1966

POPULAR ELECTRONICS

ELECTRONIC EXPERIMENTER'S HANDBOOK

SPRING EDITION

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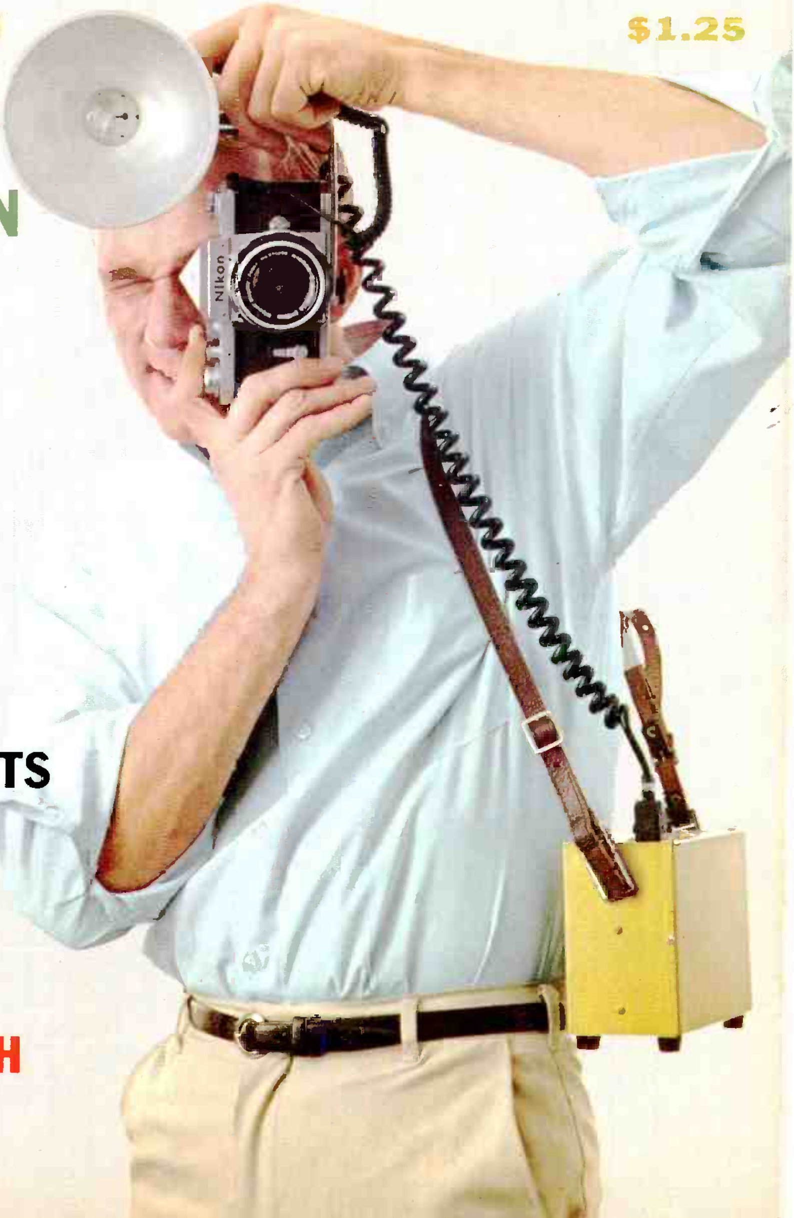

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If you have read the past 10 issues of the ELECTRONIC EXPERIMENTER'S HANDBOOK, you will be aware of two significant things. First, the phenomenal interest in electronics continues unabated and two editions of the HANDBOOK are being published each year. Secondly, at the request of our avid readers, this edition has been devoted solely to construction projects—34 of them. Each project has been carefully checked by the author, and in most instances the project itself tested by the staff of the HANDBOOK. At a rate of 3½ cents per project, this Spring Edition is one of the best bargains you can find in electronics magazines or handbooks.

Due to the season of the year, our Science Fair chapter has been replaced in this edition by a chapter on Radio Control. Several Science Fair projects are now scheduled for the Fall Edition that will go on sale in October 1966.

The cover of this edition features a universally powered electronic flash. This flash has been designed to incorporate as many safety features as possible. The circuit is straightforward, and it is expected that many readers will study this flash to gain some idea of how electronic flash guns operate. Your Editors were impressed by the performance of this flash and believe that nothing like it has ever appeared in print before.

—THE EDITORS

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CHAPTER

1

USEFUL HOUSEHOLD PROJECTS

In this Spring 1966 Edition of the ELECTRONIC EXPERIMENTER'S HANDBOOK, a 3-part emphasis has been placed on "Household" projects. Two of the projects are strictly photographic—including one of the few published stories on the home construction of an electronic flash. This particular story was especially prepared for the Spring '66 EEH, and nothing like it has appeared in print before. The second photographic story concerns a very capable strobe or electronic flash slave unit.

Automotive electronics takes up a sizable share of this chapter with projects like the POPULAR ELECTRONICS capacitive discharge ignition system (page 19); a simple dwell meter (page 36); a novel engine idle calibrator (page 39); and a 12-volt d.c.-operated fluorescent lamp (page 16).

There are a number of distinctive home projects, and your family will be impressed by the electronic "versatility" of the "Lighting Controller" (page 41) or the "Dymwatt" (page 50). Just for fun and games, investigate the "Coin Tosser" (page 46). Last, but not least, is the "Fence Charger," a project frequently requested by the thousands of EEH readers.

BUILD

By **CHARLES CARINGELLA**

THE electronic flash, or speedlight, is a basic necessity for the serious-minded amateur and professional photographer. If you have an interest in photography —as well as electronics—you will find this construction project of considerable interest.

Very few build-it-yourself articles on electronic flash units have appeared in print. There have been two reasons for this absence of construction projects: (1) the performance of a unit was not commensurate with the building cost, and (2) the unit was unsafe. The project described below easily overpowers both of these objections. Its performance is equal to that of professional speedlights costing more money; and if the builder carefully follows the construction and wiring instructions, this unit is as safe as any flash now sold in a photography store.

How the Circuit Works. The schematic diagram of the shoulder pack is shown in Fig. 1. Basically, the circuit consists of an a.c./d.c. power supply that charges a photoflash storage capacitor.

A special feature of the main power transformer, *T2*, is dual primary windings: one for a.c. and the other for d.c. operation. The a.c. winding is connected to the 117-volt a.c. line when power

ELECTRONIC FLASH

Universally powered photoflash can be constructed from these carefully engineered detailed plans

switch *S1* is in the "AG" position. A second transformer, *T1*, operates in conjunction with the center-tapped winding of *T2*, as part of a simple d.c.-to-d.c. converter. Transistors *Q1* and *Q2* serve as the converter's switching transistors. while *T1* provides the necessary feedback for oscillator action. A 6-volt battery, *B1*, powers the d.c.-d.c. converter section and is switched into the circuit when switch *S1* is in the "DC" position.

High-voltage a.c. appears across the secondary of *T2* when *S1* is in either the "AC" or "DC" position. Neon glow lamp *I1* indicates the presence of high voltage across the secondary. This lamp serves a dual purpose. It not only indicates the presence of high voltage, but it indirectly indicates the condition of battery *B1*. The lamp glow diminishes as the batteries get weaker.

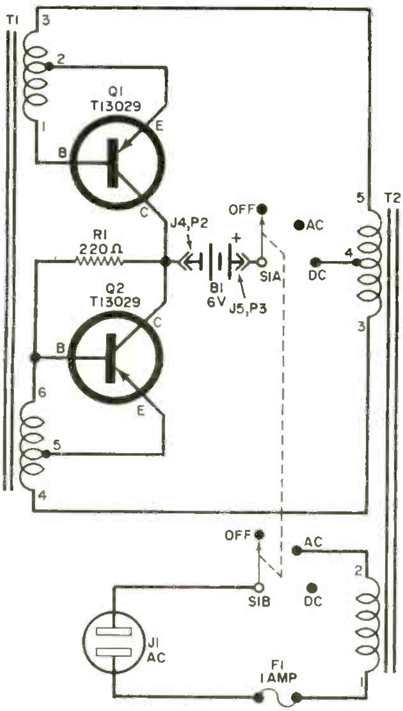


Fig. 1. The shoulder pack is the power supply for the electronic flash. A transistorized d.c. to d.c. converter boosts the battery voltage to the value necessary to charge flash capacitor C2. On house current the pack operates like a simple voltage doubler circuit.

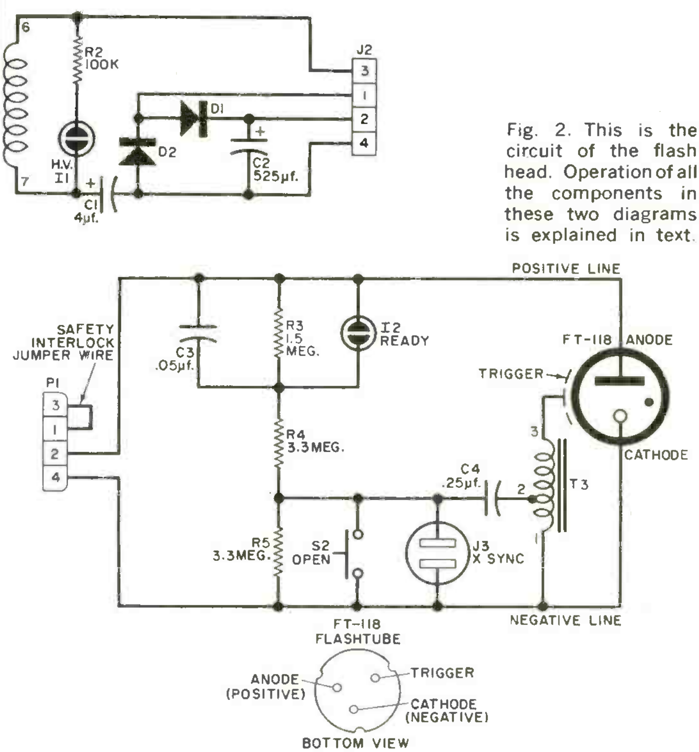


Fig. 2. This is the circuit of the flash head. Operation of all the components in these two diagrams is explained in text.

The secondary output voltage of *T2* is about 200 volts a.c. Diodes *D1* and *D2*, along with capacitors *C1* and *C2*, form a voltage doubler network, which rectifies and doubles the secondary output voltage. Photoflash capacitor *C2* charges to almost 450 volts d.c. The energy stored in *C2* is used to flash the flash-tube.

One of the connections from the secondary of *T2* (pin 6) is routed through the power jack, *J2*, and back to the input of the voltage doubler network. A jumper wire, located between pins 1 and 3 of *P1*, completes the circuit when *P1* is plugged into *J2*. This arrangement serves as a safety interlock to keep *C2* from being charged when *P1* is disconnected.

A schematic diagram of the flash head is given in Fig. 2. When *C2* is charged, the full d.c. voltage appears across the flashtube. The flashtube, however, is designed not to flash (due to its "hold-off" voltage rating) until a high-voltage pulse is applied to the trigger electrode.

The high-voltage pulse is derived from *C4* and *T3*. Capacitor *C4* is charged through the divider network consisting of *R3*, *R4*, and *R5*. One side of *C4* is also connected to the camera shutter contacts via *J3*. When the shutter contacts close, *C4* is discharged and the pulse is stepped up by *T3* to a peak value of approximately 6000 volts.

The 6000-volt pulse is applied to the trigger electrode of the flashtube. Once the pulse is applied, the gas within the flashtube is immediately ionized, making it highly conductive. The photoflash capacitor, *C2*, then discharges all of its energy into the flashtube, causing the brilliant flash of light.

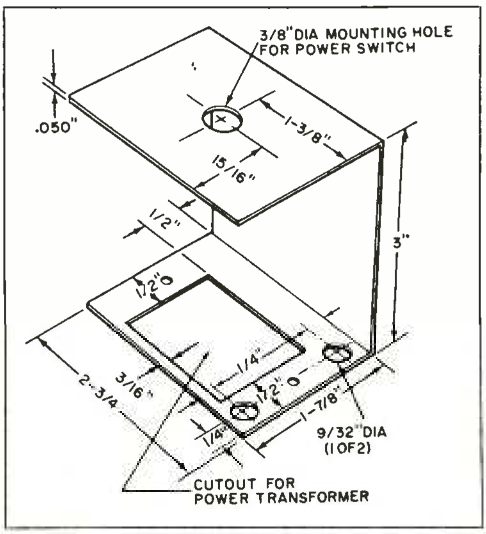


Fig. 3. Only a part of the necessary metal work is shown in this drawing of the power supply sub-chassis. Read the text on the facing page for details.

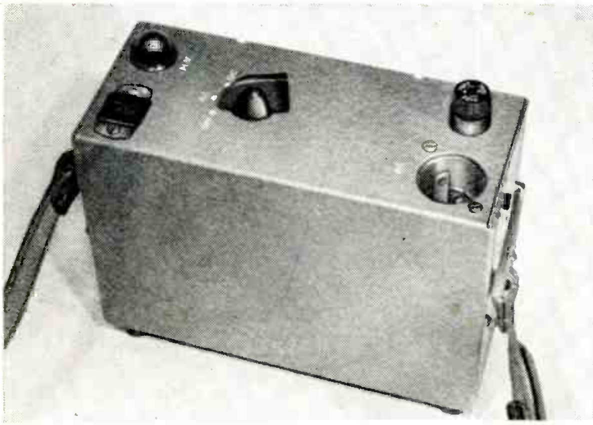
PARTS LIST

B1—Four D-size batteries—see text
C1—4-µf., 450-volt electrolytic capacitor
*C2—525µf. 450-volt electrolytic capacitor (Cornell-Dubilier FWSN-10001 or Aerovox FF-2)**
C3—0.05-µf. 400-volt paper capacitor
C4—0.25-µf. 400-volt capacitor
*D1, D2—1N547 rectifier**
F1—1-ampere fuse, type 3AG
I1, I2—NE-51 neon lamp
J1—Chassis-mounting a.c. male receptacle, with recessed shell (Amphenol 61-M10 or equivalent)
J2—Four-contact, chassis-mounting socket (Cinch-Jones S-304 or equivalent)
J3—Rectangular chassis-mounting a.c. female socket (Cinch-Jones SR2 or equivalent)
J4, J5—Tip jack (one red, one black)
P1—Four-contact plug with cable clamp (Cinch-Jones P-304 or equivalent)
P2, P3—Phone tip plug
*Q1, Q2—Germanium power transistor (Texas Instruments TI3029 or equivalent)**
R1—220-ohm, 1-watt resistor
R2—100,000-ohm, ½-watt resistor
R3—1.5-megohm, ½-watt resistor
R4, R5—3.3-megohm, ½-watt resistor
S1—Double-pole, 3-position, single-section miniature phenolic rotary switch (Centralab PA-1003 or equivalent)
S2—Miniature normally-open push-button switch (Grahill 23-1 or equivalent)
*T1—Inverter transformer (UTC PF-6)***
*T2—AC/DC photoflash power transformer (UTC PF-5)***
*T3—Trigger transformer (UTC PF-7)***
*1—General Electric FT-118 flashtube (available from photo stores)**
*1—Reflector, type 165-P-157 (Weber Brass Co., 3344 Payne Ave., Cleveland, Ohio, $4 postpaid)**
1—2¾" x 2⅛" x 2⅝" aluminum chassis box (LMB 100 or equivalent)
1—7" x 5" x 3" aluminum chassis box (LMB 145, or equivalent)
2—Dual battery holders for D cells (Keystone 176 or equivalent)
*2—Transistor mounting kits (Motorola MK-15, or equivalent)**
1—Fuse holder (Buss HKP, or equivalent)
1—Pilot light holder for NE-51 lamp
1—Coiled cable, three-conductor, with one conductor not used, extends from 10" to 4½' (Belden 8495 or equivalent)
1—6" x 2¾" strip of 0.050"-thick aluminum
Misc.—Rubber feet (4), ⅜" grommets (2), solder, screws, etc.

**A kit of parts containing these components is available from Caringella Electronics, Box 327, Upland, Calif. 91786, for $26 ($6 below cost of parts if purchased separately). Shipping weight, 3 lb. California residents must add 4% sales tax. The reflector collar may be purchased separately for $2.00.*

***These transformers, if not available locally, can be obtained from Harvey Radio, 103 West 43 St., New York, N.Y. 10036, for approximately $17.25, plus shipping cost.*

The "Ready" light is neon glow lamp *I2*. The "Ready" light blinks on and off when the photoflash capacitor has sufficient charge to flash the flashtube. This value can be anywhere from 400 to 450 volts d.c. A simple relaxation oscillator circuit (*C3* and *R3*) causes *I2* to blink at a rate proportional to the charge on *C2*. The greater the voltage, the faster the rate.



In this top view of the electronic flash shoulder pack, note the location of the jacks, pilot light, fuse holder and switch S1. Compare this photo with the drawing below to orient component location.

Switch *S2* is in parallel with the shutter contacts. It can be used to "open" or "flash" the circuit. You can test the flash with it at any time without operating the camera shutter.

Construction. Before beginning construction, round up all the needed components. You can save more than $6 by ordering a kit of parts rather than buying some of the parts separately. The kit consists of photoflash capacitor *C2*, diodes *D1* and *D2*, transistors *Q1* and *Q2*—plus their mounting kits, the FT-118 flashtube, plus reflector and collar.

Begin construction of the electronic flash with the power supply subchassis. This subassembly chassis is partially detailed in Fig. 3. Besides the holes shown in this drawing, holes must be drilled in the 2¾" x 3" face to mount the transistors and their sockets. Because of differences in size of switches, hardware, and other components, the holes for mounting *Q1* and *Q2* have not been drawn. However, once you have all the

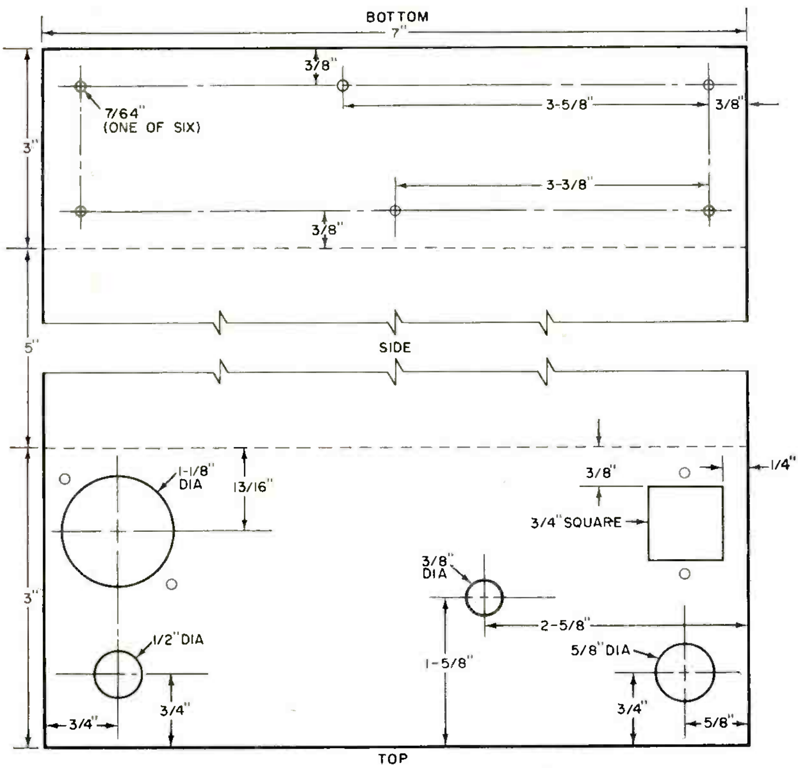


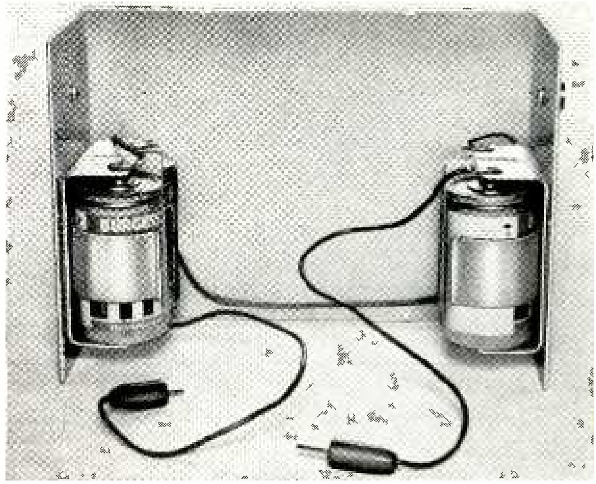
Fig. 4. The power supply or shoulder pack was built in a LMB box—a type commonly available in the west, but somewhat rare on the east coast. The dimensions for metal working shown here are predicated on the use of the LMB 145 box. If it is unattainable, the builder should pick out the closest substitute and adjust the metal working measurements accordingly.

subassembly components and before you do any drilling, lay out the parts, scribe the chassis, and use a center-punch. Work carefully and neatly. The unit was purposely made to be compact.

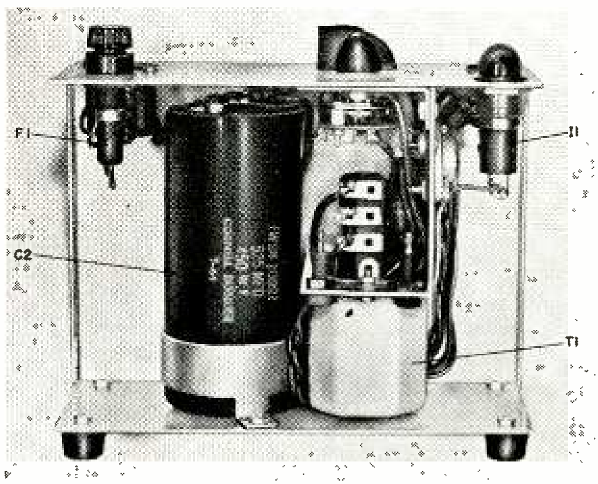
Particular care is necessary in drilling the holes for *Q1* and *Q2* to be sure that clearance for the base and emitter pins and hold-down screws is on at least a 1/8" radius. When mounting the transistors, use a mica insulator, and if silicon grease is available, coat both sides of the insulator to obtain better heat transfer.

After mounting the transistor sockets, push the shaft of *S1* through a lock washer, then the hole in the subchassis, and temporarily mount it in place with a nut. Solder diodes *D1* and *D2* to a 3-terminal tie strip, then mount the strip in between *P2* and *P3* as shown in the photos. One of the bolts holding *T2* also holds the terminal strip. If you cannot find a 3-terminal strip that mounts vertically, you can fabricate one from a 3- or 4-terminal strip by cutting off one mounting leg and rotating the other leg to the position shown.

Then wire in *S1*, *T1*, *T2*, *R1*, *C1*, *Q1*, *Q2*, *J4*, and *J5*. Solder two 10" lengths of black insulated wires, one to terminal 1 of *T2* and the other to the long contact on switch *S1b*. Let these leads



These two photos show how the power supply or shoulder pack is mated. In the photo above, the D cells—mounted in battery clips—are bolted to the two end plates of the shoulder pack wraparound. The batteries are wired in series and, for convenience, the positive and negative leads end in color-coded insulated tip plugs. The power supply subchassis and capacitor C2 must be positioned so that the batteries will slip into the small space available.



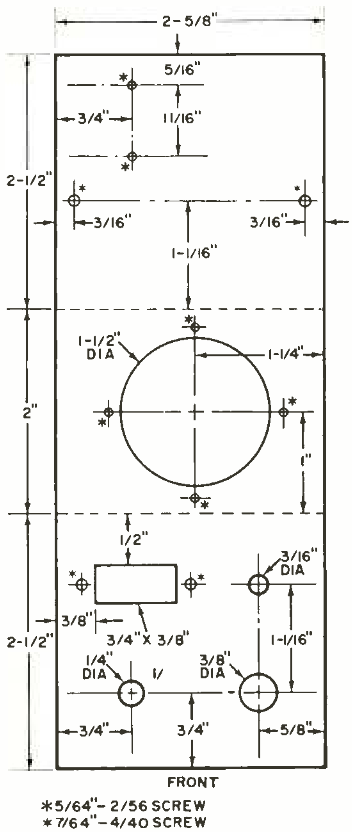


Fig. 5. Although the components in the flash head are not cramped, the builder should follow this metal working drawing as closely as possible.

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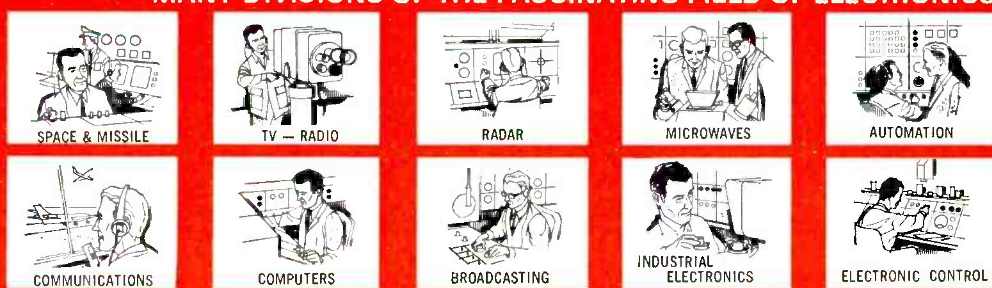

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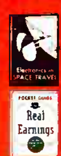

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dangle free; they will be connected later. Now set the subchassis aside and go to work on the main chassis.

Use Fig. 4 as a guide to cut out and drill the main chassis, but check the actual component fit before you do any sheet metal work. Mount *J1*, *F1*, *I1*, *J2*, and *C2*.

Before mounting *C2*, attach two 11″ lengths of good insulated wire to its terminals. To avoid damage, observe polarity; make the positive wire red, and the negative wire black. Run these two wires around the subassembly to *J2*. Be sure that the wires and the capacitor terminals do not short to the chassis or any other components or hardware. For safety's sake, tuck these wires between the chassis and *C2* and *T2*. (*Caution: Do not touch C2's terminals or its leads, even with the power disconnected, unless you are absolutely certain there is no voltage present. The only way you can be sure is to place a jumper across C2's terminals.*)

Secure the subassembly to the main chassis by first removing the nut that holds *S1* in place, pass *S1*'s shaft through the opening in the chassis, position the subassembly as shown in the photographs, and replace the nut. A 3/8″ flat washer placed under the nut protects the chassis against wrench marks and adds to the professional look.

Solder the 10″ black lead from terminal 1 on *T2* to *F1* and the other 10″ black lead to *J1*. Now add a wire between the remaining terminals of *F1* and *J1* to complete the 117-volt a.c. input circuit. The rest of the wiring is straightforward—just make certain that you observe polarity of the capacitors, diodes and the batteries, and that all connections are soldered and well insulated.

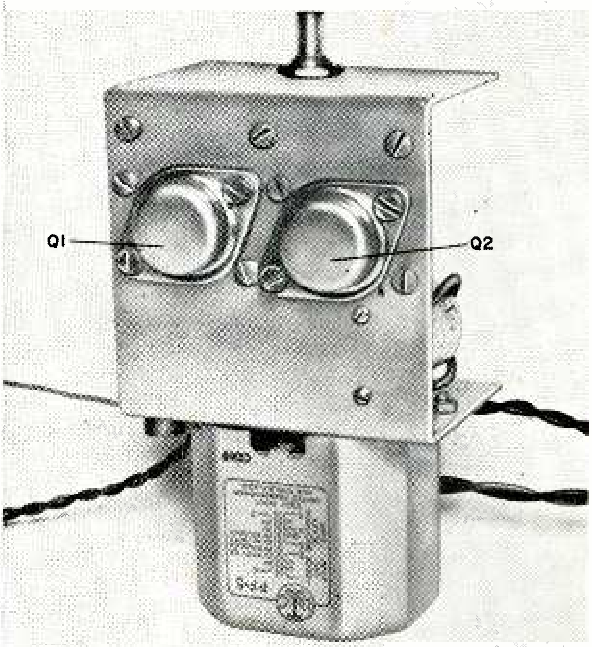
The four D cell batteries are retained in holders bolted to the sides of the chassis cover. Here again, you should gauge the location of the battery holders to be sure they clear the components on the chassis when the cover is screwed into place. Wire the holders so that all the batteries are in series. Solder 10″ lengths of red and black hookup wire to the positive and negative battery output treminals respectively. Connect appropriate colored tip plugs (*P3* and *P2*) to the other end of these leads.

The Flash Head. Figure 5 details the metal work necessary to assemble the flash head. The dimensions shown are reasonably critical—especially if you intend to make a carbon copy of the unit shown here.

Resistors *R3*, *R4*, and *R5*, and capacitor *C3* are mounted on a Cinch-Jones 2006 terminal strip before the strip is installed. Looking at the strip from the top down (in the photograph of the flash head), mount *C3* and *R3* between terminals 1 and 3; *R4* between terminals 3 and 4; and *R5* between terminals 4 and 6. Clip off terminal 5 for the extra room needed to slip the lead from the photoflash trigger pin to terminal 3 of *T3*.

There is no socket for *I2*, just short flexible leads soldered to the base of the bulb and to terminals 1 and 3 of the tie point strip. The location and wiring of the other components (Fig. 2) is obvious once the terminal strip has been installed. The flashtube and its wafer base is fitted into the neck of the reflector and crimped into place.

Mounting the reflector to the box can be accomplished in two ways: it can be attached with three or four small right-



Completed power supply subchassis should look like this. Holes to mount the transistors and transformer T1 are not detailed in Fig. 3 but are shown here.

angle brackets, or with a retaining collar similar to that shown in Fig. 6. This collar can be machined from plastic or aluminum, and fastened to the small box with four *4-40* x ¼″ machine screws. The neck of the reflector is inserted into the collar and protrudes about ¼″ into the box. A setscrew on the collar holds the reflector in place.

Connections are made to the flashtube by soldering directly to its pins. Avoid excessive use of solder flux to prevent high-voltage leakage paths. The lead from the trigger electrode to *T3* must be short and very well insulated (it carries more than 6000 volts). The coiled cable with *P1* connected to it is routed through a grommet in the box. (Use a restraining clamp to prevent the cable from slipping out of the box.)

Operating Information. The "Ready" light (*I2*) will start blinking when the charge on *C2* has reached about 425 volts. If the batteries are fresh and the power supply is running, *C2* will continue to charge to about 450 volts. This charge can be held by *C2* for 10-15 minutes, and during this period the photographer should have the power supply switched off. This is a good habit to learn as it will add many flashes to the life of your D cells. Of course, if recycling is important, leave the power supply running.

The blinking rate of the "Ready" light is determined by the charge on *C2*. At maximum charge, the blinking rate should be about 30-40 flashes per second. As the voltage on *C2* drops, the blinking rate will also drop until it reaches 4-6 flashes per second. Don't shoot when the blinking rate is less than 4 flashes.

The choice of the kind of D cell determines the recycling time in the d.c. mode of operation. The author evaluated three types of D cells and arrived at the following conclusions.

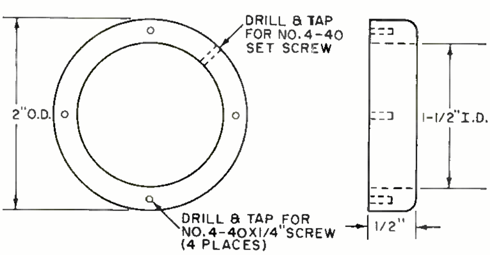
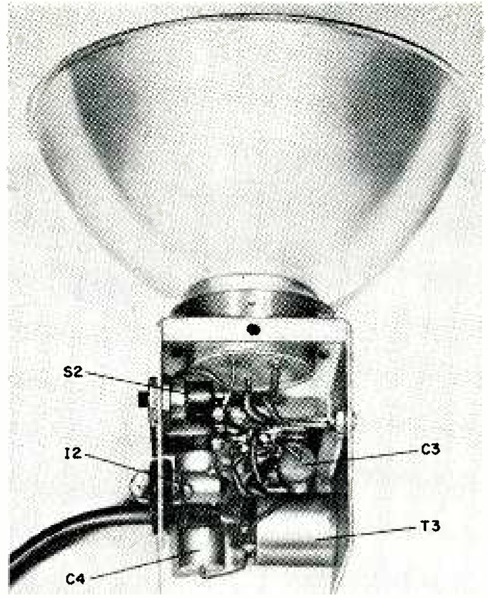


Fig. 6. This is the collar made to hold the flash reflector to the flash head box. The author has available a collar machined of aluminum for $2.00.



Inside view of flash head shows location of some components. Connections to the flash tube are all soldered in place. Insulation of the lead to the trigger lead is important—it carries 6000 volts!

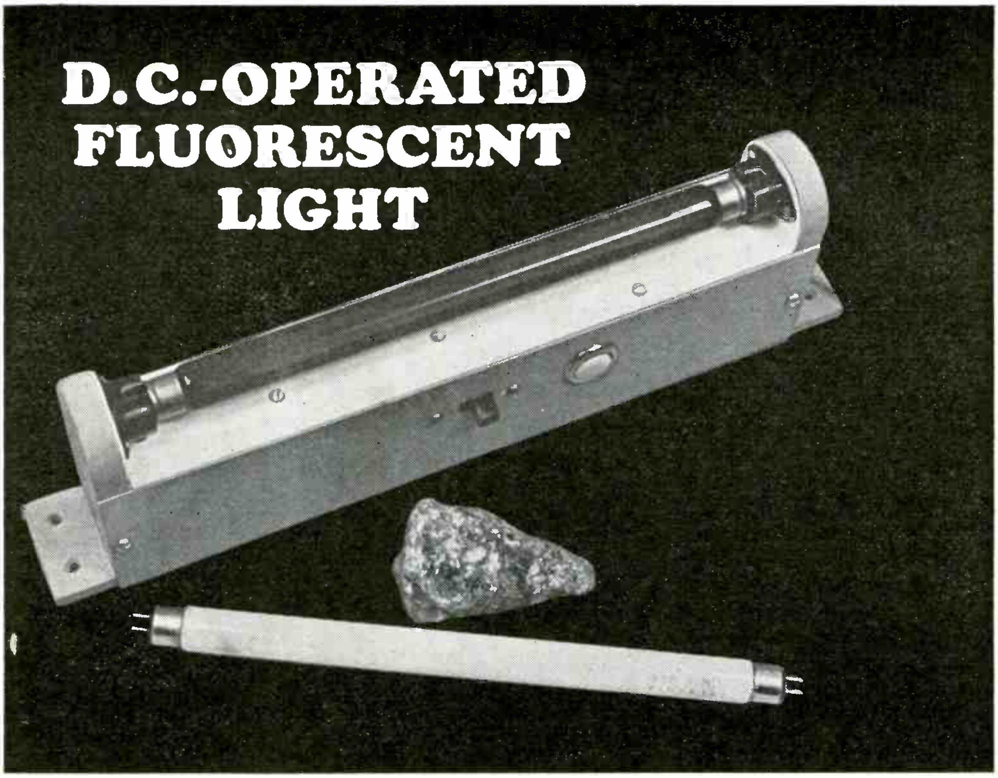
Ordinary D cells: Average 40 flashes before becoming useless. Average recycling time was 40 seconds with fresh batteries and 60-70 seconds near the end of battery life.

Alkaline D cells: Tested were the Eveready E95 and Burgess AL-2. Average of 60 flashes and a recycling time of 12 seconds with fresh batteries and 20 seconds near the end of useful battery life.

Nickel-Cadmium D cells: Tested were the Eveready N57 and Burgess CD10. These excellent batteries recycle in 5-7 seconds until discharged. The user should expect to get at least 300 flashes per battery charge (not per set of batteries).

It is possible to recharge regular and alkaline D cells to extend useful life before it's necessary to throw them away. The nickel-cadmium battery is quite expensive, but this is all in initial cost since under average conditions you can recharge these batteries over 100 times. One set of nickel-cadmium batteries should last for many years.

(*Continued on page* 134)



D.C.-OPERATED FLUORESCENT LIGHT

By BEN RICHARDS

Portable emergency light doubles as luminescence detector

MADE TO ORDER for wherever a portable light is needed, this battery-operated fluorescent light will find favor with sportsmen, hobbyists, and rock collectors alike. The light works off a 12-volt battery and uses a 6-watt tube. By substituting a "black light" for the white tube, rock hunters can use it to locate mineral specimens.

Since the light can be used in many different ways, construction should be tailored to satisfy your needs. For instance, those rock hunters may find it desirable to enclose the unit in a light-tight box with a tray and viewing hood to permit daylight sorting of rocks. Motorists will find it advantageous to use a cigarette lighter type of plug to obtain a quick power connection in the event of an emergency. Sportsmen and campers may want to add a watertight battery compartment to the unit to hold a lantern-type battery.

How It Works. Operating fluorescent lamps from d.c. usually presents a problem: the supply voltage must be higher than the "striking" voltage of the lamp and power is wasted in the resistive ballast which must be used to limit lamp current. Not so if an efficient transistorized inverter steps up low voltage d.c. to high voltage and high frequency a.c. —a simple series capacitor can then serve as a reactance-type current limiter. The circuit used here produces more than half again as much light output as an incandescent bulb drawing the same battery power, a feature which campers and boaters who are concerned with conserving their batteries will appreciate.

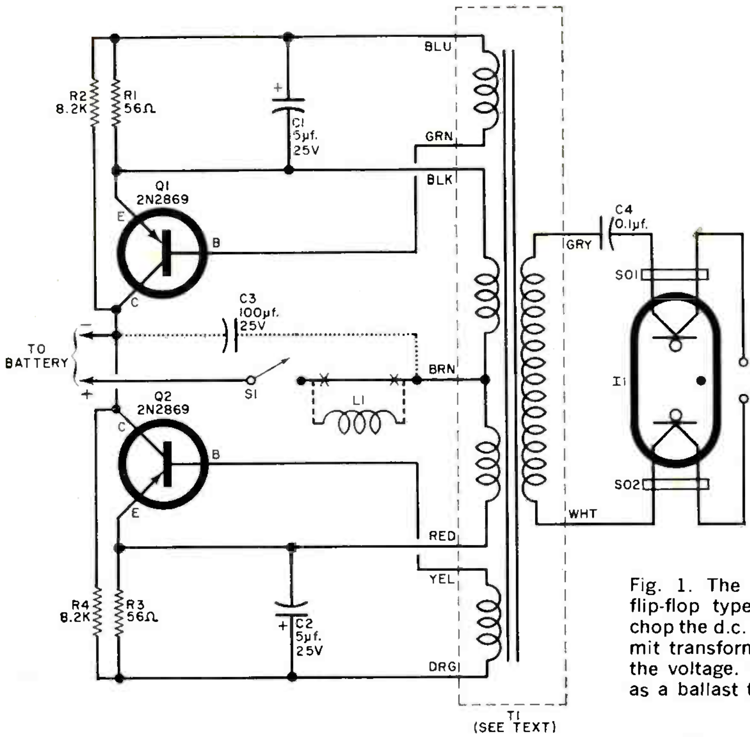


Fig. 1. The two transistors in a flip-flop type of oscillator circuit chop the d.c. battery voltage to permit transformer action to step up the voltage. Capacitor C4 is used as a ballast to limit lamp current.

The circuit, shown in Fig. 1, incorporates two transistors and a saturable core transformer with feedback windings to produce an audio oscillation at a frequency determined primarily by the transformer. The a.c. output voltage is connected to the fluorescent lamp (*I1*) through capacitor *C4*, which serves to limit load current.

The type of lamp employed has filaments at both ends of the tube to "preheat" the gas in order to facilitate lamp ignition. Note that the function of *S2* is to allow current to flow through both filaments as long as it is closed. The hot filaments heat and ionize the gas in the lamp, so that current can flow through the gas from one end of the lamp to the other. The hotter the gas, the more current that can flow; the more current that flows, the hotter the gas becomes. The external current limiter prevents "runaway" and destruction of the lamp and other circuit components.

Capacitor *C3* and coil *L1* are optional and are used to cut down radio interference. If you do not use *C3* and *L1*, connect the switch directly to the brown lead on *T1*. Do not connect the brown lead to the negative side of the battery. A 2- or 3-ampere fuse can be placed in series with the switch. However, the fuse may not act fast enough to protect the transistors if you apply too much voltage or fail to observe polarity.

PARTS LIST

C1, C2—5-μf., 25-volt capacitor
C3—100-μf., 25-volt electrolytic capacitor—optional
C4—0.1-μf., 10%, 600-volt tubular capacitor (Sprague 6PS-P10 or equivalent)
I1—6-watt fluorescent lamp (Sylvania F6T5/CW cool white or F6T5/BL black light, or equivalent)
L1—45 turns of #15 enameled wire, two layers wound evenly on ¾"-O.D. dowel—optional
Q1, Q2—2N2869 transistor
R1, R3—56-ohm, ½-watt resistor
R2, R4—8200-ohm, ½-watt resistor
S1—S.p.s.t. switch
S2—Momentary-contact, push-to-close switch
SO1, SO2—Miniature two-pin fluorescent lamp socket (GE 95X276 or equivalent)
T1—Type EC-0104-IP saturable transformer (available from Milwaukee Electromagnetics, P. O. Box 4476, Milwaukee, Wis. 53207, for $5.60 postpaid)
Misc.—Wood parts, aluminum, celluloid shield

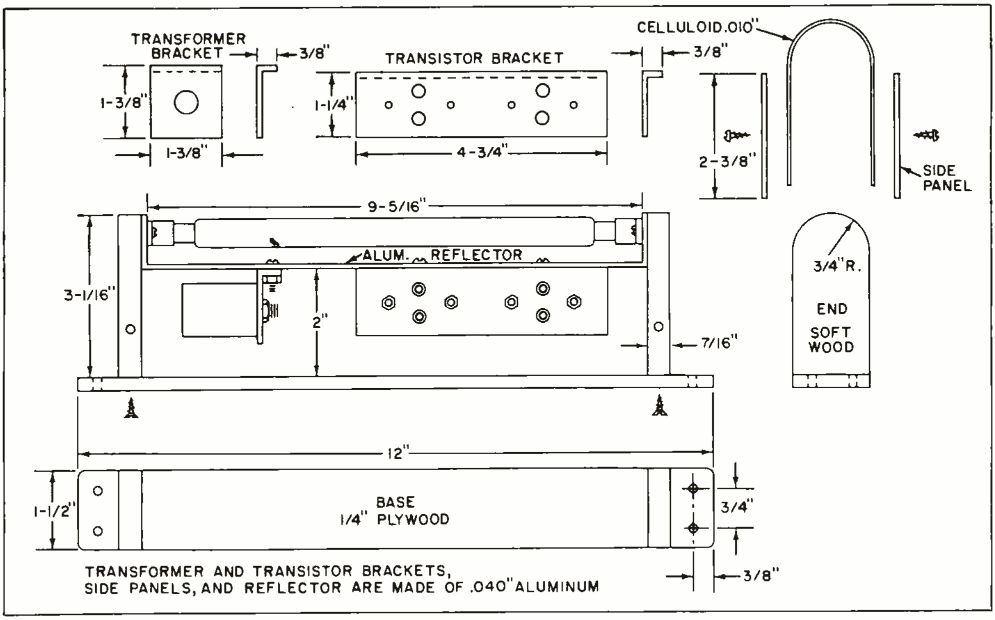


Fig. 2. Celluloid shield forms a window and insulates the side panels from the aluminum chassis. The unit can be fastened to a container built to hold two 6-volt lantern-type batteries connected in series.

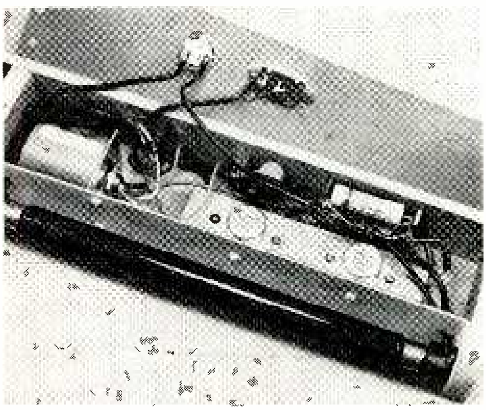


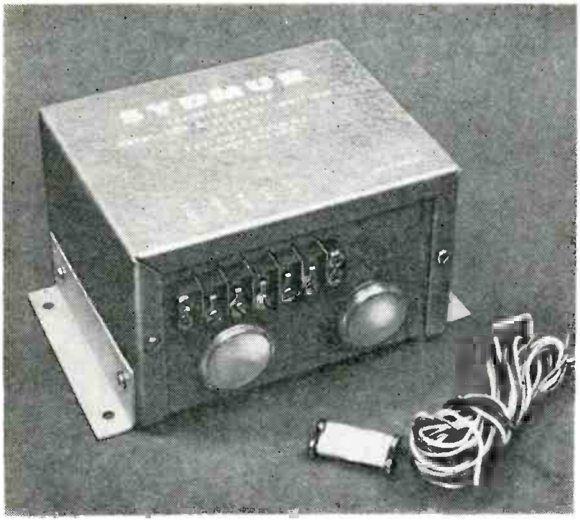
Fig. 3. Layout is not critical, but space transistors as far apart as possible to dissipate the heat.

Construction. Assemble the base, ends, aluminum reflector, and sockets as shown in Fig. 2. Note that the same screws hold the lamp sockets and reflector to the soft wood ends. The transistors are mounted on an aluminum bracket which in turn is mounted on the reflector. The transformer is mounted on another bracket and attached to the reflector in the same manner. The on-off switch and starter button can be installed on either aluminum side panel. Most of the components are connected between terminal strips mounted on the wood base.

Connections to the two transistors can be made by soldering directly to the pins. Care must be exercised not to damage the transistors with excessive heat; use a pair of long-nose pliers as a heat sink when soldering. Transistor layout is not critical, but they should be spaced as far apart as possible to allow for dissipation of heat when in operation.

If the small amount of audible noise from the unit is disturbing, pack some foam rubber, styrofoam, or other acoustic absorbent material around the transformer. When installing the celluloid (or plastic) shield, be sure it insulates the aluminum side panels from the reflector in order to isolate and completely enclose the electrical circuit.

Testing and Use. If you are sure of your wiring and supply voltage polarity, turn the unit on and depress the starter button for a few seconds. The lamp should operate with normal brilliance if battery voltage is about 12 volts. Current drawn should be around 0.9 ampere. The circuit should work on 9 to 15 volts with lamp brightness corresponding to voltage; higher voltage levels tend to shorten lamp life. –30–



TRANSISTORIZED CAPACITOR DISCHARGE IGNITION SYSTEM

By MURRAY GELLMAN

Put more spark into your gasoline engine to enhance performance

INCREASED gas mileage, quicker starting even in cold weather, longer life for breaker points and spark plugs, more power at high speed, and less ignition interference on ham and CB rigs are claimed for the transistorized Capacitor Discharge Ignition System. A one-two punch has been delivered to conventional ignition systems, and it's beginning to look as though they will be replaced by electronic systems in the very near future.

The first blow was struck with the introduction of the transistor system. The transistor system relieves the breaker points from having to carry all the current in the ignition coil's primary circuit, but still depends upon a large magnetic field around the ignition coil. The size of the field, among other things, depends upon the amount of time available between sparks. This time is shorter at higher engine speeds and it is quite normal for the high voltage to fall off at the higher speeds.

Until the transistor was put to work, a practical limit on the amount of current that could flow through the primary circuit to build up the magnetic field was determined by the size of breaker points. In order for the points to handle more current, larger points are needed, but there is a practical limit to point size. The transistor ignition system eliminates the points as a stumbling block so far as current is concerned, although breaker points still have to be in good condition and properly timed.

More than enough current is now available to the coil. But the regular coil wasn't designed to take much more current, so a new coil became desirable, one with a higher turns ratio, that is, one that would take all the current from the transistor in the amount of time between sparks. The drawback now is that the same high current is drawn at slow speeds and while starting. The battery has all it can do to satisfy the starter motor and chances are when you need it most, like on a cold winter morning, you'll be looking for a battery booster.

Several things have been done to overcome this effect: use of ballast resistor jumpers when starting, relays to connect the battery more directly to the coil, etc. But even before the designers had a chance to fully eliminate the bugs in the original transistor ignition system, the second blow was struck. Another system was brought out for public consideration and use: the transistorized capacitor discharge ignition system which uses the original ignition coil and associated equipment. It draws very little current, and makes cold-weather starting much easier.

The capacitor discharge system, by no means a newcomer, was originally a thyratron operated device; it now takes on a completely new look and promises to become the new standard in a very short time. This transistorized capacitor discharge ignition system has a transistor power supply and a capacitor to fire the ignition coil. As there is never any d.c. on the ignition coil, the coil works more effectively, and remains much cooler in the system. A negative-ground, 12-volt system is described here.

Construction. Assembly of the entire ignition system can be accomplished in less than half an hour. A printed circuit board, made of G 10 (fiberglass impregnated) material and heavy copper foil, simplifies the construction considerably.

