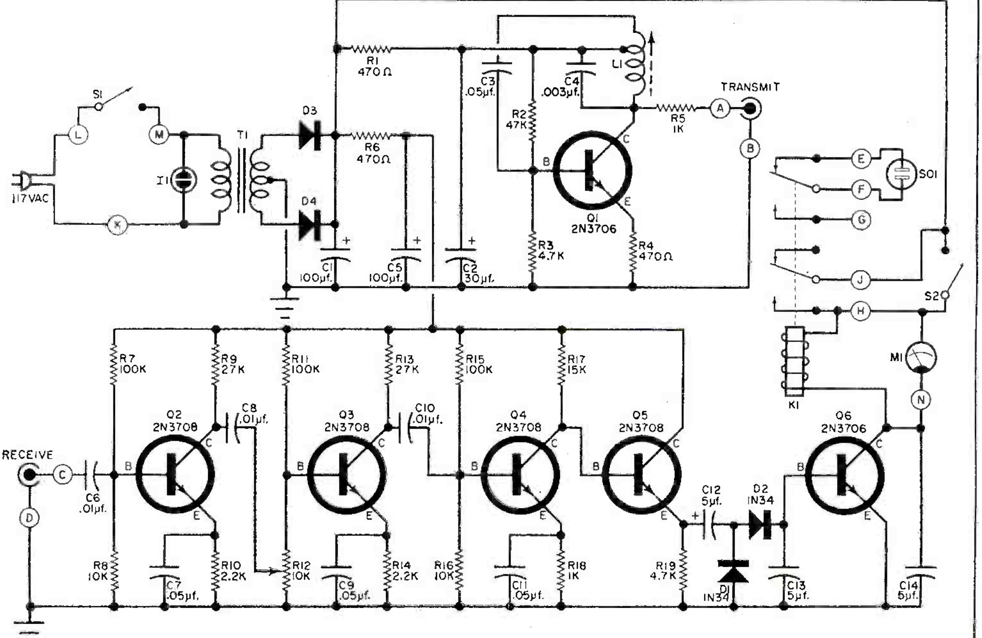


Fig. 1. One-transistor oscillator, Q1, generates an ultrasonic signal which is beamed through the air and back to the receiver, Q2 to Q6. Alarm sounds when beam is interrupted.

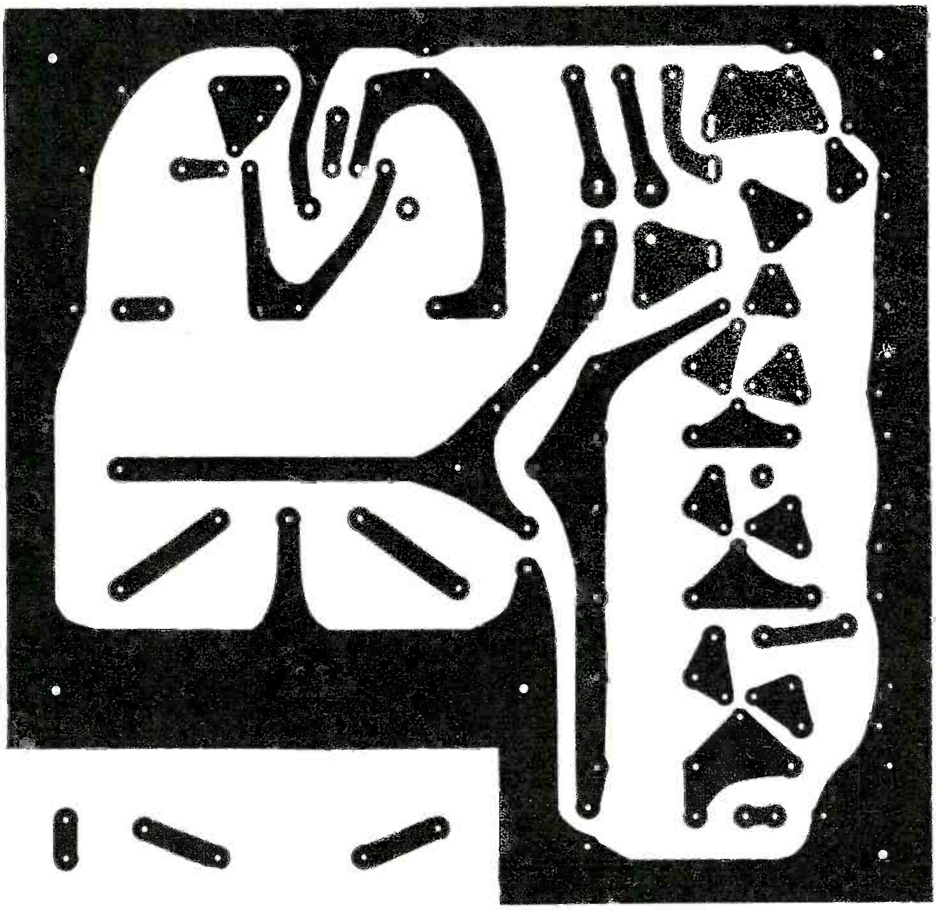


Fig. 2. Actual size photo of conductor side of printed circuit board. Components can be mounted on any type of chassis, but care should be exercised to prevent stray leakage, or coupling.

mitter and one from the receiver, can be placed up to 50 feet apart to protect a large area. Any interruption of the beam causes an alarm. Even a fire in the area between the transducers can create enough air turbulence to set off the system.

How It Works. The transmitter portion is nothing more than a single transistor oscillator circuit (*Q1*) which directly drives the output transducer connected to terminals *A* and *B* (Fig. 1). Coil *L1* and capacitor *C4* make up a resonant tank tuned to 25 kc. Feedback from the coil to the base of *Q1* through *C3* helps sustain the oscillations. Resistor *R5* isolates the transducer from the tuned circuit and prevents variations in the transducer and its cable capacitance from affecting oscillator operation too much.

The receiver, consisting of transistor circuits *Q2* through *Q6*, picks up the signal from the input transducer, amplifies it, and energizes relay *K1*. Transistors *Q3*, and *Q4* are conventional common emitter amplifier stages. Potentiometer *R12* acts as a level and sensitivity control. Transistor *Q5* is used as an emitter follower and provides the low output impedance needed to drive the half-wave voltage-doubler rectifier consisting of *D1*, *D2*, *C12* and *C13*. The resulting d.c. voltage is used to turn *Q6* "on." Transistor *Q6* drives the alarm relay.

The circuit is arranged so that the relay is held in at all times when there is a signal present. A drop or absence of signal causes the relay to open, and the

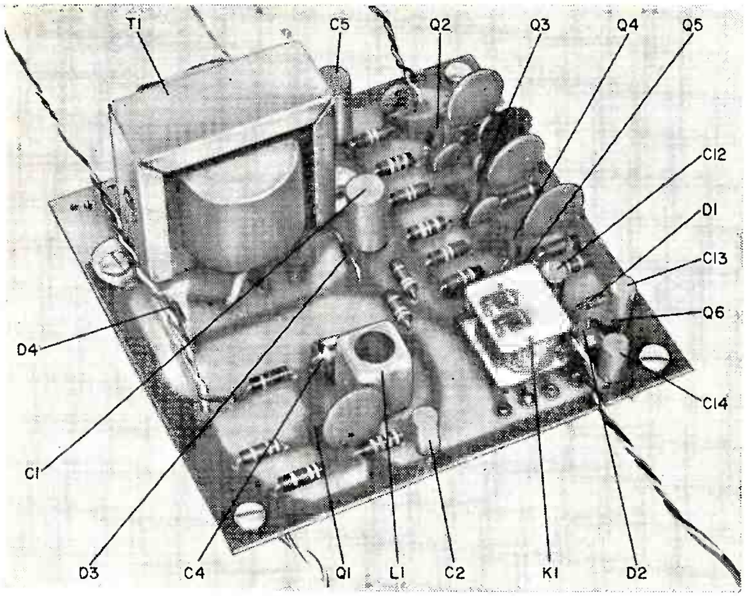


Fig. 3. No attempt at conserving space is made. Relatively large open areas reduce undesirable coupling between transmitter and receiver. Component location on the board is easy to determine, but the callouts sprinkled around the photo may give you more confidence as you drop in each part. Be sure to observe polarity of diodes and electrolytics.

alarm to sound, or a counter to operate, etc. This is a type of "fail safe" operation, in that a defect in the system, power failure, transducer failure, circuit failure, etc., will cause the alarm to sound. The circuit is compromised if the same power source is used to activate the external alarm. However, this condition can be easily remedied, as described in the installation instructions.

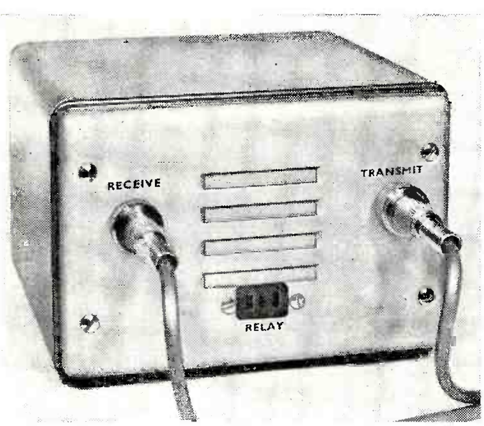


Fig. 4. By locating the receiver and transmitter output and input connectors on the rear cover, the entire package takes on a clean professional look.

Switch $S2$ must be placed in the *Reset* position (closed) before the system will operate. With the switch in this position, the relay will kick in and out every time the sound beam is on and then broken. For counting or other activities requiring self-resetting, the switch should be left in the *Reset* position. But for alarm purposes, the switch should be placed in the *Reset* position only long enough for the relay to kick in.

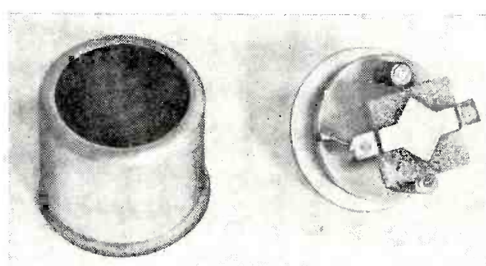


Fig. 5. If vibration of hardware in the transmitting transducer creates an audible sound, carefully open case and insert small piece of foam plastic.

Once the relay is "on," move the switch to the *Operate* position; relay contacts *J* and *H* will continue to complete the relay circuit and hold the relay "on" until the beam is interrupted. When the beam is broken, the relay opens. The relay will not close even if the beam is restored, and the alarm will sound continuously until the switch is manually

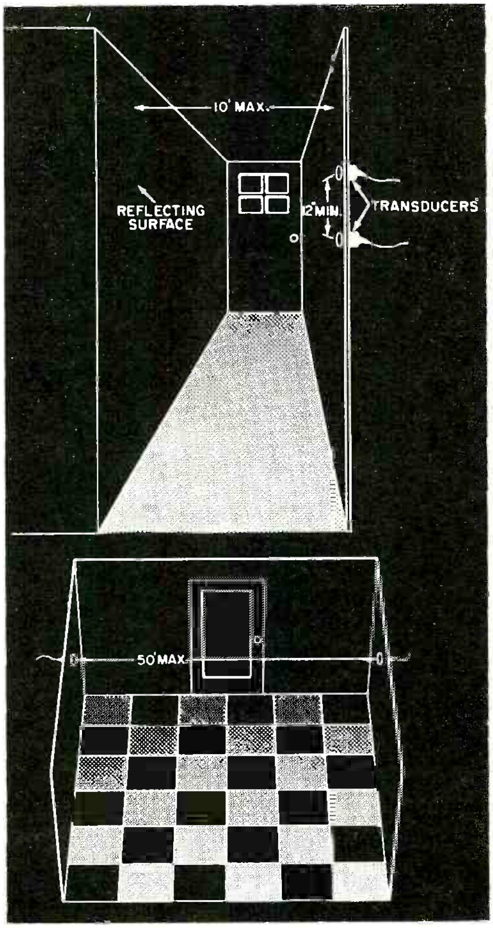


Fig. 6. To cover a narrow passageway, both transducers can be mounted on the same wall; for a wider area, up to 50', the direct-path technique is used.

placed in the *Reset* position once again.

Power for the transmitter and receiver is derived from the 117-volt line, stepped down by *T1*, rectified by *D3* and *D4*, and filtered by *C1*, *R6*, and *C5*, and by *R1* and *C2*. Actually, any 12-volt d.c. supply, able to deliver about 50 ma. of current will do. Batteries can also be used.

Construction. Although an etched and drilled circuit board is available, you can make your own board, using the actual size photo (Fig. 2) as a guide, or mount the parts in any manner more convenient for you. If you do change the layout, avoid stray coupling between the transmitter and receiver sections, but in any event observe polarity of electrolytic capacitors and diodes.

After all the parts are mounted on the circuit board, connect wires to points *A* through *M*. These should be about 8 inches long. Twist together leads *A* and *B*; *C* and *D*; *E*, *F* and *G*; *K*, *L* and *M*; and *J*, *H* and *N*.

Mount the switches and meter on the front panel, and the transducer connectors and alarm connector on the back panel, as shown in the photos. Use shielded microphone cable and appropriate connectors for the transducers. For a 50-foot spread, each cable need be only 25 feet long. A phono plug connects the transducer to the cable. Any type of cabinet can be used to house the circuit.

Adjustment. Mount the transducers about 20 feet apart. Turn the sensitivity control fully clockwise (viewed from the knob side) and turn on the power. Place *S2* in the *Reset* position and advance gain control *R12*. As the control is turned counterclockwise, the meter reading should increase; and at approximately 8 volts, the relay should be heard to click in. If the relay does not close—or if the reading doesn't reach 10 volts—at the full counterclockwise position of the gain control, the slug in *L1* should be adjusted.

Use a nonmetallic alignment tool to turn the slug about halfway into the coil form. Now slowly turn the slug out of the form and watch the meter reading. When the reading reaches 10 volts, reduce sensitivity and keep adjusting until a peak or maximum reading is obtained. Turn the alarm *off* and back *on* to be sure that the adjustment is stable. If the meter reading does not return to the same place or is zero, tune for the second highest reading.

If you find that the best transmitter adjustment causes the transmitting transducer to make audible sounds, damp the transducer. The high drive level can cause the crystal or internal parts of the transducer to "sing" at an audible frequency. Carefully open the transducer case by straightening the crimped edge on the back of the transducer to remove the cover. Then carefully insert a piece of foam plastic (not rubber) under the crystal as shown in Fig. 5. The pad should be approximately 3/8" square by 1/16" thick. Replace the cover and seal the seam with rubber cement to prevent the transducer case from rattling.

If everything seems to be in working order, set the sensitivity control to obtain a 10-volt reading and have someone take a walk to break the path between the transducers. The meter reading should drop to zero and the relay should drop out.

Installation. You can mount the transducers for direct or for reflected beam operation as shown in Fig. 6. Direct-type operation is more effective over greater distances. With the reflected-type setup, both transducers can be mounted on the same wall to cover hallways and small rooms. Do not use more cable than necessary for the receiving transducer; the longer the cable, the more capacitance it has; and the greater the capacitance, the greater the loss in signal to the receiver. If the system is to be used as an intruder alarm, mount the transducers high enough and in such a way that a cat or a dog will not break

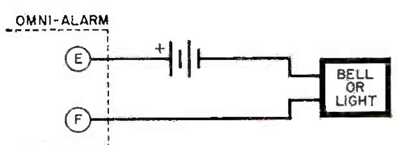


Fig. 7. Simple alarm circuit can be compromised by cutting one of the wires. Use of a battery causes the alarm to sound in the event of a power failure.

the beam and cause a false alarm—unless you would like to know about the uninvited four-legged visitor.

Keep the beam as far away from heating or air conditioning ducts as possible. Although this system will tolerate some air motion, violent or turbulent motion can set it off. The Omni-Alarm cannot normally be used outside, especially in a windy place—the "sound" beam can be blown away enough to cause the alarm to trip.

Any type of alarm device that can be activated by a switching action can be connected to the relay contacts. Perhaps the simplest arrangement is that of a bell or light connected to points *E* and *F* as shown in Fig. 7. But while this hookup will work fine, it can be put out of commission simply by cutting the wires.

If you want to make the installation tamperproof, you can enclose the external alarm and its circuitry in a locked steel box, mounted high above ground level. The alarm will sound if an intruder breaks the beam, cuts or shorts the wires, or if there is a power failure. Two identical relays are used as shown

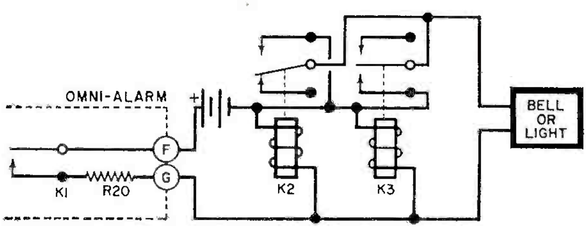


Fig. 8. Fail-safe external alarm system will cause an alert if the wires are cut or shorted, if the battery is weak, or if the power line should fail.

in Fig. 8. All relays have a higher pull-in than drop-out current, and you can take advantage of this characteristic. Resistor *R20*, installed in the alarm control unit, is selected to allow a small current to flow through *K2* and *K3*, which is too small to pull in the relays, but large enough to hold them in. Set the alarm and manually close the contacts of *K2*. Now, if anyone cuts the wires or breaks the beam to open *K1*, *K2* will open and sound the alarm. If someone shorts the wires, *R20* is bypassed and *K2* closes, and sounds the alarm.

If you want to be real "mean," you can put a Microswitch in the bottom of the case. Then the alarm will sound if the case is picked up. An added safety feature inherent in this type of circuit is that the alarm will sound when the batteries approach their end life.

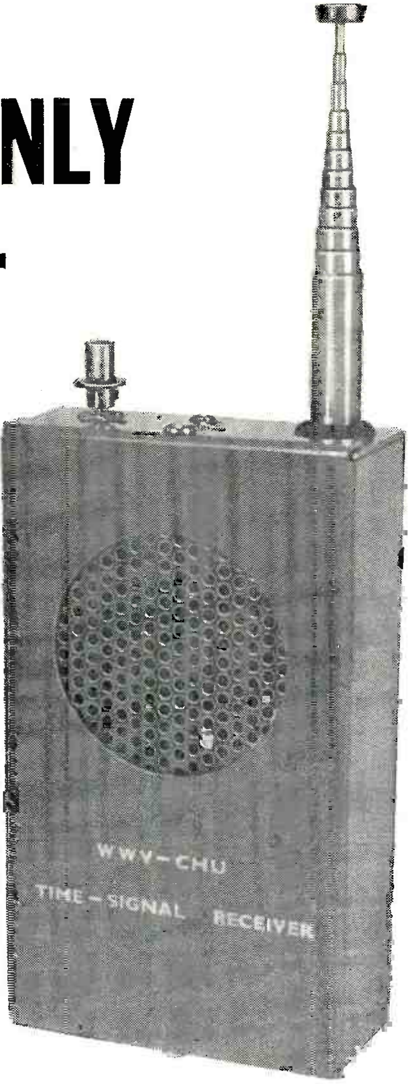
To obtain pinpoint control in a production line setup, you can insert one or both of the transducers into one end of a 1"-diameter plastic tube. This reduces the range. Distances of one to three feet can be monitored without feedback problems. —30—

BUILD

Time-Signal-ONLY Receiver

EASILY DUPLICATED TRANSISTORIZED RECEIVER IS CRYSTAL-CONTROLLED ON CHU OR WWV

By **CHARLES CARINGELLA,** W6NJV



BUILD a portable time-signal receiver and you can tune in on standard time broadcasts from your living room, picnic table, boat, car, or even from a private plane. This miniature receiver is a complete superhet circuit with crystal-controlled local oscillator, prepackaged pretuned i.f. module, and *transformerless* audio amplifier. A printed circuit board makes it easy to build and only a screwdriver (no test equipment) is needed for alignment!

Standard time signals can be heard in almost every country in the world. In the United States, radio stations of the National Bureau of Standards (all having the call-sign WWV) continuously transmit time signals on a number of frequencies. Besides accurate time-signal information, the transmissions also provide: standard radio frequencies, standard audio frequencies, standard musical pitch, standard time intervals, radio propagation forecasts, and geophysical alerts. This receiver can be used to monitor WWV on a frequency of 10 MHz or 15 MHz.

You can also use the time-signal receiver to tune in CHU, Ottawa, Canada, on a frequency of 7335 kHz, or on 14.670

MHz. The CHU time-signal broadcasts are very popular because of their voice-time announcements each *minute.* A short tone or "beep" is broadcast each second.

The model of the WWV-CHU receiver shown on page 19 (a portable, crystal-controlled, 8-transistor receiver) can be built for a little more than thirty dollars. It has an r.f. amplifier, a mixer, a pre-aligned J. W. Miller i.f. amplifier, and a push-pull Class B audio output. Powered by an ordinary transistor radio battery, the receiver has a low power consumption and battery life is quite good.

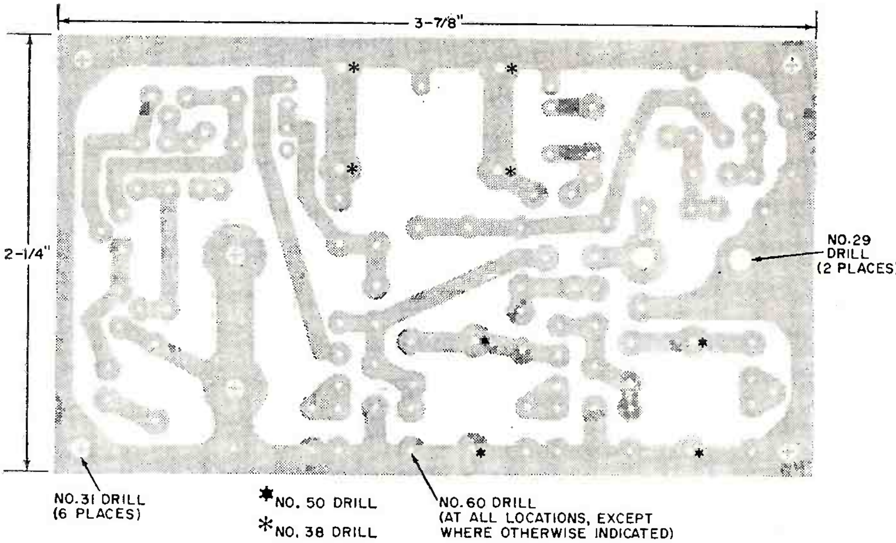
The WWV-CHU receiver is portable and can be used anywhere. A telescoping, built-in whip antenna can be extended to 52 inches for increased signal pickup. The audio stage drives a built-in speaker. In a noisy environment, or for private listening, an earphone can be plugged into the jack provided for that purpose. Since the receiver is crystal-controlled, there is no need to tune for the station.

Sensitivity is excellent, being better than one microvolt for a S/N ratio of 10 dB, which compares favorably with the large multi-tube communications receivers. Although the circuit is fairly complex, the receiver is *easy* to build. There are *no* coils to be wound since prewound, molded r.f. chokes are used. The receiver is even *easier* to align. The only piece of "equipment" needed for alignment is a screwdriver.

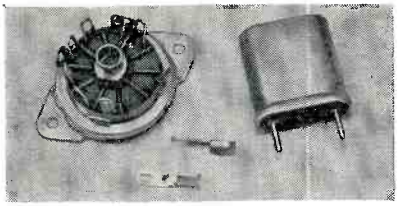
How It Works. The r.f. front end uses several new, low-cost, encapsulated, *npn* silicon transistors. Transistor *Q1* is the r.f. amplifier, and transistor *Q2* is the mixer. Coils *L1* and *L2* are prewound iron-core r.f. chokes and are specified as being either 10 μH or 5.6 μH. If 10-μH chokes are used, then CHU on 7335 kHz or WWV on 10 MHz can be tuned. The 5.6-μH chokes will enable the receiver to be tuned to three time-signal stations: WWV on 10 MHz, CHU on 14.670 MHz, or WWV on 15 MHz. Midget trimmer capacitors *C2* and *C6* tune or resonate the chokes to the respective frequencies. Transistor *Q3* is the local oscillator, which is crystal-controlled and "untuned." Fundamental crystals are used in this circuit.

The miniature i.f. module eliminates the need to build a separate i.f. amplifier. Within the module are two transistors, three i.f. 455-kHz transformers, a crystal diode detector stage, and miscellaneous decoupling capacitors.

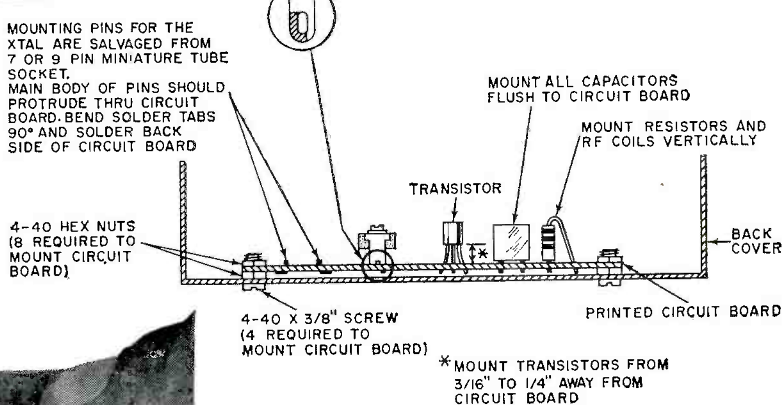
The volume control is potentiometer *R12.* There are *no* transformers in the audio amplifier section so that cost and receiver weight are kept down. The audio preamplifier is *Q4*, a *pnp* germanium transistor. Transistors *Q5* and *Q6* operate push-pull Class B in a complementary-

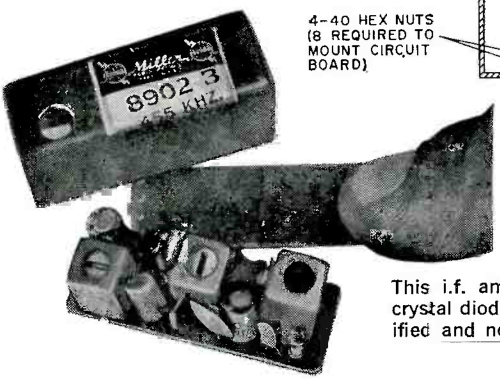


Copper foil side of homemade printed circuit board should have the outline shown in the 1:1 drawing above. Holes to pass wire leads are drilled with a #60 drill. All other holes are drilled to the sizes indicated.

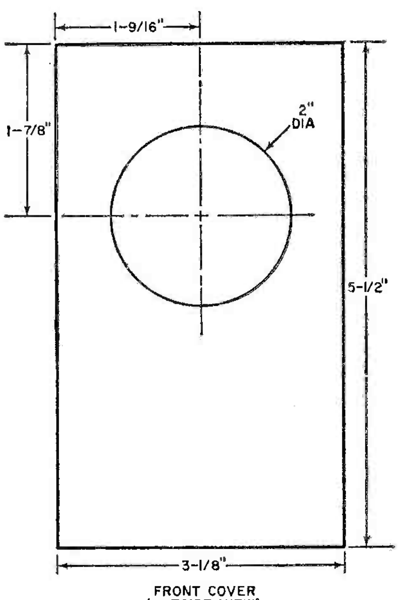


The edge-view drawing of the printed circuit board shows special preparation of the C2 and C6 soldering tabs. Shown in photo at left is method employed to obtain socket clips to hold the crystal. Use an expendable 9-pin socket.

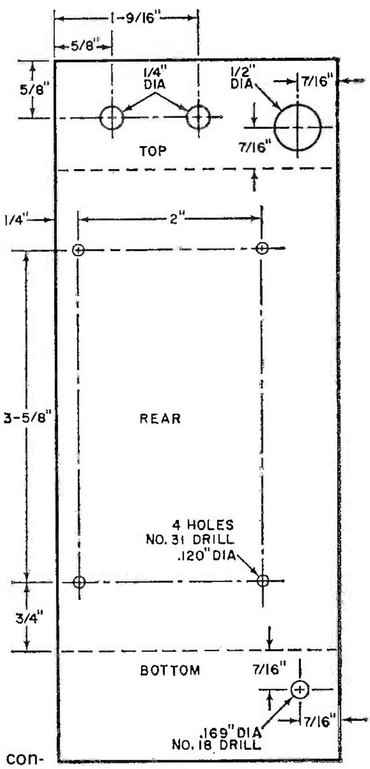




This i.f. amplifier contains two transistors, three i.f. transformers, and crystal diode detector. Be sure to get the J. W. Miller Model 8902-B specified and not the older-style Model 8902 with outboard i.f. transformer.



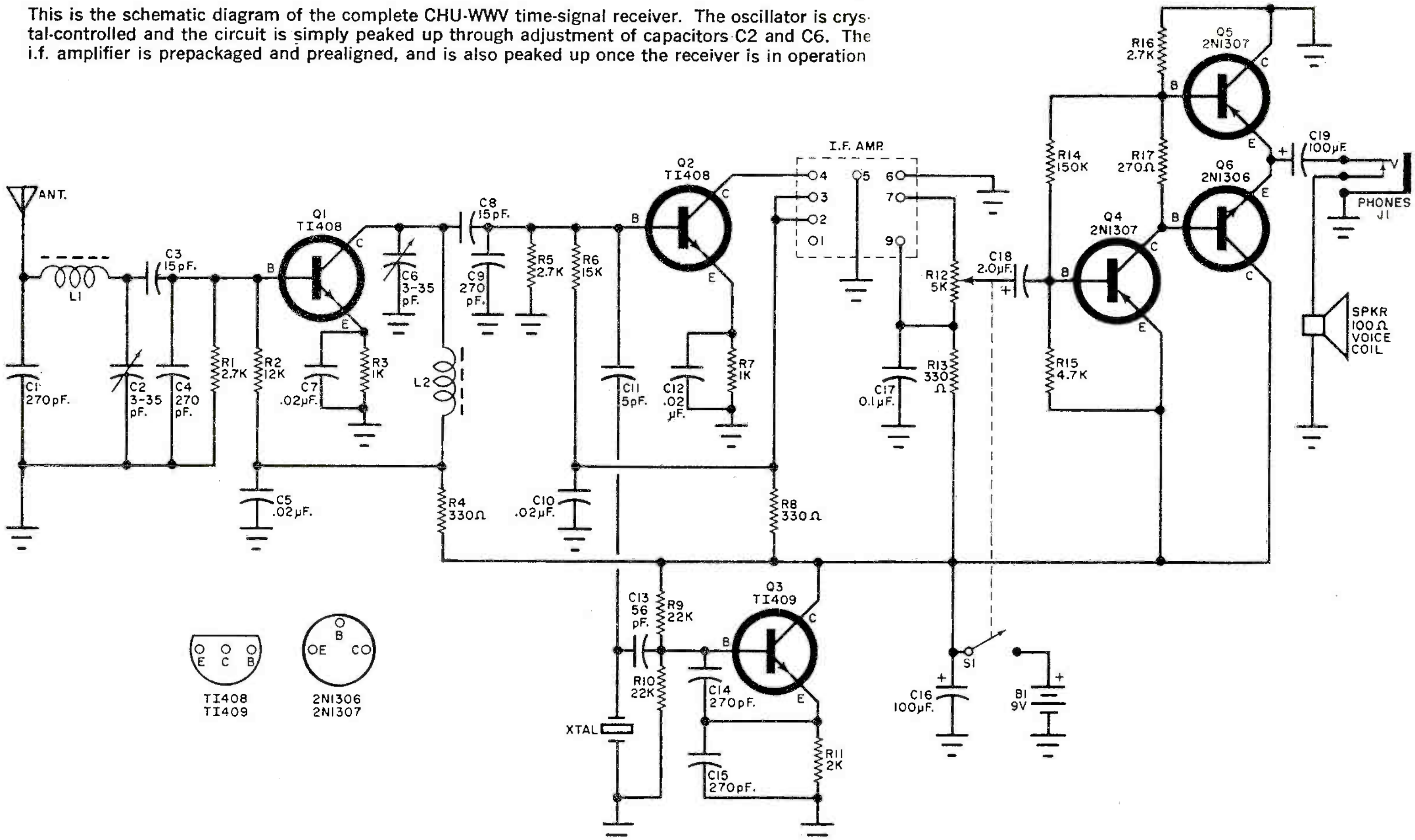
FRONT COVER
(OUTSIDE VIEW)



BACK COVER
(INSIDE VIEW)

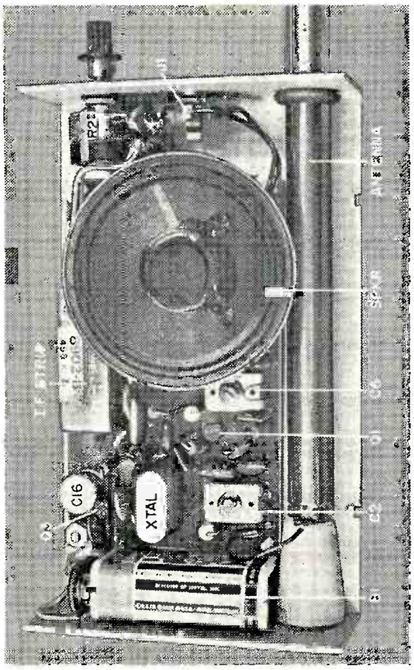
If you purchase an LMB aluminum box No. 139, you can duplicate construction of the receiver shown on the cover using these dimensions.

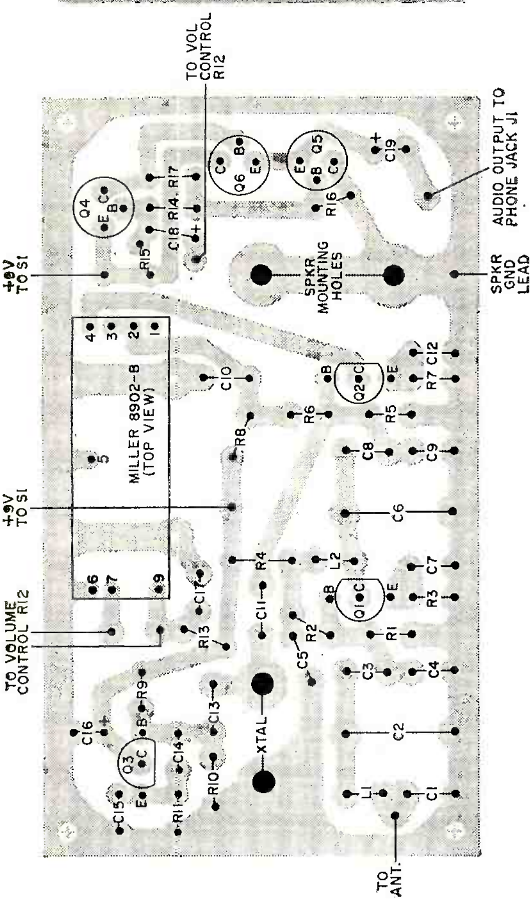
This is the schematic diagram of the complete CHU-WWV time-signal receiver. The oscillator is crystal-controlled and the circuit is simply peaked up through adjustment of capacitors C2 and C6. The i.f. amplifier is prepackaged and prealigned, and is also peaked up once the receiver is in operation



Use the layout of the top side of the printed circuit board shown below to spot the positions for the components in the wiring diagram above. Holes for the loudspeaker apply only if a Quam 2¼" PM speaker is installed in the space provided.

Compare photo below with board layout at left. Speaker is now fastened to printed circuit board and the chassis cover with speaker cutout slips over U-shaped back cover seen in this photo.





symmetry configuration. A 100-ohm speaker is fed from the audio output stage through closed-circuit phone jack *J1*. When headphones are plugged into the phone jack, the speaker is automatically disabled. Any impedance headphone can be used. The audio output stage delivers over 50 milliwatts of power.

Construction. The entire time-signal receiver circuit is constructed on a printed circuit board measuring only 3⅞" x 2¼" in size. A glass epoxy circuit board, etched and drilled, is available from the author (see Parts List).

Component mounting should follow that shown in the photo at left. All resistors are mounted vertically and all capacitors mounted as close to the printed circuit board as possible. Prior to mounting the miniature trimmer capacitors, *C2* and *C6*, cut the soldering tabs as shown on page 21.

Space limitations will not permit the use of a crystal socket on the printed circuit board. Instead, two socket pins salvaged from a 7- or 9-pin tube socket are soldered directly to the board. Once these have been soldered in place, also as shown on page 21, they serve as the "socket" for the crystal.

All of the transistors should be mounted approximately ¼" away from the circuit board. Carefully observe correct placement of the "flat" side of transistors *Q1*, *Q2* and *Q3*. As usual in soldering transistors, keep the heat applied to the leads to a minimum, but consistent with a good connection.

The connecting leads to the circuit board (from *B1*, *J1*, *R12* and *S1*) should be approximately 2" long. These will be cut to the proper length once the circuit board has been installed in the chassis box. The speaker mounts directly on the printed circuit board where the holes are provided—it is installed last. Two *4-40* screws secure the speaker to the printed circuit board.

Prepare the metal box by drilling the holes in the back cover and making the 2" cutout in the front cover (see drawing on p. 21). Cement a 2½" x 2½" piece of perforated sheet aluminum in back of the 2" cutout. Use epoxy cement for this step. If you wish, you can paint the perforated sheet before cementing it in place.

PARTS LIST

B1—9-volt battery
C1, C4, C9, C14, C15—270-pF, 500-volt, dipped silver mica capacitor
C2, C6—3-35 pF, miniature trimmer capacitor (similar to Arco 403)
C3, C8—15-pF, 500-volt, dipped silver mica capacitor
C5, C7, C10, C12—0.02-µF, 75-volt miniature ceramic capacitor (similar to Lafayette 33 R 6906)
C11—5-pF, 500-volt, dipped silver mica capacitor
C13—56-pF, 500-volt, dipped silver mica capacitor
C16, C19—100-µF, 12-volt, miniature printed circuit electrolytic capacitor (similar to Lafayette 99 R 6086)
C17—0.1-µF, 75-volt, miniature ceramic capacitor (similar to Lafayette 33 R 6908)
C18—2.0-µF, 6-volt, miniature printed circuit electrolytic capacitor (similar to Lafayette 99 R 6070)
J1—Miniature closed-circuit phone jack
L1, L2—10.0-µH miniature iron core r.f. choke (similar to J.W. Miller 9310-36) or 5.6-µH miniature iron core r.f. choke (similar to J.W. Miller 9310-30); to tune 7-10 MHz, use the 10.0-µH chokes, and to tune 10-15 MHz, use the 5.6-µH r.f. chokes
Q1, Q2—Npn low-cost silicon r.f. transistor (similar to Texas Instruments TI408, Semitronics T-33, etc.)
Q3—Npn low-cost silicon r.f. transistor (similar to Texas Instruments TI409, Semitronics T-33, etc.)
Q4, Q5—2N1307 germanium pnp transistor
Q6—2N1306 germanium npn transistor
R1, R5, R16—2700-ohm, ½-watt resistor
R2—12,000-ohm, ½-watt resistor
R3, R7—1000-ohm, ½-watt resistor
R4, R8, R13—330-ohm, ½-watt resistor
R6—15,000-ohm, ½-watt resistor
R9, R10—22,000-ohm, ½-watt resistor
R11—2000-ohm, ½-watt resistor
R12—5000-ohm potentiometer with s.p.s.t. switch, ¾"-diameter (similar to Lafayette 32 R 7363)
R14—150,000-ohm, ½-watt resistor
R15—4700-ohm, ½-watt resistor
R17—270-ohm, ½-watt resistor
S1—S.p.s.t. switch (on R12)
SPKR—2¼"-diameter PM speaker (similar to Quam 22AO6Z100 for exact mounting on printed circuit board)
XTAL—Fundamental frequency crystal, 0.01% tolerance, with HC/6U holder (similar to International Crystal Type FA-5); use 7790.0 kHz to receive CHU on 7335 kHz ($3.30); use 9545.0 kHz to receive WWV on 10.0 MHz ($3.30); use 14,215 kHz to receive CHU on 14,670 kHz ($4.40); use 14,545 kHz to receive WWV on 15,000 kHz ($4.40); any crystal available from International Crystal, 18 N. Lee, Oklahoma City, Okla. 73102 plus postage
I.F. AMP.—Subminiature, 2-transistor i.f. package (must be J.W. Miller 8902-B)
1—Printed circuit board (available from author with mounting hardware for $2.50 postpaid)
1—5½" x 3" 1¼" aluminum box (similar to LMB 139)
1—Telescoping antenna; 52" fully extended, 5⅞" retracted; 8-32 stud at bottom (similar to Lafayette 99 R 3008)
1—Steatite cone insulator (similar to E.F. Johnson 135-501)
Misc.—½" rubber grommet, battery clip, plastic knob for R12, wire, solder, etc.

*To assist in building the WWV-CHU receiver, the author has available a complete kit of parts containing the printed circuit board, i.f. strip, one crystal (your choice of frequency), and a painted cabinet for $33.50, postpaid. Write to Caringella Electronics, P.O. Box 327, Upland, Calif. 91786. California residents should add 4% sales tax. Wired and tested units are $49.50.

Mount the telescoping whip antenna through a ½" rubber grommet in the hole in the top of the back cover. The bottom of the whip is held by a steatite insulator. The solder lug, provided with the antenna, should be installed between the bottom of the antenna and the top of the insulator. Next, install the volume control, *R12*, and the phone jack, *J1*.

The completed circuit board, with speaker installed, is mounted last. If you follow the layout provided in the drawings, the speaker will automatically line up directly behind the 2½" opening when the front cover is installed.

Place a solder lug under the *4-40* nut in the lower left-hand corner of the circuit board. The solder lug will thus serve as the ground point for the negative lead of the battery. Run the battery's positive lead along the underside of the circuit board and solder the end to switch *S1*.

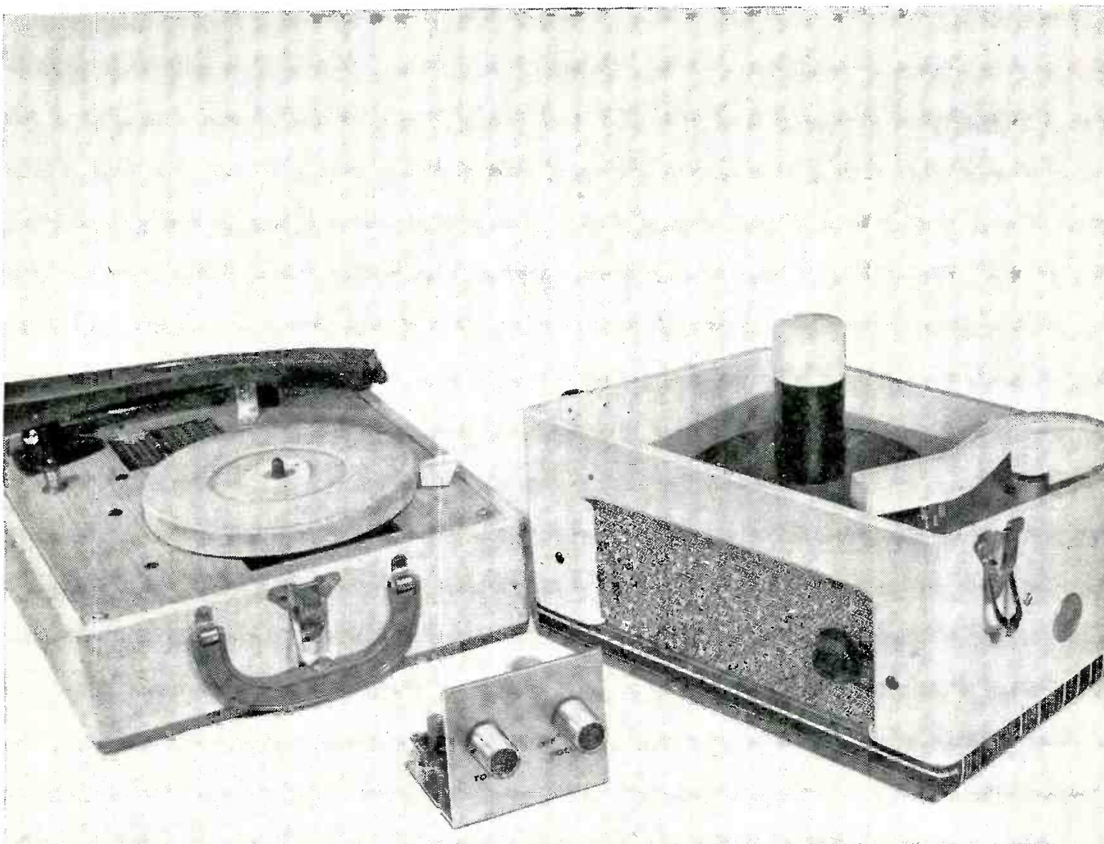
Alignment and Operation. The completed receiver can be aligned with an "on the air" signal from WWV or CHU. Since the receiver's local oscillator is crystal-controlled, there is no need to "hunt" for the station.

Assuming propagation conditions will permit reception of the desired station at the time you select (see box entitled "Time Signal Broadcasts"), simply tune *C2* and *C6* for maximum station volume or background noise. Also, a slight "tweaking" of the input transformer in the i.f. strip might be necessary. A hole in the top of the i.f. module enclosure allows access to the input transformer tuning slug.

In most cases, the built-in antenna is all that is needed. However, it is possible to improve reception with a "long wire" antenna. An external antenna can be clipped to the top of the whip. The

(*Continued on page* 148)

UPDATE TO SOLID STATE

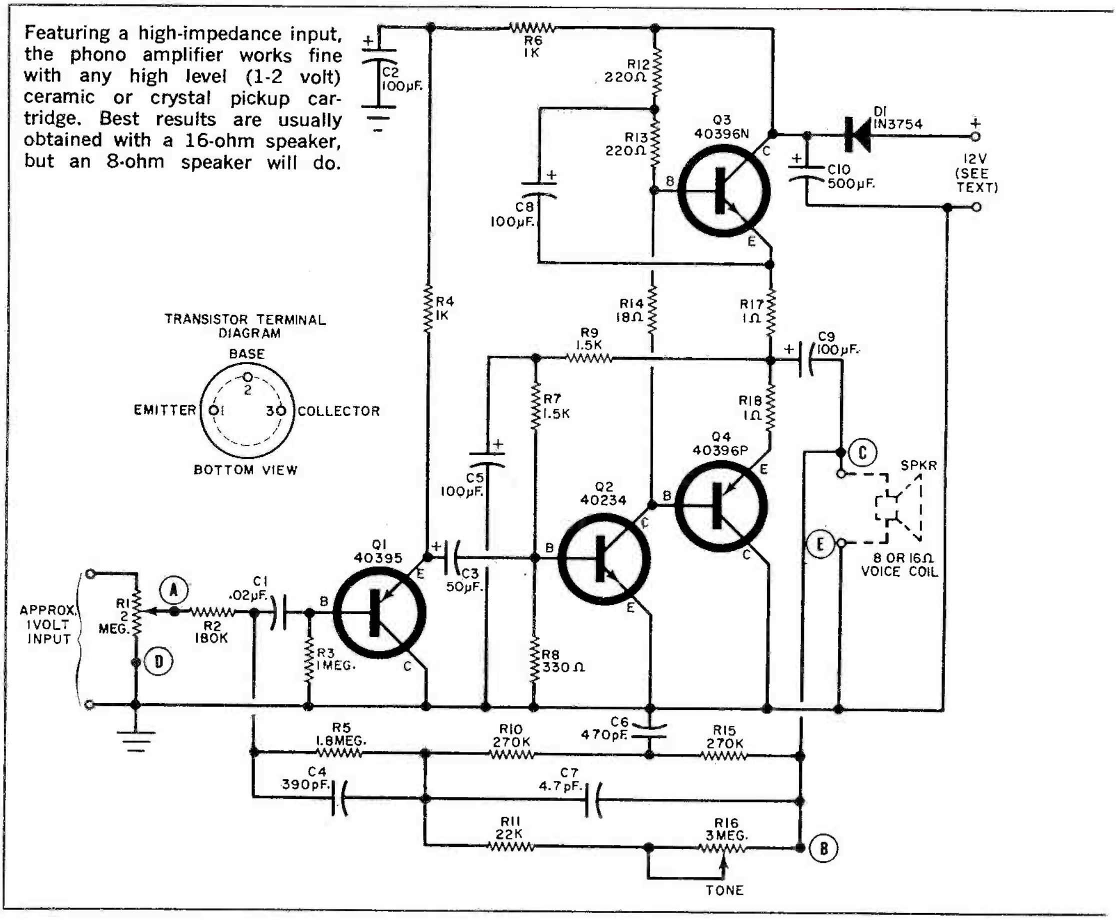


LOW-COST, INSTANT-PLAY TRANSISTORIZED PHONOGRAPH AMPLIFIER IS IDEAL REPLACEMENT FOR OLDER TUBE TYPES

UNLIKE the proverbial "tempest in a teapot," this solid-state phonograph amplifier really kicks up a storm. Featuring push-pull output amplification for more power, less distortion, and truer fidelity, the unit has been designed to satisfy the need for an inexpensive, easy-to-build phonograph amplifier that will operate satisfactorily with most high-level, low-cost ceramic or crystal cartridges.

Whether you'd like to update that old discarded record player or assemble a new one around the solid-state amplifier design, this four-transistor unit is sure to please all but the most discriminating listener.

By LOUIS E. GARNER, JR.



Featuring a high-impedance input, the phono amplifier works fine with any high level (1-2 volt) ceramic or crystal pickup cartridge. Best results are usually obtained with a 16-ohm speaker, but an 8-ohm speaker will do.

How It Works. The amplifier input from a phono cartridge is applied to the base of emitter follower *Q1* (as shown in the schematic diagram, above) through volume control *R1*, limiter resistor *R2*, and coupling capacitor *C1*. With *Q1* serving as an impedance-matching device, this transistor provides a high input impedance to the source and a low output impedance to driver *Q2*.

Transistor *Q1*'s output, developed across *R4*, is applied to the base of *Q2* through *C3*. Bias for this stage is provided through *R3*. The output of *Q2* is then direct-coupled to push-pull amplifiers *Q3* and *Q4*. The *R7-R8* divider combination, together with *R9* and *C5*, provide a compensated base bias for *Q2*.

A common output from the push-pull amplifiers is developed across emitter resistors *R17* and *R18* and coupled through *C9* to the speaker voice coil. Resistors *R12, R13,* and *R14,* together with *C8,* provide the base bias voltage for *Q3* and *Q4.*

A special type of feedback equalization network in the tone control circuit provides low-frequency roll-off compensation whenever the volume control is turned up fully. The network components consist of *C4, R5, R10, C6, R15, C7, R11* and *R17*. Potentiometer *R16* is the tone control. The main advantage of this equalization arrangement is that it improves tonal quality without introducing excessive losses. The amplifier can be powered directly by a 12-volt battery. However, since the attached record changer will usually be a.c.-operated, it will be advantageous to employ either a 12-volt filament transformer, or make a direct connection to the 12-volt auxiliary winding on the phonograph motor.

Diode *D1* and capacitor *C10* provide a

PARTS LIST

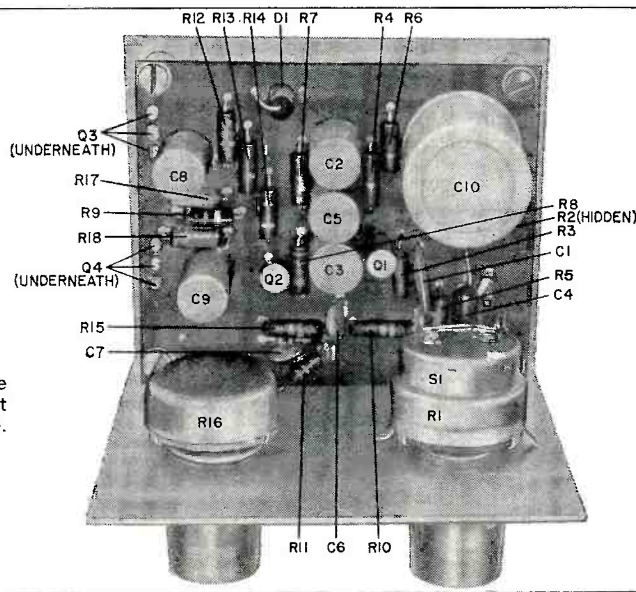
C1—0.02-μF, 50-volt disc ceramic capacitor
C2, C5, C8, C9—100-μF, 15-volt electrolytic capacitor
C3—50-μF, 15-volt electrolytic capacitor
C4—390-pF disc or tubular ceramic capacitor
C6—470-pF disc or tubular ceramic capacitor
C7—4.7-pF disc or tubular ceramic capacitor
C10—500-uF, 25-volt electrolytic capacitor
D1—50-volt PIV diode (RCA 1N3754 or equivalent)
Q1—RCA 40395 transistor
Q2—RCA 40234 transistor
Q3—RCA 40396N transistor (see text)
Q4—RCA 40396P transistor (see text)
R1—2-megohm potentiometer, audio taper (with s.p.s.t. switch S1)
R2—180,000-ohm resistor
R3—1-megohm resistor
R4, R6—1000-ohm resistor
R5—1.8-megohm resistor
R7, R9—1500-ohm resistor
R8—330-ohm resistor
R10, R15—270,000-ohm resistor
R11—22,000-ohm resistor
R12, R13—220-ohm resistor
R14—18-ohm resistor
R16—3-megohm potentiometer, audio taper
R17, R18—1-ohm resistor
(All resistors ½ watt)
S1—S.p.s.t. switch (on R1)
1—3¼" x 2¾" x 3" (approx.) L-shaped aluminum chassis/panel
2—Heat sink clips (RCA SA2100)
Misc.—Knobs (2); ½"-long standoff spacers (4); screws, nuts, lock washers, solder, etc.

NOTE: A complete kit of parts, including an etched circuit board, is available from DEMCO, 219 W. Rhapsody, San Antonio, Texas 78216, for $9.50 postpaid

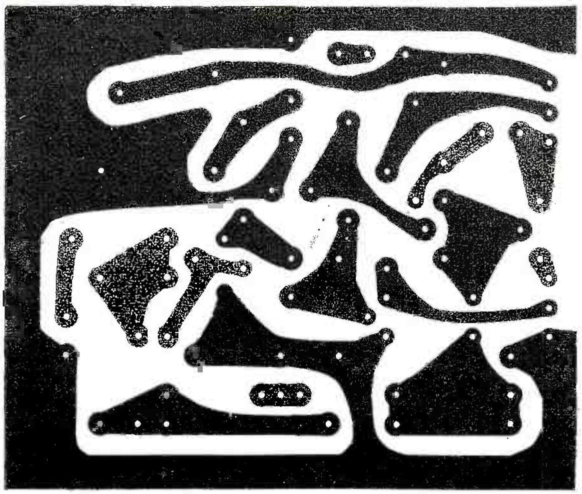
rectified d.c. output to operate the unit. For battery-powered motors, or when you want to use a battery supply for the amplifier, *D1* serves to protect the circuit from an accidental battery polarity reversal.

Construction. The amplifier can be assembled on the 3¼" x 2¾" x 3" L-shaped aluminum chassis, or on any other convenient-sized chassis. If you are doing a conversion job, investigate the possibility of using the existing chassis; in most cases, it will be quite adequate. You may even be able to use your old volume and tone controls—if these are of the proper resistance. But bear in mind that a metal chassis must be used to provide adequate heat-sinking for output transistors *Q3* and *Q4*. These transistors (RCA 40396N and 40396P) are matched pairs, and must be purchased as such.