The most important parts required are the SCR (*Q3*) and the transistor transformer (*T1*). This transformer is a special type, and can be purchased directly from SYDMUR (P. O. Box 25A, Midwood Station, Brooklyn, N. Y., 11230) for $14.95. The SCR can be purchased locally. SYDMUR claims their SCR's are pretested and exceed manufacturer's specifications. A special selection of

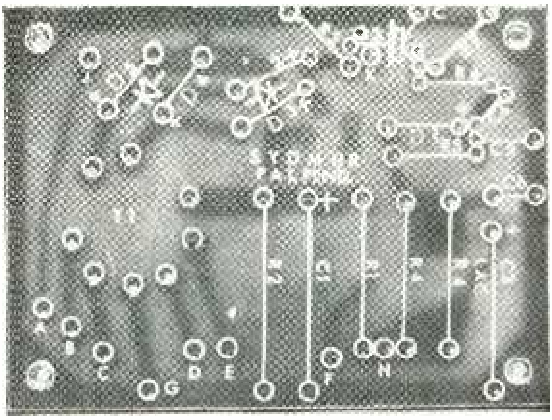
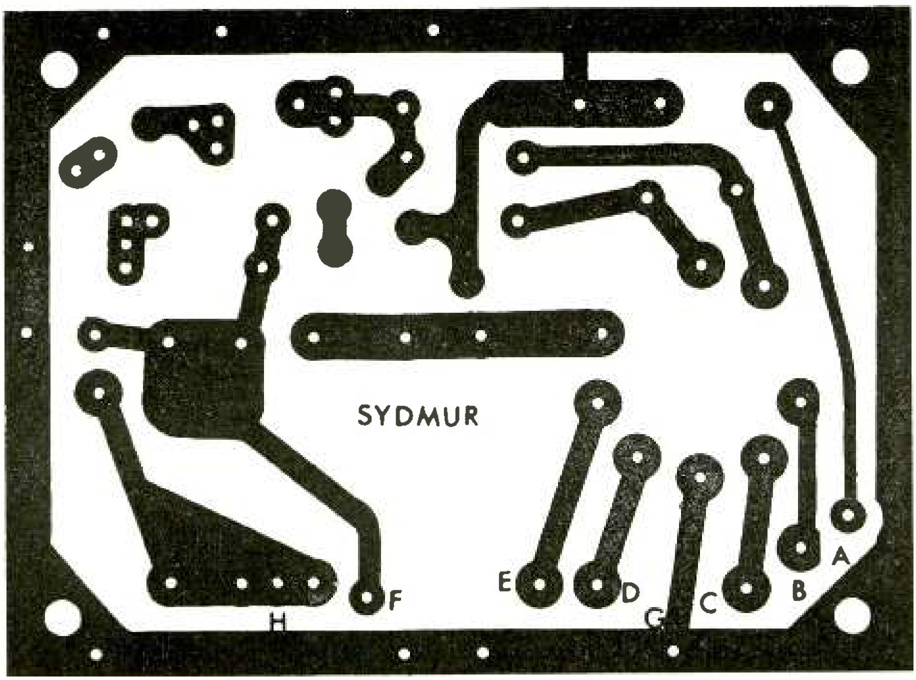
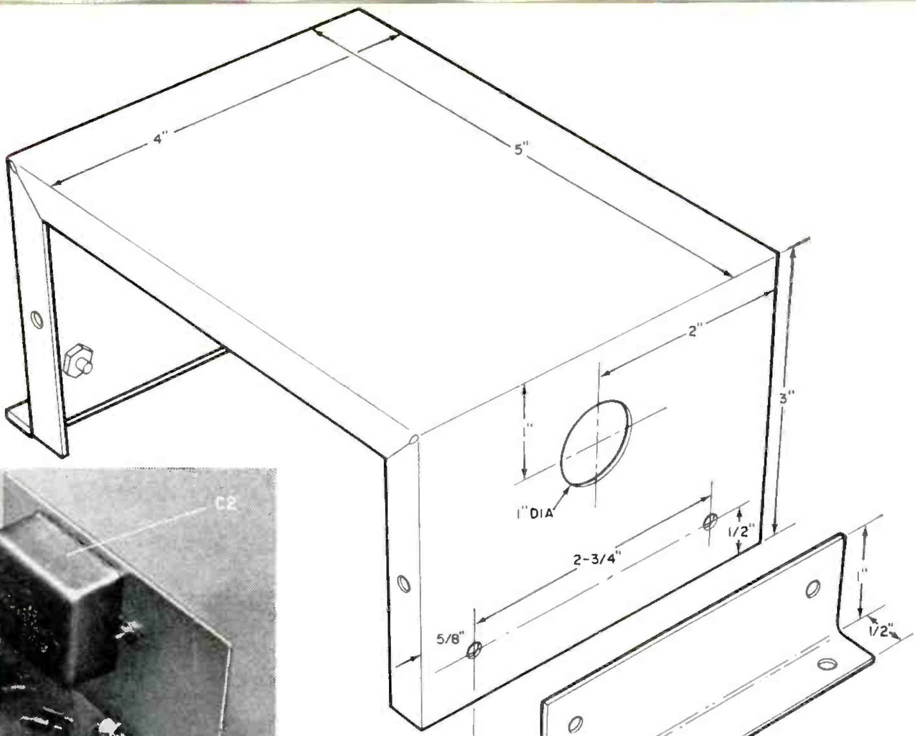
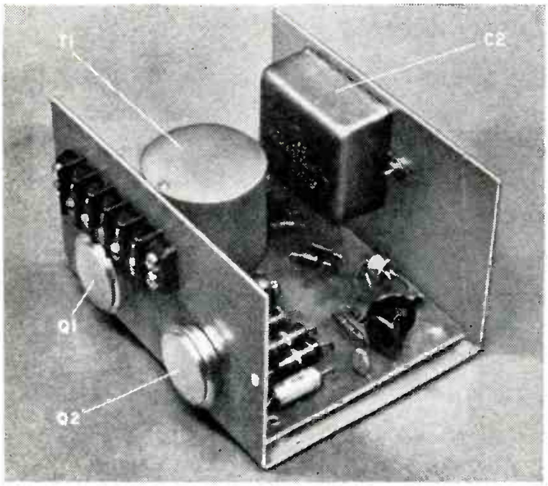


Fig. 1. Component side of circuit board (left) shows parts location and orientation. SYDMUR kit has all components color-coded, and the appropriate colors marked on the board to speed assembly. Actual size photo of board (below) will help you make your own. Do not change alignment of conductor paths.







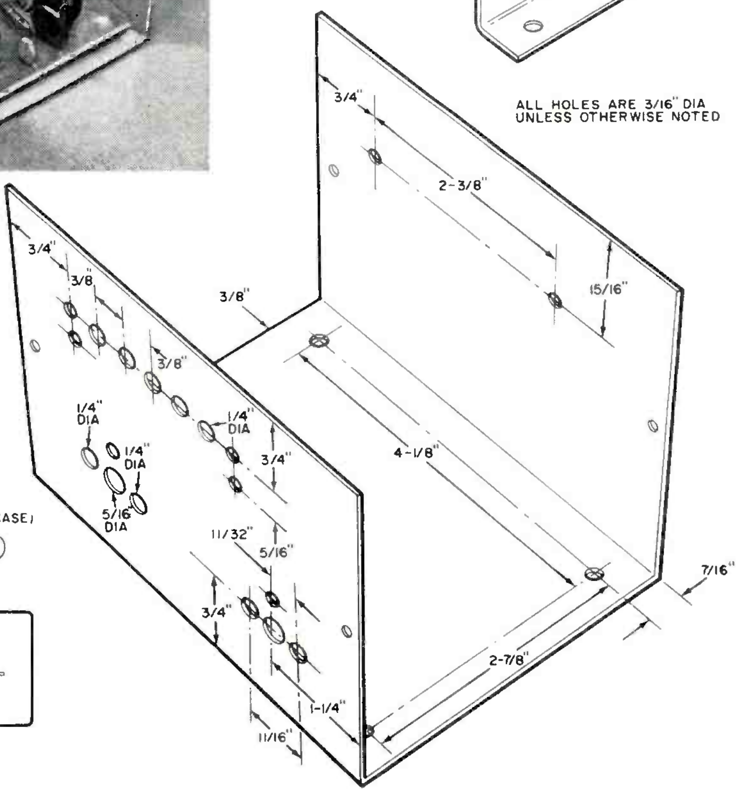
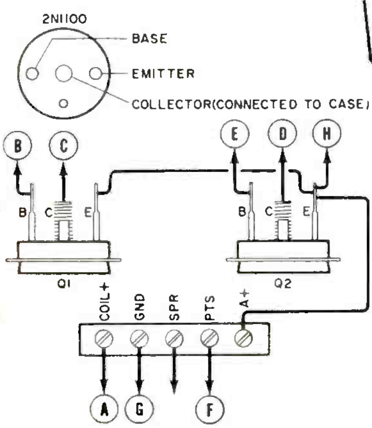


Fig. 2. Locate and drill all holes accurately. Large 1" hole is for screened air vent. Size and spacing of holes for terminal strip can vary. Mounting sequence is: Q1, Q2, terminal strip, completed board, and bathtub capacitor. Transistors must not touch the cabinet.



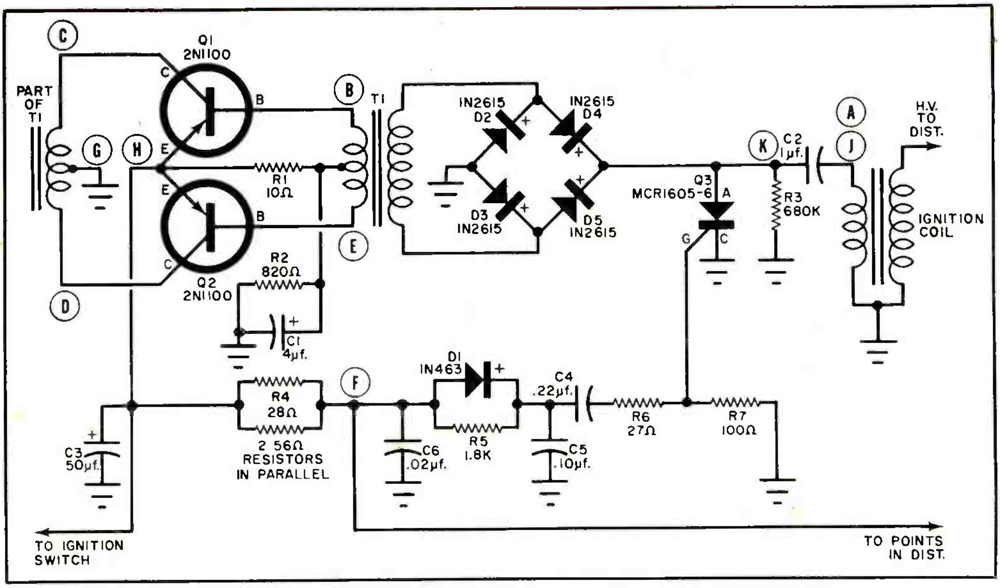


Fig. 3. Transistors Q1 and Q2 "chop" the battery input to enable T1 to step up the voltage, which is then rectified and used to charge C2. The potential stored in C2 is then "dumped" into the ignition coil.

SCR's is made to insure optimum performance; they are priced at $7.45 each, including a heat sink. The other parts are not critical, and they can be obtained from your local parts dealer.

Should you decide to make your own printed circuit board, follow the actual size and layout as shown in Fig. 1. Do not change any lines, or false triggering of the SCR can result.

First install all the components on the printed circuit board or other suitable chassis, and put it aside. Use rosin core solder and observe polarity of all diodes. Next, prepare the cabinet as shown in Fig. 2 and mount the transistors and terminal strip. Do not mount the bathtub capacitor until the circuit board has been put in place.

When installing the transistors, coat both sides of a mica insulator with silicon grease to act as a heat conductor and electrical insulator between the transistors and the cabinet. Line up the holes of the mica insulator with the holes in the cabinet. Next, insert the transistors (they can fit only one way). Then place a fiber washer over each transistor bolt, and follow with a metal washer and solder lug. Bolt the entire assembly into place.

Be certain that the transistor pins do not touch the metal cabinet. Use an ohmmeter to check this out. Connect one lead to the cabinet and the other to the transistor case and then to the pins. If there is a reading on the ohmmeter, recenter the transistor.

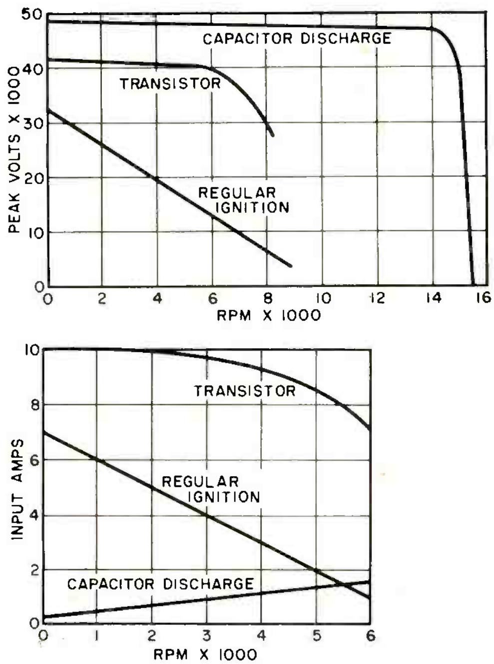


Fig. 4. Capacitor discharge system has highest voltage output and lowest current drain at road speeds.

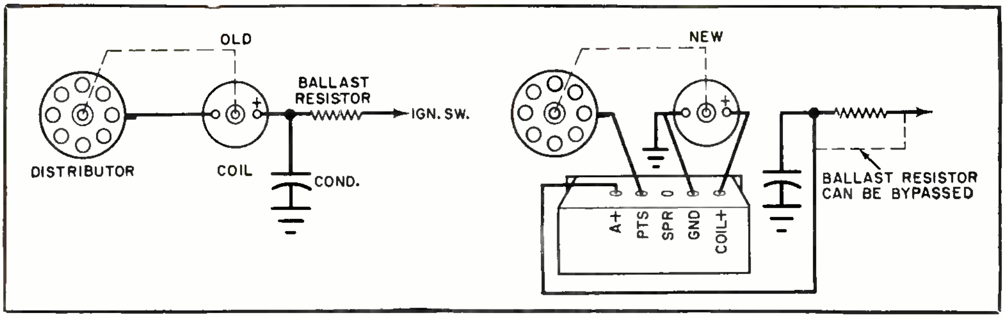


Fig. 5. Simple wiring change needed to install capacitor discharge system. To get the most out of the new installation, points, plugs, coil, wire, and distributor cap should be clean and in good condition.

PARTS LIST

C1—4-µf., 50-volt electrolytic capacitor
C2—1-µf., 600-volt bathtub capacitor
C3—50-µf., 25-volt electrolytic capacitor
C4—0.22-µf., 25-volt ceramic capacitor
C5—0.1-µf., 100-volt ceramic capacitor
C6—0.02-µf., 150-volt ceramic capacitor
D1—1N463 silicon diode
D2, D3, D4, D5—1N2615 silicon diode (SYDMUR ER61A)*
Q1, Q2—2N1100 power transistor
Q3—Motorola MCR1605-6 silicon-controlled rectifier (SYDMUR SCR 1268 with heat sink)
R1—10-ohm, 2-watt resistor
R2—820-ohm, 1-watt resistor
R3—680,000-ohm, ½-watt resistor
R4—28-ohm resistor (two 56-ohm, 2-watt resistors in parallel)
R5—1800-ohm, ½-watt resistor
R6—27-ohm, ½-watt resistor
R7—100-ohm, ½-watt resistor
*T1—SYDMUR SPC-4 special transformer**
1—3" x 4" x 5" cabinet
Misc.—1" wire-screen snap-in plug, 5-terminal barrier-type terminal strip, circuit board, 4 3/16" spacers, machine screws, terminals, etc.

*The following parts are available from SYDMUR, P.O. Box 25A, Midwood Station, Brooklyn, N.Y.: ER61A @ $1.80; transformer T1, $14.95 (T1 is a proprietary product of SYDMUR . . . no coil winding information available); SCR 1268, $7.45; complete kit including a specially made cabinet, $44.50; and a completely wired unit, $60.00. A positive ground system at $47.50, and a 6-volt system at $44.50 are available completely wired (not in kit form).

Mount the board into place with machine screws and be sure that there is enough clearance on all sides and top and bottom to prevent short circuits. Connect a wire from point *C* (next to *T1*) to the collector and a wire from point *B* to the base of *Q1*. Connect a wire from point *D* to the collector; a wire from point *E* to the base; and a wire from point *H* to the emitter of *Q2*. The emitters of both transistors should be connected together and to the A+ terminal on the terminal strip. Finally, connect a wire from point *A* on the board to the *Coil+* terminal on the strip; a wire from point *G* to the *GND* terminal; and a wire from point *F* to the *PTS* terminal.

How It Works. When the ignition switch is turned on, the battery voltage is applied to the emitters of *Q1* and *Q2*. (See Fig. 3.) Transistors *Q1* and *Q2* are forward-biased through the resistive divider (*R1* and *R2*). Usually, whichever transistor has the most gain will conduct first. First one transistor conducts, and then the other, in a flip-flop manner. This form of oscillation repeats itself regularly and continuously; transformer action steps up the voltage to about 375 volts, which is then rectified by the full-wave bridge (*D2, D3, D4* and *D5*).

The d.c. voltage output from the bridge rectifier then charges capacitor *C2*. Capacitor *C2* stores this d.c. energy until the *SCR* (*Q3*) conducts. Resistor *R3* improves regulation and acts as a bleeder to discharge *C2* when the ignition switch is turned off.

When the points in the distributor are closed, the SCR (*Q3*) is an open circuit across the power supply. Also, when the points are closed, *R4* allows about 500 ma. of current to flow across the points to help keep them clean. When the points open, current flow through *R4*, *D1*, *C4*, *R6* and *R7* causes a positive pulse to be applied to the gate of *Q3*, which then flips into conductivity very rapidly (approximately 1 microsecond), discharging *C2* through the primary of the ignition coil.

Notice that the voltage impressed across the primary is on the order of 375 volts and not the usual 6 or 12 volts. The ignition coil can now produce a much hotter and "faster" spark. Actually, "faster" spark simply means a steeper slope (rise time) of the spark's waveform as it would appear on an oscilloscope. It is this very short rise time, inherent in a capacitor discharge system, that makes it possible to fire fouled and defective spark plugs. Another important gain is the fact that the coil does not have to draw current while the breaker points are closed to build up a large magnetic field as in conventional ignition systems.

At high engine speeds in conventional systems, not enough time is available to build up the magnetic field to maximum, and so there is a very definite drop in voltage, as shown in Fig. 4. Note that in this capacitor discharge system there is essentially no drop in voltage up to 15,000 rpm. Since engine speeds rarely exceed 5000 rpm, there is no drop in voltage over the entire range of usable engine speeds.

At the instant *Q3* conducts, it also shorts out the power supply, forcing the power transistors (*Q1* and *Q2*) into a quiescent state. The transformer (*T1*) is specially designed to prevent high transients and self-oscillation of the power transistors when *Q3* conducts. After *C2* discharges through the coil and *Q3*, the ignition coil—because of a flywheel type of action and its sinusoidal type of response—sets up a reverse current which develops a negative voltage on the anode of *Q3* and positively halts conduction. The SCR would normally shut off as the anode voltage approached zero. Polarity of the bridge rectifier happens to be just right to remove any residual negative voltage and to keep it within safe limits.

As soon as *Q3* stops conducting, the power supply turns on. By this time the same sinusoidal action of the ignition coil is now heading in the other direction and tends to aid the power supply in charging up *C2*, further reducing the charging time. All this is accomplished in less than 300 microseconds.

To prevent the SCR from conducting on point bounce or high impulse noise, the voltage on *C4* and *C5* back-biases *D1* and bleeds off through *R5* at a slower rate than the charge time (about 0.5 millisecond). Capacitor *C6* helps to prevent any high-frequency noise that may create r.f. interference from getting out of the ignition system.

Note that the original coil is used and that the unit will perform on a battery voltage range from 9 to 16 volts.

Checking It Out. Before installing the system, you may want to satisfy yourself that all is in working order. The system can be tested if there is an ignition coil and a 12-volt battery available. Follow the installation instructions.

Care must be exercised when connecting the coil. A wire from the high voltage output should be gapped a maximum of 1″ from the minus side of the ignition coil. There is a possibility of breaking down the internal insulation of the ignition coil if you omit this load.

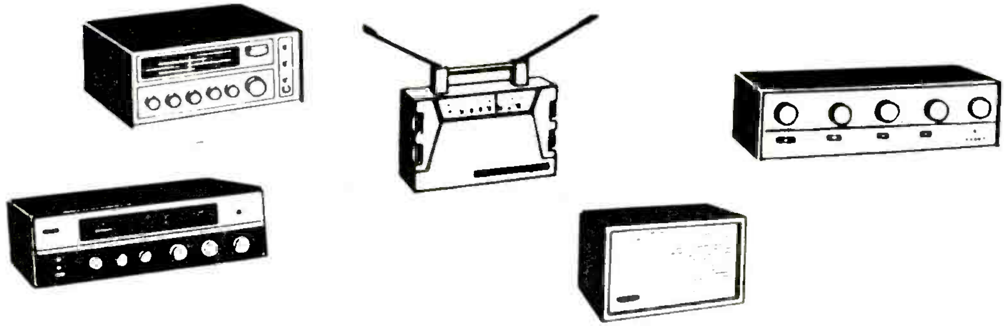
Instead of using the breaker points, a wire can be connected from the *GND* terminal and brushed along the *PTS* terminal on the strip. Do not touch the ignition coil or high voltage lead while you are making this test, or you might get a nasty jolt.

Installation. Mount the unit close to the ignition coil, but as far as possible from the manifold. Remove all wires from the ignition coil. Also remove any capacitors if they are attached to the coil. Reconnect the wire or wires and the capacitor (if any) that were on the coil's plus terminal, to the *A+* terminal on the unit. Connect a wire from the *COIL +* on the unit to the + on the ignition coil. See Fig. 5.

Now connect a wire from the engine ground (the coil's clamp can serve as a ground) to the other side of the ignition coil—and to the *GND* terminal on the unit. Connect the wire from the terminal on the distributor to the *PTS* terminal on the unit. Be sure all connections are tight and well insulated, and do not let wires or metal touch the transistors.

It is advisable to install a new set of breaker points, and to clean the distributor head and the rest of the ignition system. Follow the car manufacturer's recommendations as to timing and gapping of points. If the spark plugs are shot, they'll work, but it is better to begin with your best foot forward.

When you turn the ignition switch on, a slight hum will be heard from the unit. Start the engine. —30—



Wireless Re-Broadcaster

Broadcast music or sound from your hi-fi, FM tuner, or TV set to every AM radio in the house—all it takes is a simple one-tube unit

By KEN DOBLER

REBROADCAST anything that comes out of a loudspeaker. You can get FM programs on all the AM radios in your home. Television sound and music from your tape recorder or phonograph can be heard on the kitchen radio. Your portable transistor radio can become another listening end of a paging or intercom system. You can remote-monitor your CB, amateur or short-wave receiver on any AM radio within range of the Wireless Re-Broadcaster (*WRB*). The *WRB* can be attached to the speaker leads of any program source (*PS*).

The speakers at the *PS* can be switched off or left on while you are rebroadcasting. When the *WRB* is shut off, the *PS* is not affected in any way and will function in a normal manner. The *WRB* is also equipped with a *Modulation* level control and a visual *Level* indicator to handle the high-level signals taken directly from loudspeaker leads, and can function properly over a wide range of input signal strengths.

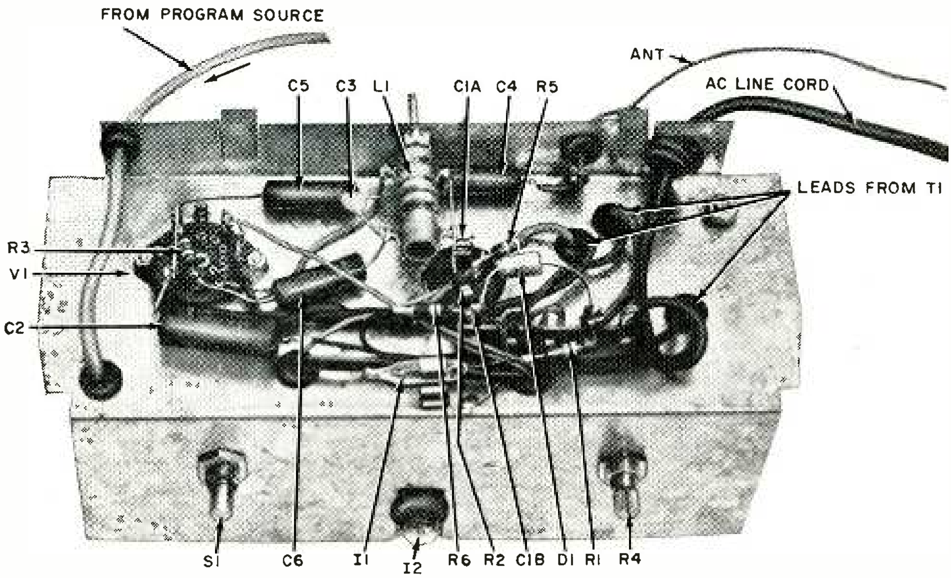
The circuitry is easy to understand and easy to put together. Parts are standard, few in number, and readily available. Use only enough antenna length to transmit a signal to your own sets. Part 15 of the FCC regulations and a neighbor's complaint can put an end to your rebroadcasting days if you cause interference. So keep it down and find a spot

Wireless Re-Broadcaster

Unique use of "S"-type fuse clip is shown below: it's soldered directly to the chassis and holds neon lamp I1. Grommets protect wires at various feedthrough points. Lamp I2, also grommet-held, can be moved up or down to line up with opening in front panel.

PARTS LIST

C1a/C1b—40-µf., 150-volt, and 20-µf., 25-volt dual electrolytic capacitor
C2—0.047-µf., 200-volt capacitor
C3—150-pf. ceramic disc capacitor
C4, C5, C6—400-pf., 400-volt capacitor
D1—1N3254 diode or equivalent
F1—3-ampere fuse (optional)
I1—NE-2 neon lamp
I2—NE-51 neon lamp
L1—Oscillator coil (Miller 71-OSC, or equivalent)
R1, R6—100,000-ohm, ½-watt resistor
R2—10,000-ohm, ½-watt resistor



on the band that doesn't conflict with a regular broadcast program.

A dual-triode vacuum tube (12AT7) is used as an oscillator and series modulator. A series modulator can be recognized by the fact that the plate voltage supply is in series with the modulator and modulated tubes. The unit is powered by a half-wave power supply isolated from the a.c. line by *T1*.

Construction. A wooden cabinet (8″ x 4″ x 4″) can be made and stained to match existing furniture. The chassis is fabricated from a piece of sheet metal cut and bent to the proper shape. A separate chassis pan and front panel could be put together instead.

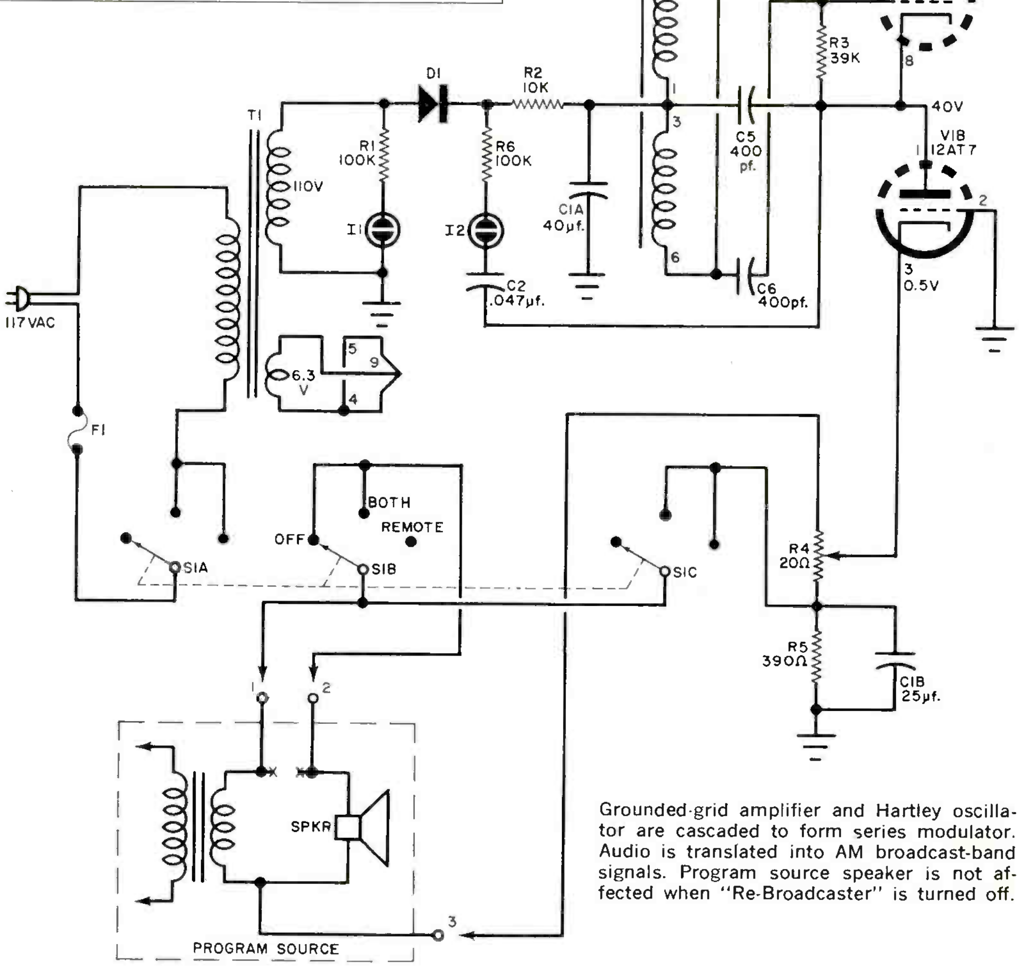
Cut a notch rather than a hole in the front panel for the neon lamp modulation *Level* indicator. The outer groove of the grommet holding the lamp can now act as a runway to grip the sides of the slot. The lamp can then be moved up or down to line up with an opening in the cabinet. Lettering on the cabinet's Masonite front panel can be done with a ⅛″ plastic lettering guide over a strip of gold writing foil.

Wiring is not critical; just check all connections before turning on the power. An "S"-shaped fuse clip makes a convenient holder for the neon "off-on" indicator. Solder the clip directly to the chassis, so that it is upright and the upper opening faces the front. Insert the lamp into the upper opening.

Keep the antenna lead down to 10 feet to avoid difficulty with FCC regulations.

How It Works. Signals taken from the speaker circuit of a *PS* are fed to the *Modulation* level control, potentiometer *R4*, through switch *S1b* and *S1c*. More or less signal (depending upon the control setting) is passed to the cathode of the modulation portion of the tube (*V1b*). Triode section *V1b* is hooked up as a

R3—39,000-ohm, ½-watt resistor
R4—20-ohm wire-wound potentiometer (auto radio remote-speaker mixer type)
R5—390-ohm, ½-watt resistor
S1—3-pole, 3-position rotary switch
T1—Power transformers primary, 117 volts; secondaries, 110 volts and 6.3 volts (Olson T-173 or equivalent)
V1a/V1b—12AT7 dual-triode vacuum tube
Misc.—6' a.c. line cord, 4' three-conductor audio cable, 9-prong miniature tube socket, 5-point terminal strip, grommets, knobs, "S"-shaped fuse clip, 10' indoor antenna wire



Grounded-grid amplifier and Hartley oscillator are cascaded to form series modulator. Audio is translated into AM broadcast-band signals. Program source speaker is not affected when "Re-Broadcaster" is turned off.

grounded-grid amplifier. The grounded grid shields the input from the output circuit and prevents oscillation. Input signals applied to the cathode vary cathode potential with respect to the grid in "step" with the signal. This action varies and controls current flow through the tube, making the tube work like an ordinary amplifier.

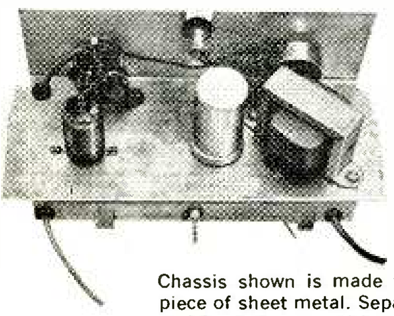
Triode section *V1a* functions as part of a typical Hartley oscillator. The tuned tank circuit consisting of coil *L1* and capacitor *C3* is across the grid and plate of this triode while the signal at the coil's tap is at cathode potential. Capacitors *C5* and *C6* serve as d.c. blocks. The values of the components in the tank circuit determine the generated frequency. Varying the adjustment of coil *L1* will enable you to select a quiet spot on the AM broadcast band.

The generated radio frequency in tube section *V1a* is amplitude-modulated by the signals from section *V1b* and then "piped" into the atmosphere by the antenna. Capacitor *C4* serves as an antenna coupler.

The modulation *Level* indicator circuit is also very simple. In the presence of an audio signal, plate voltage of triode section *V1b* varies with the applied signal. As the cathode goes more negative, the tube conducts more and plate voltage goes down; as the signal goes more positive, the tube conducts less and plate voltage goes up. Neon lamp *I2* "looks" at this varying plate voltage through capacitor *C2*. Resistor *R6* is a current limiter. When plate voltage goes down, the voltage across *I2* increases and "fires," provided that the applied signal is of the proper level. The lamp should flicker on and off in "step" with the program. Too high a volume level will cause the lamp to stay on, even during very low signal passages.

Transformer *T1* provides heater voltage to the tube as well as an isolated line voltage to the rectifier. Actually it is stepped down a bit from 117 volts to 110 volts. While the exact voltage is not critical, it is best not to deviate too much. Neon lamp *I1*, across the secondary of transformer *T1*, serves as a pilot light.

The B+ developed by half-wave rectifier *D1* and the filter components (resistor *R2* and capacitor *C1a*) is fed to the plate of tube *V1a* through the top half of coil *L1*. Both tube sections act as a dynamic voltage divider between



Chassis shown is made from one piece of sheet metal. Separate pan and front piece could be employed. Tabs on apron act as backstops.

B+ and ground. The exact distribution of voltage depends upon the way each section conducts.

Installation. To connect the *WRB* to the *PS*, follow the schematic diagram. Connect line *3* to one side of the speaker. Open the lead going to the other side of the speaker at any convenient point and connect line *1* to the end closest to the output transformer, and line 2 to the end nearest the speaker. This completes the project, except for setting the frequency of the *WRB*.

Turn on the *PS* and an AM radio. If you are working alone, place the AM radio, the *PS*, and the *WRB* close to each other to cut down the leg work. Set the selector switch in the *Both* position and the *Modulation* level control in the fully counterclockwise position on the *WRB*. Turn up the program on the *PS* to a moderate volume level and advance the *Modulation* level control on the *WRB* until the *Level* indicator flashes in "step" with the program. Tune the radio to a clear spot on the dial and adjust the oscillator coil on the back of the *WRB* until the signal is heard in the radio. If you don't get the signal on one end of the band, try the other end.

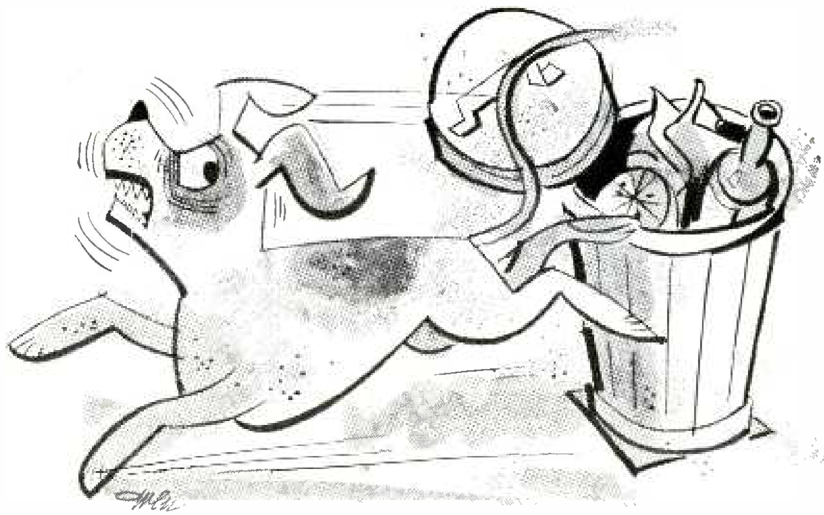
When the selector switch is in the *Off* position, the *PS* operates normally. In the *Both* position, the *PS* operates normally and the *WRB* transmits the program. In the *Remote* position, the speakers at the *PS* are cut off, but the *WRB* continues to transmit the signals from the speaker line.

The *Modulation* level control need only be used when the selector switch is in the *Both* position. Its main function is to limit the amount of signal sent to the broadcaster when the *PS* volume level is high. In the *Remote* position, the *Modulation* level control should normally be turned fully counterclockwise and the *PS* volume adjusted for proper level.

Since too much bass can cause distortion, it is better to keep the bass control at a minimum setting during preliminary adjustments and then advance it for the most pleasing tone.

After becoming familiar with the operation of the controls and the best setting for your AM radio, you will find the *WRB* easy to operate, mystifying to friends, and loads of fun. -30-

ELECTRIC



FENCE CHARGER

Marauder monitor curbs canine capers. Stop garden invasions and garbage can inspections at four o'clock in the morning

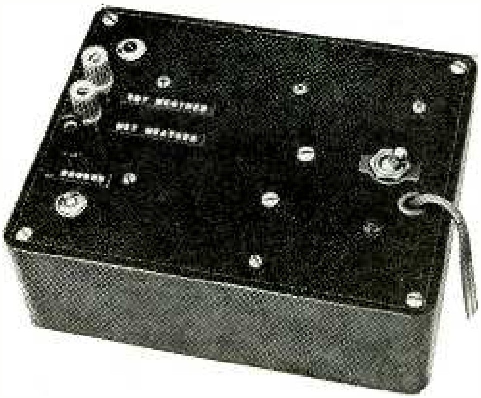
By LYMAN E. GREENLEE

KEEP your disposition from going to the dogs by charging up a few things. You can build a small fence charger that will deliver a wallop big enough to make any self-respecting dog or cat think twice before investigating the contents of your garbage can a second time. The punch is a high-voltage shock of short duration and is harmless to man or beast. Cost of construction is low—you may already have most of the parts on hand.

How It Works. A small isolation transformer (*T1*) isolates the fence charger from the house power line for safety, as shown in the schematic diagram. A ⅛-ampere "slow-blow" fuse carries the small normal load of the charger and also withstands the initial current surge which may occur when the unit is first turned on. This is normal for equipment having capacitor input filtering in the power supply.

Capacitors draw relatively large current as they go from 0-to-operating voltage levels. The output from the transformer secondary goes through a current limiting resistor (*R1*) to the silicon rectifier (*D1*). Resistor *R1* protects the rectifier from starting current surges. The rectifier's pulsating d.c. output is smoothed by capacitors *C1* and *C2* and by resistor *R3*. The NE-2 neon light (*I1*) serves as a pilot light—it not only shows whether

ELECTRIC FENCE CHARGER



Small unit teaches hounds to behave. Short duration pulses are harmless.

the charger is on or off, it also tells you if the B+ power supply is working up to this point in the circuit. Resistor *R2* limits the amount of current that can be passed by the neon light. Output from this half-wave rectifier power supply is approximately 140 volts.

The relay coil (*K1*) is a normally-closed s.p.s.t. type with a coil resistance of from 3000 to 8000 ohms. Upon application of power, the relay tends to become energized almost immediately and to open the circuit through itself and transformer *T2*. Since enough time must be allowed for the current to build up, and, in turn, for the magnetic field to go to maximum in transformer *T2*, capacitor *C4* is used to hold the relay armature down for about one second. Timing depends upon the values of the capacitor and the coil resistance, as well as the characteristics of the relay. Spring tension on the relay armature can be changed to increase or decrease the on-off time. Relays with coil resistance varying from 1000 to 10,000 ohms have been tried by the author and all of them have worked. Variations in hold-down time ranged from about 0.1 to 3 seconds.

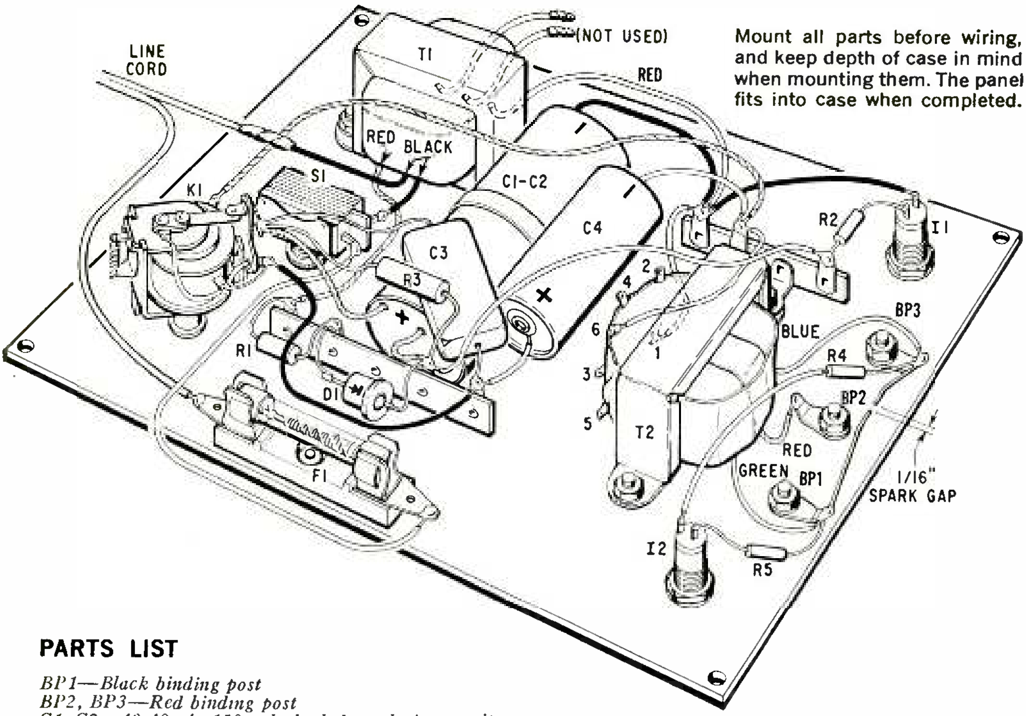
When the relay points open, current ceases to flow through *T2*, the magnetic field collapses and induces a voltage across what is now the transformer's secondary winding, and the voltage appears at terminals *BP1* to *BP3*. The quicker the magnetic field collapses and the higher the turns ratio of the transformer, the higher the voltage produced. Note that this transformer was originally intended for audio output work and is used in the reverse manner in this project. Therefore, what was originally the primary winding is now the secondary.

Capacitor *C3* serves the same purpose as the capacitor across the points in a conventional automobile ignition system. It overcomes the inertial effects of the current, minimizes arcing across the points, and takes on a charge which series-aids the voltage from the power supply when the contacts close.

The second neon light (*I2*) connected across the secondary of *T2* flashes momentarily with each pulse applied to the fence if all is well. Resistors *R4* and *R5* are current limiters for *I2*. The spark gap protects the transformer against damage from internal arcing and also from electrostatic or lightning charges that might be picked up on a long length of fence wire connected to the charger.

The shock pulse generated is completely safe due to its short duration. Any possibility of a dangerous or lethal voltage being applied to the fence because of component failure is remote. Transformer *T2* can pass only a small current and is isolated from the house power line. The B+ component is "chopped up" by the relay. If the relay contacts stick open or closed, no high voltage can be developed on the fence. Should transformer *T1*, diode *D1*, or capacitors *C1*, *C2*, and *C4* short, the fuse would probably blow or resistor *R1* would burn out. In any event, there would still be no high voltage on the fence.

Construction. The charger should be built in a Bakelite or plastic box, or at least on an insulated board, as shown in the illustrations. Provide a good ground connection for terminal *BP1*. All parts are mounted on the cover. Keep in mind the 2⅛" space between the cover and the bottom of the case when

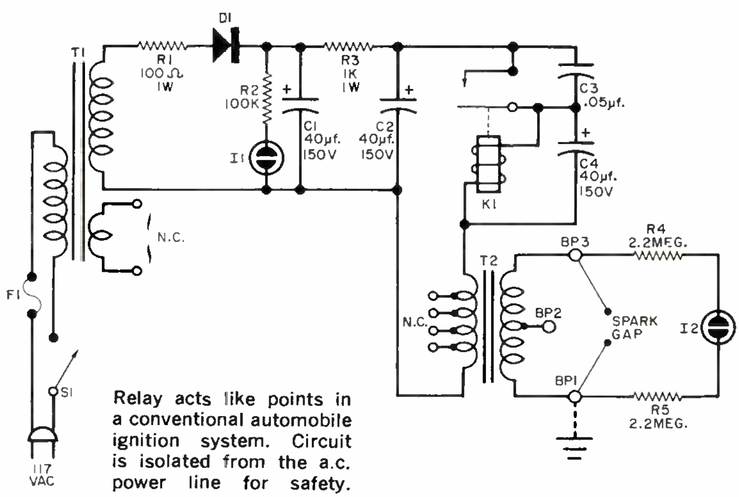


Mount all parts before wiring, and keep depth of case in mind when mounting them. The panel fits into case when completed.

PARTS LIST

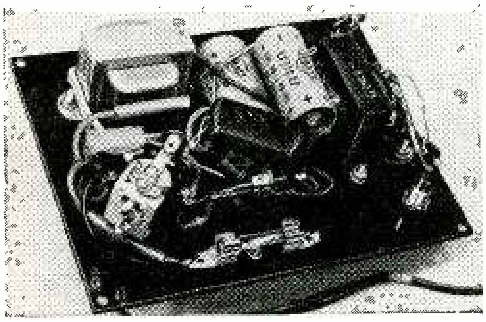
BP1—Black binding post
BP2, BP3—Red binding post
C1, C2—40-40 µf., 150-volt dual electrolytic capacitor
C3—0.05-µf., 600-volt mica capacitor
C4—40-µf., 150-volt electrolytic capacitor
D1—1N1763, 400-PIV, 500-ma. silicon rectifier
F1—1/8-amp. "slow-blow" fuse
I1, I2—NE-2 neon light
K1—S.p.s.t., normally-closed relay with 5000-ohm coil (Potter & Brumfield LB5 or equivalent)
R1—100-ohm, 1-watt resistor
R2—100,000-ohm, 1/2-watt resistor
R3—1000-ohm, 1-watt resistor
R4, R5—2.2-megohm, 1/2-watt resistor
S1—S.p.s.t. toggle switch
T1—Isolation transformer: primary, 117 volts; secondary, 125 volts @ 15 ma. (Stancor PS8415 or equivalent)
T2—4-watt universal output transformer (Allied Radio 62 G 023 or equivalent)
1—2 5/32" x 5 9/32" x 6 13/16" Bakelite instrument case and cover
Misc.—Line cord, 3/8" grommets, fuse holder, 4-terminal strip, neon-light sockets, hookup wire, machine screws and nuts, etc.

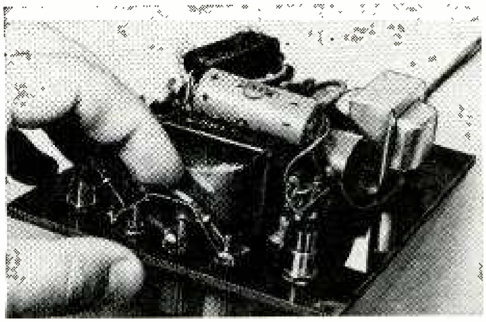
NOTE: A complete kit of parts with drilled and finished box, ready for easy assembly, is available from Mobil Electronics, Inc., 3023 Mounds Rd., P. O. Box 1132, Anderson, Ind., for $21.95; postpaid.



Relay acts like points in a conventional automobile ignition system. Circuit is isolated from the a.c. power line for safety.

ELECTRIC FENCE CHARGER


Spring tension on normally-closed relay should provide good contact. Tighten to increase "on" time.


Spark gap protects the transformer. Adjust size to prevent continual firing with no load attached.

mounting the various parts. The cover has to fit into the case when the instrument is completed.

Prearrange the parts in the cover, as shown in the photos, and mark the position of the various mounting holes. All parts should be mounted before wiring. The 6-volt filament wires from the isolation transformer are not used; the ends of these wires should be taped and folded around the transformer and tucked out of the way.

The output transformer has a series of taps for impedance matching. Locate the two outer ends of the tapped winding and wire them into the circuit. One way to identify the outer ends is to use an ohmmeter. Select the two terminals that have the most resistance between them.

The high-voltage side of the output transformer has three insulated wires which may be colored red for the center tap, blue for one end, and brown or green for the other end of the winding. Connect the brown or green wire to the black binding post (*BP1*), the red wire to the middle red binding post (*BP2*), and the blue wire to the end red binding post (*BP3*).

You can construct a spark gap by soldering a fairly stiff wire about 2″ long to each lug on the outer binding posts. Shape the two wires so that their ends are about 1/16″ apart and suspended in air away from other terminals and cabinet, as shown in the pictorial.

Check the wiring when completed. If you're satisfied with it, place the cover in the case, plug in the unit, and flip the switch. If all is well, the relay will start pulsing. Don't screw down the cover until you have checked the spark gap to see that it is not firing. Normally the gap should be just big enough to prevent no more than occasional arcing. You may also want to vary the armature tension by adjusting the spring to get the right timing cycle. Spring tension should be strong enough to insure a good contact when the relay trips out. The relay should stay closed for about 0.1 second.

Operation. Connect the black binding post to a suitable ground connection, and connect the fence to be charged to one of the red binding posts. Use the middle binding post for wet weather and the outer one for dry weather. On a dry day a higher voltage is needed to force current through dry ground. In wet weather a high voltage could be a disadvantage because the current would tend to leak across the insulators. The higher the voltage, the higher the leakage. When the ground is wet, a low voltage is just as effective. Approximately half the voltage and twice the amperage is available from the black and middle red post. Maximum high voltage is obtained from the black and outer red post.

To test for leakage in the fence circuit, connect a NE-2 neon light in series with the fence and the red binding post being used. The higher the intensity of the flashes, the greater the leakage. To

(*Continued on page* 145)

SIMPLE DWELL METER

By T. C. PENN

Best possible gasoline engine performance results from a combination of many ingredients—not least of which is the dwell angle

THE use of a dwell meter to adjust the spacing of the breaker points of an automobile is well known to mechanics and is now becoming familiar to the "do-it-yourself'er." Several transistor circuits of varying complexity have been published for dwell meters. In view of these previously published circuits, a circuit as simple as the one to be described here might well be viewed with skepticism. But in addition to justifying the simpler circuit on the basis that it has been used successfully for the past two years, it will be shown that this dwell meter is even more accurate than some of the circuits that have been published in the past.

Before touching on the details, some discussion of what a dwell meter can and cannot do might be worthwhile. For example, a dwell meter will not insure "up to 20% more horsepower" nor "up to 5 more miles per gallon of gas." A dwell meter by itself is useful only in adjusting the breaker-point gap in the distributor. It is very useful with modern engines which provide for such adjustment while the distributor cap remains in place. A dwell meter is also useful in checking the breaker point condition of older engines since it replaces the function of a gap gauge.

Each time the cam lobe of the distributor pushes open the breaker points, a spark plug ignites. Changing the dwell angle (during which the points remain closed) changes the point spacing and obviously changes the angle the cam makes when the points first open. In other words, it should be appreciated that any adjustment of the breaker-point gap requires that the engine be re-timed.

The mechanical-electrical characteristics of most single breaker point ignition systems are chosen to hold the points closed (dwell) twice as long as they are open. The dwell duty cycle is therefore two-thirds and that is really all that needs to be remembered regardless of

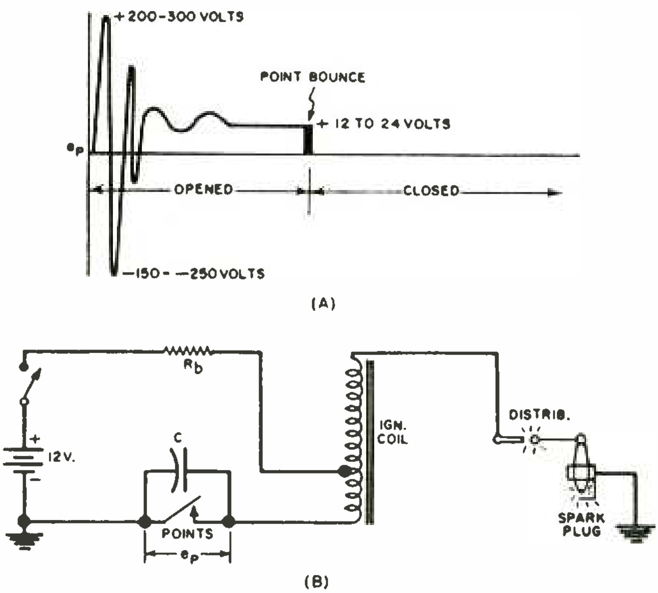
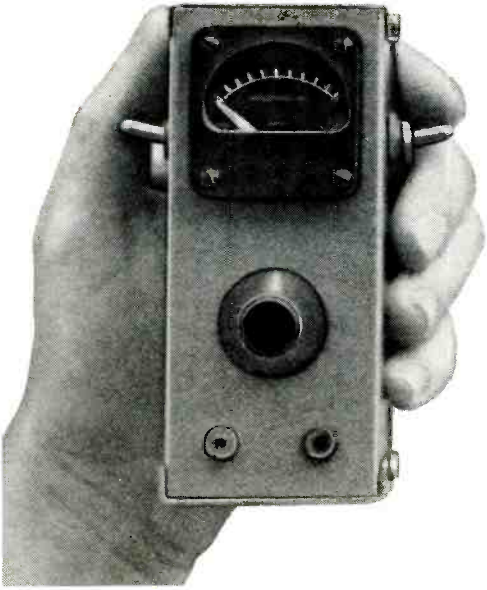


Fig. 1. Examination of voltage swing at the ignition with an oscilloscope would reveal a waveform similar to that at right. The very large swing (or transient) is due to the resonance of the ignition coil as "tuned" by the capacitor across the breaker points. Dwell time, or dwell angle, is the amount of time in angular degrees that the points are closed.



the number of cylinders. Not every model of every car has been checked, so you are encouraged to check the specs of your own car.