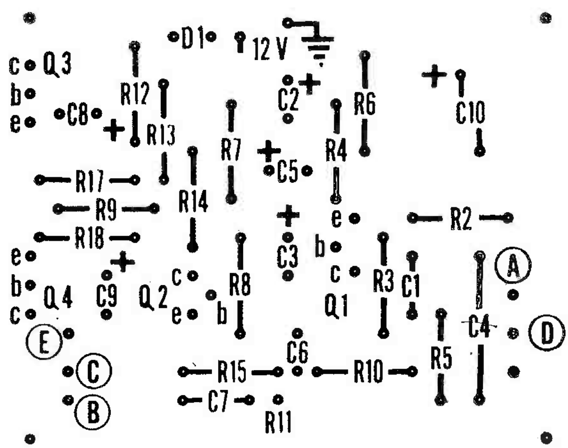
It is far more convenient to mount the components on a printed circuit board or simply on a perforated phenolic board than to wire them directly to the chassis. The size board required will be determined essentially by available spacing, but a 3" x 3" board is usually suitable. If you prefer to use a printed circuit board, or want to work from a kit, these are available from DEMCO (see Parts List).



Except for Q3 and Q4, which are mounted underneath the circuit board, all components are visible.



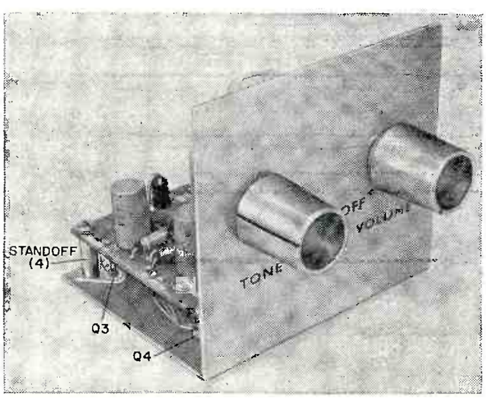
Actual size photos show foil side (left) and component side (below) of printed circuit board that can be used instead of point-to-point wiring. A packaged kit is also available (see Parts List).



It is recommended that the builder employ point-to-point wiring on the phenolic circuit board because of the simplicity of the circuit. Besides, you will get a greater feeling of accomplishment when the job is completed.

Transistors *Q3* and *Q4* are mounted directly on the chassis in any convenient location. The other transistors, *Q1* and *Q2*, can be mounted on the circuit board. As shown in the illustrations, both the volume and tone controls are panel-mounted.

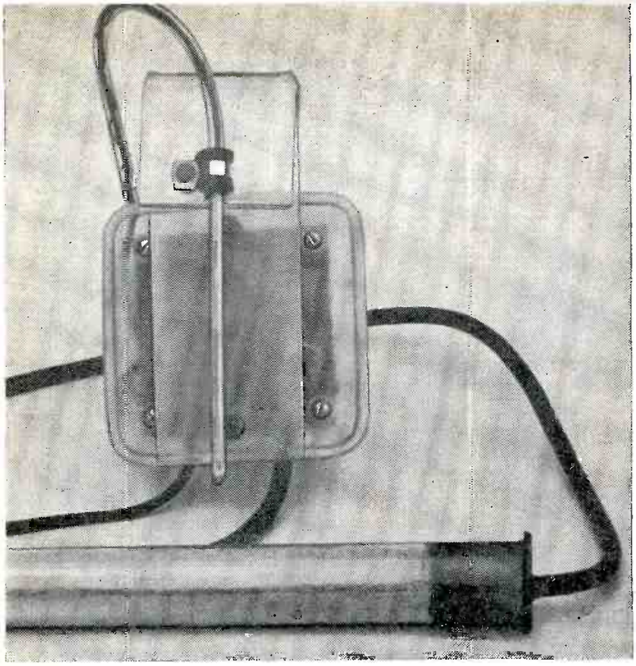
The circuit board is mounted on spacers as shown, although this arrangement can be varied to suit any preferred installation. Connect the external wires from the pickup cartridge to the ungrounded side of the volume control, and connect the ground shield to a good chassis ground. (Cartridges such as the Sonotone 2TA-S and Astatic 70-TS, 74-TS or 76-TSB can be used.) Connect the loudspeaker voice coil to the "C" and "E" terminals (see schematic).



Transistors Q3 and Q4 can be inserted in small metal cable clamps and installed underneath the standoffs used to support the printed circuit board.

If an auxiliary motor winding or a filament transformer is used as a power source, connect one lead of the 12.6-volt winding to diode *D1*'s anode, and the other lead to ground. If a battery is being used instead, connect the positive lead through a s.p.s.t. switch installed on the volume control (*R1*) to the anode terminal of *D1*. In this case, motor power is controlled by a separate switch.

After double-checking your work, apply power—and enjoy good listening.–30–



STATIC-FREE THERMISTORIZED AQUARIUM HEATER

NO MORE RADIO INTERFERENCE FROM YOUR AQUARIUM HEATER . . . THERMISTOR-CONTROLLED SOLID-STATE DESIGN EMPLOYS NOISELESS SCR SWITCHING

By A. E. DONKIN, W2EMF

WHETHER YOU'RE an amateur ichthyologist or just a fellow with a few tropical fish, you'll want to build this transistorized thermistor-controlled aquarium heater, and get rid of that annoying radio interference that your present bimetallic thermostat produces. What's more, you'll be able to maintain precise temperature control to within ± 0.5-degree of setting.

When equipped with a standard 75-watt submersible heater, the unit will operate satisfactorily in small tanks—up to 20 gallons—and maintain the desired tank temperature within a differential of up to 10 degrees F above ambient. For larger aquariums, or where greater temperature differentials exist, a larger heater can be employed or a full-wave rectifier substituted for the single rectifying diode used.

How It Works. As shown in Fig. 1, *Q1* functions as part of the sensing circuit while *Q2* acts as a triggering device to turn on *SCR1*. Thermistor *TH1* and *R1* form a voltage divider that provides a variable base bias for *Q1*. Potentiometer *R3* in *Q1*'s emitter establishes the operating range of the transistor, and thus serves as the temperature control adjustment.

In operation, if the tank temperature is below normal, the relatively large voltage drop across *TH1*—due to its high resistance at low temperatures—places a high reverse base bias on *Q1*, cutting off the transistor.

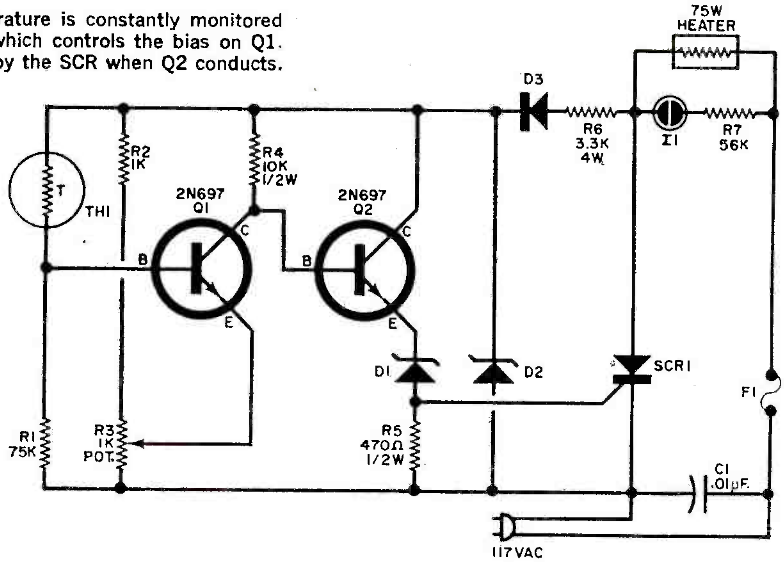
With *Q1* at cutoff, the forward bias developed across *R4* drives *Q2* in a high state of conduction and the zener or avalanche breakdown voltage of *D1* is exceeded. Thus, the emitter voltage across *R5* is applied to the gate of *SCR1* to turn on the device which energizes the heater in its anode circuit.

As the water temperature increases, causing the thermistor resistance to go down, *Q1* becomes forward-biased and conducts. The output at the collector overcomes *Q2*'s forward base bias, and this transistor is driven into cutoff. This turns off *SCR1* and the heater is de-energized.

Diode *D2* is a voltage regulator that maintains the d.c. at the cathode of rectifier *D3* at a constant 18-volt level. Neon lamp *I1*, in series with *R7*, is a test device used during initial adjustment of the unit.

Construction. To assure maximum operating safety, the thermostat's electronic circuitry is housed in a plastic freezer container rather than in a metallic box. Begin construction by preparing the aluminum panel shown in Fig. 2. It is made from a 1½" x 2⅝" by 1⁄16"-thick aluminum plate laid out and drilled to the dimensions given, and

Fig. 1. Water temperature is constantly monitored by thermistor TH1, which controls the bias on Q1. Heater is turned on by the SCR when Q2 conducts.



then made into an L-shaped bracket. Not shown are two small holes that must be drilled to mount the bracket.

Secure the bracket to the circuit board (see Fig. 3) using two *6-32* x ¾" screws inserted from the bracket side of the board through two ⅜"-o.d. x ½"-long standoffs and nuts. Do not install the remaining two standoffs at this time.

Mount the fuse holder where shown, then install and wire up the remaining parts. In the model shown here resistor *R6* consists of three 10,000-ohm, 2-watt resistors in parallel. This combination was used for no other reason than the fact that they were readily available. However, it is more convenient to use a single 3300-ohm, 4-watt resistor instead.

Also, if desired, *Q1* and *Q2* may be wired directly into the circuit, eliminating the transistor sockets. Be sure to use a low-wattage iron when soldering transistors and diodes, and avoid overheating these devices. And be sure to observe diode polarities.

When installing the SCR mounting kit, apply a little silicon grease between the aluminum panel and the mica washer to improve heat conduction. The thermistor must be mounted in a glass tube and the wires run through a small plastic air hose that you can get from an aquarium supply store. To seal the thermistor glass tube at one end, use a Bernz-O-Matic type torch to heat the tube until it is red-hot, and then draw

PARTS LIST

C1—0.01-μF, 150-volt ceramic disc capacitor
D1—Z4XL6.2 silicon zener diode (GE)
D2—Z4XL18 silicon zener diode (GE)
D3—1N3755 silicon diode (RCA)
F1—3-ampere fuse (and fuse holder)
I1—NE-2 neon lamp
Q1, Q2—2N697 transistor
R1—75,000-ohm, ½-watt resistor
R2—1000-ohm, ½-watt resistor
R3—1000-ohm, ½-watt miniature molded composition potentiometer
R4—10,000-ohm, ½-watt resistor
R5—470-ohm, ½-watt resistor
R6—3300-ohm, 4-watt resistor
R7—56,000-ohm, ½-watt resistor
SCR1—2N3228 silicon-controlled rectifier
TH1—Thermistor (Veco 51A1 from Newark Electronics, or Fenwal Electronics EMC4 from Allied Radio)
1—75-watt submersible aquarium heater
1—3¼" x 3¼" x 2⅜" plastic freezer container with cover
1—2" x 7" piece of ¼"-thick plexiglass
1—2¾" x 2¾" perforated phenolic board
1—1½" x 2⅝" piece of 1/16"-thick aluminum plate
6—⅛"-i.d. x ½"-long standoffs
Misc.—6-32 x 1"-long screws with four flat washers and nuts (2); small plastic clamps (3); 6-32 x ¾"-long screws with nuts (4)

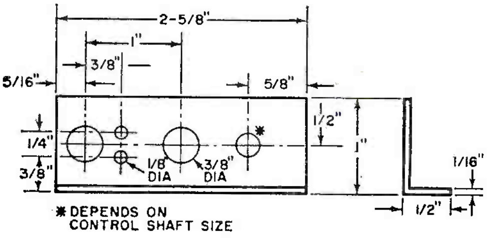


Fig. 2. Mounting bracket is made from 1/16"-thick aluminum plate cut to dimensions given. It acts as a heat sink for SCR1 and as a support for R3.

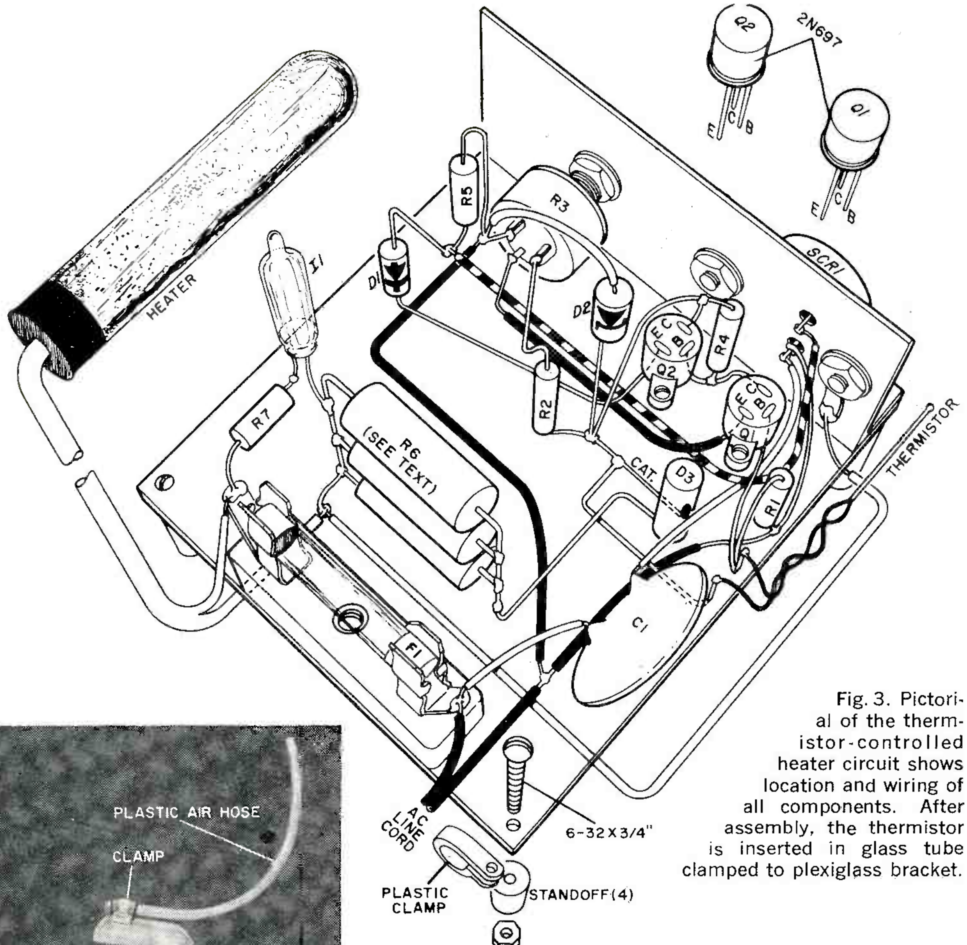


Fig. 3. Pictorial of the thermistor-controlled heater circuit shows location and wiring of all components. After assembly, the thermistor is inserted in glass tube clamped to plexiglass bracket.

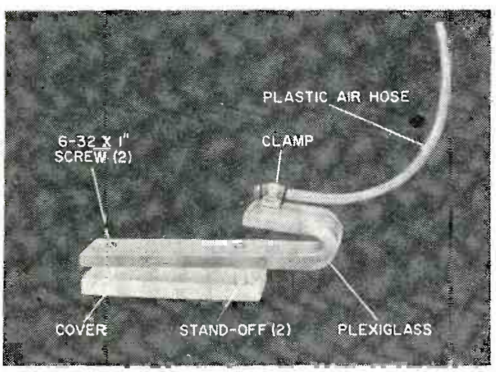


Fig. 4. Mount formed plexiglass on plastic container cover using standoff supports and screws indicated. Use a flat washer on either side of the cover to prevent premature rupture of the plastic. Thermistor glass tube shield is secured under clamp.

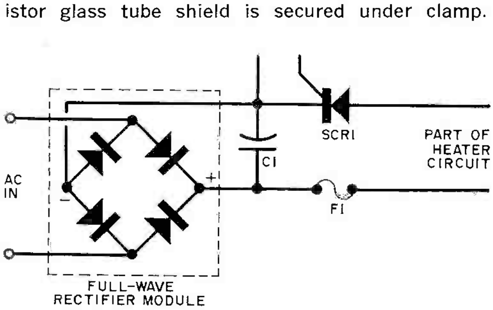


Fig. 5. A full-wave bridge rectifier in the line circuit causes the SCR to conduct on both half cycles, resulting in a doubling of the heater power.

out the glass so that it seals itself. If you want to round off the sealed end of the tube, simply heat the end some more.

Testing. After carefully checking out your wiring, give the circuit a dry run—outside of the aquarium. Plug in the unit and adjust temperature control potentiometer *R3* until the neon light comes on, indicating that the heater is working.

Now place the thermistor glass tube in the palm of your hand and squeeze the tube gently to apply a little heat. If the light goes out, the indication is that all is working well. If the light stays on, try readjusting *R3* slightly until it goes out.

Caution: Do not operate the heater out of water for any extended period of

(*Continued on page* 145)

DWELL METER ADAPTER

Use your voltmeter to adjust your ignition points with precision

By DAVID H. BOZARTH

TO OBTAIN the hottest possible spark under most operating conditions in a conventional ignition system, the dwell angle of the ignition points should be adjusted in accordance with the manufacturer's specifications in most cases. If the need for a dwell meter does not justify the cost of purchasing one, you can build this voltmeter adapter to enable your meter to read out dwell angle. By using parts from the surplus market, you should be able to hold the total cost below $2.00.

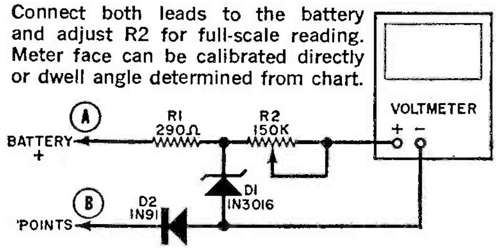
Construction is straightforward and—except for observing polarity—assembly, wiring, and parts layout are not critical. The adapter can be made to plug directly into a voltmeter as shown, or be connected to the voltmeter with a pair of leads. The meter "averages" the pulses and gives a voltage reading which is essentially proportional to the percent of time the points are closed. This percentage may be related to degrees by use of the dwell angle conversion chart on page 147.

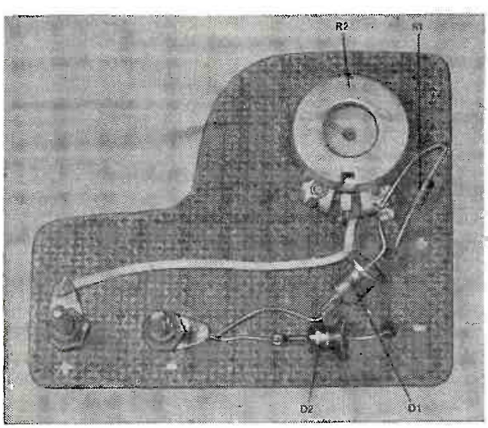
To calibrate the adapter, attach lead *B* to the negative side of the battery and adjust *R2* to obtain a full-scale reading on the meter. Use the 5-volt d.c. scale if your meter has one, otherwise the nearest one to it but below the 6.8-volt limit imposed by the zener diode. A full-scale reading would then be an indication of essentially 100% dwell time (points always closed).

To use the adapter, remove lead *B* from the battery and attach it to the terminal on the distributor going to the primary winding of the ignition coil. (It may be easier to attach the lead to the coil.) On an 8-cylinder engine, for example, if you obtain a 3-volt reading on a 5-volt scale, simply multiply 3 volts by 9 (9° per volt) and you'll arrive at a dwell-angle indication of 27°.

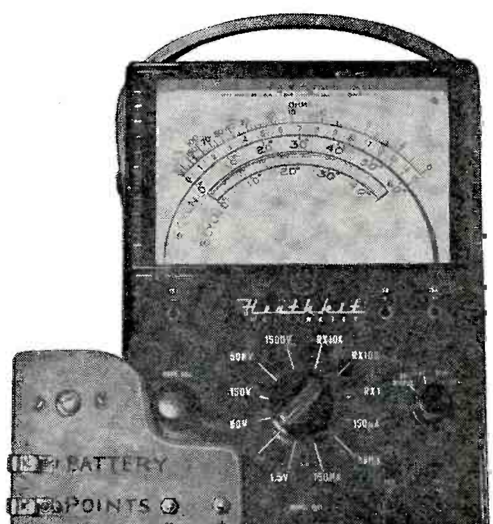
(*Continued on page* 147)

Connect both leads to the battery and adjust R2 for full-scale reading. Meter face can be calibrated directly or dwell angle determined from chart.





All parts, including banana plugs, are mounted on a piece of fiberboard shaped to conform to the meter.



Only two leads are needed to complete hookup to positive side of battery and ignition points.

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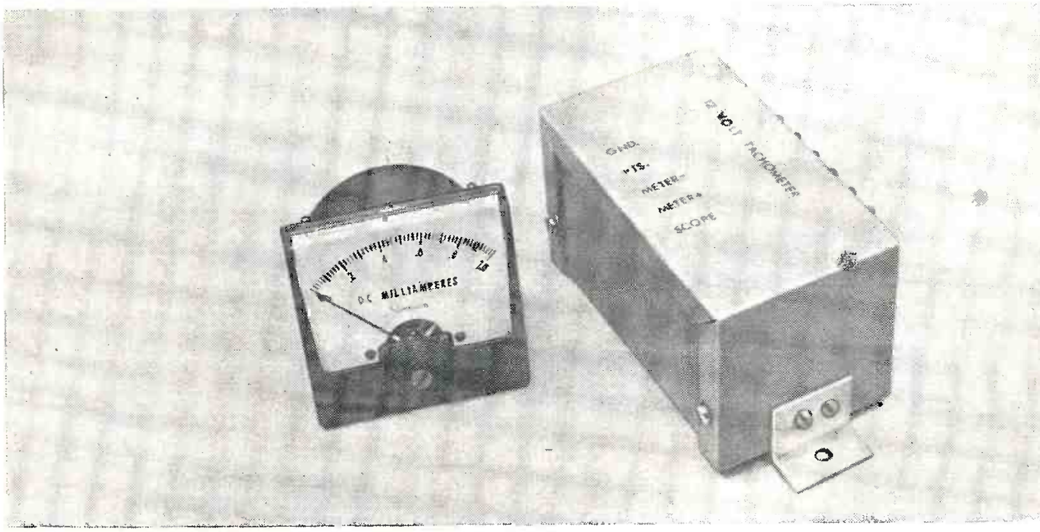
CIRCLE NO. 19 ON READER SERVICE CARD

SOLID-STATE TACHOMETER for CD

By MURRAY GELLMAN



ABSENCE of inductive kick across the ignition points in a capacitor discharge (CD) or transistor ignition system prevents many commercially available tachometers from operating properly. Some of these tachs use a vibrator type of chopper and batteries; others use diodes and transistors which are not fast enough to give a true rpm indication. Still others, especially those with inductive input components, tend to load down the ignition system, depriving it of a significant amount of high voltage. Here's a tach that requires very few parts and no batteries, is easy to build, and won't steal any high voltage from your spark plugs.

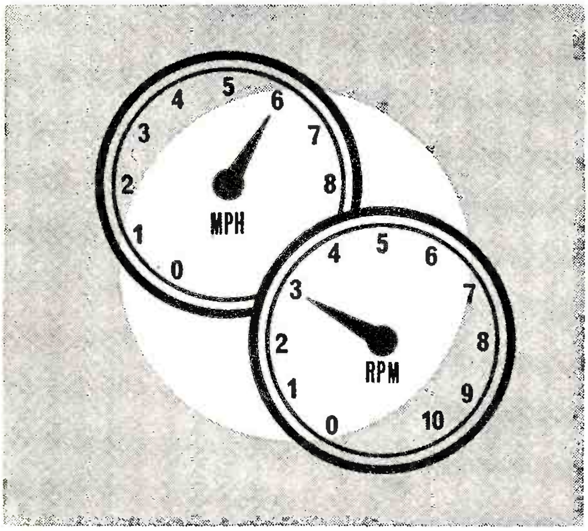
The entire works including the meter can be put into one package, or as is commonly done, divided into two units—the meter, as one unit, acting as a receiver, and the other components in another unit acting as a sender. The receiver can be mounted on the dash or steering column within view of the driver; the sending unit can be located in any convenient place, including the engine compartment—but keep it away from the hot engine.

How It Works. In a negative-ground CD or transistor ignition system, the battery voltage appears across the points as a positive-going rectangular pulse when the points open and close. The pulse is applied across *D1* and *R1.* Zener diode *D1*, a 1N3017, limits the pulse peak applied across the remainder of the circuit to 7.5 volts. Since this is well below the lowest battery voltage in a 12-volt system, the meter readings will not wander with fluctuating battery voltage.

Capacitor *C1* takes on a charge through the meter and resistors *R2* and *R3* and through *D3* when the points are open and the battery voltage is across the points. If the points were to remain open all the time, *C1* would charge up at a decreasing rate until it was essentially fully charged. Current through the meter would fall off accordingly. Initially the meter needle would start out very high on the scale and fall off to practically zero, if the needle could respond fast enough. But the engine doesn't stand still and the points keep opening and closing.

When the points close, *C1* discharges through *D2*, the closed points, and *R1*, and is ready to take on the next surge of current when the points open again. If *D2* and *D3* respond fast enough, then the average current through the meter will depend more upon the number of

or TRANSISTOR IGNITION SYSTEMS



pulses in a given time (frequency) than upon the width or shape of the pulse. The faster the circuit responds, the greater its ability to "track" the leading edge of the pulse.

Another benefit of this type of current monitoring is that the dwell time of the ignition points becomes less of an error factor and the meter reading takes on another dimension of accuracy to more perfectly reflect engine rpm. The trick then is to use a pair of diodes that have a high-speed switching action characteristic.

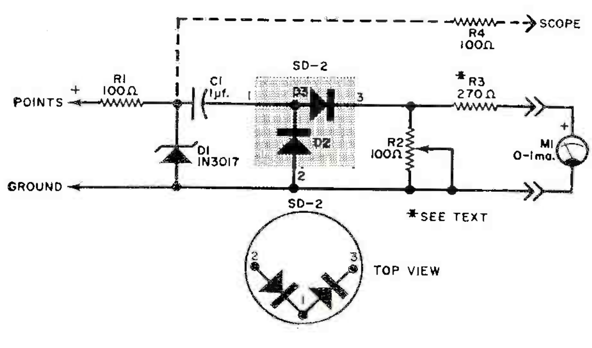
Since we have minimized—if not eliminated—pulse amplitude, pulse width, and pulse shape as meter-response factors, and have "forced" the meter to respond to the leading edge of the pulse, this circuit can be relied upon for extremely accurate readings, and to surpass many commercially available products. As the meter readings are directly proportional to the pulse frequency and since pulse frequency is in direct proportion to engine rpm, the meter can be calibrated to read out rpm.

Resistors *R2* and *R3* are used to calibrate the meter. Resistor *R4* is optional and need not be installed, unless you intend to monitor the waveform across the points with a scope. Not shown is a 0.005-μf. capacitor which can be put across *R2* to act as an r.f. bypass to prevent the tach from causing radio interference.

Construction. All parts except the meter are enclosed in a 2¼" x 4" x 2¼" box. Two small L-brackets are attached to the sides of the box to facilitate mounting. Parts layout is not critical, and a larger or smaller box can be used if desired.

The size of the meter does not matter, either, but the meter movement should be 0-1 ma. for a 10,000-rpm full-scale reading, or 0-500 μa. to obtain full-scale deflection at 5000 rpm. You could then use the existing scale and multiply by 1000 to determine rpm. (A reading of

Current through the meter is a function of pulse frequency; pulse frequency is a function of engine rpm. Fast-acting diodes (SD-2) enable the circuit to respond to the leading edge of the pulses to minimize significance of pulse shape and width. Zener diode D1 regulates voltage peaks to make the readings independent of battery voltage fluctuations.



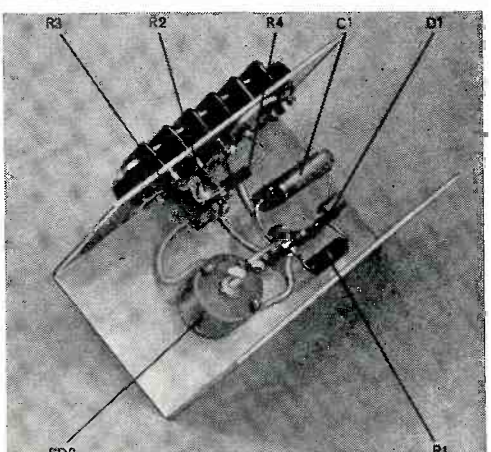
3.5 ma. would indicate 3500 rpm.) When other commercial rpm meters are used, *R3* may have to be jumped, as some of them incorporate 0-2 ma. movements. Regardless of scale markings or meter movements used, you should calibrate the tach before you install it in your car.

Diodes *D2* and *D3* are fast-acting avalanche types, and are available in matched pairs to within 5% for forward conduction, rise time, and linearity. (See Parts List.) These diodes (Module SD-2) are encapsulated in a compound to keep them both at the same temperature. Maximum variation in the rpm reading due to temperature change is less than 1%. You can substitute other fast acting diodes for this purpose, such as 1N645, but you are more likely to do better with the SD-2 module. By all means observe po-

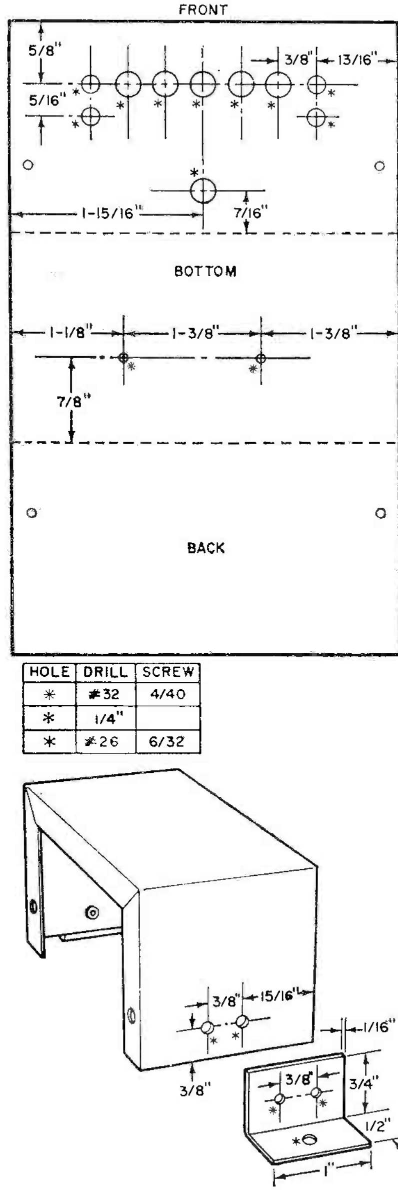
PARTS LIST

B1—12-volt battery
C1—1-µf., 100-volt capacitor (for 6-volt systems or 2-cycle engines, use 2 µf.)
C2—2-µF, 100-volt capacitor
D1—1N3017 zener diode (for 6-volt systems, use a 1N3824)
D2, D3—SYDMUR SD-2 module (1N645 or equivalent)*
D4—1N91 diode
D5, D6—1N34 diode or equivalent
M1—0-1 ma. meter for direct calibration to 10,000 rpm (for 5000-rpm maximum reading, use 0-500 µa. meter)
Q1—2N173 transistor
R1—100-ohm, 1-watt resistor
R2—100-ohm carbon, lock-shaft potentiometer
R3—270-ohm, ½-watt resistor
R4—100-ohm, ½-watt resistor
R5—150-ohm, 2-watt resistor (use 47-ohm, 2-watt resistor for capacitor-discharge ignition systems)
R6—6800-ohm, 1-watt resistor
S1, S2—S.p.s.t. switch
T1—Low-voltage rectifier transformer; 117-volt primary, 24-volt center-tapped secondary
1—2¼" x 4" x 2¼" box (Premier PMC 1003, or equivalent)
Misc.—Terminal strips (2), L brackets (2), machine screws and nuts, wire, etc.

**Available from SYDMUR, P.O. Box 25A, Midwood Station, Brooklyn, N.Y., for $3.50.*



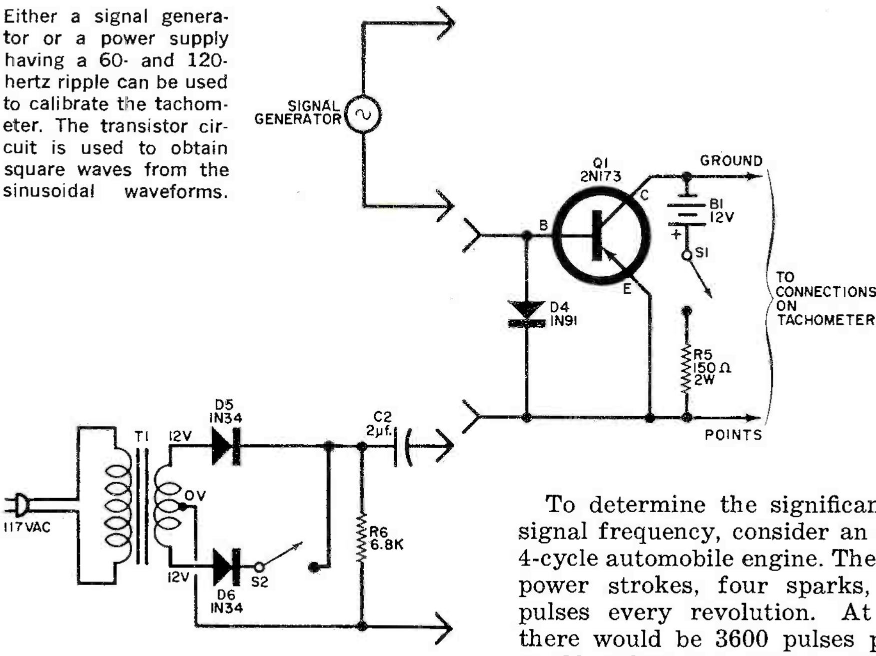
Parts layout of sending unit is not critical. Fast-acting diodes are encapsulated to keep them both at the same operating temperature for minimum error.



HOLE	DRILL	SCREW
*	#32	4/40
*	1/4"	
*	#26	6/32

Location and size of holes may vary for different style of terminal strip. It's a good idea to lay out all parts before drilling any holes in the box.

Either a signal generator or a power supply having a 60- and 120-hertz ripple can be used to calibrate the tachometer. The transistor circuit is used to obtain square waves from the sinusoidal waveforms.



larity of the diodes and the external connection to the distributor.

Potentiometer *R2* is a locking-shaft type to prevent adjustment drift due to vibration.

Calibration. The tach can be calibrated with an audio oscillator having at least a 10-volt r.m.s. output. You can take advantage of the 60- or 120-hertz pulses developed in an ordinary half-wave and full-wave rectifier circuit as shown in the diagram. When *S2* is open, the output frequency is 60 hertz; and when it is closed, the output pulses occur at 120 hertz. In order to obtain a rectangular pulse which more nearly resembles the pulse from the distributor, you can feed the test signal from the generator or the rectifier circuit through the wave squarer made up of *Q1*, *D4*, *B1* and *R5*.

To determine the significance of test signal frequency, consider an 8-cylinder, 4-cycle automobile engine. There are four power strokes, four sparks, and four pulses every revolution. At 900 rpm, there would be 3600 pulses per minute or 60 pulses per second. Therefore, a test signal of 60 hertz is equivalent to 900 rpm. By the same token, a test signal of 120 hertz simulates 1800 rpm.

For maximum meter accuracy, select a check point as close as possible to the engine speeds you are most likely to attain most of the time. Since circuit action is essentially linear, all you need is a single test point. Refer to the calibration and conversion chart to find out what test signals you can use for 4-, 6-, and 8-cylinder, 2- and 4-cycle engines.

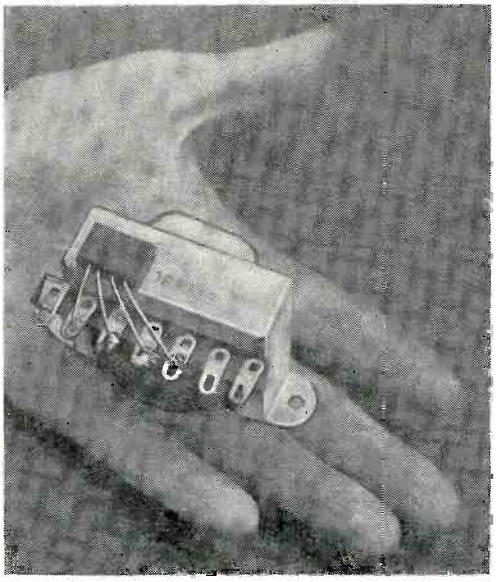
Special Considerations. For 2-cycle engines, capacitor *C1* should be a 2-μf. unit. For 6-volt ignition systems, *D1* should be a 1N3824 zener diode (4.3 volts), *R1* a 39-ohm, 1-watt resistor, and *C1* a 2-μf. capacitor. For positive ground systems, simply reverse the leads going to the distributor from the tachometer. Happy motoring. –30–

CALIBRATION AND CONVERSION DATA CHART

Cylinders	K		fK (4-cycle engine) = rpm			R3
	2-cycle engine	4-cycle engine	60 hertz (rpm)	120 hertz (rpm)	200 hertz (rpm)	(approx. ohms)
4	15	30	1800	3600	6000	47
6	10	20	1200	2400	4000	150
8	7.5	15	900	1800	3000	240

BUILD A

HANDFUL OF POWER

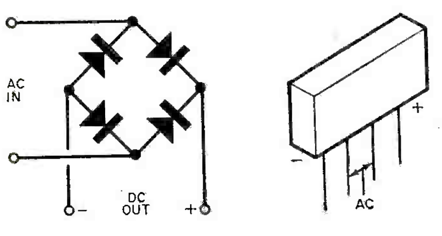


TINY MODULAR RECTIFIER CIRCUITS SIMPLIFY CONSTRUCTION OF A.C.-OPERATED D.C. POWER SUPPLIES

By **EDWARD M. LONG**

A NEW generation of pre-packaged full-wave bridge rectifiers for a.c.-operated low-voltage d.c. power supplies has recently appeared on the horizon. Made of matched diffused-junction silicon rectifiers encased in epoxy, these units can be used with any filament transformer to provide a "handful" of d.c. power for operating transistorized circuits, low-voltage d.c.-operated equipment, or for test purposes.

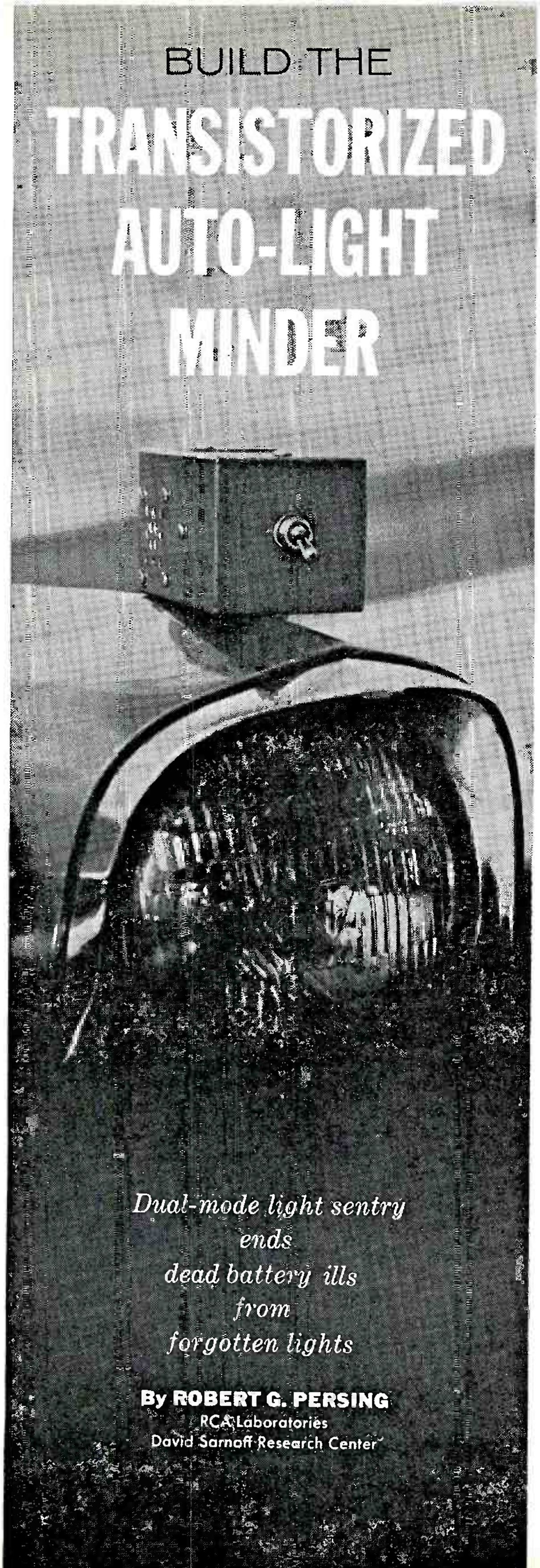
These prepackaged rectifiers are currently being produced by a number of firms, and are being marketed through electronic parts distributors. The Mallory FW-50 unit, rated at 1.5 amperes, 50 PIV, was selected for illustrative purposes. It can be used with either a 12-volt or 24-volt miniaturized filament transformer.



Hardly bigger than a thumbnail, the new prepackaged bridge rectifiers offer numerous advantages to the circuit designer as well as to the experimenter.

The power supply in the photo shows the rectifier module mounted on the transformer (Olson Electronics T-290) and connected through a terminal strip. Both the rectifier and the terminal strip are fastened on the transformer with epoxy. The extra lugs on the terminal strip can be used for mounting a filter circuit, if one is desired.

As shown in the diagram, the a.c. input leads are connected to the center legs while the d.c. output leads are connected to the outer legs. If it is desired to improve the d.c. regulation of the power supply, a bleeder resistor can be connected across the d.c. output terminals. The value of the bleeder will depend on the load requirements. —30—



BUILD THE

TRANSISTORIZED AUTO-LIGHT MINDER

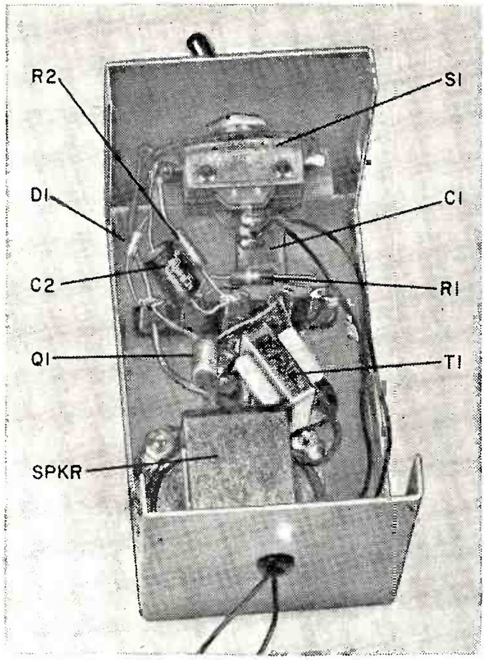
Dual-mode light sentry ends dead battery ills from forgotten lights

By ROBERT G. PERSING
RCA Laboratories
David Sarnoff Research Center

HAVE YOU EVER left your car in a parking lot and returned several hours later to find that you forgot to turn your lights off and that your battery has run down? Join the club. This kind of negligence seems to be most prevalent on rainy, overcast days or at dusk when many people have their lights on. For only $7, and a few hours of your time, you can build the "Auto-Light Minder" and eliminate the problem forever.

When you install the Auto-Light Minder in your car, it will sound an alarm if you leave your lights on after you turn off the ignition. Turn the lights off, and the alarm will stop. It's that simple. And there is a circuit for every car, whether it has a 6- or 12-volt positive or negative ground system.

The Auto-Light Minder also has a reverse mode of operation, which lets you intentionally leave your lights on when the ignition switch is off . . . without sounding the alarm. But when you turn on the ignition switch, the alarm sounds off to remind you that you are trying to start your car at the same time your lights are on, and also to alert you to the fact that the alarm is not set to work in a forward mode. The Auto-Light Minder is foolproof, and it never "forgets."



Simplicity of construction and small number of components enable you to quickly assemble the light minder and to end forgetting to turn the lights off.

PARTS LIST

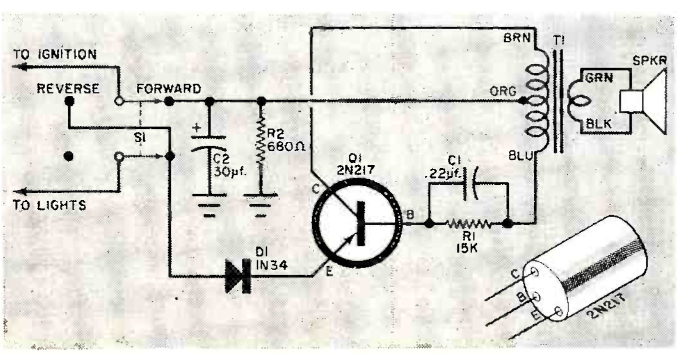
C1—0.22-µf., 25-volt (minimum) ceramic capacitor
C2—30-µf., 15-volt (minimum) electrolytic capacitor
D1—1N34 diode
R1—15,000-ohm, ½-watt resistor
R2—680-ohm, ½-watt resistor
Q1—2N217 transistor (for positive ground electrical systems, use a 2N647—see text)
S1—D.p.d.t. switch
T1—Output transformer: 400-ohm, center-tapped primary; 11-ohm secondary
1—1½" 11-ohm speaker
1—2¼" x 2¼" x 4" box (Premier PMC 1003 or equivalent)
Misc.—Terminal strip, grommet, machine screws and nuts, wire, etc.

How It Works. The Auto-Light Minder is essentially a one-transistor oscillator circuit that works when battery voltage is applied only to the emitter of *Q1*. Battery voltage is fed to the unit from two possible places in the car: the ignition system and the light system. Sometimes this voltage comes from either one of these places and sometimes it comes from both places.

In the forward mode of operation, battery voltage from the ignition system is connected to the collector, and battery voltage from the light system is connected to the emitter; if the ignition switch is on, and the lights are on, both the collector and the emitter of *Q1* are at the same potential. Under these conditions, the circuit will not oscillate, and the alarm will not sound. If the ignition is turned off, and the lights are left on, the collector is returned to ground through part of *T1, R2* and *C2,* and develops the bias voltage necessary for the circuit to oscillate. If you turn the lights off, the supply voltage is removed from the emitter and the circuit ceases to oscillate. Diode *D1* protects the transistor against a reverse battery voltage.

In the reverse mode of operation—you merely flip *S1* to obtain either the forward or the reverse mode—the voltage from the light system is completely disconnected from the Auto-Light Minder, and the lights can be turned on without triggering the alarm. However, when the ignition is turned on, it will place the necessary voltage on the emitter of *Q1* and cause the alarm to sound. To shut off the alarm, throw *S1* into the forward position and you won't be bothered again unless you shut off your engine and leave your lights on.

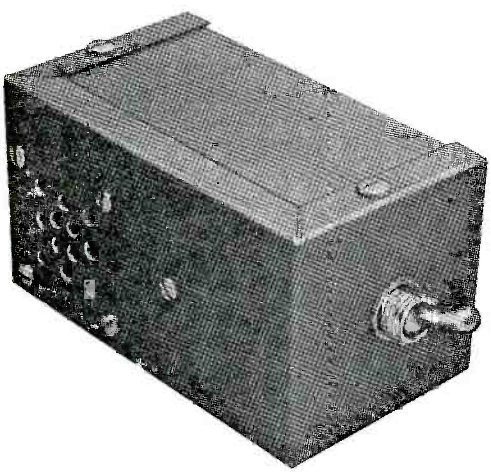
The negative ground Auto-Light Mind-



One-transistor oscillator "sounds off" when the full-battery voltage is applied to the emitter only. In the "Forward" position of S1, the alarm will sound if the lights are on and the ignition switch is off. In the "Reverse" position, the lights can be left on without sounding the alarm only if the ignition switch is off. Just as you are not likely to forget to turn off your lights with this device, you are not likely to have difficulty starting your car because you are trying to do so with the lights on.

er shown is easily adapted to a positive ground system, with only three minor—but very important—differences in the wiring: (1) a 2N647 *npn* transistor is used for *Q1*; (2) the positive side of electrolytic capacitor *C2* is connected to the ground lug of the terminal strip; and (3) the anode of diode *D1* is connected to the emitter of *Q1*, and the cathode goes to *S1*. The instrument can be operated in either 6- or 12-volt systems without any circuit changes.

Construction. All components are mounted in a small metal box. Begin construction by drilling holes to mount the tiny speaker, switch, terminal strip, and grommet. The approximate location of the components is shown in the photograph. Drill several small holes for the speaker grille and insert a piece of grille cloth or wire mesh between the speaker and the box to prevent possible damage to the speaker.



Completed unit should be located within easy reach of the driver. Only two wires connect the alarm to the lights and ignition system. Ground the case.

One side of the transformer can be held in place with one of the speaker mounting screws, and the other side with the same screw that is used to mount the terminal strip. All the small components are connected either to the terminal strip or to the switch. Be sure to use a heat sink when soldering the diode and transistor leads.

The wires going from *S1* to the ignition switch and to the light switch should be well insulated and flexible to withstand vibration. These leads should be sufficiently long to avoid strain and should be marked to insure correct connections to the ignition and light systems.

Installation. A location near the driver's seat is desirable in order to keep *S1* within easy reach. Do not block the speaker opening. In most cases, under the dash near the steering column is the best place for the unit. A couple of self-tap screws will hold the box in place. Before drilling holes in the dash for the screws, make sure that your drill or screws will not damage any wires or instruments behind the dash.

The lead to the ignition system should be connected to the ignition switch terminal which is connected to the ignition coil. If you have difficulty in getting to the ignition switch, you can make this connection at the ignition coil; but be sure to make it on the top side of the primary winding of the coil, and not the side going to the distributor.

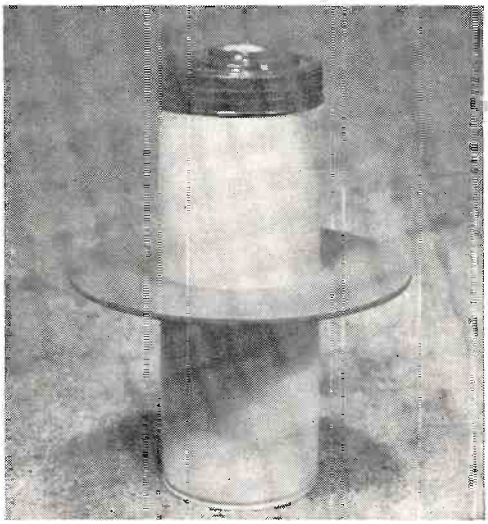
Connection to the light system should be made at the light switch terminal which is connected to the taillights. Since the taillights go on when the parking or driving lights are on, the "Auto-Light Minder" will work on the high and low beams, and when the parking lights are on.

Be careful not to create a short circuit while you are installing the unit. Disconnect one side of the battery to be on the safe side. An accidental short with a screwdriver or wrench will cause sparks to fly and possibly destroy or fuse the points of contact.

To check for correct operation, set *S1* in the forward position with the ignition switch off, and turn on the lights. The alarm should sound. Turn on the ignition switch, and the alarm will stop (it should not be necessary to start the car). Now flip *S1* to the reverse position, and the alarm should sound. Turn the ignition off (*S1* still in the reverse position and the lights still on), and the alarm will stop. Return *S1* to its forward position, turn your lights off, and then forget about forgetting to turn off your lights. —30—

$2 INTRUSION ALARM

BLAST OF SOUND GREETS ANY UNWELCOME VISITORS



This innocent-looking thingumajig is a burglar alarm. Knock it over and it emits a raucous, honking noise. Secret of the alarm is a mercury switch.

The author used a metal strap attached to the horn and battery holder to mount the mercury switch. The cardboard ring, which permits the alarm to roll, is simply press-fitted to the tubular container.

THAT'S RIGHT! For a two-dollar bill you can build a portable, dependable, effective alarm. It gives forth with a strident honk whenever a door or window to which it is connected is opened or moved.

The heart of this warning device is the innards from one of those cheap (79¢) bicycle horns seen in auto supply and novelty stores. These horns consist of a very loud honker, a single "D" cell holder, and a push button. While you're in the auto supply store, also purchase one of those tubular cans of tire patching material.

Cut a ½" hole in the metal lid of the tubular can and solder the horn-battery unit to the inside of the lid. Then substitute for the horn button a glass tube mercury switch which is available from most electrical supply houses.* Attach the switch to the battery holder in such a position that the mercury closes the contacts and blows the horn when the unit is tilted from a vertical position.

When you place the alarm upright against a door (in the direction it opens), opening the door will knock the alarm over and sound a warning. If the door opens in the opposite direction, a length of string looped from doorknob to alarm will pull the alarm over. Similarly, a length of string from the alarm to a window will pull it over when the window is opened.

You can also attach the alarm to the door of a cabinet, the lid of a storage chest, a power tool you don't want moved, or anything of this kind. Its small size makes it very handy to take on trips (remove the battery first) for use on those poorly secured hotel and motel doors. And you'll probably think of many other uses for this two-buck alarm.

—*R. L. Winklepleck*

**Mercury switches are also available from Poly-Paks at about three for a dollar.*

CHAPTER

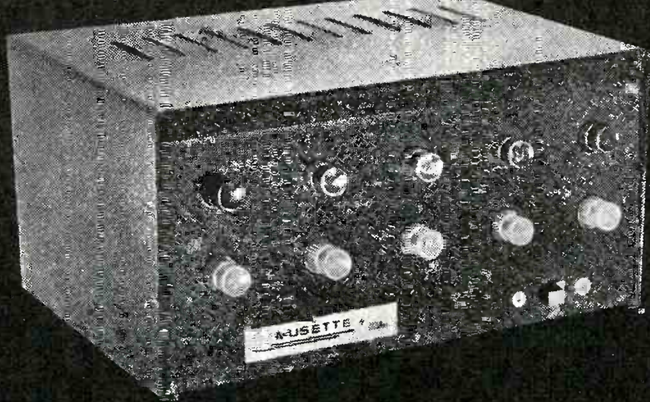
2

AUDIO STEREO HI-FI PROJECTS

If you are a regular reader of the ELECTRONIC EXPERIMENTER'S HANDBOOK, you will not be surprised to find that Dave Weems has provided us with a couple more speaker system enclosure stories. This makes it nine Handbooks in a row that have featured Dave's hi-fi designs. In this issue of EEH, there are two entirely different enclosure ideas—one with "acoustic resistance" (page 61) and one with a labyrinth (page 56). If you're handy with woodworking tools, we're sure you'll find either one of these enclosures a satisfactory addition to your hi-fi outfit.

Several low- and medium-power color organs have been published in previous editions of EEH. At the request of many readers, we asked Don Lancaster to build a color organ that had "power"—and he came up with the "Musette"—750 watts of colorful illumination (page 46). The design is relatively simple and the power-handling capabilities make this one of the most attractive (no pun) projects we've published.

Chuck Caringella's stereo headset adapter (page 53) may—at first glance—seem like a lot of useless nonsense, but look at it closely and then look at your stereo amp. Can you balance, vary, and switch the sound from your easy chair? If you can't—this project is for you.