An eight-cylinder engine has a timing cam which turns 45° between the successive firings of spark plugs. The nominal dwell angle is two-thirds of this angle, or 30°. In a six-cylinder engine, the timing cam rotates 60° between ignition times, and thus the nominal dwell angle is 40°. A tolerance of ±5% is quite acceptable.

Faulty dwell settings produce undesired results, as might be expected. If the dwell angle is too small, the current in the primary of the ignition coil does not reach its proper amplitude at high speeds. This causes the ignition coil voltage to decrease. In addition, the breaker points are thrown open so wide that severe contact bounce results when they close. If the dwell angle is too large, the points are not opened wide enough and arcing will take place across the points, resulting in decreased point life and low voltage.

How It Works. The dwell meter to be described is based on the same principle as that illustrated by the old electronics riddle. "An electrical black box has three terminals accessible for an ohmmeter check. Terminals 1 and 2 read open circuit, both terminals 2 and 3 as well as 1 and 3 give a half-scale reading on *all* ranges. What is in the box?" The usual answer is a vibrator or chopper. The duty cycle of the chopper is 50%, so the meter reads halfway between open and short circuit.

Unfortunately, the voltage waveform appearing across the breaker points of an automobile is not quite as ideal as a chopper. Figure 1 illustrates a typical waveform of the point voltage in a negative-ground system. (For positive-ground systems the waveform is inverted.) Note the large magnitude transients caused by resonance of the coil with capacitor *C* across the points. If one is tempted to use a clipper or a Schmitt trigger to produce a rectangular pulse of the same length as the open time, the negative transient will momentarily turn off the

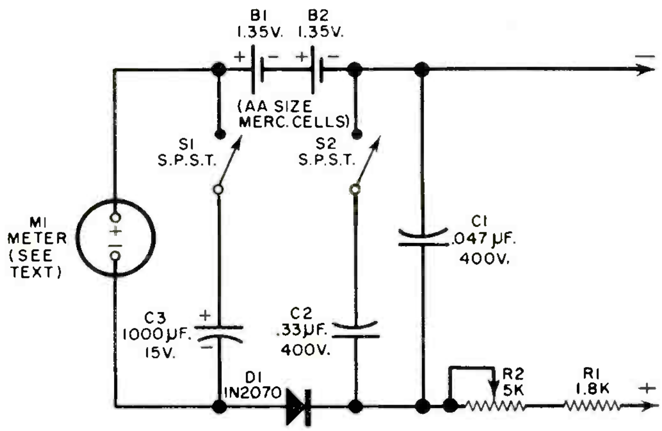


Fig. 2. Simplicity is the key word in the design of this dwell meter. "Plus" lead goes to "hot" or plus terminal of the ignition coil in negative ground systems. This circuit has provisions to measure dwell angle when the ignition coil cannot be reached. See text for details.

clipper or reverse the Schmitt trigger. The shaped waveform will therefore not be representative of the open time of the points.

Figure 2 is a schematic of the dwell meter. When the meter is connected across the points of an automobile, the internal batteries drive the meter to full-scale as long as the points remain closed. As the points open, the 200- to 300-volt positive spike is unable to produce current flow through the meter due to the diode. At the same time the *RC* product chosen is such that the subsequent negative voltage spikes are also unable to cause current to flow through the meter. When the points again close, *C1* is discharged through *R1* and *R2 via* the points. The internal batteries again drive the meter toward full-scale. The meter reads linearly in duty cycle, 0 being points fully open, and 100% deflection, fully closed. A linear angular scale may be added for dwell if preferred, although two-thirds full-scale is the nominal dwell reading, as mentioned previously. Inasmuch as almost any meter movement up to 10 ma. is suitable for this application (a 2" Weston 500-μa. meter with internal resistance of 235 ohms was used by the author), the following rules of thumb are included for the constructor:

(1) Choose a battery voltage which requires a limiting resistance (*R1* plus *R2*) that is at least ten times larger than the internal resistance of the meter.

(2) Choose *C1* so that the product of the limiting resistance (in ohms) × *C1* (in μf.) is approximately 250.

(3) Choose *C2* approximately eight times larger than *C1*.

If these rules are followed, the dwell meter can be used with reliability over a wide speed range and not just at idle speed where dwell adjustments are being made. This permits checking for "point bounce" and "floating." Capacitors *C2* and *C3* have been included to facilitate adjusting the points of automobiles not having external access to a point-adjusting screw.

Operation. To use the dwell meter on an automobile engine with negative ground, having external access to the points, the following instructions apply:

(1) Switch out *C2* and *C3*.

(2) Connect the "plus" lead of the dwell meter to the junction of the ignition-coil primary and the points. This terminal is readily available on the ignition coil.

(3) Connect the "minus" lead to a ground.

(4) Turn on ignition switch without starting. If the points are closed, the dwell meter will read up-scale. If points are open, momentarily crank engine until points stay closed.

(5) With ignition switch still on and the points closed, adjust *R2* for exactly full-scale deflection.

(6) Start engine and read dwell meter directly for duty cycle (or add degree scale if preferred).

(7) Set the point-adjusting screw for two-thirds full-scale (6.7 if your meter reads 10 full-scale).

(8) Reset engine timing.

These instructions are also applicable for positive-ground ignition systems by merely reversing the meter leads.

For engines not having external access to the points, the following instructions apply:

(1) Switch in *C2*.

Perform steps 2, 3, 4, and 5 as before with due regard to polarity of ground.

(6) Remove center wire (high tension) from distributor and place on or near a ground away from the carburetor. This minimizes chance of coil damage due to internal arcing.

(7) Remove distributor cap and rotor.

(8) Crank engine with starter and read dwell while cranking. (If necessary, meter may be damped by switching in *C3*.) Stop, adjust points, crank again until satisfied.

(9) Reassemble distributor, insert high-tension wire, and time engine.

This dwell meter is very handy for checking point condition of any car by simply clipping the meter in, calibrating, then starting the engine. It has been used with satisfaction by several persons in the past two years on engines with 4-, 6-, and 8-cylinders; one of these autos had a transistor ignition system.

A chassis box was chosen for the housing with the switches mounted for one-hand operation as shown in the photo. The meter shown is a readily available surplus unit. Leads should be unplugged when not in use to conserve batteries, or a power switch could be added. —30—

TACHOMETER & ENGINE IDLE SPEED CALIBRATOR

Low cost, easy-to-make tester calibrates tachometers under actual conditions without any other equipment

By JAMES S. SHREVE

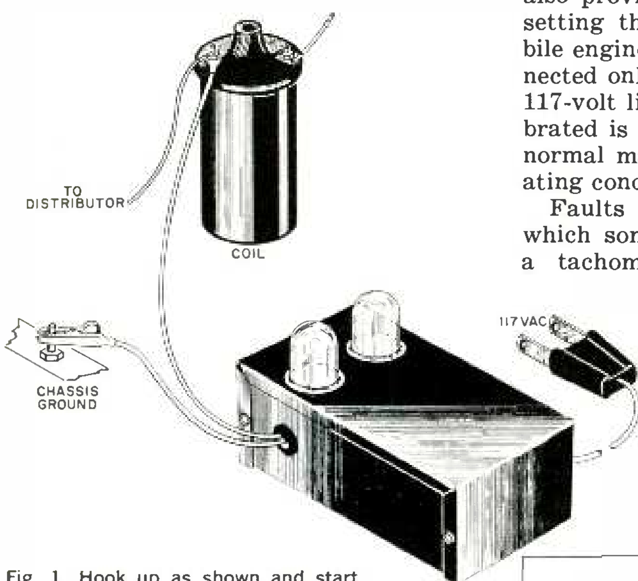


Fig. 1. Hook up as shown and start the engine; both lights will flash. At sync speeds, only one stays on.

THIS simple circuit enables you to calibrate automobile tachometers and check their accuracy. In many cases it also provides an independent means for setting the idle speed of your automobile engine. In use, the calibrator is connected only to the engine and a 60-cycle, 117-volt line. The tachometer to be calibrated is connected to the engine in the normal manner to establish actual operating conditions.

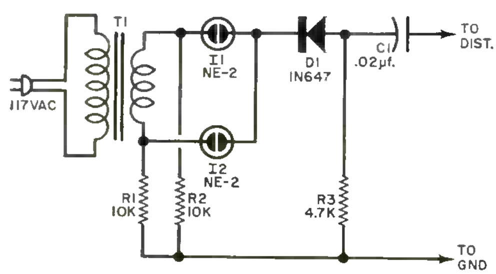
Faults leading to improper readings, which sometimes escape detection when a tachometer is bench-tested instead of tested in the car, have no place to hide. For this reason, the calibrator described here is especially good for testing accuracy of new tachometer designs.

How It Works. The calibrator has two neon lamps which alternately flash on and off when the unit is properly connected to the car and the a.c. power line. The rate of flash diminishes as the engine speed approaches either 450 rpm or 900 rpm for an 8-cylinder car, or 600 rpm or 1200 rpm for a 6-cylinder car. When each lamp flashes about once per second, engine speed is off by only 1.7%.

PARTS LIST

C1—0.02-µf, 600-volt capacitor
D1—1N647 diode rectifier
I1, I2—NE-2 neon lamp
R1, R2—10,000-ohm, ½-watt resistor
R3—4700-ohm, ½-watt resistor
T1—24-volt transformer (Burstein-Applebee stock No. 18B506 or equivalent)
1—5¼" x 3" x 2⅛" metal case
Misc.—A.c. line cord, 5- or 6-point terminal strip, two grommets, two alligator clips, and two neon lamp sockets

Fig. 2. Pulses from the ignition coil are keyed to the 60-cycle a.c. power line and cause the neon lamps to blink out a calibration signal.



As the engine reaches exactly one of the test speeds given above, one of the lamps will stay on and the other will stay off.

Figure 1 shows the hookup to the car and Fig. 2 is a schematic diagram of the calibrator. The principle of operation is rather simple: the whole idea is based on a coincidence of pulses from the distributor and the 60-cycle a.c. line voltage.

The ringing voltage produced in the primary circuit when the ignition points open passes through *C1* and appears across *R3*. Every positive swing of the ringing voltage passes through diode *D1* and attempts to ignite the neon lamps (in some cases the lamps do go on from ignition pulses only). At the same time, the voltage from the secondary winding of *T1* is also applied to the neon lamps. Therefore, at any given instant the potential across the neon lamps will be increased or decreased by *T1*.

While the potential across one lamp is increased, the potential across the other lamp is decreased by the same amount. The "favored" lamp fires at intervals or continues to fire and the other lamp is either extinguished at intervals or remains off. The speed of the alternate on-and-off action varies with the degree of out-of-sync conditions between the two comparison voltages.

When the distributor pulses are synchronized with the 60-cycle line, only one lamp is favored each time and appears to remain on all the time. Its partner never receives adequate voltage to fire; and thus it remains off all the time. A slight change in engine speed, either faster or slower, will again result in first one lamp, then the other, being in the favored position.

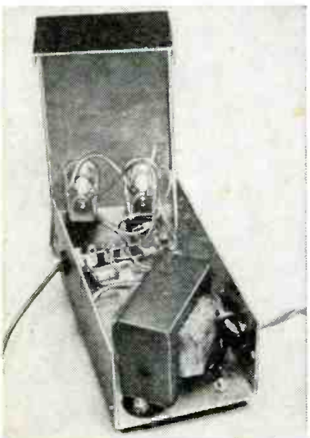
The lower of the two sync points for a given engine takes place when one ignition pulse occurs for every two cycles of line current. The higher sync point shows up when one ignition pulse occurs for every cycle.

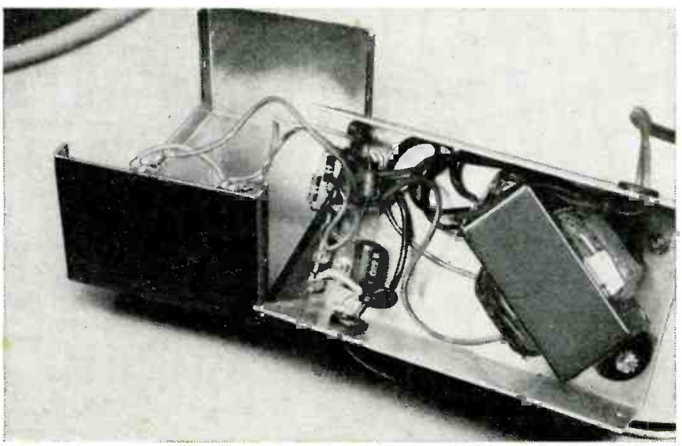
The calibrator will not work when primary circuit pulses are too low, too high, or of very short duration. Short duration pulses are found in transistor and capacitor ignition systems, but not in the conventional ignition system. High and low voltage pulses normally will not have to be reckoned with in an ignition system that is operating properly. If the pulse is too low, the neon lamps will not ignite; if the pulse is too high, the lamps will not shut off.

Construction. Layout of parts is not critical. A terminal strip supports all of the components except the transformer. It is desirable, if space permits, to install the calibrator in the tachometer's housing. Otherwise, a small metal or plastic cabinet can be used. The neon

(*Continued on page* 148)

Fig. 3. Allow enough room for neon lamp sockets to clear terminal strip when meshing both halves of the box. Lay out parts in any convenient manner. Neon lamps can be mounted in grommets or sockets.

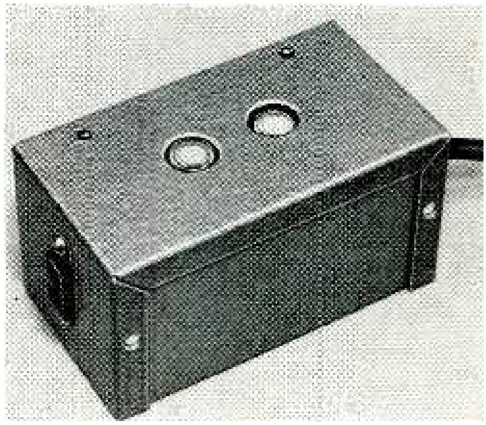




Self-Regulating Lighting Controller

Get even light even when day changes to night—build this automatic device

By EDWARD P. NAWRACAJ and FRED FORMAN



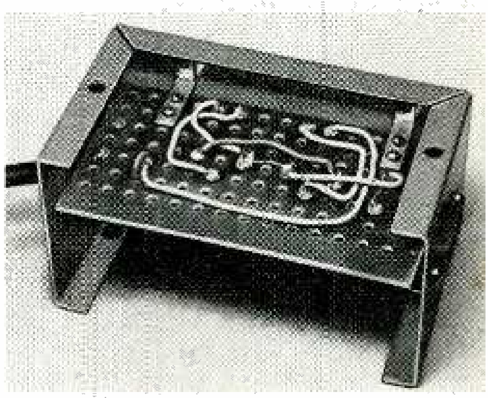
Point the "eyes" away from direct light to automatically compensate for varying ambient light levels.

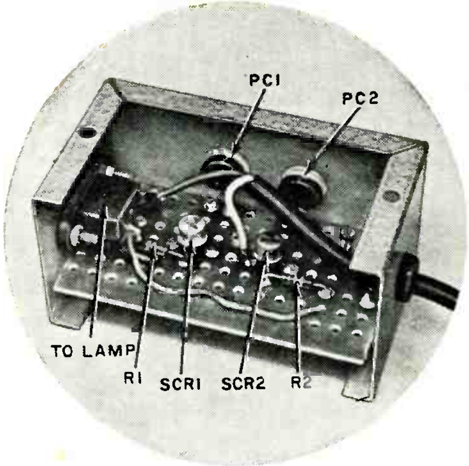
TURN off the lights and the regulated lamp goes on. Turn on the lights and the regulated lamp goes off. Let the overall ambient illumination vary between daytime and nighttime, and the regulated lamp will vary in intensity in the opposite way. The lighting controller "wants to see" the same amount of light regardless of how bright or dim the day or night, and will automatically compensate for varying levels of illumination. You can establish an average round-the-clock light level limited only by the power-handling capabilities of the controller.

How It Works. Photoconductive cells *PC1* and *PC2* are in series with resistors *R1* and *R2* respectively, and form simple voltage dividers to apply triggering voltages to the gates of silicon-controlled rectifiers *SCR1* and *SCR2*. When the ambient light level is low, the resistance of the photoconductive cells is high. Proportionally higher voltages are developed across the cells and applied to the appropriate SCR gate.

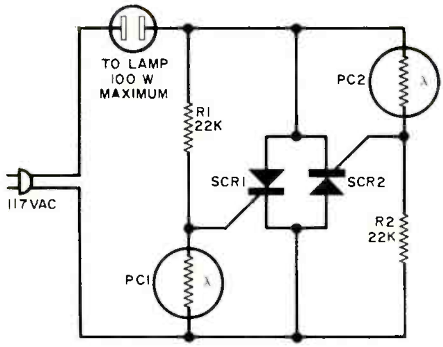
The SCR's fire when the gates and anodes are sufficiently positive with respect to the cathodes. The higher the

Simplicity of construction is the keynote of the controller. Only four components are on the chassis.





The two SCR's can be connected directly to the board and soldered into the circuit, or plugged into appropriate sockets. Avoid overheating the SCR's when soldering.



Brilliance of regulated lamp depends on how long each SCR is on.

positive voltages, the sooner the SCR's conduct, and the longer they stay on. The longer the SCR's stay on, the brighter the regulated lamp.

Once the SCR's conduct, the gates have no further control and conduction takes place until the anode voltage is removed or reduced below the holding point. This happens each time the 60-cycle line voltage reverses. When the line voltage reverses, the SCR that was on—or conducting—switches off, and the SCR that was off switches on. When ambient light levels increase, the resistance of the cells decrease, and so down goes the amount of control voltage applied to the gates of the SCR's.

The 22,000-ohm resistors establish a preset range of overall operation. Variable controls of about 50,000 or 75,000 ohms can be substituted to shift the range to satisfy most requirements.

Construction. Any available box—even a cigar box—can be used to house the controller. There is nothing critical about construction or location of the parts. Only four parts (the SCR's and resistors) are mounted on a perforated phenolic board used as a chassis. The cells are mounted on the case, as is the regulated lamp's socket.

Aim the cells away from any direct light, including the regulated lamp, in order to get them to respond to ambient conditions. The regulated lamp will flicker on and off if you point it at the photocells. Differences in parts values, due to normal commercially accepted tolerances, may cause one photocell to do more work or be more responsive than the other. To prevent this possibility, you should use matching components.

The SCR's used by the author are RCA 2N3228's, costing less than $2 each (Motorola MCR 1304-4's and Texas Instruments TI 3012's will also work. The photocells are Clairex CI 505's at about $3 each (the Lafayette 99 G 6322 at 99 cents will serve as well). Resistors *R1* and *R2* are 22,000-ohm, ½-watt units. A 4" x 2¼" x 2¼" metal box and other miscellaneous small hardware are also needed.

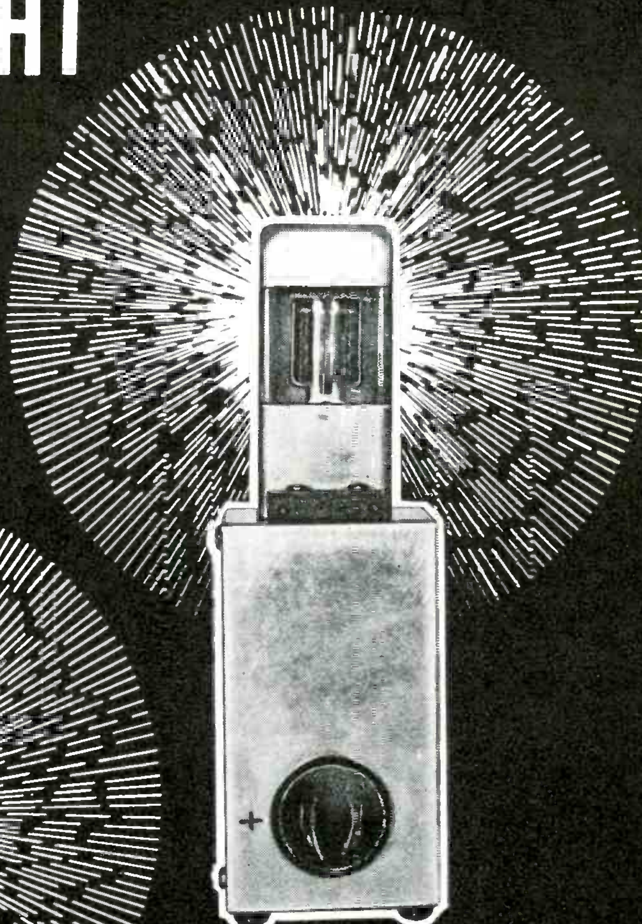
The 2N3228, without a heat sink, has a 1.57-ampere maximum rating when it is conducting for half the time, as is the case when the controlled lamp is full on. With less than half conduction time, greater current-handling ability is possible. With a suitable heat sink, the same SCR can safely handle up to 3.2 amperes or about 375 watts of power.

Other Uses. Many other applications are possible for the controller. It can be used to activate a relay which, in turn, would switch on or off other types of loads, such as alarm devices, appliances, and motor-driven machinery. Larger lamp loads could also be turned on or off by such a relay.

When the controller is used in this manner, however, it becomes a simple on/off triggering device, and you will not get varying and intermediate levels of illumination from the lamp. —30—

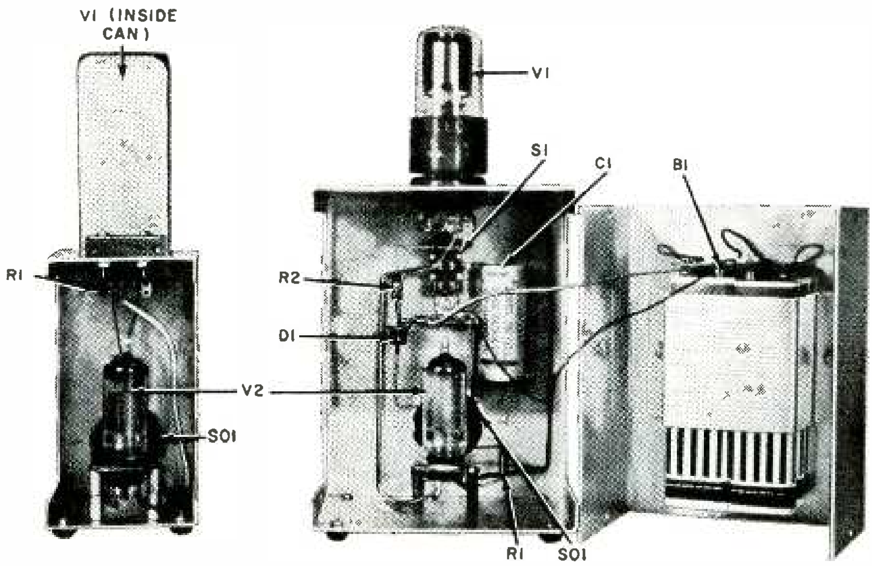
STROBELIGHT SLAVE

By W. F. GEPHART



Convert any electronic flash unit to a cordless, reliable, light-actuated slave with an easy-to-build adapter

HOW OFTEN have you wished you had more convenient and better flash units to provide fill-in light for photographs of large groups, sports events, or in other critical spots where the light is unfavorable? When you talk about "better," chances are you mean electronic strobe units with their reliability, quick recycling time, and (in recent years) relatively low cost. When it comes to convenience, a prime requisite is the elimination of awkward, hazardous, unreliable cables.



PARTS LIST

B1—180 volts (four Burgess U-30 45-volt batteries or equivalent)
C1—20-µf., 250-volt electrolytic capacitor
D1—1N539 silicon diode or equivalent
*R1—10-megohm, ½-watt resistor**
R2—680,000-ohm, ½-watt resistor
S1—D.p.d.t. slide switch
*SO1—Panel-mounting female receptacle, a.c. type (Amphenol 61-F or equivalent)**
*V1—929 phototube**
*V2—5823 gas triode**
*1—Octal socket**
*1—7-pin miniature socket**
1—2¼" x 2¼" x 4" aluminum box for basic unit, or 3" x 4" x 5" box for booster unit*
Misc.—Shield can for V1, 1" spacers* for mounting V2, 6-32 hardware*, terminal strip, scrap aluminum for battery retainer, battery terminals, rubber feet*, wire*, solder*.*
*Only the parts marked with an asterisk are used in the basic Strobelight Slave.

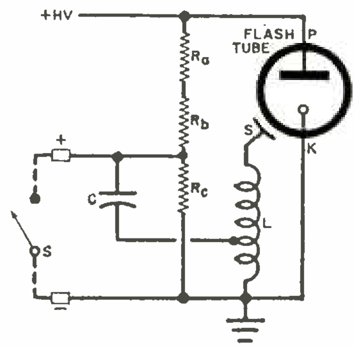


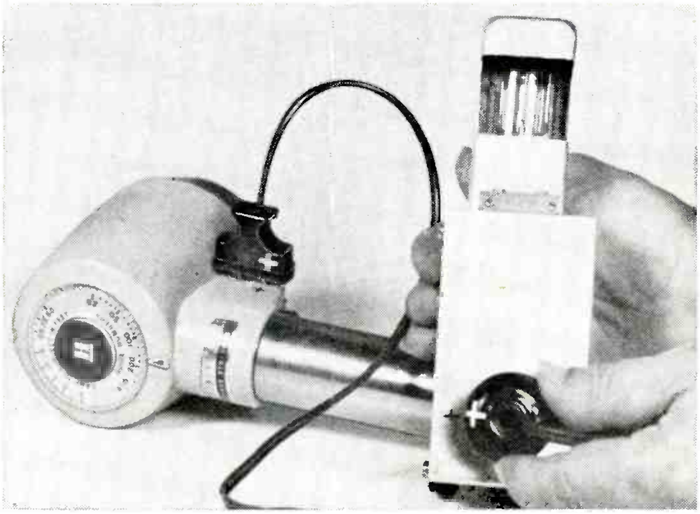
Fig. 1. Shutter discharges capacitor through coil to fire typical strobe.

In addition to the inherent problems cables present, different strobe units cannot always be wired together—in some cases damage may result. Even if the units are similar and designed for parallel operation, polarities must be carefully observed.

What the foregoing list of factors adds up to is the "Strobelight Slave," a simple adapter, described here in two versions, which can be used to convert any electronic flash into a light-operated slave unit. With the slave, the strobelight can be remotely located, responding instantly to the flash from the master strobe fired by the camera shutter.

Typical Strobe Operation. Figure 1 shows the firing arrangement used in most electronic flash units. High voltage is applied to the flash tube between its plate and cathode, while the starter anode is connected to ignition coil *L*. Capacitor *C* is charged to a certain percentage of the high voltage through the voltage divider consisting of *Ra*, *Rb*, and *Rc*. When the shutter contacts (*S*) close, the capacitor discharges through the lower part of the coil, inducing a very high voltage in the upper part, and causing the flash tube to fire.

Basic Slave Circuit. A look at the Strobelight Slave Circuit shown in Fig. 2 reveals how it works. The 5823 (*V2*), a gas-filled triode, operates as a switch. At least 150 volts must be applied between the plate (pin 1) and the cathode (pin 7 or pin 3). No conduction occurs until a certain voltage appears on *V1*'s



Basic Strobelight Slave is shown connected to strobe with a cord terminating in plugs on both ends. Both plugs and the sockets on the strobe unit and either slave unit should be marked with plus signs to avoid damage from cross-polarizing units.

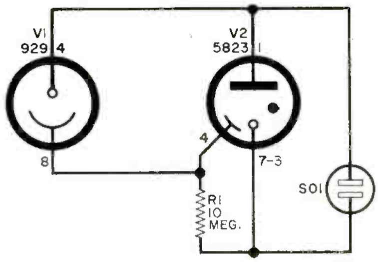


Fig. 2. Basic Strobelight Slave is self-powered, can be used if charging voltage is 150 volts or more.

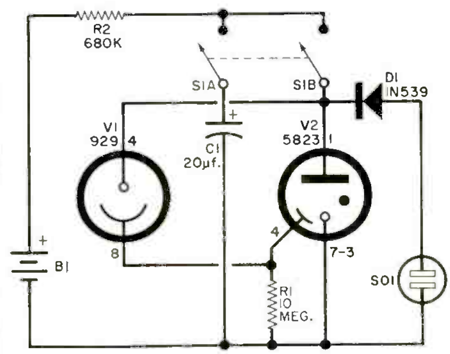


Fig. 3. Booster slave uses batteries to fire V2 with low-voltage type strobes.

starter anode (pin 4). When this happens, the tube then fires, and conducts to such an extent that the plate and cathode are literally shorted. Of course, this condition causes the remote strobe unit plugged into *SO1* to flash.

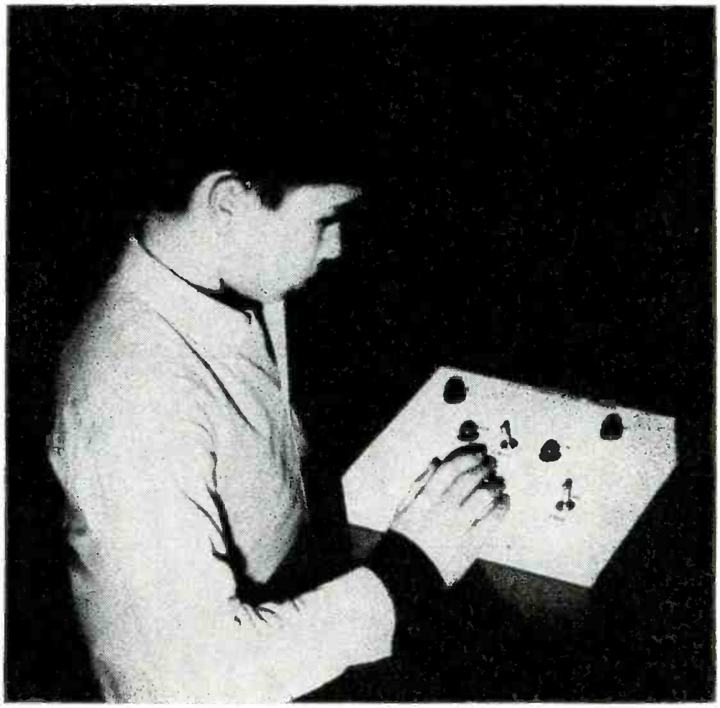
The trigger voltage for *V2* is generated by *V1*, a 929 phototube, in response to the light from the master strobelight. The basic Strobelight Slave shown in Fig. 2 is, therefore, completely self-powered, and may be used with any strobe having a shutter capacitor charging voltage of at least 150 volts.

Booster Slave. The second version of the Strobelight Slave shown in Fig. 3 provides supplemental voltage for the slave trigger tube when the capacitor charging voltage of the strobe is less than 150 volts. Here, *B1* is used to charge *C1* through *R2*. This insures that the full battery voltage is available to fire *V2* when light strikes *V1*, since, when fully charged, *C1* bolsters the current capacity of *B1*. Diode *D1* isolates the internal slave voltage from the strobe unit, but permits current to flow in a forward direction when *V2* fires, firing the strobe connected to *SO1*.

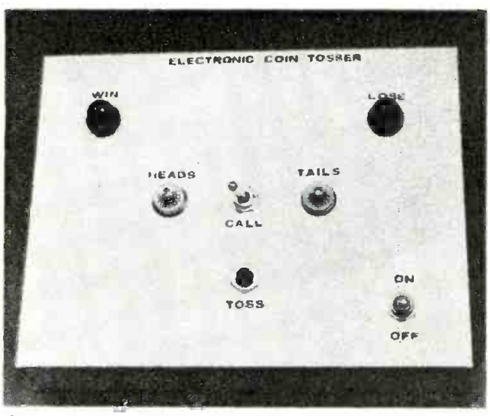
The second version of the Strobelight Slave also includes switch *S1* to cut *B1* out of the circuit when the slave is used with units having high shutter contact charging voltages—normally *S1* is on only when used with units having low charging voltages. However, when a strobe unit has a charging voltage over

(*Continued on page* 147)

TRUE YES HEADS BLACK WIN GREEN



HERE'S a clever computer-type gadget that will provide hours of fun for "youngsters" of all ages, and at the same time teach basic computer logic. A good science fair project, the "Electronic Coin Tosser" simulates electronically the toss of a coin. The probability of the *HEADS* lamp lighting is 50:50. That is, if the game is played one hundred times, the heads will come up approximately fifty times.



CALL switch leaning towards HEADS allows WIN lamp to light if electronic flip-flop stops on heads. Press TOSS button to match wits with the "brain."

To play the game, turn the power switch on and allow time for the lights to quit blinking. Now make your call by throwing the *CALL* toggle toward *HEADS* or *TAILS*. Toss the coin by pressing the *TOSS* button momentarily. The lamps begin to blink, and increase in speed; suddenly the blinking stops; and just as suddenly you win or lose, for the *HEADS* or *TAILS* lamp goes on, and so does the appropriate *WIN* or *LOSE* lamp.

Theory of Operation. A computer-type logic diagram for the game is shown in Fig. 1. Like a double-throw switch, the flip-flop circuit places a signal first on one side, then on the other. Looking at the switch or the flip-flop circuit at any given instant, you will find that when there is an *on* condition on one side there is an *off* condition on the other, and vice versa. Actually, any binary type of indication can be programmed, such as 1 and 0; on and off, plus and minus, hot and cold, black and white, heads and tails, etc.

In this project, the readout is *HEADS* and *TAILS*, and *WIN* and *LOSE*. If the flip-flop in our game stops on heads, the *HEADS* output will be a 1 and the

ELECTRONIC COIN TOSSER

By WOODROW POPE
Design Engineer
Collins Radio Co.

FALSE
NO
TAILS
WHITE
LOSE
RED

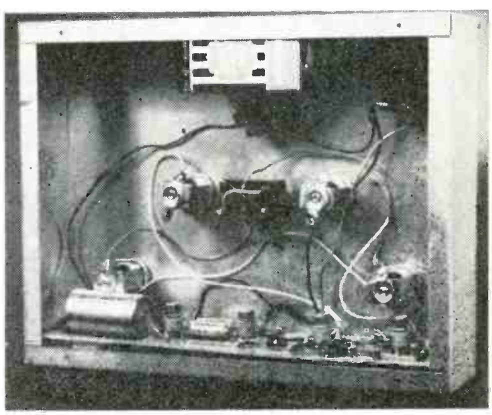
TAILS output will be a 0. These signals as well as the signals from the *CALL* heads and tails switch are fed to a series of logic gates. There are four *AND* gates (*G1*, *G2*, *G3*, *G4*) and 2 *OR* gates (*G5*, *G6*). Each gate has provisions for two input signals and one output signal. The output signal depends upon the input signal.

To simplify matters, consider heads to be 1 and tails to be 0 when heads are called. When tails are called, tails be-become a 1 and heads a 0. The *AND* gate requires a 1 on both inputs to give a 1 on the output; a 1 and a 0, or a 0 and a 0, on the inputs gives a 0 on the output. An *OR* gate requires a 1 on either input to give a 1 on the output; a 0 and a 0 on the inputs give a 0 on the output.

In order to light the *WIN* lamp, a logic 1 on its input is needed. This means the *OR* gate (*G5*) must have a logic 1 on at least one of its inputs. To reach this condition, one of the *AND* gates must have logic 1's on both its inputs.

Assume heads is called. This puts a logic 1 on input #1 of gate *G1* and gate *G4*. It also puts a logic 0 on input #1 of gate *G2* and on input #2 of gate *G3* (logic 0 means tails was not called). Also assume that the flip-flop circuit stops on heads, putting out a 1 on the heads output and a 0 on the tails output.

So now we have: a 1 on inputs #1 and #2 of gate *G1*, and it puts out a 1; and both inputs of gate *G2* have 0's, and it puts out a 0. Gate *G5* now has a 1 on input #1 and a 0 on input #2 and so it puts out a 1, and causes the *WIN* lamp to light. What about gates

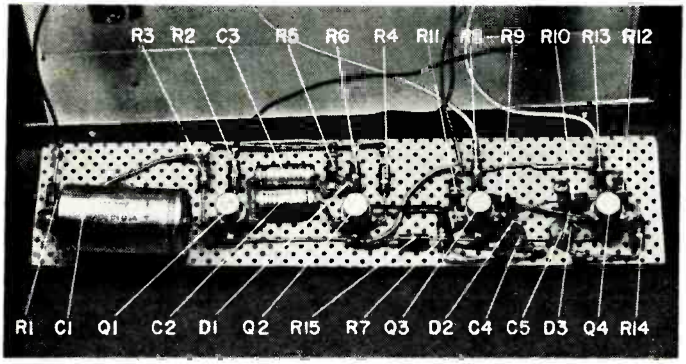


Rear view of Electronic Coin Tosser shows simplicity of wiring and assembly. Battery can be held in place with a dash of glue, or a suitable bracket.

G3 and *G4*? Gate *G3* has a 1 on input #1 and a 0 on input #2, so its output is a 0. Gate *G4* has a 1 on input #1 and a 0 on input #2, so it too puts out a 0. Gate *G6* has 0's on both inputs, so its output is 0 and the *LOSE* lamp does not light. Try your hand at the three other possible combinations.

How It Works. The circuit consists of an astable and a bistable multivibrator, as shown in Fig. 2. The astable multivibrator looks like an ordinary collector-coupled circuit except that the two bias resistors (*R3* and *R4*) are connected to a 150-μf. capacitor (*C1*). When the *TOSS* button (*S1*) is closed, *C1* takes on a charge from *B1* through *R1* and applies this voltage to *R3* and *R4* and allows the astable multivibrator to oscillate. Oscillations continue until the voltage across *C1* falls below the level required to forward-bias *Q1* and *Q2*.

The output from the collector of *Q2* is fed to the inputs of the bistable multivibrator through *C4* and *C5*. The signal at this point is in the form of a square wave and triggers the bistable multivibrator (*Q3* and *Q4*). In the absence of an input signal, either *Q3* or *Q4* is conducting all the time. When *Q3* conducts, *Q4* is off, *I3* is on, and *I4* is off. When *Q4* conducts, *Q3* is off, *I3* is off, and *I4*



All components are mounted on Vectorbord with push-in terminals. Use of transistor sockets eliminates possible soldering heat damage to the transistors. Entire assembly can be secured to the cabinet by a machine screw and nut at each end. Use suitable standoffs to keep the bottoms of the push-in terminals from touching the cabinet.

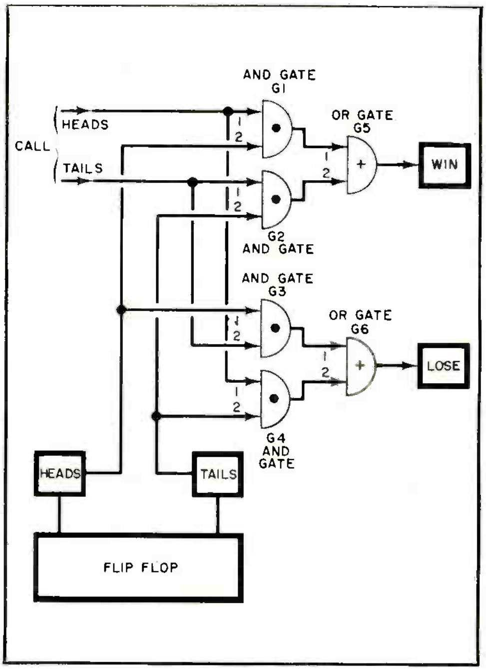


Fig. 1. Computer logic diagram shows action required to light WIN or LOSE lamps. Selection of heads with the CALL switch places a 1 on input #1 of G1 and G4. If the flip-flop oscillator stops on heads, it places a 1 on the inputs of G2 and G3. All other inputs on G1 through G4 have a 0. Since G1 is the only gate with a 1 on both inputs, its output is a 1. AND gates have an output of 1 when both inputs are 1. OR gates (G5 and G6) require at least a 1 on either of the inputs to signal a 1 on the output. A 1 output from an OR gate is needed to light the WIN or LOSE lamps. Since G5 has a 1 on one of its inputs, its output is 1 and the WIN lamp lights. See text and try your hand at logic.

is on. In the presence of an input signal, *Q3* and *Q4* cycle on and off continuously. When the input signal is removed, the circuit reverts back to one of its two possible stable states.

Switch *S3* connects *I1* and *I2* in series with the appropriate circuit. When the call is heads, *I1* is in series with *I3* and *I2* is in series with *I4*. If tails is called, the series connections are interchanged; *I1* and *I4* are in series, and *I2* and *I3* are in series. If the manual selection of heads or tails coincides with the random electronic selection of heads or tails, the *WIN* light (*I1*) goes on; otherwise the *LOSE* light (*I2*) lights up.

Construction. A 2" x 7" x 9" aluminum chassis is used to hold the game. The circuit is built on a piece of 1¾" x 8" Vectorbord using push-in terminals.

Layout is not critical but care should be taken when soldering diodes and transistor leads so that they do not become overheated. Polarity of diodes and electrolytic capacitors must be observed. Transistor sockets are convenient to use and eliminate the possibility of ruining a transistor with a soldering iron.

A d.p.s.t. switch (*S2*) is used as an on/off switch, but a s.p.s.t. unit will do just as well. Connect the positive side of the battery directly to the lead serving as ground.

The chassis is finished with flat white paint and lettered with rub-on decals. Lenses for the *WIN* and *LOSE* lamps are colored green and red respectively. *HEADS* and *TAILS* lens color could be either amber or white. —30—

PARTS LIST

B1—9-volt battery (Burgess 2N6 or equivalent)
C1—150-µf., 100-volt d.c. electrolytic capacitor (d.c.w.v. could be as low as 10 volts)
C2, C3—7-µf., 50-volt d.c. electrolytic capacitor
C4, C5—0.002-µf. ceramic capacitor
D1, D2, D3—1N34A diode
I1, I2, I3, I4—#49 lamp
Q1, Q2, Q3, Q4—2N404 transistor
R1—680 ohms
R2, R6—1000 ohms
R3, R4—6800 ohms
R5—3300 ohms
R7, R14—10,000 ohms
R8, R13—68 ohms
R9, R10—1200 ohms
R11, R12—100,000 ohms
R15—15 ohms
(all resistors ½-watt carbon, ±10%)
S1—Normally open push-button switch
S2—D.p.s.t. toggle switch (s.p.s.t. may be used)
S3—D.p.d.t. toggle switch
1—2"x7"x9" aluminum chassis
4—Lamp holders with lenses; 1 red, 1 green, and 2 amber
Misc.—1¾"x8" Vectorbord and push-in terminals, or equivalent, to hold components; four transistor sockets (optional); battery connector terminals; and wire

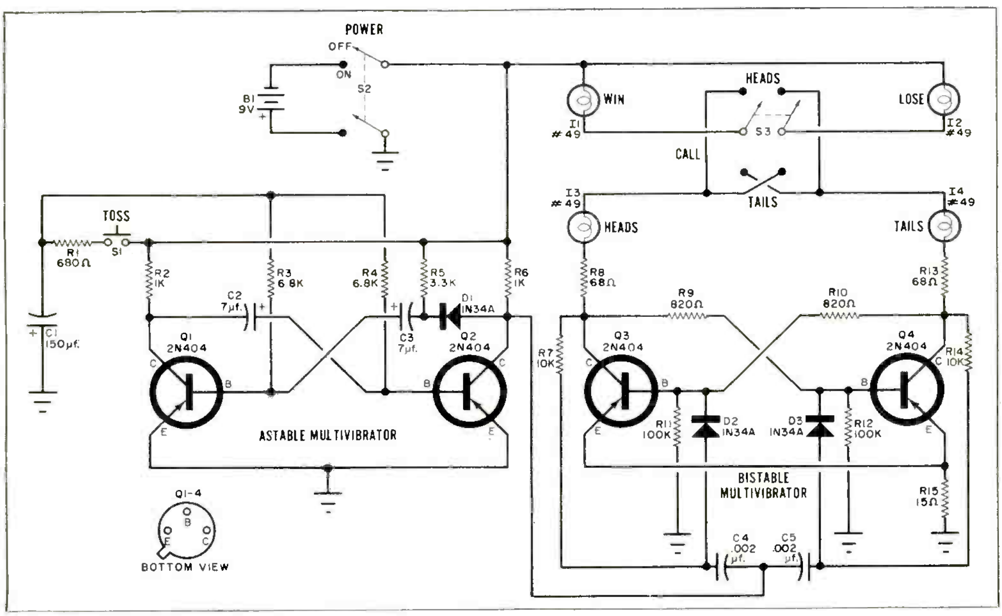
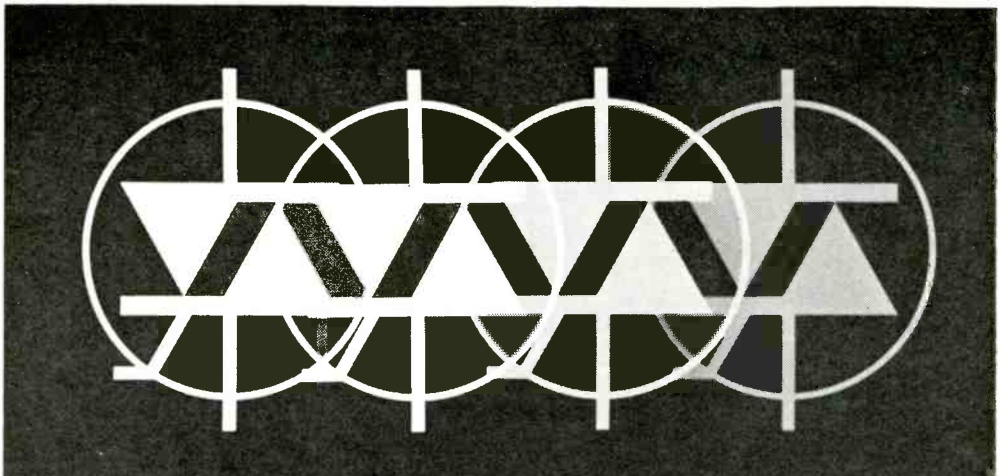


Fig. 2. Bistable multivibrator flip-flops from heads to tails only when the astable multivibrator is in action. Position of S3 and electronic selection of heads or tails determines the win or lose indication.



THE DYMWATT

By DON LANCASTER

Build a full-wave motor speed control and light dimmer with new Triac semiconductor and four other components

MEET the "Dymwatt." It's a no-nonsense light dimmer and power-tool speed control that provides up to 600 watts of 117-volt a.c. with a symmetrical waveform and full-range, variable power output. The circuit uses only five electronic parts and fits in the palm of your hand.

With the Dymwatt, you can get precise control of incandescent lights, photofloods, soldering guns and irons, and electric drills. It will also control any motor rated up to ½ horsepower and equipped with brushes—including most, but not all, sanders, fans, and electric mixers. The only things this control can't handle are fluorescent lights and induction motors—but neither can most of the ordinary power controls.

The two special parts in the circuit, *Q1* and *D1*, price out at $4.65 and $1.02 respectively. This puts the Dymwatt's cost at less than $6 if you've got a volume control, a box, and two stock capacitors.

The "Triac." Older control designs call for SCR's. A single SCR provides a half-range type of control, as between half and full brightness, or between zero and half brightness. To provide full-wave, full-range control, you have to add parts—usually a second SCR, a single mechanically switched diode, or a full-wave bridge rectifier.

The "Triac" is a new semiconductor which makes possible full-wave control without the need for all the extra components. The electrical equivalent of SCR's back to back, it operates equally well in both current directions, and with either a positive or negative gate pulse!

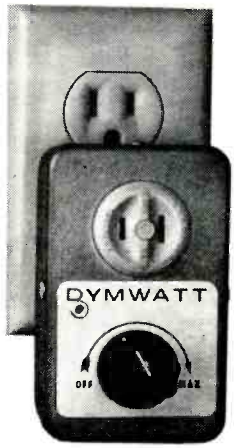
Two of the Triac's three leads (*T1* and *T2*) are connected in series with the load. The third connection is the gate lead (*G*). (The designations *T1* and *T2* simply mean terminal 1 and terminal 2. Designations of anode and cathode, unfortunately, cannot apply in this case. An equivalent set of components for the Triac would contain seven transistors and several resistors.)

A small signal pulse can trigger the Triac so that it will fire just like a thyratron, and switch on full or partial power to the load. Conduction stops when the current through the load circuit drops to zero. This happens every time the a.c. voltage goes through zero. It also happens when the load is removed, or the circuit is opened.

How It Works. Current through potentiometer *R1* (see Fig. 1) charges capacitor *C1* up to 30 volts, which is the breakdown voltage of the special pulse diode (*D1*). At 30 volts, the pulse diode "snaps" on and delivers a pulse to the Triac gate. The Triac then turns on, allows full current flow through the load, and shorts out the *R1, C1* circuit. Diode *D1* keeps conducting until *C1* is discharged, and then turns off. The Triac continues to conduct until the a.c. line voltage alternates and goes through a zero.

The larger *R1* is, the longer it takes to charge *C1* and the longer it takes to turn on the Triac. The fact that the Triac shuts off at the end of each ½ cycle of line voltage, plus the delayed start of conduction, reduces the conduction time and the effective voltage (r.m.s.) accordingly. Thus, it becomes apparent that increasing or decreasing the value of *R1* controls the r.m.s. voltage. See Fig. 2.

If *R1* is nearly zero in value, *C1* charges very rapidly, and nearly full power reaches the load. If *R1* is very large in value, *C1* never reaches 30 volts within the 60-cycle swing. With each alternation of voltage, *C1* starts to charge in the other direction. Under this condition, gate pulses cannot be



Finished Dymwatt can be plugged into one opening of a duplex receptacle without obstructing the other. You have a choice of using the controlled or noncontrolled outlet. Cost of this full-wave unit is less than that of commercially available half-wave controllers.