BUILD THE

MUSETTE

A true high-fidelity multichannel musical kaleidoscope for home entertainment

By DONALD E. LANCASTER

MORE COLORFUL than a performance of Swan Lake by Disney's spectacular dancing waters . . . more vibrant than any Discotheque party you've seen . . . "Musette," the color organ *par excellence*, swings and sways as it interprets your favorite tunes in delightful kaleidoscopic animation.

Unlike most low-cost, low-power, photocell-operated color organs (see article in POPULAR ELECTRONICS, March, 1965, p. 43), Musette is truly a high-fidelity, high-power instrument. It separates the applied audio from your hi-fi amplifier, AM, FM, or FM stereo receiver into component frequency bands (hereafter called channels). Five such channel separations are provided to cover the full frequency range (see Fig. 1).

The output from each of the five channels can operate up to a 150-watt color purity spotlight to put on a spectacular dancing performance indoors on your wall or ceiling, or outdoors on a special display. For, Musette plays tunes in lights—instead of sounds—by translating the pitch, rhythm, and loudness of speech or music to corresponding variations of color, hue, and brightness.

As a five-channel spotlight control center, Musette can be used for dance hall or patio decoration, as stage lighting for the "Little Playhouse," or as an advertising and sales attraction.

If you are willing—and able—to tackle a really advanced project, and can afford to lay out the 80-odd-bucks for materials alone, the building of Musette should prove to be a rewarding experience. If, on the other hand, you can't swallow

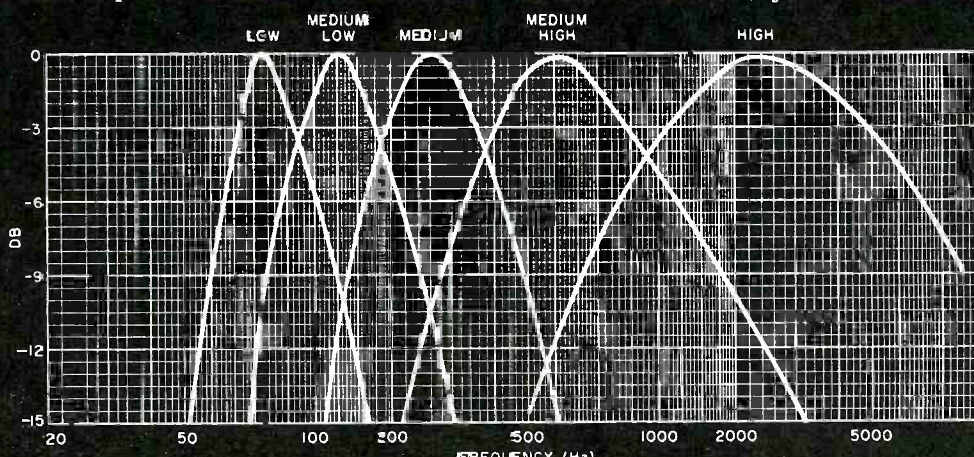
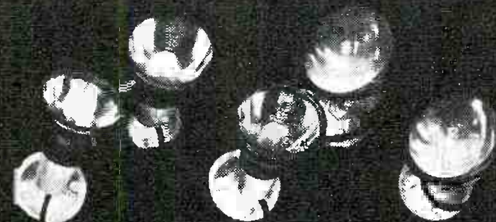


Fig. 1. These frequency response curves show the relative attenuation of each band of frequencies in the audio spectrum.

COLOR ORGAN



the high price tag in one gulp, you can still bite off, build, and use the unit one channel at a time, adding more channels when money and time permit.

For maximum utilization of the organ while building, you should start with the *high* and *medium* frequency channels. These channels cover a relatively wide range of instruments. Then you can tackle the *medium high, medium low,* and *low* channel, in that order.

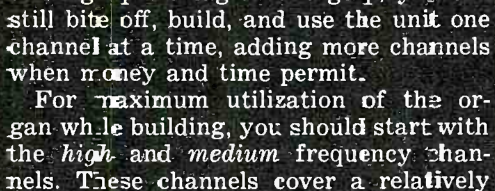


Fig. 2. Simplified schematic shows how an SCR can be made to fire in synchronism with the a.c. line frequency.

Simplified Circuit. To understand the inner workings of Musette first consider the simplified lamp control circuit of Fig. 2. A lamp in series with a silicon-controlled rectifier (*SCR1*) makes up the load across the output of a full-wave rectifier (*D1* through *D4*).

The SCR that controls the lamp is triggered by a pulsing circuit consisting of avalanche breakdown (trigger) diode *D5*, a capacitor charging circuit (*C1-R1*) and biasing resistor *R2*.

When the charge on *C1* reaches 30 volts, trigger diode *D5*, interposed between the charging capacitor (*C1*) and the SCR gate, switches on, causing the capacitor to discharge and trigger the SCR. The ratio of *on* period to *off* period, and thus the average brightness of the lamp, is determined by the adjustment of *R1*, which establishes the charging time of *C1*. Thus, if *D5* turns on the SCR at the start of each half cycle, the lamp will stay on longer than if the SCR is turned on later in that half cycle.

Now if a negative voltage is applied to the cathode side of *D5*, the effect will be to pre-bias the diode so that it conducts and triggers the SCR earlier during each half cycle. The greater the negative bias, the earlier the SCR will be turned on, and the longer will be the *on* cycle that applies power through the lamp. Initially, potentiometer *R1* is adjusted to set the lamp at a minimum brightness level. Then, any varying negative voltage across *R2* will produce a corresponding variation in brightness levels.

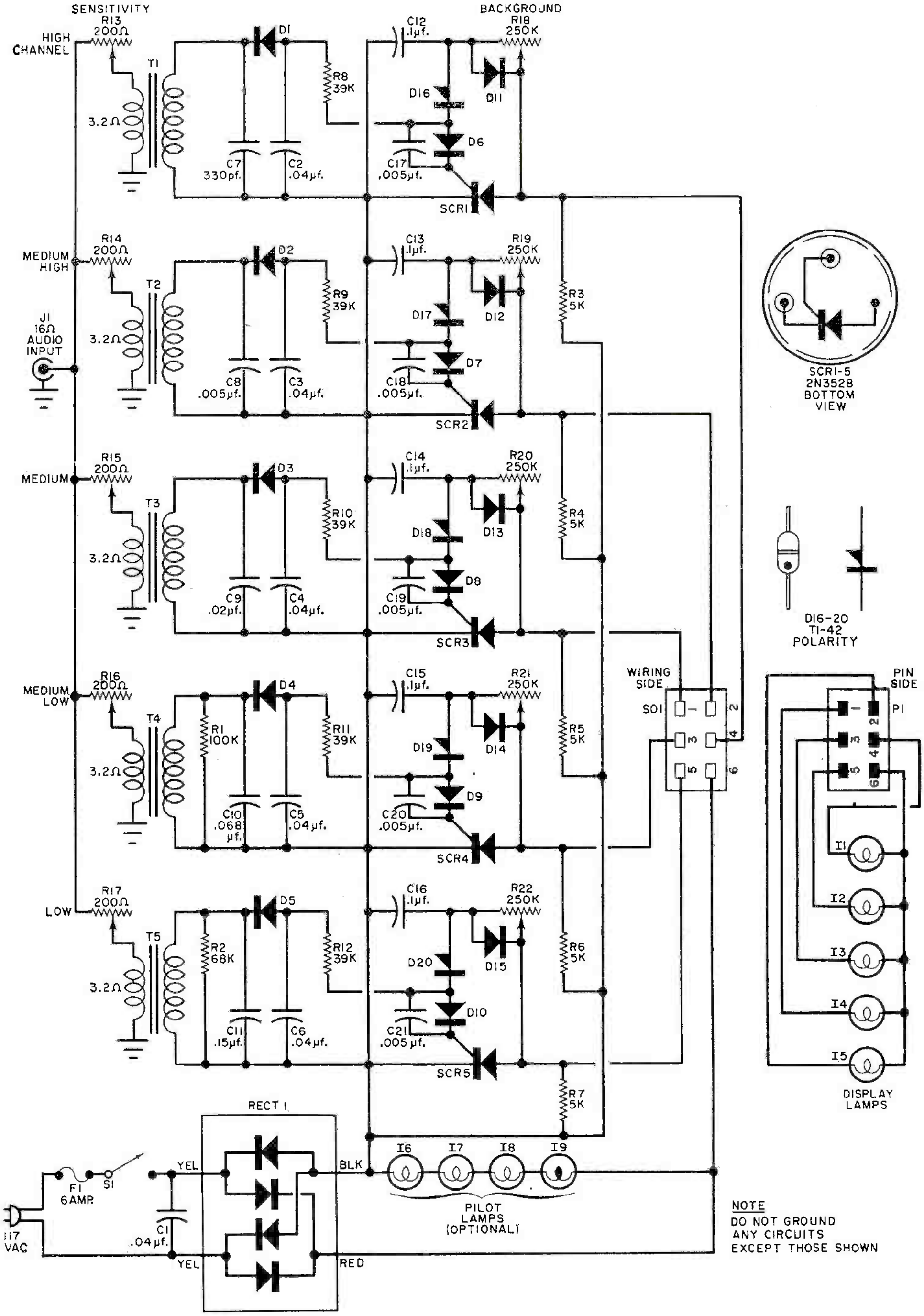


Fig. 3. Overall circuit of five-channel color organ is made up of five basic circuits easily identified by individual input transformers (T1 through T5). Each circuit operates its own display lamp.

PARTS LIST

C1-C6—0.04-μf., 200-volt Mylar capacitor
C7—330-pf., 600-volt disc capacitor
C8, C17-C21—0.005-μf., 600-volt disc capacitor
C9—0.02-μf., 200-volt Mylar capacitor
C10—0.068-μf., 200-volt Mylar capacitor
C11—0.15-μf., 400-volt Mylar capacitor
C12-C16—0.1-μf., 200-volt Mylar capacitor
D1-D10—1N4001 silicon diode (or equivalent)
D11-D15—1N4003 silicon diode (or equivalent)
D16-D20—Texas Instruments TI-42 pnpn trigger diode, or Motorola MT 30 trigger diode
F1—6-ampere fuse (and fuse holder)
I1-I5—117-volt, 150-watt interference filter spotlight (General Electric PAR38 DICHRO-COLOR in red, orange, yellow, green, and blue, priced at $4.98 each, and available from electrical supply houses—or any combination of incandescent 117-volt lamps not exceeding 200 watts per channel nor less than 10 watts per channel)
I6-I9—28-volt pilot light (GE 313)—optional
J1—Phono jack
P1—6-prong, high-current cable clamp plug (Cinch Jones P-306-CCT)
R1—100,000-ohm, ½-watt resistor
R2—68,000-ohm, ½-watt resistor
R3-R7—5000-ohm, 5-watt wirewound resistor (Ohmite 995-5B-5000 or equivalent)
R8-R12—39,000-ohm, ½-watt resistor
R13-R17—Centralab TT-2 potentiometer, 200-ohm Twist-Tab mount, linear taper
R18-R22—Centralab TT-50 potentiometer, 250,-000-ohm Twist-Tab mount, linear taper
RECT 1—10-ampere, 200-volt, single-phase, full-wave bridge rectifier assembly (Motorola MDA 962-3 at $4.85—no heat sink required)
SCR1-SCR5—2N3528 silicon-controlled rectifier (RCA), 1.6 amperes, 200 volts
SO1—6-prong, high-current socket (Cinch Jones S-306-AB)
S1—S.p.s.t. slide switch, 6 amperes, 110 volts
T1-T5—Thordarson 24S54 audio output transformer: primary, 15-20,000 ohms; secondary, 3.5 ohms, 5 watts (do not substitute); available from Newark Electronics, No. 5F2004, for $1.28 each in lots of 5, plus shipping
1—8" x 6" x 4½" cabinet (LMB CB-2, available in grey, brown or black)
*1—Set of Tenite translucent knobs (10 knobs colored red, orange, yellow, green, blue, and milky white)—optional**
*1—6¾" x 2⅜" printed circuit board***
1—7" x 3¼" x 1/32" aluminum sheet (for bracket)
4—Bayonet pilot light sockets (Leecraft 7-11)
Misc.—¼"-high spacers (4), ¾"-high spacers (8), #6 hardware, pop rivets, line cord (minimum 6-amp. rating), Heyco strain relief, wire, solder, display cable (Belden 8467), swivel-type outdoor sockets for display lamps, plywood base and junction box, display materials, reflectors or diffusors, 6-terminal strip

*Set of 10 knobs available for $3 postpaid from Musette, c/o Arthur Emerson, 4229½ N. 23rd Ave., Phoenix, Arizona 85015

**Etched and drilled fiberglass circuit board (less parts) available for $3.50 postpaid from DEMCO, Box 16297, San Antonio, Texas 78216; a special kit of major components is $40.00

In practice, this negative voltage is obtained from a rectified and filtered audio signal by an action similar to that which produces the a.v.c. voltage in an AM receiver.

Actual Circuit. Now, let's look at the overall schematic of the five-channel color organ (Fig. 3). Each channel is identified by a separate input transformer (*T1* through *T5*).

Except for the fact that each channel responds to a different portion of the audio spectrum, and thus each colored light represents a specific band of frequencies, all the channels operate in the same manner. Therefore, it will suffice to explain how a single channel operates. To make matters easy, let's discuss the channel at the top of Fig. 3. This happens to be the *high* channel.

Potentiometer *R13,* in the primary of input transformer *T1,* is used to adjust the sensitivity of the channel. Capacitor *C7,* together with the inductance provided by the secondary of *T1,* forms a parallel resonant bandpass filter. The audio across *T1* is rectified by *D1* and filtered by *C2* and *R8,* a changing negative voltage that is applied across *R8* to prefire *D16* and vary the brightness of the spotlight in the anode circuit of *SCR1.* Diode *D6* and capacitor *C17* isolate the negative voltage from the SCR's gate. All other components operate as described for Fig. 2.

Operating power is obtained from the a.c. line, and rectified by the diodes forming the full-wave bridge rectifier. Pilot lamps *I6* through *I9* provide illumination for the special translucent knobs used in the project. The display lamps (*I1* through *I5*) are connected in series with their respective SCR's through plug *P1* and socket *SO1.*

If you are an old pro and can wire directly from a schematic diagram, you may—but need not—use a printed circuit board for component layout. Actually, the only advantage you get from a printed circuit board is the elimination of point-to-point wiring which usually requires more layout space. However, in special instances like this color organ, the use of a printed circuit is almost an absolute necessity. First, the layout has been arranged to minimize and/or eliminate the chance possibility of feedback. Secondly, the printed circuit board affords the best means to mount

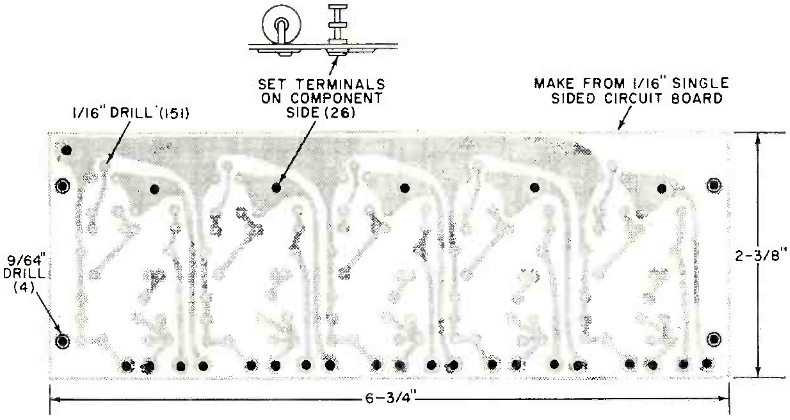


Fig. 4. Printed circuit board showing overall dimensions and drill sizes for all holes required.

your SCR's. Thus, whether you buy or etch your own—use a PC board.

If the author's design is followed, you will come up with a presentable unit that will work just as well as it looks. But you can vary the packaging, as preferred, without loss of performance.

Whatever you do, *don't* substitute any other type of input transformer for *T1* through *T5*, and be sure to use the exact value of capacitors specified for *C1* through *C7*. The reason is that each transformer and its corresponding tank capacitor comprise a parallel resonant circuit which determines the frequency bandpass of each channel.

Construction. You can start construction with the circuit board, which should be etched and drilled as shown in Fig. 4. If you prefer, you can buy this PC board (see Parts List). Mount the components on the PC board as shown in the layout guide (Fig. 5), and then put the board aside temporarily.

Cut and form an aluminum mounting bracket for the controls and pilot lamps as shown in Fig. 6. Both the dimensions of the bracket and the spacing for the mounting holes are determined by the chassis enclosure selected.

After mounting the controls and the pilot lamps on the bracket, install the bracket on the chassis, following the spacing shown in Fig. 7. Carefully measure the shaft positions, and drill or punch out the front panel holes to accommodate the potentiometer shafts. If

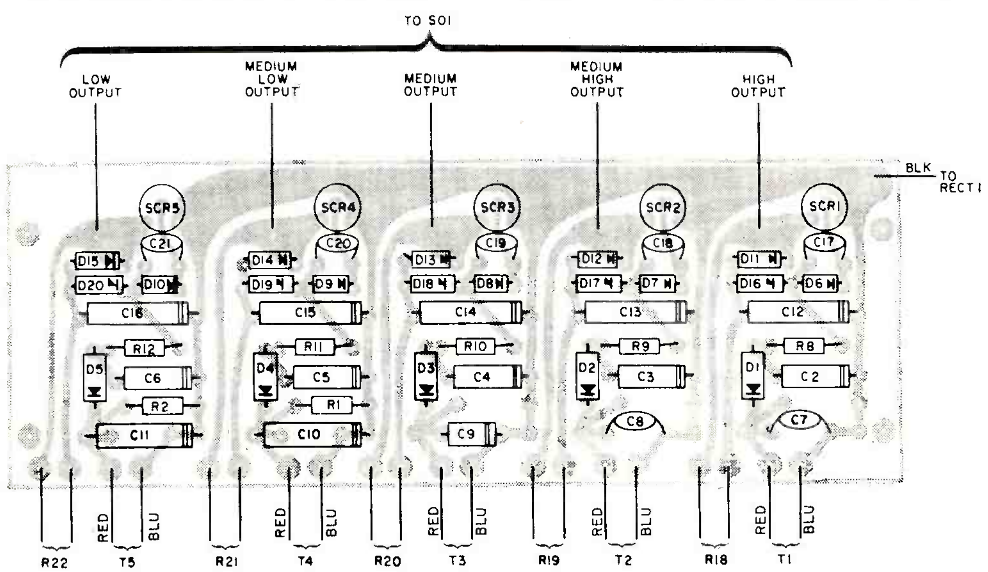


Fig. 5. When mounting parts on the printed circuit board, be sure to position the diodes with the polarity markings as shown. Also, make all input and output connections from terminal pins on the circuit board.

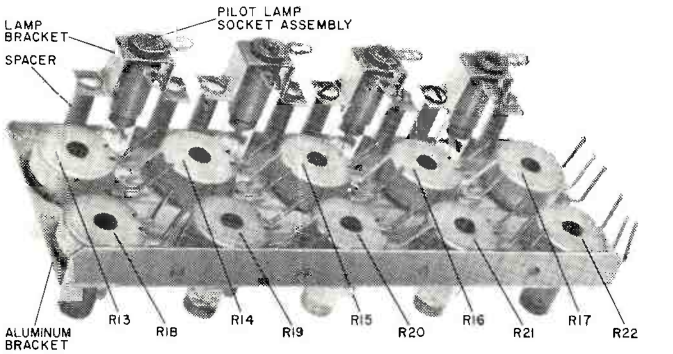


Fig. 6. The pilot lamps and controls are first preassembled on the aluminum bracket which is then mounted 5/16" behind the front panel.

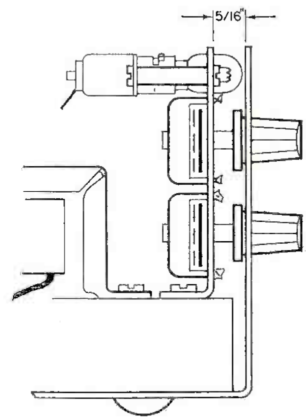


Fig. 7. Be sure to allow indicated spacing between aluminum bracket and instrument's front panel, to clear the pilot lamps.

you plan to use the recommended Tenite translucent knobs, bear in mind that each hole should be slightly larger than the knob diameter.

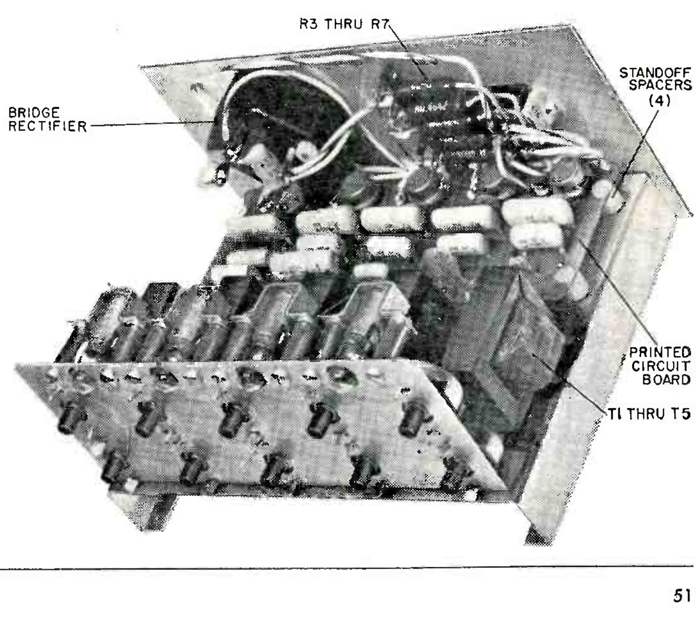
To avoid costly errors when drilling the front panel holes, make a cardboard template to use as a drill guide once you have verified all the dimensions. If you decide not to use the special knobs, make the front panel holes just large enough for the shafts. (In this case, the pilot lamps may be unnecessary.)

Finally, drill the mounting holes for the power switch in the front panel. If you don't have a rectangular punch, you can make the rectangular switch cutout by first drilling a large enough hole, and then filing the hole into a rectangular shape as required.

Now turn to the rear panel and determine a suitable layout for the input and output connectors (*J1* and *SO1*), the fuse holder, and the line cord strain relief. From Figs. 8 and 9 you can determine the best place to mount the full-wave bridge rectifier, as well as resistors *R3* through *R7* which are installed on the inside of the rear panel. Observe the mounting position of the terminal strip.

Install the circuit board on the chassis (see Fig. 8) using four spacers. The transformers are secured to the top surface of the chassis, between the front

Fig. 8. This fully assembled unit shows printed circuit board mounted on four standoff spacers. Run all point-to-point wiring to the controls and pilot lamps before installing the transformers.



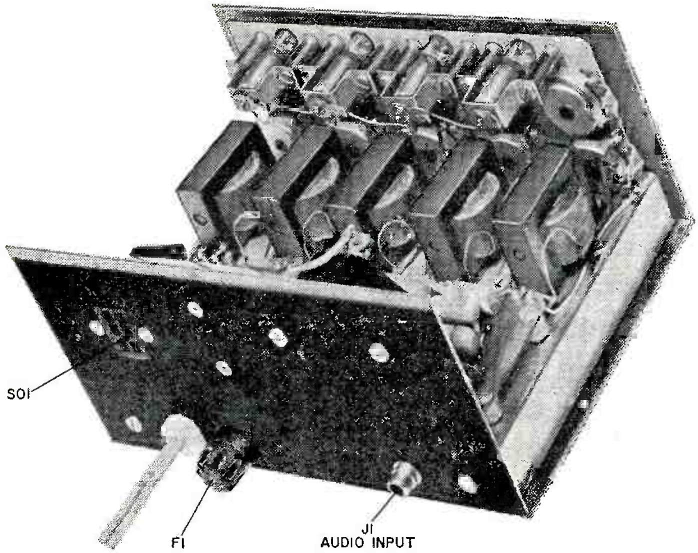


Fig. 9. Rear view of color organ with cover removed shows fuse holder F1, input jack J1, and color lamp receptacle SO1.

panel and the circuit board, with #6 hardware.

After all the parts are installed, you can begin the point-to-point wiring. Start with the power circuit by completing the connections on the rear panel. Then wire up the four pilot lamps in series as shown in Fig. 3. Wire the transformer and potentiometer leads next. After you have made all connections shown in the schematic, start testing out the instrument.

Testing. With the power switch set to the *off* position, connect an audio line from the output of your amplifier (across the speaker voice coil or the 16-ohm speaker terminals) to the input jack (*J1*) on the rear panel.

Measure the voltage, in turn, across capacitors *C2* through *C6*. Depending on the input voltage from the audio amplifier, and the setting of the respective *SENSITIVITY* potentiometers (*R13* through *R17*), the voltage across each capacitor should be somewhere in the range between −1 and −16 volts.

Best operation is usually obtained with the sensitivity control set approximately 1/8 of the way up from minimum resistance. In any case, avoid turning any of the pots all the way up as this will only overdrive the channel.

After testing and adjusting the sensitivity of each channel, disconnect the audio input. Finally, connect a 25-watt incandescent test lamp from the *hot* lead going from output receptacle *SO2* to the anode of one of the SCR's. Apply input power and vary the corresponding *BACKGROUND* potentiometer (*R18* through *R22*) to check the operation of the channel under test. The lamp should glow smoothly from minimum brightness to full brightness. Then set the potentiometer for minimum brightness. Check each of the remaining channels in the same manner.

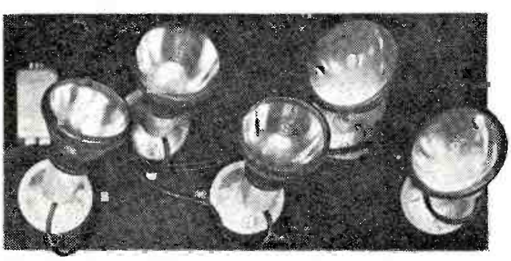
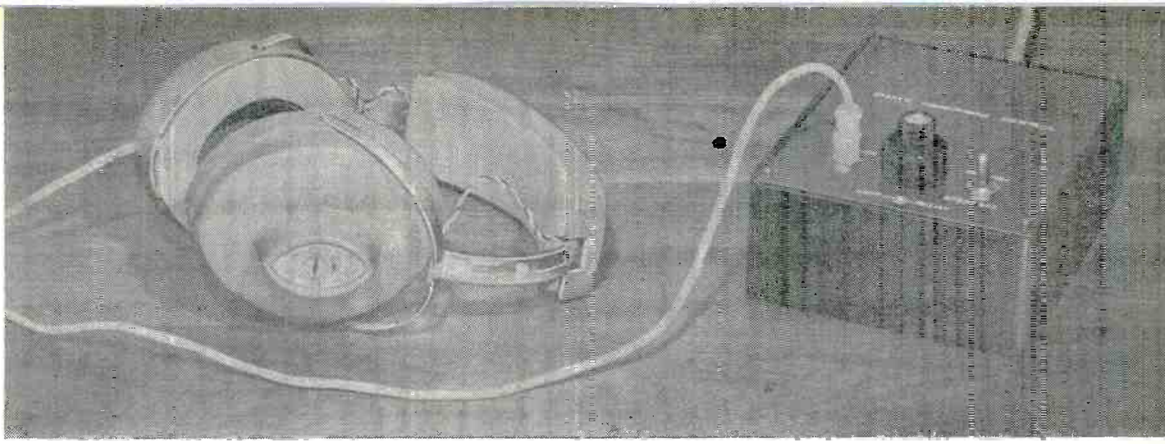


Fig. 10. The individual color spotlights which make up the display can be arranged on a common baseboard as shown for reflected or diffused projection.

Preparing a Display. A typical display arrangement is shown in Fig. 10. It is made up of five swivel-type outdoor spotlights mounted on a sheet of 13″ x 27″ x 3/4″-thick plywood. The size of the board can be varied to suit specific applications. If the lamps are to perform inside a display, you can use either diffused

(*Continued on page* 139)



CERTAIN solid-state hi-fi/stereo amplifiers require special consideration when stereo headphones are to be used. If you own one of these amplifiers, here is "how-to-build-it" information on a universal speaker/headphone control unit—which, incidentally, can also be employed with any conventional tube-type stereo amplifier. With this control unit, you can remotely select speaker or headphone operation—and adjust headphone volume level—without leaving your easy chair.

Stereo headphones offer the hi-fi enthusiast the optimum in stereo realism—in complete privacy—without having to sit in a fixed listening location. The stereo listener is not bothered by the usual household sounds, and conversely, others can read or watch television undisturbed.

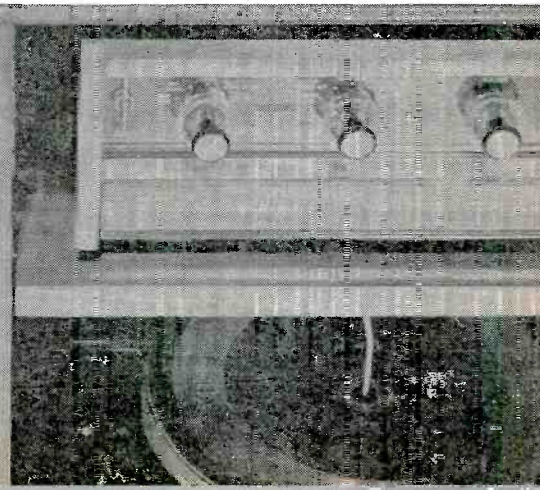
Some stereo amplifiers incorporate a built-in, standard, 3-conductor phone jack for stereo headphones, while in several of the *new* solid-state stereo amplifiers a special circuit for stereo headphones must be devised. A typical example of the latter is the Heath Model AA-21 or AA-21C.

BUILD A

Stereo Headphone Control Unit

Ideal companion for transistorized amplifiers combines safety from burnouts with maximum convenience

By CHARLES CARINGELLA



No Common Grounds. The Heath AA-21 requires that the speaker "common" line in the left channel be completely isolated from the "common" line in the right channel. The "common" terminal in the output of each channel is electrically above chassis ground. Each "common" line is returned to ground within the amplifier through a 0.18-ohm resistor. Both resistors are part of networks which provide a form of current feedback. Therefore, the common-terminals cannot be tied together with one "common" line into a 3-wire stereo headphone circuit, nor can the common lines be grounded to the AA-21 chassis. This means that two wires must be run to each speaker. You cannot run one "hot" wire to each speaker and use a single "common" return.

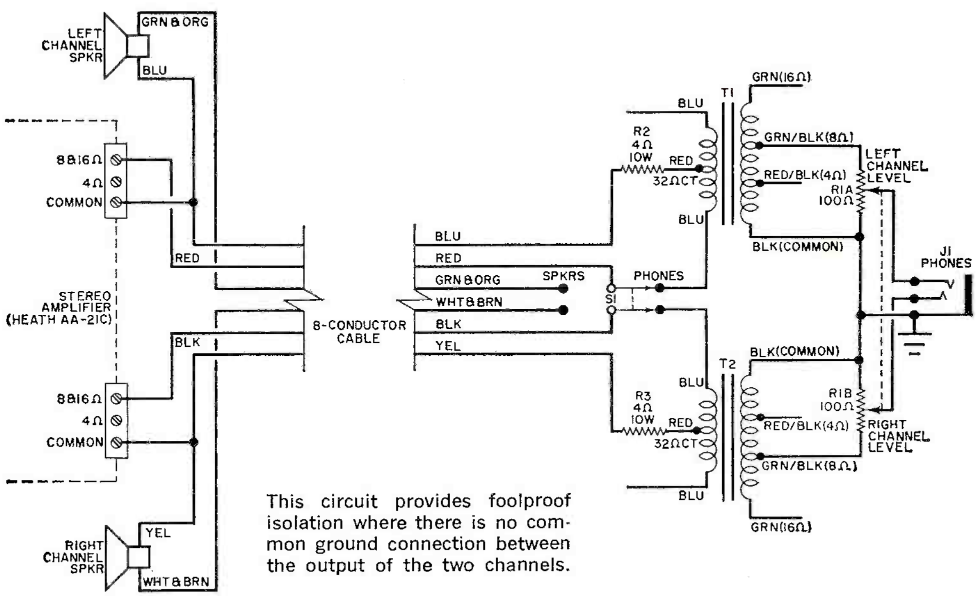
Conventional stereo headphones are sold wired to a 3-conductor phone plug. One conductor is connected to the left-channel earphone and another conductor to the right-channel earphone. The "common" return leads for both earphones are tied together to the third conductor, which also serves as the grounding sleeve, in the phone plug.

Obviously, such stereo headphones cannot be used directly with the amplifier described above since the "common" leads are tied together. The stereo headphone control unit shown in the schematic diagram allows headphones to be used with such an amplifier, without modifications to the amplifier or to the headphones. The control unit adapts the "4-wire" output of the amplifier to the "3-wire" headphone set.

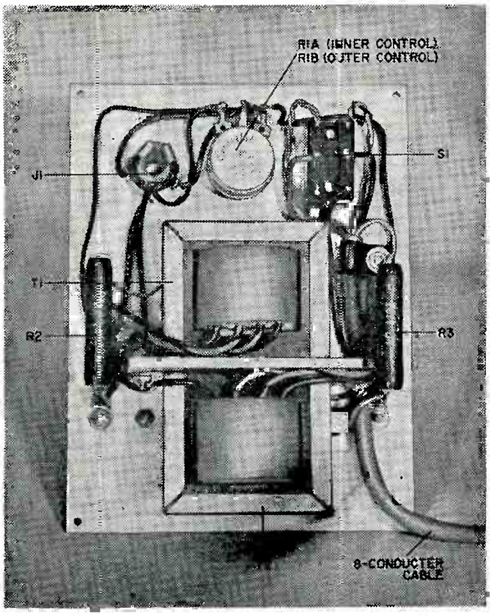
How It Works. Complete isolation between channels is made possible by using two transformers, *T1* and *T2*. The primary of *T1* is connected to the output of the amplifier left channel and the primary of *T2* goes to the right channel.

PARTS LIST

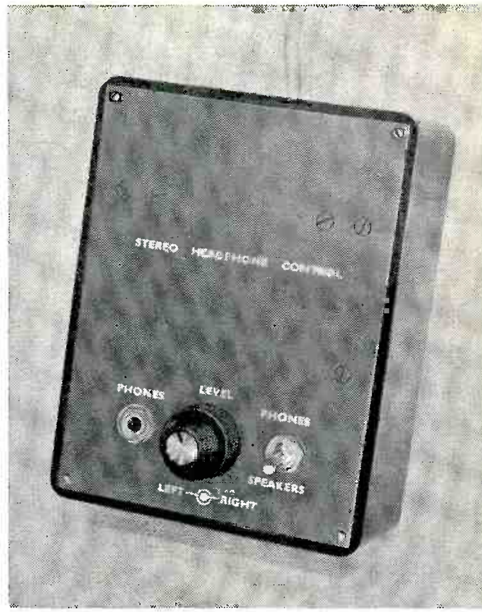
J1—3-conductor, open-circuit, standard phone jack (Switchcraft 12B or equivalent)
R1a/R1b—Dual 100-ohm potentiometer with concentric shafts (R1a—Centralab "Fastatch" F1-100; R1b—Centralab "Fastatch" R1-100, Centralab FFS012, 3/4"-long sleeve shaft, Centralab RFS102, 1 1/8"-long inner shaft)
R2, R3—4-ohm, 10-watt wire-wound resistor
S1—D.p.d.t. toggle switch
T1, T2—Transistor output transformer; primary impedance, 32 ohms, CT; secondary impedance, 4, 8, and 16 ohms (Merit A-2745 or equivalent)
1—Length of 8-conductor cable—as required (Belden 8448 or equivalent)
2—6-lug terminal strips (Cinch-Jones 2006 or equivalent)
1—Angle bracket, made from 1/8"-thick sheet aluminum
1—5" x 6 1/2" panel, made from 1/8"-thick sheet aluminum
1—6-13/16" x 5-9/32" x 2-5/32" black molded plastic instrument case (Harry Davies 260 or equivalent)
1—Set of dual concentric knobs
1—Plastic cable clamp for 1/4"-diameter cable



This circuit provides foolproof isolation where there is no common ground connection between the output of the two channels.



The author made a simple aluminum bracket to mount the two transformers back to back. Remainder of internal wiring is obvious from this rear view.



A 25′ length of cable connects the control unit to your amplifier. You can place unit alongside your easy chair and switch from speakers to headphones.

The secondary windings of *T1* and *T2* drive the stereo headphones. The secondary "common" leads are tied together and connected to ground. Concentric potentiometers *R1a* and *R1b* serve as the volume level controls. Dual knobs are attached to the concentric shaft and it is possible to adjust the two volume controls individually or simultaneously. Switch *S1* selects either speaker or headphone operation.

An 8-conductor cable connects the headphone control unit to the amplifier. Almost any length of cable can be used. It is possible to run the cable across an average-size room (25-30 feet) without noticeable high frequency loss.

Resistors *R2* and *R3* are connected in series with the primaries of *T1* and *T2* for amplifier protection against overload at low frequencies. The Heath AA-21 is designed to operate into a minimum of 4 ohms *resistive* load. Since the d.c. resistance of the primaries is quite low, resistors *R2* and *R3* must be used in series with the windings. You can omit *R2* and *R3* if the control unit is used in conjunction with some of the other stereo amplifiers.

Construction. The completed control unit is housed in a molded plastic instrument case as shown in the photos. A 5″ x 6½″ front panel is made from ⅛″-thick sheet aluminum. After all the necessary holes have been drilled, the panel can be sprayed with lacquer of a suitable color. Instrument decals can be added for a finished "professional" appearance.

An inside view, showing the location of all components, can be seen on this page. Parts layout is not critical. Transformers *T1* and *T2* are mounted on an L-shaped bracket also fabricated from ⅛″-thick sheet aluminum.

The multi-conductor connecting cable has an outside diameter of approximately ¼″. A suitable hole should be drilled in the top side of the instrument case to allow the cable to pass through.

Using the Control Unit. Only one adjustment is necessary, and that is, properly phasing the left and right channels. For proper operation, the two earphones should be "in phase." This means that the diaphrams in the earphones should move in and out at the same time when they are driven by identical signals.

If you own a Heath AA-21, you have probably "phased" the speakers properly by following the procedure outlined in the instruction manual. The AA-21 is

(*Continued on page* 142)

PUT AN AIR BRAKE ON YOUR WOOFER

How to get good bass response out of a $5.95 speaker without boom

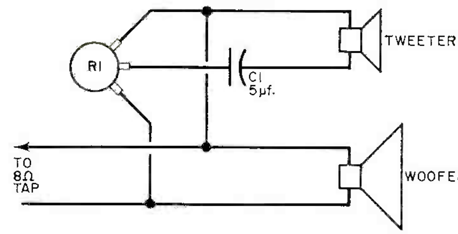
By DAVID B. WEEMS

AN INTERESTING development in the evolution of the bass reflex enclosure was "friction loading" as used by Goodmans of England, wherein an "acoustic resistance unit" (A.R.U.) is placed across the open port to reduce the boom effect. While it really worked, it was criticized by some audio designers as a waste of power—the audio equivalent of driving a car with the brakes on—but the concept is ever with us and is gaining more advocates.

Actually, the speaker itself undergoes a kind of braking action to reduce overshoot and distortion. In the case of expensive speakers, the braking action is enhanced by a powerful magnetic field through which the voice coil travels. Low-cost speakers are more likely to suffer from "hangover" due to weak magnets; poor suspensions don't help either. Because the magnets are costly, their weight alone is sometimes a fairly good indication of speaker quality, particularly within a brand line. However, consideration of weight alone can be quite misleading, as different magnet materials have different magnetic strengths per ounce. When it comes to magnets for speakers, the larger the magnetic strength (gauss), the better.

But if the speaker is completely enclosed and vented to provide just enough resistance to the air flow, the restoring force to the cone is quite similar to that obtained from the magnetic field surrounding the voice coil. Therefore, instead of trading dollars for magnets to put on the brakes, when you build an enclosure, you can incorporate the A.R.U. feature.

Air brakes and large magnets are fine, but there is more to a good speaker. In the case of a woofer and its low frequency response characteristic, the lower the cone resonant frequency the better. The $5.95 speaker used here checked out unusually well in this respect; resonance in "free air" was on the order of 35 to 40 hertz. A separate small tweeter and an L-pad is used to handle and balance the upper portion of the audio spectrum.

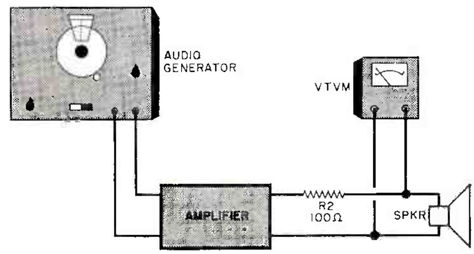


Low and high audio frequencies are separated by C1 and kept in balance by L-pad R1. For best results, the tweeter and woofer must be wired in phase.

Experiments With a $5.95 Woofer. The first experiment saw the woofer mounted in a 1 cu. ft. box similar to the "Cinderella" enclosure (October, 1965). Performance was fairly good, but the 35- to 40-hertz bass resonance of the speaker—when enclosed in the box—moved up to 75 hertz, and so some potential bass response was lost. Turning up the bass control on the amplifier helped, but the overall effect was that of a woofer with a mild case of claustrophobia. The sound was not as satisfying as that produced by the small woofers in the Cinderella system. Evidently, a larger box was in order.

Next, continuing with the infinite baffle concept, a larger enclosure was used. In the new sealed box, the bass resonance dropped to 55 hertz, and the bass response was much better than you would expect from a low-priced woofer—sound was good but not spectacular. Indications were that the size of the enclosure was right, and the time had arrived for the addition of the A.R.U. feature.

Then the tedious part of the experiments began—drilling holes by installments and testing the results of each additional set of holes. The tests clearly demonstrated the inadvisability of just putting any old speaker in any kind of box. So, if you want to adapt this idea to other speakers, and make your own tests, you'll have to use an audio generator and a VTVM connected as shown in the diagram of the test setup.

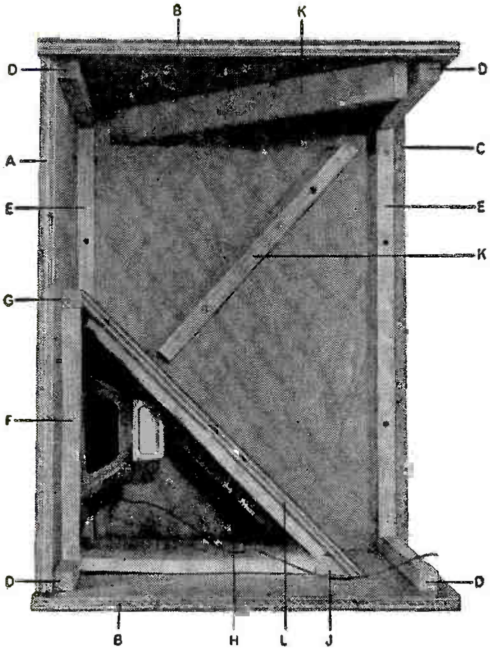


Typical test setup required to determine speaker and enclosure resonant frequencies if you use a different speaker or change cabinet dimensions.

The first batch of holes was drilled in the bottom of the box, converting the system from a sealed enclosure to a bass reflex type. With each series of holes, the voltage across the speaker voice coil was checked as the audio generator signal was varied from 200 hertz down to 20 hertz. The first sweep showed a voltage peak at 70 hertz and another at 25 hertz. Since these peaks were not even close to equal distance from the original peak of 35-40 hertz, it was obvious that the box was mistuned. Going back over the frequency run again showed that the peaks were also greatly unbalanced in amplitude, the lower peak being about twice as high as the upper peak.

Unfortunately, too many holes had been drilled. Tacking two layers of ½-inch polyurethane foam plastic over the holes brought the upper peak down to 60 hertz and lowered the amplitude of the lower peak, which proved that you can tune a bass reflex enclosure with an A.R.U.

After closing some of the bottom holes to obtain better matching, work was begun on the enclosure interior. After all, the original purpose of the box was to try the air brake idea with a resistive compartment around the woofer. Next, 165 ¼-inch holes were drilled into the triangular side piece (*M*) and the sloping back panel (*L*) until the remaining voltage peaks at 54 hertz and 21 hertz were insignificant. That point was reached with 170 holes in the sloping panel. A further frequency run showed dips in sound output at some points—apparently internal reflections were



Except for the front, all inside surfaces of the woofer cage are covered with foam plastic. Loosely pack the woofer cage with a sheet of fiberglass.

BILL OF MATERIALS

A—18" x 22" x ¾" plywood for front and rear (2 required)
B—17½" x 19½" x ¾" plywood for top and bottom (2 required)
C—17½" x 22" x ¾" plywood for sides (2 required)
D—16½" x ¾" x ¾" cleat (4 required)
E—22" x ¾" x ¾" cleat (4 required)
F—11" x ¾" x ¾" cleat
G—11¾" x ¾" x ¾" cleat
H—16½" x ¾" x 1½" cleat
J—11" x ¾" x 1½" cleat (1 side faced 45°)
K—1" x 2" diagonal brace for top, back, and both sides (about 96" required)
L—17½" x 12½" x ¾" plywood
M—11¾" x 11¾" x ¾" plywood (cut diagonally
1—3-sq. ft. sheet of polyurethane foam plastic
1—3-sq. ft. sheet of fiberglass
1—2-yd. piece of cheesecloth
1—24" x 28" piece of grille cloth
4—4" legs (optional)
*1—CTS-10WF 10" woofer**
*1—TS-5051 3½" tweeter**
C1—5-µf., 25-volt capacitor
*R1—8-ohm L-pad (Calrad LP-8 or equivalent)**
Misc.—1¼" x 8 flat-head wood screws (1 box), 2½" x 8 flat-head wood screws (6), glue, plastic, veneer, or stain and varnish, molding, etc.

*Available from McGee Radio Co., 1901 McGee St., Kansas City 8, Mo. (Woofer, $5.95; tweeter, $2.95, L-pad, $1.49. Shipping cost extra.)

NOTE: Cleats and braces can be made from pine; all other lumber is at least 5-ply wood.

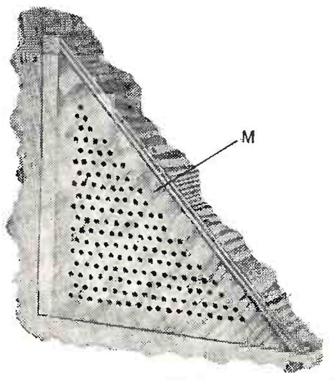
causing cancellations. Foam plastic was stretched over the drilled panels, and the compartment was filled with fiberglass to alleviate this problem.

Compared to earlier listening tests, the sound quality was significantly improved. The bass response appeared to be smooth and extended further downward in range from the former limits. However, there was one criticism offered by careful listeners; the low end seemed to be too well damped. Several more sets of holes were drilled in the sloping panel, bringing the total up to 250. This change produced a fuller bass, but still not boomy. However, the lack of boom produced a slight imbalance in favor of the tweeter, and so a tweeter control (*R1*) was added as a further refinement.

Construction. You can cut costs by using the cheapest grade of construction plywood available; such material is satisfactory from a performance standpoint, but for good appearance must be covered. However, a good furniture finish calls for a good grade of lumber.

Except for the diagonal braces (*K*) which are used to stabilize the large unsupported surfaces, and the cage around the woofer, construction of the enclosure is quite ordinary. Strips of ¾" x ¾" pine (*D, E, F,* and *G*) are screwed and glued to the front panel, and cleat *H* is fastened to the side panel in a similar manner, to simplify construction of the woofer compartment. The drilled triangular side panel of the cage (*M*) is fastened to the bottom and front with glue and with six 2½" x 8 flat-head

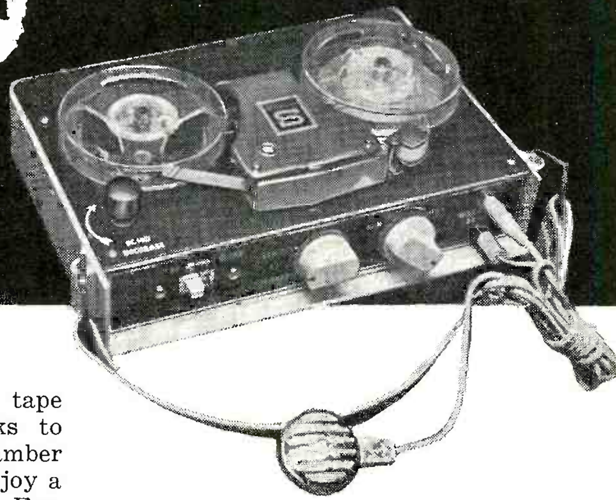
(*Continued on page* 141)



Cage side cover is held in place by 2½"-long screws fed into front and bottom of cabinet from outside, and by 1¼" screws through piece L.

BUILD A TAPE RECORDER ECHO CHAMBER FOR UNDER $10

...and enjoy a new dimension in sound



By **STEPHEN E. AUYER**

DO YOU HAVE an inexpensive tape recorder and about ten bucks to spare? Why not build an echo chamber for the tape recorder and really enjoy a new dimension in sound effects? Few devices can add as much pleasure and enjoyment to tape recording as an echo chamber. And as a family fun-maker and entertainer, it has no peer.

Actually, an echo chamber is a very simple device. It takes a recorded sound, delays it, and then sends it on to follow the original sound. The delayed sound is heard as an echo, and produces a very pleasant effect.

How It Works. An additional pickup head is installed on the tape recorder about two inches away—in the direction of tape travel—from the recording head (for tape speeds of 3¾ ips). A signal is recorded on the magnetic tape as it passes the original head. As the tape moves on, the same signal is picked up by the new head (Fig. 1), amplified by *Q1*, and re-recorded as an echo a short time later. The setting of *R5* determines how much of the signal is fed back and re-recorded to produce a strong or weak echo as desired; distance between heads determines echo separation.

The echo chamber preamplifier circuit is shown in Fig. 2. Transistor *Q1* in a common emitter configuration provides sufficient gain to the delayed signal. Base bias is achieved by the voltage divider action of *R1* and *R2*. The collector voltage is developed across *R4*.

Capacitor *C2* bypasses emitter resistor *R3* to eliminate degeneration, while *C3* serves to block d.c. from across *R5*. Capacitor *C5* couples the audio to the recorder amplifier.

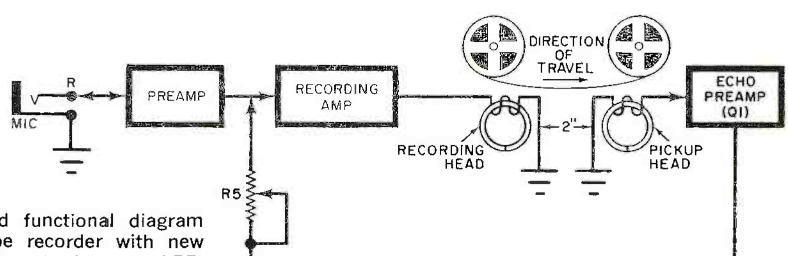


Fig. 1. This simplified functional diagram shows a modified tape recorder with new head, echo preamplifier, and echo control R5.

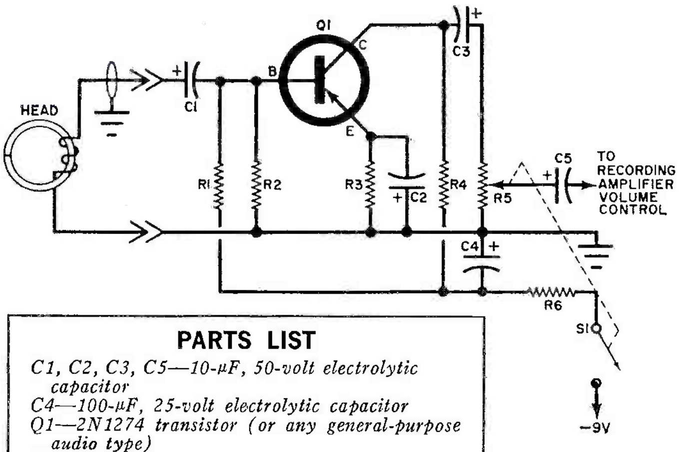


Fig. 2. The echo preamplifier employs a single common emitter stage to provide the necessary gain for the echo effects. Shielded cable connects new pickup head to preamplifier. Capacitor C4 and resistor R6 eliminate hash in tape recorders with brush-type d.c. motors.

PARTS LIST

C1, C2, C3, C5—10-μF, 50-volt electrolytic capacitor
C4—100-μF, 25-volt electrolytic capacitor
Q1—2N1274 transistor (or any general-purpose audio type)
R1—47,000-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor
R3, R6—1000-ohm, ½-watt resistor
R4—4700-ohm, ½-watt resistor
R5—5000-ohm potentiometer (with switch S1)
S1—S.p.s.t. switch (mounted on R5)
1—Tape head (Midland 25-735 or Lafayette 99 R 6194)
Misc.—Small piece of perforated phenolic board, knob, mounting hardware

Construction. The preamplifier can be assembled on a 2" x 3" piece of perforated phenolic board, using push-in Vector terminals for the connections. If there is a space problem, you can use a smaller board and simply utilize both sides of the board. Mount the assembled board in any convenient spot in the recorder using stand-off spacers or two right-angle brackets which you can make from a thin piece of aluminum cut to the proper size.

Install the echo control (*R5*) at any convenient spot on the tape recorder deck. Then connect the + (plus) side of *C3* to the echo control (see Fig. 2). Now wire the plus side of *C5* to the center lug of *R5*, and the other side of the capacitor to the output terminal of the tape recorder volume control. And be sure to establish a good common ground between preamplifier and recorder.

Mount the second tape head approximately two inches away from the first head, in the direction of tape travel. A word of caution: in many of the lower priced units, all parts of the tape do not make uniform contact with the head as the tape passes over it. For best results, you must therefore make certain that the second head covers the same part of the tape as the original head.

During operation, the echo control (1) is turned up just enough to produce the desired echo level. If greater echo separation is desired, move new head (2) further away from the main recording head.

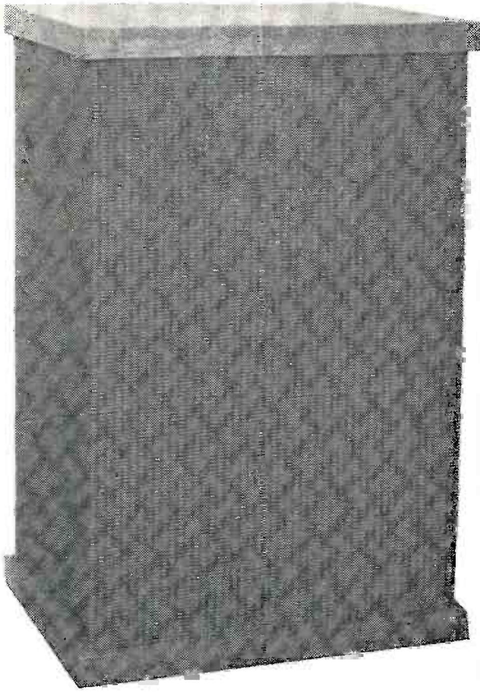
It may be necessary to install additional tape guides to keep the tape properly aligned. These can be made from a ½"-long, ⅛"-o.d. brass spacer, and can be secured to the deck with ¾"-long #4 hardware. Use shielded cable when connecting the new head to its preamplifier.