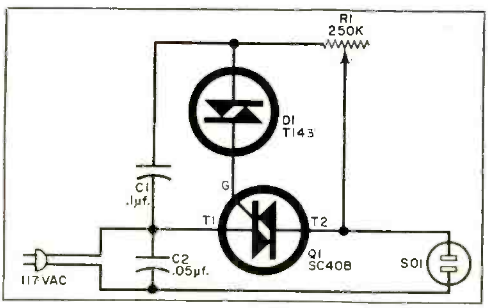
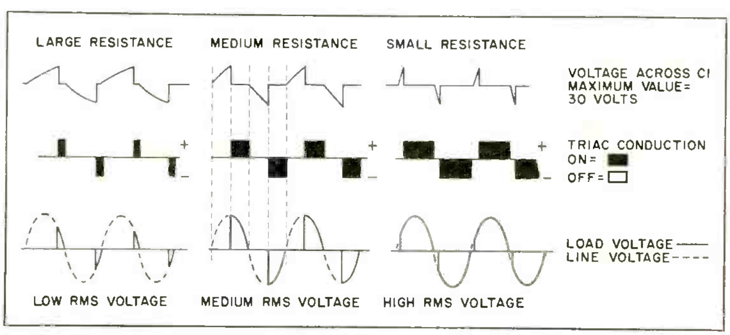


Fig. 1. The Triac (Q1) will conduct in either direction. A positive or negative gate pulse can trigger conduction and control r.m.s. output voltage.

The heat sink on the inside of the case and the dial plate on the outside are held in place by a rivet (hidden by the capacitor) and the potentiometer nut.

Fig. 2. When C1 reaches 30 volts, D1 conducts and triggers Q1. The sooner the gate pulse is developed with respect to the 60-cycle line voltage, the higher the effective output voltage. With little or no resistance in the circuit, the output is maximum. As the resistance increases, the output decreases. If the resistance is made high enough, the output is 0.



produced and the Triac remains cut off. By making *R1* variable, it is possible to adjust for maximum or minimum power output.

Capacitor *C2* is directly across the line to prevent any high-frequency pulse, which might be set up by the fast switching action of the Triac, from radiating down the power line and becoming a source of radio interference.

Construction. The Triac should be mounted on an aluminum heat sink. A ⅛"-thick piece of aluminum will do the trick. Bend it in a vise or small brake and then drill the holes. Use insulated mounting hardware and silicone grease to mount the Triac, as shown in Fig. 3. The Triac *must* be electrically insulated from the heat sink. Test the setup with

(*Continued on page* 144)

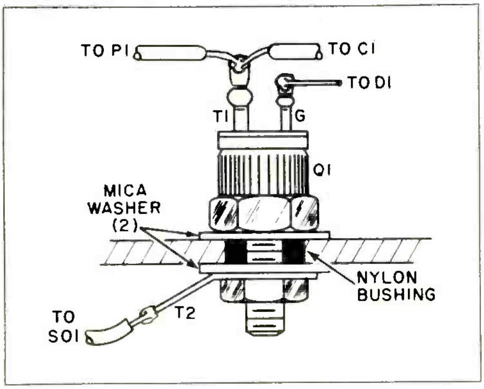


Fig. 3. Silicone grease, two mica washers, and a nylon bushing are used to mount Triac on heat sink to get thermal conduction without electrical contact.

PARTS LIST

C1—0.1-µf., 600-volt capacitor
C2—0.05-µf., 600-volt capacitor
D1—Texas Instruments TI-43 bilateral trigger diode
P1—A.c. plug (Amphenol 61-M or equivalent)
Q1—General Electric SC 40B Triac
R1—250,000-ohm carbon potentiometer, linear taper
SO1—A.c. socket (Amphenol 61-F or equivalent)
1—2¼"x2¼"x4" case, and cover
Misc.—Silicone grease, knob, ⅛" "Pop" rivets, spaghetti, solder, wire, nameplate, and ¼" solderless terminal, 2¼" x 1⅞" x ⅛" piece of aluminum, etc.

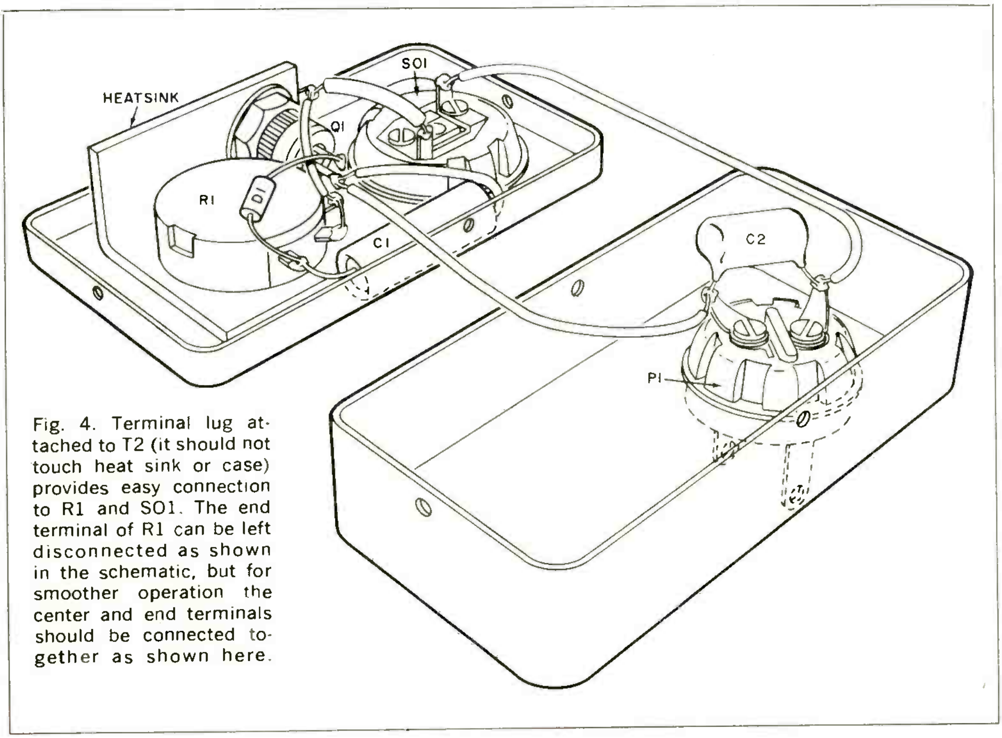
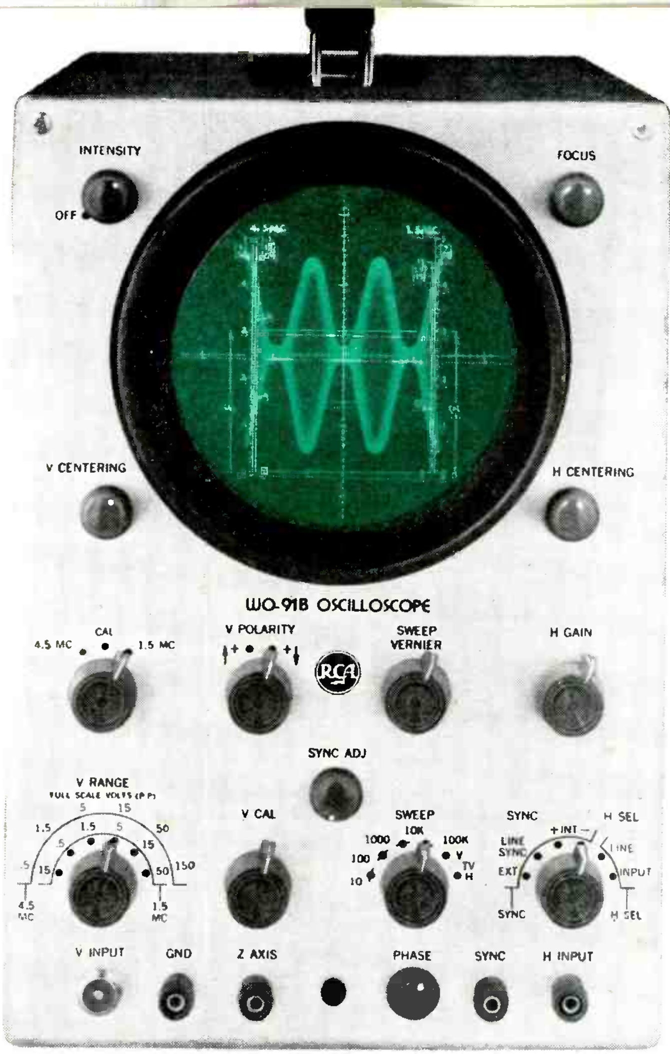


Fig. 4. Terminal lug attached to T2 (it should not touch heat sink or case) provides easy connection to R1 and SO1. The end terminal of R1 can be left disconnected as shown in the schematic, but for smoother operation the center and end terminals should be connected together as shown here.



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CHAPTER

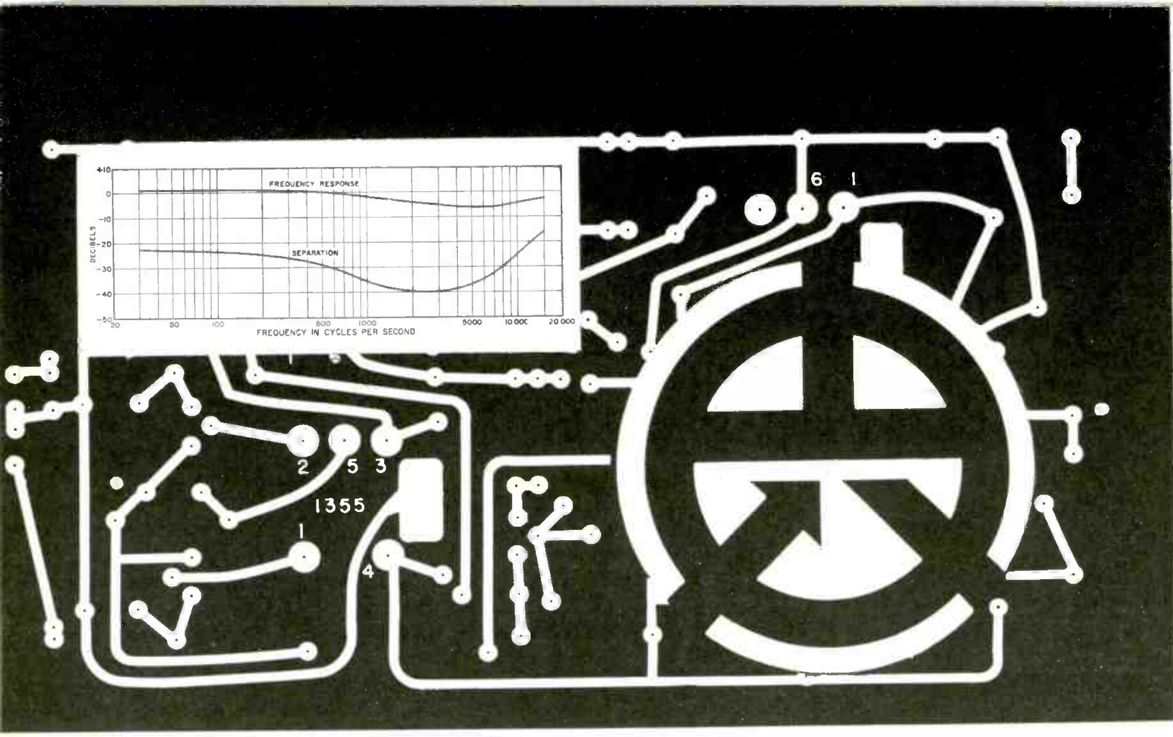
2

AUDIO STEREO HI-FI PROJECTS

Diversity is the key word for this chapter, and all the projects have been selected for maximum reader interest. There are two unusual speaker enclosures, a multiplex adapter, a small public address or intercom amplifier, and a handy stereo balance indicator.

Both of the major electronics construction project stories involve the use of printed circuit boards. Both authors sell these boards at very reasonable prices and both projects have been exhaustively tested by the ELECTRONIC EXPERIMENTER'S HANDBOOK staff. It is the consensus of staff opinion that use of the printed circuit boards absolutely insures easy reproduction of the projects by the home builder and virtually eliminates faulty performance. Sufficient detail has been provided in both articles to enable the do-it-yourself'er with printed circuit board etching facilities to make his own.

Our favorite speaker enclosure designer has returned (Dave Weems has had enclosure designs in each of the last six issues of the HANDBOOK) with a modernized version of a bass reflex patented many years ago. From all reports, the sound from this design is most pleasant and the bass well-rounded.



TRANSISTOR FM MULTIPLEXER

By O.D. CARLSON

Double your pleasure from your hi-fi FM tuner or radio with an automatic switchless FM stereo adapter and stereo indicator

MANY tried and true mono tuners can die a premature death because their owners want stereo reception. However, the addition of a suitable multiplex adapter can prolong the tuner's life. The Transistor FM Multiplexer is a quality, high-fidelity component utilizing a widely accepted time-sharing concept to reconstitute stereo programs in the home. The adapter features a stereo indicator to show when a stereo program is coming through, a switchless stereo-to-mono capability, and a separation of 25 to 30 db across the audio band.

Audio passing through this time-sharing type of multiplexer is not subjected to the nonlinear phase distortion of bandpass filters, as is the case with some matrix-type adapters. Both mono and stereo programs are played through the adapter and electronically switched back and forth, from left to right, at a 38-kc. rate, without any discernible depreciation of quality. Stereo, when it is present, comes out like magic.

How It Works. Signals from an FM tuner are fed to the base of *Q1*. (See Fig. 1.) The 19-kc. pilot component in the stereo multiplexed signal is filtered out in the emitter tank circuit (*T1* and *C3*). All remaining signals are amplified and fed through the 67-kc. filter (*T3*) to an emitter follower (*Q2*). The audio signal is then fed to the collectors of switching transistors *Q5* and *Q6*.

As these transistors are switched on and off, the signal appears first at one emitter and then at the other at a

38-kc. rate. If this switching rate is precisely synchronized with the 19-kc. pilot signal of a stereo station, the left and right components of a stereo program are separated and recovered.

From the switching transistors, the signal passes through the appropriate de-emphasis networks (*C14, R16, C15* and *C16, R17, C17*). Standard 75-microsecond de-emphasis is employed, effectively filtering out any 38-kc. signal that may be introduced by the switching action. For that matter, all frequencies greater than 20 kc. are reduced or eliminated by the de-emphasis network. This is fine for the audio signals going to the loudspeakers, but no good for the signals from the tuner to the multiplexer. The multiplexer has to see the total stereo signal, which also has components greater than 20 kc. and so the signal take-off point in the tuner is *before* the de-emphasis network but *after* the detector.

Returning to the emitter tank circuit of *Q1* in the multiplexer, the 19-kc. pilot signal is fed to two identical amplifiers (*Q3* and *Q7*). Transistor *Q3* amplifies the signal to synchronize the 19-kc. oscillator (*Q4*). The collector tank circuit of this transistor is tuned to the second harmonic of the amplified 19-kc. pilot signal and passes a 38-kc. signal to the switching transistors via *T4*.

To see how the stereo indicator works, let us go back again to the emitter tank circuit of *Q1* and follow the signal path through *Q7*. The amplified 19-kc. pilot signal from *Q7* is rectified by *D1*, providing a negative-going signal to the base of *Q8*, and causing it to conduct and illuminate *I1*. Since the pilot signal is present only on multiplexed broadcasts, the lamp will go on when the receiver is tuned to an operating stereo

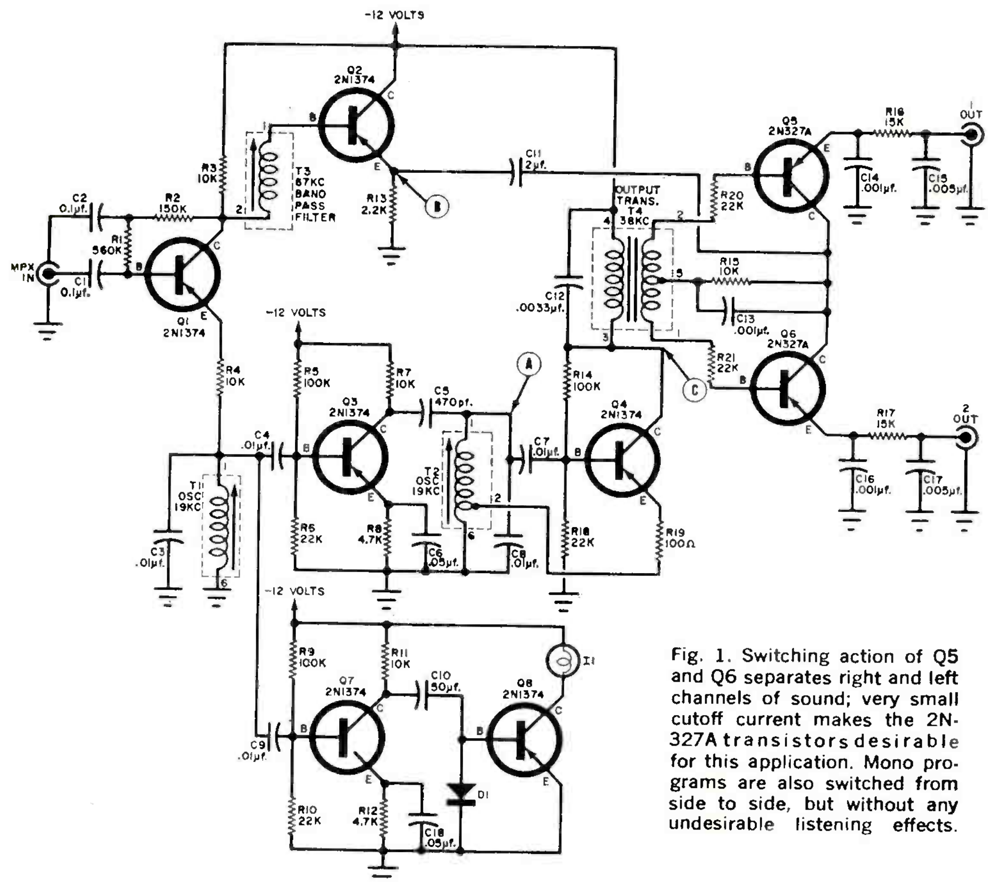


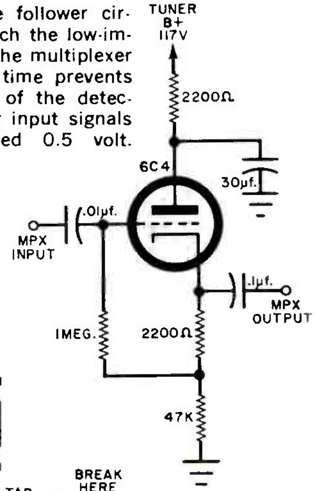
Fig. 1. Switching action of Q5 and Q6 separates right and left channels of sound; very small cutoff current makes the 2N-327A transistors desirable for this application. Mono programs are also switched from side to side, but without any undesirable listening effects.

station. Pilot signal input levels of less than 0.2 volt are sufficient to operate the lamp driver circuit.

Construction. A printed wiring board can be made from the full-scale drawing. However, you can use any other conventional wiring technique and type of chassis. A 6" x 3" undrilled phenolic circuit board containing all internal wiring is available from the author. (See Parts List.)

First, mount the transformers; connect only one spade-type projection on each transformer can to ground, and cut off the other one. Resistors, capacitors, and interconnecting leads for power and indicator lamp follow in just this order. Bend the lead ends slightly to hold them in place and then solder. You can cut off excessive lead lengths either before or after soldering, depending upon which

Fig. 3. A cathode follower circuit serves to match the low-impedance input of the multiplexer and at the same time prevents excessive loading of the detector stage. Adapter input signals should not exceed 0.5 volt.



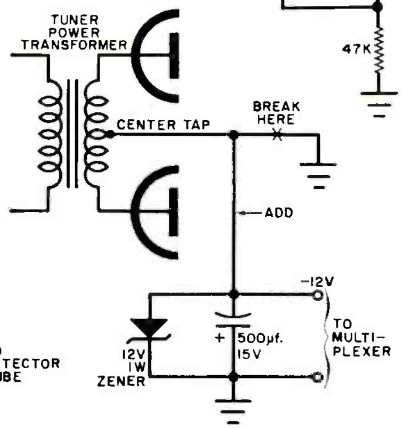


Fig. 4. Zener diode and filter capacitor added to the tuner's power supply eliminate need for an external power source for the multiplexer.

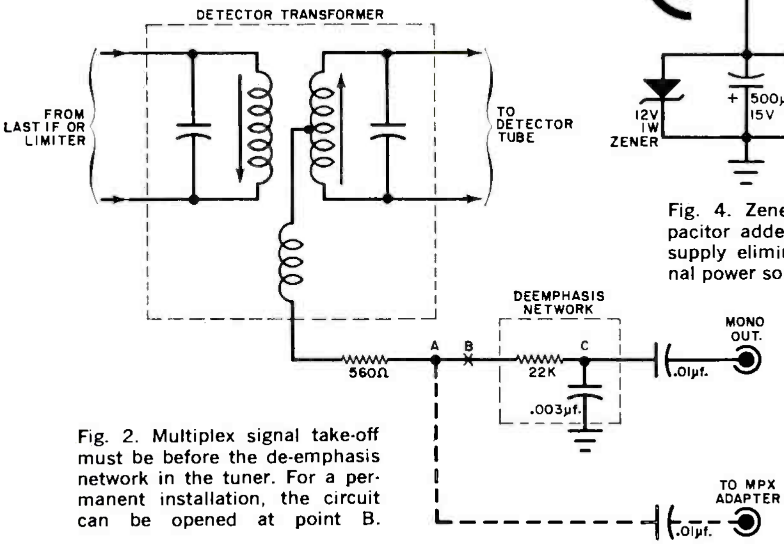


Fig. 2. Multiplex signal take-off must be before the de-emphasis network in the tuner. For a permanent installation, the circuit can be opened at point B.

is easier for you. For best results, do a neat soldering and wiring job and avoid lifting the foil with excessive heat and pressure.

Leave the installation of the transistors and the diode for last. If a transistor socket is used for *Q4*, the oscillator can be easily disconnected during alignment of the adapter simply by removing the transistor. All other semiconductors are soldered directly to the circuit board. Allow approximately 3/8" of air space above the board for clamping a heat sink to each transistor lead as it is soldered.

Connection to FM Tuner. Reception of stereo FM programs places more stringent requirements on a tuner and its antenna than for mono broadcasts. Greater bandwidth and sensitivity is needed for stereo receivers. The extra bandwidth allows for the standard spread of mono signal frequencies plus the stereo signal frequencies. The need for increased sensitivity is evident from the fact that a portion of a given stereo radio station's overall signal strength contains stereo signals. The main channel, therefore has less than maximum power.

PARTS LIST

C1, C2—0.1 µf.
C3, C8—0.01 µf.
C4, C7, C9—0.01 µf.
C5—470 pf.
C6, C18—0.05 µf.
C10—50 µf. electrolytic
C11—2µf. electrolytic
C12—3300 pf.
C13, C14, C16—0.001 µf.
C15, C17—0.005 µf.

All capacitors other than C10 and C11 ceramic disc or mica, 15 volts or better

D1—1N457 diode
I1—Indicator lamp (G.E. 344 or equivalent)
Q1. Q2, Q3, Q4, Q7, Q8—2N1374 transistor
Q5, Q6—2N327A transistor
R1—150,000 ohms
R2—560,000 ohms
R3, R4, R7, R11, R15—10,000 ohms
R5, R9, R14—100,000 ohms
R6, R10, R18—22,000 ohms
R8, R12—4700 ohms
R13—2200 ohms
R16, R17—15,000 ohms
R19—100 ohms
R20, R21—22,000 ohms

All resistors ¼ or ½ watt, ± 10%

T1, T2—Oscillator coil (J.W. Miller 1354-PC)
T3—Bandpass filter (J.W. Miller 1352-PC)
T4—Output transformer (J.W. Miller 1355-PC)
1—Circuit board (ODC 1664)*
1—7" x 5" x 2" metal cabinet
Misc.—Lamp socket, phono jacks, hardware, etc.

**An undrilled 6" x 3" phenolic circuit board is available for $2.50 from O. D. Carlson, 414 Edgewood Ave., Linwood, N. J.*

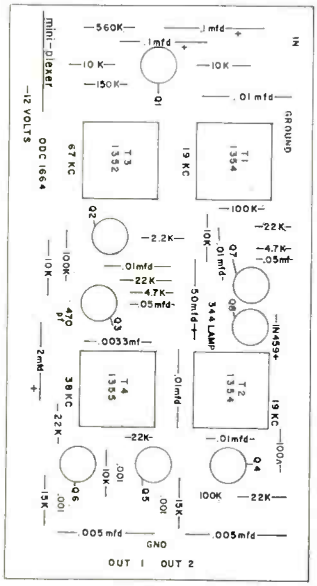


Fig. 5. Component side of board shows parts layout. In spite of its miniature size, there is ample space between the components.

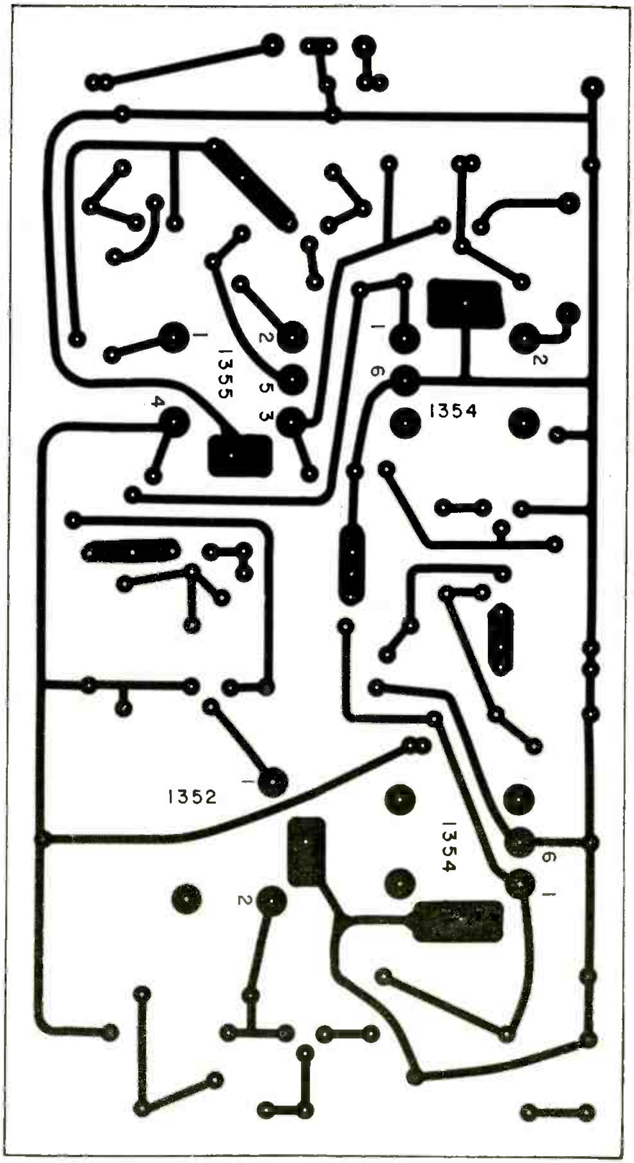
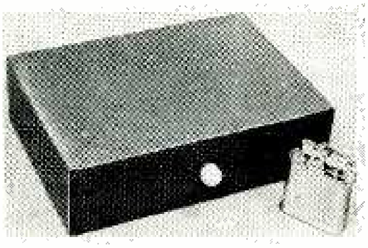


Fig. 6. Actual size of the printed circuit board. Materials are available from your local parts distributor to enable you to make your own board. Or undrilled boards having both sides printed in foil, as shown here and in Fig. 5, can be purchased directly from the author.

FM MULTIPLEXER



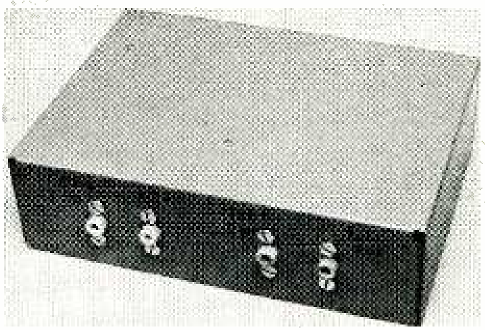


Fig. 7. Indicator lamp on front of cabinet goes on when stereo signals are tuned in. Electronic switching eliminates all external controls.

Tuners having a cathode follower output tube are easily modified to supply proper stereo signals, since this type of circuit already has a low output impedance. All you have to do is hook up the multiplexer in front of the de-emphasis network, as shown in Fig. 2. For a permanent installation, disconnect the de-emphasis network in the tuner (usually an 0.001- or 0.003-μf. capacitor on the output end of the 68,000- or 22,000-ohm resistor which is attached to the grid of the first stage after the detector), and turn the tuner's volume control to maximum (if it affects the signal take-off point).

Volume is not adjusted at this point in the system unless the signal to the multiplexer is in excess of 0.5 volt, because reduction here could diminish the 19-kc. pilot signal needed for the oscillator and other circuits in the adapter. On the other hand, excessive signal strength will cause distortion. About 0.3 volt makes the unit work just fine.

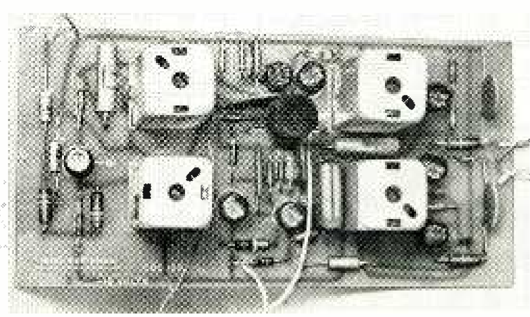
Since the multiplexer is used for both mono and stereo programs, de-emphasis of all signals is reinserted in the multiplexer.

Tuners not equipped with multiplex outputs are generally not satisfactory for stereo reception due to narrow bandwidth and sometimes lack of sensitivity, but with certain modifications and a good antenna can be made to work. In a

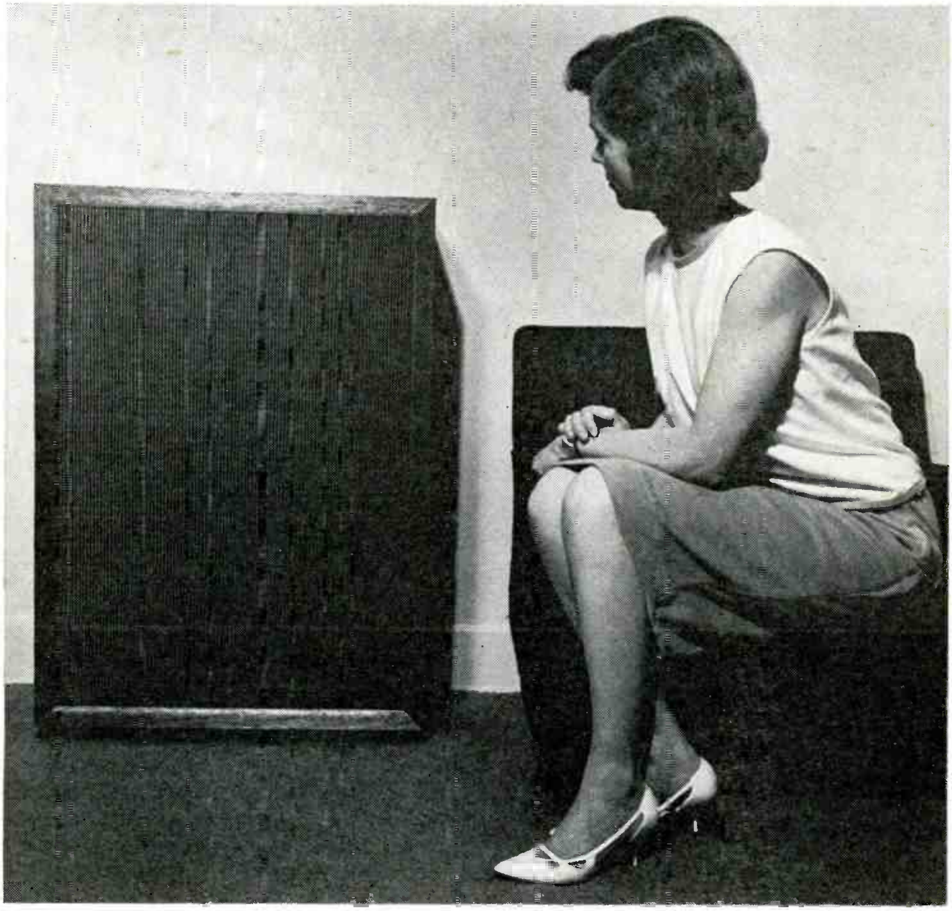
(*Continued on page* 137)

Fig. 9. A printed circuit board or any other standard wiring technique can be used. All components are mounted on one side. Keep transistors about 1/4" above the board, or install in sockets.

Fig. 8. Twisted leads are used as self-shielded conductors. The lead acting as a shield is connected only to the ground foil on the board. A bare wire connects the ground side of the jacks to a single ground point on the circuit board.



MR. THURAS' MAGIC BOX



By DAVID B. WEEMS

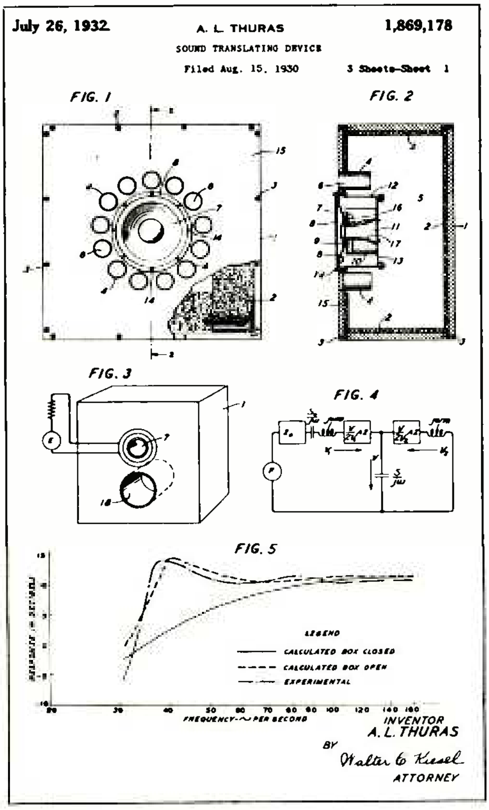
The distributed port bass reflex was invented 35 years ago; with a modern-day hi-fi speaker, it sounds better than ever

MY INTRODUCTION TO HI-FI occurred about 15 years ago when I heard a speaker in a bass reflex enclosure. I was so impressed I bought some plywood and started building bass reflex cabinets, finally owning more boxes than I had speakers to fit. A few years later, I learned about the use of ducts or "tunnels," which permitted a reduction of enclosure volume for a given resonant frequency. Since just about all commercial cabinets of the era had only single ports, the ducted port was apparently a new development of vague and mysterious origin.

Another variation in the bass reflex cabinets of the '50's was the "distributed port," consisting of several small holes drilled in the face of the baffle to replace the single large hole. The proponents of the distributed port claimed that a smoother hi-fi response resulted from the resistive force that the multiple small holes exerted on the flow of air through them.

Then the stereo age arrived, and the need for double speaker systems created a demand for compact enclosures. We began to hear less about distributed ports and more about the ducted port, which now finally had its day. Those pioneers of the 1950's who had advocated them were simply ahead of their time.

Recently I became curious about the origin of the bass reflex. I knew that its invention by A. L. Thuras of Bell Telephone Laboratories had probably had greater influence on high-fidelity speaker systems than any other development, but details on just what he invented seemed non-existent. Finally after a fruitless search in hi-fi books and several libraries, I sent 25 cents to the U. S. Patent Office and received a copy of Patent No. 1,869,178, "A Sound Translating Device."



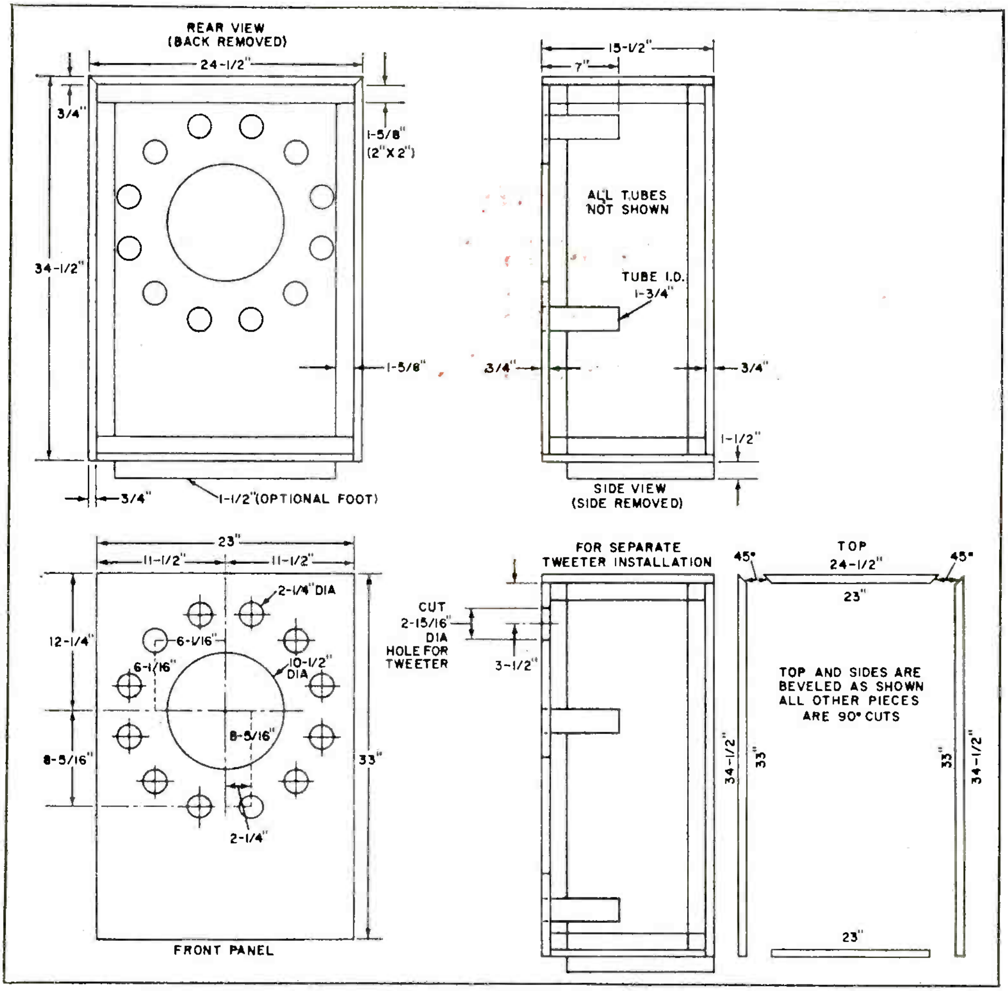
A. L. Thuras filed a patent application for this distributed port enclosure on August 15, 1930, and assigned the patent rights to the Bell Telephone Company. He called it a "Sound Translating Device."

I eagerly examined the drawings, expecting to find the typical boxed-in speaker with a rectangular port below it in the front panel. To my surprise there was instead a series of short pipes surrounding the speaker. Not only did Thuras invent the bass reflex, but a "distributed duct" bass reflex. But the real shocker came when I looked at the patent filing date: August 15, 1930!

The more I studied the patent specifications, the more intriguing they became. The enclosure had esthetic drawbacks, such as a square face and a volume of more than 9 cubic feet, but I was convinced that the original design had unusual merit if only it could be matched to present-day speakers. Finally I decided to try, and here is the result—a smooth-operating "sound translating device" of the highest order. It is designed to operate with the University "Mustang" series of speakers.

Construction. The box itself is conventional. You may make minor changes in construction, but you should not change the inside dimensions. If you make any significant volume changes, good luck, but don't expect to predict a match for any particular speaker or resonant frequency from the published bass reflex charts you might have on hand. Those charts apply to single ports or ducts and are not valid for the multiple pipe baffle. I found this out when the indicated pipe length proved to be too short.

Except for the cardboard tubes, the materials are conventional and readily available. You can probably find tubes of the diameter listed at a neighborhood furniture store or rug dealer, but if the store is a small one, you may have to ask the owner to reserve one or two for you. My nearest furniture store had two empty tubes twelve feet long standing in a corner waiting for the trash collector. If you can't find tubes with the same inside diameter, you may have to use larger ones, changing the number of tubes to maintain approximately the same cross-sectional area. Or you can cut square openings and fabricate plywood ducts with inside dimensions of $1\frac{9}{16}$″ x $1\frac{9}{16}$″.



Outline drawings above show the general arrangement to use in building a duplicate of A. L. Thuras' distributed port reflex. A University "Mustang" speaker was tested in this enclosure and sounded fine. If more highs are desired because of room acoustics, mount a separate tweeter as shown at the lower right.

BILL OF MATERIALS

Cut from ¾" plywood:
2—23" x 33" pieces for front and back panels
2—15½" x 34½" pieces for sides
1—15½" x 24½" piece for top
1—15½" x 23" piece for bottom

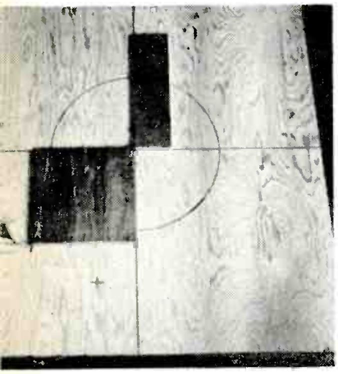
Cut from fir or pine 2 x 2's (actually 1⅝" x 1⅝"):
4—10¾" pieces for corner cleats
4—23" pieces for top and bottom cleats
4—30" pieces (approx.—cut to fit) for side cleats

12—2¼"-o.d., 1¾"-i.d., 7"-long pieces of cardboard mailing tubes for pipes
1—6-1/16" x 6-1/16" piece of cardboard or wood for pattern board
1—2¼" x 8-5/16" piece of cardboard or wood for pattern board

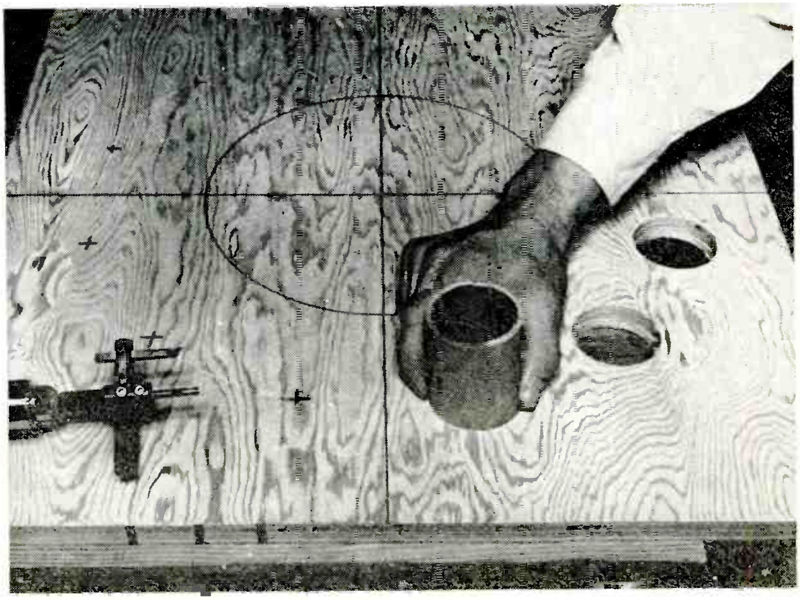
Misc.—7 doz. #9 x 2" flat-head wood screws (see text), glue, grille cloth, trim, legs—if desired

The first step after cutting out the parts is to screw and glue the braces or cleats to the top and bottom. The sides are then fastened to the top and bottom, using glue and screws through the corner braces into the sides. It is then possible to cut the side cleats, which serve as anchors for the front and back, to fit exactly. Incidentally, if your lumber dealer does not have pre-cut 2 x 2's, he may supply you with pieces that have been ripped from 2 x 4's. In that case the dimensions may be slightly different and require longer or shorter screws. Be sure to check the screw length.

The only part of the design which re-



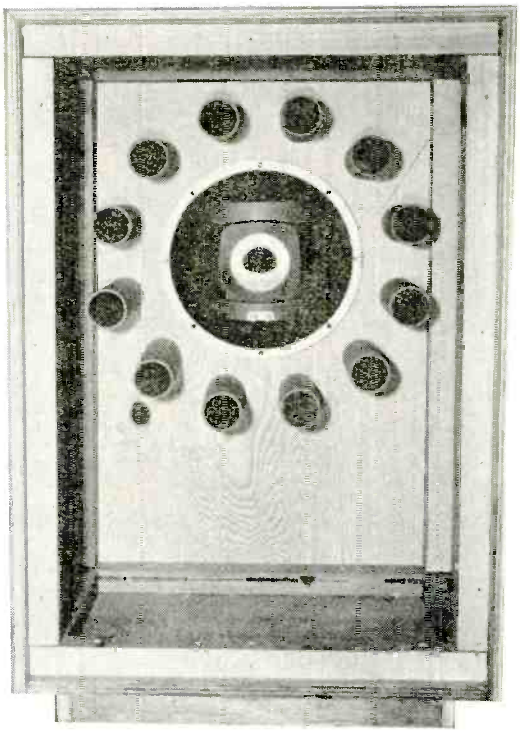
Centers for port holes are marked out using two pattern boards. Dimensions of the boards are given in the Bill of Materials. How they are used is described below.



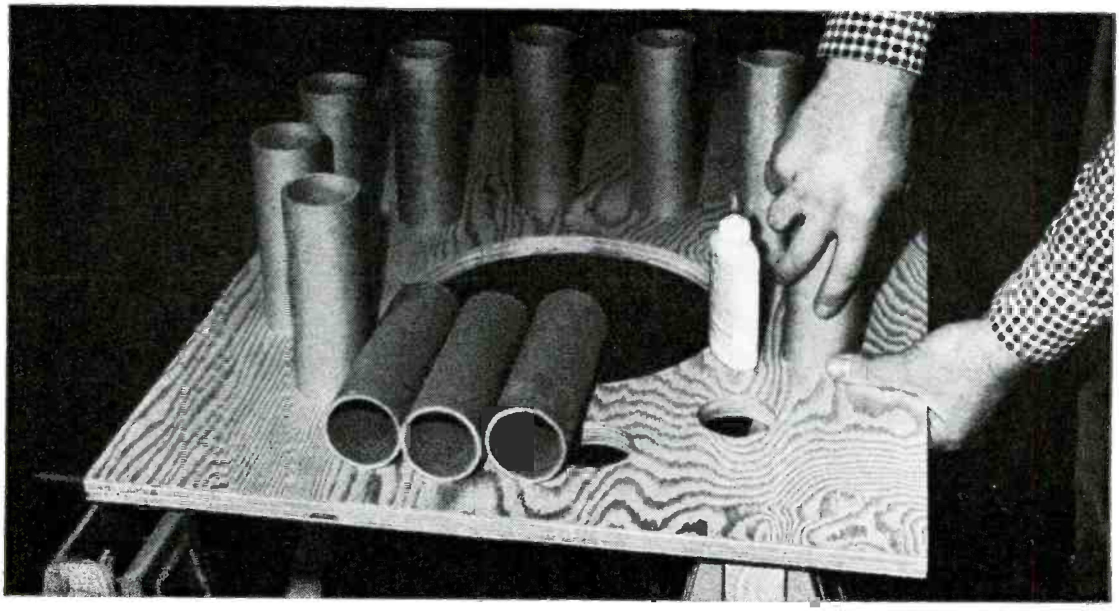
Bore the port holes using a heavy-duty "fly" or circle cutter with a low-speed electric drill. An Arco hole saw can be employed if the diameter of the saw matches the outside diameter of the cardboard tubes.

quires careful planning and measuring is the front baffle. I found that "pattern boards" made from scraps of plywood greatly simplified the location of the 12 holes for the pipes. First locate and draw the circle for the speaker cutout; then divide the circle into quadrants, extending the lines to the edges of the board. The middle hole in each quadrant can then be located by positioning the 6¼₁₆"-square pattern board with one corner at the center of the circle and the sides bounded by the quadrant lines as shown in the photo. The other two holes in each quadrant are located by positioning the other pattern board with the longer side first on one quadrant line, then the other, keeping a corner at the circle's center (see photo).

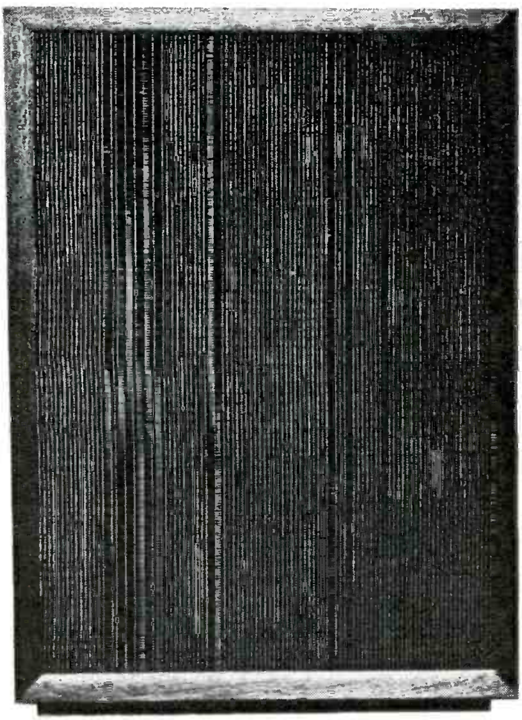
The holes can be easily cut with a circle cutter and a large portable drill. It's possible to cut them with a small high speed drill, but such an operation is hazardous. Keep a firm control on the drill at all times and a safe distance between it and your knees or feet. Cut some sample holes in waste plywood first and check for a tight fit with a piece of tubing. When the cutting of the port holes and speaker opening is completed, glue the 7-inch tubes in place so that



This rear view of the speaker enclosure does not show the cheesecloth and cotton batting used to dampen boomy resonances. See text on next page.



The cardboard tubes should fit snugly into the port holes. The length of the tubes recommended for use with a University "Mustang" speaker is 7 inches. Glue each of the tubes in place so that the end of the tube is exactly flush with the front panel.



Ordinary plastic grille cloth is carefully tacked to the front of the enclosure. Mitered strip of molding covers the tacks and frayed ends of the cloth.

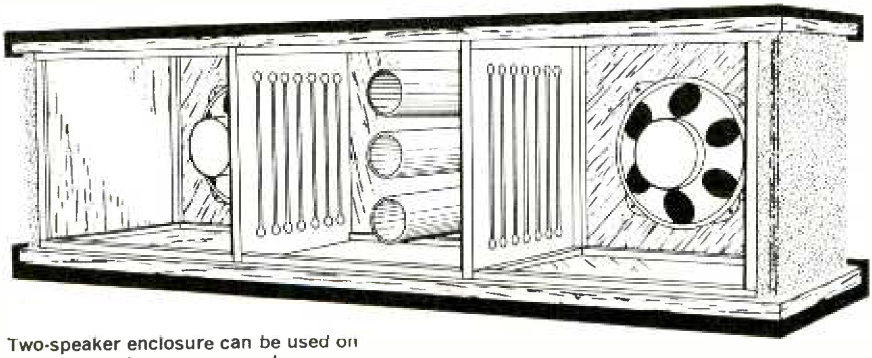
the end of each tube is flush with the front of the board. Mount the board, and you are ready to finish the cabinet.