Operation. Set up your recorder for normal recording. While monitoring the signal being recorded, increase the setting of the echo control (*R5*) until the desired amount of echo is produced. If the echo control is advanced too far, you will get an annoying feedback.

If your recorded sound comes out too "brassy," chances are the recording heads are not properly aligned. To correct this condition, loosen the screws that mount the second head, and rock the head slightly from side to side until the best response is obtained.

You can get an interesting effect by connecting the tape recorder monitor output to your hi-fi system, while the recorder is set to the *record* position. Then, as you talk into the microphone, your voice—plus its echo—will be heard.

For an extra-special sound effect, try connecting the output of an audio oscillator to the echo chamber. Then vary the frequency of the oscillator while recording. -30-



BUILD A

LONG-TAILED PHASE INVERTER

By **DAVID B. WEEMS**

NEW LABYRINTH-TYPE SPEAKER ENCLOSURE DESIGN ANSWERS OLD QUESTIONS WITHOUT RAISING NEW ONES

IF THERE'S one thing most audio experts seem to agree on, it's that the battle over the relative merits—or demerits—of different speaker enclosure designs rages on unabated.

Advocates of the labyrinth-type enclosure have long attested to its superior reproduction qualities at the lower limits of the speaker's frequency range. They also claim better transient response and less obvious effects of any mismatch.

Proponents of the bass reflex type enclosure counter by noting that one can easily correct a mismatch in a bass reflex cabinet without resorting to major surgery. They will even admit to superior low-frequency response in horns or pipes while claiming that the latter tend to impede reproduction in the midrange.

Many authorities have downgraded the bass reflex enclosure by stating flatly that if critics call the labyrinth a resonant pipe, then the bass reflex is nothing more than a resonant box.

But even the most fanatic partisan will admit, privately, that not even his own pet speaker system is perfect. That being the case, any new speaker or enclosure design always evokes a great deal of interest—and suspicion.

A New Design. From England comes a new speaker enclosure design which has been dubbed an *acoustical transmission line* by its designer, A. R. Bailey, of the Bradford Institute of Technology. At first glance, it looks somewhat like a labyrinth enclosure, except that the length of the pipe—eight feet—suggests a departure from labyrinth design.

An unusual feature is that the cabinet is filled with long-fiber wool, in contrast to the common practice of just lining the wall surfaces of an enclosure. In all probability, Bailey got his name for the enclosure from a theory for electrical transmission lines, which states that if a line of finite length is terminated in a resistance equal to the characteristic impedance of the line, disturbances along the line are not reflected back to the source, and such a line will behave as though it were of infinite length. The fiber wool acts as the terminating resistance in an acoustical transmission line.

But the more you look at Bailey's enclosure, the more it looks like a modified labyrinth. Recall that labyrinths provide maximum damping at one-quarter wavelength while maximum sound output is obtained at one-half wavelength. The 8′ length specified by Bailey corresponds to a quarter-wavelength at 35 Hz—just about the resonant frequency specified for the woofer.

In reality, Bailey's contribution seems to be mainly the long-fiber wool which damps resonant frequencies and produces an ultra-low-pass filter that eliminates midrange interference. Also, with this design, speaker mismatch is difficult to detect.

Bailey's speaker enclosure design employs an oval-shaped British speaker that is not generally available. It has, therefore, been modified slightly by the author to accommodate an American-made low-resonance 12″ speaker—the Allied Radio KN-888HC. Also, since long-fiber wool is not generally available, kapok has been substituted.

The enclosure presented here performs well in the 50 to 60 Hz range and has excellent transient response. But this doesn't mean that everybody will like it; after all, not everybody likes lobster, either.

Incidentally, this version of Bailey's enclosure is called the *long-tailed phase inverter* simply because it has an extra-long curled tube which reverses the phase of the low-frequency rear wave coming from the speaker to reinforce—rather than cancel—the sound coming from the front of the cone.

Construction. An important design feature of any speaker enclosure is its rigidity. And although labyrinths are not subject to unduly high pressures, every precaution must be taken during construction to insure the utmost in rigidity.

BILL OF MATERIALS

2—4′ x 7′ sheets of ¾″ plywood
1—10′ length of ¾″ x ¾″ clear pine (for cleats)
1—5′ length of 1½″ x ¾″ clear pine (for cleats)
1—Box of #8 x 1¼″ flathead wood screws
24—#8 x 2″ flathead wood screws (for sides)
4—¼″ x 2″ bolts (for mounting speaker)
3—Pounds of loose kapok
Misc.—Grille cloth, wood trim, nails, glue, cheesecloth, wool or cotton batting, clamps

This means that screws should be closely spaced and in tight, and that all joints should be glued in place.

Your first task, of course, will be to cut the plywood and pine cleats to the sizes specified in the Table Of Dimensions. One important rule of thumb is to *measure twice, cut once.* Also, a note of caution: when cutting out the 18″ slot in panel *K*, be careful to make the slot just wide enough to accommodate panel *J* snugly.

Overall dimensions for the enclosure, including measurements for panel mounting, are given in Fig. 1. Additional construction details appear in Fig. 2. Note that panel *H* is first cut at 45° so that one side has a width of 5¾″ while the other is only 5¼″ wide. Then the longer side is trimmed down so that the thickness of the tapered edge is ¾″.

After sanding down all the panels, and before assembly, draw a guide line through the middle of panels *G*, *H*, *I*, and

Table of Dimensions

IDENTIFICATION	SIZE	QUANTITY
	¾″ Plywood	
A, B	22½″ x 37½″	2
C, D	18″ x 37½″	2
E, F	18″ x 24″	2
G	22½″ x 14½″	1
H	22½″ x 6¼″	1
I	22½″ x 6″	1
J	22½″ x 18″	1
K	9¾″ x 23″	1
	¾″ Clear Pine	
Front (lower sides)	¾″ x 23″	2
Front (bottom)	¾″ x 10″	2
Front (top)	¾″ x 22½″	1
Front (upper sides)	¾″ x 13½″	2
Rear (sides) & diagonal brace for back	1½″ x 36″	3
Rear (top & bottom)	1½″ x 22½″	2

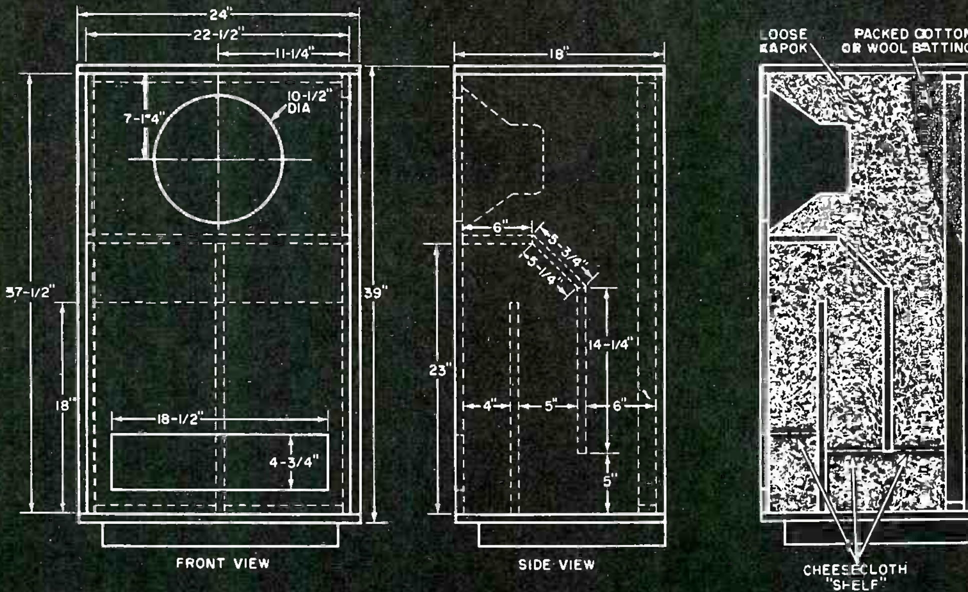
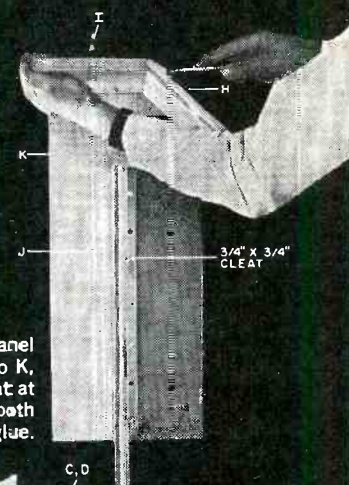


Fig. 1. Overall dimensions are provided in front view drawing of phase inverter enclosure (above). Location and mounting dimensions of interior panels are shown in the side view. At upper right, finished cabinet is packed with kapok, while interior surfaces are lined with a thin layer of cotton or wool batting.



After fitting panel J tightly into K, secure the cleat at the joint with both screws and glue.

Fig. 2. The slot in panel K (below) must be cut to close tolerances to insure a tight fit during assembly. Panel H is first cut at a 45° angle and then the points are cut off.

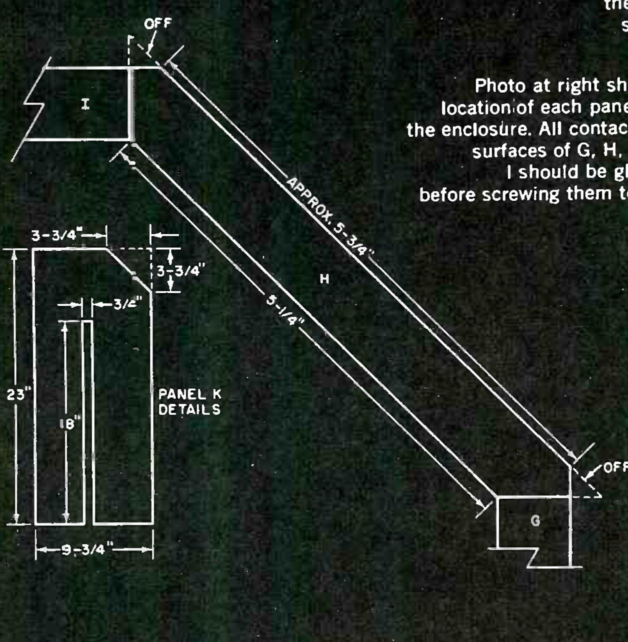
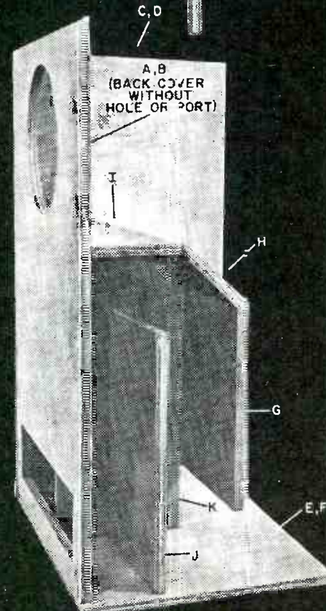
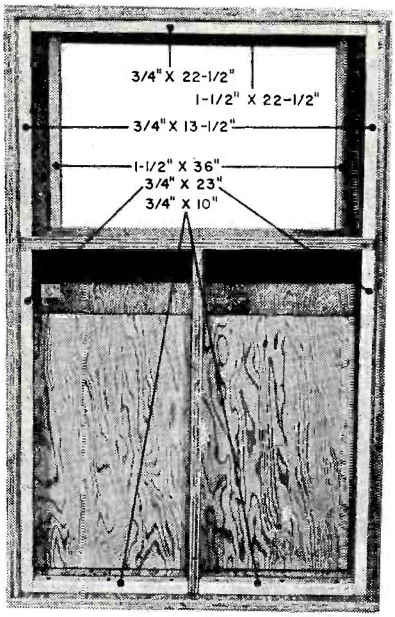
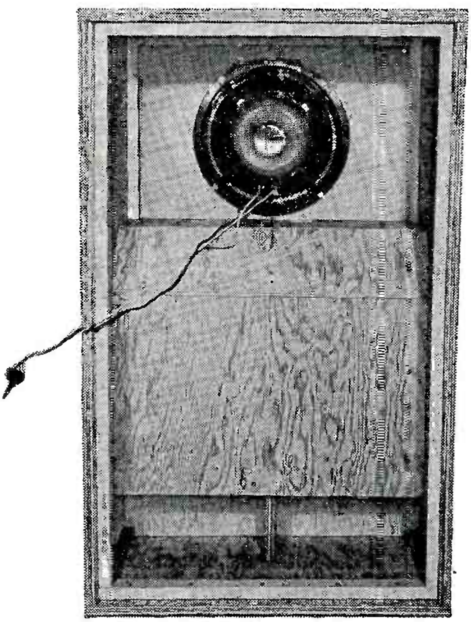


Photo at right shows location of each panel in the enclosure. All contacting surfaces of G, H, and I should be glued before screwing them to K.





After cutting and fitting the cleats, apply a little glue to the contacting surfaces, and nail them in place temporarily with small nails. Then secure them permanently with #8 x 1¼" flathead screws.



Rear view with back cover removed shows modified labyrinth appearance of phase inverter enclosure prior to packing of cabinet with kapok. The speaker shown is Allied Radio's KN-888HC, which replaces the British speaker used in the original design.

J where they will be attached to panel *K*. After panel *J* has been pushed into position, attach a ¾" x ¾" x 18" cleat to panels *J* and *K* (see photo) using glue and screws.

All contacting surfaces of panels *G*, *H*, and *I* should be liberally glued and then screwed to panel *K*. Screws should go diagonally through *H* into *I* and *G* (see Fig. 2).

Next, you can mount the previously assembled panels on the bottom piece, *E*, after which you add the sides, *C*, and *D*, and the top, *F*. Incidentally, you will find it a lot easier to add cleats to these parts before assembly. Note from the illustrations that the partitions are recessed ¾" in from the front and sides of the baseboard in order to accommodate the front and side panels.

Apply glue to the edges of the partitions and then nail the front and side panels to the partitions. Then add a few 2"-long screws to give extra strength to the joints.

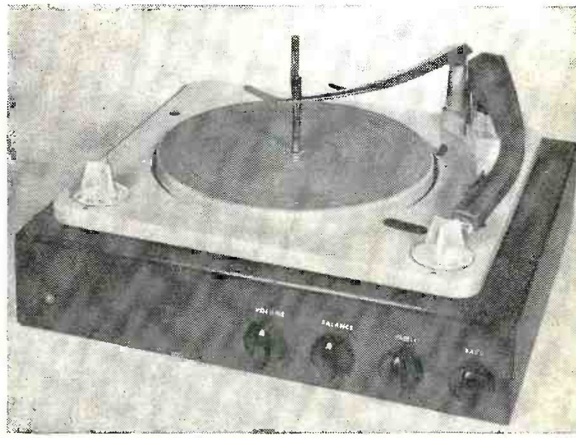
This is a good time to pack the middle section of the labyrinth with kapok. (Long-fiber wool is preferred, of course, if you can get it.) However, because kapok tends to settle, you should tack a single layer of cheesecloth from the bottom of panel *G* to the back of panel *J* (see Fig. 1).

After half-filling the partitions, make a pillow of loose kapok wrapped in cheesecloth and drape it over the top of *J* to fill the upper middle section as well as the front tube. Now you can attach the front panel using both glue and screws to secure it in place. Turn the cabinet upside down and finish filling the front tube with kapok right up to the level of the port. Tack another cheesecloth partition across from the top edge of the port to the front of panel *J*. Then fill the area behind the port with kapok.

Finishing Touches. Paint the side and front of the labyrinth with flat black paint and allow it to dry thoroughly before adding the grille cloth. It is advisable to cover the port with a piece of open-weave black cloth.

Because grille cloth is available only in 36" widths, and since the height of the cabinet is 39 inches—not including feet—it is necessary to use trim that

(*Continued on page* 141)



INEXPENSIVE INTEGRATED
SOLID-STATE STEREO RECORD PLAYER

Cool, compact amplifier fits into record changer base

By JAMES E. ROHEN, K8NQH/2

ONE MAJOR TREND these days in hi-fi circles is towards integrated sound systems in which all components are in one cabinet. This trek towards compactness has been considerably aided by the availability of small all-transistor amplifiers that run cool and sound good.

The push-pull amplifier used here has 10 transistors, measures only 8½" x 6" x 1½", puts out about 8 watts (music power), and has a frequency response of 30 to 20,000 Hz. It costs only $19.95. According to the Burstein-Applebee catalog, the amplifier is marked down in price because of factory overproduction, and is a high-quality import. It requires only 10 volts a.c. for power, which can be obtained from a transformer selling for $2.00. See Parts List on page 66.

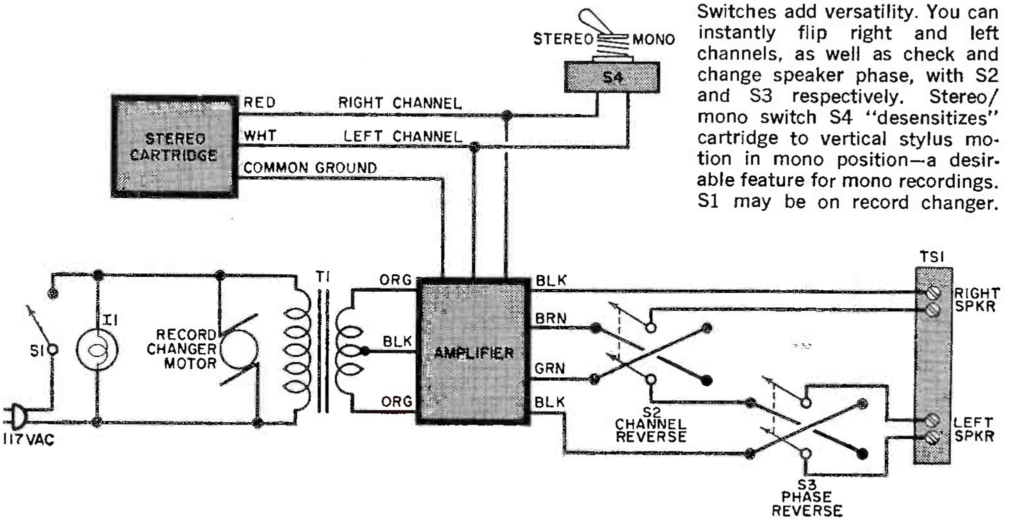
Assembly. You can spend an evening assembling a compact integrated stereo record player and enjoy many years of record listening. All you have to do is drill a few holes, mount a few components, and solder a few connections. The completed unit is adaptable to AM and FM tuners, tape decks, etc.

Connect the step-down transformer to the a.c. line through the record changer on-off switch to automatically shut off the amplifier after the last record has played. If you intend to connect a tuner to the amplifier, use a separate on/off switch to allow operation of the tuner without having the record changer running.

No dimensions are given for location of the holes in the changer base as different changers have different size bases, and different clearances inside the base. The bezel plate furnished with the amplifier can be used as a template for marking the position of the front panel controls. The transformer and other switches can be placed wherever they will fit. Before cutting any mounting holes, let the changer run through a change cycle to be sure that there is enough clearance between the amplifier and other components you install and the record changer mechanism.

Optional Features. A pilot light, and speaker channel and speaker phase reversal switches are optional items, but do much to enhance the record player's versatility and ease of operation. The wiring diagram shows how to hook up these switches.

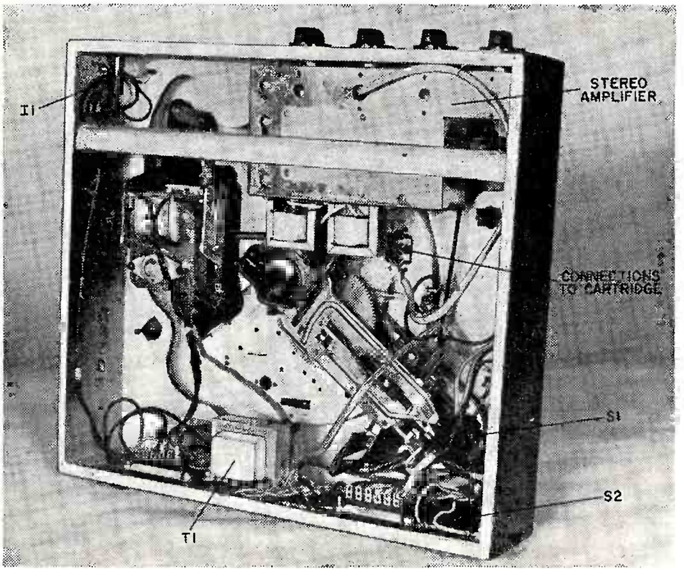
The speaker channel reversal switch is handy when a friendly neighbor comments that the French horn is playing on the wrong side of the orchestra. The phase reversal switch enables you to quickly change the phase of the speaker in one stereo channel to agree with the phase of the speaker in the other chan-



Switches add versatility. You can instantly flip right and left channels, as well as check and change speaker phase, with S2 and S3 respectively. Stereo/mono switch S4 "desensitizes" cartridge to vertical stylus motion in mono position—a desirable feature for mono recordings. S1 may be on record changer.

PARTS LIST

I1—Pilot light (Drake indicator lamp with built-in resistor, Tinnerman nut mounting)
S1, S4—S.p.s.t. toggle switch
S2, S3—D.p.s.t. toggle switch
T1—Power transformer: primary, 117 volts; secondary, 20 volts with center tap (Burstein-Applebee, Kansas City, Mo., 18B508, $1.99)
1—Push-pull amplifier (Burstein-Applebee, 30C27, $19.95)
1—Stereo record player, ceramic cartridge



Solid-state stereo amplifier runs cool and is compact enough to fit into record changer base. Parts location is not critical, but adequate clearance for the changer mechanism must be provided. It's a good idea to run the changer through a cycle by hand in order to check clearance requirements.

nel. Proper phase is achieved when the sound is best.

A stereo-mono switch is also shown and is optional, but it can improve the sound from many mono records. When the switch is open, normal stereo operation is obtained. When the switch is closed, both channels are paralleled and the cartridge becomes effectively insensitive to vertical stylus movement. (Vertical stylus motion on a mono record can cause undesirable responses in a stereo cartridge.) All wires leading to the cartridge and stereo/mono switch should be shielded and grounded at one end. —30—

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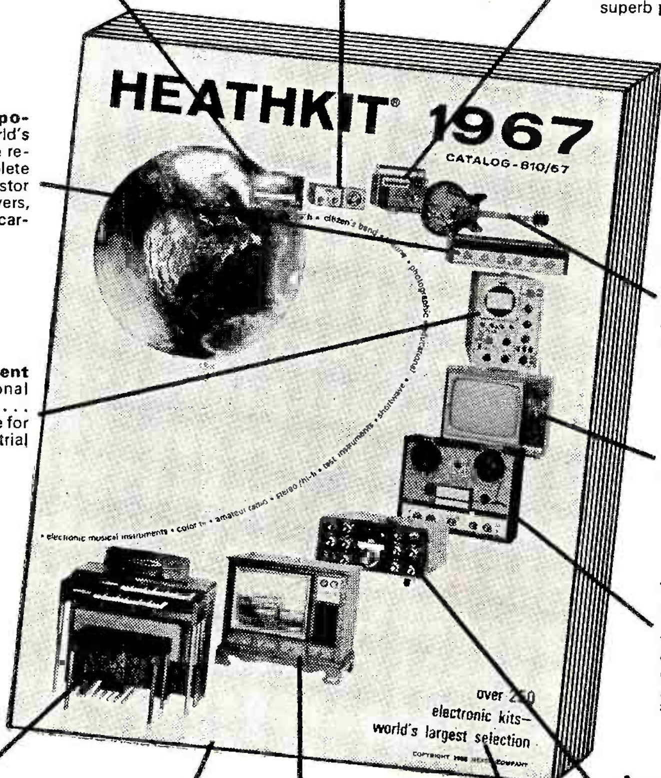

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CIRCLE NO. 8 ON READER SERVICE CARD

INTERSTATION HISS SUPPRESSOR FOR FM TUNERS

By JAMES T. SAMUELSON

IF YOU HAVE a hi-fi FM tuner similar to the Heathkit PT-1, the addition of only four parts will kill the "Niagara Falls" sound effect heard between stations. This interstation hiss is unwelcome and unnecessary. A hiss suppressor can be added to most FM tuners equipped with a built-in tuning meter amplifier.

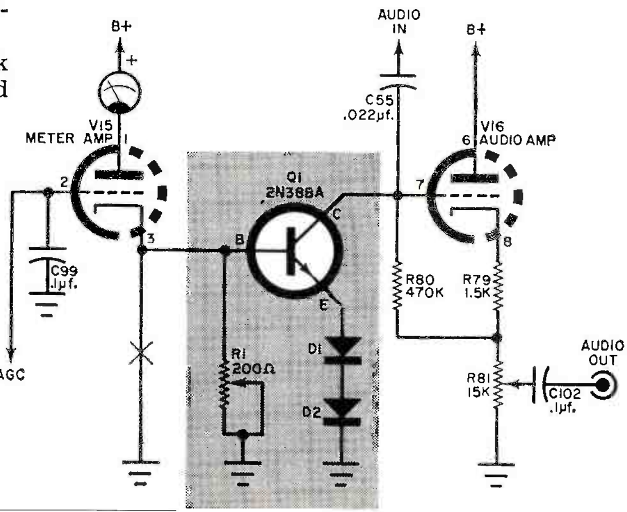
Referring to the schematic diagram, you simply open the cathode-to-ground connection of *V15* at *pin 3*, and wire in the parts as shown. A small piece of phenolic board can be used to support the added components. Connect the collector of *Q1* to *pin 7* of *V16*. Then set potentiometer *R1* to a desired threshold level, and button up the set.

Interstation hiss, or "white noise" as it is often called, is usually heard when r.f. or i.f. amplifiers are operating under maximum gain conditions. When no signal or a very weak signal is present, little or no a.g.c. voltage is developed and the amplifiers run wide open. A strong or medium signal, on the other hand, develops a negative voltage which biases the amplifiers to a lower amplification level and reduces white noise accordingly.

When negative a.g.c. voltage is weak or missing, *V15* also runs wide open, and a relatively large current runs through *R1*, *V15*, and the meter, developing a relatively large voltage across *R1*. This voltage at the junction of *R1* and *Q1* is positive with respect to *Q1*'s emitter and causes *Q1* to conduct, "shorting" the signal input (which is now nothing but noise) on the grid of *V16* to ground.

But when a signal is present, a.g.c. voltage cuts down the current flow through *V15*, reduces the voltage drop across *R1*, removes the forward biasing voltage on the base of *Q1*, and *Q1* stops conduction. When *Q1* doesn't conduct, collector resistance to ground is very high and the audio amplifier operates as though the anti-hiss circuit doesn't exist.

Threshold level is determined by *D1* and *D2* (general-purpose silicon diodes), and the setting of *R1*. Once *R1* is adjusted, it does not have to be reset, except perhaps to compensate for tube aging. A fixed resistor can be substituted for *R1* after it has been properly adjusted and the amount of resistance needed in the circuit is determined. –30–



This circuit can be added to any FM tuner with a tuning meter amplifier and a cathode follower or audio amplifier output. Only four components are needed and they can be mounted on a small piece of punched phenolic board measuring only 1" x 2". The "subchassis" can then be attached to a convenient support under the chassis deck of the FM tuner. To keep the size small, a low-cost, multiple-turn potentiometer is suggested for R1; after several months of use, as the tuner tubes began to age, this control still did not require resetting.

CHAPTER

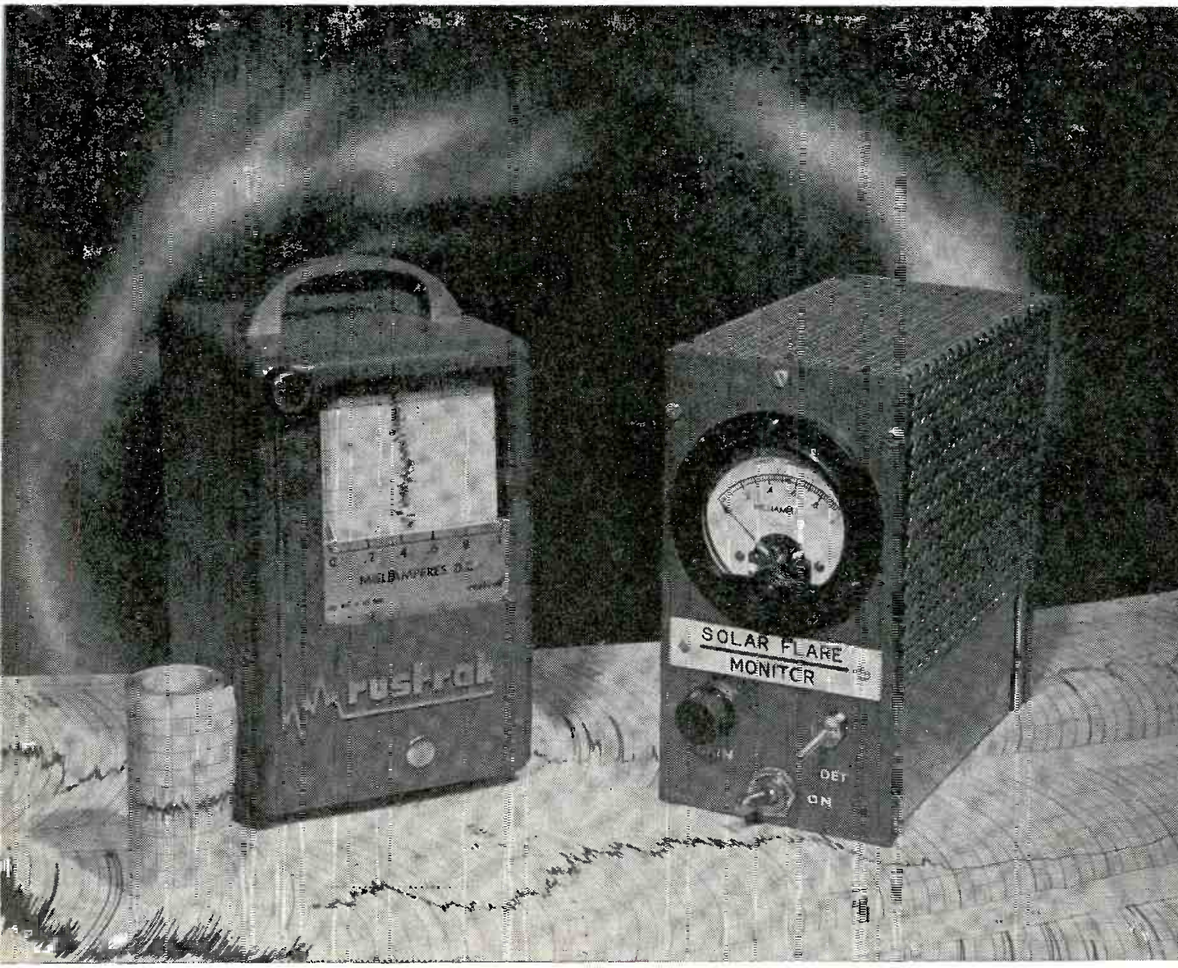
3

COMMUNICATIONS SWL CB HAM

Maybe we're letting the cat out of the bag—in more ways than one—with the feature construction article in this chapter (page 72). Not only does the sun emit very low frequency r.f. radiation—particularly from sunspots—but this receiver can be used to monitor the blast-offs of the larger booster rockets. The mechanics of how these rockets emit low frequency r.f. are not completely understood and very little has appeared in the technical electronics press on this hush-hush topic. Nevertheless, it is known that booster rockets can be detected in this fashion—regardless of the distance between the launch site and the receiver. Undoubtedly, both the U.S. and Soviets maintain extensive low frequency receiving and monitoring stations around the globe for this purpose. So, if you build this project, and can find a clear channel with no interference (QRM), you may be rewarded by spotting solar flares—and if you're very lucky—a missile blast-off.

Show this project to friends interested in radio astronomy, weather, etc. But, be careful; you may end up building a couple of receivers, instead of just one for your own use.

LISTEN IN ON THE SUN



COVER STORY

THREE-TRANSISTOR VLF RECEIVER TUNES IN ON SOLAR FLARES

By HOWARD BURGESS, W5WGF

FEW THINGS happen in space that are as important to earthlings as those which occur on the surface of the sun. Centuries ago, Chinese astronomers were fascinated by the black "spots" that appeared to travel across the solar surface. Latter-day scientists simply referred to these imperfections as "sunspots"—for lack of a better name—and were quick to ascertain that the number and area occupied by the sunspots varied from week to week, month to month, and in particular, from year to year. Sunspots affect every living being, and while our principal interest in them is in regard to radio wave communications over long distances, the effects of sunspots have been correlated with the growth of tree rings, severity of winter storms, etc.

Throughout the next few years, anyone using the short-wave bands will find that the sunspots have produced some unusual effects. Some high-frequency bands may be momentarily blacked out while other bands will open up over unusual DX paths. Thousands of CB operators will be tempted by the rare 27-MHz skip conditions, and millions of TV viewers will occasionally pick up strange stations on their screens from thousands of miles away. This will be the period of the sunspot maximum; some scientists are predicting that the 1969 maximum will be only slightly below the great sunspot peak of 1958-59.

What Are Sunspots? The cause of sunspots has puzzled scientists for many years. However, according to recent investigational work, when some of the larger planets in our solar system form a special pattern in space, it is assumed that the force fields created combine to disturb the hot gasses of the sun. This same combination of forces probably drives atomic particles, from the sun, through space like the beams of a giant cathode-ray tube.

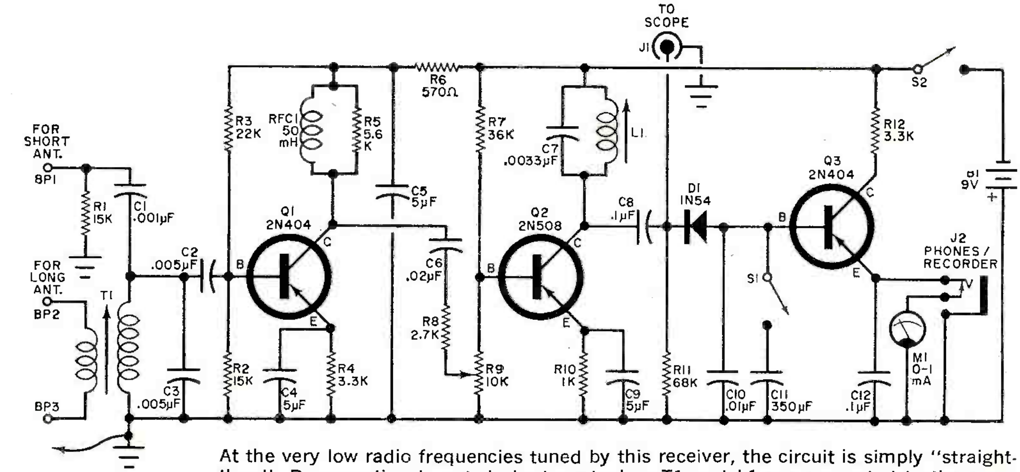
Sunspots themselves are violent stormlike disturbances that appear to move across the face of the sun, but do not really do so because the sun is actually rotating and changing its position in our field of view. They vary in definite cycles. At intervals of about 11 years, the number of sunspots reaches a peak and then declines to a very low amount. The highest portion of the peak can last as long as two to two-and-one-half years.

The sunspots discharge atomic particles and radiation into outer space and these particles and radiation seem to originate in turbulent areas known as solar flares—which appear to the astronomer as huge flames spouted by the sunspot. The flares (or bursts) last for less than two to three minutes, but during this short interval intense radiation is released. At the peak of sunspot activity, a number of bursts can take place in one day.

Effects of the space debris on the ionosphere and the resulting blackouts have been discussed in many articles appearing in POPULAR ELECTRONICS and the contemporary press.

"Warning" Receiver. The radiation given off by a solar flare travels at the speed of light and arrives at our planet in about eight minutes. However, the charge particles drag along at about a thousand miles per second and arrive outside the earth's atmosphere 24-36 hours later. The particles that arrive late affect all short-wave transmissions, while the fast-moving radiation has a pronounced effect on the lower frequencies and occasionally causes a short period of radio blackout.

By listening in on the sun, it is possi-

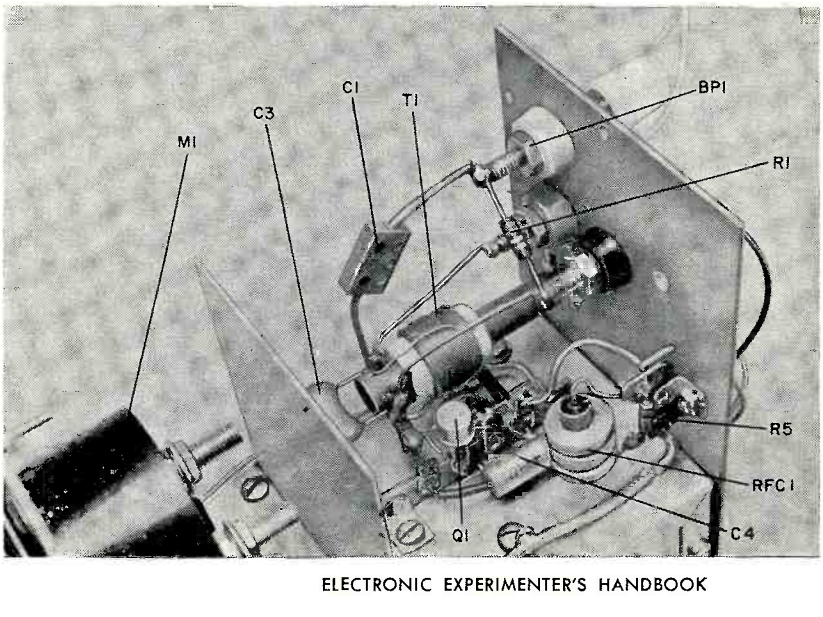


At the very low radio frequencies tuned by this receiver, the circuit is simply "straight-thru." Regeneration is not desired, and when T1 and L1 are resonated to the same frequency, R9 must be turned down to curb feedback. Output jack J1 is optional if the user wants to "look" at some of the strange VLF signals between 25 and 35 kHz.

ble to predict in advance some of the solar flare effects on short-wave transmission. A simple "spherics" receiver (short for atmospherics, or lightning static) can give these advance warnings and should alert the operator to the fact that poor propagation conditions may be expected a day or so later.

The very low frequency region around 20-30 kHz has a higher level of atmospheric background noise than perhaps any other portion of the radio spectrum. Within minutes after a solar flare has occurred, the level of this atmospheric noise will rise to an even higher value, remain at this high level, and then diminish slowly. To make use of this phenomenon, all that the experimenter needs is a simple receiver tuned to about 30 kHz. Such a receiver in its simplest form can be built for around $10.00. Many little extra improvements can be added to the basic unit at little or no extra cost—especially if you have a supply of surplus or salvaged parts available.

The Circuit. The receiver described in this article consists of two transistors operating as amplifiers tuned to the band between 25 and 35 kHz. These transis-



All of the components surrounding transistor Q1 are positioned above the chassis. Although presumably T1 and L1 would only be tuned once, they are both mounted with knobs attached to the threaded shafts. The three binding posts permit the receiver to be connected to a variety of antennas—short, long, or of an "in-between" size.

PARTS LIST

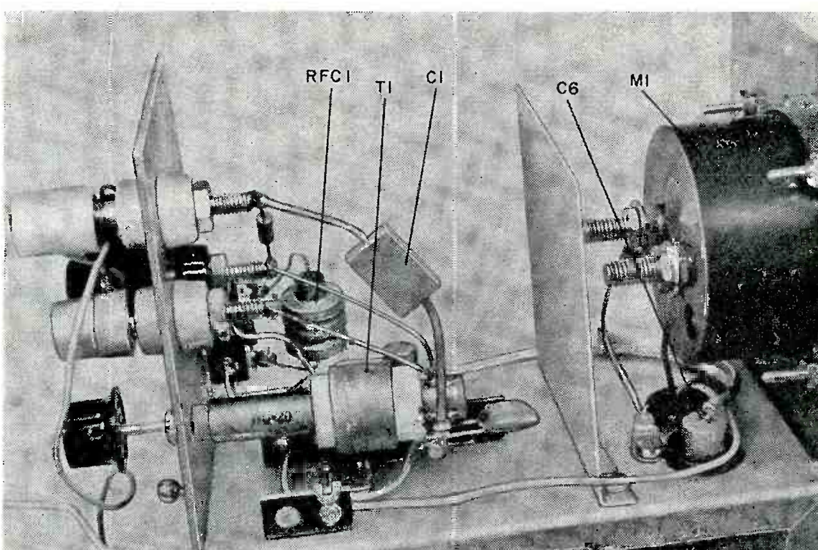
B1—9-volt transistor battery
BP1, BP2, BP3—5-way binding post
C1—0.001-μF mica capacitor
C2, C3—0.005-μF mica capacitor
C4, C5, C9—5.0-μF, 15-volt electrolytic capacitor
C6—0.02-μF paper capacitor
C7—0.0033-μF ceramic capacitor
C8, C12—0.1-μF paper capacitor
C10—0.01-μF paper capacitor
C11—350-μF, 15-volt electrolytic capacitor
D1—1N54 crystal diode
J1—Optional female connector (BNC, RCA, etc.) for scope cable
J2—Closed-circuit phone jack
L1—8-60 mH variable inductor (similar to J. W. Miller width control coil 6319)
M1—0-1 milliampere meter, full scale
Q1, Q3—2N404 transistor, or similar
Q2—2N508 transistor, or similar
R1, R2—15,000-ohm, ½-watt resistor
R3—22,000-ohm, ½-watt resistor
R4, R12—3300-ohm, ½-watt resistor
R5—5600-ohm, ½-watt resistor
R6—570-ohm, ½-watt resistor
R7—36,000-ohm, ½-watt resistor
R8—2700-ohm, ½-watt resistor
R9—10,000-ohm potentiometer, audio taper
R10—1000-ohm, ½-watt resistor
R11—68,000-ohm, ½-watt resistor
RFC1—50-mH r.f. choke
S1, S2—S.p.s.t. toggle switch
T1—4-30 mH variable inductor (similar to J. W. Miller width control coil 6316)
Misc.—Aluminum box, terminal boards, knobs, wire, solder, etc.

tors are followed by a diode rectifier whose output is amplified by another transistor will work at these frequen- or, if available, a chart recorder. All of the tuned circuits use ordinary TV width control coils as inductors. Almost any transistor will work at these frequencies, although the resistance values shown in the circuit diagram apply particularly to the 2N404 and 2N508—both of which are inexpensive and work well.

The diode circuit which rectifies the noise into a d.c. component needs no explanation except for capacitors *C10* and *C11*. These capacitors are used to smooth out the individual noise and static pulses into a slowly varying output which follows only the major changes in the atmospheric background noise—such as solar flares, or severe local thundershowers. The actual value of *C11* will depend upon the resistance of the meter or recorder coupled to transistor *Q3*. The value should be between 15 and 350 microfarads. Switch *S1* removes *C11* from the circuit and shortens the time constant of this stage when it is desirable to monitor the lightning flashes during a local thundershower.

A phone jack, *J2*, is provided for connection to the external chart recorder—which is the ideal instrument for monitoring solar flares. Until recently the cost of chart recorders has been prohibitive, but now they can be found on the surplus market at reasonable prices, or a brand-new chart recorder—such as that pictured on the cover of the Handbook—can be purchased for under $90.

Construction. Construction of the low-frequency solar flare monitor is relatively non-critical. The only precau-



Note the aluminum shield that the author found necessary to add above the chassis to prevent feedback from the meter to the input circuitry surrounding Q1. Coupling capacitor C6 is mounted in a rubber or plastic grommet so that one lead is above the chassis, the other lead below it. Leads to the meter pass through another grommet.

tion that must be observed is to shield the circuitry surrounding transistor *Q1* from the circuitry surrounding transistors *Q2* and *Q3*. Using commonly available components, the simplest solution to this problem is to build the receiver in, and on, a small aluminum box. The first stage of the receiver is mounted on the outside of the box and the second stage and metering circuits are inside the box.

To make the receiver more attractive, two end panels were cut from thin aluminum sheet metal. These were given a coat of automotive touch-up enamel and a screen cover was bent to fit around the end pieces. The cover can be fashioned from Reynold's perforated aluminum. Some builders may find it necessary to cut the bottom out of the box to prevent a closed r.f. loop being formed around the detector coil.

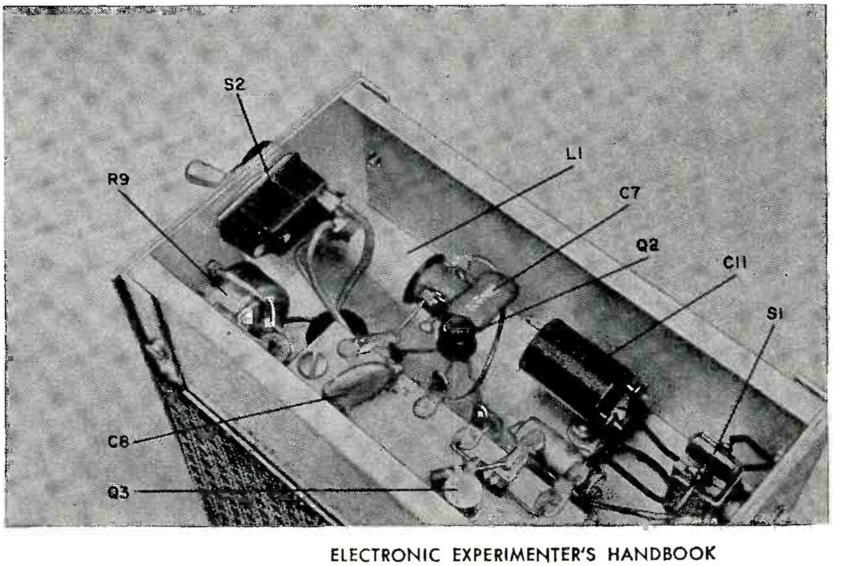
In the receiver built by the author, the transistor circuits were all mounted on small terminal boards, and the terminal boards were wired before being mounted on the chassis. Although the slug-tuned inductors need to be adjusted only once during the original tune-up process, the coils were placed on the front and rear panels for convenience. Care should be taken to make sure that choke *RFC1* is mounted at right angles to the core of r.f. transformer *T1*. The photographs show the appropriate mounting positions. Improper mounting of the collector load choke of *Q1* will cause this stage to go into oscillation. If oscillation persists in this circuit, reverse the leads to *RFC1*.

The 9-volt battery, *B1*, is mounted outside of the cabinet to make battery changing easier. If the unit is to be used over a long period of time, a larger-sized battery can be employed and left outside the retaining clip. Another feature that has been added to the author's model is an output jack to feed an oscilloscope. If a scope is available, the builder can use it to detect unwanted signals and self-oscillation.

Meter *M1* can be any 2" meter with a d.c. sensitivity between 50 μA and 1 mA. Resistor *R12* limits the current that will be drawn through the meter and/or the recorder. The value shown will permit somewhat over 1 mA to flow if the recorder has an internal resistance of 1000 ohms.

Tuning and Operation. After double-checking the wiring and connecting the receiver to an appropriate battery power supply, turn *R9* toward the ground end, and attach an outdoor antenna to either *BP1* or *BP2*. For the time being, connect the ground lead to *BP3* and wire *BP3* to a good "earth" ground. When battery switch *S2* is turned on, the meter will kick slightly and may read a very small current—which is the normal leakage present in transistor *Q3*.

Advance gain control *R9* slowly. If the meter suddenly goes off scale, regeneration is present. This regenerative



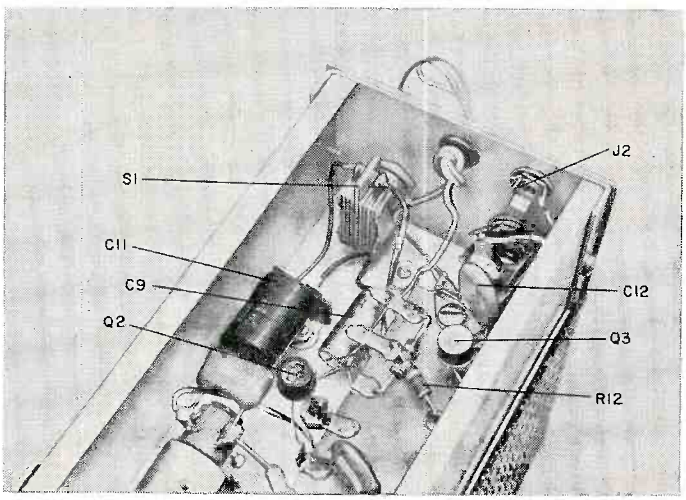
The three photographs on these facing pages show the arrangement of all parts mounted under the chassis. The author found it necessary to cut out the bottom of the aluminum chassis to eliminate "closed loop" regenerative feedback—otherwise the open bottom has no effect on receiver performance.

action can be controlled by changing the value of *R5*—reducing the value of this resistor should reduce the tendency toward regenerative oscillation. The receiver should show signs of regeneration with the antenna connected and the gain control turned "full-on."

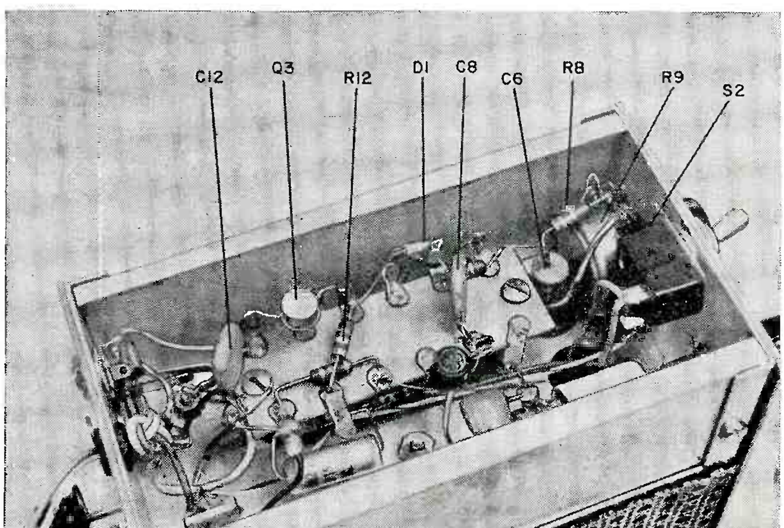
The simplest way to tune up this receiver is to use an audio oscillator. Couple the output of the oscillator loosely to the antenna and tune *T1* and *L1* for maximum meter reading.* Tuning should be done with the antenna connected, since the antenna can change the resonance of *T1*. If an audio oscillator is not available, the tuning can be peaked by simply adjusting *T1* and *L1* for maximum background noise. Adjustments are always made for maximum meter deflection. A fluorescent light is an excellent substitute generator and an antenna lead brought close to the lamp bulb will always show a high reading. Reduce the gain of *R9* as *T1* and *L1* are tuned for maximum readings.

After the receiver has been tuned—say to a frequency of 27 kHz—plug in a pair of earphones and open switch *S1*. You should hear nothing but a small amount of noise. If any low-frequency CW signals are heard, the receiver must

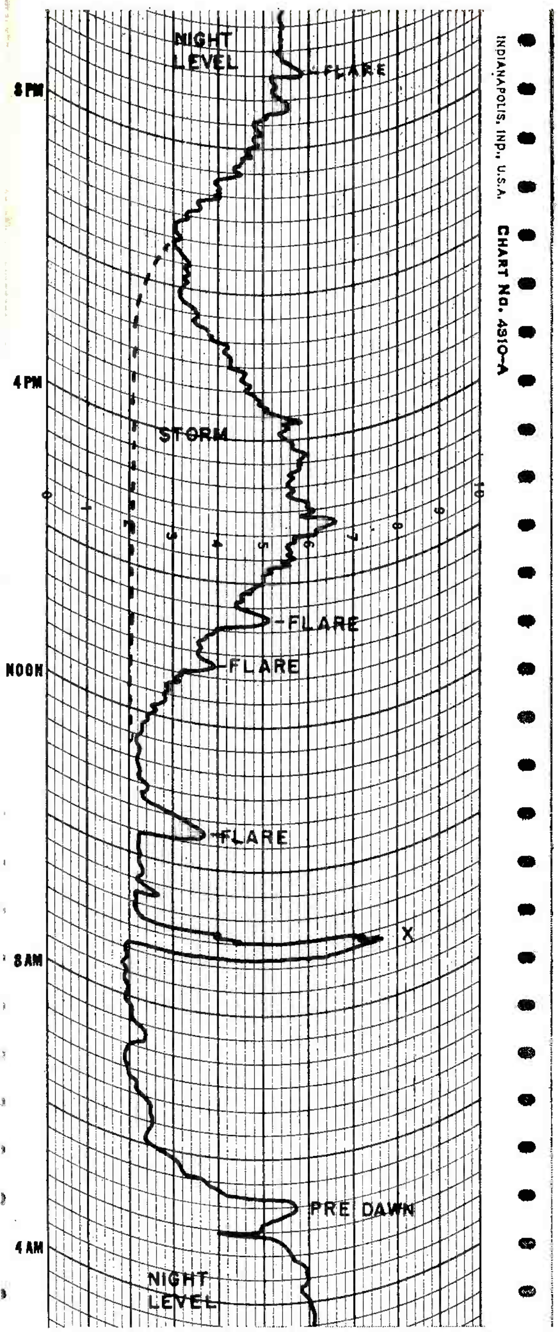
*Don't be fooled into thinking you can hear a "tone signal"—remember that you are using your audio generator to line up the receiver, not a modulated radio-frequency generator.



This view is toward the rear of the chassis. Jack J1 is under J2—one jack being regular phone size, the other a miniature. Switch S1 controls the time constant of the output circuit so that a chart recorder can read a rough average of the background noise—not individual noise bursts. Circuit values given are suitable for use with a Rustrak low-cost chart recorder such as the one shown on the cover.



A solder lug terminal board is used here to support the parts in the circuit around transistors Q2 and Q3. The transistor leads are soldered to the terminals to eliminate a need for sockets. Board can be pre-assembled and then mounted under the chassis with 6-32 screws, metal standoffs, lockwashers and nuts.



This "fake" chart recording shows some of the things you might observe with this VLF receiver. Reading up, the nighttime background noise level drops before sunrise, rises to a new peak, then falls to the usual daytime level. The sudden "kicks" in the graph (except the "X") are solar flares. The last flare of the day, at 9 p.m., is buried in the nighttime noise. Thundershowers produce considerable electrical disturbance, shown peaked here between 2 and 4 p.m. The "kick" at "X" indicates the type of noise associated with rocket booster firings.

be retuned to avoid these signals. All tuning should be done during the day with the antenna connected. When the receiver is ready for use, your first observation will be that the nighttime noise level is several times greater than the daytime noise level.

After verifying the differences in the noise level, adjust gain control *R9* for a nighttime noise level reading about two-thirds of the way up the meter scale. Just before dawn, the background noise level will drop. It will continue at a low level throughout the day with slight variations until sundown, when it will quickly rise to the nighttime level. However, a daytime thundershower can raise the background noise level to a very high meter reading.

Identifying Solar Flares. The occurrence of a solar flare will produce a sharp rise in the daytime background noise level. The peak noise level will hold for several minutes and slowly subside. On occasion, the fading out of the solar-flare-induced noise burst may last for more than a hour and this slow-fade helps to distinguish a solar flare from unusual electrical noises. A local electrical noise will usually rise fast and drop fast. Of course, thundershowers will always mask solar flare indications.

Many experimenters may find that it is possible to detect natural electrical disturbances when no clouds are visible in the sky. If capacitor *C11* is switched out of the circuit, it is possible to see each lightening stroke on the meter.

A few words of caution will prevent disappointment in the use of this receiver. The output of the receiver will not be a nice smooth line with an occasional lump that can be labeled "solar flare." Many things, known and unknown, can be read with the help of this receiver. In one day's recording, the author logged three solar flares, a severe thundershower up in the mountains, what appeared to be a rocket booster blast-off, and the sudden onslaught of a very noisy electrical motor.

So, when you get many signals, do a little detective work and find the source, if possible. A strange little squiggle on your recording chart could be a missile test in Mongolia, or—your neighbor's toaster. —30—

BUILD THE MODBOX

End guesswork with this plug-in adapter—now you can instantly check percent and quality of modulation

By GEORGE J. WHALEN

ASK ANY amateur or CB operator about the efficiency, power input, or stability of his AM phone transmitter and you'll likely be in for fifteen minutes of enlightening statistics about final amplifier plate current, grid excitation levels, and field strength measurements. Then, ask him what his average percentage of modulation is. In all probability, you'll be met with a blank stare and an answer something like: "Oh, about a hundred percent . . . I guess."

You can hardly blame him for not knowing much about his modulation, simply because most transmitters have no provisions for checking either quality or percent of modulation.

The "Modbox" takes the guesswork out of monitoring modulation. It is a simple, inexpensive modulation analyzer, designed for easy addition to any plate-

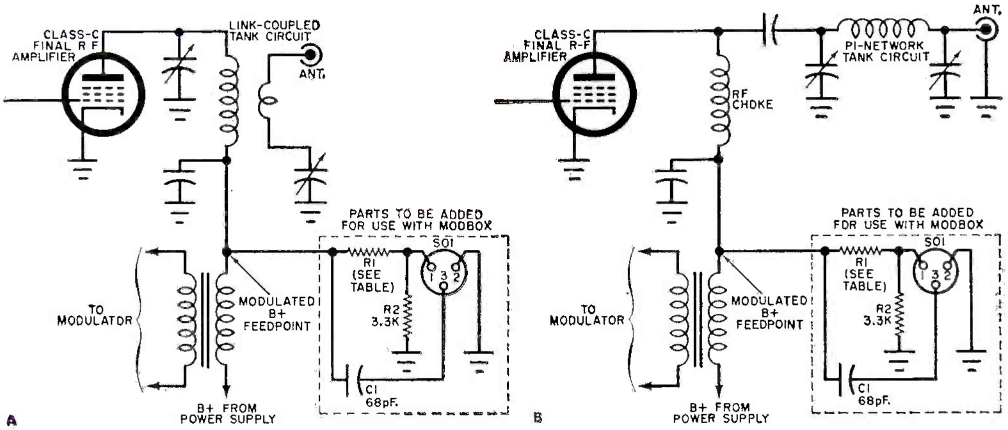


Fig. 1. Voltage divider R1 and R2, and harmonic frequency coupler C1 are installed in the final r.f. amplifier to obtain a sampling of harmonics and B-plus voltage without upsetting transmitter operation.

modulated AM transmitter or transceiver running up to 200 watts input. It provides three important monitoring features: first, it reads your average percentage of modulation; second, it flashes a warning whenever overmodulation or serious distortion is occurring in your final amplifier; and third, it lets you hear the audio applied to the final amplifier, for an on-the-spot listening test. This three-way quality check is the best insurance policy you can get against splatter, hum feedback, distortion, and loss of contacts due to poor modulation.

How It Works. A ratio voltmeter circuit is used to measure percentage of modulation, a peak-reading neon lamp "voltmeter" to detect overmodulation and audio distortion, and a direct audio monitoring circuit to couple audio out of your rig to a pair of headphones for a listening quality check.

The ratio voltmeter circuit makes it possible to measure both a.c. and d.c. voltages and the relative amounts of each voltage present with respect to the other. From these readings it is an easy matter to determine percent of modulation.

For safety's sake, the ratio voltmeter used in the Modbox operates from a resistive voltage divider installed in your transmitter's final amplifier as shown in Fig. 1. In this manner, high voltages are kept off the Modbox cable. The divider resistors have negligible effect on the transmitter and may be installed without violating any FCC regulations.

To better understand the operation of the ratio voltmeter circuit, imagine that the transmitter is in operation, but without modulation. Unmodulated B+ appears across *R1* and *R2*, and is divided down to a low voltage across *R2*, on the order of about 10 volts. This low voltage is connected by cable (through pin 1) to the Modbox (Fig. 2) where it appears across *CALIBRATION* potentiometer *R5*, but is blocked from the meter circuit by capacitor *C2*. When *PUSH TO CAL* switch *S1* is depressed, a path is created for d.c. to flow, through resistor *R3*, to d.c. milliammeter *M1*, and *R5* can be adjusted to obtain a full-scale reading of 1 mA. After this adjustment is completed, *S1* is released. The ratio voltme-

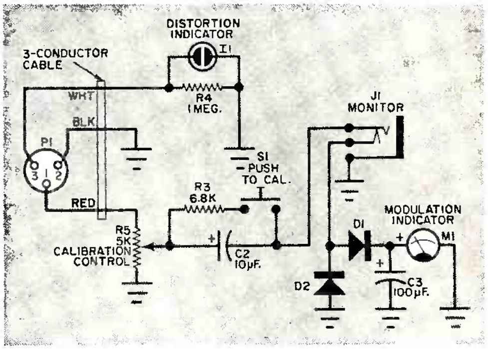


Fig. 2. Modulation indicator tells how much a.c. signal is present with respect to unmodulated d.c., to provide a percent modulation figure. Distortion indicator I1 lights up in the presence of harmonic frequencies which are generated by overmodulation.

ter is now calibrated for the unmodulated d.c. plate voltage in the final amplifier, and is ready to accurately measure a.c. modulation voltages with reference to this d.c. voltage.

When you speak into the microphone, your rig's modulator applies an a.c. modulating voltage to the final amplifier, superimposed on the d.c. plate voltage. This combination of voltage is also divided down by *R1* and *R2*, and appears across *R5*. Since *S1* is open, d.c. is blocked from the meter circuit, but the a.c. modulating voltage is coupled to rectifier diodes *D1* and *D2* and the meter by *C2*. Rectified audio voltages are filtered by *C3* and *M1* indicates the relative effective value of the a.c. modulating voltage. For 100% modulation, *M1* will give a reading of 0.7 mA. Readings exceeding 0.7 mA indicate overmodulation, which could result in "splatter" and distortion.

The distortion-indicating circuit is coupled to the modulated B+ by *C1* (Fig. 1) and because of the small amount of capacitance (68 pF) does not readily see audio voltages at frequencies in the range of 300 to 3000 Hz. However, when a condition of overmodulation exists, high-frequency harmonics are usually generated in the final amplifier on the order of 10,000 to 30,000 Hz, which are more easily passed by *C1*. When the harmonic voltages appear across *R4* and exceed a peak of about 65 volts, the neon lamp (*I1*) flashes and provides a visual indication.

A listening quality check of the audio can be made simply by plugging a pair of 2000-ohm headphones into jack *J1*. The rectifier and meter circuit is disconnected when the phones are plugged in. Potentiometer *R5* can be used as a volume control to adjust the sound level in the headphones.

PARTS LIST

C1—68-pF, 3000-WVDC, ceramic capacitor
C2—10-µF, 25-WVDC, electrolytic capacitor
C3—100-µF, 6-WVDC, electrolytic capacitor
D1, D2—1N2070 silicon rectifier (or equivalent)
I1—NE-51 neon lamp
J1—Single closed-circuit phone jack (Switchcraft 12A or equivalent)
M1—Miniature 0-1 mA d.c. milliammeter (Lafayette 99 R 5052 or equivalent)
P1—Miniature male shielded cable connector (Amphenol MPM3L or equivalent)
R1—See Table 2
R2—3300-ohm, ½-watt resistor
R3—6800-ohm, ½-watt resistor
R4—1-megohm, ½-watt resistor
R5—5000-ohm, ½-watt linear taper potentiometer (Mallory U-14 or equivalent)
S1—S.p.s.t. normally-open push-button switch (Switchcraft 201 or equivalent)
SO1—Miniature female shielded chassis connector (Amphenol PCG-3 or equivalent)
1—5" x 2¼" x 2¼" aluminum utility box (Premier AMC 1004 or equivalent)
Misc.—⅜"-i.d. and 5/16"-i.d. grommets, 3-conductor cable, terminal strip, knob, screw, nut, wire, solder, etc.

Construction. Layout and type of cabinet used are matters of choice and are not critical. The few parts required for the entire circuit could be made to fit into your present rig, if you have the space on the front panel for *M1*. However, you will get more mileage out of the Modbox if it is a separate unit; you can plug it into different transmitters as needed.

A 5" x 2¼" x 2¼" aluminum utility box can be used. The holes should be located and drilled as shown in Fig. 3.

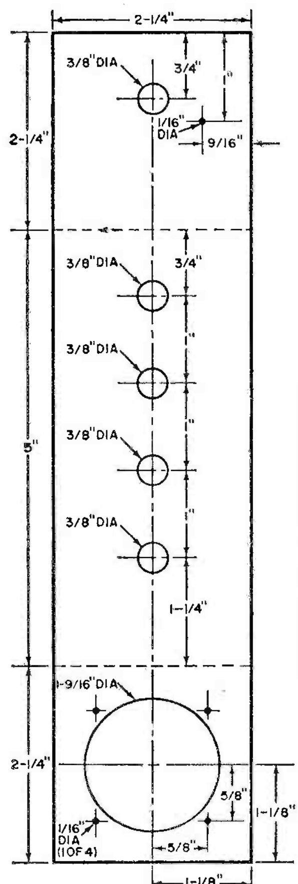


Fig. 3. Type of box used and layout are not critical, but make the four bolt holes for the meter a bit oversized to permit rotating the meter if necessary to keep it straight. If you have enough room on your transmitter, you can mount all the parts directly on it, and thus do away with the cable and the box.

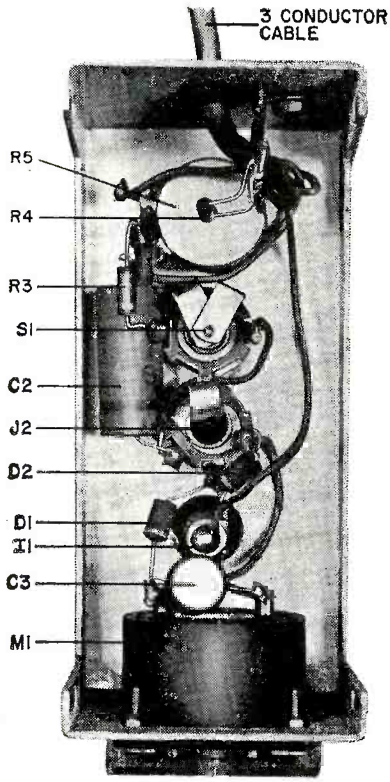


Fig. 4. Mount the parts in any convenient manner, but observe polarity of the meter, diodes, and electrolytic capacitors. Use a clamp to hold the cable.

The meter hole should be made to conform to the meter used. Mark the positions of the four meter-mounting screw holes and drill them somewhat oversize to permit slight rotation of the meter, if necessary, to mount it straight.

Appearance counts in home-brew gear just as much as it does in commercial equipment. So, if you want a really professional-looking job, smooth all burrs, polish the box with fine steel wool, paint, and apply decals. A final coat of clear acrylic lacquer will protect the unit from normal wear and tear. Four tiny rubber feet cemented to the bottom half of the box will enhance the appearance of the unit and protect your furniture.

When the chassis work and appearance details have been completed, assemble the three-conductor cable and connector *P1*. Cable length is not critical, but it should be just long enough to make a neat hookup to your transmitter. If you have to cut the shaft of *R5* down to size, do so without subjecting the control head to stress. The neon lamp is held in place with a 3/8"-i.d. grommet.

Mount the meter after you have completed the wiring. Be sure to observe polarity of the meter, diodes, and electrolytic capacitors. And avoid overheating the diodes when soldering.

Calibration. No calibration is necessary as the meter readings are relative to the setting of *R5* for an unmodulated signal. However, if you would like to double-check your work, you can put together the test setup shown in Fig. 5. The VOM should be a 20,000 ohms-per-volt meter, capable of good accuracy on the low-voltage a.c. and d.c. ranges. Do not substitute a peak-to-peak VTVM for the VOM since this procedure calls for a meter capable of reading r.m.s. rather than peak a.c. voltages.

Connect the test setup to the Modbox, but do not connect the primary of the transformer to the 117-volt a.c. source just yet. Set the VOM to read d.c. volts and adjust *R6* until the VOM reads 6.3 volts d.c. Next, depress switch *S1* and adjust the Modbox *CALIBRATION* potentiometer (*R5*) until meter *M1* shows 1 mA. Readjust *R6* if necessary, to obtain the 6.3-volt d.c. reading on the VOM. Then, without disturbing any adjustments, release *S1*, set the VOM to read a.c. volts, and connect the calibrator to 117 volts a.c. The VOM should read 6.3 volts a.c., and Modbox meter *M1* should indicate 0.7 mA—corresponding to a 100% modulation reading.

If *M1* reads higher than 0.7 mA, decrease the value of the 6800-ohm resistor (*R3*) and repeat the calibration check. If *M1* reads lower than 0.7 mA, increase the value of *R3* and repeat the calibration check. One precaution: the a.c. voltage from the transformer must be no more and no less than 6.3 volts for this calibration procedure.

If you want to convert your meter to a direct-reading modulation meter, transfer the readings from the accompanying calibration chart (Table 1) onto the meter face, using a fine-pointed pen or colored pencil. If you are just interested in knowing how close your average modulation percentage comes to 100%, mark a line on the meter scale just beyond the 0.7-mA division and write in "100%"

above it. Then, carefully fill in the scale divisions between 0.7 and 1 mA in color, so that readings exceeding the 100% mark will stand out at a glance. If you wish, you can type out a small chart and cement it to the side of the case.

Transmitter Hookup. Select a suitable place in the transmitter, preferably as close to the final amplifier as possible, and mount *J1*. Next, compare your transmitter's schematic diagram with the two typical final amplifier circuits shown in Fig. 1, and locate the modulated B+ feed-point in your circuit. Once you've located the connection point, determine the d.c. plate voltage appearing at that point, either by measuring it directly or from the transmitter schematic. The plate voltage in your transmitter determines the value of divider resistor *R1*. See Table 2.

Install *R1*, *R2*, and *C1* in your final amplifier circuit, and keep the leads as short as possible. Insulate any lead which might come in contact with the chassis. Pay particular attention to the grounding of *R2*, and pin 2 of *SO1*. After these components have been installed, connect the Modbox to the transmitter by plugging *P1* into *SO1*, and perform a quick continuity check on the interconnecting cable. Be sure that the Modbox's case shows continuity with the transmitter's chassis. Check all wiring carefully, button up the Modbox—and your transmitter—and you're ready to try it out on the air.

On The Air. It's a good idea to run your transmitter into a dummy load to make your adjustments and to avoid cluttering up the airways with extraneous sounds prior to going on the air, especially after a modification or repair has been made. Warm up the rig, cover the microphone or run the modulation control down to zero to prevent modulation of the carrier, depress the *PUSH TO CAL* switch (*S1*) on the Modbox and simultaneously adjust the *CALIBRATION* potentiometer (*R5*) until the meter indicates 1 mA. Release *S1* and speak into the microphone at a normal level. If your rig has a modulation gain control, bring the level up while speaking, observing the meter as it "kicks" in response to your speech. Bring the mod-

(*Continued on page* 149)

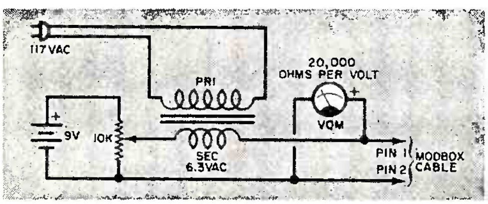


Fig. 5. Simple test setup for calibration purposes can be put together with a 9-volt d.c. and a 6.3-volt a.c. source. However, the Modbox is essentially foolproof, and does not require a calibrator.

MODBOX METER CALIBRATION CHART

METER READING (d.c. mA)	% MODULATION
0	0
0.07	10
0.14	20
0.21	30
0.28	40
0.35	50
0.42	60
0.49	70
0.56	80
0.63	90
0.70	100
0.71 to 1.0	Overmodulation

Table 1. You can obtain direct meter readings of percent modulation by inscribing these figures on the meter dial, or you can paste this table on the side of the box. If you are just interested in knowing how close you can get to 100% modulation, without overmodulating, paint that portion of the dial above 0.71 mA in red, or any suitable color.

VALUE OF RESISTOR R1

FINAL R.F. AMPLIFIER D.C. PLATE VOLTAGE	OHMS	WATTS
150	36,000	2
175	43,000	2
250	62,000	2
325	82,000	4
400	100,000	4
475	120,000	4
550	130,000	5
625	150,000	6
700	180,000	6

Table 2. Value of R1 depends upon the final amplifier's plate voltage. If necessary, you can parallel a couple of resistors to obtain needed wattage and resistance. Don't go below the wattage indicated.

SURE-SHOT Q5-er HOOKUP

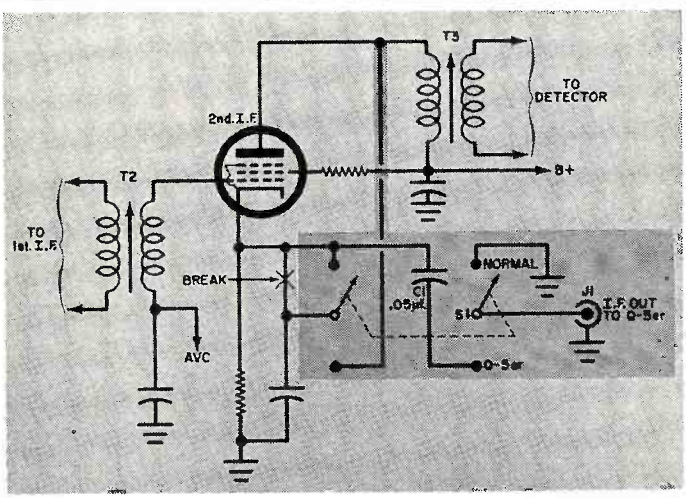
WHY DETUNE YOUR I.F. WHEN YOU CAN ISOLATE YOUR BC-453

IF YOU ARE in possession of a surplus BC-453 long-wave receiver, you have probably given thought to using the BC-453 as a "Q5-er." Unlike the commercially available "Q-multipliers" (Heathkit, WRL, etc.) that electronically increase the *Q* of an i.f. stage—thus increasing selectivity—the Q5-er is a separate receiver with its own highly selective i.f. strip. When you use the Q5-er, you disable your regular receiver's detector and audio and use those in the BC-453.*

In the circuit shown on this page, the author modified the second i.f. stage in his short-wave receiver so that this stage could also act as a cathode follower. The output of the cathode follower is then fed into the antenna terminal of the BC-453 through jack *J1*. A d.p.d.t. low-capacity rotary switch (*S1*) enables the operator to switch back and forth between the Q5-er and the regular receiver. Without this cathode follower arrangement, the input of the BC-453 would have been taken from the plate of the second i.f. tube and consequently misaligned i.f. output transformer *T3*.

Mount switch *S1* as close to the i.f. stage as possible to curb potential feedback problems. Use coaxial cable or a good shielded lead between the switch and jack *J1*. Although there is modest loss of signal strength through the cathode follower arrangement, the BC-453 has more than enough "sock" to compensate for the unity gain of the rewired i.f. stage. —*Bradley J. Thompson*

**The BC-453 tunes through the 455-kHz i.f. of most receivers. The i.f. signal is converted to 85 kHz where better selectivity can be obtained without resorting to Q-multiplier gadgets.*



In the "Normal" position, the receiver operates as originally designed. In the "Q5-er" position, the output of the i.f. stage is bypassed to ground and the 455-kHz i.f. signal fed into the connection to the Q5-er.

BUILD:

POWERHOUSE 2-TUBE SHORT-WAVE RECEIVER

By CHARLES GREEN, W6FFQ

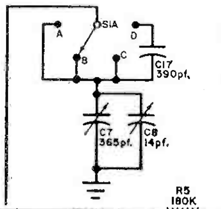
DON'T LET THE "2-TUBE" ANGLE THROW YOU . . . THIS RECEIVER IS ACTUALLY THE HOTTEST THING AROUND

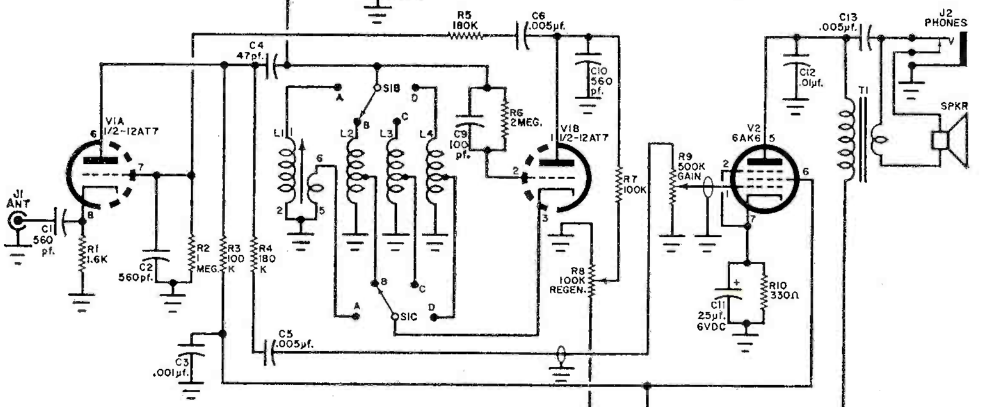
HERE'S a short-wave receiver that's built like a brick house, yet fires up like a real powerhouse. True, it cannot claim style . . . but it sure can boast plenty of class. Far more important is the fact that it pulls in more stations—from all over the world—than many commercial short-wave receivers with a lot of fancy circuitry that adds nothing but complexity. This "little monster" covers frequencies from 500 kHz to 30 MHz in four bands! How about that?

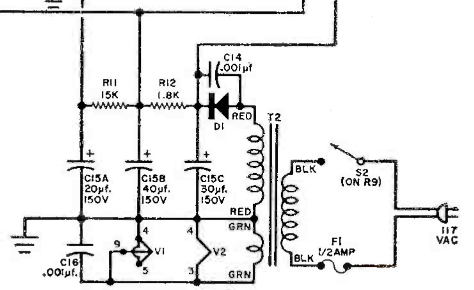
Just imagine picking up your local broadcast stations, then switching to the marine band, then to the international short-wave bands, all the way down to the 10-meter amateur band! A simple bandspread tuning circuit is incorporated to provide maximum selectivity in the crowded bands, and provisions are included for either speaker or headset operation.

About the Circuit. The "little monster" is a transformer-operated regenerative receiver employing switchable coils (see Fig. 1). A twin triode (12AT7) op-

Fig. 1. Featuring a sensitive regenerative circuit, this transformer-operated receiver employs a single triode functioning as r.f. amplifier and regenerative detector, and a power pentode as audio driver.







erates as an r.f. amplifier and regenerative detector. A power pentode (6AK6) drives the speaker or headphones through output transformer *T1*. Transformer *T2*, silicon diode *D1* and a filter consisting of *C15*, *R11* and *R12* provide B+ power.

The r.f. signals from the antenna are cathode-fed to grounded-grid reflex amplifier *V1a* through *C1*. The amplified output is applied to *V1b* through *C4*. The detected audio is fed back to the grid of *V1a* through *C6*-*R5*, and after amplification is coupled to gain control *R9* thru *R4*-*C5* before it is applied to *V2*.

Switch *S1* selects the coils for the desired band while *R8* varies the regenera-

PARTS LIST

C1, C2, C10—560-pF, 400-volt ceramic disc capacitor
C3, C14, C16—0.001-µF, 400-volt ceramic disc capacitor
C4—47-pF, 400-volt ceramic tubular capacitor
C5, C6, C13—0.005-µF, 400-volt ceramic disc capacitor
C7—10-365 pF variable capacitor
C8—2-14 pF miniature variable capacitor (E.F. Johnson 160-107 or equivalent)
C9—100-pF, 400-volt ceramic tubular capacitor
C11—25-µF, 6-volt electrolytic miniature capacitor
C12—0.01-µF, 1000-volt ceramic disc capacitor
C15—20-30-40 µF, 150-volt electrolytic capacitor
C17—390-pF, 400-volt mica capacitor
D1—1N1697 diode
F1—½-ampere fuse (and fuse holder)
J1—Phono jack
J2—Closed-circuit phone jack
L1—Oscillator coil (J.W. Miller 71-OSC or equivalent)
L2, L4—B & W 3016 Miniductor coil
L3—B & W 3013 Miniductor coil
R1—1600-ohm, ½-watt resistor
R2—1-megohm, ½-watt resistor
R3, R7—100,000-ohm, ½-watt resistor
R4, R5—180,000-ohm, ½-watt resistor
R6—2-megohm, ½-watt resistor
R8—100,000-ohm potentiometer, linear taper
R9—500,000-ohm potentiometer, audio taper (with on-off switch S2)
R10—330-ohm, 1-watt resistor
R11—15,000-ohm, ½-watt resistor
R12—1800-ohm, 2-watt resistor
S1—3-pole, 4-position rotary switch
S2—S.p.s.t. switch (on R9)
T1—Output transformer: primary, 10,000 ohms; secondary, 4 ohms (Stancor A3879 or equivalent)
T2—Power transformer, 125 volts @ 15 mA and 6.3 volts @ 0.6 ampere (Stancor PS-8415 or equivalent)
V1—12AT7 tube
V2—6AK6 tube
SPKR—4", 3.2-ohm speaker
1—8" x 6" x 4½" aluminum box (LMB 146 or equivalent)
1—8" x 5½" x 1/16"-thick aluminum sheet
Misc.—Terminal strips, a.c. line cord, knobs, 7-pin and 9-pin tube sockets, etc.

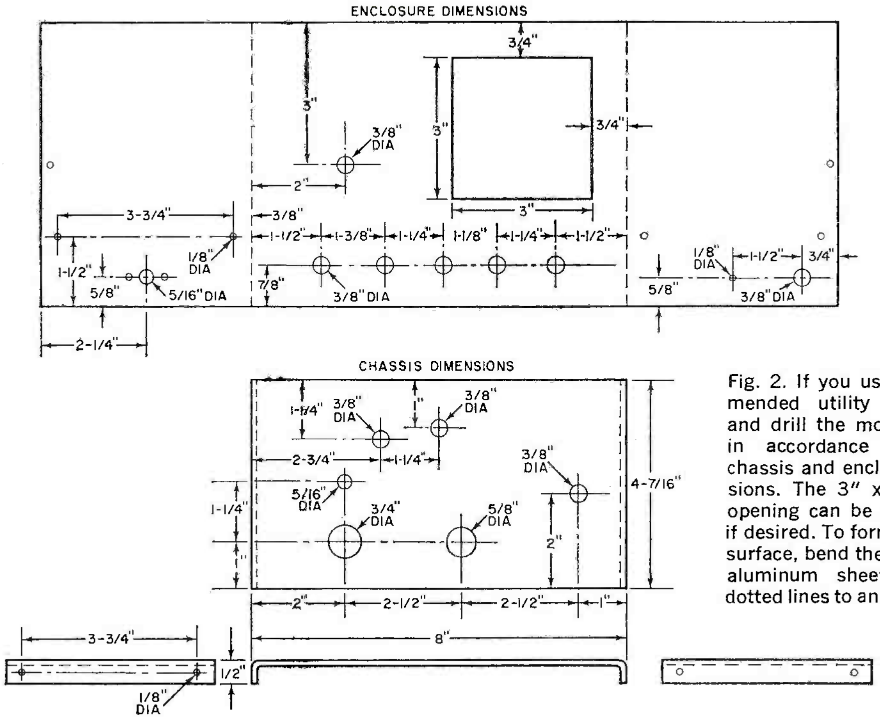


Fig. 2. If you use the recommended utility box, punch and drill the mounting holes in accordance with these chassis and enclosure dimensions. The 3" x 3" speaker opening can be made round, if desired. To form the chassis surface, bend the edges of the aluminum sheet along the dotted lines to an angle of 90°.

tion of the detector. Capacitor *C7* is the main tuning capacitor and *C8* provides bandspread tuning. Band A covers approximately 0.5 to 1.6 MHz; band B from 1.7 to 5 MHz; band C from 4.5 to 14 MHz; and band D from 13.5 to 30 MHz.

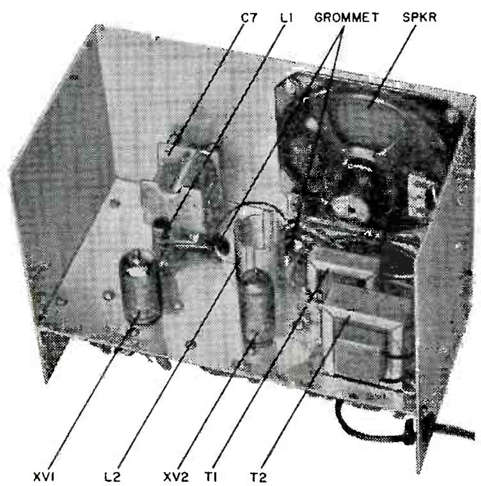


Fig. 3. Assemble major components on the chassis at the locations shown. Be sure to use four ⅜"-long spacers between capacitor C7 and front panel.

Construction. The receiver is assembled on a 1/16"-thick 4 7/16" x 8" aluminum plate mounted in a utility box (LMB 146) approximately two inches from the bottom of the box. The speaker, dial plate, and the tuning and operating controls are all mounted on the front panel of the utility box.

Mounting dimensions and drill sizes for the chassis and cabinet are given in Fig. 2. After drilling out and deburring the holes, install the tube sockets, rubber grommets, speaker and metal grille, transformers, coils, and the tuning capacitor at the locations shown in Fig. 3.

Coil details and terminal connections are given in Fig. 4. Note that the B & W coils must be cut down to a specified number of turns, and that in each case a #6 ground lug is attached to one end of the coil. To attach the lug to the coil, file the lug to get a sharp edge, heat it, and then insert it into the plastic coil form nearest the end of the coil, after soldering the coil terminal to the lug. Use the shortest lead possible. The ground lug is secured to the chassis with a #6 self-tapping screw.

You can now follow the pictorial diagram (Fig. 5) for the layout of com-

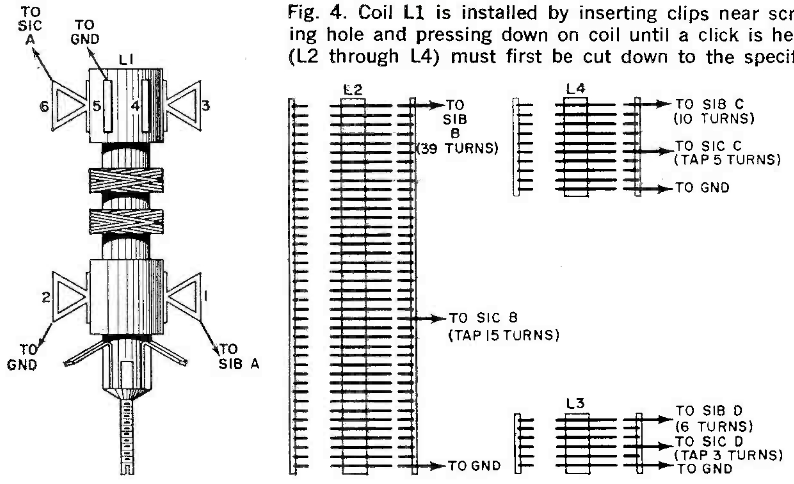


Fig. 4. Coil L1 is installed by inserting clips near screw end into mount—ing hole and pressing down on coil until a click is heard. The B & W coils (L2 through L4) must first be cut down to the specified number of turns.

ponents and circuit wiring. Be sure to dress the 6.3-volt filament wires close to the chassis while keeping them away from the coils. Keep all wiring as direct and as short as possible.

Use ⅜″-long spacers to mount the tuning capacitor to the front panel, and make sure the lugs on the capacitor are not grounded to the chassis. After completing the assembly, install the template (Fig. 6) on the front panel over the tuning capacitor. Then install a tuning knob with pointer and the remaining control knobs.

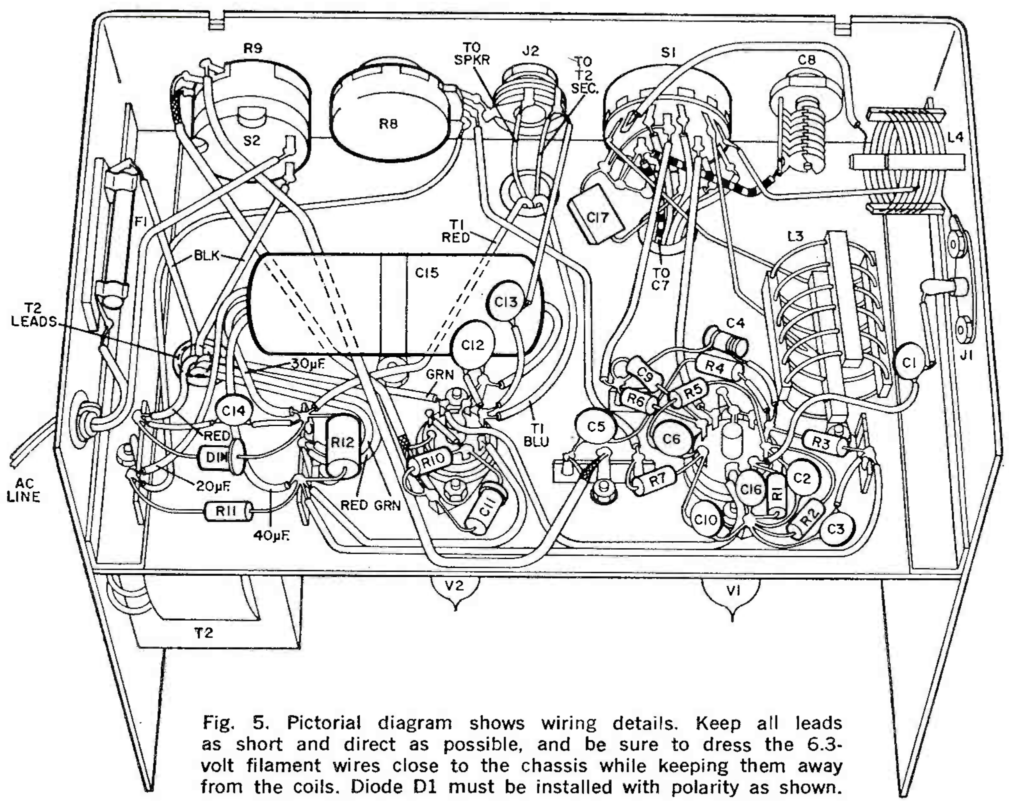


Fig. 5. Pictorial diagram shows wiring details. Keep all leads as short and direct as possible, and be sure to dress the 6.3-volt filament wires close to the chassis while keeping them away from the coils. Diode D1 must be installed with polarity as shown.

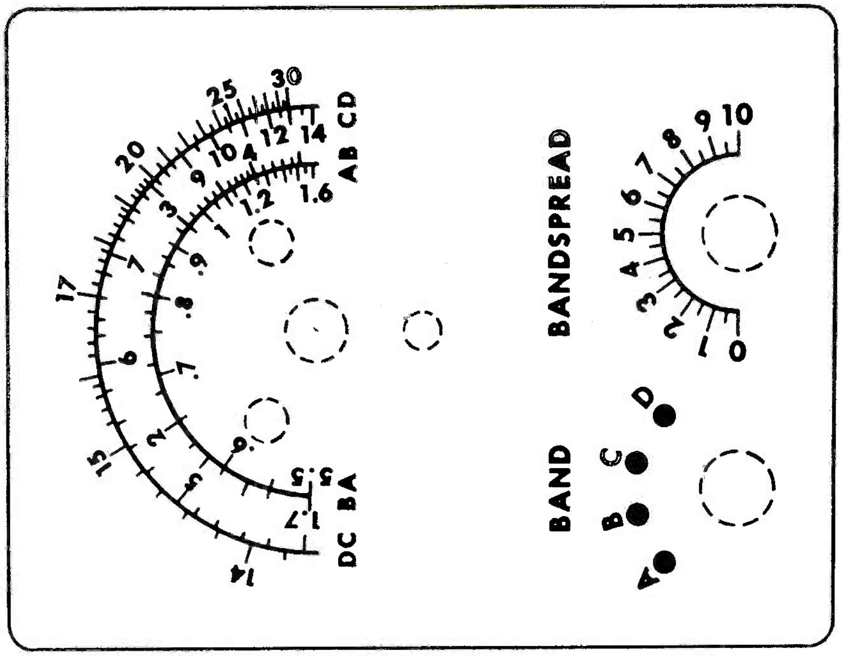


Fig. 6. This dial can be cut out, or redrawn, and pasted on receiver front panel. Actual calibration markings can be made when receiver is tuned to signals of known frequency.

Adjustments. During initial adjustment of the receiver, you may find that the frequencies of the stations tuned in do not correspond to the dial markings. This could be due to lead dress and other variables that can change the receiver tuning slightly. If this is the case, it is suggested that you either modify the template by changing the markings on it, or else make a new template which you can calibrate as necessary.

If you have a signal generator, then by all means use it to calibrate your dial settings. If you happen to live in the vicinity of a broadcasting station and find that your receiver is swamped by strong signals, you can easily clear up this condition with a series wave trap connected between the antenna jack and chassis.

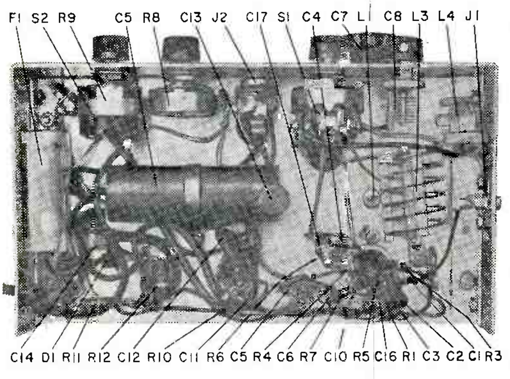
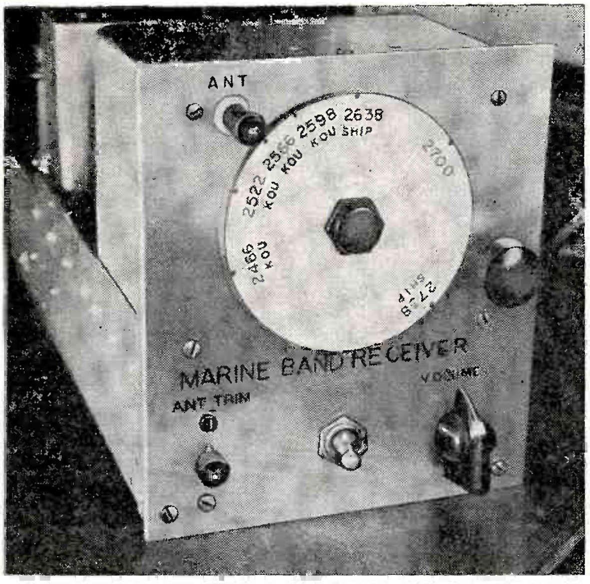


Fig. 7. Layout is simple and uncramped. Plastic fuse cover prevents accidental contact with a.c. line if you're working on the receiver with power on.

Use a J. W. Miller 71-OSC coil with a 365-pF trimmer capacitor connected between pins 1 and 2 (the grid winding) of the coil to form the trap. Then simply adjust the trimmer until all interference is reduced to a minimum. This adjustment should not affect reception of other stations.

Operation. Plug in the receiver to a convenience outlet and turn the *GAIN* control all the way up. Hook up a good antenna to *J1*, and advance the *REGEN* control until you hear a loud noise or a whistle. Then back off on the *REGEN* control until the noise or whistle just disappears, and your station should come in loud and clear.

With a little practice, you will soon become a pro at adjusting the *REGEN* to the proper level while you pull in stations from all over the band. —30—



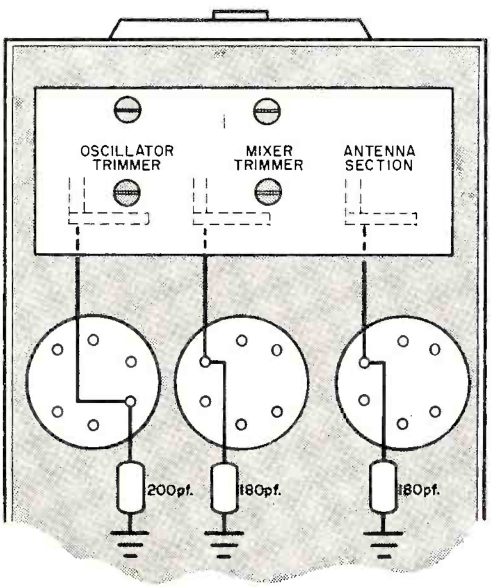
BC-454 GOES MARITIME

By E. H. MARRINER, W6BLZ

Bandspread your military surplus receiver to tune the small boat coastal frequencies

A dial was fabricated showing some of the more important maritime ship and shore frequencies used on the west coast. Listeners on the east coast should set their receivers so that WWV on 2.5 MHz is in the middle of the tuning range. The converted BC-454 makes an excellent "second" receiver for home use, or may be battery-operated in a small boat.

ANY small boat owner or SWL can change a BC-454/ARC-5 receiver into a bandspread 2.5-MHz marine band receiver. The BC-454 24-volt unit is easily modified for 117-volt a.c. operation (see "Converting Your First Command Receiver," POPULAR ELECTRONICS, June, 1963). To confine the original 3.0-6.0 MHz tuning range to 2.2-2.8 MHz, the builder need only buy three capacitors and wire them in parallel with the existing tuning gang.



This combination wiring/pictorial diagram shows the exact wiring position of the three silver mica fixed capacitors. Placing these capacitors in the circuit bandspreads the receiver's tuning range.

Turn the receiver over and remove the bottom plate. The tuning capacitors are ganged together under the aluminum box cover that runs from one side of the receiver to the other. Temporarily remove this second protective cover. Using the diagram as a guide, mount three silver mica capacitors in the approximate physical positions indicated. If you wire-trace the electrical position of these capacitors, you will see that they are in parallel with the tuning gang and r.f., mixer, and oscillator coils.

When the capacitors are soldered in place, tune in a station around 2500 kHz and peak up the antenna trimmer capacitor on the front panel. Next, adjust the mixer tuning gang (the middle capacitor) padder for maximum signal strength. And you're in business. If you find the oscillator frequency needs adjusting to cover the approximate frequency range mentioned above, touch up the oscillator padder. Then replace the capacitor cover and the bottom plate.

Keep in mind that radiotelephone conversations are not to be revealed to a third party. Discussing, recording for playback, and disclosure of such conversations is a violation of the 1934 Communications Act. —30—

CHAPTER

4

LAB and TEST EQUIPMENT PROJECTS

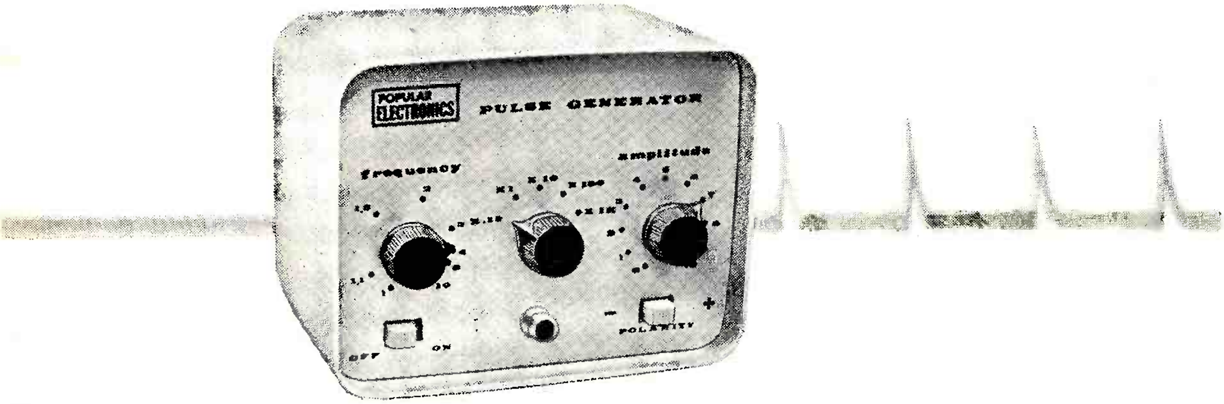
If you read all the advertisements for test equipment kits, you may be surprised to find that some readers of the ELECTRONIC EXPERIMENTER'S HANDBOOK actually build some of their test gear. More often than not, the reason that hobbyists build test equipment is that they are looking for something special, something not found in run-of-the-mill equipment. With that thought in mind, your editors selected the following test equipment projects as being something out of the ordinary.

The "Pulser" (page 92) is undeniably a piece of equipment that not every hobbyist is going to build, or even want in his shop. But, wait a minute—take a look at the circuit. Did you ever see a generator that was simpler? Or had the output range? Or had the frequency range? Probably not, because this generator is built around a third generation solid-state component—the four-layer diode.

And, if we want to talk about third generation components, the IC in the $6 amplifier (page 103) certainly qualifies. This handy little project could be useful around any lab or workshop bench.

ADVANCED EXPERIMENTER PROJECT

PULSE GENERATOR



By **DON LANCASTER**

Variable amplitude and frequency trigger for counting, testing, and experimenting

A GOOD commercial pulse generator can sport a $200-and-up price tag. Here is a versatile unit you can build for less than $15 . . . or as little as $2.00. If your workshop is well-stocked, chances are you will only need to buy one $2 part. The circuit is simple, foolproof, and easily built in one or two evenings.

The Pulser produces a free-running series of sharp trigger pulses, variable from 0 to 10 volts in amplitude and with a variable repetition rate of from one pulse every ten seconds to 11,000 pulses per second. It has five overlapping scales and a choice of pulse polarity. It is battery-operated and draws less than 0.0005 ampere, and can put out almost 8 watts of peak pulse power.

To boot, the Pulser has a low-output impedance and is short-circuit-proof. You can run it all day into a dead short. The rise-time is quite snappy—only 50 nanoseconds. Pulse width varies from scale to scale, but always stays at roughly 1/1000 of the repetition time.

Applications. An important experimental use for the Pulser is as a trigger source for multivibrators and counter circuits. If you have a scope, here is a convenient pulse source for resonance demonstrations, time constant experiments, and "Q" measurements. It is dandy for testing radio control modules and escapements, and doubles as a trigger source for experimental transistor and SCR power inverter circuitry.

The lower repetition rates are tops for timing displays, exhibits and flashers. For example, you can use the Pulser to trigger an SCR lamp controller. Set the Pulser to 58 hertz and the bulb will smoothly oscillate at a 4-hertz rate. Place a photocell in front of the light, and you'll wind up with an ultra-low-frequency audio oscillator.

The Pulser easily drives a speaker and produces a series of "pock-pock-pock" sounds to enable you to check out speakers and output transformers. You can also use it as a signal injector for all sorts of audio testing and troubleshooting. And, finally, you can use the "pocks" themselves; the unit will serve as a metronome or as a darkroom timer.

How It Works. It's all made possible by a new semiconductor which sells for $2 . . . a *four-layer diode.* Unlike ordinary diodes, the four-layer diode is a voltage-sensitive switch. It is normally *off*, leakage current is negligible, and it snaps *on* when it "sees" 12 volts. It stays *on* as long as there is significant current (more than 1 ma.) left in the circuit. In the *on* state, the impedance is so low that you must limit the current externally; otherwise the diode will destroy itself. Just like a regular diode, the four-layer diode operates only in the forward direction.

Add two resistors, a capacitor, and a battery to the diode, and you have a pulse generator, as shown in the simplified circuit of Fig. 1. Capacitor *C* takes on a charge from *B1* through *R1*. When the charge reaches 12 volts, the diode snaps *on*, producing a sharp spike across current limiting resistor *R3*. This spike is the output pulse and is almost 10 volts high; its width is *R3* x *C*.

As the capacitor discharges (very rapidly, since *R3* is much smaller than *R1*), less and less current flows through the diode, and it finally turns *off* when the capacitor voltage drops close to zero. As battery current through *R1* in this circuit is held to 0.5 ma. or less, it cannot hold the diode *on*; the capacitor recharges, and repeats the cycle.

One output pulse is produced for each charge and discharge cycle. The waveforms in Fig. 2 show the exponential charge-discharge waveform at point *A* in the simplified circuit, the sharp output pulse at point *B*, and their relationship to the *on-off* time of the diode.

Figure 3 shows the entire circuit of the Pulser. You can change the frequency by varying *R2* or by switching in different capacitors. Potentiometer *R2* provides a continuously variable frequency range, on the order of 11 to 1. Each of the five capacitors is ten times

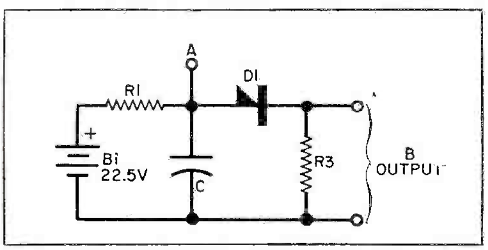


Fig. 1. Four-layer diode conducts when the capacitor charges up to about 12 volts, and stays "on" as long as there is more than 1 ma. of current flow.

PARTS LIST

B1—22½-volt battery
C1—30-µf., 15-volt electrolytic capacitor
C2—3-µf., 15-volt electrolytic capacitor
C3—0.3-µf., 200-volt Mylar capacitor
C4—0.03-µf., 200-volt Mylar capacitor
C5—0.003-µf. mica capacitor
D1—Four-layer diode (Motorola M4L3054, available from Allied Radio, $2.00)
J1—Phono jack
R1—47,000-ohm, ½-watt resistor
R2—500,000-ohm, 2-watt potentiometer (linear taper)
R3—250-ohm, 2-watt potentiometer (linear taper)
R4—3.3-ohm, ½-watt resistor
S1—S.p.s.t. slide switch
S2—Single-pole, five-position wafer switch (Mallory 3215J or equivalent)
S3—D.p.d.t. slide switch
1—3" x 4" x 5" case, approx. (Zero Z58-78-52 or Bud CU-2105A or equivalent)
1—4" x 5" dialplate (an anodized hard aluminum Metalphoto dialplate with POPULAR ELECTRONICS on it is available from Reill's Photo Finishing, 4627 North 11th St., Phoenix, Ariz. 85014; in silver color for $2.75, or blue, red, or copper for $3.25, postpaid in U.S.A.)
Misc.—Battery holder; #10 nylon countersunk washers (4); nuts and bolts; knobs (3); wire; solder; etc.

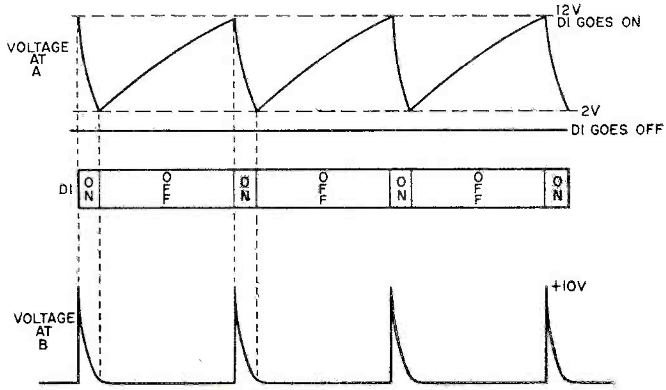


Fig. 2. Typical capacitor charge-discharge waveform is present at point "A" in Fig. 1. At output "B," the rise time is so fast that you'll need a fairly good scope to see it. When the diode is "off," the capacitor has a chance to build up a charge until it is large enough to trigger the diode into conduction. Current flow through the diode is relatively so very large that the capacitor discharges and cannot take on a new charge until the diode stops conducting.

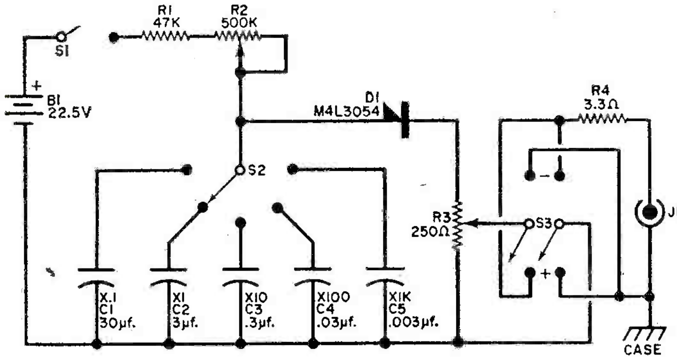
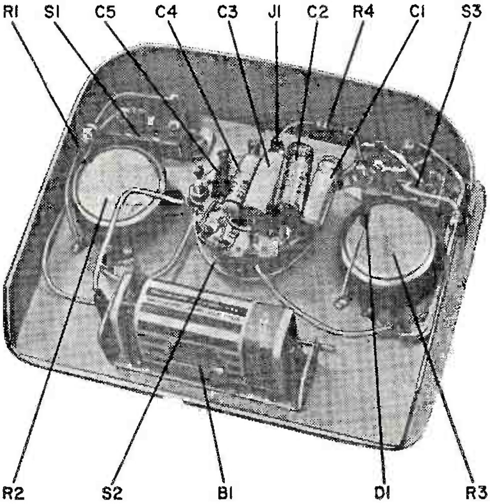


Fig. 3. Frequency depends upon battery voltage and amount of resistance and capacitance in the circuit. Combination of R1 and R2 provides an 11 to 1 spread within each of five decade ranges. Pulse repetition rate can be varied from 1 every 10 seconds to 11,000 each second.

its neighbor, and they provide five frequency ranges in decade steps from x 0.1 to x 1000.

In spite of its simplicity, this *RC* configuration makes it possible to select any frequency within the Pulser's range. Potentiometer *R3* varies the output pulse amplitude; it works like a volume control. Switch *S3* performs the simple task of reversing output pulse polarity. And to make the whole thing short-circuit-proof, *R4* limits peak current to a safe value.

Construction. You can build the Pulser in a plain-Jane fashion in a 3″ x 4″ x 5″ Minibox, or assemble the unit in a deep drawn aluminum case, as shown in the photos. Any chassis will do; the one shown here was made from a piece of 5″ x 7″ x 1/32″ soft aluminum.



Only electrical connection to the chassis is at J1. The unused side of S2 conveniently serves as a terminal strip for the common capacitor leads.

The switches, battery bracket, and chassis sides are "pop"-riveted in place, but you can use 6-32 x ¼″ machine screws and nuts if you wish. The Keystone 177 battery holder is a suitable mount for a 22½-volt battery, but you can modify a penlight cell holder (Keystone 139) if you are not able to get a 177. (Note: no part of the circuit, including even one side of the battery, comes in contact with the case, except for outer portion of *J1*.)