Don't forget to use padding on at least the top, one side, and back—more if you wish. The pipes offer a convenient anchor for a particularly effective placement of padding. I made a "doughnut" of heavy cotton batting sandwiched between layers of cheesecloth and cut openings in the cheesecloth for the pipes; this suspends the sheet of batting just in back of the speaker without totally enclosing the speaker and putting a pressure compartment around it.

Variations. For a full-range speaker such as the University M-12T or M-12D, construct the enclosure as shown here. If you want to use a separate woofer-tweeter arrangement such as the M-12 "Mustang" woofer plus the T-202 super tweeter, the front panel can be inverted with the woofer and pipes in the lower part and a tweeter opening cut near the top. If you substitute other speakers, the bass resonance of the speaker should be similar to that of the "Mustang" series, or about 40-50 cycles.

If you build this enclosure, you can honestly tell your friends that it's 35 years ahead of its time. —30—

THE SLIM



Two-speaker enclosure can be used on its side as above, or on end as seen below. Novel filters (the slotted boards) and ports furnish bass boost.

TWOSOME

For big bass from a small box, try this unique enclosure using center decompression chamber

By HAROLD HUFNAGEL

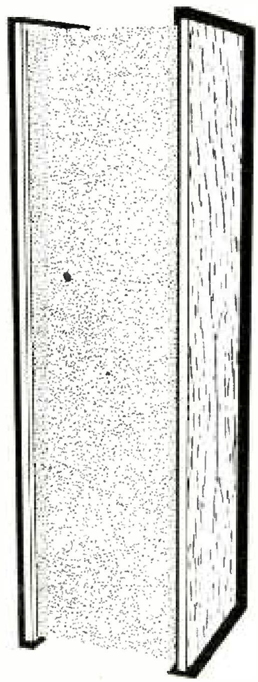
WANT to know how to pack good, strong bass, as well as clear, sparkling highs, into a speaker cabinet measuring just 10″ x 10″ x 36″? Interested in economy? Would you like to have a speaker system that can proudly take its place among your living room furniture, or on a convenient bookshelf? If your answer is "yes" to these questions, "The Slim Twosome" is for you.

A combination of filters and a decompression chamber increase air column length and enhance bass response without detracting from the highs. Two full-range 6″ speakers pumping in phase can move as much air as a larger speaker. The filters dampen speaker action without a build-up of excessive back pressure. The ports relieve the cabinet of internal pressures and, when properly tuned, can improve bass response, as in a bass-reflex enclosure.

Construction. Ordinary ½″ plywood can be used for the front, back, sides, and ends. However, you may choose—as did the author—to use hardwood or veneered plywood for the "sides" (top and bottom if the cabinet is laid flat). The remaining exposed surfaces are covered with grille cloth.

First cut the two 10″ x 36″ side panels, taking care not to mar the outside surfaces. The cleats used to hold the

(Continued on page 70)



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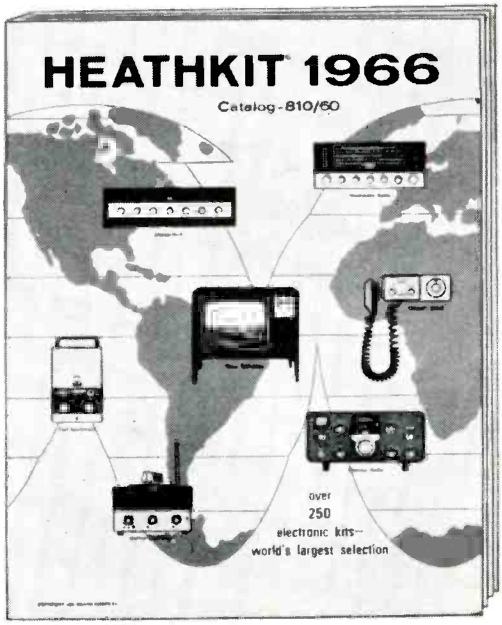

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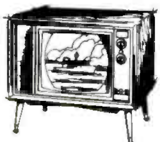

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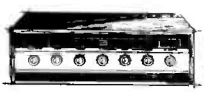

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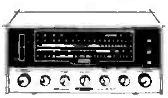

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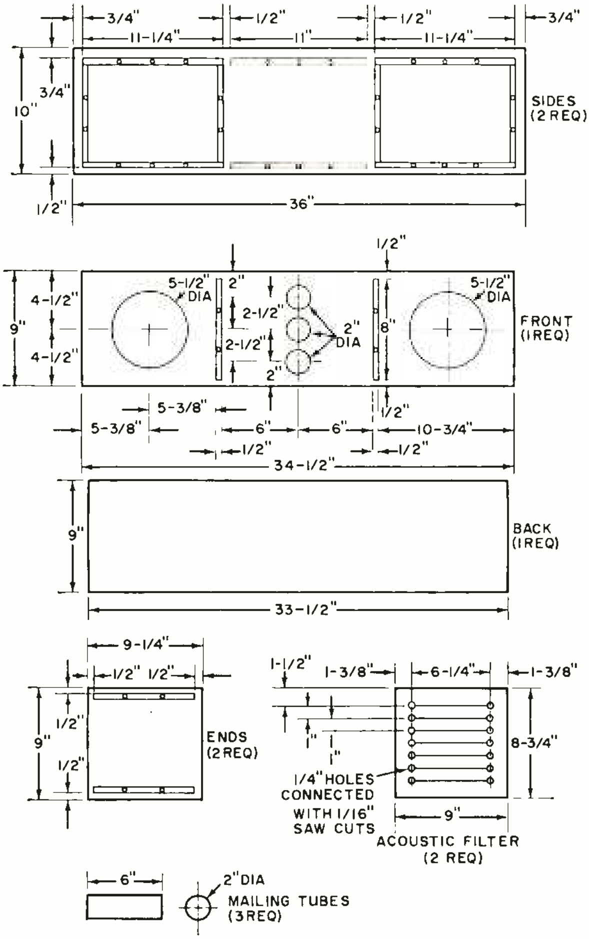


Construction of enclosure is detailed at left. All panels can be made from 1/2" plywood, with 1/2"-square stock making up the cleats. Cut all pieces exactly to size; place cleats as shown for easy assembly.

enclosure sections together are made of ½"-square stock. Cut enough pieces of the right length for the two sides, and place them exactly as shown in the detail construction drawings above. Secure them in place with glue and screws. Cut the front, back, and ends from ordinary plywood, and fasten cleats to the front and ends as shown.

The end pieces are glued and screwed to the cleats on the side pieces using ¾" flat-head #6 wood screws. Drill holes for the screws through the ends, countersinking the holes ⅛" so the screw heads will be below the outside surface of the enclosure. (Note: The cleats on the *end pieces* are later used to mount the front and back.)

Glue and screw the front in place, countersinking screw holes as before. After drilling and cutting the filter slots in the filters, slide them in place between the cleats as shown, and firmly screw them to the adjacent cleats to prevent any vibration.

Final Assembly. The ports are made of three 6" pieces of mailing tube 2" in diameter. First give them several coats of shellac, then glue them in place, filling any openings around them with sawdust and glue. Line the speaker chambers with a ¾" layer of acoustic padding on the ends, sides, and the back panel area that will cover the speaker chambers; no padding is placed on the filters or in the decompression chamber.

The front and ends of the author's cabinet were finished by covering them with grille cloth after the bare wood was painted flat black so that shadows would not show through the cloth. The side panels can be finished to your liking.

If plywood is used for the sides, you can finish the edges very easily by covering them with "flexible wood trim" available from most lumberyards. The trim is simply glued in place with contact cement. Fit grille cloth between the sides, stapling it to the rear edge of the ends and near the edges around the front. Gold cording or molding will conceal the staples.

While the exact type of speakers you choose for your "Slim Twosome" is not overly critical, be sure to get wide-range types such as the Lafayette Radio 99 R 0028, priced at $6.25. There are other similar units which can be used.

Install the speakers, and wire them to a terminal strip on the rear panel, taking care to connect them both in the same phase—i.e., so both cones move in or out together. Small both in terms of size and the investment required, "The Slim Twosome" can be counted on to give big listening pleasure. -30-

THE BARGAIN PAGE AMPLIFIER

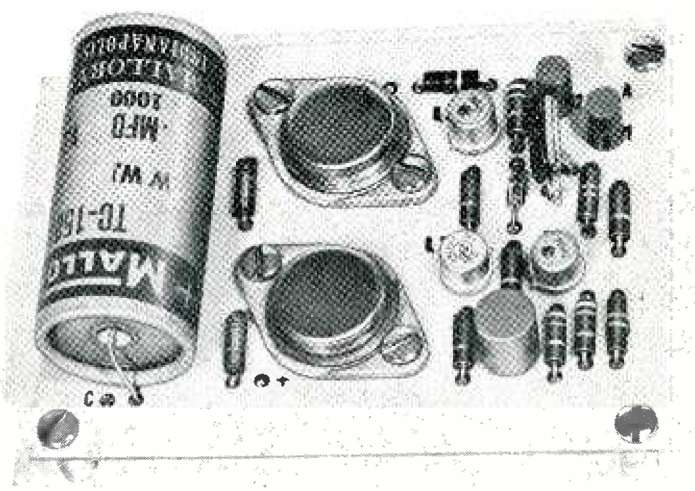
All-purpose transistorized printed circuit board amplifier has 3-watt output over an audio range of 30 to 20,000 cycles

By DANIEL MEYER

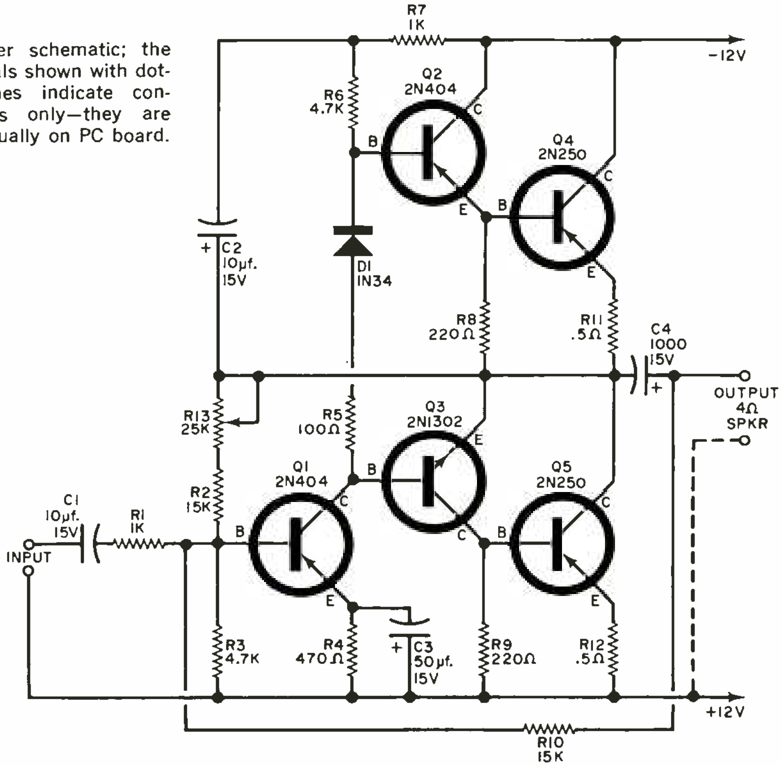
IF YOU are like most electronics experimenters, you spend considerable time browsing through catalogs and flyers from parts dealers and distributors. Also, if you're like the author, those tempting packages of bargain-priced transistors are just too much to resist. Sometimes we get stung, but this amplifier has proven to be an extraordinary exception—the push-pull power output transistors are commonly available TO-3 (diamond shape) types that can be purchased surplus from Poly-Paks, TAB, Transistors Unlimited, etc. The following transistors will all work well in this circuit: 2N250, 2N251, 2N256, 2N276, 2N301, 2N553, and 2N1046.

All of these transistors will give you a power output of about 3 watts without excessive distortion. (If you feel that improved performance above 10,000 cycles is necessary, use 2N1046 transistors at *Q4* and *Q5*.) Don't forget to check the leakage of surplus transistors. Some, but not all, transistors sold for bargain prices are "seconds" and will not give you the maximum possible performance from this amplifier.

The "Bargain Page Amplifier" is a versatile little package of audio power. It may be operated from either a positive- or negative-ground 12-volt automotive supply. It can be used as a mobile public address system, modulator,



Amplifier schematic; the terminals shown with dotted lines indicate connections only—they are not actually on PC board.



PARTS LIST

C1, C2—10-µf., 15-volt electrolytic capacitor
C3—50-µf., 15-volt electrolytic capacitor
C4—1000-µf., 12-volt electrolytic capacitor
D1—1N34A germanium diode (or equivalent)
Q1, Q3—2N404 transistor (or equiv.—see text)
Q2—2N1302 transistor (or equivalent—see text)
Q4, Q5—2N250 transistor (or equivalent)
R1, R7—1000 ohms
R2—27,000 ohms
R3, R6—4700 ohms
R4—470 ohms
R5—100 ohms
R8, R9—220 ohms
R10—15,000 ohms
(All resistors ½ watt)
R11, R12—0.5-ohm (wind 15" length of #36 magnet wire on a ½-watt, 10,000-ohm resistor to shunt internal resistance)
R13—25,000 ohm trimmer potentiometer
Misc.—Circuit board available from DEMCO, 430 Redcliff Drive, San Antonio, Texas 78216 for $2.50 (epoxy glass) or $2 (phenolic base); solder, wire, batteries, cabinet, etc.

Optional Power Supply

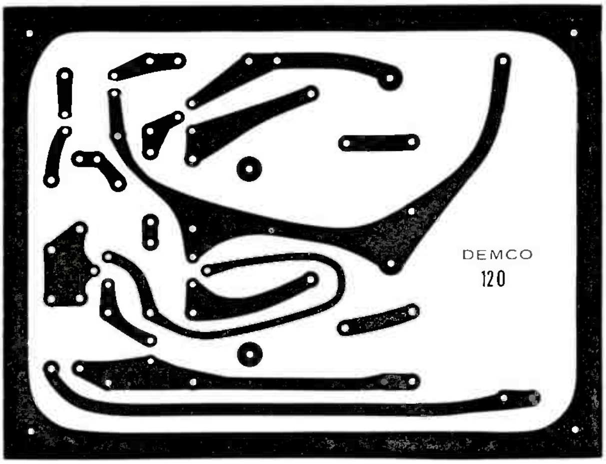
C5—500-µf., 12-volt electrolytic capacitor
C6—1000-µf., 12-volt electrolytic capacitor
D2, D3—50-PIV @ 1-amp. silicon diode (Mallory S-50 or equivalent)
D4—1N3022 zener diode, 12 volts at 1 watt (Texas Instruments)
Q6—2N256 transistor (or equivalent)
R11—100-ohm, ½-watt resistor
S1—S.p.s.t. toggle switch
T1—Filament transformer; primary, 117 volts a.c.; secondary, 24 volts a.c. CT

or audio amplifier. The amplifier makes a neat, practical audio system for use with a low-cost portable phonograph. The setup for such a project can be very simple—a pair of 6-volt lantern batteries, plus the amplifier tucked away in the back of a speaker baffle.

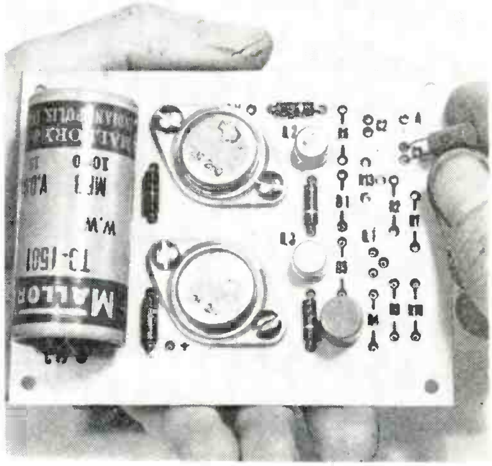
Because this unit has a wide frequency response, it can be used with wide-range speakers in a hi-fi system.

How It Works. The output transistors, *Q4* and *Q5*, although in series with the 12-volt power supply, look like push-pull amplifiers to an audio signal. These two transistors are slightly forward-biased to minimize distortion at low volume levels. With no signal input, *Q4* and *Q5* draw about 15 ma. At full volume output with this circuit, the output transistors will draw up to 400 ma. The mode of operation is Class AB_2; transistor *Q4* can be thought of as amplifying the negative portion of the audio signal and *Q5* as amplifying the positive portion.

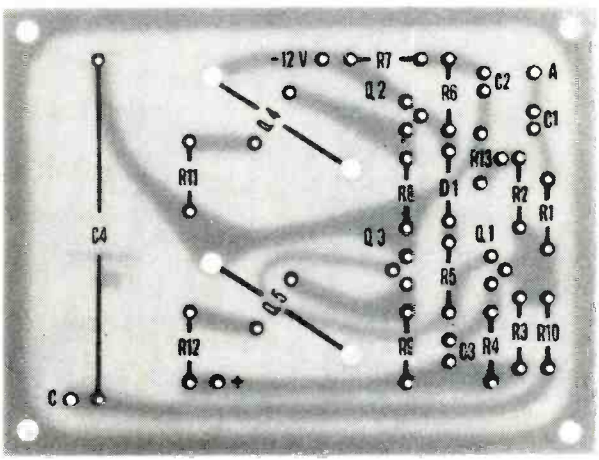
Transistor *Q2* is a phase inverter as



Using template above, you can etch your own circuit board—or you can get one from DEMCO (see photograph below). The address is given in the Parts List at left.



Using dirt-cheap transistors, this amplifier can produce 3 watts without a heat sink by running the power output transistors far below their maximum rating.

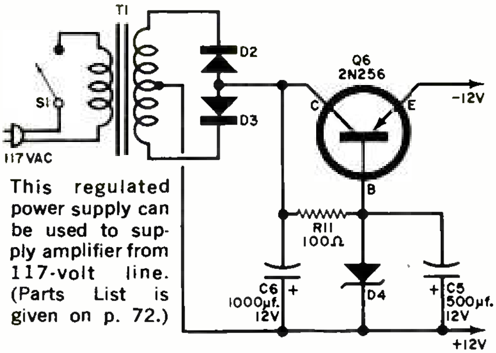


well as a low-impedance driver amplifier. Transistor *Q3* performs a similar function sans the phase inversion. Voltage amplification to drive these two transistors is provided by *Q1*. The collector of *Q1* is fed directly to the base of *Q2* and through *D1* and *R5* to the base of *Q3*.

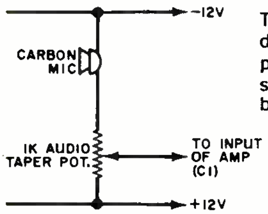
Diode *D1* performs two functions: it provides slight forward bias (with *R5*) and also acts as a temperature compensator. The voltage drop across the diode decreases as the temperature of the whole amplifier increases. This counteracts the thermal runaway possibilities of this type of circuit.

Both d.c. and a.c. feedback are used between the output and input transistors. Resistor *R2* provides a d.c. path and capacitor *C4* an a.c. path. Feedback lowers distortion, improves stability, and broadens the frequency response. Total feedback is about 20 db.

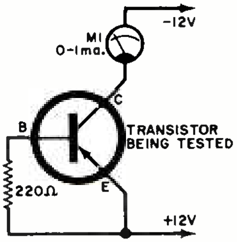
Construction. A printed circuit board on which to build this amplifier is available from the author at a modest charge. Construction time is thereby reduced to less than one hour and the chances of wiring errors or unwanted feedback are eliminated completely. A board can be made in your own workshop following the layout shown above. Point-to-point wiring with Vectorbord® and push-in terminals can be used if care is exer-



This regulated power supply can be used to supply amplifier from 117-volt line. (Parts List is given on p. 72.)



The amplifier can be driven from any source providing 0.5 volt of signal; connect a carbon mike as shown here.



Check your power transistors for leakage with the simple circuit at right. A zero reading, or more than 1 ma. of leakage current, indicates that the transistors will not work in the amplifier.

cised to reduce the possibility of the wiring introducing feedback.

You can make a number of possible substitutions at *Q1*, *Q2*, and *Q3*. Each must have at least a 12-volt breakdown (V_{ceo} in the RCA *Transistor Manual*), and in the case of *Q2* and *Q3*, a current gain of 50 or more. Transistors *Q4* and *Q5* are equivalent to 2N1038-1 transistors manufactured by Texas Instruments and selling for about $3 apiece.

Testing and Installation. Before installing your bargain transistors, it is a good idea to test them for excessive leakage using the circuit shown above. If the meter reading is either zero or over 1 ma., the transistor should not be used in this amplifier. Transistors with leakage currents of between 0.1 and 0.8 ma. are O.K.

After assembling the amplifier and installing the transistors, connect a 0-100 milliammeter in series with the battery or power supply and the amplifier. Current drain should be from 20 to 50 ma. with no signal input. If the drain exceeds 50 ma., reduce the value of *R5* to 47 or 68 ohms. On the other hand, if the current drain is below 20 ma., increase *R5* to 120 or 150 ohms.

Emitter stabilizing resistors *R11* and *R12* reduce the chances of thermal runaway of *Q4* and *Q5*. These very low ohm resistors are wound from 15″ lengths of #36 magnet wire on the body of a ½-watt resistor with a value of 10,000 ohms or greater. Solder the ends of the magnet wire to the resistor leads so that the length of wire shunts the internal resistance.

Another test to improve the fidelity of your "Bargain Page Amplifier" may be performed after it is assembled. Couple the amplifier to a 1000-cycle audio input source and a 4-ohm resistive output load. Also connect the input of an oscilloscope across the output and drive the amplifier from the 1000-cycle source until sine-wave clipping occurs. If the clipping is not symmetrical on the positive and negative portions of the waveform. Adjust *R13* for symmetrical clipping. If no signal generator or oscilloscope is available, adjust *R13* to obtain a 6-volt reading at the collector terminal of output transistor *Q5*.

Using the Amplifier. The printed circuit board may be mounted on metal or insulated standoffs and bolted to an appropriate size chassis. The small size of the amplifier and the modest power requirements make it suitable for many applications. If a power supply for 117-volt a.c. operation is not available, a power supply with zener diode regulation can be built using the parts and circuit shown at the top of this page.

The power output of the "Bargain Page Amplifier" will depend upon the speaker impedance—even though the amplifier can be used with any 4-, 8-, or 16-ohm voice coil speaker. However, the amplifier is a good match for a 4-ohm speaker. If an 8-ohm speaker is used, the maximum power output will only be 1.5 watts; and with a 16-ohm speaker, the output will be 0.75 watt maximum. Of course, you can always parallel two 8-ohm speakers for optimum output.

WARNING: Do not short the output connections. Do not submit the amplifier to sine-wave inputs of 10 kc. or more for over two seconds. -30-

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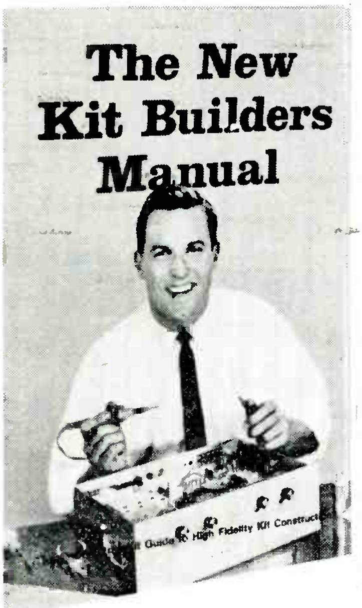

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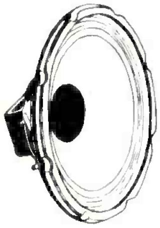


BUILD A STEREO BAL

Balance stereo speakers and find multiplex broadcasts with $4 indicator

By DAVE GORDON

THE Stereo Bal is designed to solve two common hi-fi/stereo problems. The first concerns system balance. Unless your stereo speakers are fed a balanced diet of power—the same amount to each speaker—you'll get off-center sound, and musical instruments will be reproduced either with incorrect perspective or incorrect volume.

The second problem that the Stereo Bal will solve involves FM-stereo broadcasts. Very few of the early FM-stereo tuners or receivers had built-in indicators to tell you whether or not the station being received was broadcasting in stereo. And even fewer of the multiplex adapters that converted standard FM tuners to stereo were equipped with stereo indicators.

What was needed was a simple, inexpensive (under $4), and practically foolproof gadget that could do both those jobs—and that is how the P.E. Stereo Bal came to be.

How It Works. To achieve stereo reproduction, there obviously must be a difference between the signals fed to the two speakers. Let's call the signal fed to the right speaker "A" and the signal fed to the left speaker "B." Any difference between the two signals represents the stereo information and is usually referred to as the "difference" signal or the A—B signal.

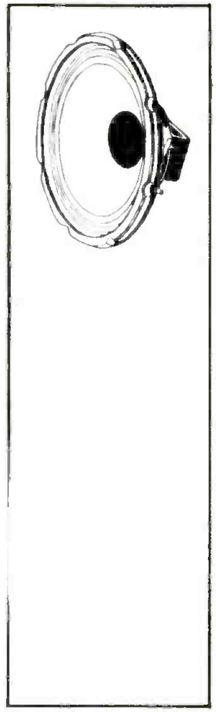
If an a.c. voltmeter were connected to the speaker terminals of a stereo amplifier (from the 16-ohm tap of one to the 16-ohm tap of the other), the meter would read no voltage as long as the same signal *at the same strength* appeared across the two 16-ohm terminals. However, as soon as there was any difference between the signals coming out of the amplifiers, the meter would respond.

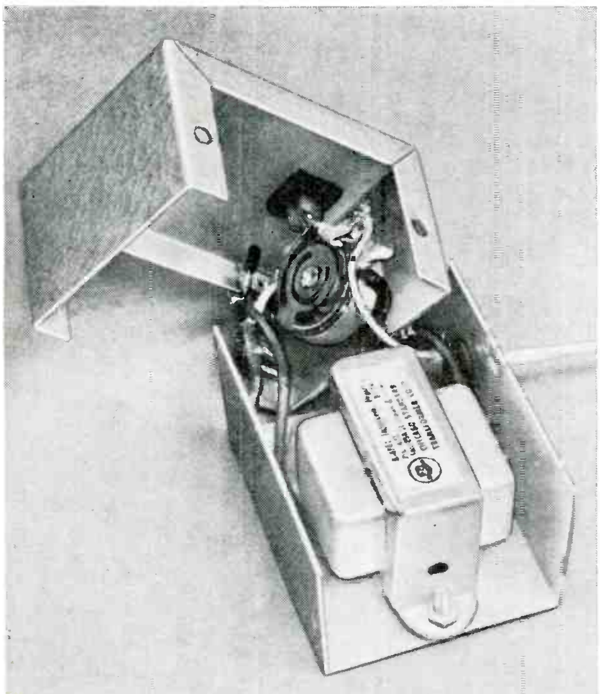
That explains where the difference signal comes from, but how do we use it in the Stereo Bal? Instead of an expensive, easily damaged meter, we use a step-up transformer (*T1*) to soup up the very small difference voltage sufficiently to light a neon lamp.

Construction. An inexpensive type of transformer that proved ideal for the soup-up job is one that normally serves as an input transformer for tube intercoms. Transformer *T1* is connected with its high-impedance side to the neon lamp. Control *R1* adjusts the sensitivity of the Stereo Bal in accordance with the loudness of the program being played.

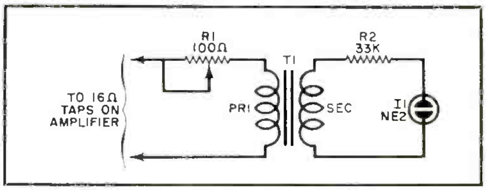
Depending upon the type of neon-lamp pilot assembly used for *I1*, you may find that resistor *R2* is already built into the assembly and hence need not be added. As an inexpensive alternative to using a pilot-lamp assembly, you can make a socketless mounting by press-fitting an NE-2 lamp into a rubber grommet. In that case, simply solder *R2* to one lead of the lamp. Do not use an NE-51 as this lamp is quite fragile.

Parts layout is not critical. In fact, the Stereo Bal's few components can be mounted on a panel rather than in the small metal box shown in the model. The sole precaution that might be





It's a tight fit, but all of the Stereo Bal components can be squeezed into a miniature aluminum box. Although the author used a small wire-wound potentiometer for R1, a carbon unit could be employed.



The Stereo Bal is fed from the 16-ohm output taps of each amplifier. There's no common ground return.

PARTS LIST

I1—NE-2 neon lamp or neon-lamp pilot assembly—see text
R1—75- or 100-ohm potentiometer (taper and value not critical)
R2—33,000- or 47,000-ohm, ½-watt resistor—see text
T1—Intercom input transformer, voice coil to grid (Stancor A-4744 or Thordarson 20A04)
1—Cabinet (Premier PMC-1000)
Misc.—Two-conductor speaker wire to reach from Stereo Bal to amplifier, hardware, etc.

necessary is to avoid mounting *T1* too close to a power transformer or phono motor.

The leads from the Stereo Bal should be connected to the highest impedance speaker taps on your amplifier irrespective of which taps the speakers are connected to. If you are using two separate

(*Continued on page* 133)

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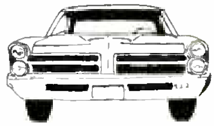
CHAPTER 3

RADIO CONTROL PROJECTS

The two articles in this chapter were written to take the mystery out of radio control circuitry. Both the transmitter and receiver are transistorized and have been designed for printed circuit board construction. Your editors believe that use of printed circuit boards is mandatory to insure faultless operation.

Construction of these two projects will give the builder a good idea of how radio control works and will probably suggest many uses for it other than models or garage door openers.

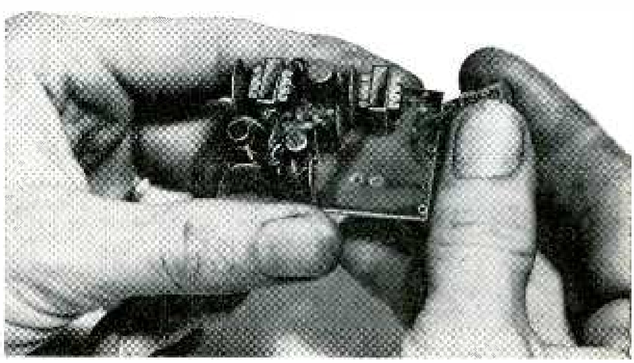
In the Fall 1966 issue of this HANDBOOK, your Editors will present several Science Fair projects instead of R/C projects.



BUILD A MINIATURE R/CEIVER

By DANIEL MEYER

You can control models and other gadgets on land, at sea, or in the air, with this 1½-ounce, three-transistor receiver

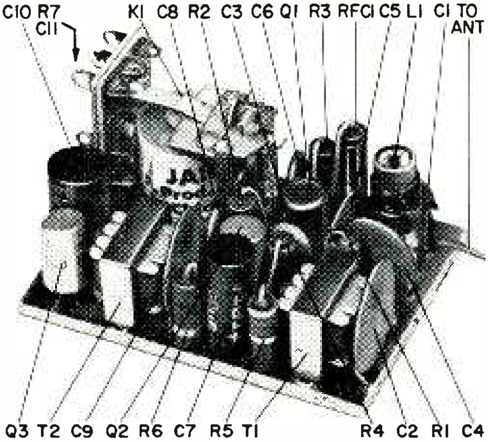


LESS THAN half the size of a package of cigarettes, this lightweight, three-transistor radio-control receiver can be used in cars, boats, and in the home. It's suitable for remote operation of toys, models, garage doors, or any other control application you might have. The receiver circuitry contains a sensitive superregenerative detector, a tone-modulated selector, and a relay in the output. Its small size is made possible by the use of transistors and a printed circuit board—which allows quick assembly of components.

The R/Ceiver is operated by a 600- to 800-cycle tone-modulated carrier on the 27-mc. remote-control channels. This type of operation makes it possible to use the rather broad tuning superregenerative detector without interference problems. Voice modulation even on the same channel will almost never energize the receiver relay. A continuous tone in the proper frequency range must be received before the relay will operate.

The sensitive relay is isolated from the receiver circuits and can be connected to anything you want to control as long as the 0.5-amp., 50-volt rating of the relay contacts is not exceeded.

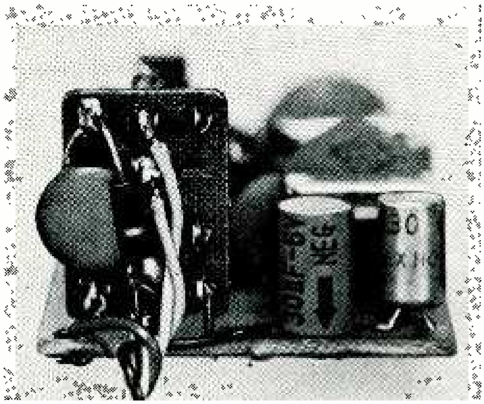
How It Works. Transistor *Q1* acts as a superregenerative detector, which oscillates at a frequency determined by tuned circuit *L1* and *C4*. Oscillation is quenched (cut off) at an ultrasonic rate, which is determined by the values of the base bias and emitter resistors and their associated bypass capacitors (*R2*, *R3*, *C3* and *C6*). Capacitor *C5*, connected to the emitter and collector of *Q1*, provides the feedback needed to sustain oscillation.



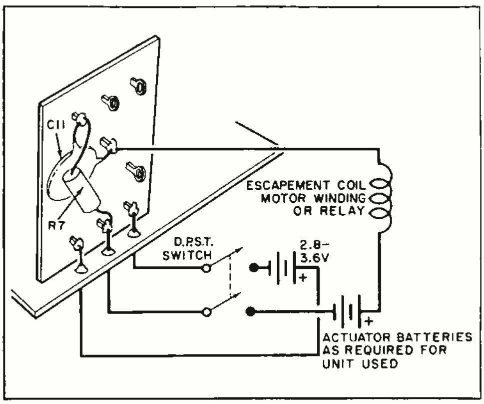
Printed circuit board permits upended parts layout to provide a compact layout with adequate space for all components. Photo is actual size. Resistor R7 and capacitor C11 are shown in detail drawing below.

The antenna is loosely coupled to the tuned circuit by *C1*. The loose coupling reduces antenna loading effects on the tuned circuit. Capacitor *C2* filters out the r.f. carrier and quench signals, and leaves just the detected tone modulation across the primary of *T1*.

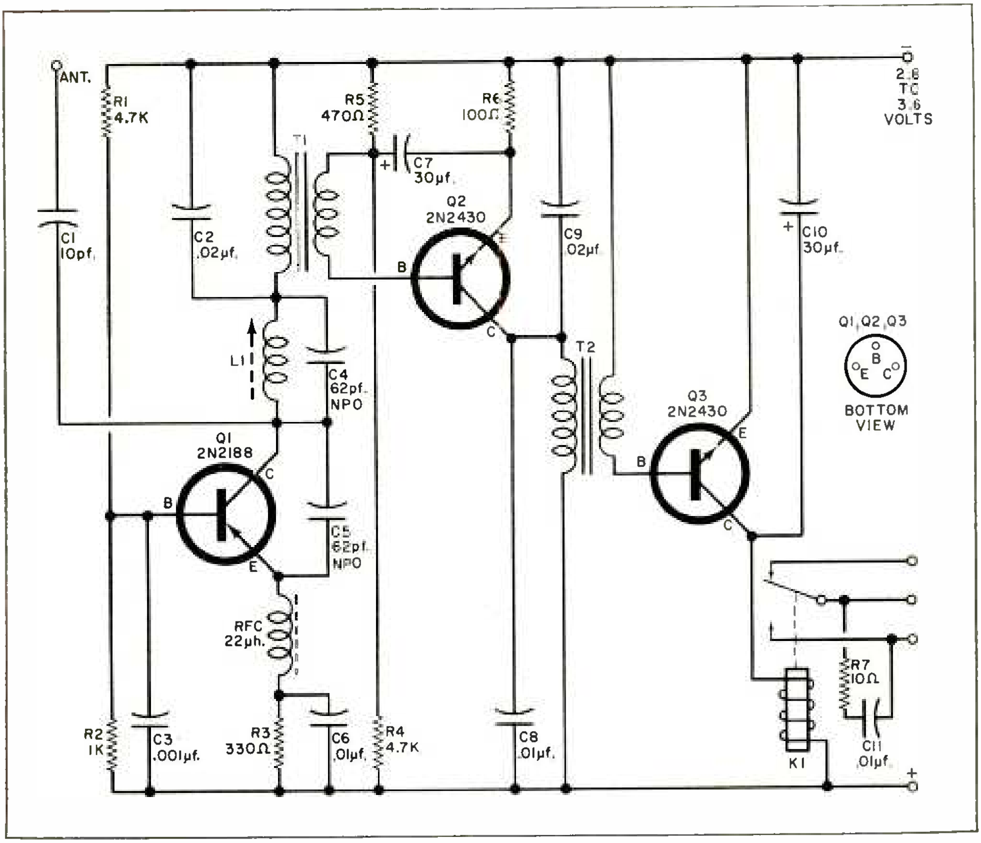
The tone signal is transformer-coupled to the base of audio amplifier *Q2*. Transformer *T2* delivers the signal from the collector of *Q2* to the base of *Q3*. Transistor *Q3* conducts in the presence of



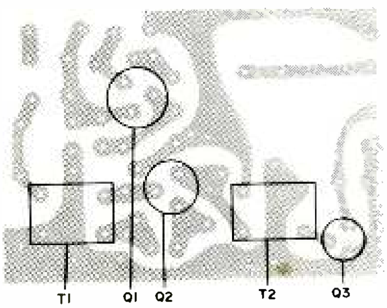
Flexible wire connected between the external components and relay board will prevent breakage due to vibration. Shock-mount unit with foam rubber.



Detail drawing shows location and connection of R7 and C11, as well as how to hook up external circuit. Do not exceed current rating of relay contacts.



Transistor Q1 is part of a sensitive superregenerative detector which demodulates a tone-modulated control signal. The tone burst only is then amplified by Q2 and passed on to Q3 to activate the relay.



Actual-size photo of printed board. Circles and squares show which openings to use for transistors and transformers, and are not part of circuitry.

PARTS LIST

C1—10-pf. ceramic capacitor
C2, C9—0.02-μf., 50-volt ceramic capacitor
C3—0.001-μf. ceramic capacitor
C4, C5—62-pf., NPO ceramic capacitor
C6, C8, C11—0.01-μf., 50-volt ceramic capacitor
C7, C10—30-μf., 15-volt electrolytic capacitor
*K1—100-ohm sensitive relay (Jaico Products Co., Chicago, or equivalent)**
*L1—7¼ turns of #26 enameled wire on 0.20"-diameter coil form, with powdered iron tuning core**
Q1—2N2188 transistor
Q2, Q3—2N2430 transistor
R1, R4—4700-ohm, ½-watt resistor
R2—1000-ohm, ½-watt resistor
R3—330-ohm, ½-watt resistor
R5—470-ohm, ½-watt resistor
R6—100-ohm, ½-watt resistor
R7—10-ohm, ⅛-watt resistor
*RFC1—22-μh. r.f. choke**
*T1, T2—Miniature interstage transformer: primary, 10,000 ohms; secondary, 2000 ohms**
*1—Printed circuit board**

*A set of parts consisting of a predrilled printed circuit board, *T1, T2, L1, RFC1,* and *K1* is available for $9 pp. from Daniel Meyer, Box 16041, San Antonio, Texas 78216 the tone signal, specifically the positive half cycles, and energizes the relay (*K1*).

Construction. Use of a printed circuit fiberglass board makes the receiver very rugged and compact, and easy to build. Start construction by mounting the transformers. Be careful not to pull the leads out of the transformers or to cut the wires when stripping the insulation. The blue and red leads are the primary side and should be installed in the transformer lead holes next to *C2* and *C9*. Bend the tabs on the transformer brackets to grip the board.

Next, install the tuning coil (*L1*) and the r.f. choke (*RFC1*). Do not use too much force on the coil, to avoid pulling the lugs out of the coil form. Install the three transistors, making sure that the leads are in the correct holes. Basing for all three transistors is shown on the schematic. Some transistors have a red dot next to the collector lead.

Now install the capacitors and observe polarity, particularly for *C7* and *C10*. Install the resistors and mount the relay. The relay coil is connected to the holes in the board with short pieces of bare wire.

Bend all component leads to grip the board, and trim. Solder all connections and avoid bridging adjacent conductors.

The antenna lead can be any piece of wire 18 inches or longer. Use of lightweight wire on the order of No. 26 AWG to interconnect the receiver to external components will keep the wiring bundle small and flexible and better able to withstand vibration. Mount the receiver in a small plastic box to prevent dust from getting into the relay.

Almost any type of actuator used with this receiver will require an arc supression network to protect the relay contacts. This network consists simply of a 10-ohm resistor (*R7*) and a 0.01-μf. capacitor (*C11*) across the relay points.

Using the R/Ceiver. If the R/Ceiver is to be used in a model airplane, it should be shock-mounted with foam or rubber material. There are many types of actuators available for use in model airplanes, cars and boats. Airborne actuators are usually of the rubber-band powered escapement type and are light in weight. Motor-driven types are generally used in cars or boats where more power is needed and weight is not a problem.

Self-neutralizing types of actuators provide alternate right and left control. Compound types provide right-side control on the first burst of tone signal, left with the second, and motor control with the third. This makes it unnecessary to remember what the last control position is. You just press the transmitter key once for right, twice for left, or three times for motor. The mechanism cycles back to neutral when the tone signal stops.

If the R/Ceiver is to be used for garage door operation or some other application requiring maximum security, cut down the size of the antenna. The receiver should not be allowed to pick up any signals that are weaker than your own weakest signal. You can make this adjustment by transmitting a signal at maximum range, then trimming the antenna and increasing the relay spring tension until the receiver will just operate.

Final Adjustments. The receiver needs 2.8 to 3.6 volts to operate. Two standard 1.5-volt cells in series can be used. (A separate power supply should be employed for the device being controlled.)

To check out the receiver, connect the batteries and put a weak signal on the air from your transmitter, or from a signal generator tuned to the proper frequency. The signal is amplitude (600- to 800-cycle) tone-modulated at a frequency within the range of 26.995 to 27.255 mc., in conformance with proper Class C operation. Modulation should be at least 85%.

Tune *L1* until the relay pulls in. Use a fiber or plastic-tip tuning tool to avoid loading and detuning effects. As you rotate the core into the coil, count the number of turns from the point where the relay first pulled in to the point where the relay drops out. Back up the core to a mid position, half the number of turns you counted.

It is very important to use a weak signal when tuning. If the signal is too strong, the tuning range will seem to be very broad, and it will be hard to find the best core setting. An alternate method of tuning is to connect a high-impedance phone across the secondary of *T2* and tune for the loudest tone. -30-

R/C TRANSMITTER

By DANIEL MEYER

Transmitter sends tone-modulated signals up to 1 mile to energize miniature R/Ceiver

THIS TRANSMITTER is designed to operate with the miniature R/Ceiver described on pages 79-82. It can also activate any other receiver using tone-modulated signals in the Citizens Band, and can be operated without a license under Part 15.205 of the FCC Regulations. Transmitter output is approximately 90 milliwatts, more than enough to control a model up to one mile, line of sight, with the proper receiver.

The unit is powered by a 9-volt battery, and up to 20 hours of operation can be had with a No. 276 Eveready battery or equivalent. Weight of the complete transmitter including battery is a trifle over 1½ pounds. Cost of parts should not be more than $10 to $12.

Construction. Thanks to the availability of a special printed circuit board and pre-wound coils, construction is easy. The parts are mounted in the positions indicated by the part numbers printed on the top side of the printed circuit board. (See Figs. 1 and 2.)

The primary side of coil *L1*, indicated by a red dot, should be installed next to capacitor *C2*. Coil *L2*'s connections are between point *B* and *RFC1*. When installing the coils, be careful not to apply too much pressure on the lugs. Work the lugs into the holes slowly, by rocking the form as it is pushed down. Rough handling can break the lugs loose from the coil form base.

After all parts are installed, bend the leads flush to the foil side of the board and cut them off so that they do not bridge any gaps between conductors. Solder the leads to the etched foil with a 25- to 50-watt iron. Use only rosin-core solder. Heat the lead being soldered and the foil at the same time and let the solder flow onto the connection. Avoid excess heat: it can cause the foil to separate from the board.

Drill out all the openings in the metal cabinet as shown in Fig. 4. Use a file to square off the opening for the switch. And use a wooden block behind the metal to prevent distorting the case when drilling or filing. The prototype transmitter is covered with a white self-adhesive vinyl plastic sheet.

Mount the rubber feet, switches, threaded spacers and antenna post as shown in Fig. 4. The antenna post is an *8-32* x ½″ panhead machine screw. It should be installed with a fiber shoulder washer on one side and a flat fiber washer on the other side of the metal to insulate the antenna from the case. Don't forget the solder lug between the head of the antenna screw and the fiber washer. Then wire in the battery clip and other leads.

Mount the circuit board on the two threaded spacers with *6-32* x ¼″ machine screws as shown in Fig. 5. Connect the wires from the antenna, switches, and battery to points *A*, *B*, *C* and *D* as indicated on the board.

How It Works. Transistor *Q1* acts as a crystal-controlled oscillator operating on the channel determined by the crystal. Coil *L1* and capacitor *C2* form a resonant circuit at the crystal frequency. The crystal provides a feedback path from the collector to the base of *Q1*. Resistors *R1* and *R2* establish the bias at the base of *Q1*. Capacitors *C1* and *C3* bypass r.f., as shown in Fig. 6.

The output stage (*Q2*) operates as a Class C amplifier. The base is link-coupled by *L1*, and resistor *R4* limits the current through *Q2* to a safe value. Collector voltage is obtained by way of *T1* and the r.f. choke. The tuned output stage consists of *L2* and stray antenna capacitance connected in series; this has a bearing on antenna resonance.

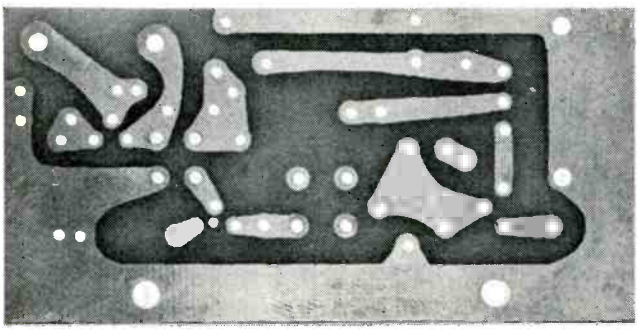


Fig. 1. Actual size photograph of printed circuit board will guide you in making your own.

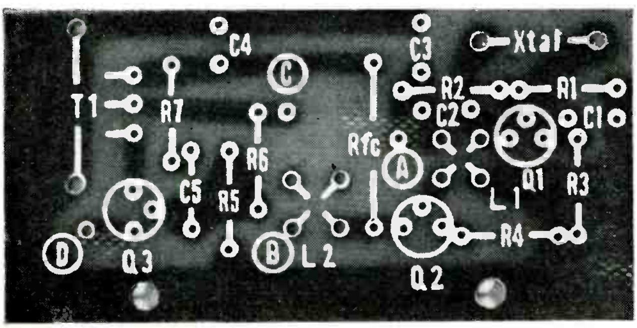


Fig. 2. Component side of board showing parts location and points at which to attach leads.

The tone generator stage (*Q3*) is an audio power oscillator. The auto-transformer (*T1*) provides feedback to the transistor base by way of *R7* and *C5*. Capacitor *C4* acts as an r.f. bypass. The emitter of *Q3* is connected to the *Tone* switch. Closing this switch completes the emitter circuit and operates the tone oscillator.

Tuning the Transmitter. The transmitter can be tuned with a field strength meter, or if one is not available, with a tuning meter you can easily make. The circuit is shown in Fig. 7.

The field strength meter can be loosely coupled to the transmitter circuit, while the less sensitive tuning meter would have to be connected to the antenna. You may or may not get a reading on the meter when the transmitter is turned on for the first time. If no reading is noted, turn the core in coil *L1* until you do get a maximum reading. Use a non-metallic tuning tool to make adjustments.

If everything is working normally, the output should reach a maximum and then suddenly drop to zero as you rotate the core. When this happens, return the core to a point a bit less than maximum. If you attempt to peak the oscillator, it will probably refuse to start after the power is turned off and then turned on. Then tune coil *L2* for maximum output.

All adjustments should be made while you are holding the case. Your body is part of the antenna circuit on this type of transmitter and adjustments must be made under in-use conditions.

After adjusting the coils, press switch *S2*. If the meter reading drops slightly

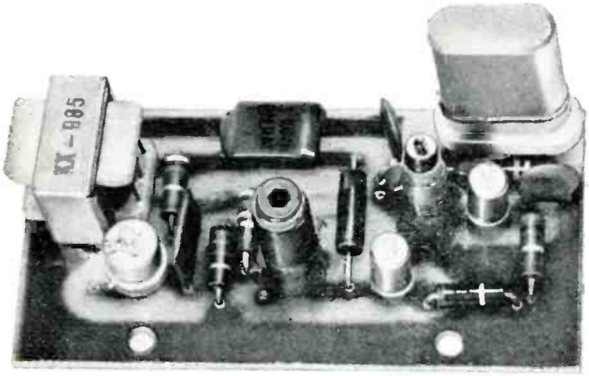


Fig. 3. Parts mounted on board, including crystal holder. Leave 1/16" air space under transistors. Connect leads to board before installing in cabinet.

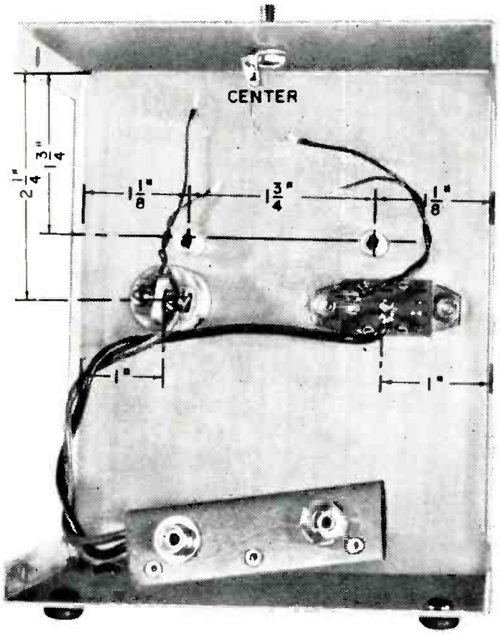


Fig. 4. Prepare cabinet and mount parts as shown before installing completed board. Note terminal located between screw and washer on antenna post.

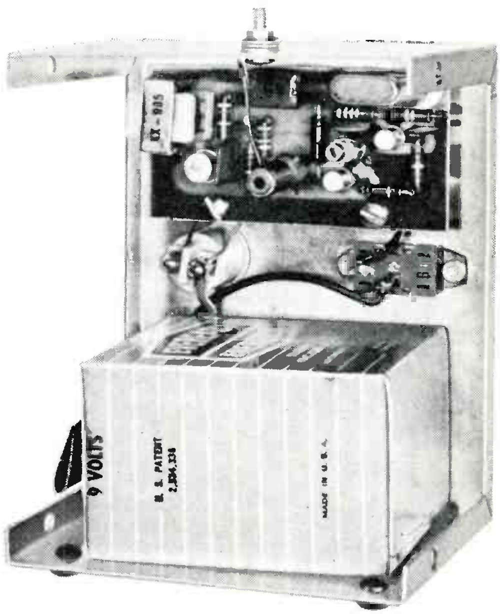


Fig. 5. After installing the board and battery, cement a piece of ½"-thick foam rubber to the inside of the cover to hold the battery in place.

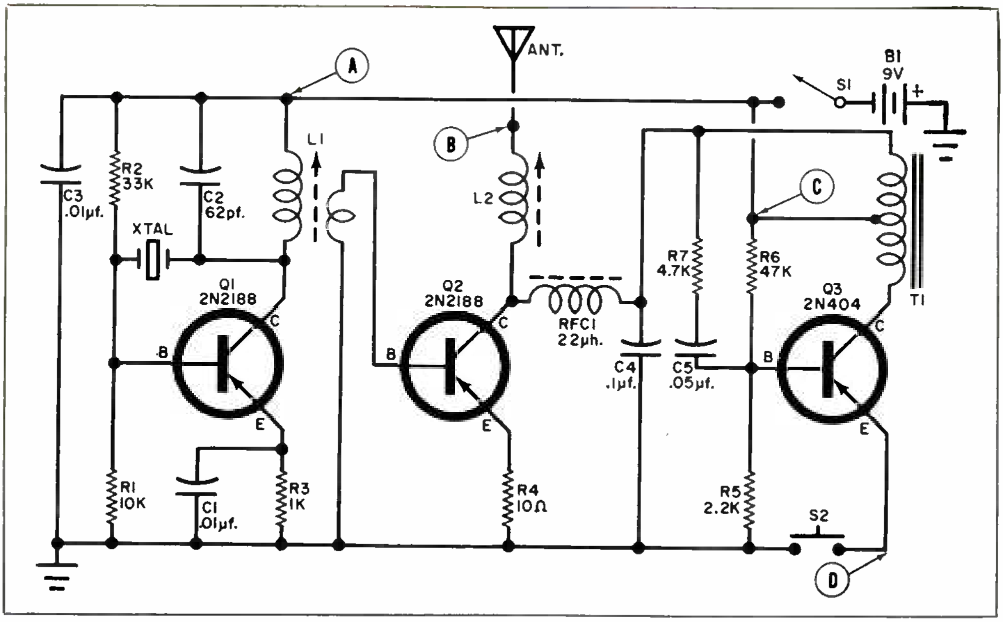


Fig. 6. Signals from the crystal-controlled oscillator (Q1) are modulated by tone generator (Q3) and boosted by the amplifier (Q2) for transmission.

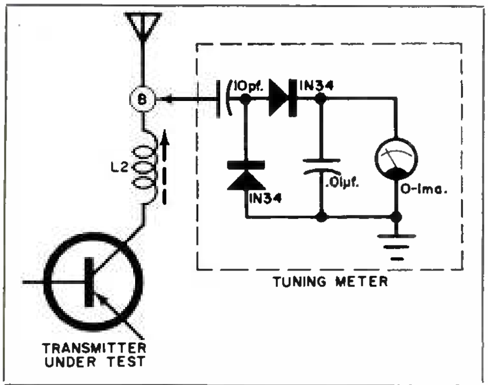


Fig. 7. Tuning meter can be easily made to align and check transmitter. Loosely couple or attach the meter to the antenna to get a usable reading.

the audio oscillator is probably working. This can be confirmed with a CB receiver if one is available.

Operation. Extend the antenna all the way, turn on the switch, and press the *Tone* button. Reduced antenna length will reduce the output. Check the battery periodically. If the battery voltage drops below 8 volts with the transmitter and the tone oscillator on, replace the battery. -30-

PARTS LIST

B1—9-volt battery (Eveready 276 or equivalent)
C1, C3—0.01-µf., 50-volt ceramic capacitor
C2—62-pf., NPO ceramic capacitor
C4—0.1-µf., 50-volt ceramic capacitor
C5—0.05-µf., 50-volt ceramic capacitor
*L1—Oscillator coil: primary, 12 turns of #26 magnet wire on 3/16" coil form with tuning core (Lafayette 34 G 8772 or equivalent); secondary, 3 turns of #26 magnet wire, bifilar wound, starting with third primary winding from the bottom end of the coil form and working down**
*L2—Tuned output coil: 25 turns of #26 magnet wire on ¼" coil form with tuning core (Lafayette 34 G 8952 or equivalent)**
Q1, Q2—2N2188 transistor
Q3—2N404 transistor
R1—10,000 ohms
R2—33,000 ohms
R3—1000 ohms
R4—10 ohms
R5—2200 ohms
R6—47,000 ohms
R7—4700 ohms
(All resistors ½ watt, ± 10%)
*RFC1—22-µh. r.f. choke**
S1—S.p.s.t. slide switch
S2—Normally open push-button switch
*T1—1600-ohm, center-tapped autotransformer***
Xtal—Third-overtone Citizens Band type crystal, 0.005% tolerance (any frequency within specified band)
1—52" telescoping whip antenna (Lafayette 99 G 3008 or equivalent)
1—3" x 4" x 5" aluminum box (Bud 2105 or equivalent)
*1—Printed circuit board**

*A set of parts consisting of the printed circuit board, T1, RFC1, and wound coils L1 and L2 is available from Daniel Meyer, Box 16041, San Antonio, Texas 78216 for $5.00.
**Available separately from Daniel Meyer for $1.00.

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CHAPTER

4
COMMUNICATIONS
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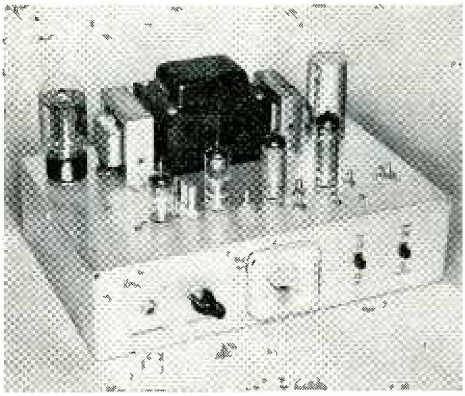
There's a very definite 2-meter ham band tone to this chapter. It is by no means accidental; rather, it was arranged by intent so that the article describing W8VVD's 144-mc. transmitter would be supplemented by suitable ideas on antennas.

For local work, try the "Stacked Halos" (page 103). For modest DX'ing, the "Swiss Quad" (page 104), a distant relative of the famous Cubical Quad, is worth an afternoon's construction. Another ham, W6FPO, presents some very interesting experimental broadcast-band DX'ing antennas (page 101).

The avid builder who likes to "roll his own" should try the "Miniature Receiver" (page 97) built around the J.W. Miller ceramic i.f. module. The "Auto Light Minder" was slipped into this chapter at the last moment—simply to fill out the page: it really belongs under the Chapter 1 heading.



BUILD THE PARAGON 144

Would you like to put a truly effective phone signal on 2 meters? Here's a little rig that's ideally suited for Novice, Technician, or General

By **HARTLAND B. SMITH,** W8VVD

WHETHER you're a Novice weary of pounding brass, a Technician fed up with 6-meter TVI complaints, or a General tired of ear-shattering QRM, there's an answer to your problem: 2-meter phone. Even if you don't live in an area where there's much 2-meter activity, it will pay you to keep a 2-meter rig on the shelf just to take advantage of VHF band openings, and possibly the satellite repeater capabilities of OSCAR III and other ham satellites to follow.

As long as you're going to give 2 meters a whirl, you'll want a transmitter that radiates a truly effective signal. The "Paragon 144," rated at 20 watts input on AM phone, has been designed to do just that. Thanks to its relatively simple circuitry, straightforward parts layout and ease of adjustment, any reader who can drill, file, saw and solder will have little difficulty in putting it on the air.

The Circuit. Referring to the schematic on page 93, *V1a*, a triode oscillator, utilizes third-overtone crystals cut for about 36 mc. Pentode *V1b* doubles the oscillator frequency to around 72 mc.; *V2* serves as a second doubler, boosting the frequency to 144 mc. An Amperex 6360 twin-tetrode, *V3*, is used as a self-neutralized push-pull final power amplifier.

Audio from the microphone is amplified by *V4a* and *V4b* and is then applied to the grid of the Class A Heising modulator, *V5*. An ordinary filter choke, rather than an expensive modulation transformer, superimposes audio from the modulator onto the d.c. power fed to the final amplifier.

An 0-5 ma. meter (*M1*) may be clipped across a number of different shunt resistors to indicate final plate current, final grid current, and the plate currents of either the first or second doubler. (These test points are indicated on the schematic as "*TP1*," "*TP2*" etc.) Silicon diodes *D1* through *D6* serve as power supply rectifiers.

Chassis Preparation. Long leads and haphazard parts placement cannot be tolerated in a 2-meter transmitter: carefully follow the layout diagramed in Fig. 1 and Fig. 2. The 3″ x 8″ x 12″ chassis should be of aluminum rather than steel—aluminum is easier to work and exhibits better conductivity than steel.

Before mounting the tube sockets, study Fig. 3 to make certain the pins are correctly oriented. The rotor of *C13* is hot with r.f., so it cannot be fastened directly to the chassis. Cut a ¾″ x 1¼″ piece of insulation from a sheet of 1/16″ polystyrene or Bakelite. Mount *C13* in a hole drilled at the center of the insulator and then fasten the insulator to the chassis as shown in Fig. 7. Make certain the ⅜″ nut on the threaded shaft bushing of *C13* clears the edges of the ½″ chassis hole (see Fig. 5) through which it protrudes.

Wiring. Wire the heaters first. Cut the green-yellow transformer wire to a length of about an inch and tape the end to prevent it from shorting against another wire or component. Ground one green wire to the mounting foot of the 4-

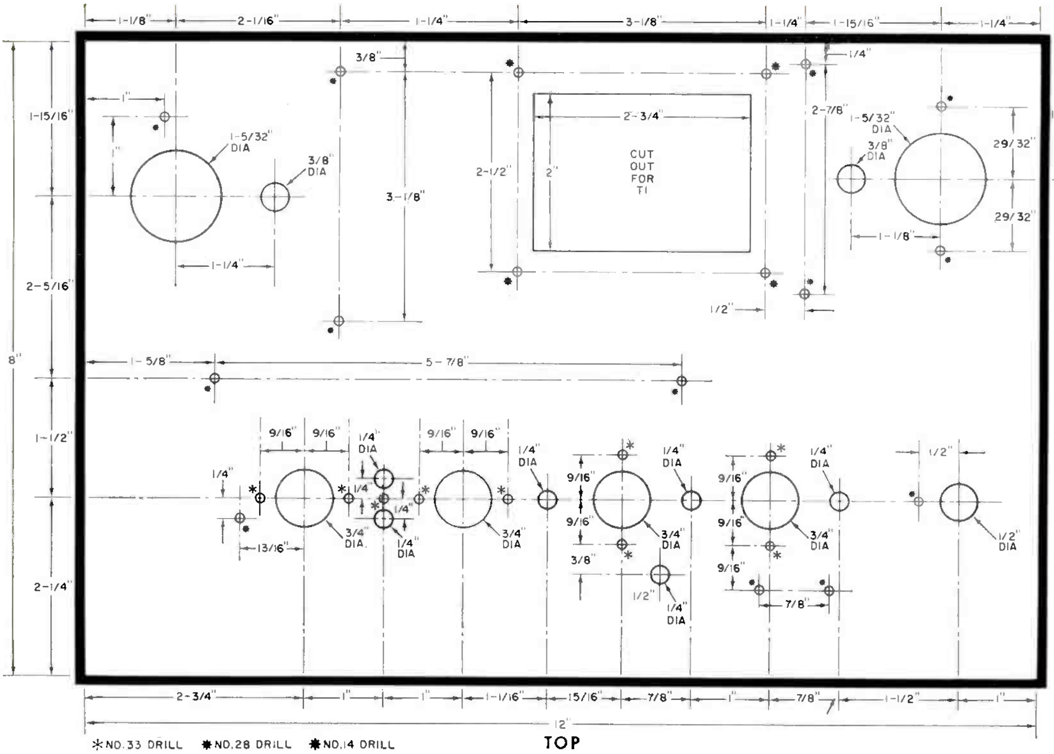


Fig. 1. Diagram shows cutouts, mounting holes in top of chassis. At front, from left to right, are V4, V1, V2, V3. Large hole at top left is for mounting V5; opposite are cutouts for T1 and for capacitor C25.

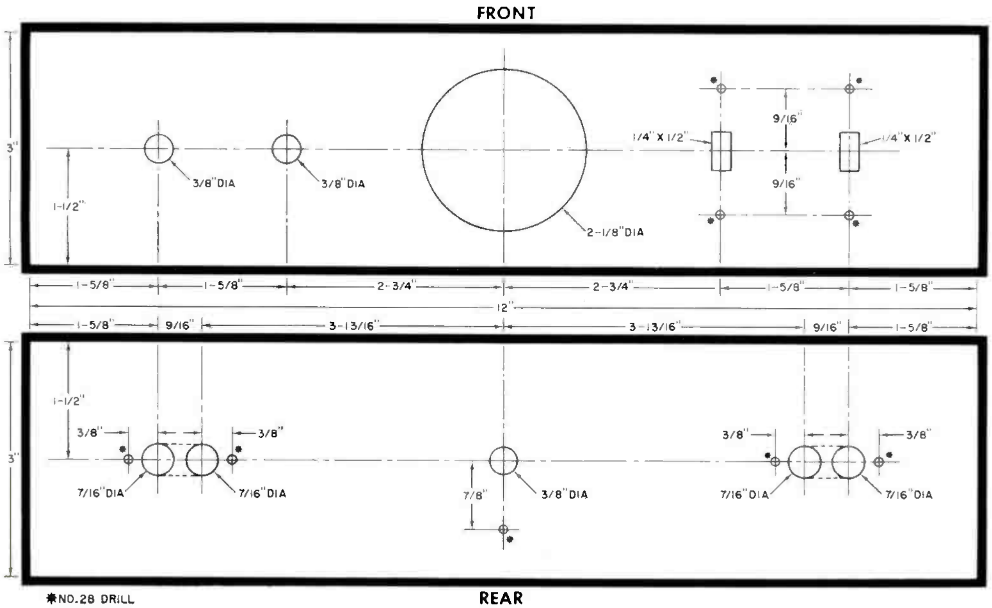


Fig. 2. Cutouts in front panel are (left to right) for mike jack, audio gain control, meter, on-off switch, and send-receive switch. Those on the rear are for mounting TS1, the a.c. line cord, and TS2.

PARTS LIST

C1—10-pf., 1000-volt NPO ceramic disc capacitor (Sprague Series 10TCC, Type Q10, or equivalent)
C2, C4, C6, C8, C10, C21, C22, C23, C24—0.001-µf., 1000-volt ceramic disc capacitor
C3, C7—25-pf., 1000-volt NPO ceramic disc capacitor (Sprague Series 10TCC, Type Q25, or equiv.)
C5—8.7-1.8 pf. miniature variable capacitor (E. F. Johnson Type 160-104 or equivalent)
C9—14.2-2.3 pf. miniature variable capacitor (E. F. Johnson Type 160-107 or equivalent)
C11, C12—8-2.2 pf. miniature variable butterfly capacitor (E. F. Johnson Type 160-208 or equiv.)
C13—32-3 pf. miniature variable capacitor (E. F. Johnson Type 160-130 or equivalent)
C14—16-µf., 150-volt electrolytic capacitor
C15, C16, C17, C18, C19, C20, C28, C30—0.01-µf., 1000-volt disc ceramic capacitor
C25—40/40/20-µf., 450/450/25-volt electrolytic
C26, C29—150-pf., 1000-volt disc ceramic capacitor
C27—10/10-µf., 450/450-volt electrolytic capacitor
D1, D2, D3, D4, D5, D6—750-ma., 400-PIV silicon diode (Lafayette Radio 19G5001 or equivalent)
J1—Standard open-circuit phone jack
L1—11 turns of #20 bare wire, spaced diameter of wire, on a ⅜" x 1⅛" phenolic slug-tuned coil form (J. W. Miller 21A000RBI coil form, available from Allied Electronics, Stock No. 63G909, @ 64 cents)
L2—4 turns of #20 tinned wire, ½" diameter, turns spaced ⅛"; ½" leads
L3—4 turns of #20 tinned wire, ½" diameter, turns spaced ⅛"; 1" leads; coil tapped one turn from C9 end
L4—2 turns of #20 tinned wire, ½" diameter, turns spaced ⅛"; 1" leads; coil tapped at midpoint
L5—6 turns of #12 bare wire, ½" diameter, turns spaced ⅛"; ¾" leads; ½" space at center of coil for insertion of L6; coil tapped at midpoint
L6—2 turns of #12 bare wire, ½" diameter, turns spaced ⅛"; 1" leads
L7—2.3-h., 150-ma. filter choke (Allied Radio 61G482 or equivalent)
L8—3-h., 150-ma. filter choke (Allied Radio 61G483 or equivalent)
M1—0-5 ma. d.c. panel meter (Emico RF 2¼C)
R1—39,000-ohm resistor
R2—100,000-ohm, 1-watt resistor
R3—100,000-ohm resistor
R4, R7—68,000-ohm, 1-watt resistor
R5, R8—82-ohm resistor
R6—47,000-ohm resistor
R9—15,000-ohm resistor
R10—1500-ohm resistor
R11—56,000-ohm, 1-watt resistor
R12—20,000-ohm, 1-watt resistor
R13—39-ohm resistor
R14—1000-ohm, 20-watt resistor
R15, R16, R17, R18, R19, R20—220,000-ohm resistor
R21—100-ohm, 20-watt resistor
R22—270,000-ohm, 2-watt resistor
R23, R27—120,000-ohm resistor
R24—2.2-megohm resistor
R25, R31—330,000-ohm resistor
R26—500,000-ohm potentiometer
R28, R30—8200-ohm resistor
R29—1000-ohm resistor
R32—150,000-ohm resistor
R33—200-ohm, 10-watt resistor

(All resistors ½-watt, 10%, unless otherwise specified)

RFC1, RFC2—1.8-µh. r.f. choke (Ohmite Z-144)
S1—S.p.s.t. slide switch
S2—D.p.d.t. slide switch
T1—Power transformer: secondaries, 650 volts @ 150 ma., center-tapped; 6.3 volts @ 5 amp; 5 volts @ 3 amp
TS1, TS2—2-screw terminal strip
V1—6AU8A vacuum tube
V2—5763 vacuum tube
V3—Amperex 6360 or 6360A vacuum tube
V4—12AX7A vacuum tube
V5—6L6GC vacuum tube
Xtal—Third overtone crystal for a frequency between 36 and 37 mc. (36.250 mc. to 36.750 mc. for Technicians and Novices)
1—Crystal socket
4—9-prong miniature tube socket
1—Octal tube socket
11—Tie strips: 4 one-terminal, 1 two-terminal, 1 three-terminal, 5 four-terminal strips
1—¾" x 1¼" piece of 1/16" polystyrene
1—1¾" x 2¼" metal shield for 6360—see text
1—3" x 8" x 12" aluminum chassis (Bud AC-424)
Misc.—#20 solid hookup wire, #12 bare wire, piece of 300-ohm twin lead, a.c. line cord and plug, pointer knob, ⅜" grommets, ground lugs, 4-36 and 6-32 machine screws and nuts, solder, decals, fine stranded wire and clips for meter leads

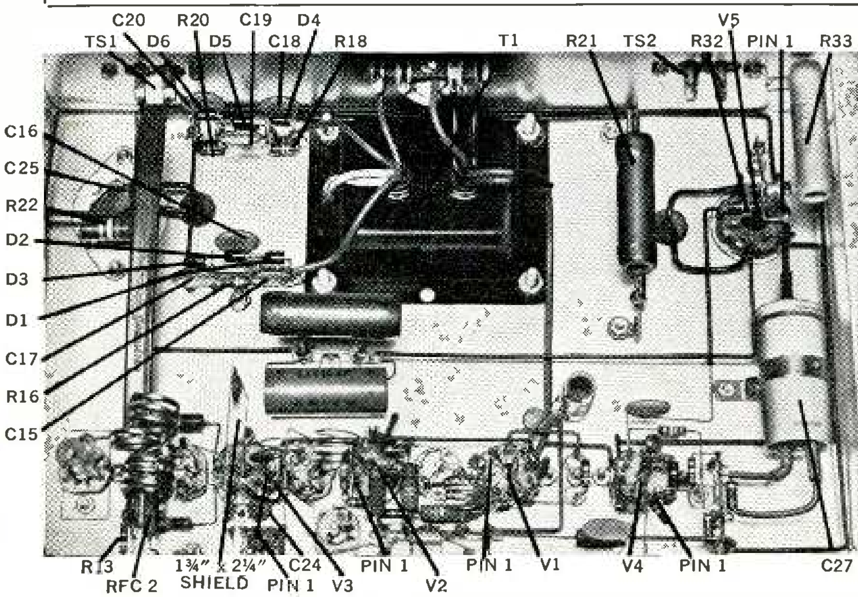


Fig. 3. An overall view of the chassis bottom looking from front to back. In building unit, it is essential that tube sockets be oriented as shown and coils positioned correctly.

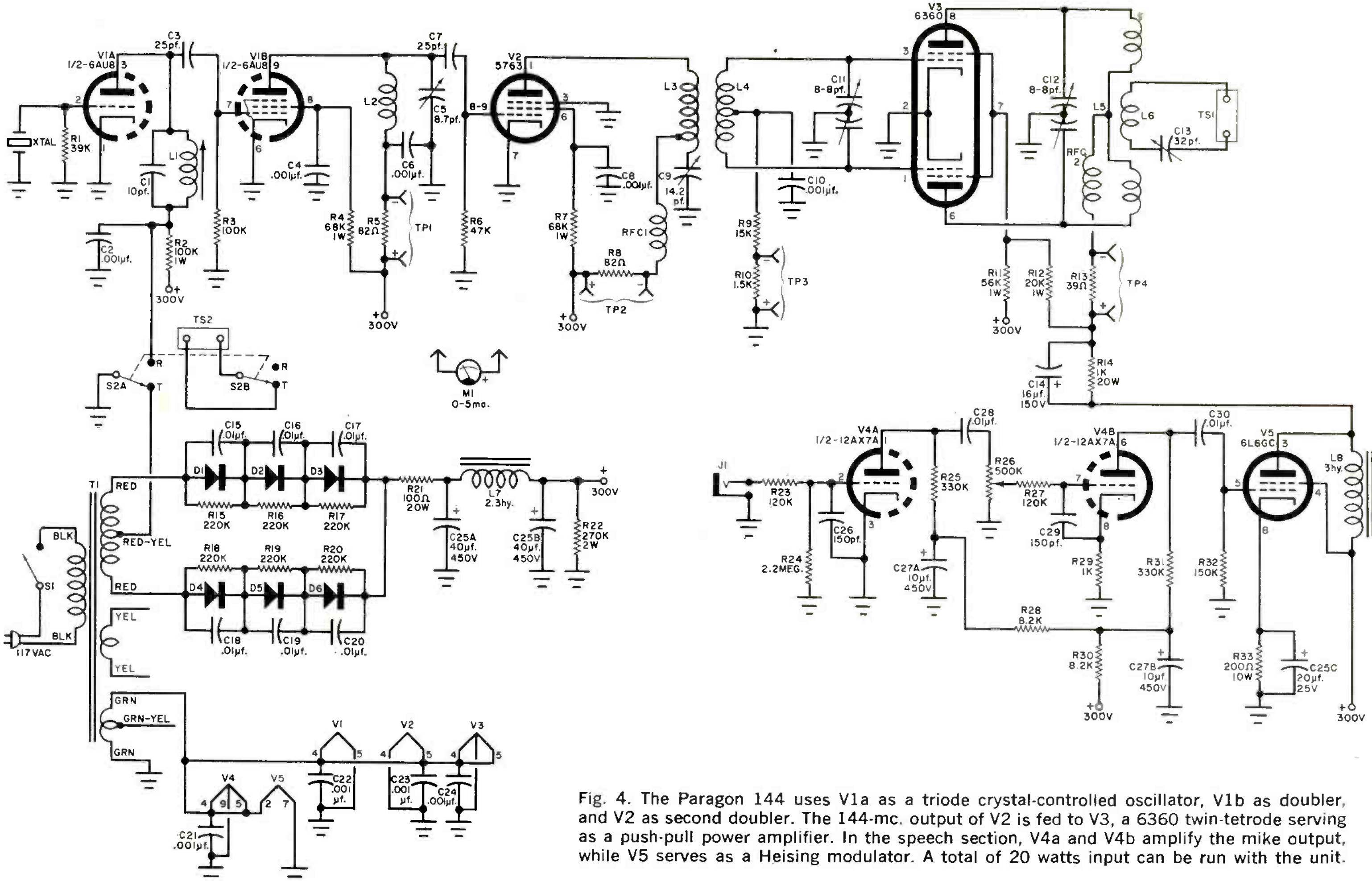
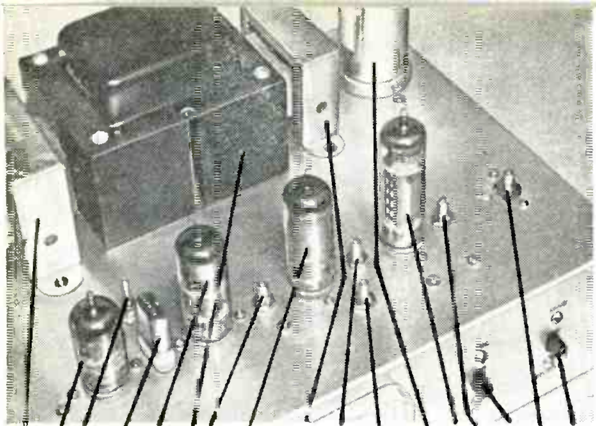
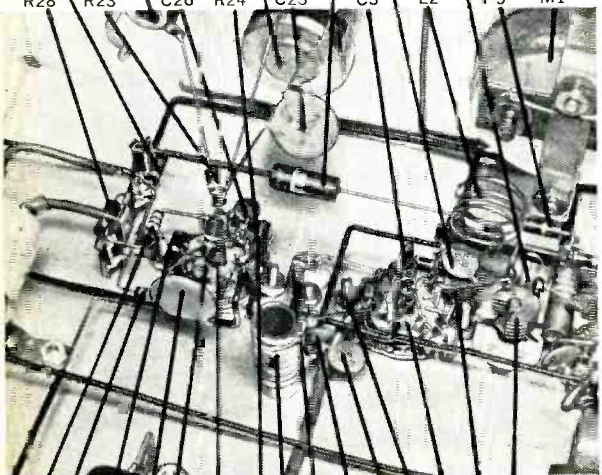


Fig. 4. The Paragon 144 uses V1a as a triode crystal-controlled oscillator, V1b as doubler, and V2 as second doubler. The 144-mc. output of V2 is fed to V3, a 6360 twin-tetrode serving as a push-pull power amplifier. In the speech section, V4a and V4b amplify the mike output, while V5 serves as a Heising modulator. A total of 20 watts input can be run with the unit.





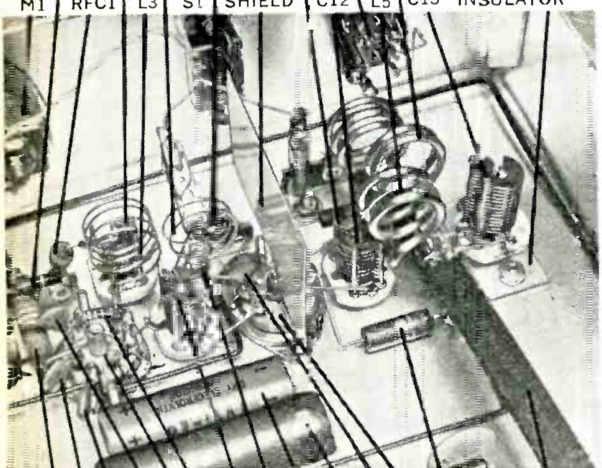


Fig. 5 (top). View of chassis top shows location of r.f. coils and capacitors, as well as other major components. Text describes how to tune up stages.

Fig. 6 (center). Photo of left side of chassis, as viewed from bottom, shows sockets of V1 and V4 and associated components; also note J1, R26, and M1.

Fig. 7 (bottom). Right side of chassis (from below) shows shield across 6360 socket, polystyrene insulator used to mount C13. Note coils L3, L4, L5, L6.

lug terminal strip on the rear edge of the chassis (see Fig. 3). Run the other green wire to pin 4 of *V1*. Connect one branch of the heater line to pin 5 of *V2*, and then to pins 4 and 5 of *V3*. Run the other branch first to pins 4 and 5 of *V4*, and then to pin 2 of *V5*. Cut off and tape the yellow transformer wires.

The long wires going to *S1* and *S2*, as well as those carrying d.c. to various parts of the circuit, should be kept out of the way by running them along the chassis edge. Be sure to observe correct polarity when wiring in diodes *D1* through *D6*, and the electrolytic capacitors (including *C14*).

Solder all chassis connections associated with *V1*, *V2*, *V3*, and *V4* directly to the socket mounting flanges. Run each ground lead from the specified tube pin to the nearest point on the flange. Ground the metal center post of each miniature socket. Shorten the leads of the 0.001-μf. bypass capacitors until they barely reach the appropriate terminals and the socket flanges.

Wind all coils, except *L5* and *L6*, with No. 20 solid tinned wire obtained by stripping insulation from the hookup wire you are using. Space the winding of *L1* (wound on a slug-tuned coil form) sufficiently to prevent the turns from shorting against one another. Coat the finished coil with polystyrene cement.

Use a penlight cell as a temporary winding form for the balance of the coils. After each has been completed, stretch it lengthwise until the turns are spaced 1/8" apart.

Solder one end of *L2* to *C5*'s stator support rod nearest *V1* (see Fig. 6). The opposite end of this coil goes to the nearest terminal of a 4-lug tie strip located directly behind *M1*. Capacitor *C6* and *R5* also go to this same terminal, as shown in Fig. 6. Connect the ground end of *C6* to the rotor lug of *C5*. Solder one end of *L3* to a stator support rod on *C9* (see Fig. 7). The opposite end of this coil goes to pin 1 of *V2*. Attach *RFC1* to the coil, one turn from *C9*. Connect *L4* to the stator lugs of *C11*, rather than to the stator rods. The ends of *L5*, on the other hand, go to the rods, rather than to the lugs, of *C12*. Both the grid and plate leads of *V3* run to the stator lugs of *C11* and *C12*.

A few words of explanation will clear up any confusion which may exist as a result of the foregoing discussion of lugs and rods. Each miniature variable capacitor used in the Paragon 144 has small solder lugs for making electrical connections to both the rotor and stator plates. In those cases where it is impractical to utilize the stator lugs, connections can be made to the stator support rods which extend about 3/16" beyond the rear of the capacitors.

To prevent self-oscillation, the input and output circuits of *V3* must be shielded from each other. Suitable material may be obtained from a well-tinned vacuum-type coffee can. Make the shield 1¾" x 2¼". Scrape the paint off the printed label side of the tin and solder the shield to the center post and terminal 9 of *V3's* socket. Cut a small notch in it to clear terminals 4 and 5. The shield's position is illustrated in Figs. 3 and 7.

Solder *L6* to the two center lugs of a 4-lug terminal strip. Install 300-ohm twin-lead between the terminal strip and *TS1*. Solder a 5" length of stranded hookup wire to each terminal of *M1;* attach miniature alligator clips to the free ends of these wires.

Note that *R23, C26, R27,* and *C29* filter out r.f. energy which might otherwise be rectified by the first two audio amplifier stages and cause annoying r.f. feedback to develop in the modulator section of the transmitter. These capacitors and resistors will function effectively only if they are installed in the proper manner. Cut one lead of each resistor to a length of ¼". Connect the short lead of *R23* to pin 2, *V4a,* and the long lead to *J1*. The short lead of *R27* goes to pin 7 of *V4b,* while the long one goes to the center terminal of *R26*. Trim the leads of *C26* and *C29* to ¼". Capacitor *C26* goes between pins 2 and 3 of *V4a*. Connect *C29* to pins 7 and 8 of *V4b*.

Adjustment. First carefully check the completed transmitter for wiring errors, then plug in a 36-mc. crystal, *V1, V4,* and *V5*. Connect *M1* across *R5 (TP1),* and plug in the a.c. cord. Set *R26* for minimum gain and turn the slug of *L1* fully counterclockwise when viewed from the top of the chassis. Throw *S1* to "On," and, after a one-minute warm-up, throw *S2* to "Send." If the crystal is oscillating, the meter needle will rise to about 1. As you screw the coil slug clockwise, the reading will slowly drop to about 0.8, and then suddenly jump to approximately 1.5 when the crystal goes out of oscillation.

If the meter reads 1.5 at all settings of *L1,* the crystal is not oscillating. Check for either a wiring error associated with *V1,* or too many turns on *L1*. When you finally have *V1* working properly, set *L1* for a meter reading between 0.9 and 1. Flick *S2* up and down several times to make sure the crystal starts up readily.

During the following tune-up procedure, refer to the chart on page 96 when you want to know the actual value of current indicated by *M1* as it is clipped across the different shunt resistors.

Disconnect the a.c. plug and connect the meter leads across *R8 (TP2)*. (Caution! Never touch the meter leads without first removing the a.c. plug from the wall socket!) When changing the leads to a different test point, make certain the clips do not short against other components. Always keep them as far as possible from the coils and tuning capacitors.

Replace the a.c. plug and insert *V2* in its socket. After warm-up, throw *S2* to "Send." As you tune *C5,* the meter indication should vary between about 1.6 and 2.4. Set *C5* for the lowest meter reading, cut the power, and turn the chassis over and examine it. If *C5's* plates are somewhere between minimum and maximum capacity, *L2* has the proper inductance.

CURRENT MEASUREMENTS			
Test Point and Measurement	Typical Reading	Multiply By	Actual Current
TP1—V1b plate current	.9	20	18 ma.
TP2—V2 plate current	1.6	20	32 ma.
TP3—V3 grid current	1.6	2	3.2 ma.
TP4—V3 plate current	2.3	40	92 ma.
Note: Variations of ±15% are normal			

Measurements shown in chart are made by clipping leads from M1 across appropriate test points. After initial tune-up, meter can be connected permanently across TP4 for monitoring final plate current.

If minimum current occurs at minimum capacity, less inductance is needed. If full capacity is required for a current dip, the inductance is too small. Squeeze the turns together to increase the inductance, or pull them apart to lower it. If there is no current change as *C5* is tuned, recheck the wiring associated with *V1b* and *V2*.

The next step is to move the meter clips to *R10* and connect a 15-watt light bulb across *TS1*. Plug in *V3*. Turn the power on and tune *C9* and *C11* for the highest meter indication. It should be in the neighborhood of 2 if *L3* and *L4* have been correctly wound and installed. If the highest reading is obtained with either *C9* or *C11* at the extremes of their ranges, stretch or squeeze the coils as suggested in the previous paragraph.

Slowly tune *C12* and *C13* until the light bulb glows most brightly. Use a nonmetallic screwdriver on *C13*. Now, adjust *L1* counterclockwise until the meter drops to approximately 1.6.

After pulling out the power plug, connect the meter clips across *R13* (*TP4*). Re-install the plug and experiment with various settings of *C12* and *C13*, and the position of *L6* with respect to *L5*. In this way, you'll become thoroughly familiar with how these adjustments affect transmitter output as indicated by the meter needle and bulb brightness.

Plug a crystal or ceramic microphone into *J1*. Advance *R26* until the meter needle flickers very slightly and the bulb intensity increases noticeably as you speak into the mike. Do not raise the gain beyond this level. More audio will merely result in excessive distortion and a broad signal.

The transmitter is now ready to go on the air. Connect a 300-ohm feedline between *TS1* and a good 2-meter beam antenna. Adjust *C12* and *C13* so that the meter reads between 2 and 2.5 at resonance dip. This indicates an input power of between 16 and 20 watts.

Tips On Operation. Most 2-meter operators use crystal-controlled rigs and tend to stick to a single frequency. However, if you decide to purchase a number of crystals in order to hop around the band, it will pay you to put knobs on *C12* and *C13* so you won't have to hunt up a screwdriver to QSY.

You can ignore the other adjustments when changing crystals if you stagger-tune them. To do this, set *L1* and *C9* for a meter indication of 1.5 with your lowest frequency crystal in the socket. For this tuning operation, the meter is connected across *R10* (*TP3*). Peak *C5* and *C11* for a 1.5 reading with your highest frenquency crystal, and from then on, just retune *C12* and *C13* slightly when you change frequency.

Once you have the transmitter working properly, the meter clips can be connected permanently across *R13* to permit you to monitor plate current during each transmission. The antenna change-over and receiver muting relays in your shack may be controlled by *S2b*, thereby providing you with one switch operation. Access to *S2b* is provided by *TS2*.

Results. When the prototype was first put on the air, it produced 18 QSO's from 20 calls, a 90 percent batting average. Comments received over the air were uniformly complimentary with regard to signal strength and audio quality.

If you live in relatively flat country and use a 6- to 8-element beam mounted 40 or so feet in the air, the Paragon 144 will provide consistently strong signals at a distance of about 30 miles. Usable signals can be expected up to 40 or more miles under normal day-to-day conditions. A higher tower and larger antenna, or a hill-top location, will stretch these figures significantly. However, when skip conditions are good, you'll be able to work 300 miles and beyond, even with a low-gain, chimney-mounted antenna array. -30-

Miniature I.F. Module Superheterodyne Pocket Receiver

By CHARLES CARINGELLA

Modern electronics module concept gets more elements into less space and greatly reduces number of tie points. Two i.f. amplifiers and detector take up only 0.375 cubic inch.

ROUND-THE-CLOCK listening pleasure will be your reward for doing a good building job on this modern transistor superheterodyne broadcast-band radio. It is a complete unit and can be put into your pocket. It can also give your phonograph or tape recorder the ability to sound off with broadcast-band programs. No test or alignment equipment is needed to construct the radio.

A pre-aligned i.f. amplifier module only 1½" x ½" x ½" in size speeds construction and simplifies wiring. The module contains 24 parts including a ceramic filter, two transistors, two transformers and a diode detector.

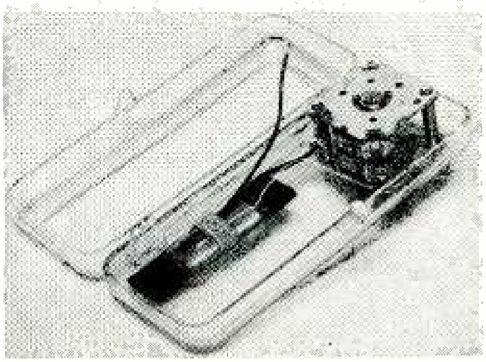


Fig. 1. Variable capacitors C1a and C1b are held in place by machine screws. The antenna loopstick can be cemented to the case, or just allowed to "float" in place.

Except for the antenna loopstick, variable capacitor and phono jack, all components including the i.f. module are mounted on a small board, measuring just 2⅞" x 1⁹⁄₁₆", as shown in Fig. 2. This is not a printed circuit. All the components are hand-wired.

How It Works. Transistor *Q1* serves as an r.f. amplifier, local oscillator and mixer. (See Fig. 4.) The input circuit, consisting of a variable capacitor (*C1a*) and an antenna ferrite loopstick (*L1*), tunes the broadcast band. Local oscillator coil *L2* is tuned by variable capacitor *C1b* to a frequency that is always 455 kc. above the frequency of the incoming signal. Capacitors *C1a* and *C1b* are ganged.

The incoming r.f. signal and the local oscillator signal are mixed in transistor *Q1*. Sum and difference frequencies as well as the r.f. and oscillator signals appear at the output of *Q1*. The miniature i.f. transformer (*L3*) is tuned to 455 kc., and allows only the difference frequency to pass on to the next stage. The primary of *L3* is part of the collector load circuit of *Q1;* the tap on this winding is not used.

The next two i.f. stages are in the module, as is the detector stage, as shown in Fig. 6. Bandwidth is fairly narrow, thanks to the ceramic filter between pin 2 and the 390-ohm resistor, but not narrow enough to prevent good reception of music. The bandwidth is about 8 kc. at −6 db. It is therefore possible to obtain good selectivity. The 455-kc. i.f. signal is amplified by each of the two pre-tuned transistor stages and then demodulated by the crystal diode detector. The audio signal goes through a low-pass filter to pin 7 and then to the top of the volume control, potentiometer *R6*. From the volume control the signal is fed directly to an earphone jack. Additional transistor stages can be added, if desired, to drive a loudspeaker. A patch cord could be used to connect the radio earphone jack to the input of a tape recorder or phonograph. A feedback loop from the detector to the base of the first transistor in the module provides a.v.c. action. Overall gain of the i.f. module is about 55 db.

A loudspeaker is usually preferred, but there are several advantages to using an earphone: fewer transistors are needed, battery life is longer because power consumption is lower, and you can listen without disturbing anybody. An earphone can also provide exceptionally good fidelity—bass notes, which can not be reproduced by a small speaker, can be heard in an earphone, because the earphone is directly coupled to the ear and does not have to move a large vol-

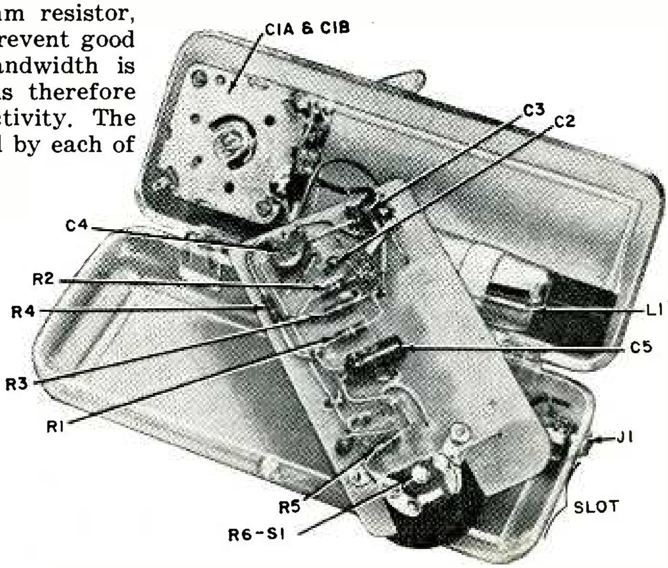


Fig. 2. Bottom view of the circuit board. Notch permits volume control to work without undue stress. The slot in the case allows volume control knob to turn freely.

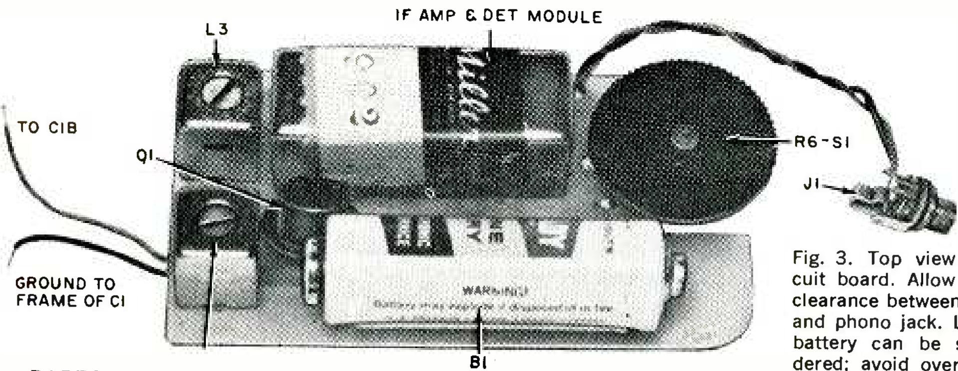


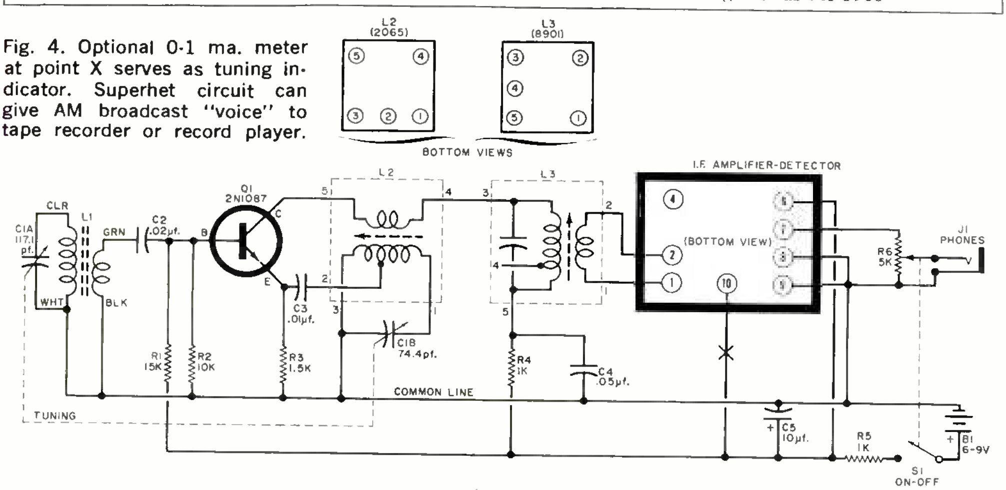
Fig. 3. Top view of circuit board. Allow enough clearance between battery and phono jack. Leads to battery can be spot-soldered; avoid overheating.

PARTS LIST

B1—6- to 9-volt transistor radio battery (NEDA 1606 or equivalent)
C1a/C1b—Miniature 2-gang variable capacitor; 117.1-pf. r.f. section, and 74.4-pf. osc. section
C2—0.02 µf., 3 volts }
C3—0.01 µf., 3 volts } *miniature ceramic disc capacitors*
C4—0.05 µf., 10 volts }
C5—10-µf., 12-volt electrolytic capacitor
J1—Phono jack, subminiature type
L1—Ferrite antenna loopstick (Miller 2010 or equivalent)
L2—Oscillator coil, miniature (Miller 2065 or equivalent)
*L3—I.f. transformer, miniature (Miller 8901 or equivalent)**
Q1—2N1087 transistor
R1—15,000 ohms }
R2—10,000 ohms } *all resistors,*
R3—1500 ohms } *¼ watt, ±10%*
R4, R5—1000 ohms }
R6—5000-ohm potentiometer with s.p.s.t. switch (Lafayette 99 G 6019 or equivalent)
S1—S.p.s.t. switch (on R6)
*1—I.f. amplifier module (Miller 8902)**
1—2⅞" x 1 9⁄16" phenolic or laminated board
1—3000- to 7000-ohm dynamic earphone
1—4¼" x 1¾" x 1" plastic box

*The Miller 8902 module and the Miller 8901 transformer are available together as the 8903

Fig. 4. Optional 0-1 ma. meter at point X serves as tuning indicator. Superhet circuit can give AM broadcast "voice" to tape recorder or record player.



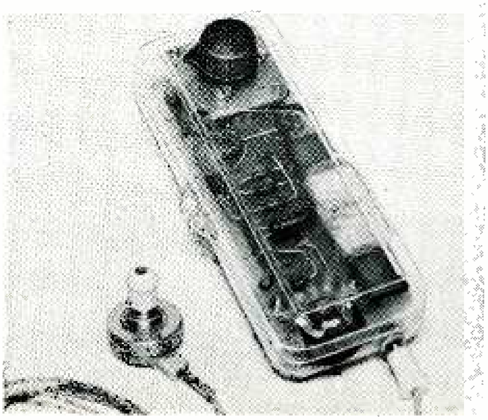


Fig. 5. Tuning dial can be mounted under knob on finished radio. High-impedance earphone provides good audio frequency response.

ume of air as a loudspeaker does. Earphone impedance should be anywhere from 3000 to 7000 ohms. Do not use a low-impedance phone, as it will load down the output circuit excessively.

If you wish, you can add a tuning meter to the circuit. Insert a 0-1 milliampere meter in series with the lead going to terminal 10 on the i.f. module.

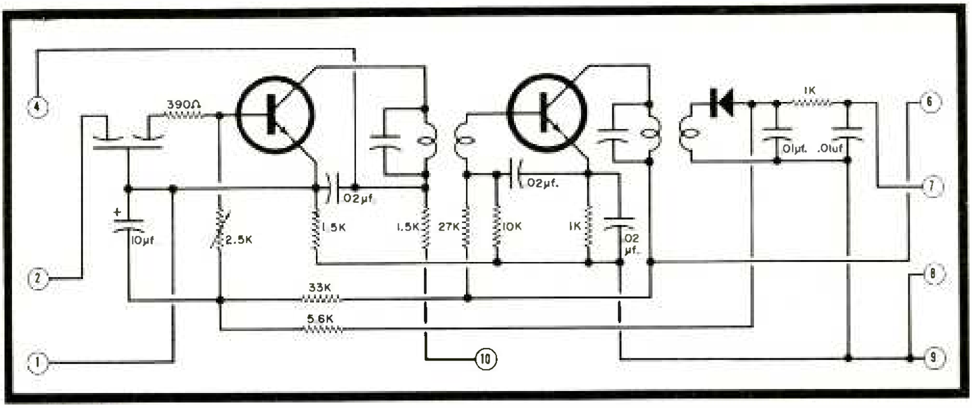
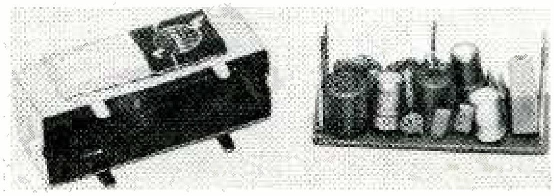


Fig. 6. Miniature i.f. strip is pre-aligned and pre-packaged. A detector stage is also included. A ceramic filter limits i.f. response to improve receiver selectivity without damaging audio quality. Overall gain is 55 db and output is sufficient to direct-drive an earphone. Bandwidth is 8 kc. at—6 db. Photo at right shows how actual components were fitted into can.



(See point *X* in Fig. 4.) The radio draws only 3 milliamperes.

Construction. The completed broadcast radio is shown in Fig. 5. It was built to fit into a small plastic box, which is readily available. You can choose any size box, as long as all the parts fit and are arranged in an orderly manner—the best thing to do is follow the photographs. Do not use a metal case. A shielded antenna usually develops into a situation of apparent radio silence.

Mount *C1* directly to the case. *L1* can be held in place by a dab of cement or just allowed to "float." The black and white wires from *L1* are soldered directly to the capacitor frame. The clear wire is soldered to *C1a,* the capacitor with a greater number of plates. The green lead is attached to *C2* on the circuit board later.

The circuit board assembly is shown in Figs. 2 and 3. Parts location is not critical, but here again it is best to follow the layout as shown. Keep the leads short and avoid overheating the transistors when soldering. Notch out the board to allow the volume control (*R6*) to be mounted without undue stress or strain. Enough of the knob should protrude so that it can be easily reached when the assembly is finally placed into the case. A 3/4" x 1/8" slot is cut out on the side of the case to allow the knob to stick out about 1/16".

Connect all the metal cans to a common ground line. This line is also connected to the frame of the variable capacitor. Short leads can be soldered directly to the battery. Next to the slot in the case, install the miniature phono jack.