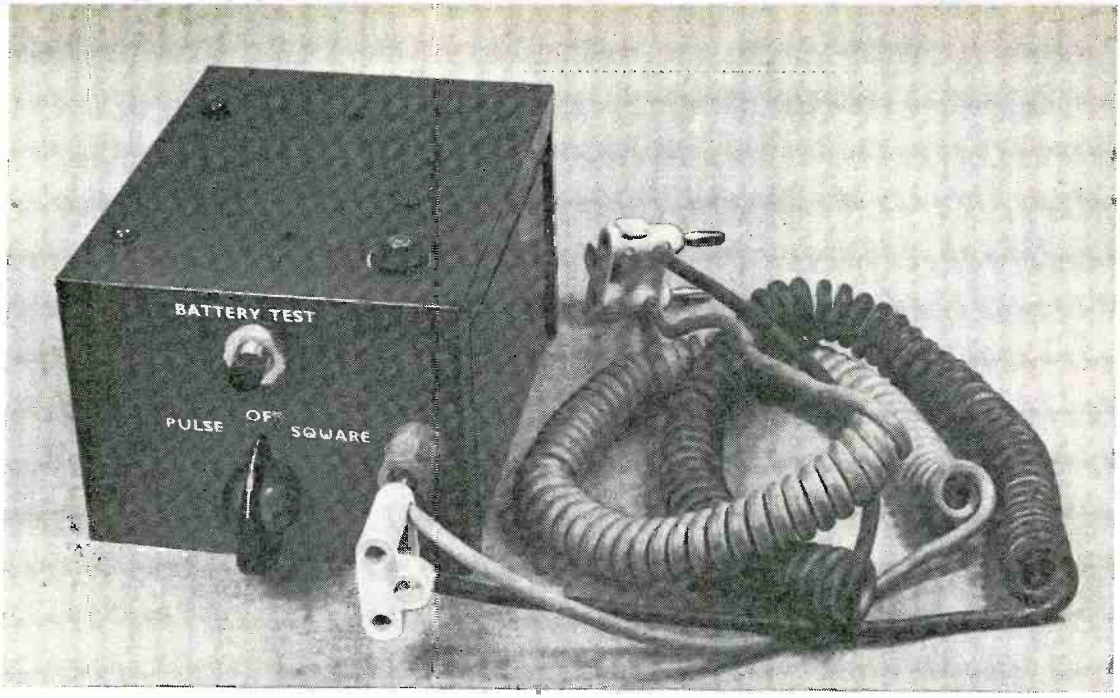
The dialplate is drilled to match the openings in the chassis for the controls and output jack; the nuts on *J1*, *R2*, *R3* and *S2* hold the plate in place. Four feet for the bottom of the case can be made from four #10 nylon countersunk washers and four #6 panhead sheet metal screws. The screws through the front two feet also go through the chassis, and hold it in place.

Wiring is a cinch. All unused terminals on *S2* are tied together and used to secure the negative ends of the capacitors.

Modifications. Any reasonable value can be employed for any of the parts, but the battery supply should be 22½ volts or more. Use linear pots; avoid ordinary volume controls. Audio controls with their log tapers will give you a nonlinear scale.

Larger tantalum capacitors can be used to extend the range on the low end. The high end is limited by *D1* and cannot be increased.

The scales are only accurate to ± 15 percent, and will vary with battery voltage and the exact values of capacitors used. If you need greater accuracy, go to a line-operated, zener-regulated supply and hand-pick your capacitors. —30—



BUILD: SOLID-STATE SCOPE CALIBRATOR

Low-cost, high-efficiency calibrator also serves as portable signal source

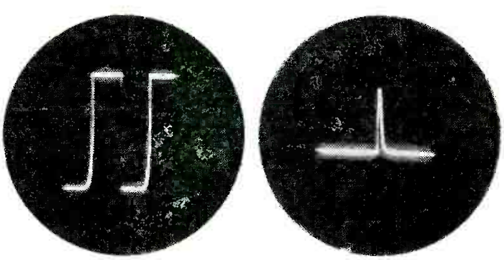
By FREDERICK FORMAN and EDWARD NAWRACAJ

SIMPLE, useful, accurate . . . that about sums up this versatile oscilloscope calibrator which puts out a selectable 10-volt, 1020-Hz square-wave or a 50-microsecond, 1- to 2-volt amplitude, 1020-Hz pulse. With this $18-to-build instrument, you can not only check the vertical calibration and time-base (horizontal) linearity of your oscilloscope, but get this . . . you can even check its basic sweep frequency! The calibrator can also serve as a portable signal source with one thousand and one applications.

How It Works. The scope calibrator (Fig. 1) is basically a simple solid-state astable multivibrator designed to close tolerances. Transistors *Q2* and *Q3* comprise the multivibrator, whose frequency is determined essentially by the values of timing components *C1*, *C2*, *R3* and *R4*. The nominal 1020-Hz frequency can be reduced to an exact 1000-Hz signal by merely shunting *C1* and *C2* with a 20-pf. capacitor.

Emitter follower *Q4* serves to isolate the multivibrator from the loading effects of the output circuit while functioning as an impedance-matching device. Transistor *Q1* serves only as a battery condition indicator. It is employed in an emitter follower configuration with a 10-volt lamp (*I1*) serving both as an indicator and as the emitter resistor.

As the source battery deteriorates, its output gradually approaches the zener



Actual photographs of square-wave (left) and pulse (right) produced by solid-state scope calibrator.

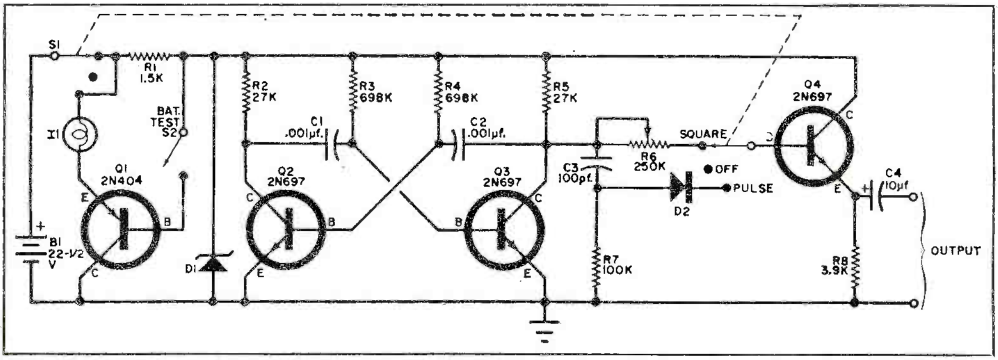
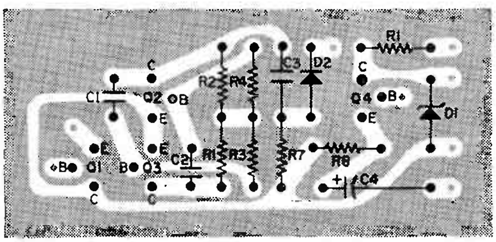


Fig. 1. Essentially a square-wave generator, the scope calibrator also produces a positive-going pulse for test purposes. The battery condition is monitored by means of the test lamp (I1) in Q1's circuit.

(*D1*) voltage, reducing *Q1*'s base bias, and thus causing the lamp to glow more and more dimly. This can be observed by pressing the battery test switch (*S2*). However, because the calibrator would normally be used only on occasion, rather than continuously, the life of the battery can be expected to approach its no-use or shelf life.



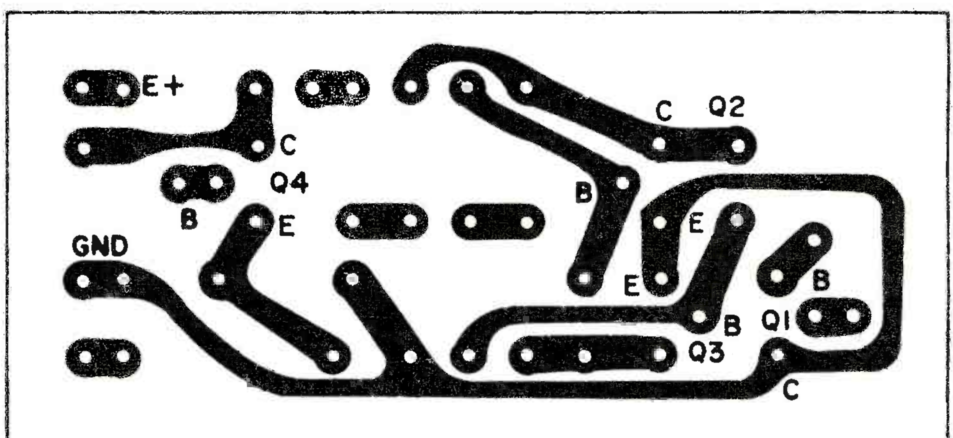
COMPONENT SIDE OF PC BOARD

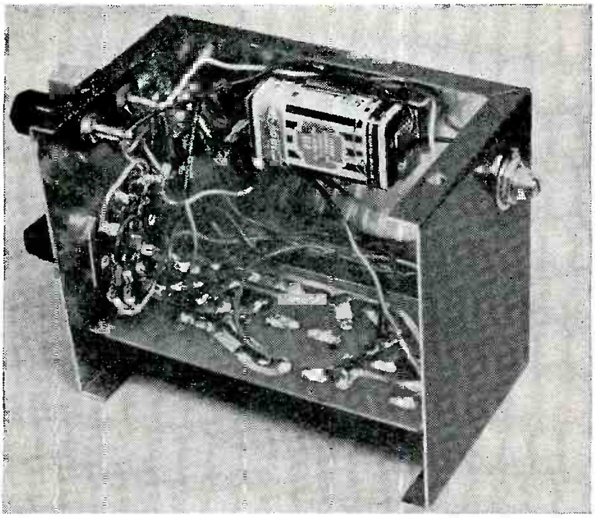
Fig. 2. Be sure to observe polarities of diodes D1 and D2, and capacitor C4, as shown above. An actual-size photo of the foil side of the printed circuit board appears below.

PARTS LIST

B1—22½-volt battery
C1, C2—0.001-µf., 2% disc capacitor
C3—100-pf. disc capacitor
C4—10-µf., 25-volt electrolytic capacitor
D1—12-volt zener diode (Sarkes Tarzian VR12A or equivalent)
D2—1N457 diode
I1—10-volt indicator lamp (Sylvania 10 ES or equivalent)
Q1—2N404 transistor
Q2, Q3, Q4—2N697 transistor
R1—1500-ohm, ½-watt, 10% resistor
R2, R5—27,000-ohm, ½-watt, 10% resistor
R3, R4—698,000-ohm, ½-watt, 1% resistor
R6—250,000-ohm carbon potentiometer
R7—100,000-ohm, ½-watt, 10% resistor
R8—3900-ohm, ½-watt, 10% resistor
S1—2-pole, 3-position rotary switch
S2—S.p.s.t. momentary-contact push-button switch
1—5" x 4" x 3" utility cabinet (Bud C-1795 or equivalent)
*1—2¼" x 4" printed circuit board**
Misc.—Binding posts, battery holder, machine screws, solder, hookup wire

*Available from Fred Forman, 2421 West Berwin Ave., Chicago, Ill., for $2 drilled or $1.50 undrilled.





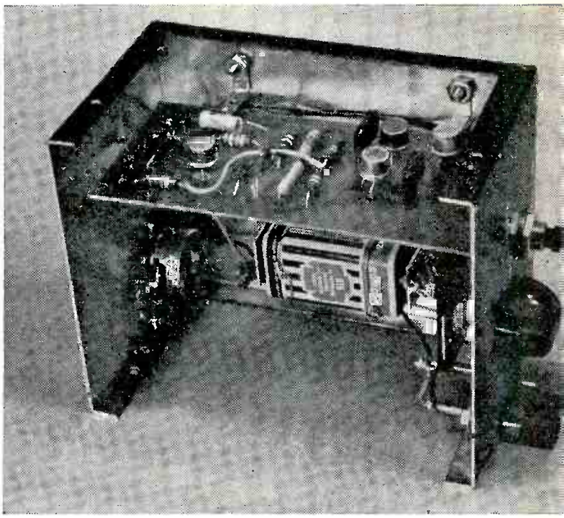


Fig. 3. The bottom cover has been removed to show how printed circuit board is mounted in the cabinet. In view at left, the unit is on its left side. In view at right, the unit is turned on its right side.

Series resistor *R1* drops the battery voltage to within 0.1 volt of the nominal 12-volt zener diode level.

The multivibrator square-wave output which appears at the collector of *Q3* measures approximately 12 volts. This is reduced to the required 10 volts by adjustment of *R6*. To produce the 50-μsec. pulse, the square wave at *Q3* is differentiated by *C3-R7*, and rectified by *D2* to remove negative overshoots. The output is switched to *Q4* by *S1*, and coupled to the external circuit through *C4*.

Construction. Although the model shown uses a printed circuit board (which the author sells for $2—less parts), you can lay out the circuit on a

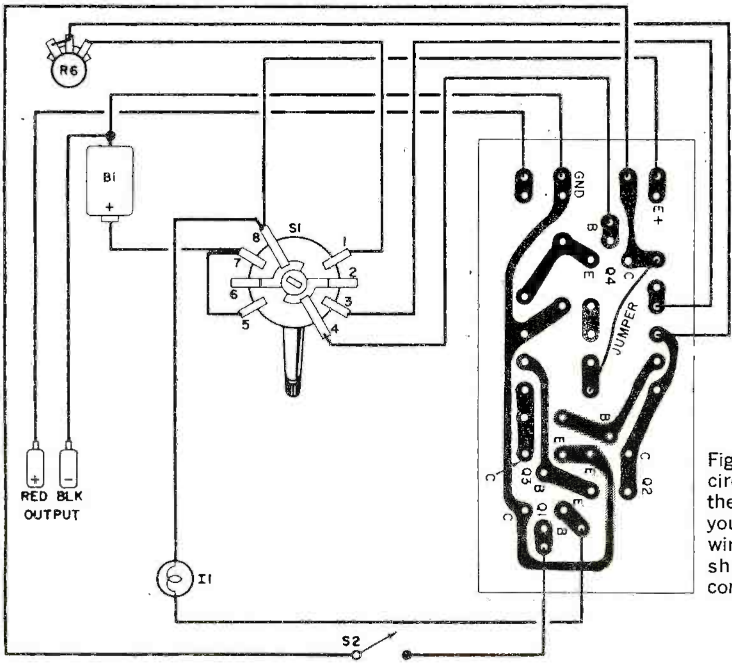
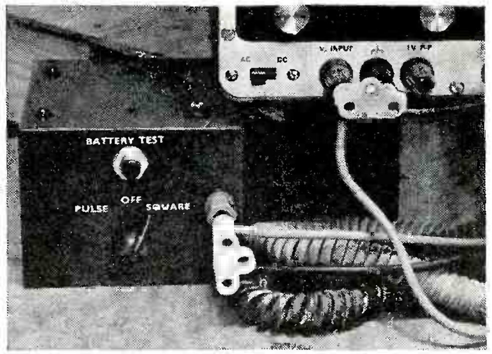


Fig. 4. If you use a printed circuit board, these will be the only wiring connections you will have to run. Jumper wire shown on the circuit board should be mounted on the component side of the board.

When you use the calibrator, connect its output to your oscilloscope's vertical input. Be sure to place a plastic graticule, ruled 10 lines to the inch, over the face of your scope for greater accuracy.



piece of 2½" x 4½" unclad perforated phenolic board if you wish. Use flea clips or solder lug strips for the connections.

The calibrator is housed in a 5" x 4" x 3" utility cabinet. The selector switch (*S1*), battery test switch (*S2*), and output binding posts are mounted on the front panel. You can also mount the battery test lamp on the front panel, to the left of the selector switch, although it is shown here mounted on the top of the unit. Calibration potentiometer *R6* is on the unit's back panel, and the battery can be secured at any convenient spot inside the cabinet.

Mount the parts on the component side of the circuit board in accordance with Fig. 2. Then install the circuit board in the cabinet (Fig. 3) and complete the wiring connections as shown in Fig. 4.

Adjustment. With the battery installed, adjust the amplitude of the square wave to exactly 10 volts, as follows:

(1) Set selector switch to *SQUARE* and connect a jumper between *Q3*'s base and ground to disable the multivibrator.

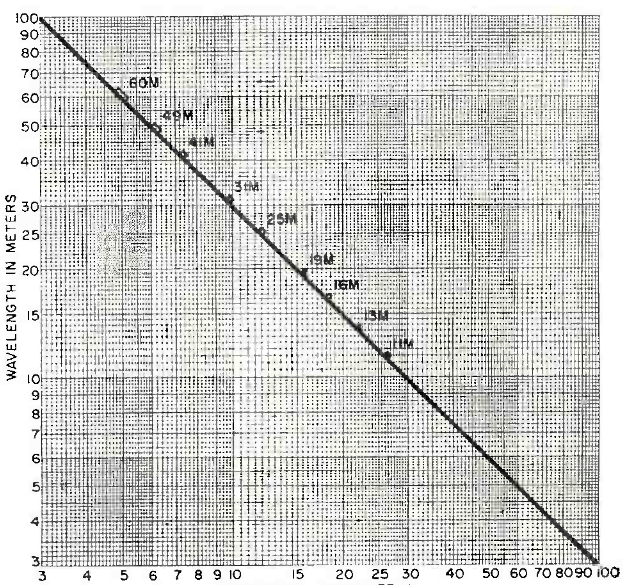
(2) Connect an accurately calibrated d.c. voltmeter across *R8* and adjust potentiometer *R6* (on the rear of the unit) for a 10-volt meter reading. Then remove the jumper and voltmeter.

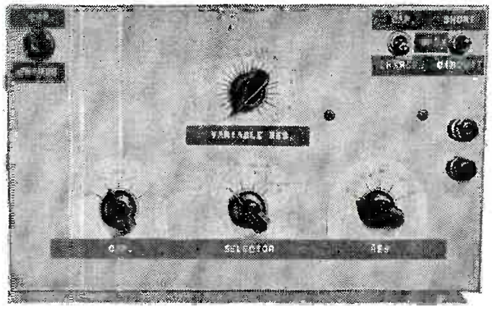
After calibrating your scope, you can use it to measure the pulse at the calibrator's output. You cannot adjust the pulse amplitude independently since this is a function of the square-wave frequency. —30—

FREQUENCY-TO-METER CONVERSION CHART FOR HAMS & SWL'S

By **JAMES G. LEE,** W6VAT

WHEN you're planning to install antennas for various frequencies, it's useful to have a rough idea of the equivalent wavelengths. You could use the formula: wavelength (meters) equals 300 divided by frequency (megahertz), but this quick-look chart will give you almost as precise an answer. The formula is only necessary when you want to cut an antenna to the nearest fraction of a meter. Calibrated to cover the 3.0- to 300-MHz range, this chart makes it possible to convert from frequency to meters or vice versa. Read up and across for meters, across and down for MHz. —30—





COMBINATION RC SUBSTITUTION BOX

By CARLETON A. PHILLIPS

Just flip the switch to substitute heavy-duty resistors or capacitors individually or in series or in parallel networks in your construction projects

HERE'S AN ITEM that's a must for shack or shop—an *RC* substitution box which provides substitute resistors and capacitors individually, or in series or parallel *RC* combinations. You can use it to bridge suspected defective components, or to rapidly switch in different values of resistance and capacitance to

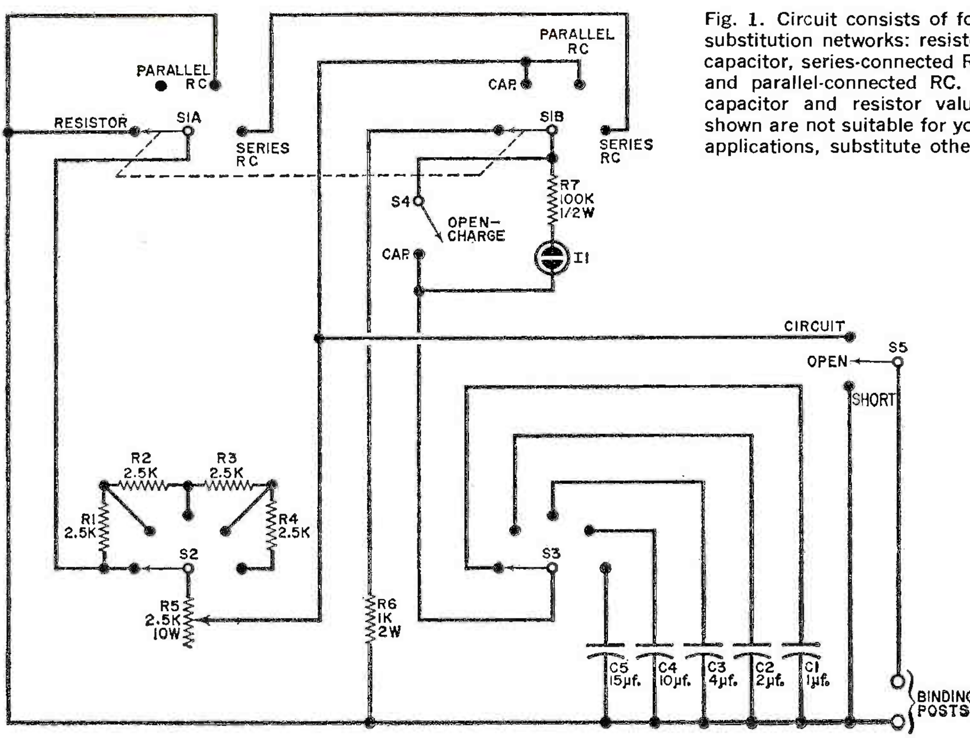


Fig. 1. Circuit consists of four substitution networks: resistor, capacitor, series-connected RC, and parallel-connected RC. If capacitor and resistor values shown are not suitable for your applications, substitute others.

check transistor characteristics and circuits, and to perform various electronic experiments. Simple to build, it can be fashioned from ordinary parts.

How It Operates. Essentially, the substitution box is composed of a bank of capacitors and a bank of resistors which can be switched in by front panel controls to obtain desired values. See Fig. 1.

To use the box as a substitute resistor, place the *SELECTOR* switch in the *RES* position, and rotate either the *RES* switch (*S2*) or the *VARIABLE RES* control (*R5*) for the value you want. The *RES* control, which switches in one or more resistors (*R1* through *R5*), provides a resistance value of from 0 to 12,500 ohms in increments of 2500 ohms. The *VARIABLE RES* control fills in all the values between each 2500-ohm step.

To use the box as a substitute capacitor, place *S1* in the *CAP* position, and rotate the *CAP* switch (*S3*) to select the capacitance you want.

When bridging a suspected defective capacitor, especially in a transistor circuit, throw the *CHARGE* switch (*S4*) to the *OPEN* position to allow the substitute capacitor to charge slowly through *R7* and *CAP CHARGE* lamp *I1*. When the capacitor is charged, the lamp will go out. Now you can throw *S4* into the *CAP* position. This procedure prevents temporary healing of the bridged capacitor, if it is defective, and current surge. By rotating the *SELECTOR* switch back to the *RES* position, charges built up on the capacitors used in the substitution box will be dissipated through *R6*.

To obtain a parallel-connected resistor and capacitor network, rotate the *SELECTOR* switch to the *PARALLEL RC* position. Capacitance value is selected by *S3* and resistance value by *R5* and *S2*. To obtain a series-connected resistor and capacitor, place the *SELECTOR* switch in the *SERIES RC* position.

PARTS LIST

C1—1 µf.
C2—2 µf.
C3—4 µf.
C4—10 µf.
C5—15 µf.
(C1–C5: *600-volt paper capacitors*)
I1—NE-51 neon lamp
R1, R2, R3, R4—2500-ohm, 10-watt resistor
R5—2500-ohm, 10-watt potentiometer
R6—1000-ohm, 2-watt resistor
R7—100,000-ohm, ½-watt resistor
S1—Two-gang, four-position rotary switch
S2, S3—Five-position rotary switch
S4—S.p.s.t. toggle switch
S5—S.p.s.t. toggle switch with center-off position
2—Binding posts
1—7" x 12" x 4" box (Bud CU-2111A or equivalent)
Misc.—Knobs, hardware, etc.

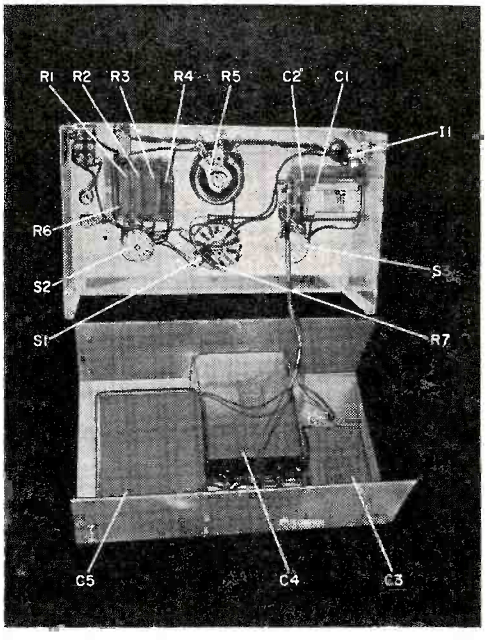


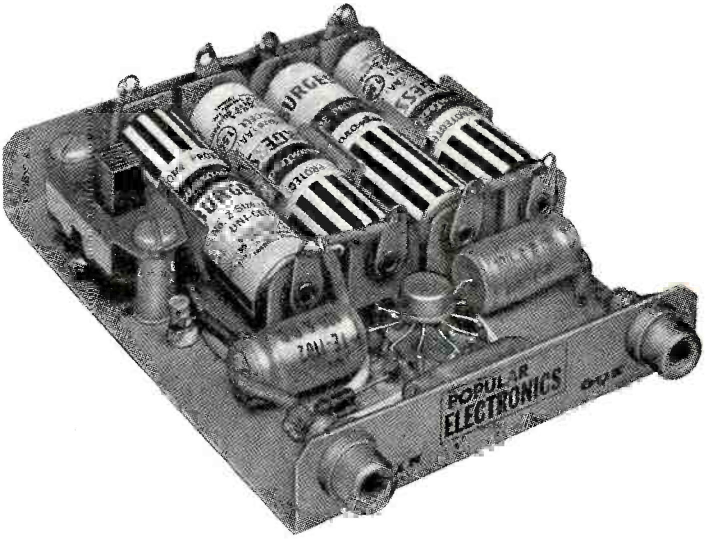
Fig. 2. Use of heavy-duty components puts this substitution box in a class all by itself. You need have no fear of burning out the 10-watt resistors.

Construction. All components are mounted in a 3" x 5" x 7" box as shown in Fig. 2. You can select any assortment of resistors and capacitors to put into the substitution box should you desire a different range of values from that shown. If electrolytic capacitors are used, polarity should be observed and indicated at the *BINDING POSTS*. Paper capacitors were used here to avoid polarity problems.

All components, except for the three large capacitors, are fastened to the cover of the box. The resistors can be mounted on a small phenolic board. The board can be fastened to the cover, but kept in the clear by a pair of standoff bushings. —30—

CIRCLE NO. 12 ON READER SERVICE CARD→

AT LAST...



By DON LANCASTER

AN INTEGRATED CIRCUIT AMPLIFIER you can build for under $6!

SIMPLE PROJECT OPENS DOOR TO NEW MICROCIRCUITS

HERE'S the "bargain basement" integrated circuit (IC) amplifier that hobbyists and experimenters have been waiting for. Ideally suited for use as a phonograph or dynamic microphone preamplifier, as a boost amplifier in a receiver i.f. or r.f. stage, as well as in practically all applications employing low-level signals, the complete IC amplifier can be built for under $6.00. The IC, packaged in a TO-5 case, contains the equivalent of six 2N918 transistors and seven resistors, and provides a voltage gain of 40, a current gain of 120, and a power gain of nearly 5000.

Frequency response is essentially flat from 20 Hz to 30 MHz, and distortion is negligible at outputs of up to 0.7 volt peak-to-peak. Clipping occurs at output levels of 1 volt peak-to-peak and over. When assembled with the external components itemized in the Parts List, the IC amplifier has an input impedance of 3300 ohms, and an output impedance of approximately 25 ohms.

How It Works. The integrated circuit amplifier (Fig. 1) consists of two separate transistor differential amplifiers (they respond to the difference between

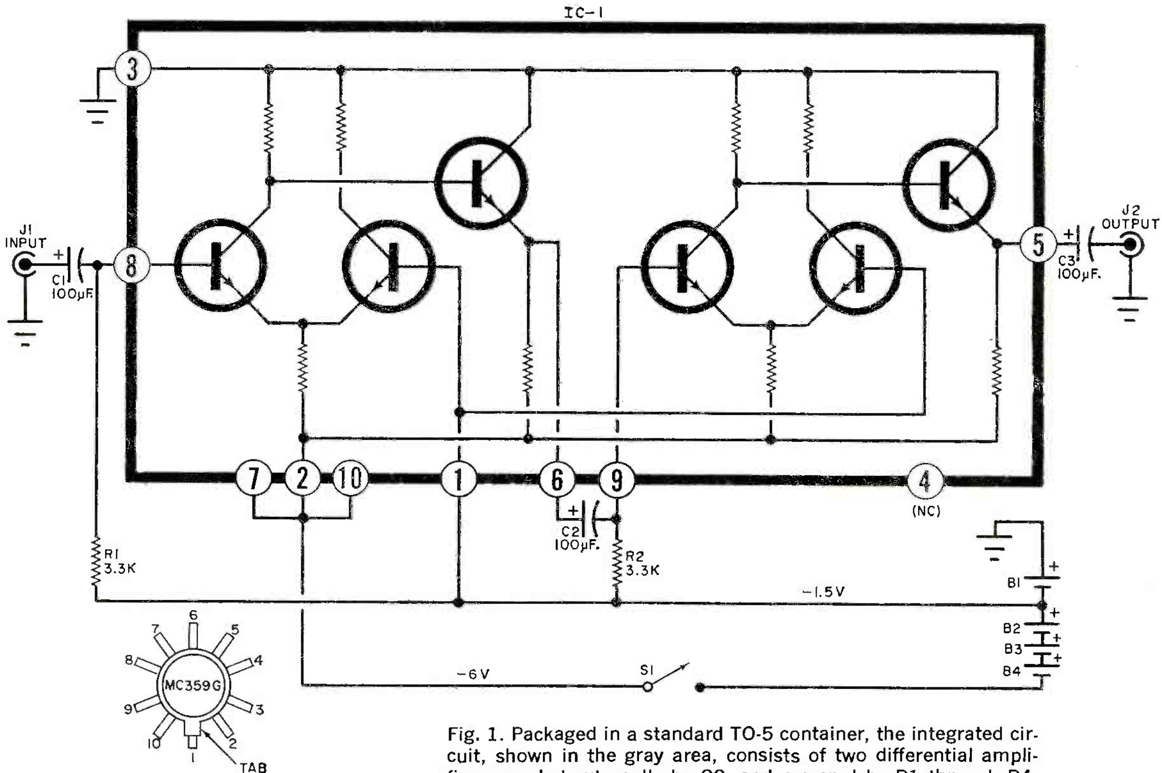


Fig. 1. Packaged in a standard TO-5 container, the integrated circuit, shown in the gray area, consists of two differential amplifiers coupled externally by C2, and powered by B1 through B4.

two voltages), each of them coupled to an emitter follower stage. The output of the first emitter follower is applied to the base of the second differential amplifier input transistor through coupling capacitor *C2*.

Capacitor *C1* couples the input from *J1* to the base of the first amplifier which is biased through *R1*. Resistor *R2* applies bias to the base of the second differential amplifier input transistor. The IC amplifier output is applied to *J2* through *C3*.

Base bias for the second transistor of each amplifier pair is applied directly from a 1½-volt tap on the 6-volt supply battery. The full supply voltage is applied to the circuit through *S1*.

Important: The values of capacitors *C1*, *C2*, and *C3* determine the frequency response of the circuit. For low-frequency response (about 20 hertz) only, 100-μF capacitors are used; for frequencies above 100 kHz, 0.02-μF disc capacitors are used *instead* of the 100-μF units. For a full frequency coverage (20 hertz to 30 MHz), parallel the two capacitor values.

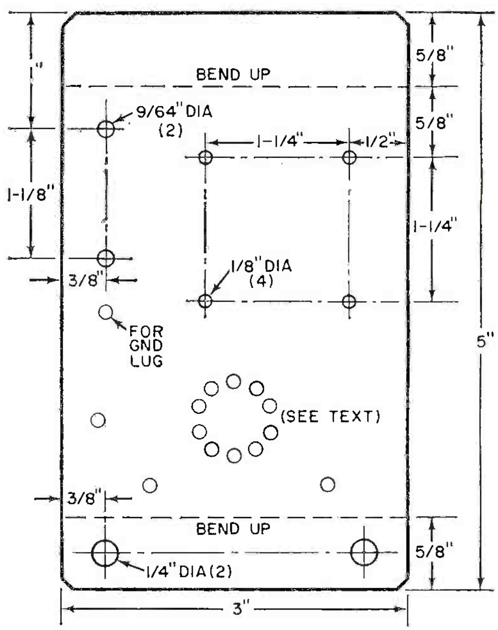


Fig. 2. The complete IC, including the battery supply, can be mounted on a small (3" x 5") aluminum plate, drilled and bent to form a chassis support.

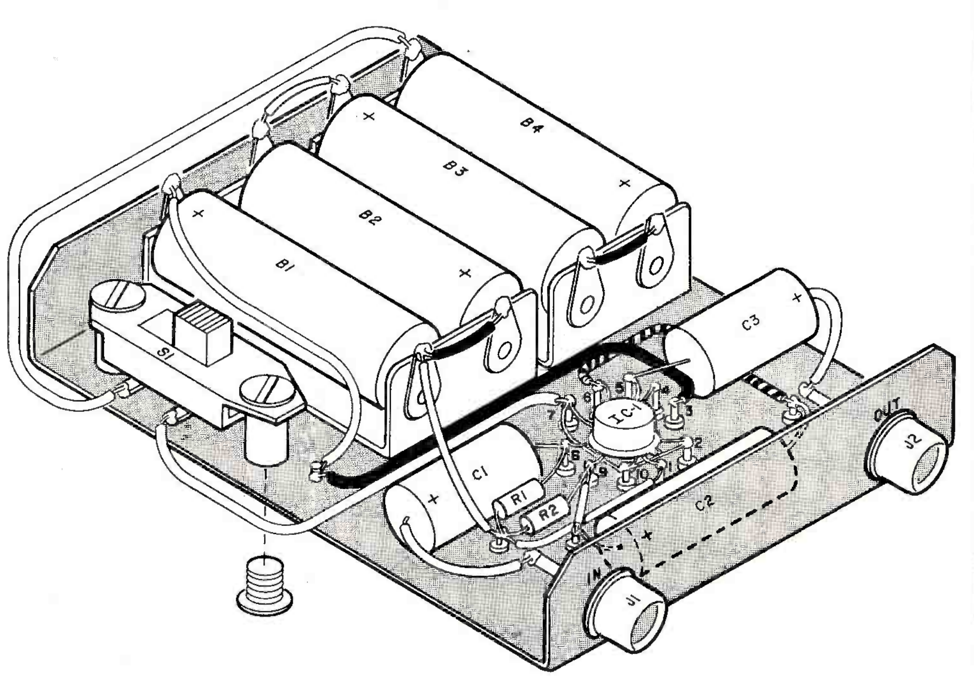


Fig. 3. Pictorial of fully assembled integrated circuit shows simplicity of layout and wiring details. The 10 teflon terminals that mount the TO-5 case can be replaced with one Sealectro IC socket.

Construction. The circuit is easily assembled on an improvised aluminum plate laid out and drilled as shown in Fig. 2. The IC socket used by the author is made up of 10 teflon press-fit standoff terminals inserted into appropriate-sized holes drilled in the plate. Then the leads from the IC case are fanned out and each soldered to a standoff.

However, it is possible that the builder may want a much easier and efficient procedure. A single Sealectro press-fit socket (see Parts List) can be press-fitted in a ½" hole drilled in the plate instead of bothering with the 10 small holes.

The four ⅛"-diameter holes in the upper portion of the plate mount the two penlight battery holders that are either riveted or screwed to the plate. Slide switch *S1* is mounted on ½"-long spacers threaded at both ends for #6 screws, through the two 9/64"-diameter holes. The three unidentified holes in the vicinity of the IC socket accommodate press-fit standoffs that serve as tie points for component leads. The input and output jacks are mounted on the raised front panel as shown in Fig. 3.

All circuit components should be mounted and wired in place before installing the IC package; but do not

(*Continued on page* 138)

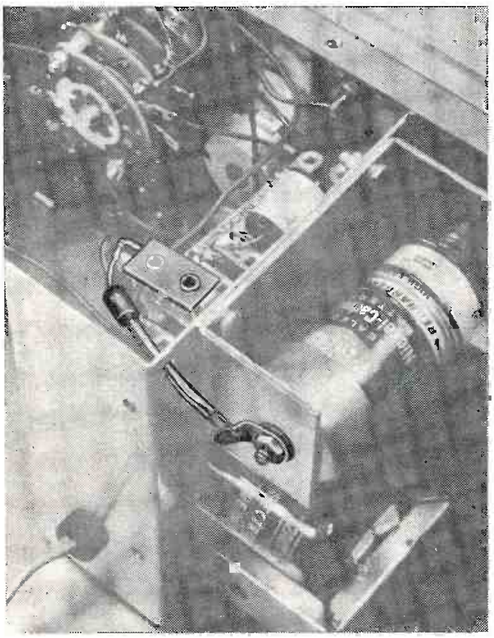
PARTS LIST

B1, B2, B3, B4—1.5-volt penlight cell
C1, C2, C3—100-μF, 6-volt electrolytic capacitor for 20 Hz to 1.5 MHz; 0.02-μF ceramic capacitor (10 volts or more) for 100 kHz to 30 MHz; both values in parallel for full range
IC1—Motorola dual two-input gate MECL circuit (Allied Radio MC359G, $3.70)
J1, J2—Chassis-mounting phono jack
R1, R2—3300-ohm, ¼-watt resistor
S1—S.p.s.t. slide switch
1—Sealectro IC 10-pin socket, Part No. RTC-1010 SL
1—3" x 5" sheet of 1/32"-or 1/16"-thick aluminum
Misc.—Battery holders for four penlight cells (2), teflon press-fit terminals (13), ground terminal, ½"-long threaded spacers (2) with #6 ¼"-long screws (4), rivets or screws for battery holder, solder, hookup wire

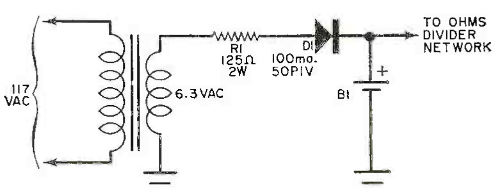
ETERNAL VTVM "C" CELL

Substitute a rechargeable battery —and forget it

By **GARRY BOROSS**



Looking inside a typical VTVM (Heathkit IM-13), note how Eveready N54 nickel-cadmium cell slips into battery holder. Only two additional parts are needed. Tie point is added to support wiring connections between R1 and diode rectifier D1. Filament connection is made at pin 9, V2, in this case.



EVERY seasoned experimenter/hobbyist will agree that the VTVM is a basic tool for circuit testing and electronics repair work. But it has one shortcoming—hidden inside that metal case is an ordinary flashlight battery. Too often this battery is forgotten until the experimenter realizes that the ohmmeter readings are way off and a corrosive fluid is seeping out the bottom of the VTVM case.

If you believe that an ounce of prevention is worth a pound of cure, try substituting a nickel-cadmium battery (*B1*) for that old flashlight cell.* Simultaneously, wire into the VTVM a simple half-wave rectifier using a silicon diode. This diode (*D1*) and a series current limiting resistor (*R1*) are fed from the 6.3-volt filament winding.

The nickel-cadmium cell can be inserted into the battery holder in the VTVM. Or, if you would like to solder the battery into the circuit, you can obtain a nickel-cadmium cell equipped with soldering tabs. When power is applied to the VTVM, the battery will receive a small trickle charge—generally 20-30 ma. There is no danger of the battery being overcharged, even if the VTVM is left on continuously. —30—

**Mercury batteries are not used in VTVM's because of their high internal resistance. Alkaline batteries are occasionally recommended for use in VTVM's, but they sometimes release corrosive gases that damage switch contacts.*

CHAPTER
5

This is the "fun" chapter in the ELECTRONIC EXPERIMENTER'S HANDBOOK. The seven projects are a "mix" of Science Fair ideas, practical jokes, and games. As a practical joke, we recommend the "Tickle Stick" (page 125)—a harmless, but surprising little gadget that will provide you with hours of fun. For games, try either the "Dozen" (page 114) or the "Reflexometer" (page 127).

As a Science Fair project, our highest recommendation goes with the "Li'l Atlas" (page 119), one of those science-fiction devices that you see every now and then in the movies. Suspended below an electromagnet is a small globe of the earth. As gravity pulls the globe down, the magnet pulls it back—just enough to counteract the pull of gravity—and the globe is seen hanging in space with nothing touching it. This is a project you really must build in order to appreciate the startling effect.

A LIGHT on one side of this mystery box flashes, and a ring jumps toward it like a trained animal. Within a few seconds a light on the opposite side flashes, and the ring leaps over to it with the same rapidity. This action continues as long as power is applied.

What facet of space-age technology has made it possible for a light to attract what appears to be a black metal ring? Is it an ionic generator of some sort, or some heretofore unknown plasma or form of energy at work? What electronic genius thought this thing up in the first place? Chances are that you will get as many different explanations as there are viewers, if you insist upon answers to your questions.

The flashing light creates the illusion of attracting the ring, and the illusion attracts a crowd. Aside from the commercial aspect of being able to capture the attention of large groups of people, a principle of mutual induction can be demonstrated and the project should make an intriguing entry in science fairs or other similar events.

How It Works. A slow-revolving (6-rpm) timing motor alternately energizes a coil located at each end of a semicircular soft iron rod. See Fig. 1. Coil *L1* is energized when contact 1 or 3 is touched by the rotating arm; coil *L2*, when contact 2 or 4 is made. When a coil is energized, a magnetic field is created.

The soft iron rod in the center of the coil concentrates much of the energy in the magnetic field and increases the coupling of the magnetic field to the aluminum ring. This causes an induced current to flow in the ring, which sets up a

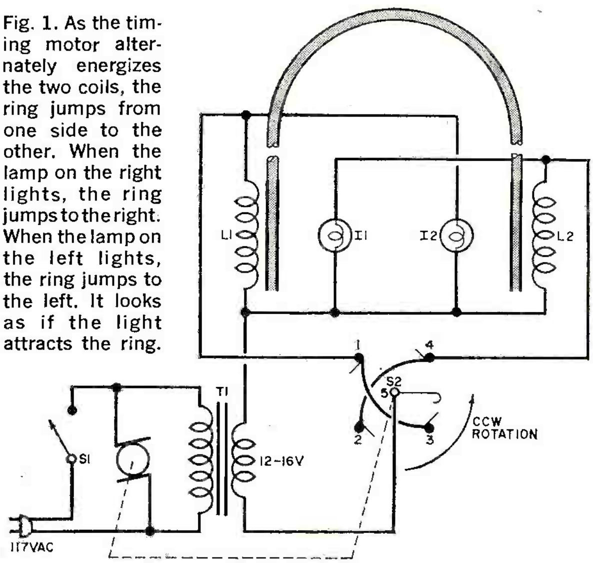


Fig. 1. As the timing motor alternately energizes the two coils, the ring jumps from one side to the other. When the lamp on the right lights, the ring jumps to the right. When the lamp on the left lights, the ring jumps to the left. It looks as if the light attracts the ring.

THIS AMAZING RING HOPS FROM ONE SIDE TO ANOTHER, CHASING THE FLASHING LAMPS

By WALTER B. FORD

BUILD THE CROWD STOPPER

magnetic field of its own. These fields magnetically oppose each other, and the ring is vigorously repelled. It shoots upward and away from the coil, travels around the loop, and lands on the other side, near the other coil. When the other coil is energized, the ring is shot back to where it came from. This back-and-forth motion is in step with the rotation of the timing motor.

The timing motor operates directly off the 117-volt line. Coils *L1* and *L2* operate off the 12-volt secondary winding of *T1*. Lamp *I1* is wired across *L2* and lights when this coil is energized. Similarly, lamp *I2* is connected across *L1* and lights when *L1* is energized. Because each lamp is physically located opposite its coil, there is the illusion that the lamp attracts the ring.

Construction. Drill the Masonite panel as shown in Fig. 2. Place the drilled panel over the open space on the aluminum chassis; then mark and drill around the flanged edges of the chassis as shown. Drill a few additional holes in the chassis for ventilation, line cord entrance, switch mounting, and rubber feet.

Remove any nicks from the 24" soft iron rod being used for the loop, with a fine file or sandpaper. Then polish the rod with emery cloth and steel wool. Make a wood form for shaping the loop (Fig. 3). Attach another piece of wood to the form by means of a back plate so as to provide a slot for holding one end of the rod.

Place the form and back plate in a vise, and insert the iron rod into the slot so that the end of the rod is positioned 5⅞" from where the semicircle ends. Bend the steel rod around the form, using a rubber mallet or block of wood as necessary. If one side of the rod is

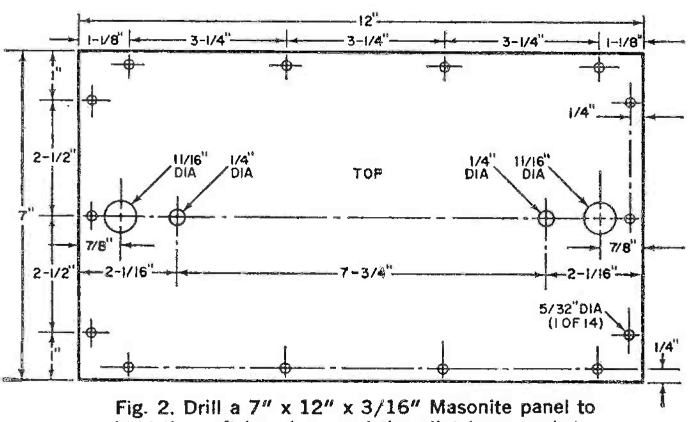


Fig. 2. Drill a 7" x 12" x 3/16" Masonite panel to hold the soft iron loop and the pilot lamp sockets. Position of mounting screw holes is not critical.

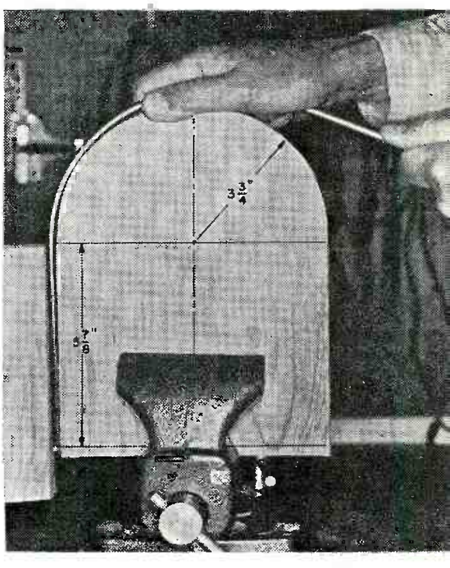


Fig. 3. Carefully bend the rod around the wood form to obtain a smooth shape in the loop. Rod must be clean and free from burrs to permit the ring to travel freely without interference.

PARTS LIST

I1, I2—12-16 volt miniature bayonet lamp
L1, L2—See text
S1—S.p.s.t. toggle switch
S2—See text
T1—Filament transformer; 117-volt primary, 12-16 volt secondary, 2 amp., minimum (Allied Radio 62 G 331 or equivalent)
1—6-rpm timing motor, 117 volts a.c., 60 cycles —see text
1—7" x 12" x 3/16" piece of Masonite
1—2¾" x 2¾" x 3/16" piece of Masonite
1—3" x 7" x 12" aluminum chassis (Bud AC-408 or equivalent)
1—24" soft iron rod, ¼" diameter
2—1⅜" fiber or Micarta washers, ⅛" thick
1—8' length of soft iron wire, 16 or 18 gauge
1—22-gauge enameled magnet wire—see text
2—Pilot light assemblies (Allied Radio 7 E 891)
1—½" brass rod, ½" diameter
4—Pieces of 20- or 22-gauge round brass tubing, ¼" o.d., ½" long
1—½" piece of 20- or 22-gauge seamless aluminum tubing, ⅜" o.d. (won't work with a seam)
4—5/16" x 9/16" pieces of 26-gauge spring brass
1—5/16" x 1⅞" piece of 26-gauge spring brass
Misc.—Line cord, ¾" x 6-32 brass round-head machine screws (4), 2" x 6-32 steel round-head machine screws (2); 6-32 hexagon brass nuts (8), 6-32 hexagon steel nuts (2), rubber screw bumpers (4), ⅜" x 6 sheet metal screws (14), ½" x 1½" wood dowels (2), ¼" rubber grommet, ¼"-20 hexagon steel nuts (4), ¾"-diameter steel washers with ¼" center (2), #6 lock washers (4); and #6 brass washers (4)

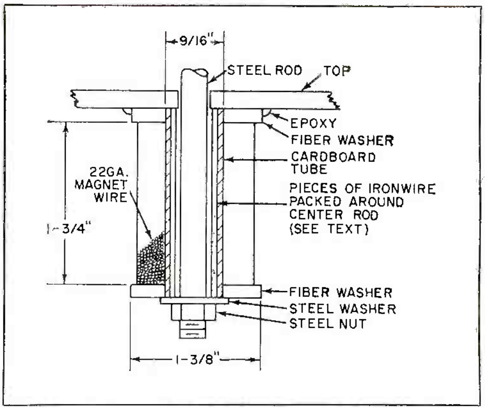


Fig. 4. Construct coil forms as shown. Each coil takes about 80 feet of No. 22 enamel-coated wire. A ½-pound spool should be enough for both coils.

longer than the other after forming, cut it to make both sides even. Then thread about ½" from the ends using a ¼" die.

Construction of L1 and L2. Make two coil forms with fiber or Micarta washers and strips of thin cardboard as shown in Fig. 4. Wrap a strip of 2"-wide cardboard around a ½" wood dowel and apply glue between the layers of cardboard without getting any glue on the wood dowel. Drill holes in the fiber coil ends to fit the cardboard tube and cement the tube and the ends together. Then drill two 1/16" holes in one end washer of each coil form to pass the wires through.

Wind approximately 80' of No. 22 enamel-covered magnet wire on each form. The exact amount is not important, but it is important to wind the coil turns close together and evenly. Suppliers of magnet wire generally sell the wire wound on ½-lb. spools. One such spool is usually enough for both coils.

Mount the pilot light assemblies to the Masonite as shown in Fig. 5. Then center the two coils on the underside of the panel and over the ¼" holes, and cement the coils in place. The aluminum ring

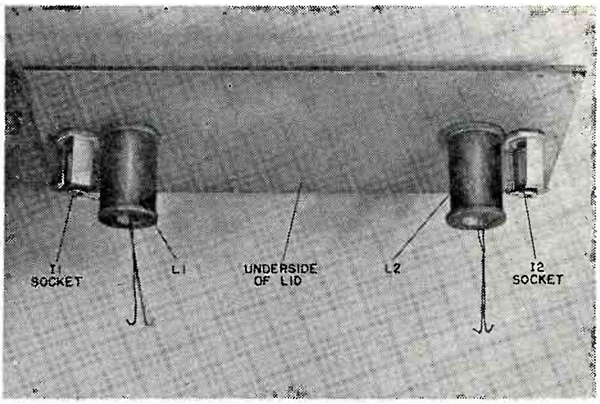


Fig. 5. Cement the finished coils to the bottom of the panel. Use extra long coil leads to avoid undue stress on the connections when assembling the unit.

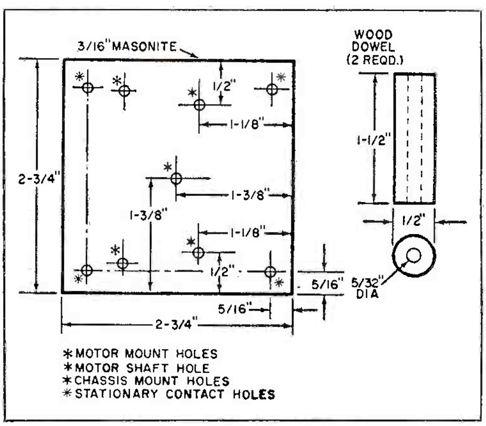


Fig. 6. Fabricate the rotary switch on a 2¾" x 2¾" piece of Masonite and bolt it to the chassis using two ½"-long dowels and 2"-long screws.

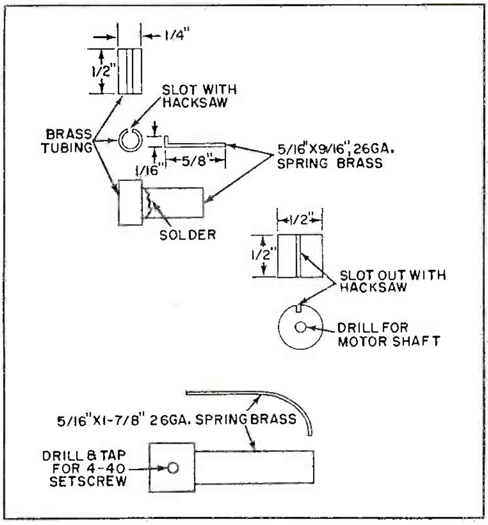


Fig. 7. Contacts are made from strips of spring metal soldered to short lengths of tubing. Drill the rotating contact to fit snugly on the motor shaft.

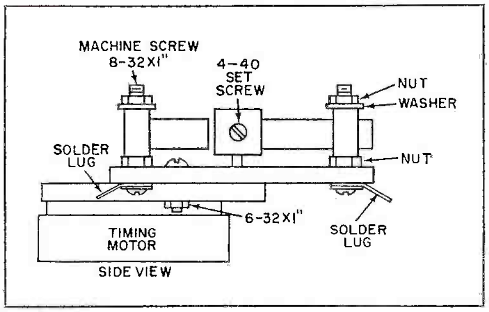


Fig. 8. Stationary contacts (side view) should be positioned to provide gentle contact and timed to extinguish the light just before the ring reaches it.

which flips back and forth on the steel loop is made from ½"-long, ⅜"-o.d., 20- or 22-gauge aluminum tubing; both ends of the ring should be reamed before the ring is placed on the loop.

Insert the ends of the loop from the top of the panel through the centers of the coils until the ends extend ¼" beyond the coils. Then turn the unit upside down and support the ends in the same position. Cut a number of pieces of No. 16 or 18 soft iron wire, each slightly less than 2" long, and straighten the pieces as much as possible. Then insert the wires around the steel loop ends (Fig. 4) in the center of the coils, applying a coating of epoxy cement to each piece as it is inserted in place.

Tightly pack both coils with the wires. You'll find it easier to insert the wires if you sharpen one end of the wire with a file. Then cut notches in the steel washer to clear the coil leads; place the washers and nuts over the ¼" rod projecting from the coil ends. Do not tighten the nuts until the epoxy glue has set.

Drill the 2¾" x 2¾" Masonite board used to mount switch *S2* as shown in Fig. 6. Measure the spacing of the mounting holes on your timing motor and drill corresponding holes in the base.

Herbach and Rademan Inc., 1204 Arch St., Philadelphia, Pa., 19107, offers a line of synchronous timing motors from ½ to 30 rpm. The 6-rpm model is priced at $4.95, f.o.b. Philadelphia. Motor rpm is not critical and almost any timing motor, down to 1 rpm, will work well.