Position the board in the case when completed. Connect the green wire to *C2* and two wires from the volume control to the phono jack.

Alignment. If all is well with your radio, you will hear background noise or, hopefully, a radio station or two when you first turn it on. The alignment and peaking adjustments are made from off-the-air signals. All you need is a nonmetallic screwdriver. Do not force any of the screws or slugs; they should turn easily. Try to get any station and adjust *L3* for maximum. In the absence of a station, adjust for maximum noise.

Rotate the knob until the plates are almost fully meshed. This is the low end of the broadcast band. With the aid of another radio, as a "standard," locate a station at the lowest end of the band. Adjust the slug in oscillator coil *L2* until

(*Continued on page* 138)

Compact BCB DX Antennas

Attention to antenna design helps dig out those buried BC stations

By F. J. BAUER, JR., W6FPO

TRADITIONALLY, the rule applied to broadcast-band antennas has been "the longer the better." While this rule still holds, it is also true that when antenna length is already short compared to the wavelength of the signal being received (as is the case with most practical BCB antennas), a further reduction in length, within certain limits, has little effect on antenna efficiency.

Almost any single wire antenna of random length will give good results when used with one of the antenna couplers which were described in the 1965 Fall Edition of the ELECTRONIC EXPERIMENTER'S HANDBOOK ("Soup Up That AM Broadcast Receiver"). In the author's case, tests made with a 100-foot horizontal, a 50-foot horizontal, and a 33-foot vertical antenna showed little difference in performance when DX'ing the BCB with a medium-priced communications receiver.

"Loaded" Whip. Since most antennas for BCB reception are "short" anyway, why not "load" the antenna with an inductance above its center for greater efficiency? To try this idea, the author used a 9-foot whip mounted on a pole with a 24-foot down-lead making up the rest of a 33-foot vertical. An adjustable ferrite antenna coil was connected at the base of the whip as shown in Fig. 1, and the base of the antenna grounded. A transistor radio held near the antenna wire was used to resonate the antenna. The radio was tuned to a weak station at the high-frequency end of the band, and the coil slug adjusted for maximum volume.

To tune such an antenna across the broadcast band and also couple it to the receiver, one of the antenna couplers featured in the article mentioned above should be used, and is shown in Fig. 1 within the dotted lines. The capacitor used in the tuner is a 100-pf. mica unit, and the coil is simply another ferrite antenna coil. Tests with the loaded whip showed a very worthwhile improvement in signal strength—WMAQ, Chicago (670 kc.), for example, was three "S" units higher in Los Angeles with the loading coil in the circuit.

Loop Antenna Cuts QRM. What about adjacent-channel DX? If the strength of strong local stations can be reduced somewhat, it becomes possible to copy

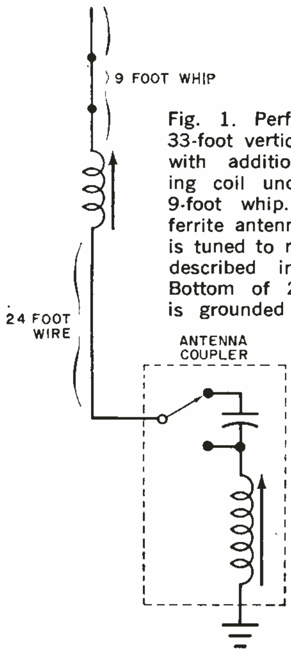


Fig. 1. Performance of 33-foot vertical improves with addition of loading coil under topmost 9-foot whip. Coil is a ferrite antenna type, and is tuned to resonance as described in the text. Bottom of 24-foot wire is grounded for tuning.

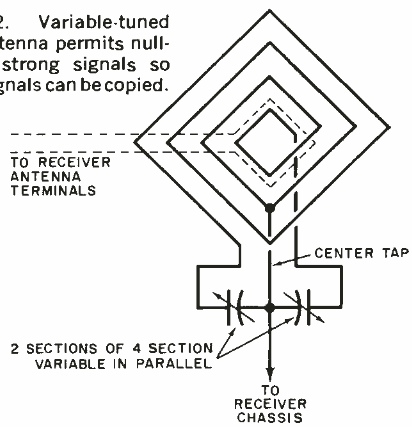
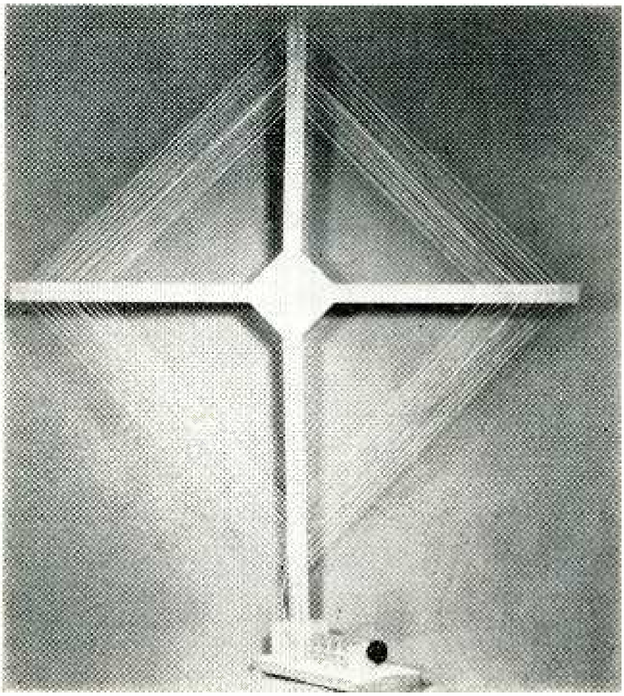


Fig. 2. Variable-tuned loop antenna permits nulling of strong signals so weak signals can be copied.



Crossarms of loop are made with 1/4" x 1 1/2" x 44" plywood strips—the vertical arm in one piece and the horizontal in two pieces. Join the three strips together with 6"-square pieces of plywood nailed and glued on each side of the joint. In the author's unit, the loop was mounted in a wooden block fastened to the base holding the tuning capacitor. The loop itself, which is wound 1" in from the ends of the arms, is supported with wire brads. The one-turn coupling coil is wound on the back of the arms opposite the center turn of the loop and as close to it as possible. Three connections are made to the receiver as shown in the diagram on p. 101, two to the antenna terminals and one to the chassis. Note: do not ground the loop to the chassis of an a.c.-d.c. radio due to the shock hazard which might result.

stations in the background. Wave traps were tried but were of little use. In some instances the trap acted more like an antenna than a trap, and merely aggravated the interference problem.

A loop antenna was considered next. If properly built, it would have reasonably good signal pickup and a sharp null at right angles to the plane of the loop. Its directional characteristics would make it possible to null out, to some extent, strong ground-wave signals from local stations.

Although the author's loop looks like a throwback to the 1920's, it performs better than expected. In Los Angeles, for example, it is possible to reduce the signal of a powerful local, KMPC on 710 kc., to receive Chicago, WGN on 720 kc., with little or no interference. After playing around with this circuit for a while, you will often be able to separate and identify distant stations on the *same* frequency by rotating the loop antenna for a null on one of the signals.

Loop Construction. At its largest, the loop measures 42" across, and consists of 13 turns of stranded wire spaced 1/2" apart. Construct the crossarms of the loop as described in the caption above. To couple the loop to the receiver, wind a separate one-turn coupling coil on the back of the cross-arms opposite the center turn and as close to it as possible.

The best way to tune the loop is with a salvaged four-section variable capacitor of the type used in older receivers. When you pair the sections by connecting them in parallel, the effective maximum capacity of the two resulting sections is well over 600 pf. A similar arrangement can be worked out by ganging two double-section TRF variable capacitors, which are readily available from most electronic parts houses.

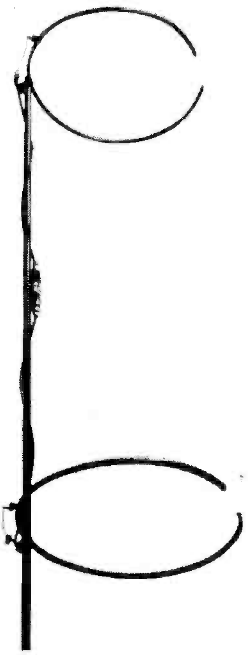
Connect the capacitor sections as shown in Fig. 2, and make the three connections to the receiver (to the antenna terminals and ground). With the center tap disconnected, turn the loop for *minimum* signal on a strong local station. Next, place the center tap at approximately the center of the loop, and tune the variable for *maximum* signal. Adjust the tap for minimum signal, and, again, tune the capacitor for maximum. The variable capacitor is retuned as you tune across the broadcast band.

You'll be surprised at the improvement in your BCB DX score! —30—

2 Halos Stacked for 2 Meters

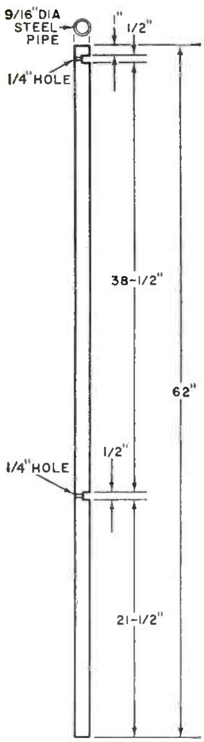
Easy-to-build high-gain antenna for fixed or mobile use

By BOB SARGENT, WAØ66I



Right: Coaxial "T" connection ties the transmission line to both halos. Gamma match faces same way and is adjusted for minimum SWR.

Below: Cut slot just wide enough to accommodate halos. Mount pole so that the bottom halo is as high above the ground as possible.

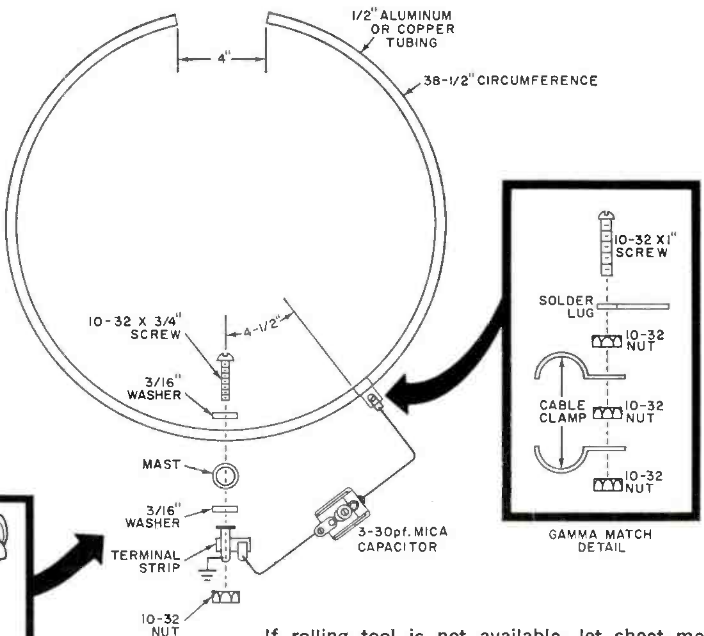


HALO ANTENNAS are like ½-wavelength dipoles in many ways. They are cut to the same size, they are horizontally polarized, and they can be stacked for additional gain. However, the bidirectional characteristic of the dipole changes to an omnidirectional pattern when the dipole is curved to form a halo.

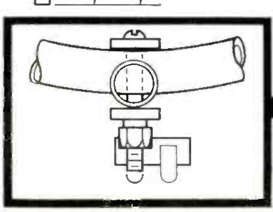
Horizontally polarized antennas favor horizontally polarized signals and are less susceptible to ignition noise and vertically polarized waveforms. Gain of a halo over a ¼ wavelength vertical Marconi type is usually about 8 db. A gain of 12 db can be expected from a two-halo stack.

At 2 meters a stacked halo arrangement becomes manageable and suitable for mobile work, since the higher frequencies make it possible to employ smaller size antenna elements. The om-

(*Continued on page* 143)



GAMMA MATCH DETAIL



HALO MOUNTING DETAIL

If rolling tool is not available, let sheet metal shop do the forming. Do not drill mounting hole before the halo is shaped; weakened metal bends easier. Weatherproof with nonconductive paint.

BUILD A 144-MC. Swiss Quad ANTENNA

By **HERBERT S. BRIER,** W9EGQ

All-metal, 2-meter cubical quad uses new ideas proposed by HB9CV—front-to-back and front-to-side ratios are over 25 db

ALTHOUGH the "Cubical Quad" directional antenna has several obvious advantages, including high gain and economy of construction, the mechanical strength to cope with high winds is not an outstanding feature of the Quad constructed of bamboo and wire. The *all-metal* "Swiss Quad" described in "Across the Ham Bands" in the April, 1965, issue of POPULAR ELECTRONICS (page 74) has generated great interest among the ham fraternity.

The Swiss Quad retains the electrical advantages of the usual Quad, but adds strength and durability. A 144-mc. Swiss Quad can be built in a few hours at a cost of less than $4.00. It will give a real *hop* to your signals.

Design. If the centers of the horizontal members of a two-element Quad are pushed in until they touch, they may be joined—both electrically and mechanically—to the central support pipe. If the horizontal members are metal tubing, the Quad becomes a self-supporting structure without an auxiliary framework.

Coupling the centers of the horizontal members of the Quad together and to the support pipe is permissible, because these points are at zero r.f. potential. But, because a portion of the elements are partially bent back upon themselves, the overall dimensions of the antenna should be approximately 10% greater than for a conventional Quad cut for the same frequency.

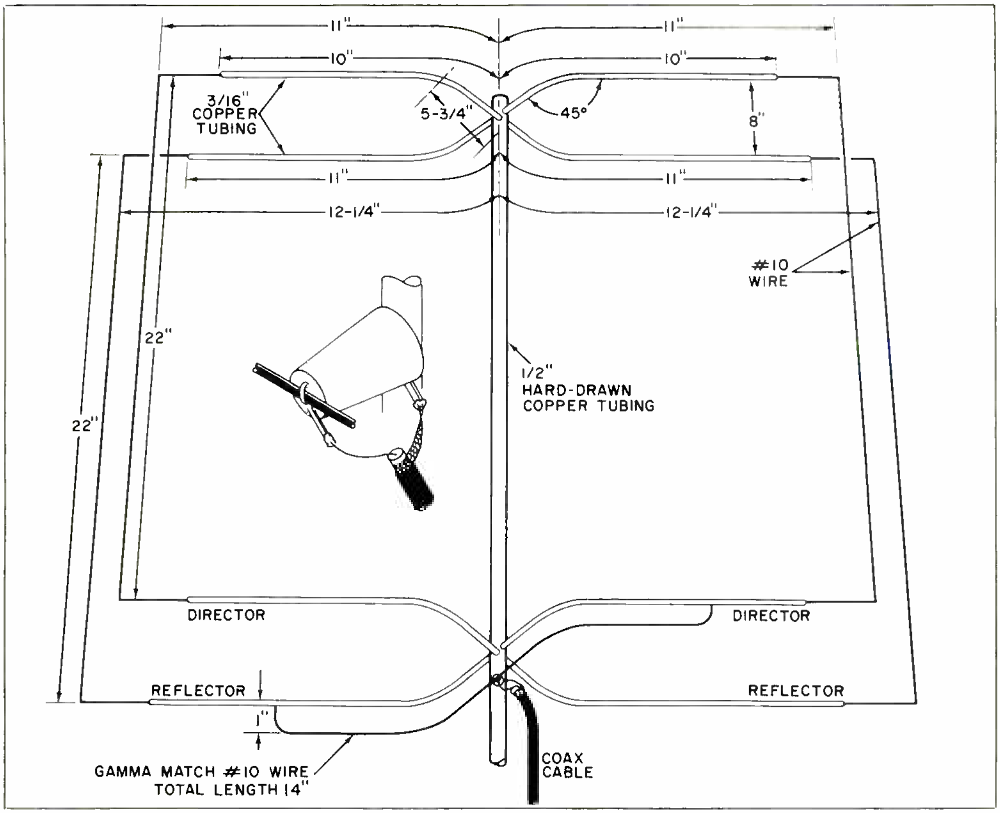
The designer of the Swiss Quad, Rudolf Baumgartner, HB9CV, accommodated this increased size by adding to both the horizontal and vertical dimensions. I have found, however, that there is no significant difference in results if either the horizontal or vertical dimensions are kept the same as in a conventional Quad, and the other dimensions are increased sufficiently to restore resonance at the desired frequency.

Construction. The 144-mc. Swiss Quad is made of copper wire and tubing which is available in hardware and plumbing supply houses. To build a duplicate of my Swiss Quad, first straighten the 3/16" copper tubing by rolling it on a flat surface while tapping it lightly with a wooden mallet. Cut off four 21" lengths.

Now take the hard-drawn 1/2"-diameter copper tubing and drill a 13/64" hole a half inch from the top end. Line up the drill so that the bit passes through the diameter of the tubing and comes out on the opposite wall. Drill another pair of 13/64" holes 22" below the first pair in the same manner. Then rotate the tubing a quarter turn, and drill a third pair of 13/64" holes 3/4" from the top end and at right angles to the first pair; and drill a fourth pair 22" below the third pair. Finally, drill a 9/64" hole a half inch below the bottom 13/64" hole and in line with the first and second pairs.

Mount the standoff insulator in the 9/64" hole on the supporting rod. Place a solder lug under and on top of the insulator. You may have to do a bit of juggling to line up the screw through the 9/64" hole from the inside to catch the insulator, but it can be done.

Slide the four pieces of 3/16" tubing through the 13/64" holes, and position them so that they all extend 10" from the center of the 1/2" supporting rod to one side and 11" from the center to the



You can build a Swiss Quad in a few hours using readily available copper wire and tubing. The mast can be any convenient length. Sweat elements to the support pole with a heavy soldering iron or butane torch.

BILL OF MATERIALS

1—7' length of 3/16" copper tubing
1—3' length of ½" hard-drawn copper tubing
1—12' length of #10 plastic-insulated copper wire
1—⅝" cone-type standoff insulator (E. F. Johnson #135-501 or equivalent)
2—Solder lugs

other side. Solder them in place, using a husky soldering iron (250 watts or larger) or a small torch.

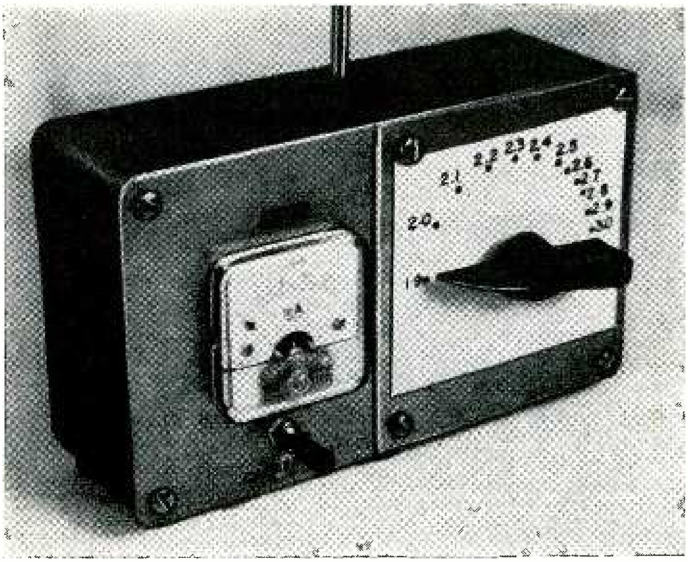
Measure 5¾" from the center of the supporting rod along the 3/16" tubing, and bend the 3/16" tubing horizontally 45° so that the end sections of each adjacent 10" and 11" length are parallel and spaced eight inches apart. It is not necessary that the bends be sharp; slightly rounded corners are preferred.

Remove the plastic insulation from a 14" length of #10 wire which serves as the *gamma* matching rod. The rod is approximately 12" long and soldered at each end to the radiating elements; it is spaced an inch away from the elements. Do not solder the ends of the *gamma* rod until you have had an opportunity to adjust it, as described below. Cinch the solder lug on top of the standoff insulator around the center of the *gamma* rod, and solder it and the center conductor of the 50-ohm (nominal) coaxial feed line to the *gamma* rod. Solder the cable shield to the other solder lug.

Slice the insulation off the remainder of the #10 wire, and cut four 30" lengths. Four inches from each end of these lengths, bend the wire at right angles to form shallow U's 22" wide. Slip the ends of these U's into the corresponding top and bottom 3/16" copper tubing to the dimensions shown in the drawing.

Adjustment. Place an SWR bridge in the coax line and feed a small amount of r.f. into the line. Slide the wire U's

(*Continued on page* 136)



MARINE BAND WAVE-METER

By E. H. MARRINER,
W6BLZ

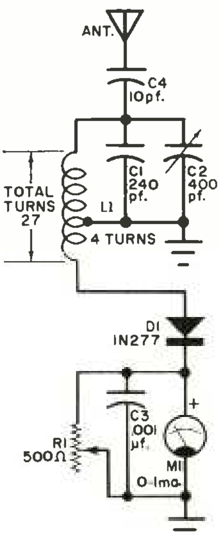
This little unit keeps tabs on your signal

SMALL boat owners, fishermen, technicians, and others who own, use, or service and install marine band radio equipment will want to duplicate this simple wavemeter designed for monitoring and tuning up shipboard transmitters in the 2-3 mc. range. The unit does not use any batteries, and can be left on to monitor transmitter output and insure that it is set to the proper channel.

How It Works. To simplify matters, the wavemeter was constructed inside a small plastic box; in most cases, enough r.f. energy will be picked up by the internal coil to operate the device. If not, the rod antenna specified in the Parts List can be added to the unit.

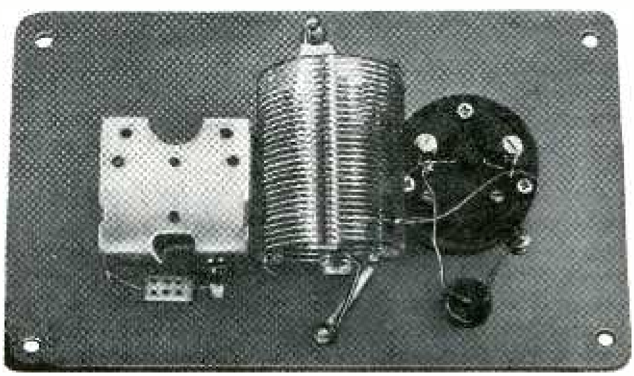
The bottom four turns of coil *L1* act as a coupling between the tuned circuit, consisting of *C1*, *C2*, and *L1*, and diode *D1*. The coupling coil prevents overloading of the tuned circuit so that the main dial (*C2*) tunes sharply and accurately. The r.f. is rectified by *D1*, and the resulting d.c. current indicated by *M1* (the meter can be made more or less sensitive by adjusting *R1*).

Construction. A small plastic instrument case (Lafayette 19 G 2001 or similar) was used to house the meter; an



Wavemeter is simply tuned circuit coupled to rectifier-meter circuit by bottom four turns of coil. Circuit tunes sharply to indicate frequency of transmitter.

As shown below, all components are mounted on front panel of wavemeter. Connections to the optional external antenna are not shown here; simply add a 10-pf. coupling capacitor and wire the antenna to the stator of C2. The top end of the coil must be mounted on an insulator as shown. Calibrate the wavemeter as described in text, using accurate generator.



aluminum cover was made for the box. As shown in the photos, all of the components are mounted on this aluminum cover: *C2* at right; the coil in the center with the above-ground end fastened to an insulator; and the meter at left. Potentiometer *R1* is just below *M1*.

It is necessary that the coil be of the dimensions specified in the Parts List, tapped at four turns, and that a 240-pf. capacitor be placed across the variable and not some other value. This will insure that the wavemeter covers the correct range.

Calibration. After the wavemeter has been assembled, it can be tested and calibrated by placing it near some r.f. source in the 2-3 mc. band. One of the best methods is to use the radiophone set itself, a crystal oscillator, a grid dip oscillator, or other signal generator of known accuracy. If the meter should read backwards, reverse either the diode or the meter.

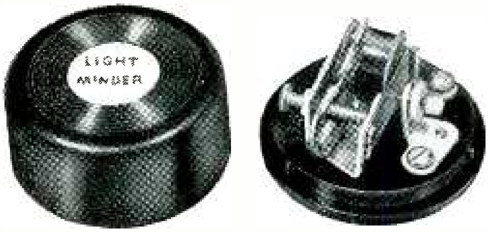
A rough dial can be made by placing a piece of paper under *C2*'s knob, and marking off frequencies in pencil. You can then ink in a finished dial and install it on the wavemeter; it should look much like that shown in the photo. A piece of clear plastic mounted over the dial will keep it clean and free from smudges.

As mentioned earlier, you can use the unit for peaking your transmitter, as well as for monitoring, if you have a commercial FCC license. For monitoring only, you can bolt the wavemeter to a bulkhead wall to keep an eye on transmitter output. A log of readings from day to day will serve as an indication that your antenna is radiating as it should be. —30—

PARTS LIST

C1—240-pf. silver mica capacitor
C2—400-pf. variable capacitor
C3—0.001-µf. ceramic disc capacitor
C4—10-pf. ceramic or mica capacitor
D1—1N277 silicon diode
L1—27 turns of #12 to #18 wire, 1¼"-diameter form, 16 turns per inch, tapped at 4 turns (B & W Miniductor #3019 or equivalent)
M1—0-1 ma. meter
R1—500-ohm potentiometer
1—2" x 3¾" x 6¼" plastic box
1—Extension antenna—optional (Lafayette 99 G 4001 @ 59 cents or equivalent)
Misc.—Wire, solder, mounting insulator for coil, aluminum sheet, pointer knob, etc.

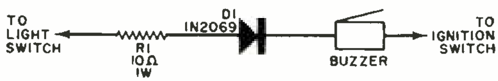
SIMPLE AUTO LIGHT MINDER



Both R1 and D1 can be mounted under buzzer cover.

IT'S EASY to forget that your headlights are still on—easier still to forget the parking lights if you turn them on while driving on a rainy or foggy day.

You can eliminate the whole memory problem entirely by building this simple Auto Light Minder that requires only three components—a 10-ohm, 1-watt resistor, the cheapest silicon diode rectifier you can locate (the author used a 1N2069), and an inexpensive code practice buzzer. The rectifier and resistor can be mounted under the buzzer cover for compactness.



Light Minder uses three components; R1 is omitted in 6-volt cars, leads reversed for positive ground.

Connect one lead of the Light Minder to the light switch, and the other to the ignition switch as shown in the diagram. The correct terminals can be identified by observing which ones show a voltage to ground when the switches are operated (avoid the accessory lead on the ignition switch, however). When the lights and ignition are both off, both sides of the buzzer are at ground potential and there is no sound. Likewise, when both lights and ignition are on, there is no potential difference.

Diode *D1* blocks current flow with the lights off and ignition on, but with the lights on and ignition off, one side of the buzzer is grounded through the low-resistance ignition system, *D1* is forward-biased by the battery, and the buzzer sounds.

Eliminate *R1* for 6-volt cars, and reverse the light and ignition leads for positive ground cars. —*R. L. Winklepleck*

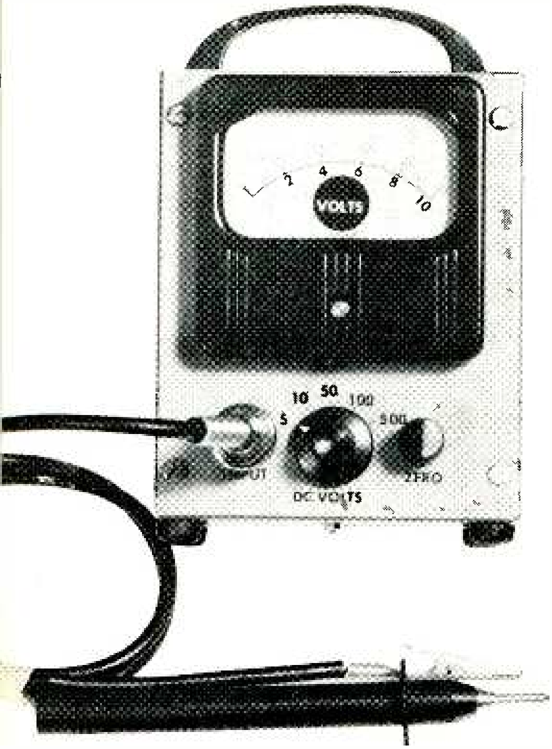
CHAPTER 5

TEST EQUIPMENT PROJECTS

A test equipment construction project should be an exceptional item—something not commonly available as a kit. Such projects can be used in conjunction with existing test equipment to extend the usefulness of such equipment or to adapt present testing gear to new applications. This philosophy has been expounded in previous editions of the ELECTRONIC EXPERIMENTER'S HANDBOOK and is continued in this one.

The article titles below are largely self-explanatory, and only one requires any comment. Don Lancaster's "Meter Face" story should be one of those articles you immediately read from start to finish. The surplus markets are still loaded with excellent meter buys—meters which would cost three or four times as much if purchased retail. The only thing wrong with a surplus meter is the scale—it generally has some military significance, but nothing whatsoever to do with the milliamps or volts you want to measure. The article tells you how to change the scale and achieve a professional appearance.

This chapter ends with some "Tips and Techniques" from POPULAR ELECTRONICS.



MINIATURE VTVM

Unit measures voltage in a.g.c., grid bias, oscillator and other high-impedance circuits without loading

By RYDER WILSON

ONE of the most useful test instruments in the electronics enthusiast's workshop is the vacuum-tube voltmeter. The VTVM enables the experimenter to measure small voltages accurately, especially in high-impedance grid bias, a.g.c., detector and oscillator circuits. Unlike the 1000- or 20,000-ohms-per-volt voltmeters which present different resistances on different ranges, the miniature VTVM to be described here has a constant resistance of 10 megohms on all ranges.

The miniature VTVM is a low-cost construction project and operates economically on batteries. It can measure d.c. voltages in five or six ranges, depending on whether a 5- or 6-point switch is used. Up to 500 volts can be measured directly; audio, r.f. and other a.c. voltages can also be measured with the demodulator probes. The miniature unit is completely self-contained in a 5″ x 4″ x 3″ metal utility box and has a large, easy-to-read, reasonably-priced, 50-μa. meter movement.

How It Works. A CK6088 subminiature beam-power-pentode vacuum tube (*V1*) is "triode"-operated in a d.c. bridge circuit. The quiescent voltage drop across resistor *R8* is balanced out by applying just enough bucking voltage to zero the meter. You simply adjust potentiometer *R11* for a zero meter reading. Potentiometer *R9* serves as a current limiter and calibrator for the meter circuit.

A positive d.c. voltage applied to the grid of tube *V1* through resistor *R7* causes a proportional up-scale deflection. The more positive the grid, the more the tube conducts and the greater the voltage drop across resistor *R8*. The greater the voltage drop, the greater the deflection of the meter. The rotary switch (*S1*) specified in the Parts List selects one of the five voltage ranges from 5 to 500 volts. Precision ±5% resistors are used in the input voltage divider network. The VTVM's accuracy is dependent upon the selection of the proper value of resistors, as well as the quality of the meter movement.

If you can get a 6-position, single-circuit switch that will fit, you can wire the input voltage divider as shown in Fig. 3, to get a very desirable 1-volt range. Actually, no change in the arrangement of the resistors in this circuit would have to be made to accommodate the 6-position switch. Jack *J1* would be connected to the first contact which would become the position for the 1-volt range. All other positions would follow in the same consecutive order as in the 5-position switch.

Because of its d.c. operation, the miniature VTVM is relatively stable and free of drift. It does not require constant resetting of the zero control.

Construction. The interior view of the VTVM shows the layout of the various components. The tube (*V1*) is held in place by a cable clamp. The circuit board is mounted on the meter terminals. Resistors *R7*, *R8*, *R9* and filament battery *B2* are mounted on the board. Resistors *R1* through *R6* are mounted, turret style, directly on *S1*. (See Fig. 6.)

Position the meter as close as possible to the top of the case to allow room for the range selector switch and panel markings. Zero-adjust control *R11* and tube *V1* are then positioned to avoid interference with other components. Place battery *B1* on the bottom of the case and hold it in position with a suitable friction clip.

The d.c. probe shown with the meter is made from a 2′ length of 52-ohm coaxial cable and a test prod connected to the center conductor. An alligator clip and a short length of insulated wire are connected to the shield inside the probe handle. In use, the test prod point is connected to the positive side and the alligator clip to the negative side of the voltage to be measured.

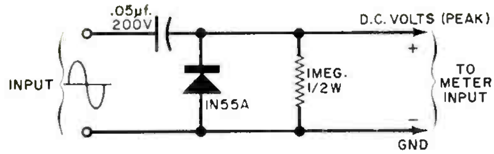


Fig. 2. Demodulator probe measures low a.c. peak voltages. Capacitance of probe leads acts as filter.

Calibration. Any known source of voltage can be used to calibrate the VTVM. A simple setup is shown in Fig. 5. However, before turning the instrument on, check for mechanical zero of the VTVM's meter. Next, set the range-selector switch to the 5-volt scale and adjust zero control *R11* until the switch just clicks on. The meter will probably read about 1.25 volts. Continue turning *R11* slowly, clockwise, until the meter reads zero. Do this with the probe connected to the meter and the alligator clip on the test prod's point, to prevent readings of stray voltages.

Adjust the 1000-ohm potentiometer on the calibrator rig to 5 volts, and apply the probe. Adjust calibrating potentiometer *R9* for full-scale deflection (the 5-volt mark on the VTVM). By successively reducing the input voltage to 4, 3, 2 and 1 volt, linearity of the meter can be compared with the meter in the test circuit. A slight nonlinearity may be observed as the input voltage is decreased, with an approximate error of ±0.1 volt at the low end of the scale.

Fig. 1. The voltage drop across the cathode resistor is in proportion to voltage being measured. The more positive the applied voltage to the grid, the greater the voltage on the resistor.

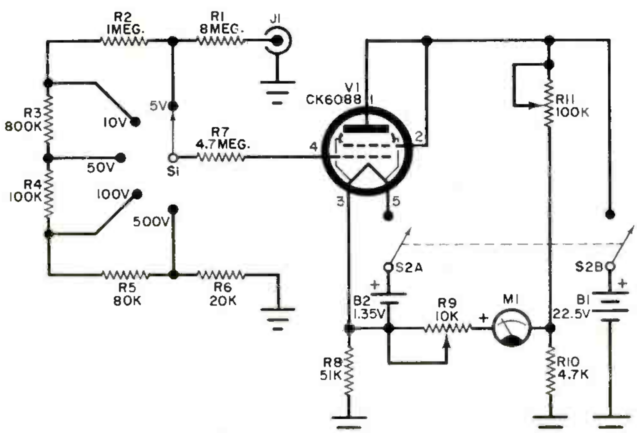
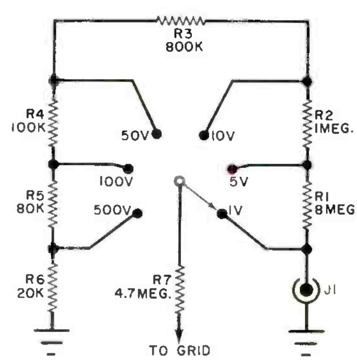


Fig. 3. Alternate hookup of voltage divider provides extra 0- to 1-volt range.



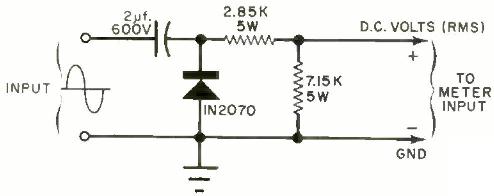


Fig. 4. Divider in demodulator probe delivers about 70% of peak voltage to meter circuit to enable direct readout of r.m.s. voltages.

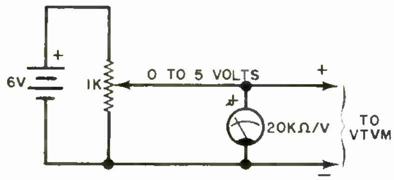


Fig. 5. Variable voltage divider circuit used to calibrate the miniature VTVM.

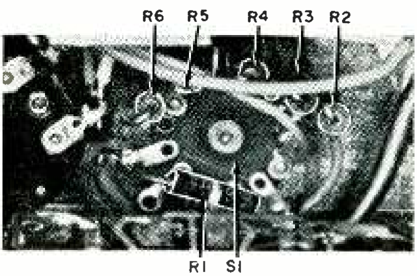
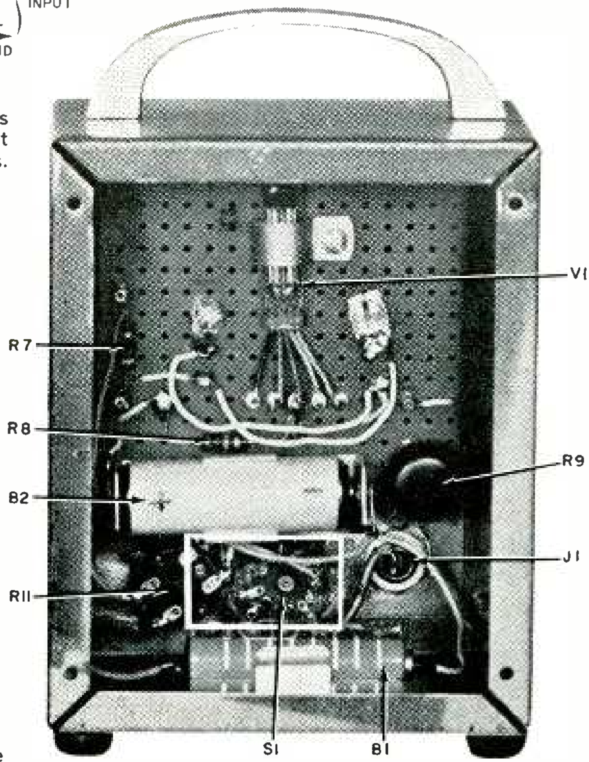


Fig. 6. Preassemble the resistors and the switch in "turret" fashion before mounting.

Fig. 7. Position meter as high as possible in case. Mount circuit board directly to back of meter.



PARTS LIST

B1—22.5-volt battery (NEDA No. 215)
B2—1.35-volt mercury cell battery (Mallory RM-12R or equivalent)
J1—Single-contact, male, panel-mounted mike connector
M1—0-50 microammeter (Lafayette 99 G 5042 or equivalent)
R1—8-megohm, ½-watt resistor (selected from 8.2-megohm stock)*
*R2—1-megohm, ½-watt resistor**
R3—800,000-ohm, ½-watt resistor (selected from 820,000-ohm stock)*
*R4—100,000-ohm, ½-watt resistor**
R5—80,000-ohm, ½-watt resistor (selected from 82,000-ohm stock)*
*R6—20,000-ohm, ½-watt resistor**
R7—4.7-megohm, ½-watt resistor
R8—51,000-ohm, ½-watt resistor
R9—10,000-ohm miniature potentiometer
*R10—4700-ohm, ½-watt resistor**
R11—100,000-ohm miniature potentiometer with d.p.s.t. switch (S2)
S1—2-circuit, 5-position switch (Lafayette 99 G 6164 or equivalent; use only 1 circuit)
S2—D.p.s.t. switch (on R11)
V1—CK6088 vacuum tube
1—5" x 4" x 3" metal utility box
Misc.—Probe tip, wire, battery clamps, etc.
*Resistors are ± 5% or better

If a greater error occurs, it could be due to a poor tube, or nonlinearity of the calibrator meter.

Use the same procedure only to check the VTVM on the other voltage scales. Actually, this is not necessary; once one scale is calibrated, all the other scales take their proper relative position. Significant errors on the other ranges would be due to employing wrong values (one or more) for resistors *R1* through *R6*. When the calibration is completed, the meter is ready for use.

Higher voltages applied to the tube's grid, beyond a certain point, have less and less effect on tube current, and at saturation have none. The meter cannot be subjected to "burn-out" currents no matter how high the voltage being tested or how low the selected voltage range on the meter. But don't poke the unit into a 16,000-volt circuit without a suitable high-voltage probe! -30-

BUILD THE MASTER CONTROL SCR SWITCHING CENTER

You can control equipment from a remote or local position with automatic or manual go—no-go type switch, photocell, or sensor

By HAROLD REED

THE silicon-controlled rectifier (SCR) is one of the most recently introduced types of semiconductors presently performing electronic miracles. It works like a high-current on/off switch, yet has no moving parts. Many devices, such as electric light dimmers and motor speed controllers, are already taking advantage of the SCR. As the demand for new semiconductors builds up, prices come down. They have already done so to a considerable extent. The SCR used in the Switching Center is a 2N2323 and costs less than $3.50, which is below the cost of many vacuum tubes.

The Switching Center can be used as the heart of burglar alarms, fire alarms, photographic control equipment, door openers, motor driven controls, etc. Control can be automatic or manual, local or remote, and can be triggered by Microswitches, magnetic reed or thermal switches, photocells, etc. The switches can be used in combination, say a magnetic reed switch to close the controller and a Microswitch to open it.

The controller is extremely sensitive; a photoconductive cell connected directly to its binding posts can actuate the relay just by "seeing" a lit match 12 inches away.

How It Works. Like a thyratron, the SCR (*Q1*) conducts when the anode is sufficiently positive with respect to the cathode. Under normal operating conditions the anode voltage is not high enough to start conduction, but is high enough to maintain current flow once it starts. The gate on the SCR performs the same function as the grid of the thyratron. When a small positive voltage is applied to the gate, the SCR fires (provided that the correct anode-to-cathode voltage is also present).

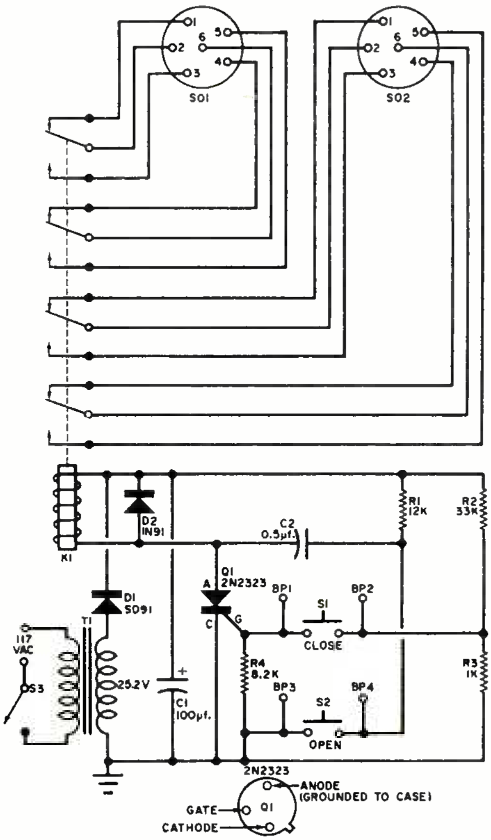
Thereafter, the gate has no control and cannot stop current flow. The only way to extinguish the SCR is to remove or reduce the anode-to-cathode voltage below the holding point. When current flow is stopped and plate voltage is restored, the gate once again is in a position to exercise control.

Relay *K1* has a four-pole, double-throw switch to provide numerous control applications. If desired, a s.p.d.t. relay can be used and is noted in the Parts List for your convenience. Both relays have a 2500-ohm coil.

The relay is energized when d.c. flows through the circuit consisting of *T1*, *D1*, *K1* and *Q1*. About 25 volts a.c. from *T1* is rectified by *D1*, filtered by *C1* and applied to *K1* and *Q1*. The d.c. control voltage applied to *Q1*'s gate is developed by the voltage divider action of *R2* and *R3*. Diode *D2* stabilizes relay action and cuts down the high inductive kick from the relay coil when the unit is switched off. Excessive voltage peaks could damage *Q1*.

In the nonconducting state, *Q1* ex-

A positive voltage at the gate of the SCR causes it to conduct and close the relay; to stop conduction, a negative pulse is applied to the anode.

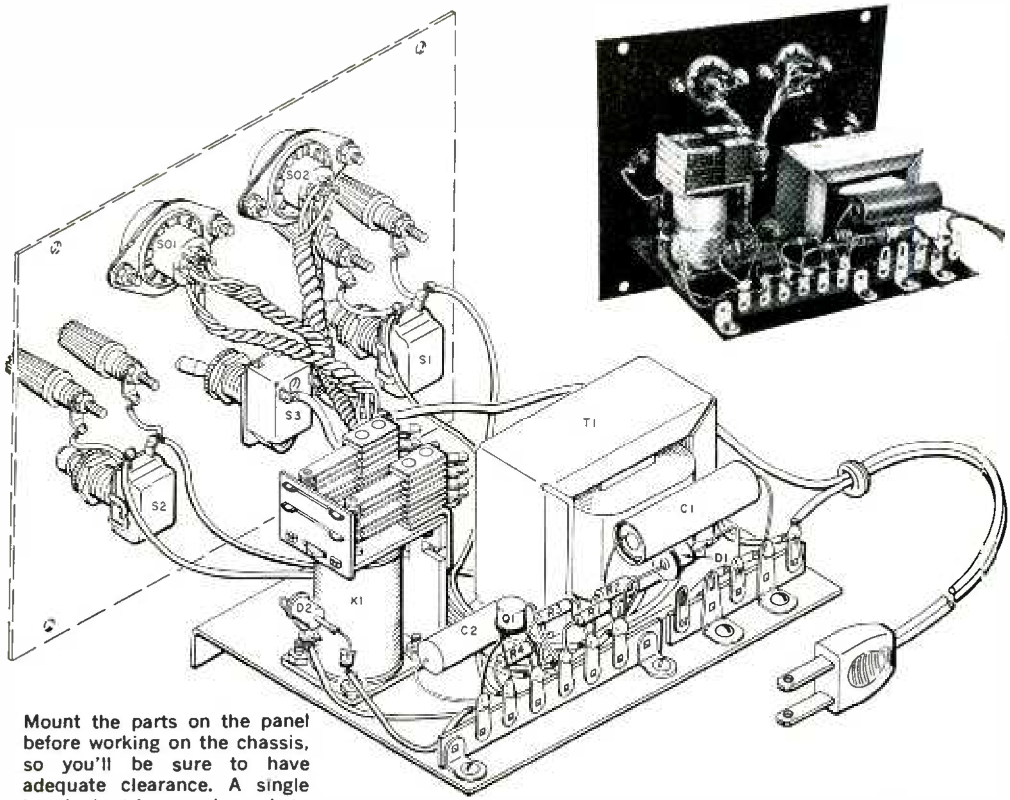


PARTS LIST

BP1 to BP4—5-way binding post (Lafayette 32 G 6430C or equivalent)
C1—100-µf., 50-volt capacitor
C2—0.5-µf., 200-volt capacitor
D1—Silicon diode (International Rectifier SD91 or equivalent)
D2—Germanium diode (General Electric 1N91)

hibits a very high internal resistance and only a very small leakage current flows; thus, *Q1*'s anode voltage is approximately equal to the d.c. supply voltage. Since this voltage is below the rated peak forward voltage of *Q1*, it will not trigger.

Under this circumstance, all it takes to fire *Q1* is a small positive d.c. pulse applied to *Q1*'s gate. As mentioned before, this comes from the junction of *R2* and *R3* via *S1*. Switch *S1* may be manually controlled or paralleled by any external switching devices attached to *BP1* and *BP2*. Internal resistance of *Q1*



Mount the parts on the panel before working on the chassis, so you'll be sure to have adequate clearance. A single terminal strip can be substituted for sockets SO1 and SO2.

K1—Relay, 4-p.d.t. or s.p.d.t., 2500-ohm coil (Potter & Brumfield GB17D or GB5D or equivalent)
Q1—2N2323 silicon-controlled rectifier
R1—12,000 ohms
R2—33,000 ohms
R3—1000 ohms
R4—8200 ohms
(R1–R4: *½-watt resistors*)
S1, S2—S.p.s.t. push-button switch (Lafayette 99 G 6218 or equivalent)
S3—S.p.s.t. on-off switch
SO1, SO2—6-pin miniature socket
T1—Power transformer: primary, 117 volts; secondary, 25.2 volts (Stancor P-6469 or equivalent)
1—4" x 5" x 6" steel cabinet (Bud C-1797)

becomes extremely low when it conducts and practically all of the d.c. supply voltage appears across *K1*. The relay closes and works any appropriate device plugged into *SO1* or *SO2*.

Once *Q1* fires, it remains in this condition, keeping *K1* closed regardless of any further switching attempts by the gate. To extinguish *Q1* and open the relay, the voltage developed across *C2* through *R1* is discharged across *Q1* by closing *S2* or by a bridging action of an external control switch. The charge on *C2* momentarily counteracts the voltage across *Q1* enough to stop conduction.

Construction. The unit shown in the photos is built in a 4" x 5" x 6" box which has a self-contained chassis attached to the front panel. All parts are easy to obtain and inexpensive. Transformer *T1* and relay *K1* are mounted on the chassis; smaller parts are soldered to terminal strips. Switches *S1* and *S2*, the binding posts, and power switch *S3* are attached to the front panel.

Two 6-contact sockets to extend the relay contactors to a convenient outlet are also mounted on the front panel. Any type of connector or terminal strip could be used for this purpose. —30—

Simple Simon Voltage Calibrators

By FRED CHAPMAN

INTERESTED in a versatile voltage-step calibrator that has, literally, hundreds of uses? While designing a wide-range VTVM the author found a need for some means of feeding calibrated millivolt signals to the meter. The answer was a simple voltage divider, whipped up around a handful of 10% resistors as shown in Fig. 1.

Jacks *J1* through *J15* are banana jacks, and the resistors are ½-watt units unless otherwise specified. A separate pair of jacks (*J3* and *J4*) accommodates the meter, while the voltage output is taken between the bottom jack (*J15*) and the jack at the desired percentage level. If you want to work with higher voltage levels, it will be necessary to increase the wattage rating of most of the components.

Figure 2 shows a grown-up version of the calibrator that you might want to put together. Note the provision for a.c. or d.c. voltages from 0.1 mv. to 1 volt with a 1-volt input; for a 6-volt input, the steps will range from 0.6 mv. to 6 volts. You simply multiply the input voltage by the percentage indication at the desired position of switch *S2*.

Transformer *T1* is a 6.3-volt filament

(*Continued on page* 142)

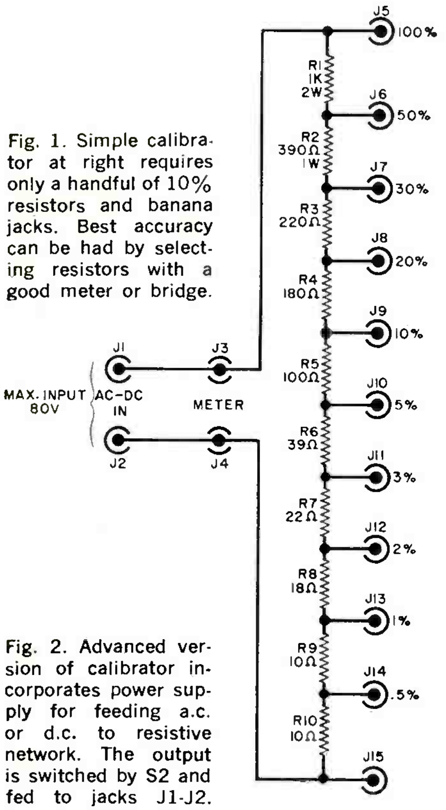


Fig. 1. Simple calibrator at right requires only a handful of 10% resistors and banana jacks. Best accuracy can be had by selecting resistors with a good meter or bridge.