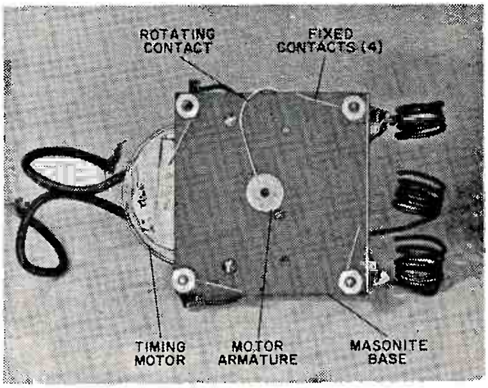


Fig. 9. Curve the rotating contact to get a gentle spring-like action. Contact and motor leads should be long enough to allow assembly without stress.

Next, start making the four stationary contacts from 20- to 22-gauge, ¼"-o.d., brass tubing cut to ½" in length. As shown in Figs. 7, 8, and 9, they are made by soldering a 5⁄16" x 9⁄16" 26-gauge piece of brass spring into the slotted tubing. When making the contacts, cut each length in line with the "grain" of the metal to prevent it from snapping when bent. The alignment of the grain can be determined by observing the direction in which the metal tends to curl when laid on a flat surface.

The rotating contact is made by soldering a strip of spring brass into a piece of slotted brass rod as shown in Fig. 7. Dress down the edges of the rotary and stationary contacts to insure quiet operation. Each of the four sta-

(*Continued on page* 138)

MEET THE MINI-ORGAN

It's electronic . . . it's transistorized . . . and it's fun to build and play

By WILLIAM S. GOHL

YOU CAN'T BUY a Wurlitzer organ like the one at Radio City for ten bucks, but you *can* build the Mini-Organ for less than that. Your youngsters will be delighted—and you'll be, too—at the ease with which such well-known tunes as "Red River Valley," "Blue Bells of Scotland," "Home, Sweet Home," and many others can be played on an instrument you can put together in a couple of hours.

How It Works. The Mini-Organ is a two-transistor, battery-operated multivibrator whose frequency (pitch) is determined by the *RC* time constant of *C1-R1* (Fig. 1). The lowest frequency of oscillation—and hence the lowest tone—is determined primarily by the value of capacitor *C1* and series capacitors *C2* through *C8*, while the highest frequency of oscillation (highest pitch) is determined essentially by the setting of potentiometer *R1* in series with resistor *R2*.

When capacitors *C2* through *C8* are alternately switched in series with *C1*, a change is produced in the multivibrator frequency which in turn produces a one-octave musical scale. Depending on the characteristics of transistor *Q2*, capacitor *C9* may be required to aid the multivibrator action. Diode *D1* provides the feedback path to sustain oscillation.

Switches *S1* through *S8* are the push-button operating keys that apply the right amount of capacitance in series with *C1* to produce the desired tones when pressed. Transistor *Q1* is an *npn*, high-current, high-frequency switching type, while *Q2* is a *pnp* audio frequency type which provides sufficient volume for comfortable listening in a small room. If greater volume is desired, the builder can add as many stages of amplification as may be necessary.

Operating power is supplied by four ordinary flashlight cells in series.

Construction. The Mini-Organ can be laid out and breadboarded on wood or on a perforated phenolic board as shown in Fig. 2. Breadboard dimensions are best determined by the builder. The push-button keys are spaced ¾" apart at the bottom of the panel, and the opening for the speaker is spaced midway between the holes for the keys and the top edge of the panel.

Main power switch *S9* can be combined with the potentiometer, or may be a separate slide or toggle switch as desired. The transistors, the 1-megohm resistor, and the capacitors are mounted on terminal strips.

The entire unit can then be housed in a plastic or wooden case as desired. The keys can either be color-coded or numbered for easy recognition.

Operation. Try out the organ by adjusting the potentiometer at different settings as the keys are depressed. If you want a lower tone, increase the value of *R2* in 500,000-ohm increments. To change the tone range slightly, change the value of *C1* in small increments. Using less capacity will give you a higher tonal range.

From here on, you are on your own. Practice with simple tunes within the instrument's range until you can master your favorites. And have fun. -30-

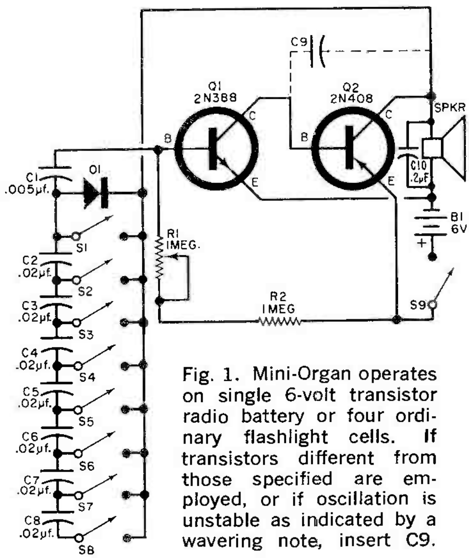


Fig. 1. Mini-Organ operates on single 6-volt transistor radio battery or four ordinary flashlight cells. If transistors different from those specified are employed, or if oscillation is unstable as indicated by a wavering note, insert C9.

PARTS LIST

B1—1½-volt cells (4 required)
C1—0.005-μf. ceramic disc capacitor
C2-C8—0.02-μf. ceramic disc capacitor
C9—0.001-μf. ceramic disc capacitor (optional —see text)
C10—0.2-μf. paper capacitor
D1—1N54 diode
Q1—2N388 transistor
Q2—2N408 transistor
R1—1-megohm potentiometer with switch
R2—1-megohm, ½-watt resistor
S1-S8—Momentary-contact push-button switch
S9—S.p.s.t. switch
SPKR.—8-ohm speaker
1—5" x 7" x 2½" plastic or wooden case
Misc.—5-lug terminal strips (3), small knob, hardware, wire, solder, etc.

Fig. 2. This photograph shows the rear panel of the author's prototype organ which was later rewired to improve lead dress. Parts are mounted on terminal strips, and the battery is strapped down in the case.

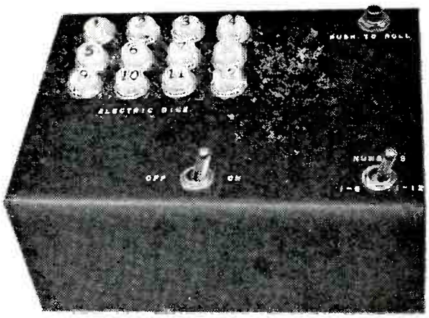
ELECTRIC DOZEN GAME

SOME TIME AGO when the author saw an advertisement for a Mallory 24-contact point rotary tap switch, the thought occurred to him that this low-cost switch might be useful in a game or gambling device. The switch detent mechanism is easily removed, and when it is eliminated the switch rotor can be continuously rotated. The switch contacts are 15° apart, and in the unit pictured on this page the two switching decks are paralleled and the contacts paired. Thus, neon lamp 9 is lit when switch *S4* is at either lug 13 or 23, lamp 3 when *S4* is at lug 1 or 20.

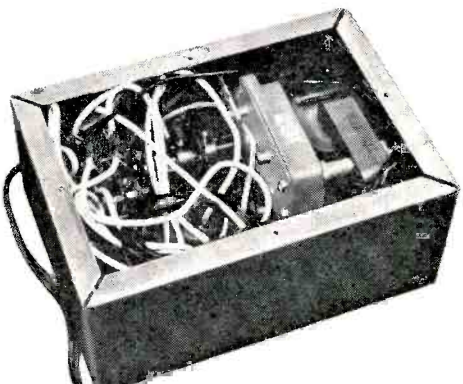
To drive the rotor, the author used a 120-rpm, 117-volt a.c. motor. The ¼" shaft of the motor is attached to the switch rotor through a flexible coupling to eliminate binding and permit the switch to be rotated freely. The wiring is obvious from the diagram, although a few words on the additional switching might be in order.

The motor is activated by a s.p.d.t. push-button switch (*S1*). If all 12 lights are required in your game, switch *S2* is closed. If only 6 lights are preferred, *S2* is opened and only the neon lamps with the numbers 1 through 6 will be lit. Without switch *S3* in the circuit, the lamps will go out as the motor revolves the rotary switch rotor. With *S3* in the circuit (and closed), the neons blink on and off as the motor works.

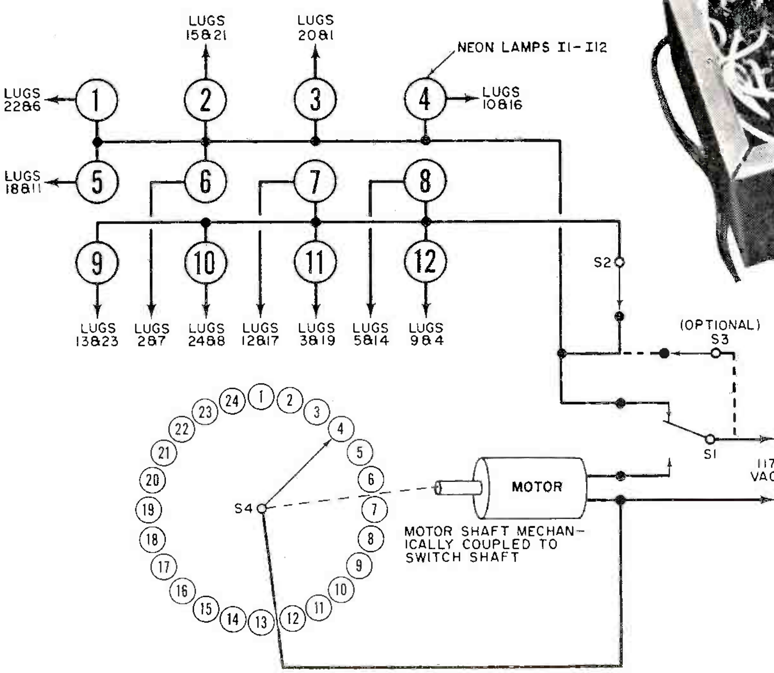
—*Ken Greenberg*



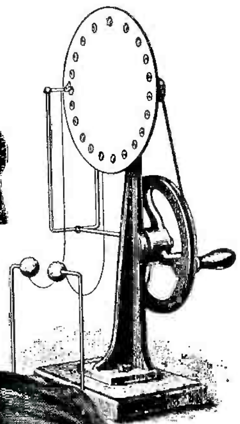
Neon lamps with imprinted numerals are available from many electronics supply houses. The author obtained his from Herbach & Rademan, 1204 Arch St., Philadelphia, Pa., for $3.50. Operation of S1, S2, and S3 is detailed in last paragraph of the text.



No attempt was made to "pretty up" the wiring. Result: this rat's nest of leads from neon lamps to switch contacts. The motor was also obtained from Herbach & Rademan (#B7-208).



SUPERCHARGED SALT SHAKER

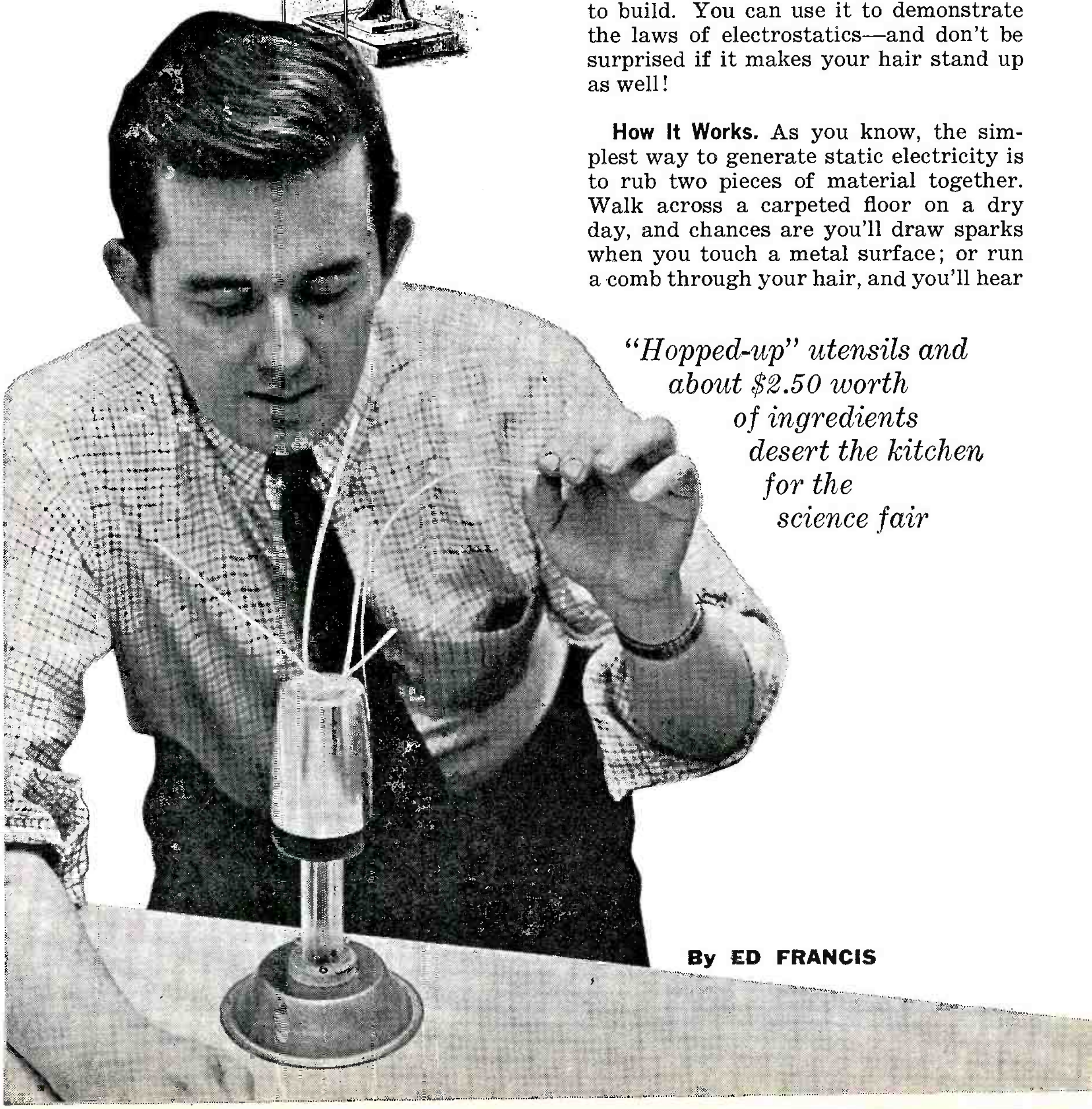


IN YOUR KITCHEN you'll find more than just food. Look around and you'll come across some of the things needed to make a small Van de Graaff generator. Here's a "recipe" for an electrostatic generator which can put out upwards of 100,000 volts of harmless static electricity, and which requires very little culinary skill to prepare. Ingredients called for include a small pie tin, a large aluminum salt shaker, and a few "condiments."

Although it's diminutive in size, there is little difference in principle between this midget powerhouse and the massive 2-million-and-more-volt units used in atomic research. This generator makes a perfect science fair project and is easy to build. You can use it to demonstrate the laws of electrostatics—and don't be surprised if it makes your hair stand up as well!

How It Works. As you know, the simplest way to generate static electricity is to rub two pieces of material together. Walk across a carpeted floor on a dry day, and chances are you'll draw sparks when you touch a metal surface; or run a comb through your hair, and you'll hear

"Hopped-up" utensils and about $2.50 worth of ingredients desert the kitchen for the science fair

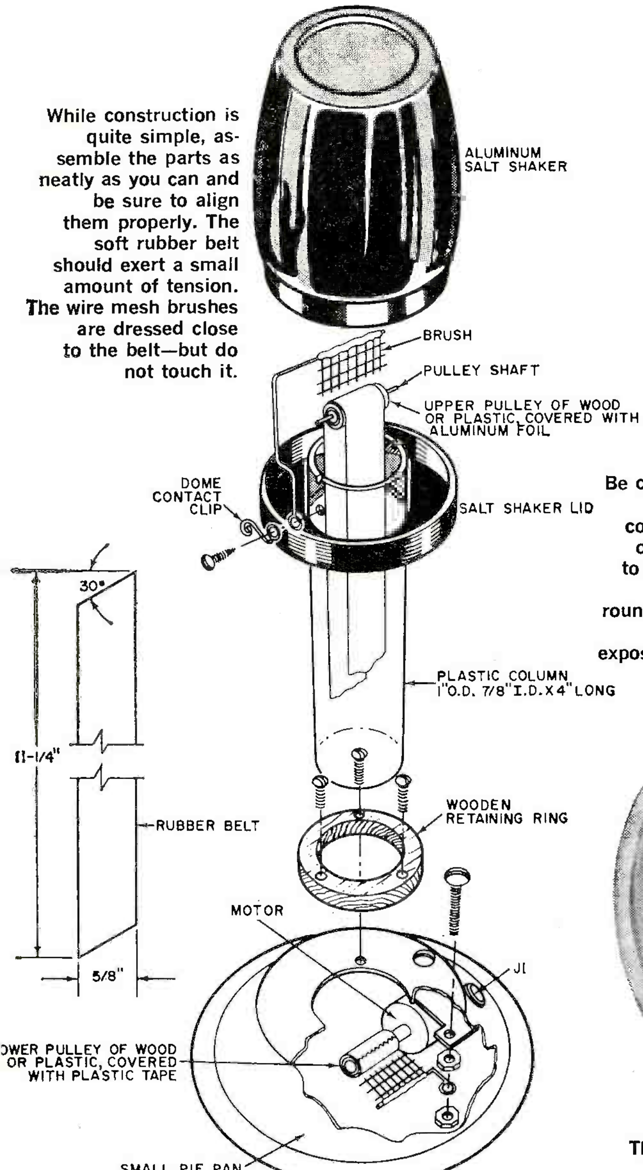


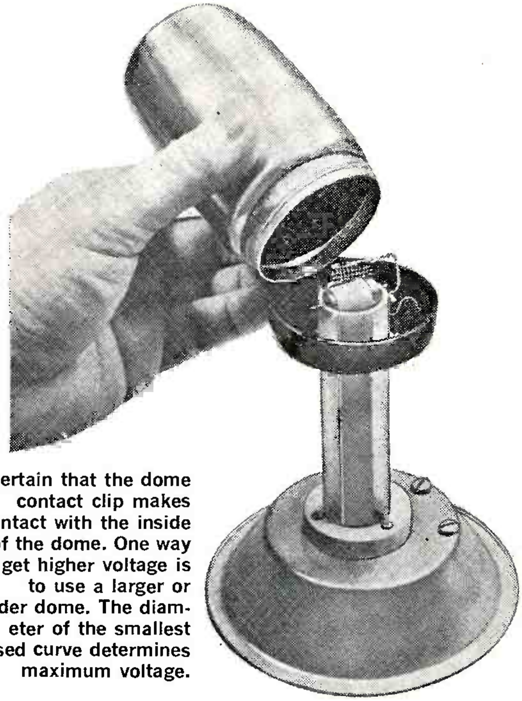
By ED FRANCIS

things snap, crackle, and pop. While this static electricity is commonplace, it is no different from that produced by the little Van de Graaff generator "cooked up" here. A hollow insulating column held in place by a pie-plate base supports a salt-shaker dome. Within the base, a small toy motor drives a rubber belt around a plastic pulley.

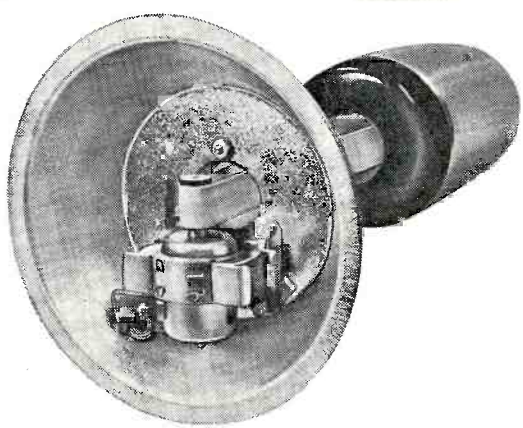
When two dissimilar substances are rubbed together, they become electrostatically charged. The one with the higher dielectric constant usually takes on a positive charge, and the other takes on a negative charge. Plastic materials generally have a higher dielectric constant than rubber, and if this is the case with the materials you select, the plastic will become positively charged by giving off electrons to the rubber. But regardless of which material is positive and which material is negative, the rubber

While construction is quite simple, assemble the parts as neatly as you can and be sure to align them properly. The soft rubber belt should exert a small amount of tension. The wire mesh brushes are dressed close to the belt—but do not touch it.

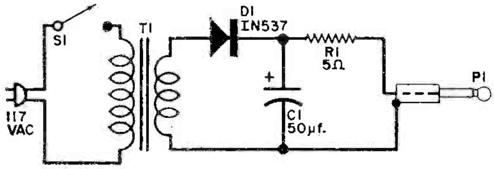




Be certain that the dome contact clip makes contact with the inside of the dome. One way to get higher voltage is to use a larger or rounder dome. The diameter of the smallest exposed curve determines maximum voltage.



The small d.c. motor can run on flashlight batteries, but you may find it more convenient to assemble a small power supply.



Optional power supply can be installed next to the motor if you use a large enough pie plate as a base, or you can mount it in a box. Construction and parts are not critical.

POWER SUPPLY PARTS LIST

C1—60-μf., 50-volt electrolytic capacitor
D1—1N537 diode or equivalent
P1—Miniature phone plug
R1—5-ohm, 1-watt resistor
S1—S.p.s.t. switch
T1—6.3-volt filament transformer
Misc.—Line cord, small chassis or box, 3′ cable

belt transfers the charge deposited on it to the dome, until a certain maximum charge is reached. This charge is dependent upon the roundness of the dome—it's usually on the order of 30,000 volts per inch of diameter of the smallest curve or point. Therefore, if you want to build up high voltage, use a large diameter ball without any ripples, points, or other small projections.

The wire mesh brushes at top and bottom merely aid the flow of electrons to or from the dome and the base, depending upon which is positive and which is negative. You can use flashlight batteries to power the motor, or you can build a small half-wave-rectifier power supply to convert the line voltage to 6 volts d.c., and eliminate the batteries.

BILL OF MATERIALS

1—Miniature hobby motor (Lafayette "Super Micro-Motor" or equivalent)
1—Large aluminum salt shaker
1—5/8″ x 11 1/4″ piece of sheet rubber
1—Small pie-plate base
1—4″ long x 1″-o.d. x 7/8″-i.d. plastic column
2—3/4″-long x 3/8″-diameter plastic rods (to serve as pulleys)
1—1 7/8″-o.d. x 1″-i.d. wood retaining ring, made from 5/16″ stock
1—1 1/8″-long x 1/16″-diameter brazing rod (for pulley shaft)
2—3/8″ x 5/8″ bronze screen brushes
1—Miniature phone jack (J1)
Misc.—Plastic electrical tape, #18 copper wire, aluminum foil, cement, nuts, bolts, etc.

Construction. Most people associate the Van de Graaff generator with a huge ball-shaped metal dome, but the shape of the metal dome need not be perfectly round as long as it has no sharp edges or small curves. An inexpensive large-size aluminum salt shaker with a plastic lid can be used with excellent results. The plastic lid is a good electrical insulator and prevents corona discharge from the small diameters of the threaded end of the salt shaker.

The column is made from a 4″ length of 1″-o.d. Lucite, Plexiglass, or polystyrene tubing. The inside diameter must be wide enough (about 7/8″) to pass the rubber belt. You might try obtaining a large pill vial from your druggist to serve as the column. The small pie tin should be large enough to keep the structure from toppling over.

Drill a hole in the center of the shaker lid which is the same size as the outside diameter of the tubing, and cement the cover in place about an inch down from what will now become the top of the column. Drill holes in the pie-plate base to mount the motor, and the jack (*J1*) for the batteries or power supply. Bolt the retaining ring made from about 5/16″ wood stock to the pie pan. Do not cement the column to this ring, at least not until after you have aligned the belt, and then only if you have to. The hole in the center of the pan is only as large as the inside diameter of the tube, and does not allow the tube to pass through the pan.

Make the upper pulley from a ¾" length of ⅜"-diameter plastic or wood dowel. Drill a 1/16" hole lengthwise through the center of the dowel and insert a ¾" length of rod cut from 1/16"-diameter brazing wire or piano wire so that it protrudes about 3/16" from each end. Cement a layer of aluminum foil around the pulley. The lower pulley is made from the same material except that it should be drilled for the motor shaft and covered with an even layer of plastic electrical tape.

Cut two notches about 1/16" deep on top of the column to cradle the upper pulley shaft. Then drill a 3/32" hole approximately one-quarter inch below one of the notches for the upper brush bracket and dome contact. Fasten the lower brush in the base on the side of the belt which travels upward.

A wide variety of motors will work with the generator; in fact, almost any miniature, fairly high rpm toy motor will do.

The 11¼" x ⅝" belt can be fashioned from a piece of thin sheet rubber of the type available from surgical supply houses or cut from an old swimming cap. Angle both ends to obtain a long, smooth butt seam. Apply rubber cement—the kind used to fix a flat tire—to each end, and when dry, carefully press the ends together and apply a thin coat of cement over the joint.

After the joint is bonded, install the belt by dropping it down through the tube and engaging both pulleys. Check the belt for proper alignment and tracking. You can do this by running the motor. If the belt doesn't track, shim up the motor where necessary, or cut one of the upper pulley notches deeper. Belt tracking can also be improved by constructing the pulleys with a slight crown or hump in the center.

Both upper and lower brush brackets are made by soldering a small piece of No. 18 copper wire, bent to shape as shown, to a ⅜" x ¾" bronze or other metal window screen material. The dome contact clip, which is also a piece of copper wire bent to shape, should be mounted so as to make contact with the inside of the salt shaker body when assembled. Use a 6 x ½" sheet metal screw to attach the contact and brush to the column.

Adjust both brushes so that they are close to the rubber belt but not touching, and in line with the pulley. Then screw the dome in place. Miniature phone jack *J1* is then mounted on the base and attached to the motor to facilitate the battery or power supply connections.

A small wooden box houses the power supply components. A miniature phone plug on the end of a 3' lead plugs into the pie pan. If you happened to use a large enough pie pan, you might get away with installing the power supply inside the base.

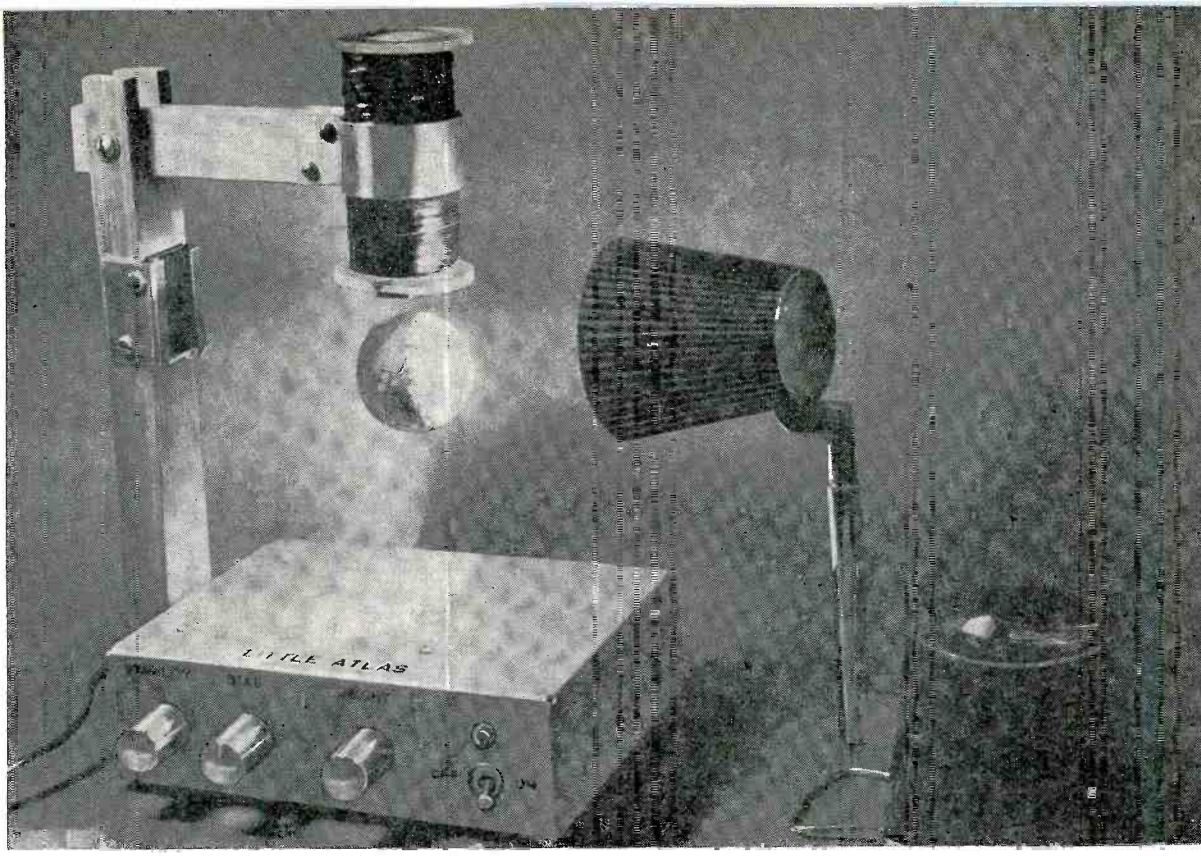
Operation. Some laws of electrostatics can be demonstrated by placing small bits of aluminum foil, paper or sawdust on the metal dome and watching them fly away from the dome as a charge is built up. These bits take off because they gain a like charge. *Like charges repel; unlike charges attract.*

The Indian rope trick, in miniature form, can be duplicated by attaching a few long strands of string or tissue paper to the dome. When the strands take on a charge, they will stand on end as they try to fly away. Touch the strands with your fingers, and they'll lean toward your hand as your body steals the charge.

A jumping ball demonstration can be performed by placing two or three small pith balls inside a small plastic tube, covering the tube with a metal disc, and placing it on top of the dome. As the balls are repelled upward from the dome, they will cling to the metal disc on top and then fall back to the dome. This action repeats itself until the disc approaches the potential of the dome.

To send corona discharge into the air, bend a piece of stripped hookup wire so that it will sit on top of the dome with one end pointed up. This end should be filed to a sharp point. Douse the lights, turn on the unit, and sit back and watch man-made lightning in miniature being produced. Another indication of the presence of corona is the peculiar smell of ozone which is usually generated.

Moisture and dirt in the column and dust on the dome will rob your unit of its prowess. So keep it clean. —30—



Li'l Atlas Defies Gravity

Like orbiting satellites, objects just float in space when magnetic attraction overcomes the pull of gravity

By WILLIAM J. PRICE

UNLIKE the Atlas of Greek mythology, condemned to carry the heavens on his shoulder for all time, "Li'l Atlas" is no myth. It's an electromagnetic photoelectric type of servo system that can establish a weightless condition on small metallic objects. And it's sure to steal the show at any Science Fair.

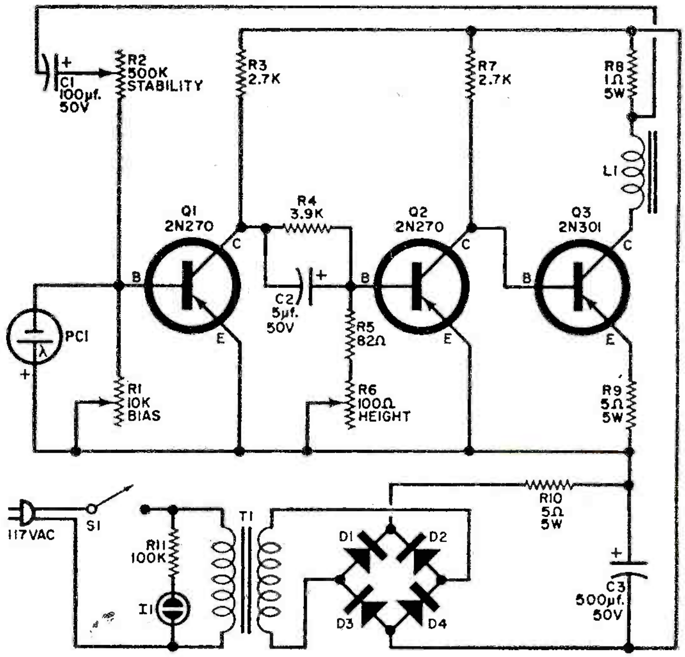
You place an object—an ordinary door key, a child's tin toy, or a small metal globe like the one shown—in the device's "sphere of influence." Then, like the boys at the Cape, you man the controls to suspend the object in space. You can move it up or down, or even wiggle it, if you wish.

How It Works. A photoelectric cell serves as a position sensor, and controls the intensity of a magnetic field that is used to counteract the pull of gravity on the object being suspended. (See photo.) Photocell *PC1* is mounted on a wooden column opposite a light source. When an object is suspended, it breaks part of the light beam reaching *PC1*.

If the object begins to fall, more light reaches the photocell, increasing the photocell's output current (Fig. 1). This current increase is amplified by *Q1* and *Q2*, and direct-coupled to power transistor *Q3*, whose output is in series with an electromagnet (coil *L1*). The resulting current increase through *L1* causes an increase in its magnetic field to overcome the pull of gravity, raising the object back up in place.

Similarly, if an object is raised above its predetermined height, less light falls on *PC1*, reducing the current to *Q3*. The magnetic field intensity is decreased, al-

Fig. 1. Like a Palace Guard, photocell PC1 keeps an eye on the object in space. If the object tends to fall, the photocell rushes the information via the transistors to coil L1 (the electromagnet) which, in turn, acts to increase the pull on the object to prevent it from falling. Conversely, if the object is being pulled too close to the coil, PC1 detects this condition and reduces magnetic pull to re-establish equilibrium.



lowing the object to drop down to its proper position.

The *BIAS* potentiometer, *R1*, controls the amount of current through *Q1* for proper operation under existing lighting conditions. Similarly, the *HEIGHT* control, *R6*, adjusts the bias on *Q2*, and establishes the height range through which an object can be suspended. The *C2-R4* coupling network stabilizes *Q2*'s base current for a smooth response. *STABILITY* control *R2* stabilizes the oscillatory tendency of the suspended object by adjusting the amount of feedback voltage developed by *R8* and fed back to *Q1* through *C1*.

The power supply is comprised of filament transformer *T1*, a full-wave bridge rectifier (*D1* through *D4*), limiting resistor *R10*, and filter capacitor *C3*.

Construction. If you use the chassis listed here, your first task is to lay out and drill the holes as shown in Fig 2. If you elect to use a different chassis, the suggested layout can still be followed except for the dimensions—which may change.

Once the chassis has been drilled and deburred, lay it aside temporarily while you proceed to make the wooden bracket,

PARTS LIST

C1—100-µf., 50-volt electrolytic capacitor
C2—5-µf., 50-volt electrolytic capacitor
C3—500-µf., 50-volt electrolytic capacitor
D1, D2, D3, D4—1N2859A silicon diode or equivalent
I1—NE-2 pilot light
L1—Coil—see text
PC1—1½" x ¾" selenium photocell (Lafayette Radio 99 R 6244 or equivalent)
Q1, Q2—2N270 transistor
Q3—2N301 or 2N2869 transistor
R1—10,000-ohm potentiometer, linear taper
R2—500,000-ohm potentiometer, audio taper
R3, R7—2700-ohm, ½-watt resistor
R4—3900-ohm, ½-watt resistor
R5—82-ohm, ½-watt resistor
R6—100-ohm potentiometer, linear taper
R8—1-ohm, 5-watt resistor
R9, R10—5-ohm, 5-watt resistor
R11—100,000-ohm, ½-watt resistor
S1—S.p.s.t. toggle switch
T1—Filament transformer: primary, 117 volts a.c.; secondary, 25.2 volts at 1 amp. (Stancor P-6469 or equivalent)
TS1—Single-lug terminal strip
1—5" x 7" x 2" aluminum chassis (Bud AC-402 or equivalent)
1—3½" x 4" Vectorbord
2—1¾" x 2" x ⅛" pieces of Lucite or Bakelite
1—TO-3 insulated transistor mounting kit
1—10"-long wooden column
1—4½"-long wooden cross arm
Misc.—Photocell mounting brackets, electromagnet mounting bracket, No. 26 Formvar insulated magnet wire (1 lb.)—see text, transistor sockets, ⅜" rubber grommet (2), #6 solder lug; ⅜"-o.d. rubber feet (4), knobs, etc.

photocell mounting bracket, and the coil support strap, as shown in Fig. 3.

Winding the Coil. The coil is wound on a ½" x ¾" x 3½" core made from laminated strips of mild steel (Fig. 4). You can have these strips made up by your local sheet metal shop, or they can be salvaged from an old power transformer core.

Clamp the laminations tightly together, then wrap a layer of black plastic tape around the core to hold the laminations close together while the coil is wound. This will also prevent the wire forming the first layer of the coil from being stripped by the sharp edges of the core. At one end of the core, keep the tape ⅜" away from the edge.

Cut a ½" x ¾" opening in the center of one of the two Lucite or Bakelite end stops. Insert the piece with the cutout over the end of the core with the ⅜" recessed tape. Center the other piece of Lucite over the other end of the core. Then, cement both pieces of Lucite in place using epoxy cement.

Allow sufficient time for the epoxy to dry thoroughly, and close-wind 800 feet of #26 Formvar magnet wire (approximately 2500 turns) on the core. Wrap one or two layers of plastic tape around the finished coil to protect the wires and hold the turns in place. Remove about one inch of varnished insulation from both ends of the coil using a fine file or sandpaper, then tin the bare wire. The d.c. resistance of the finished coil is approximately 30 ohms.

Installing the Parts. You are now ready to begin mounting the components on the 4" x 3½" prepunched Vectorbord. Do not mount *Q1* and *Q2* any closer to the 5-watt resistors than is shown in Fig. 5. Also, make certain the capacitors and diodes are connected with polarities as shown.

Mount the filament transformer and terminal strip using *8-32* x ½" screws and nuts. Note that the terminal strip is held in place with one of the transformer screws.

To mount *Q3*, drill the *base* and *emit-*

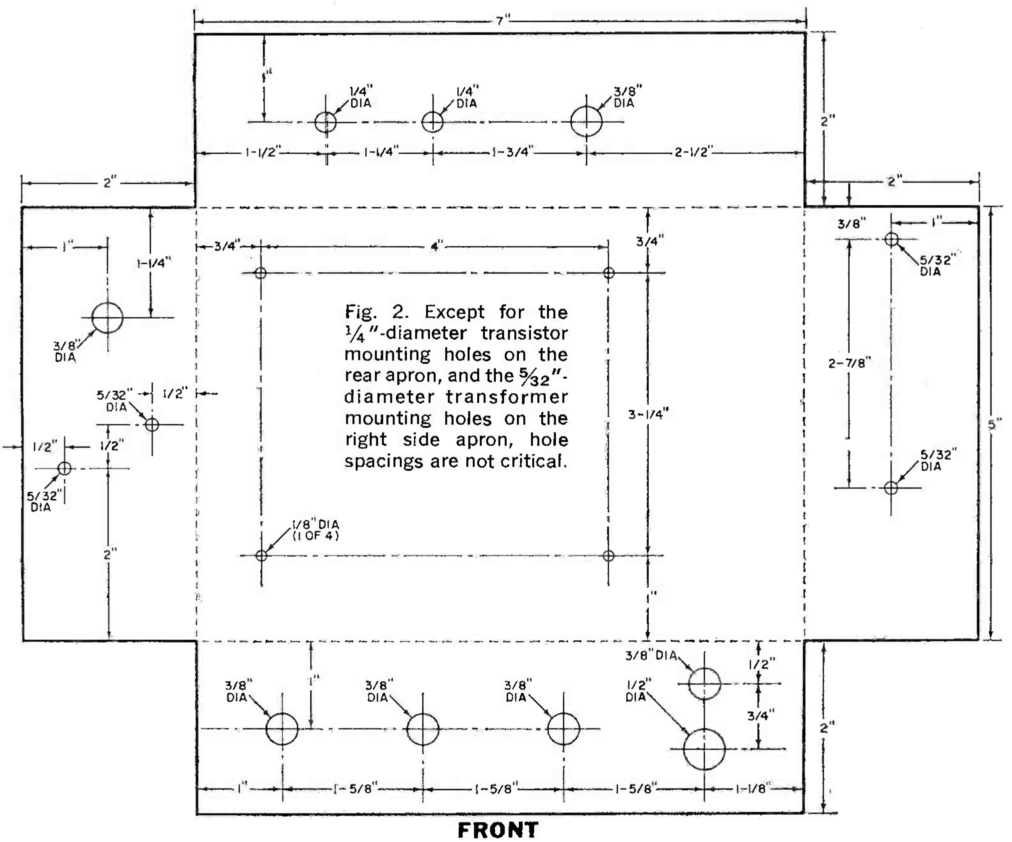


Fig. 2. Except for the ¼"-diameter transistor mounting holes on the rear apron, and the 5⁄32"-diameter transformer mounting holes on the right side apron, hole spacings are not critical.

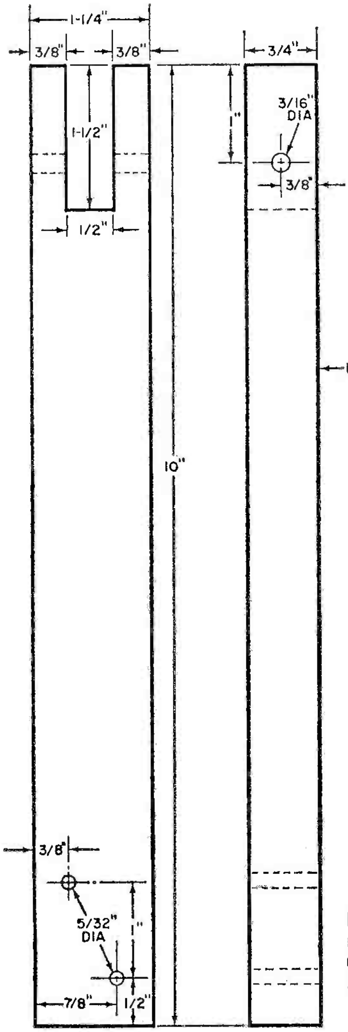
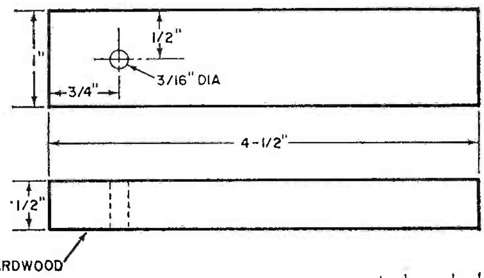
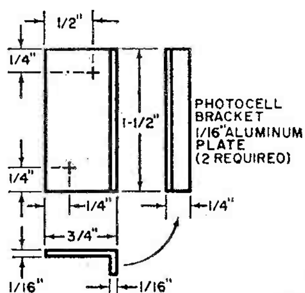


Fig. 3. These are the dimensions of the wooden support and crossarm that were used in the author's model. If desired, ¼" hardwood can be substituted for the aluminum photocell bracket.





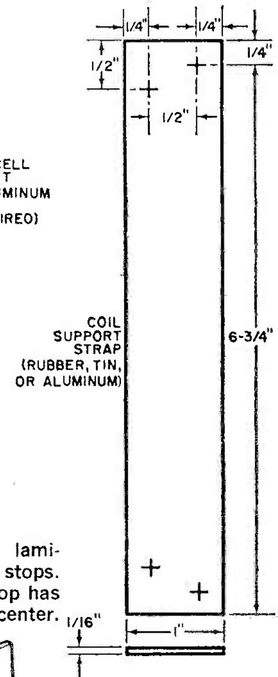
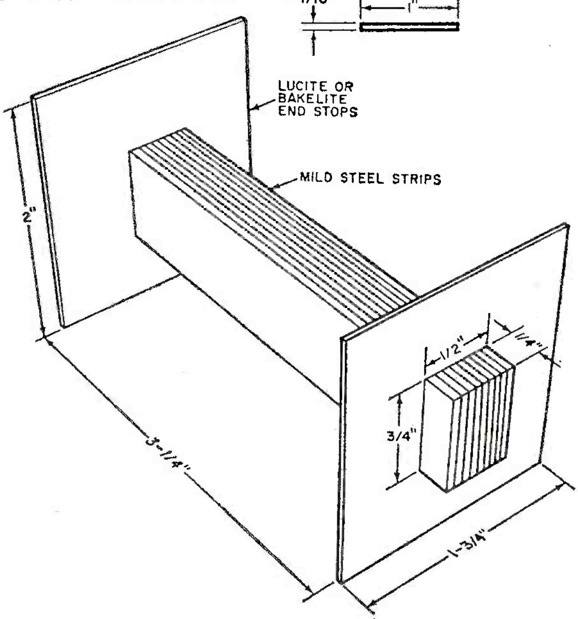


Fig. 4. Coil core showing laminated steel strips and end stops. Observe that only one end stop has a ½" x ¾" cutout in its center.



ter holes using the mounting kit's diamond-shaped mica washer as drill guide. Apply silicon heat-sink grease to the transistor mounting surface to insure good heat transfer. The base terminal must be positioned toward the top of the chassis while the emitter faces toward the bottom. The collector is grounded to the case. Be sure the #6 solder lug is mounted on the screw as shown.

Now install the two ⅜" rubber grommets, controls *R1*, *R2*, and *R6*, and the pilot light assembly. Connect a 100,-

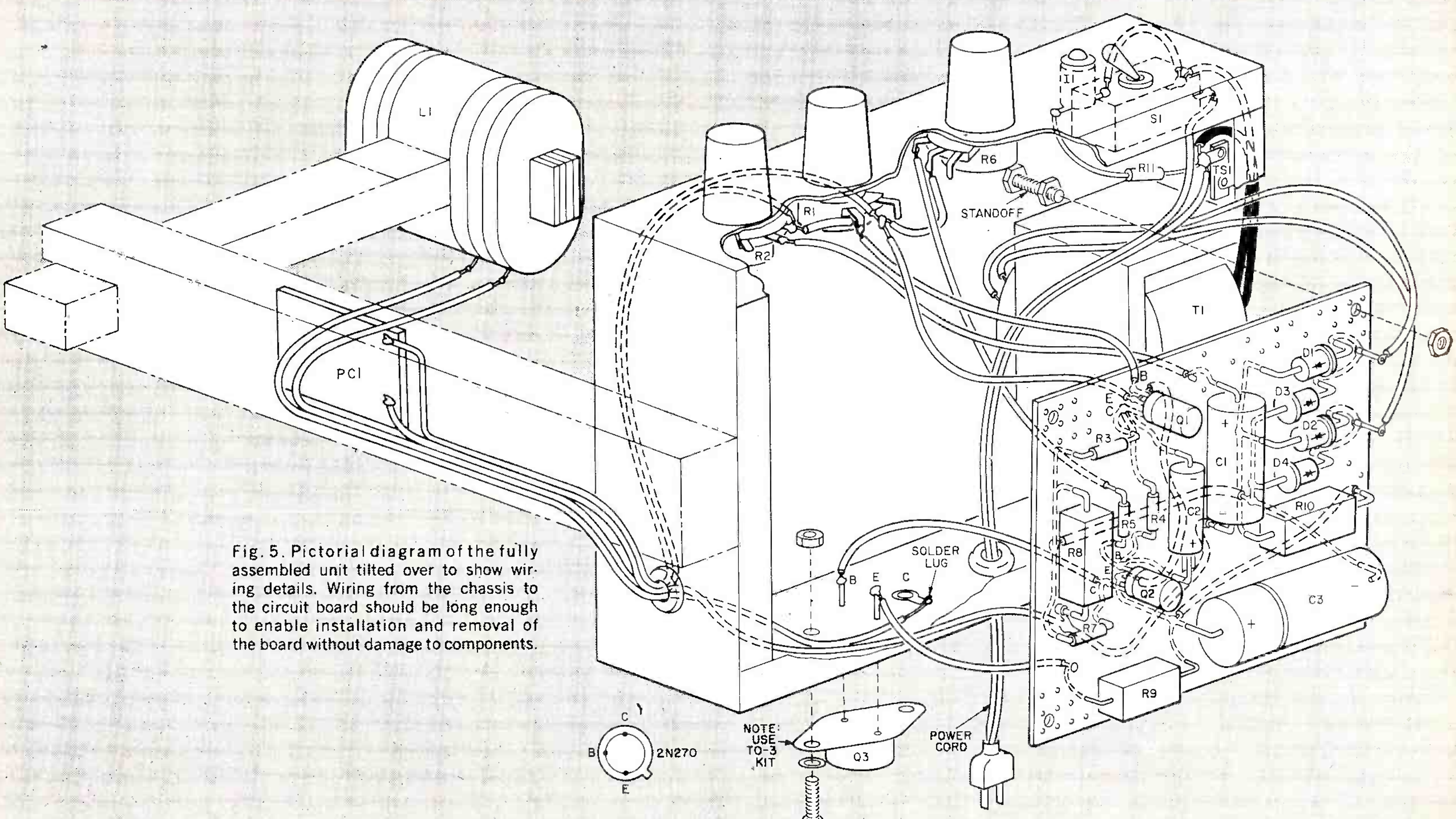


Fig. 5. Pictorial diagram of the fully assembled unit tilted over to show wiring details. Wiring from the chassis to the circuit board should be long enough to enable installation and removal of the board without damage to components.

000-ohm resistor (*R11*) from one of the pilot light terminals to the terminal strip, and connect one end of a 3" length of insulated hookup wire to the free terminal of the pilot light. Insert the line cord through the grommet provided, and connect one of the leads to the terminal strip. Then connect one of the transformer primary leads (black) to the terminal strip. Solder all leads.

Position the power switch (*S1*) close to its chassis mounting location. (Do not mount the switch at this time.) Connect the remaining transformer black lead to one of the switch terminals. Then connect the free end of the hookup wire from the pilot light to the same switch terminal, and the free lead from the line cord to the other switch terminal. Solder all leads and mount the switch on the chassis.

Mount the coil and photocell on the assembled wooden bracket as shown in Fig. 6, and secure the bracket to the chassis. Feed the leads through the grommet, and connect the wires as shown in Fig. 5.

Finally, insert four *6-32* x 1¼" screws down through the top of the chassis,

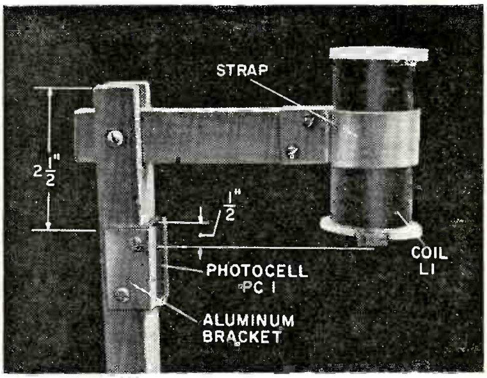


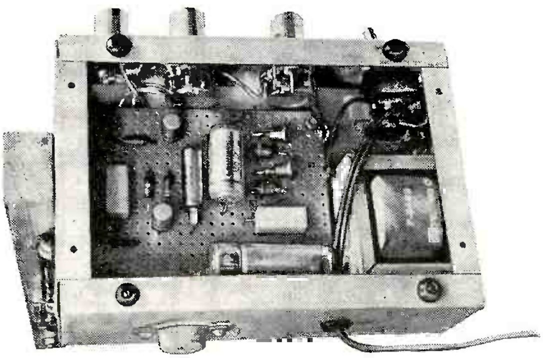
Fig. 6. The distance of the photocell from the coil is not critical. You may prefer to mount the photocell entirely away from the unit, perhaps on a wall. The coil should be aligned as shown, however.

tightening the nuts against the inside of the chassis. Thread a second nut ¼" down on the screw to act as a standoff for the component circuit board. Then mount the circuit board and complete all wiring.

Operation. Before plugging in the Li'l Atlas, check to make sure that (1) exposed coil terminals are not grounding out against the supporting metal strap, if one is used; (2) the coil and photocell are properly positioned as shown in Fig. 6; (3) all connections have been soldered, and there are no shorts.

Place a light source (a 50- or 60-watt desk lamp will do) opposite the photocell, and about two feet away from it. Position the light so that the exposed end of the coil core casts a shadow on the upper portion of the photocell. If Li'l Atlas is to perform in a strongly lighted room, shield the photocell with a piece of cardboard or paper tubing.

Now all you need is a small object that will remain suspended in space. Almost any small iron or steel object, such as a key, can be used. If you want something that will spin as it floats


Interior view showing components mounted on perforated phenolic board, suspended on standoff screws. Transistor Q3 is mounted on the chassis back panel while transformer T1 is on the inside of the right panel, directly behind the on/off switch.

around, obtain a round object such as a tiny globe which you can get in a dime or stationery store.

Turn on Li'l Atlas and set its *STABILITY* control for maximum resistance, the *BIAS* control for minimum resistance, and *HEIGHT* control to midpoint. Loosely hold the object about ¼" below the magnet, and advance the *BIAS* control until the magnet begins to pull. Then adjust the *STABILITY* control to "settle down" the object as it begins to oscillate. Remove your hand and the object will remain suspended.

You can cause the object to vibrate rapidly for special effects by advancing the *STABILITY* control. —30—

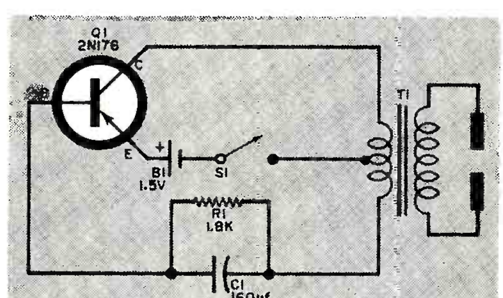
BUILD...

THE TICKLE STICK

Tickler or stimulator—take your pick; once you grab it, you'll let go quick

By FAIRIS S. BURT

ONE LOOK at the foil-covered electronic stimulator is enough to give you the creeps. Do you have enough guts to hold onto it with both hands? Under that shiny aluminum "skin" beats a "stout heart" with enough zip to pulse your muscles without so much as moving a finger. After your first reaction, if you are still holding on, you will feel great—especially after you let go. While it may come as a shock to you, the stimulator is completely safe; there's no dangerous high voltage or current to worry about.



Unusual application of filament transformer steps up Q1's pulse output to excite the electrodes—and any one who happens to be holding on to them.

How It Works. Pulses generated by a simple single-transistor modified Hartley oscillator are transformer-coupled by a reverse-connected filament transformer to a couple of electrodes. Resistor *R1* and capacitor *C1* determine the frequency of the pulses; changing the values of either of these components or changing battery voltage will change the frequency. Different frequencies create different sensations, but it's best to stick to the values given in the Parts List.

Construction. All components are mounted inside a cardboard tube about 9″ long and 2½″ in diameter. End plugs for the tube can be fashioned from styrofoam plastic such as that used in packaging. They can easily be cut to shape with a small knife. (If you can't get styrofoam, you can use wood, metal, or even cardboard.) Hollow out one plug to hold the on-off switch. Then drill a ¼″ hole ½″ from each end of the tube to accommodate the wires for the electrodes.*

Follow the pictorial diagram when wiring the unit. Note that the transistor is mounted directly onto the transformer mounting flange and the flange is bent upward slightly to allow clearance when you insert the circuit into the tube.

Use long leads between the components and the tube to allow for the removal and replacement of the entire electronic package, or just removal of the battery. Leads of 8″ or more should be used to connect *T1*'s center tap to *S1*, the emitter of *Q1* to the battery holder, and one side of the secondary winding of *T1* to the cardboard tube. The other side of *T1*'s secondary should be made about 12″ long. Strip about 3″ of insulation from the 8″ and 12″ leads attached to the primary winding of *T1*, and insert one lead through the hole in the one end of the cardboard tube and the other lead in the other end of the tube. Wrap the leads around the tube at each end once or twice.

Now cut two 4″ x 14″ strips of aluminum foil and roll them "squarely" over the tube flush with the ends of the tube, leaving a 1″ separation in the middle as shown in the photo on page 125. To obtain good electrical contact with the bared wires coming from the inside of the tube, roll the aluminum foil on tight, smooth and squeeze out any trapped air, and tape the ends. Each strip of foil must make contact with only one lead. Incidentally, a good source of aluminum foil is your local grocery store.

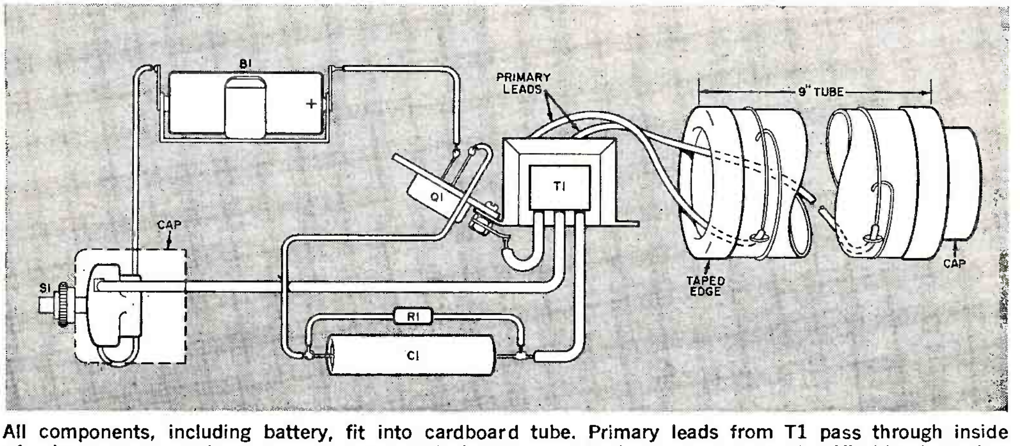
Using the Stimulator. After you insert the circuitry into the tube, tissue or other soft filler can be stuffed in to keep the works in place. Cap the two ends of the tube with the styrofoam, and you're ready to go into the shocking business.

Push the button, hold on to the two aluminum electrodes and you'll feel that stimulating flow of current travel up your arms. Then try it out on your friends. Stimulation, anyone? —30—

PARTS LIST

B1—1.5-volt battery
C1—160-µf., 10-volt electrolytic capacitor
Q1—2N176 transistor (or equivalent)
R1—1800-ohm, ½-watt resistor
S1—S.p.s.t. switch
T1—Filament transformer: 117-volt primary, 6.3-volt CT secondary (Thordarson 21F09 or equivalent)
1—9″ x 2½″ cardboard tube (approx.)
Misc.—Aluminum foil, wire, solder, etc.

**An ideal tube for this project is a stiff, white plastic rolling pin which is now being sold at most large stores. If you want to use it instead of the cardboard tube, simply twist off the handles and use a small screwdriver or knife to remove the end plugs. Enlarge the hole in one of the plugs to accommodate the switch.*



All components, including battery, fit into cardboard tube. Primary leads from T1 pass through inside of tube to the outside, and are covered with foil. About 1″ of space separates the 4″-wide electrodes.

Are you a flincher? Try your hand at Reflex . . . an electronic game of skill

BUILD A REFLEXOMETER

By JAMES FISHBECK

THE PERFECT Rx for pooped-out parties or for those rainy evenings when you're looking for something to do is to play "Reflex"—a game of skill which shows your wizardry with electronics, and also shows which of your guests can respond properly and more quickly to a given situation. The situation in this case is created by certain selected dice throws. All you need to play is a pair of dice, a set of poker chips, a jaw-tight determination to prove how fast your reactions really are, and a "Reflexometer."

Two, three, or four people can play the game.

There's a bonus for you, too; the Reflexometer has other applications both for work and for play, some practical and some not so practical.

Four hand-held push-button responders, each a different color and each manned by a different player, tie man and machine together. The first man to press the button lights a lamp that corresponds to his responder. The lamps are wired through a system of four relays which permit only one lamp to light at a time. Once a lamp lights, it remains lit even after the button is released. Second best is no good: the other lamps cannot be illuminated, at

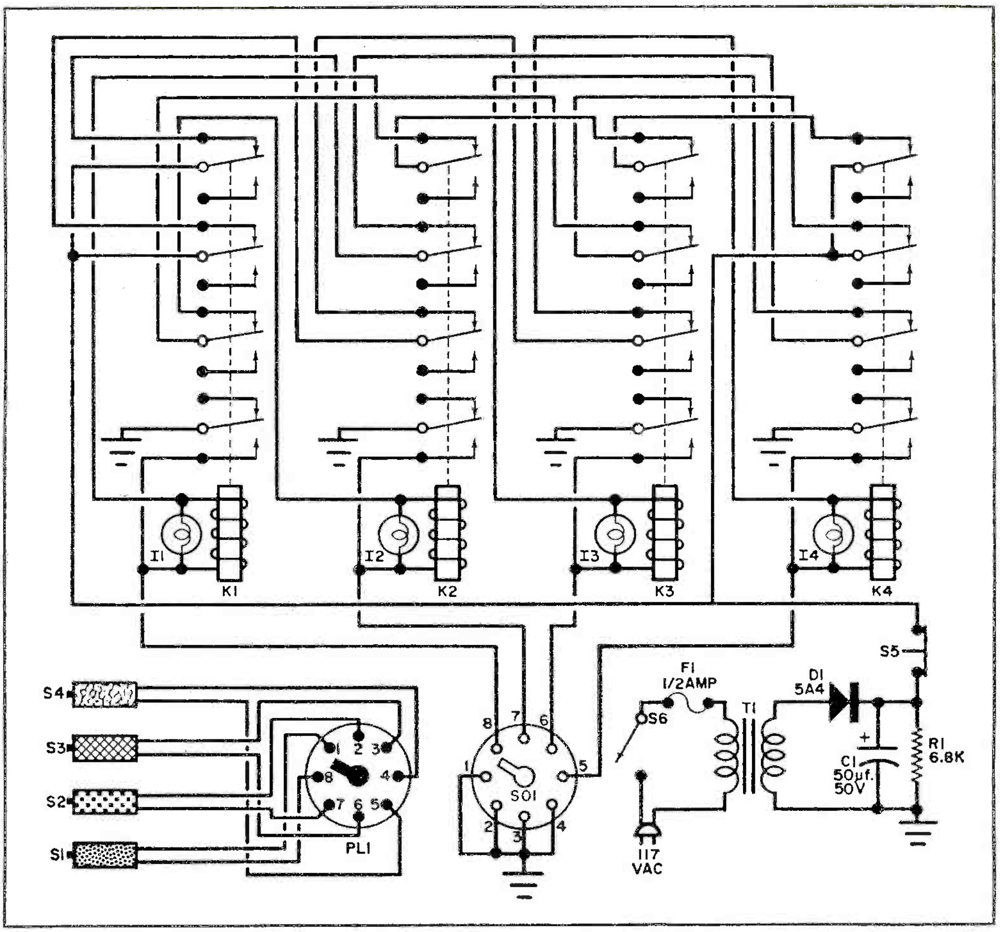


Fig. 1. Responders S1 to S4 can complete only one relay circuit at a time. The first switch closed latches its respective relay, lights its lamp, and disables the other relays until the circuit is reset.

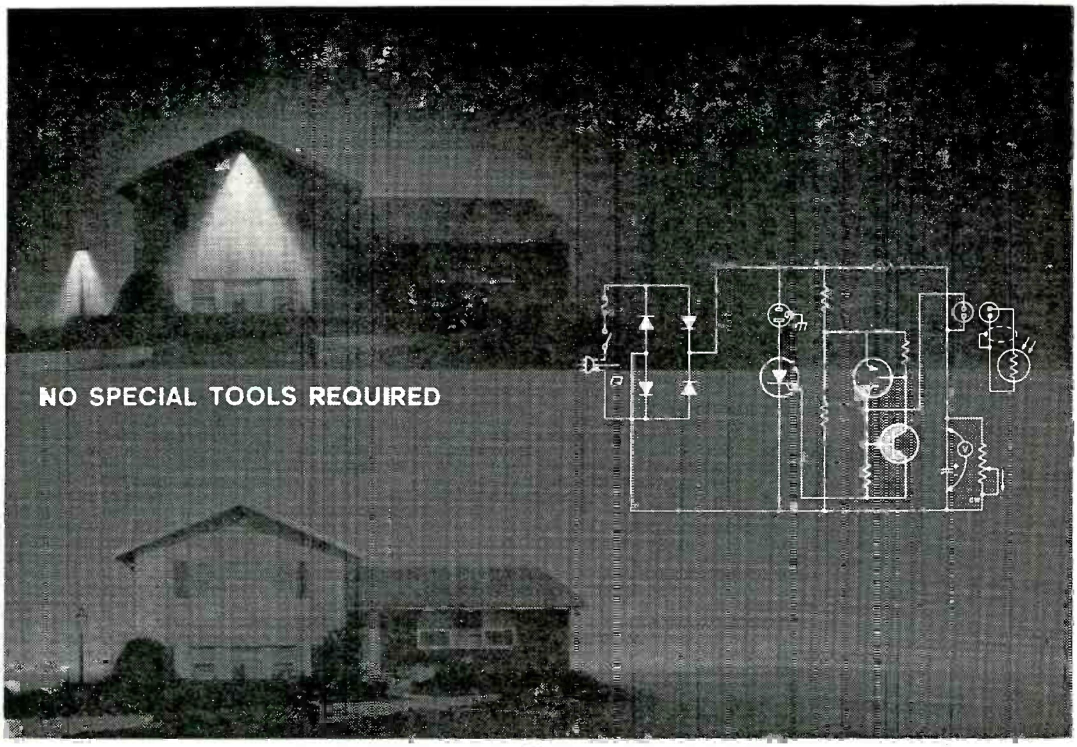
least not until the winner collects, and the reset button is pressed.

How To Play "Reflex." Each player starts with 25 poker chips. All players roll the dice once to see who starts. The one who rolls the highest number goes first. He starts the game by rolling the dice.

Any double or combination of 7, or 11, is a "reflex" roll, and the first person (including the player who rolled the dice) to press his responder switch in response to a reflex roll, wins the round and collects a chip from each of the other players. If no proper reflex action occurs on the throw, the player who rolled the dice does so again until one of the players wins. The dice are then passed to the next player on the left. Of the 36 possible combinations of the dice, 14 (approximately 40%) are reflex rolls.

Sounds simple, doesn't it? But there's a human element to complicate matters. Quite often those who respond first lose; edgy players, those most anxious to register first, are most likely to flinch. A flinch is a false or a premature response that causes the light to come on when it shouldn't. If a player flinches, and his lamp shows that he did, he pays a penalty of one chip apiece to the other players. The dice are not passed on a flinch.

Tension mounts as the game progresses, and if you are a good student of human behavior, you may try some maneuvers such as feigning a flinch to send an anxious player over the hill



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- RCA Basic Experimenter's Kit (KD2105). Containing one silicon controlled-rectifier; two transistors; five rectifiers.
- RCA Experimenter's Manual (KM-70). 80 pages profusely illustrated; 14 circuits—how they operate and how to build them.
- RCA Add-On Light Sensor Kit (KD2106). Containing one photocell for light-operated circuits.
- RCA Add-On Heat Sensor Kit (KD2110). Containing three thermistors for different temperature ranges; special solder for heat control circuits.
- Readily available passive components and hardware.

HERE IS WHAT YOU CAN MAKE...

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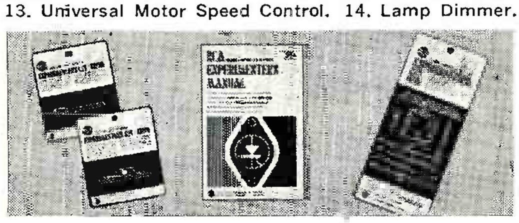

If you want to build one circuit or all 14, check with your RCA Distributor where kits and RCA Experimenter's Manual are on display. He'll be glad to help you select the kit or kits for the solid-state circuit you have in mind. Do it today!

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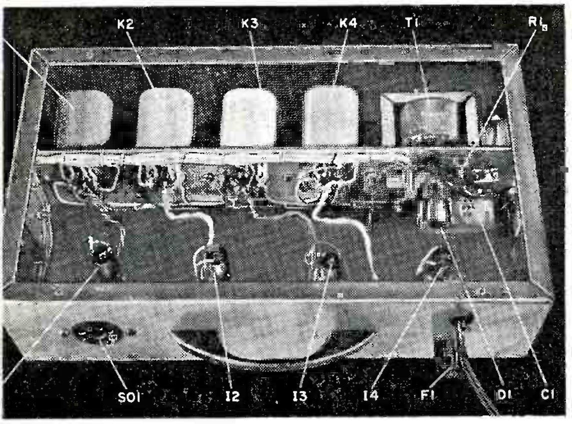

Fig. 2. Construction is simple. Another way to assemble the Reflexometer is to do away with the sub-chassis and mount the relays on top side of case.

with his nervousness. The player with the most chips, after another player loses all, is the winner.

You can also use the Reflexometer to show which event in a series of actions occurs first, such as in a foot race or a slot-car race. Switches installed on the track and wired to the unit act as impartial judges. (Perhaps, if such a device were available years ago, we would know today which came first—the chicken or the egg.)

How the Reflexometer Works. Each of the four responders, containing one of the switches *S1* to *S4* (Fig. 1), is connected to one of the relays (*K1* to *K4*)

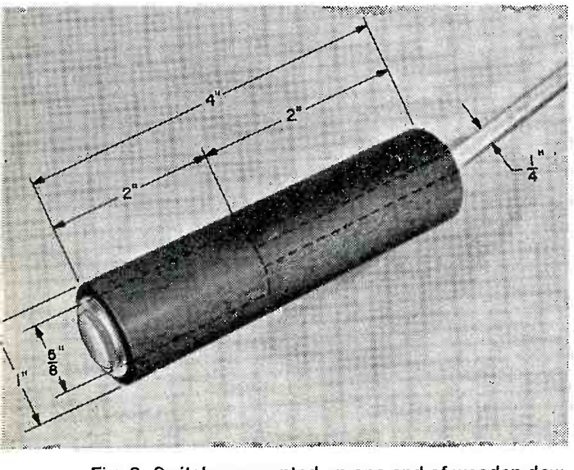

Fig. 3. Switches mounted on one end of wooden dowels make suitable hand-held responders. Any normally open push-to-close type of switch can be used.

PARTS LIST

C1—50-μf., 150-volt electrolytic capacitor
D1—5A4 diode (or equivalent)
F1—½-ampere fuse
I1, I2, I3, I4—313 28-volt miniature lamp
K1, K2, K3, K4—Relay, 4-p.d.t., 24-volts, d.c. (Potter & Brumfield KHP17D11 or equivalent)
PL1—Octal plug (Amphenol 86-PM8 or equivalent)
R1—6800-ohm, 1-watt resistor
S1, S2, S3, S4—Normally-open push-button switch (Eagle 188 or equivalent)
S5—Normally-closed push-button switch (Arrow-Hart & Hegeman 3392-AE or equivalent)
S6—S.p.s.t. toggle switch
SO1—Octal socket (Amphenol 88-8 or equivalent)
T1—117-volt to 25.2-volt filament transformer, 1-ampere (Chicago-Stancor P6469 or equivalent)
4—Colored indicator light assemblies (Dialco 931-102, 932-102, 933-102, 935-102)
1—7" x 12" x 3" aluminum chassis (Bud AC-408 or equivalent)
1—7" x 12" aluminum bottom plate (Bud BPA-1595 or equivalent)
1—2" x 13" piece of 20-gauge aluminum
1—Miniature fuse post (Littlefuse 342014 or equivalent)
1—Lamp cord, white vinyl plastic (Knight POT—25' spool)
4—1"-diameter wood dowels
Misc.—Small handle, rubber mounting feet (4), rubber grommets, hardware, hookup wire, etc.

and to one of the lamps (*I1* to *I4*). The first button depressed completes a circuit for its associated relay and indicating light. If *S1* is pressed first, for example, *I1* lights and *K1* energizes. When the armature of *K1* pulls in, one of the contacts on the relay completes the relay circuit to ground and, like an electrical latch, holds the relay energized and the lamp lit even after the responder button is released.

The three remaining sets of contacts on *K1* open the B+ leads to *K2*, *K3*, and *K4* to prevent these relays from kicking in on a second-best response. The circuit remains latched until *S5* is depressed. When *S5* is momentarily opened, *K1* de-energizes and the Reflexometer is ready for the next round of play.

Transformer *T1* steps down the line voltage to 24 volts, and *D1* functions as a half-wave rectifier. Capacitor *C1* filters the B+ and *R1* acts as a bleeder and tends to regulate the voltage.

Construction. A 12" x 7" x 3" aluminum chassis holds all the parts, except the responders. The four relays and

(*Continued on page* 150)

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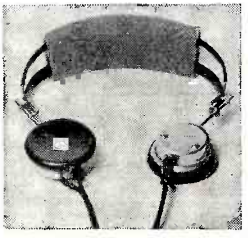
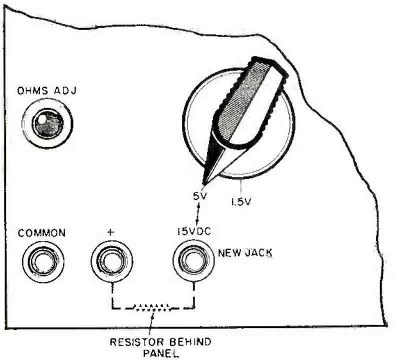
DON'T BE A SOREHEAD —CUSHION THOSE PHONES

Headbands used with conventional type earphones can become quite uncomfortable pressing against the skull, even after short periods of time. An easy way to eliminate this discomfort is to cushion the band with some inexpensive foam rubber or plastic. Just cut a 12"-long strip of the soft material, wrap it around the headband, and tape or cement the end. You can also make a foam cushion for each of the ear pieces, but be sure to cut an opening in the center so as not to obstruct the sound. —*Art Trauffer*



ADD A 15-VOLT RANGE TO YOUR HEATHKIT VOM

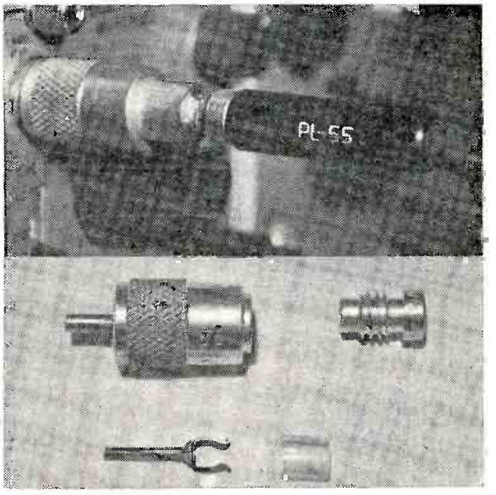
If you have a Heathkit MM-1 VOM, you can add a 15-volt d.c. range for greater ease in measuring 6- and 12-volt d.c. potentials. A 200,000-ohm, 1%, ½-watt resistor and an additional test jack are all you need for this modification. Remove the instrument panel from the meter case and drill a hole to install the new jack approximately ½" to the right of the plus (+) jack. At the rear of the panel, solder the resistor between the new jack and the (+) jack. With the *RANGE* switch set



to "5 V," and the d.c. test lead in the new jack, a full-scale deflection will indicate 15 volts. With the d.c. scale essentially linear, a mid-scale reading will indicate 7.5 volts. Inscribe "15 VDC" on the front panel directly over the new jack, using white India ink or paint. Compared to the 6- and 12-volt readings obtained on the 50-volt range, the new range provides an extra inch or two of deflection and throws the reading into a more accurate part of the meter. Input impedance is 300,000 ohms on the 15-volt range and 1 megohm on the 50-volt range. —*Jerry C. Sutton*

PHONE-PLUG-TO-COAXIAL-CONNECTOR ADAPTER

This adapter is useful for mating ordinary PL-55 type phone plugs to coaxial connectors on many types of electronic equipment. Obtain a standard PL-259 coax plug and a UG-176 cable reducer, and cut off ¼" from the shank of the reducer. Solder a short length of 3/16"-wide spring brass or bronze strip to the tip of a No. 4 or 5 flathead screw, ¾" to 1" long. Bend this strip into a stirrup



shape to conform to the standard phone plug as shown, then cover with a 5/16"-i.d. plastic sleeve. Now insert the assembly in the PL-259 so that it is firmly seated and the screw protrudes through the hollow tip of the plug. Trim and solder the screw. Next, take the shortened reducer and screw it part way into the PL-259. Insert the phone plug as far as possible and rotate the reducer until the tip of the phone plug snaps into place and touches the bottom of the stirrup. After checking final results for continuity, solder the reducer in place to prevent further turning.

—*F. W. Chesson*

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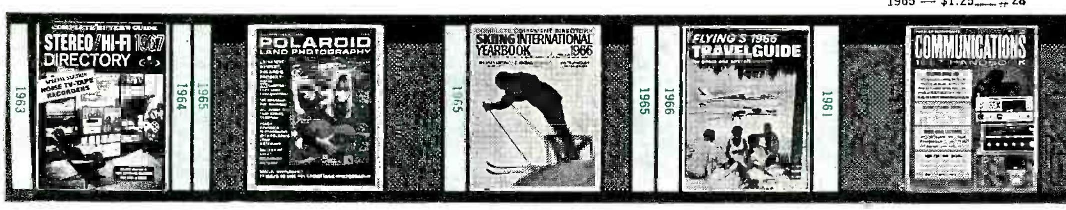

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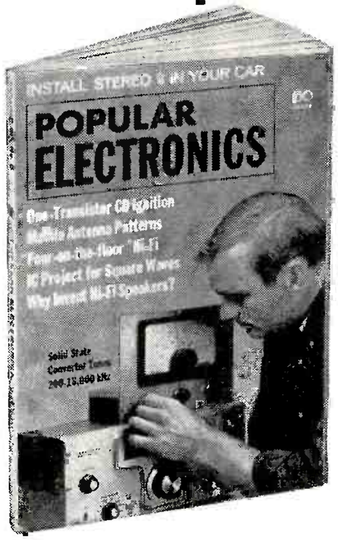

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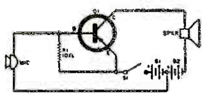

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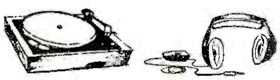

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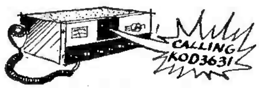

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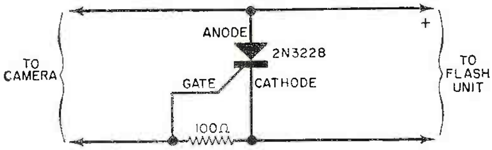
SCR TAKES LOAD OFF CAMERA FLASH CONTACTS

Photographers who constantly use an electronic or other type of flashgun will appreciate this simple, inexpensive gadget—it cuts down the high voltage and current normally



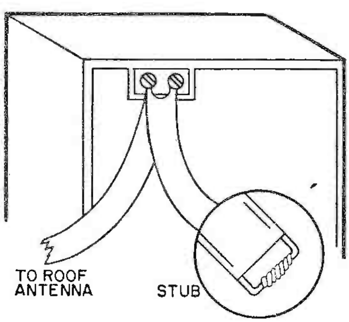
"felt" across the camera's contacts and extends their life. You can assemble the 2N3228 silicon control rectifier (SCR) and 100-ohm resistor in any small plastic container; a coin holder will do nicely. If you insert the assem-

bly in the flash cord, you'll be able to use the hookup with different flash units and with different cameras. No additional batteries are required since the gadget is powered by the flash unit. Cost is less than $2.00.

—*William S. Gohl*

MISMATCH STUB CHASES TV GHOSTS

If you're haunted by ghosts on your TV screen due to transmission line mismatch, you can clear up this condition with a mismatch stub. This is simply an extra piece of 300-ohm transmission line connected across your set's antenna terminals to correct for slight amounts of mismatch. First, tune the TV set to the spooky channel. Then connect one end of a 3′



length of lead-in wire across the set's antenna terminals, letting the free end hang loosely toward the floor. Check to see if there's an

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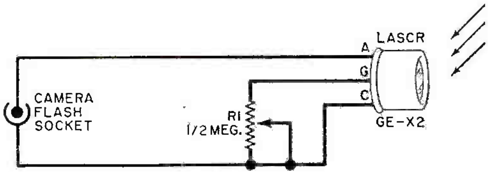
improvement in the picture. Progressively shorten the stub by cutting into the insulation with a razor blade so as to short out the pair of wires. Cut the lead at the point where the ghost disappears or is substantially suppressed. Then twist the two wires together as shown. —*Warren Todd*

"PILLBOX" FIRES FLASH UP TO 30 FEET AWAY

Small enough to fit into a pillbox, this slave unit can fire a standard or electronic flash gun at distances up to 30 feet. A General Electric X2A light-activated SCR and a sensitivity control (a ½-megohm potentiometer) are installed inside the box. A small PC socket is mounted on the case cover to connect the flash gun to the light-sensitive mechanism. Before inserting a bulb in the gun, turn the sensitivity control all the way down to prevent the gun from firing. Then advance the control just enough to allow the slave to operate when it



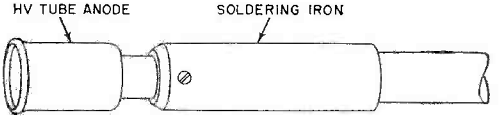
"sees" the flash gun on your camera take off. If you advance the control too much, the slave may take orders from the available light and fire before you want it to. — *William S. Gohl*

WHACKIEST MIKE IN THE SWIVEL PEN HOLDER

Pen holders make excellent swivel stands for both homemade and commercially available crystal microphones. You can glue a mike head onto the top of the pen or mount it directly in the pen holder. If you plan to use the pen case, remove the ink cartridge and drill a hole in the side of the case for the mike cable to pass through. If you decide to mount the mike in the pen holder, locate the hole in any suitable position. One thing you won't be able to do with the pen when you're through is *write*. —*Art Trauffer*

TUBE ANODE MAKES MINIATURE SOLDER POT

Want an easy-to-make solder pot to use for tinning stranded wire? Locate a burned-out high-voltage rectifier tube such as a 1B3; break the glass and remove the cup-shaped

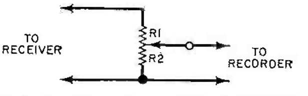


anode. Then remove the ¼" tip from a heavy-duty soldering iron and insert the anode cap. Allow the iron to heat sufficiently, and feed solder into the newly fashioned cup until it's about three-quarters full.—*Jan B. Rosenbaum*

ATTENUATOR PHONE PLUG CUTS TAPE RECORDER DISTORTION

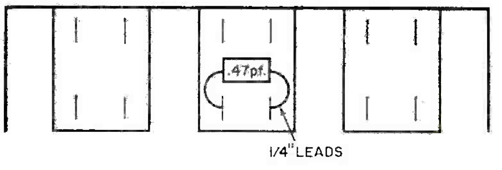
To prevent a radio or amplifier from overloading your tape recorder with high level signals, you can insert a resistive attenuator network directly into the phone plug on your tape recorder's patch cord. To determine the

value of the two resistors needed, hook up a 50,000-ohm potentiometer as shown in the diagram and adjust it for optimum recording level. Then measure the portions labeled *R1* and *R2* and replace the potentiometer with fixed ½-watt resistors of like value. —*Marshall Lincoln*



"GIMMICK" CAPACITOR INCREASES BANDWIDTH OF UHF TV BOOSTER

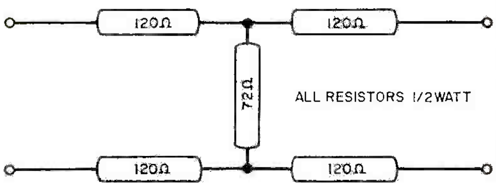
A variable frequency amplifier, such as the Blonder-Tongue UTB-1 UHF booster, can be easily modified to provide a frequency range from 440 to 910 MHz instead of 470 to 890 MHz to take in part of the UHF radio



ham band and other services. Solder a 0.47-pF capacitor or "gimmick" across the output resonant tank, and cut the capacitor leads as short as possible—they should be no longer than ¼ inch. Now connect the capacitor across the two tabs sticking out from the center wafer on the bottom of the chassis. —*Ken Greenberg*

MAKE YOUR OWN TV SIGNAL ATTENUATOR

If you live in a very strong signal area, your TV set may be troubled by too much contrast, picture tearing, multiple images, or an annoying buzz you just can't tone down. You can cure these conditions with a simple attenuator pad inserted between the set and the antenna. The pad attenuates the signal without introducing any side effects such as transmission line mismatch. In the diagram of the



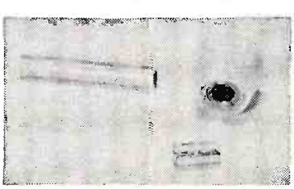
pad shown, the values given are for a 300-ohm line feeding into a TV set with a 300-ohm input. If the especially strong signals appear on one or two channels only, you can add a d.p.d.t. switching arrangement in the circuit to switch the pad in and out of the line as desired. —*Vincent Giscombe*

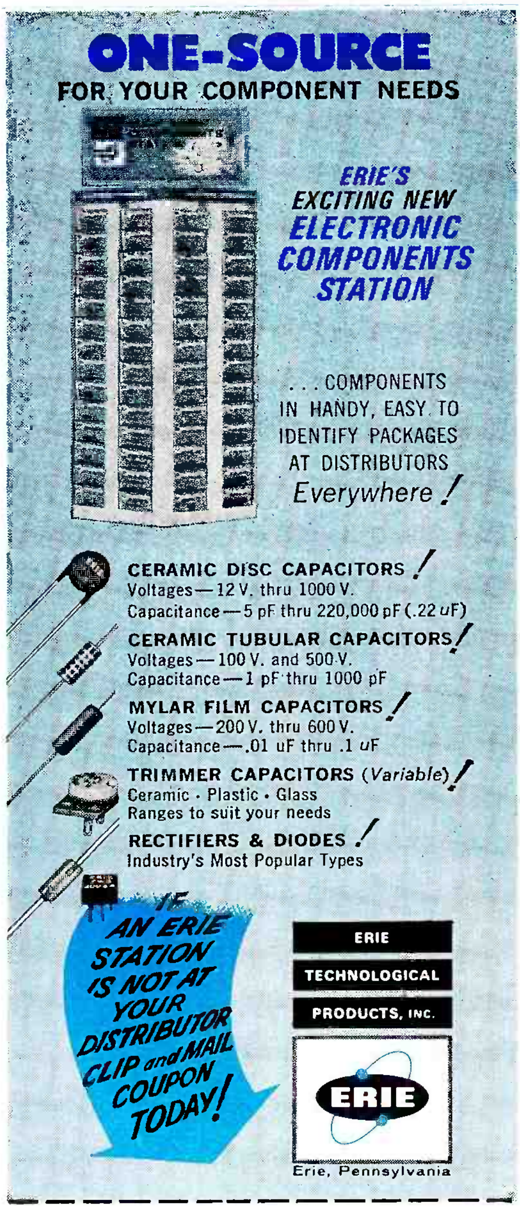
DOTS AND DASHES . . . LOTS OF FLASHES . . . IN A PAN

If you want to practice land Morse code but have no telegraph sounder, you can do a pretty good job with a transmitting key mounted on a small metal tray or pan. Before fastening the key down, try different locations on the tray until you find a place where the clicks sound the loudest. You can also make louder sounds by increasing spring tension and contact gap, and by pressing harder. —*Carl Dunant*

COPPER TUBING MAKES HANDY KNOB BUSHING

Should you find yourself in need of a control knob for a ⅛″-diameter shaft, but only have ¼″ types on hand, you can use a piece of copper tubing as a bushing to bring the knob opening down to size or the diameter of the shaft up to size, depending on the way you look at it. Cut a short length of ¼″ copper tubing, slit it so that it fits around the ⅛″ shaft, slip the tubing over the shaft, and then fit the knob into place. —*Homer L. Davidson*





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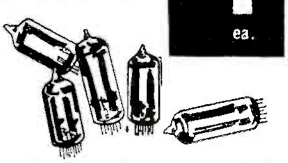

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CROWD STOPPER

(*Continued from page* 111)

tionary contacts is mounted on a ¾″ x 6-32 brass machine screw, and the rotating contact is mounted on the armature of the motor.

Timing Motor and Switch (S2). Assemble the motor and switch as in Figs. 8 and 9. If you're using a counterclockwise motor, position the four switch contacts as shown; otherwise, reverse orientation of the switch contacts.

Connect stationary switch contacts 1 and 3 together and 2 and 4 together; use solder lugs beneath the mounting screws to make it easier to solder the leads. Also, solder a 10″ lead to each pair of contacts. Then fasten the switch assembly to the bottom of the chassis with two 2″ machine screws and two 1½″ wood dowels; the motor faces down.

Final Wiring. Mount *T1* so it will clear the coils when the chassis lid is put on. When wiring the rest of the unit, make sure leads are long enough for the lid to be removed without having to break the connections. Turn the rotary contact by hand and note the pressure between it and the stationary contacts: there should be just enough pressure to make contact without slowing down the motor.

Installation. Plug the unit in, and adjust the contacts so a lamp will go out just before the flip ring reaches it. When all adjustments have been made, arrange the wiring neatly inside the chassis to prevent interference with the operation of the motor. —30—

INTEGRATED CIRCUIT AMPLIFIER

(*Continued from page* 105)

solder the leads to the IC socket until the case is in place. When wiring this unit in the circuit, observe that the locating tab on the IC is directly over pin 1. Viewed from the top of the case, the pins are numbered counterclockwise. Also, observe that pins 2, 7, and 10 are tied together and returned to a terminal on *S1*.

Operating Hints. Distortion will result if too large a signal is applied to the amplifier input. For applications not requiring a wide bandpass, a step-up transformer can be used to couple the output of the first differential amplifier to the input of the second amplifier, replacing capacitor *C2*. However, some amount of experimentation is required to select the right transformer, since poor matching of the stages can transform your amplifier into a blocking oscillator due to the sensitivity of emitter followers to inductive loads.

For additional gain, two or more IC packages can be cascaded together. But care must be taken to keep the signal at a level low enough so that clipping will not take place.

The values of *R1* and *R2* have been chosen for best overall performance and circuit stability. But where it is desirable to change the amplifier input and output impedances, the value of these resistors can be raised to as high as 22,000 ohms with only a slight loss in gain and stability. One advantage of this change is that smaller values are required for *C1* through *C3* for any given frequency response. —30—

MUSETTE COLOR ORGAN

(*Continued from page* 52)

rear projection through a plastic or glass screen, or reflected projection from a crumpled aluminum foil surface.

For best results, use *red, orange, yellow, green,* and *blue* spotlights to obtain a full spectrum of colors. It has been found that spotlights with built-in optical interference filters perform best, yielding the deepest colors, the coolest operation, and providing the best overall effect. These lamps readily produce all hues, and varying degrees of saturation.

The choice of a display, as well as the arrangement or sequence of colors for the various channels, is yours to make. One logical scheme is to drive the low-frequency color lamp—the color red—with low-frequency audio, and so on up the spectrum to blue.

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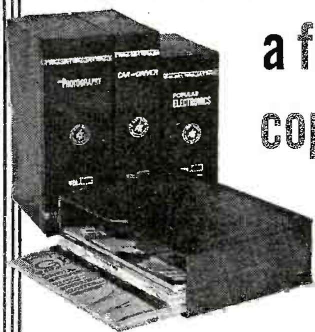

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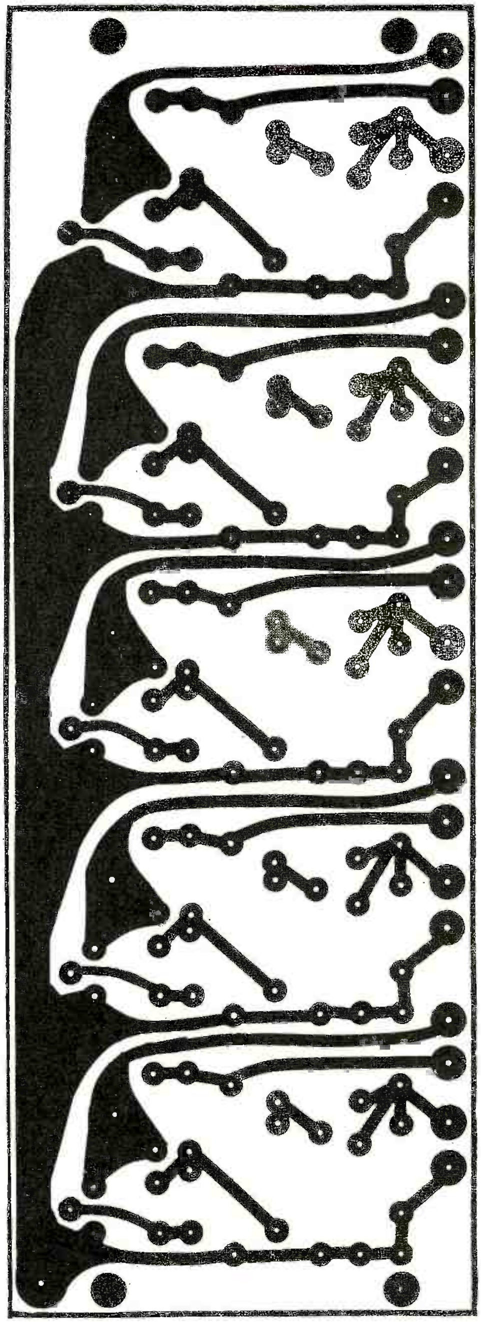

Fig. 11. Actual-size illustration of printed circuit board. For hole drill sizes, refer to Fig. 4.

Regardless of your final arrangement, we believe you will have the best color organ available, in terms of sensitivity, power output, and performance. Enjoy it. —30—

LONG-TAILED PHASE INVERTER

(*Continued from page* 61)

extends at least 1¾″ from the top and bottom edges to cover the grille cloth. But be sure to complete your finishing work on the trim before you mount the speaker, so that dust particles will not get into the speaker.

Also, cover all interior surfaces of the speaker enclosure above panel *H* with a 1″-2″ layer of cotton or wool batting. Pack the tube behind *G* with loose kapok pillows. Then make a tightly packed pillow of wool batting and attach it to the inside of the cabinet, behind the speaker.

If you find it necessary to alter some of the dimensions given in order to accommodate a different speaker, or for effects, you can do so under controlled conditions; but in no case should the cross-sectional area of the tubes be made smaller. In fact, a subtle improvement may be achieved by adding about three inches to the depth of the enclosure and by making each tube about an inch deeper. For this modification, the port should be enlarged to 18½″ x 6″.

If you have carefully followed the instructions, and have installed a reasonably good low-frequency speaker, your *long-tailed phase inverter* will provide good listening. -30-

PUT AIR BRAKE ON WOOFER

(*Continued from page* 58)

wood screws. These screws are fed into the cabinet from the outside.

When installing the woofer, run the wires through one of the holes in the side panel. The opening in the front panel for the woofer is 8½″ in diameter; its center is 6¼″ in from the side and 6¼″ up from the bottom. Stretch and tack ½″-thick polyurethane foam plastic over all inside surfaces of the woofer compartment except the front. Wrap some cheesecloth around a strip of 1″-thick fiberglass (about 1′ wide and 3′ or 4′ long) and fold this strip of pad-

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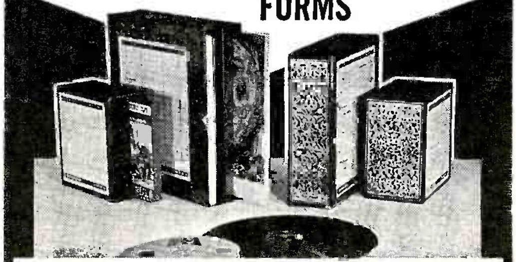

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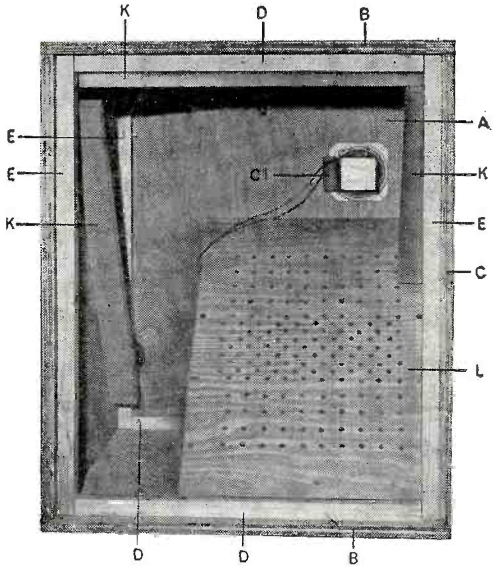

Location of tweeter is not critical. If you want to dispense with testing procedure, drill 80 ¼"-diameter holes (8 rows of 10) in woofer compartment.

ding loosely into the woofer compartment. You can then screw the sloping back panel into place.

Location of the tweeter can be any place on the upper part of the front panel. The amount of padding in the outer box is of minor importance. About a ½" layer of foam plastic on the side away from the cage and back will do. The tweeter control can be installed in any convenient location, preferably on the back panel.

You can finish and trim the outside of your enclosure to match the decor of your home. Note that the front panel is slightly recessed to accommodate the grille cloth and permit flush mounting of molding. Legs are optional. —30—

HEADPHONE CONTROL UNIT

(*Continued from page* 55)

equipped with a phasing switch which has two positions: "normal" and "reverse." If the speakers have been phased properly, the switch will be in the "normal" position.

It is simple to check the phasing of

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the headphone control unit. Place the "Mode" selector switch on your stereo amplifier in the monophonic position. Connect the control unit to the amplifier, and plug the earphones into the phone jack. The selector switch on the control unit should be in the "Speakers" position. Turn the stereo system on and adjust the speaker volume to your normal listening level, then flip the selector switch on the control to the "Phones" position and adjust the headphone volume to a comfortable level.

Now flip the phasing switch on the amplifier back and forth from the "Normal" to the "Reverse" position. The sound in the headphones will be "cleaner" and undistorted (and possibly slightly louder) in one of the positions. If this occurs when the phasing switch is in the "normal" position, no changes will have to be made within the control unit. If it occurs in the "reverse" position, then interchange the red and blue leads in the primary winding of *either T1* or *T2*. (Note: disregard the blue lead not connected.)

If your amplifier is not equipped with a speaker phasing switch, then simply alternate the red and blue leads on one of the transformers for best sound.

It is possible to operate another set of stereo headphones from the control. To do so, you add another 3-conductor phone jack to the unit. Connect the "common" lines together. Another dual 100-ohm potentiometer should be paralleled across *R1a* and *R1b* if individual control of the two headphones is desired; if not, simply parallel the new phone jack across the existing one. -30-

AQUARIUM HEATER

(*Continued from page* 31)

time since this can cause the heater to overheat and probably damage the glass tube.

Final Assembly. You are now ready to install the circuit in the plastic container. First, align the 1/4"-thick piece of plexiglass on the plastic cover as shown in Fig. 4. Measure out the loca-

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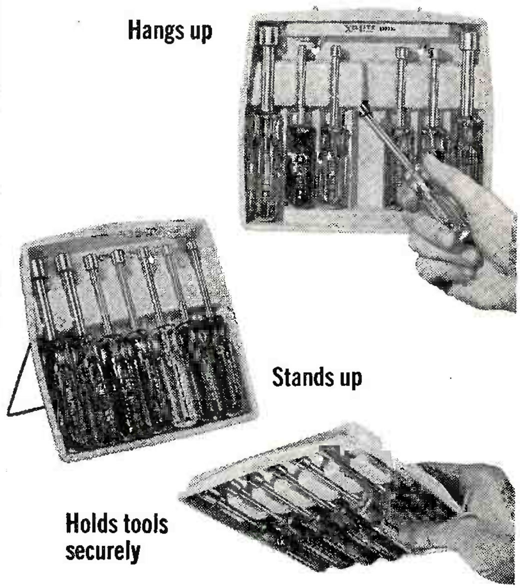

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tions for two mounting holes and then drill holes with a ⅛″ bit. Drill a third hole at the opposite end where the thermistor will be mounted.

To form the plexiglass, place the end with the two holes in a vise. Then heat the other end with a torch until it becomes soft enough to bend. Using heavy long-nose or gas pliers, bend the heated end into a hook with an opening large enough to fit over the fish tank wall.

When the plexiglass cools off, screw it onto the plastic cover using two spacers and 6-32 x 1″-long screws. Use flat washers over both sides of the cover to prevent it from tearing prematurely.

Now mount the remaining two standoffs on the circuit board using 6-32 x ¾″ screws and #6 nuts. Be sure to place a plastic cable clamp around the heater cable and another one around the line cord before securing the clamps in place between the circuit board and the standoffs as shown in Fig. 3.

Run the thermistor through the short piece of air hose, slip the glass case over it, and then secure the entire assembly on the plexiglass with the remaining clamp. The thermistor should be adjusted so that, when mounted on the fish tank, it sticks down as far in the water as possible, without water being allowed to seep through the top opening of the glass.

The entire installation must be watertight for water is a very good conductor of electricity, and unless every precaution is taken to separate this lethal combination, your entire project could wind up being a disaster.

Installation. If your circuit passes the "squeeze test," you are ready to install it in your aquarium. Just in case you haven't used one of these thermostats before, here are a couple of hints:

(1) Hang the thermostat on the outside of the fish tank, and allow the heater to rest at the bottom of the tank. Keep the thermistor well down in the water to avoid faulty operation that could cause the tank to overheat.

(2) Be sure to use a circulating pump. Even in a small tank, there may be temperature differences of five degrees or more between the top and bottom of the tank.

The heat required to maintain the

desired water temperature depends, essentially, on the difference between the water temperature and the room temperature. Since the SCR is a half-wave device, it supplies current to the heater for only half of the *on* cycle. Thus, a 75-watt heater consumes only about 37½ watts. If your heater never turns off (allow a couple of days for stabilization), you need more heat.

The easiest solution to this problem is to add another heater in parallel with the first. Another solution is to full-wave rectify the line voltage to provide power to the heater during the complete cycle of operation. A fully assembled bridge rectifier, such as the Motorola MDA-952-4, or equivalent, can be wired up as shown in Fig. 5, so that the SCR can conduct on both halves of the a.c. cycle.

Under normal operating conditions, your new thermostat should provide your tropical fish with true living comfort for years to come. Your reward is to sit back and let your little pets enjoy all the *transistorized* heat they need. —30—

DWELL METER ADAPTER

(*Continued from page* 32)

Zener diode *D1* is a 1N3016, or equivalent, rated at 6.8 volts at 1 watt. Diode *D2*, a 1N91, protects the circuit from a reverse connection to the battery. The other two components are: *R1*, a 290-ohm, ½-watt resistor; and *R2*, a 150,000-ohm potentiometer.

If your car has a positive ground ignition system, reverse the connections of leads *A* and *B* to the distributor and the battery. —30—

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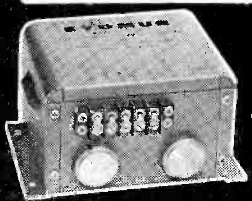

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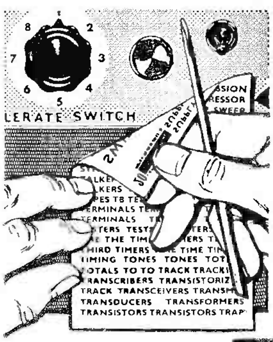

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TIME-SIGNAL RECEIVER

(*Continued from page* 24)

author found that indoor reception could be improved by placing the receiver's antenna close to a telephone or an electrical fixture.

If you find it hard to decide which "band" of frequencies is best suited to your location, you can monitor each frequency for a period of time with a communications receiver. The optimum frequencies and listening time can be determined quickly in this manner.

To change frequencies in the receiver, simply plug in the appropriate crystal, and tune *C2* and *C6*. Remember, you can cover *two* time-signal stations with the 10-μH coils, and *three* stations with the 5.6-μH coils. —30—

TIME SIGNAL BROADCASTS

CHU Reception of CHU on 7.335 MHz is possible along most of the eastern seaboard (north of South Carolina) at any time between 0400-1100 and 1400-0100 EST. On the frequency of 14.670 MHz, CHU is heard throughout the remainder of the eastern seaboard and as far west as Denver, Colo., from 0800 to 2100 CST. CHU on 14.670 MHz is also audible along the West Coast in the early evenings.

WWV Check the 10.0-MHz frequency if you live on either the East or West Coast. The signal from the new Colorado transmitters should be very strong. Try 15.0 MHz if you listen mostly during the day and you are over 600 miles away from Ft. Collins, Colo. Far West listeners may be able to pick up both WWV and WWVH, Maui, Hawaii. WWV now sends "GEOALERTS" at 18 and 48 minutes after each hour, broadcast in International Morse Code.

It will be necessary to choose the "listening" frequency best suited to your needs and to your geographical location. Reception 100% of the time, day and night, is not possible on one frequency only (unless, of course, you live close to the transmitters). Some frequencies are better at night, others during the day.

Complete information on the technical services provided by the NBS standard time stations can be found in "Standard Frequency and Time Services of the National Bureau of Standards, Miscellaneous Publication 236," which is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 15 cents. Complete technical information on CHU is contained in a leaflet entitled "Time Service Bulletin B-16," available from the Department of Mines and Technical Surveys, Dominion Observatory, Ottawa, Canada, at no charge.

MODBOX

(Continued from page 83)

ulation control up to a point where the meter reads 0.7 mA (100% modulation).

To check the *DISTORTION* indicator, whistle or shout into the microphone to intentionally overmodulate the carrier. The indicator should flicker; if it doesn't, and the meter shows more than 100% modulation, your rig's modulator may be splatter-suppressed, or have a very "bassy" response. To compensate for this condition, increase the value of *R4* in the distortion-indicating circuit until *I1* just flickers when the transmitter is intentionally overmodulated. Then plug a pair of 2000-ohm headphones into the *MONITOR* jack and listen to your audio as you speak into the transmitter's microphone. This is a good check because it tells you how you actually sound on the air.

Operating Hints. Once you've familiarized yourself with the Modbox's monitoring provisions, use them constantly on the air. Each time you work another station, keep an eye on the modulation meter and distortion indicator, doing your best to hold the modulation level as high as possible without overmodulating. Your logbook and compliments from other operators will let you know what the Modbox is doing for you.

One final word: if the Modbox says you don't have 100% modulation, believe it. Check your rig carefully before you suspect the monitoring circuit. Tubes become weak and parts do change value with age. Also, some rigs are definitely lacking in talk-power due to design skimping. The specs may say "fully-modulated," but they may be talking about a big, full 75-percent modulation capability. If your rig can't make it to the 100% mark, at least you can hold the level as high as possible by watching the meter and "riding the gain."

After you've used the Modbox for a while, listen around the band to all those other station operators who have no idea what their audio is like, and you'll agree that there's nothing like knowing for sure—with the Modbox. -30-

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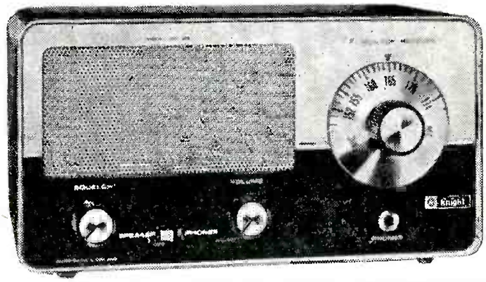

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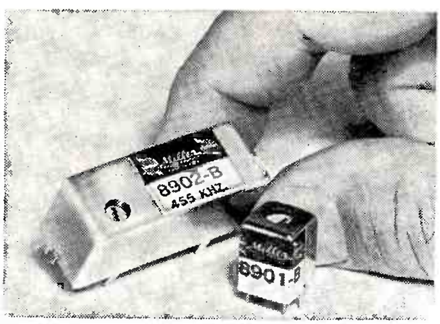

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REFLEXOMETER

(*Continued from page* 130)

power supply components are mounted on a subchassis or shelf built from a 2″ x 13″ piece of aluminum. Form a ½-inch flange on each end of the shelf. A 24-volt d.c. power supply and relay system is used to permit the selection of surplus and other easy-to-get four-pole, double-throw relays.

Assemble and wire the subchassis before mounting it inside the main chassis. To cut down costs, the relays can be held in place with sheet metal straps, and you can solder the connecting wires directly to the relay pins.

Mount the four pilot light assemblies, power switch, reset button, fuse holder, octal socket, and a handle on the main chassis. Use dome-type lens caps instead of jeweled lenses to be able to see the light better at wider angles. A low-cost way to mount the pilot lights is stick them through rubber grommets attached to the cover, and solder the appropriate wires directly to the center contact and base of the lamps. Paint each bulb a different color.

If you happen to have on hand four identical relays that require a different working voltage, such as 6 or 12 volts, you can use them, but be sure the power supply and lamps are rated accordingly.

Responders. Prepare four 4″-long, 1″-diameter wood dowels by drilling a ⅝″ hole lengthwise about halfway, then a ¼″ hole for the remainder of the way through each of them. Paint each dowel an identifying color to correspond to each of the different colored lamps. Pass one end of a 4′ length of lamp cord through the ¼″ hole and tie a knot in it about 3″ from the end to serve as a strain relief. Then connect the leads on this end of the lamp cord to the screws on the switch and force-fit the button assembly into place. The responders can be connected to the relays directly, or to an octal plug (*PL1*) as shown.

Cover the bottom of the chassis, add four rubber feet to the cover, and invite your friends over. –30–

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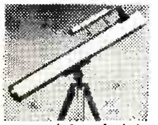

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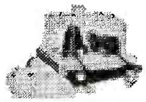

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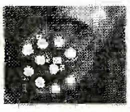

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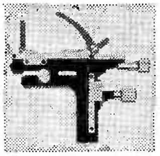

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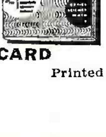

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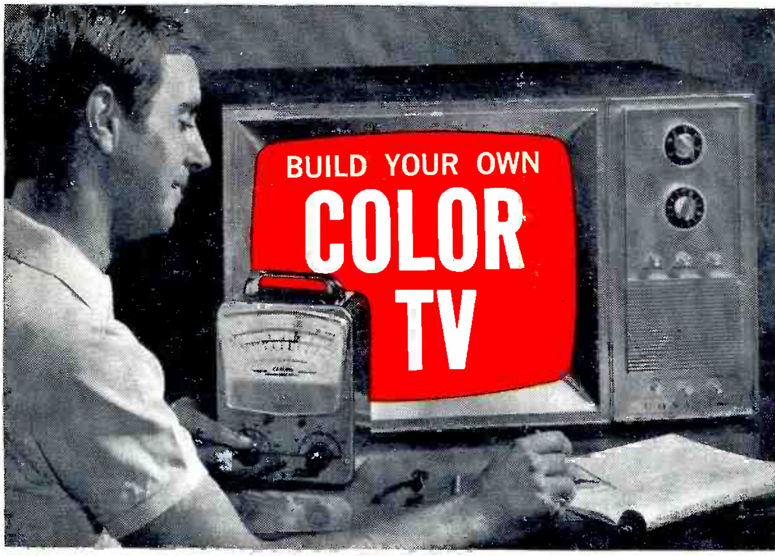

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