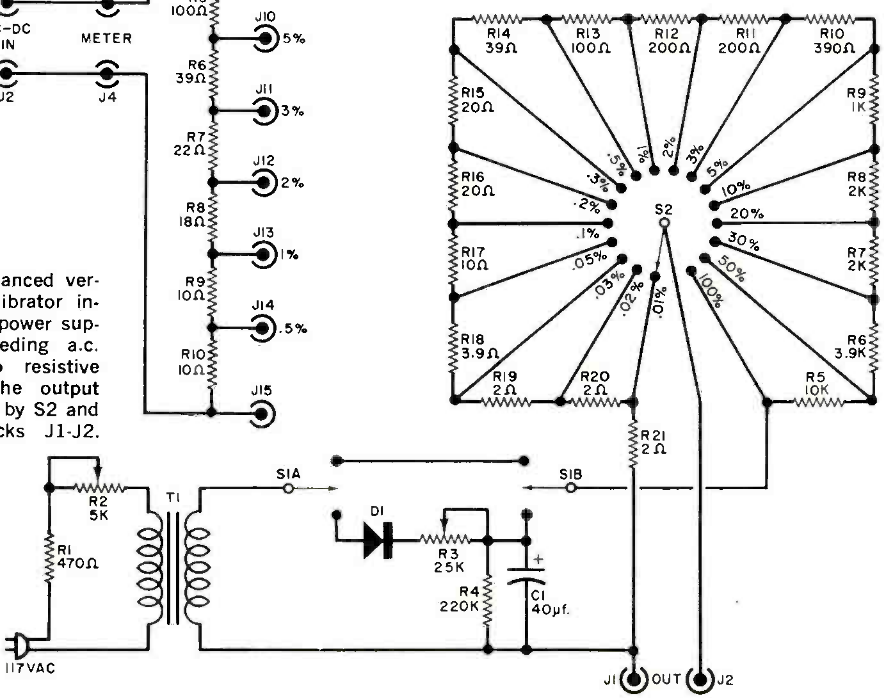
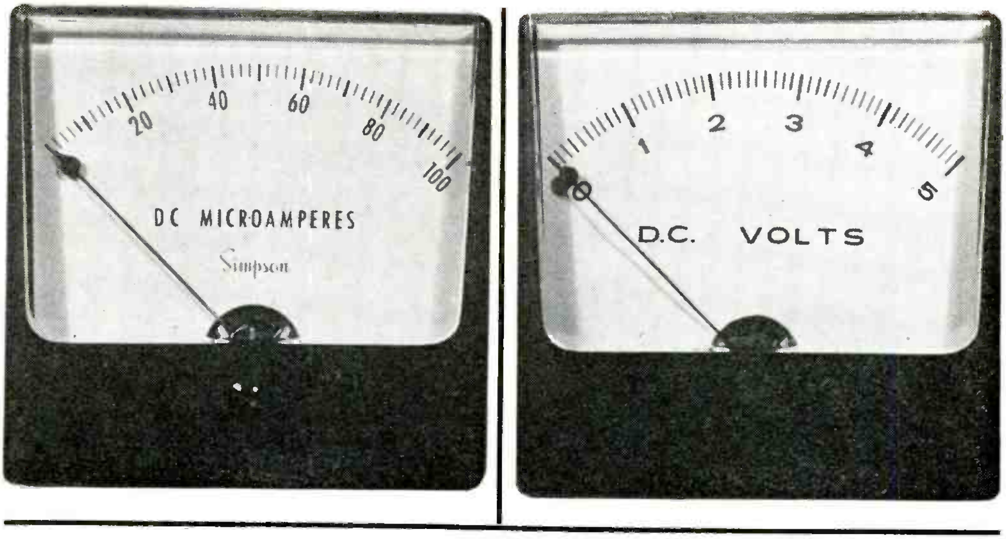


Fig. 2. Advanced version of calibrator incorporates power supply for feeding a.c. or d.c. to resistive network. The output is switched by S2 and fed to jacks J1-J2.



PUT YOUR BEST METER FACE FORWARD

Before and After. Can you determine which of the meter faces above is homemade and which is the manufacturer's original? The only tip-off is the trademark under the title.

You can make professional-looking scales with little effort and a small investment

By DON LANCASTER

WANT to change the scale of that panel meter sitting in your junk box? Or how about that surplus bargain, an 0-50 d.c. microammeter . . . calibrated as 0-75 MR/HR/FT^3 or something equally mysterious? Help stamp out sloppy meter faces! Get rid of wrong scales! You don't have to be an artist—all you need is $2.15 and some time. You'll wind up with a meter face as good as the factory original, and to your exact specifications. And each duplicate face will cost just 15 cents.

What's the catch? You simply work five times life size. In this king-size world, mistakes are few and far between, and easily corrected. Any misalignment that might creep in gets reduced 5:1 in the final reproduction. You use all prefab letters and numerals—no ink and no mess. A nearby photolithography firm then gives you the required reduction.

Measurements. The first step in making a new meter face is to carefully remove the *original*, and make all the measurements shown in Fig. 1. Multiply each one by five (except c, the scale angle), and record the results. Dimension *a* is the distance in inches between the pivot point or center and mounting screw; *b* the distance between the pivot point and title; c the scale angle in degrees; *d* the numeral radius in inches; *e* the lower division radius; *f* the middle division radius; and *g* the upper division radius.

Decide what the full-scale reading of the new meter scale will be, and choose a reasonable number of major divisions. Every major division, or every other one,

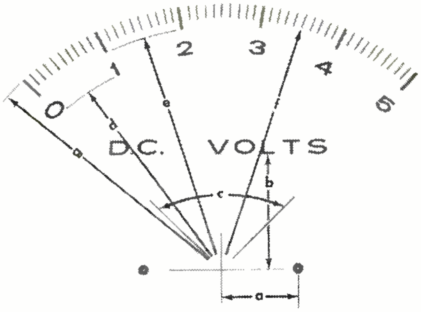


Fig. 1. Carefully measure dimensions "a" through "g" on original meter face and multiply by five. All measurements are in inches except the angle "c," which is measured in degrees with a protractor.

Fig 2. Materials you need for making a new face include instant transfer letters, a beam compass, 3/8" printed circuit dots, 1/8"- and 1/16"-wide black printed circuit tape, and white illustration board.

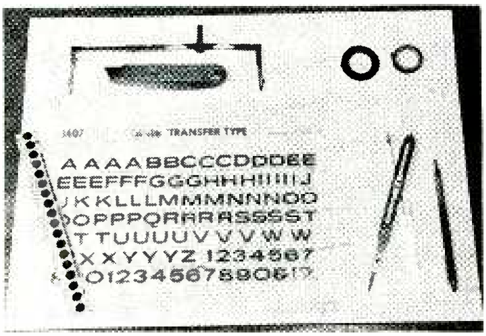
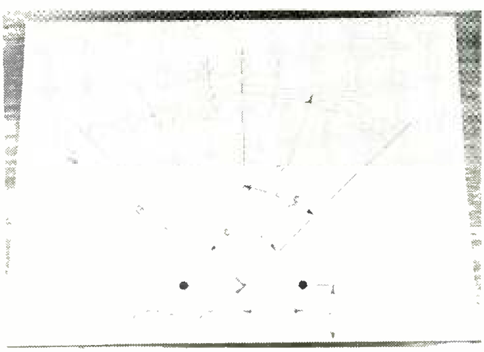


Fig. 3. The new meter face is drawn lightly in pencil on a piece of illustration board working five times up. First draw vertical center line, then add a horizontal base line 2" up from bottom of board.



should have a number below it. Limit the numbered divisions to between five and eight to make the meter easy to read. The number of minor divisions should be around 50. Each minor division should correspond to some reasonable increment, say one, two, or five of the full-scale units.

Materials and Layout. Go to the art store and buy a sheet of 1/2"-high instant transfer letters and numerals. You can also pick up a 15" x 20" sheet of white illustration board, although white cardboard or painted plywood will do. (For a meter face larger than 3 1/2", get a 20" x 30" illustration board.)

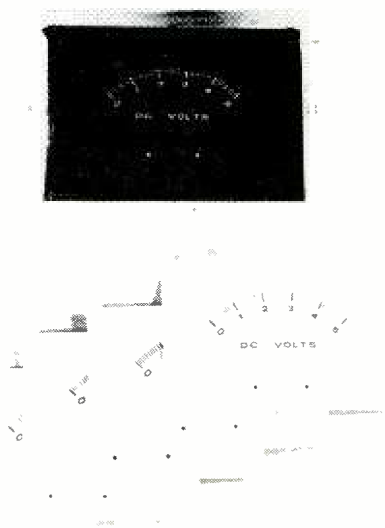
Lay out the new face as in Fig. 3, keeping all pencil lines very light so they can be easily erased. Start with a vertical center line and add a horizontal line 2" up from the bottom; use a square to insure that these two lines are perpendicular. The point where the two lines cross is the pivot point of the meter, and the basis of all the measurements detailed in Fig. 1.

Carefully and accurately locate the meter mounting holes with two 3/8"-diameter dots (black printed circuit dots are ideal for this). Using a beam compass (or a pencil and some string), swing the arcs corresponding to the tops and bottoms of the minor divisions. Using a large protractor, locate the zero and full-scale points.

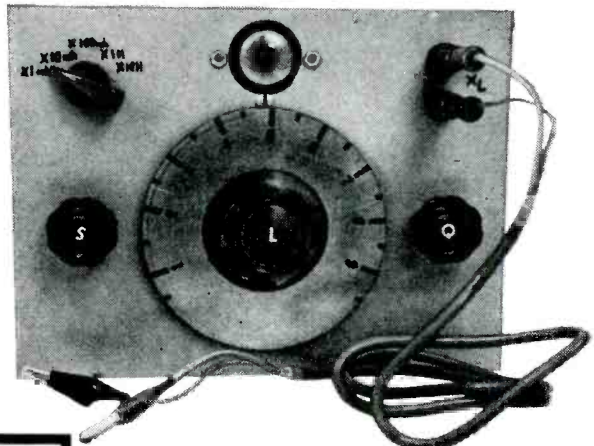
Next, with dividers (or just a ruler), lay out all the major division marks on the

(*Continued on page* 146)

Fig. 4. High-contrast photolith negative (top) is a 5:1 reduction of art work. After negative is made, it is a simple matter to get photographic contact prints (below). Mount new face as described in text.



EXPERIMENTER'S L BRIDGE



Build this multi-range inductance tester to find unknown values of r.f. i.f., audio and filter coils and chokes

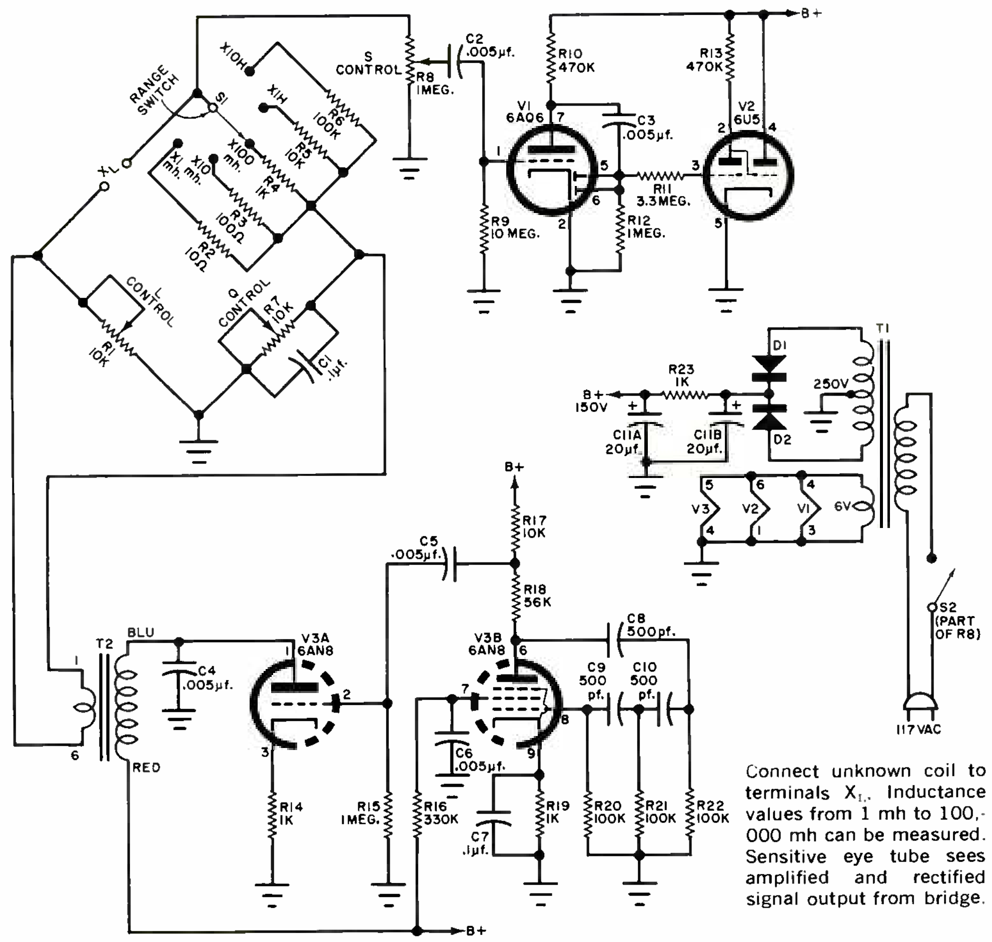
By CHARLES GREEN, W3IKH

INDUCTANCE measurements are not difficult to make, but they can fool you, especially if you have been using just an ohmmeter. A few shorted turns won't make enough of a difference to show up in a simple resistance test, yet it takes only one shorted turn to ruin a coil or choke. At times you may wish to know only if a part is good or bad. At other times you may be looking for a specific value. Either way, the "L Bridge" is a worthwhile addition to your line-up of test equipment.

In all fairness to the ohmmeter test method, it does quickly indicate open windings, shorts to iron cores and frames, and shorts between two different coils wound in close contact with each other, such as primary and secondary transformer windings. It can also spot relatively large changes in a coil's resistance, but it does all this under d.c. conditions. Most of the coils we use have to function in an a.c. circuit of one type or another.

An obvious improvement, then, would be to break away from d.c. and go to an a.c. procedure, applying an a.c. signal to an unknown inductance and determining its value by its performance in the test circuit. The easiest, cheapest way to do this is to employ a Maxwell bridge which uses an a.c. signal to measure inductance in terms of resistance and capacitance. The "Experimenter's L Bridge" is just such a unit with the ability to measure inductance values from about 1 mh to 100 h (100,000 mh) in five ranges.

How It Works. The test signal from the 1 kc. oscillator, the pentode section of *V3b*, is amplified by the triode sec-

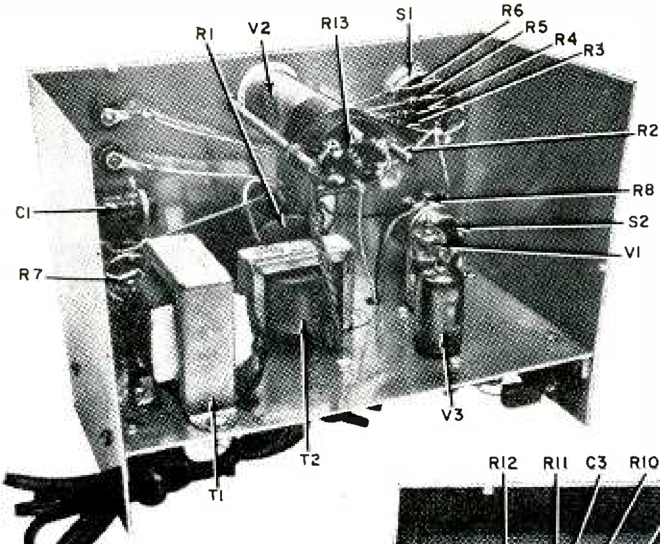


Connect unknown coil to terminals X_L. Inductance values from 1 mh to 100,000 mh can be measured. Sensitive eye tube sees amplified and rectified signal output from bridge.

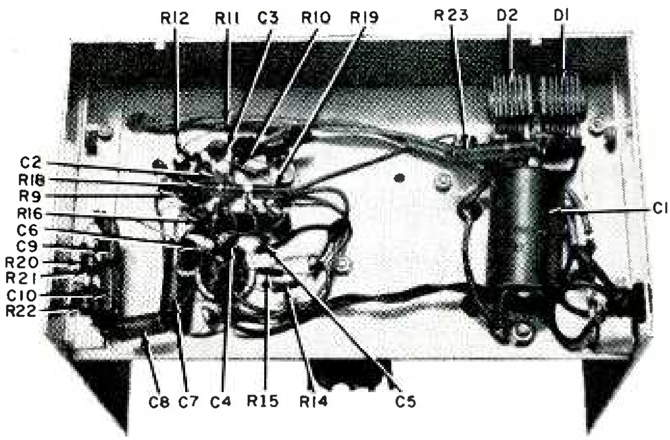
PARTS LIST

C1, C7—0.1-µf., 100-volt capacitor, ±10%
C2-C6—0.005-µf., 600-volt ceramic capacitor
C8, C9, C10—500-pf., 1000-volt ceramic capacitor, ±10%
C11—20-20 µf., 150-volts-per-section electrolytic capacitor
R1—10,000-ohm wire-wound potentiometer, linear taper
R2—10 ohms
R3—100 ohms
R4—1000 ohms
R5—10,000 ohms
R6—100,000 ohms
(R2–R6: *½-watt resistor, ±10% or better*)
R7—10,000-ohm potentiometer
R8—1.0-megohm potentiometer with S1
R9—10 megohms
R10, R13—470,000 ohms
R11—3.3 megohms
R12, R15—1 megohm
R14, R19—1000 ohms
R16—330,000 ohms
R17—10,000 ohms
R18—56,000 ohms
(R17, R18: *½-watt resistor, ±10%*)
R20, R21, R22—100,000-ohm, ½-watt resistor, ±10%
R23—1000-ohm, 2-watt resistor
D1, D2—65-ma., 130-volt a.c. input, selenium rectifier (ITT 1234AH or equivalent)

tion (*V3a*) and is then transformer coupled by *T2* to the bridge. One leg of the bridge takes the inductor under test (X_L). A direct-reading inductance-calibrated dial on the *L* control *R1* in conjunction with the *Q* control *R7* is used to balance the bridge. The sensitive tuning eye shows degree of balance. The *S* control *R8* feeds more or less signal into tube *V1* and enables the eye to "look" into large or small signals without overloading the eye circuit. Range switch *S1* places any one of five resistors in the *S1*, *R2-R6* leg. The *C1*, *R7* leg consists of a 0.1-µf. capacitor paralleled by the *Q* control. The *Q* control balances out the resistance of the coil under test while the capacitor sets up a phase con-



Install T1 and T2 at right angles to each other to minimize 60-cycle hum in the circuit. Leave room between V2 and R1 for L dial and screw head index.



Easy construction: angle brackets support flat chassis plate. Keep leads short for R20-R22 and C8-C10, in the oscillator circuit. Other wiring is not critical.

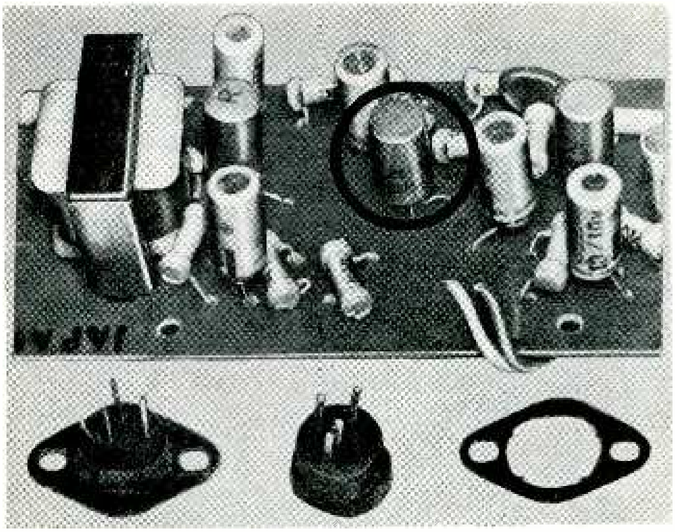
S1—1-pole, 5-position rotary switch
S2—S.p.s.t. switch (part of R8)
T1—Power transformer: primary, 117 volts; secondaries, 250 volts, CT @ 25 ma., and 6.3 volts @ 1 amp (Stancor PS 8416 or equivalent)
T2—Universal output transformer (Merit A-2902 or equivalent)
V1—6AQ6 tube
V2—6U5 tube
V3—6AN8 tube
1—4½" x 6" x 8" utility box (LMB #146)
1—4⅜" x 8" chassis, sheet aluminum
Misc.—Two 8-32x4" threaded rods, wire, etc.

dition to cancel the effects of lagging current caused by the coil. When reactance and resistance conditions across the X_L leg and the *S1*, *R2-R6* leg balance conditions across the *R1* leg and the *C1*, *R7* leg, no signal will appear at *R8*.

When the bridge is not in balance, a voltage appears across *R8*. It is amplified by *V1*, then coupled to the diode section of the same tube through *C3*, then rectified and direct-coupled to *V2*. The voltage is negative going and tends to close the eye. When the bridge is balanced, the tuning eye is wide open because the rectified voltage is then at a minimum. The values selected make it possible for each 1000-ohm division on the dial to indicate another *mh* on the lowest range. The five ranges are *x1 mh*, *x10 mh*, *x100 mh*, *x1 h*, and *x10 h*, as resistors from *R2* to *R6* are switched in respectively.

The *6AN8* oscillator (*V3b*) has an RC phase shift network consisting of *R20*, *C9*, *R21*, *C10*, *R22* and *C8* connected between plate and grid and forms a 180° shift in phase at 1 kc. It provides the positive feedback needed to maintain

(*Continued on page* 135)



The first step is to isolate the bad transistor (circled), clip it out, and clean the solder out of the holes in the printed circuit board. Replace it on the board with an inexpensive imported transistor socket with the metal mounting ring and extra pin removed.

Transistor Replacement Technique

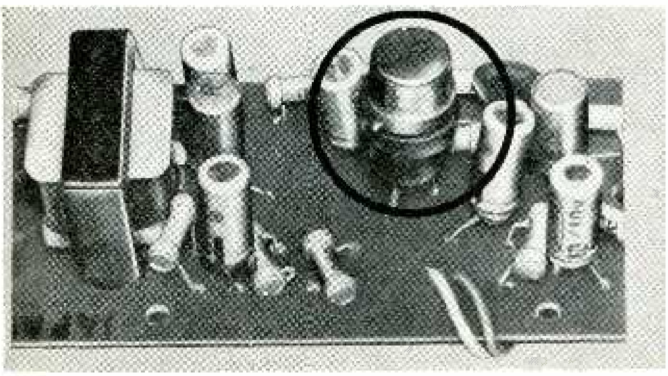
Why solder in a doubtful replacement when this trick allows a variety of substitutes?

TRANSISTOR REPLACEMENT in commercially wired gear has always been a tricky business. Not only do you have to find the bad transistor and wrestle it out of the circuit board, but you have the problem of finding a replacement transistor that will work as well as the original. This latter step can get a bit sticky if you can't identify the original transistor, or if the circuit involved is a bit critical and refuses to work with just any replacement you happen to have in the junk box.

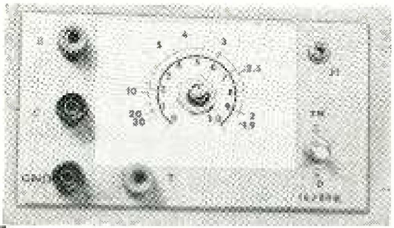
If trial and error substitution is the only answer, you can save yourself time, trouble, and a damaged circuit board by installing an inexpensive transistor socket. Since most of these sockets are equipped with four contacts, remove the contact that does not mate with the drilling pattern of the circuit board, and carefully work the remaining pins into the holes in the board. Solder the pins to the foil, and insert a substitute transistor in the socket.

When you find a suitable replacement transistor that performs to perfection, you can either leave it installed in the socket, or remove the socket and solder the transistor to the circuit board.

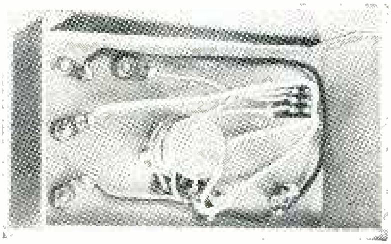
—*Roy E. Pafenberg, W4WKM*



To install the socket, carefully push the leads through the holes in the board, making sure that the orientation matches that of the bad transistor. Plug in a substitute, and you're back in business.



Knob is removed to show scale in photo at left. Jack J1 is for signal generator input; terminal posts serve as test points and outputs.



THE EXALTED POT

Sometimes even the simplest of electronic gadgets can save you countless hours of needless effort

By FORREST H. FRANTZ, Sr.

THE VERSATILE "Exalted Pot" is so simple you'll wonder why you didn't think of it yourself. All that's required to build the unit are two ganged potentiometers, a d.p.d.t. switch, assorted connectors, and a small aluminum box.

You can use it as a 1000-ohm and a 10,000-ohm resistance adjustable divider, as a substitution adjustable resistor for any value up to 10,000 ohms, or as a substitute volume control in transistor circuits. In combination with a VTVM and an audio signal generator, you can even use it for measuring capacity and inductance.

Construction Details. The unit is housed in a 2⅛" x 3" x 5¼" Minibox. The dual potentiometer (*R1-R2*) is made by using a 10,000-ohm linear unit (IRC-CTS Q11-116) and an add-on multi-section (IRC-CTS M11-108) which is a linear 1000-ohm unit. After cutting the shaft of *R2* (the 10,000-ohm unit), attach *R1* to the back of *R2*, but be careful that the wiper arm finger of *R1* is properly seated in the wiper slot of *R2* before bending the tabs and sealing the units together.

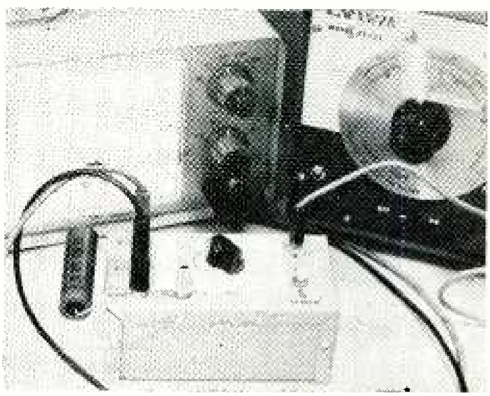
Now attach this ganged pot to the Minibox cover, and place the knob on the shaft, repositioning the potentiometer as necessary to maintain the same overshoot at each end of rotation.

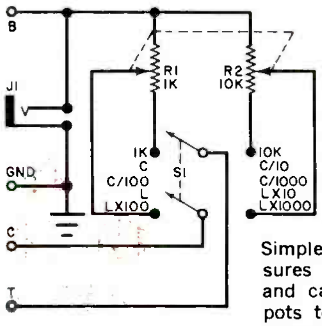
Terminal posts *B*, *C*, *T* and *GND* are available from Lafayette Radio in a kit of 10 pieces (MS-566), and each requires a 3/16" hole. The *GND* post is grounded to the Minibox, but the other three are insulated with fiber washers. Subminiature phone jack *J1* is a Lafayette 99 G 9905, and needs a 3/16" hole also. Switch *S1* is a d.p.d.t. miniature toggle switch and requires a ¼" hole. Mount all components and wire them as shown in the diagram on the next page.

Calibration. The "Exalted Pot" dial scale can be calibrated by measuring resistance at various knob settings with an ohmmeter of known accuracy. The inner scale will be calibrated from zero at one extreme to 1.0 at the other, and interpreted to mean 1000 ohms full scale or 10,000 ohms full scale, depending on the setting of switch *S1*.

The outer (capacity) scale is calibrated from 1.9 to 30μf. These capaci-

If you have an audio signal generator and a VTVM you can use the "Exalted Pot" to determine capacitor values fairly accurately. The unit will also perform many other functions as described in text.





Simple instrument measures values of coils and capacitors. Adjust pots to match voltage across unknown parts.

RESISTANCE SCALE CALIBRATIONS		
Mark Scale	S1 at 1K (ohms)	S1 at 10K (ohms)
0	0	0
1	100	1000
2	200	2000
3	300	3000
4	400	4000
5	500	5000
6	600	6000
7	700	7000
8	800	8000
9	900	9000
10	1000	10000

tor markings actually correspond to capacitive reactance at a test frequency of 100 cycles. Potentiometers *R1* and *R2*, as well as the test frequencies of 100 and 10,000 cycles, were selected to provide a wide range of measurements without having to resort to many scales. Capacitance values of 0.0019 to 30 μf. can be measured.

While not shown in the photo, the dial can also be calibrated to read values of inductance. For the values of the resistors and frequencies selected, the instrument's range is from 1 mh. to 15 h. (15,000 mh.).

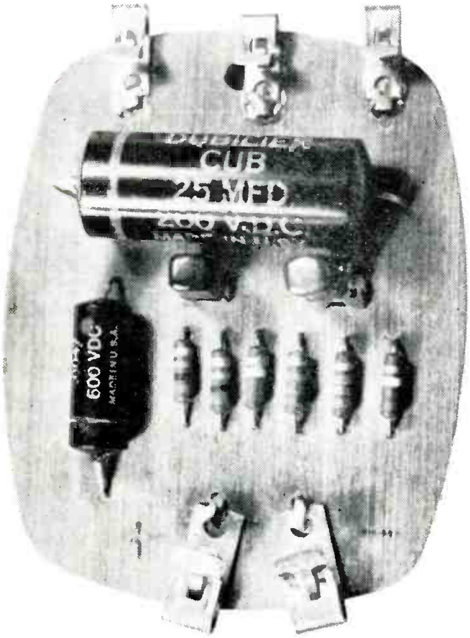
First calibrate the resistance scale. Set *S1* in the *1K* position. Rotate the control and mark the dial at each 100-ohm point. Do this carefully and use a good ohmmeter to measure the resistance as you proceed around the dial. No further calibration is needed for resistance. The other range is essentially now cali-

(*Continued on page* 139)

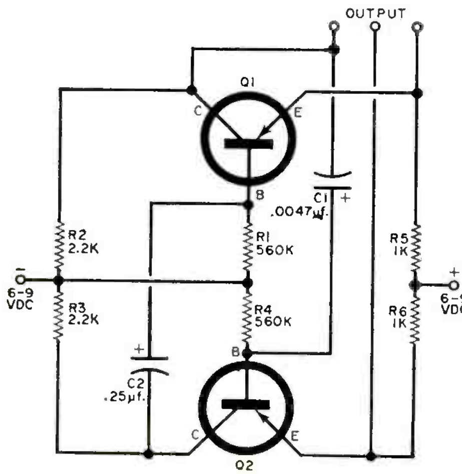
CAPACITANCE SCALE CALIBRATIONS					
		100-cycle signal		10,000-cycle signal	
Mark Scale	Resistance (ohms)	S1 at C (μf.)	S1 at C/10 (μf.)	S1 at C/100 (μf.)	S1 at C/1000 (μf.)
1.9	836	1.9	0.19	0.019	0.0019
2	800	2	0.2	0.02	0.002
2.5	640	2.5	0.25	0.025	0.0025
3	530	3	0.3	0.03	0.003
4	400	4	0.4	0.04	0.004
5	320	5	0.5	0.05	0.005
7.5	212	7.5	0.75	0.075	0.0075
10	160	10	1	0.1	0.01
15	106	15	1.5	0.15	0.015
20	80	20	2	0.2	0.02
30	53	30	3	0.3	0.03

INDUCTANCE SCALE CALIBRATIONS					
		10,000-cycle signal		100-cycle signal	
Mark Scale	Resistance (ohms)	S1 at L (mh.)	S1 at Lx10 (mh.)	S1 at Lx100 (h.)	S1 at Lx1000 (h.)
1	62.8	1	10	0.1	1
2	125.6	2	20	0.2	2
3	188.4	3	30	0.3	3
4	251.2	4	40	0.4	4
5	314	5	50	0.5	5
6	376.8	6	60	0.6	6
7	439.6	7	70	0.7	7
8	502.4	8	80	0.8	8
9	565.2	9	90	0.9	9
10	628	10	100	1	10
11	690.8	11	110	1.1	11
12	753.6	12	120	1.2	12
13	816.4	13	130	1.3	13
14	879.2	14	140	1.4	14
15	942	15	150	1.5	15

Four-Way Oscillator



Almost nothing is critical about this one—parts values may be varied to give different frequencies and waveforms. CK722's were used for Q1 and Q2.



IF YOU'D like to try your hand at a very intriguing, easy to build, inexpensive transistor project, the "Four-Way Oscillator" is for you. It generates square waves comparable in quality to those produced by a commercial audio square-wave generator, and at least several other waveforms of different frequencies, shapes and strengths. The unit can also serve as a CPO, a grid dipper modulator, or as a go—no-go transistor tester.

A quick look at the schematic tells the story—the Four-Way Oscillator is actually a simplified free-running multivibrator, unusual in that only ten components are required. With the parts values shown, square-wave output of about 800 cps can be taken from the first two terminals at the top. Varying the value of *C1* will change the output frequency. Taking the output from different combinations of terminals will give different waveforms and different frequencies. Actually, output can be taken from almost any point in the circuit—it's fascinating to experiment while watching a 'scope or while monitoring the signals with a pair of headphones.

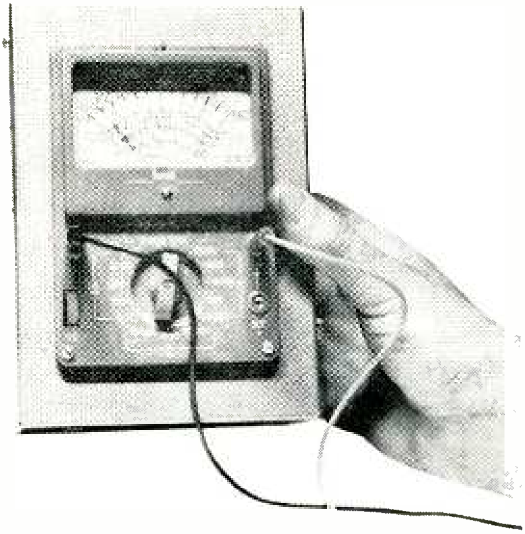
The Four-Way Oscillator makes an excellent tester for small-signal *pnp* transistors. Defective units—including those with excessive leakage—will simply not work when used to replace either *Q1* or *Q2*—CK722's in the author's unit. Power supply voltage is not critical, but better square-wave linearity was obtained with 9 volts than with 6. The value of *C2* can be made considerably smaller without affecting the circuit; changing resistor values will change the waveforms obtainable.

To keep the cost down, the author's unit was built on a small chip of Formica (kitchen cabinet dealers use them for samples, and they should be available for the asking) measuring 2¼" x 3". Holes were drilled to accommodate component leads, transistor sockets, and Fahnestock clips for battery leads and output terminals.

The oscillator makes a handy addition to any test bench.

—*L. E. Byfield, K9ADD*

THE CASE OF THE ALUMINUM ALLY



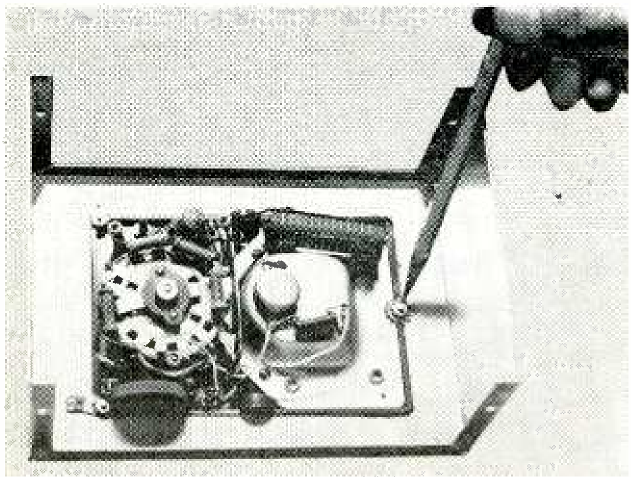
THE PLASTIC CASES used in the construction of low-cost multi-testers such as the VOM have brought into existence a new breed of electronics experimenter—the "cracked-case VOM carrier." Replacement cases simply aren't available. The solution to the situation? Just call on your aluminum ally, the utility chassis box, to house the useful remains of your VOM.

Going about it is quite easy. First, examine the damaged case. In most instances, the plastic box itself is the damaged part; if it is, discard the box. If the front plastic piece which holds the meter, switch, and pin jacks is also damaged, carefully cement this piece with a good-quality epoxy resin.

Now select an aluminum chassis box about ½" larger in each dimension than the original meter case. *Measure* a hole in the cover of the case that will pass the parts mounted on the VOM, leaving a good margin of safety. But remember, if you cut too large a hole, you'll have to start all over again with a new box.

Once the VOM face fits neatly in its new case, secure it in place. The author's VOM had pre-drilled holes which permitted the use of ½"-long screws and nuts to bolt the meter face to the case. Do *not* drill any holes in the delicate plastic VOM face. Instead, resort to epoxy resin cement—you'll have to wait from 4 to 12 hours for the cement to take hold.

Before fitting on the rear cover of the chassis box, weigh the assembly in your hand. If the VOM lacks "heft," you may want to bolt down an old audio or power transformer in the bottom of the case to prevent it from tipping over while in use. —*Homer L. Davidson*



You can cut the VOM mounting hole in the aluminum box face by using the tried-and-true method of drilling many holes edge to edge, knocking out the unwanted center piece, and filing the rough edges smooth. But the job will be much quicker and easier with a square chassis punch or an Adel hand "nibbling" tool. Author took advantage of existing holes in VOM to secure it to the front panel of the "aluminum ally."

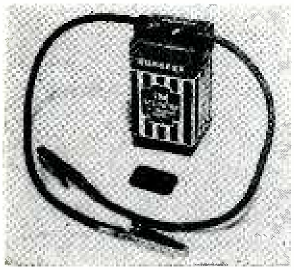
METHODS

THE BEST OF TIPS & TECHNIQUES

GADGETS

SNAP LEADS FOR WORKBENCH POWER SUPPLY

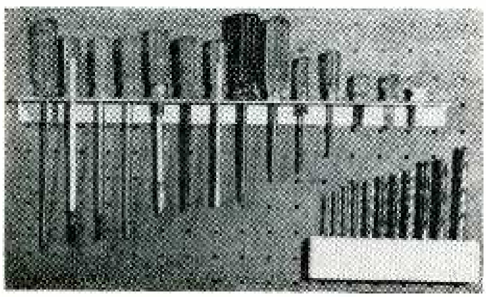
A standard transistor battery can be used as a power supply for experimental projects as well as for equipment tests on the workbench by attaching a pair of snap leads to the battery and the equipment. To make your own connector leads, salvage the terminals from a discarded type 2N6 battery or equivalent, or get a pair from your dealer. If the terminals are mounted on a terminal strip, cut the strip in half to enable them to fit on any size battery using this type of terminal. Connect the terminals to two wires, preferably one red and one black to indicate polarity. The wires should be flexible and durable. Finally, connect an insulated alligator clip to the other end of each wire.



—Luis Vicens

PEG-BOARD TOOL HOLDERS MADE FROM SCRAP MATERIALS

Peg-board tool holders can be made from readily available scrap materials, such as a convenient length of angle iron or aluminum. Along one side of the metal, drill a series of holes or slots to hold the tools. On the other side, fashion two peg-board hooks

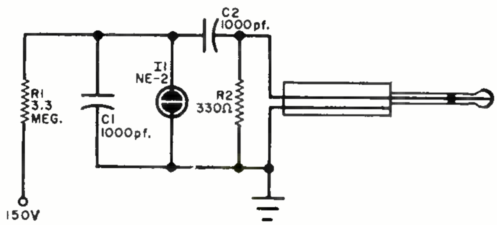


by hacksawing two slots about ¼" apart approximately 2" in from each end and bend to shape. These newly formed hooks should be spaced to line up with the peg-board holes. For an easy fit, use a file or grindstone to round off the edges and reduce the diameter of the hooks if necessary. A scrap block of wood can also be utilized as a tool holder, as shown in the photo.

—Carleton A. Phillips

SIMPLE GDO MODULATOR FITS INTO PHONE PLUG

Do you need a modulator for your grid dipper? The circuit below is that of a simple neon lamp oscillator with an output from 200 to 1000 cycles. Resistor *R1* can be increased or decreased to compensate for any variation in B-plus. Coupling is accomplished through *C2,* whose reactance is negligible at these frequencies. Resistor *R2*

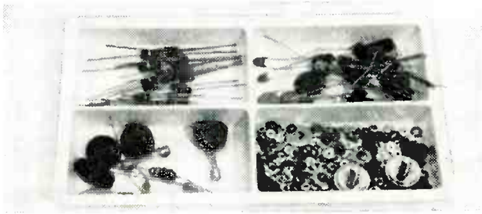


controls the amount of modulation, and can be adjusted to give a pleasant sound. (A 1000-ohm potentiometer could be used instead of a fixed resistor.) The entire circuit can be built into a PL-55 phone plug. A suitable socket should be mounted on the front or rear of the GDO case and connected to a convenient B-plus point on the GDO power supply. The B-plus lead from the modulator can then be conveniently connected. If the PL-55 won't fit into your GDO, mount a suitable plug on any small container—such as a 35-mm. film container—that will hold the modulator parts.

—David W. Beaty, K7MNC

SPEED UP KIT ASSEMBLY WITH A SEAFOOD PARTS TRAY

The next time you buy frozen seafood at the supermarket, look closely at the package. Some of this frozen food—notably fish cakes and patties, and such delicacies as flounder stuffed with crab meat—are packed in plastic trays like the one in the photo (on p. 128). The trays have 4 compartments, each of which is just the right size for small components such as resistors, capacitors, nuts, bolts, etc. A couple of these trays can vastly speed up kit assembly—you simply sort parts into compartments before you begin. The tray illustrated here



is used by National Food Marketers, Inc., Blue Anchor, N.J., and carries the "Home Spot" registered trademark.

—*W. B. Stevenson*

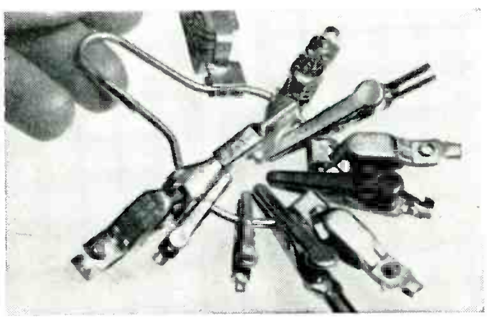
TUNE THE TRAP WITH YOUR TRANSMITTER

In the absence of a signal generator, tunable traps designed to operate within the frequency range of an available transmitter can be tuned accurately with the aid of a field strength meter and the transmitter. Simply connect one side of the trap to a short length of wire and the other side to a field strength meter, set the transmitter on the desired frequency, and tune the trap for a null reading. Watch your signal strength, keeping it down to a minimum, and rock the trap adjustment to be sure you are at the bottom of the response curve.

—*Richard Mollentine*

CUT CLIP CLUTTER WITH SHOWER CURTAIN RINGS

You can rack up assorted test clips on one or more shower curtain rings and keep them handy on the tool-board behind your workbench. A ring can be hung on any

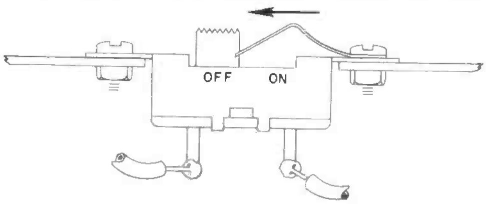


convenient nail or hook. If kept in the tool box, the racked-up clips are not likely to go astray or get mixed up with other hardware, tools, and miscellaneous parts.

—*John A. Comstock*

ERSATZ PRESS-TO-DO-SOMETHING SWITCH

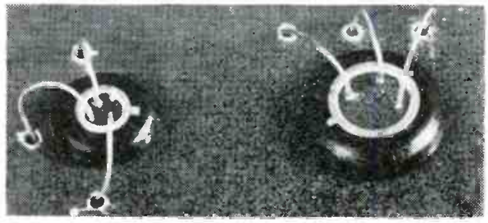
The next time you are stuck for a press-to-do-something / release-to-do-something-else type of switch, and all you have is a slide switch, fashion a small piece of springy metal into a "V" shape, drill a hole in it to accommodate the machine screw on the



appropriate side of the slide switch, and mount it as shown. Cut or file a small notch in the slide handle to keep the spring in place. A normally open or normally closed switch can be improvised as required. —*A. Rosenblum*

GROMMET-TIRED TRANSISTORS PREVENT SHORT CIRCUITS

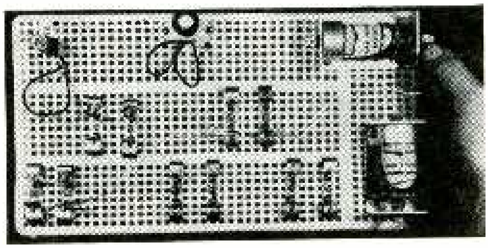
Grommets can be used to protect lead-mounted transistors against vibration and short circuits. You simply fit a grommet over a transistor in much the same way as you would fit a tire over a wheel. This technique will also permit you to leave longer leads on the component and provide a little more protection against heat damage from the soldering iron. Use of a



grommet may slightly increase operating temperatures, but ordinarily will not create a problem in small current circuits. A 3/16"-i.d. grommet is suitable for the smaller TO-18 transistor case and a ¼"-i.d. unit can be stretched to fit over the larger TO-5 container. —*Don Lancaster*

PLASTIC DRAIN TRAYS IDEAL FOR PROJECT BREADBOARDING

Plastic cutlery drainage trays stolen from the kitchen make breadboarding experimental circuits easier and quicker. The holes will accommodate all the nuts and bolts and other hardware you need. Hook-up wire can be conveniently threaded through the holes and run on both sides of the tray. You can easily cut larger holes for controls and tube sockets with a pocket



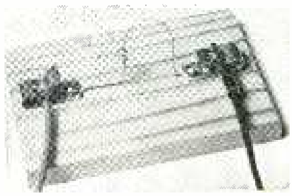
knife. The sides of the tray are deep enough to provide sufficient clearance for many components. —*Margie V. Erickson*

CHEATER CORD CONNECTS PROJECTS CONVENIENTLY, SAFELY

Do the line cords on your experimental circuits keep getting shorter? Each time you "borrow" a cord from one project to use on a newer circuit, the number of cordless old projects grows larger, and you wind up with a shoebox full of three-inch line cords. One simple solution to the problem is to install a cheater cord connector on everything you build. In addition, a certain margin of safety can be derived from the use of a cheater cord. If something happens that requires a quick disconnect, a tug on the line cord will cut off the power. —*Don Lancaster*

CATWHISKER DETECTOR ECHOES YESTERYEAR

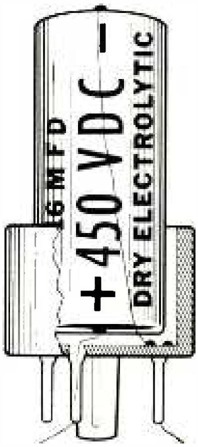
For a nostalgic return to the pioneering days of radio, try your hand at making a catwhisker crystal detector. Carefully break the glass of either a new or discarded 1N34A germanium diode and keep the cathode end containing the little wafer of germanium. Solder the lead to a Fahnestock clip and screw the clip to a small wood base. When soldering the crystal, grip the lead with a pair of pliers (which acts as a heat sink). Also solder a 2" length of thin, stiff wire to another Fahnestock clip and fasten



this clip to the base as shown. File the free end of the wire to a point and bend it to contact the crystal. You can use this catwhisker detector in your favorite circuit and have fun finding the most sensitive spots. —*Art Trauffer*

MAKE YOUR OWN PLUG-IN CAPACITORS

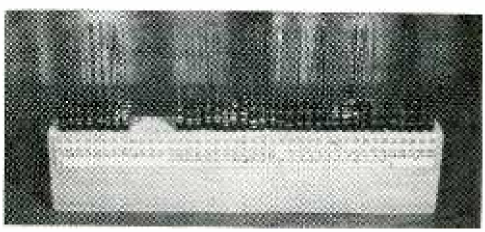
When building new equipment from scratch, you can make your own plug-in capacitors if space on the chassis permits. They will simplify replacement should it become necessary. First salvage the bases from old octal tube sockets, carefully removing all the old glass and cement. A hot soldering iron will clear the tube pins, and you can rewire the base to accommodate your capacitor. Just be careful to note the pin numbers and the correct polarity. With an octal socket wired to hold the plug-in capacitor, you can change capacitors without soldering or de-soldering—as easily as tubes.



—*James V. Conklin*

RESISTOR STORAGE BLOCK

A handy way to keep resistors ready for instant use is to build a storage block for them. Three rows of holes drilled in the block will allow three resistors of each value to be stored; the hole spacing should be the same as the line spacing of the typewriter used for the identification slip which



is cemented to the side of the block. Six lines to the inch is just right for ½-watt resistors, and double or triple spacing can be used for 1-watt or 2-watt resistor blocks. Drill the holes 1⅝" deep using a 5/64" drill. You may want to apply a coat of clear lacquer or varnish to the resistor value slip to keep it clean. —*Thomas H. Charters*

Build a Stereo Bal

(Continued from page 77)

amplifiers, it may be necessary to run a lead between the two amplifier chassis. However, don't run the lead unless it appears that the Stereo Bal won't work without it.

How to Use the Stereo Bal: *As an FM Stereo Indicator and Output Balance.* With the tuner switched to mono, tune in a known mono station. Set the amplifier balance control to center or normal balance. Tune in a station and adjust the tuner's two output controls (if your tuner has output controls) for minimum flickering of the Stereo Bal's lamp. (When there is a separate output control for each channel of your stereo tuner, the best technique is to turn one control about 9/10 full up and then adjust the other control for balance.) Now switch the tuner to stereo and the bulb should flicker only on stereo program material; the brightness and duration of the flicker will depend upon the amount of stereo separation in the program material. It may also be possible to use the lamp's flickering to adjust the stereo separation of those tuners that have a control for that purpose.

For Phono and Overall System Balance. If you have a stereo preamplifier and stereo power amplifiers with input level controls, set the preamplifier for mono and center the preamp's balance control. Play a record and adjust the power amplifier's two input level controls using the same technique as given above to balance the tuner's outputs. If the power amplifier doesn't have input level controls, simply adjust the preamp's balance control for minimum lamp flicker. Incidentally, whenever there are both power amplifier input level controls and tuner output or other program source level controls to be balanced, the power amplifier should always be adjusted first.

While the Stereo-Bal works well in most stereo systems, it may not respond too well when used with certain high-efficiency speakers. Some sensitivity has been sacrificed for simplicity and economy. —30—

Electronic Flash

(*Continued from page* 15)

Using the Electronic Flash. There are four things you should consider when using the electronic flash: camera sync, shutter speed, guide number and type of film.

Your camera must have X sync to work properly with this flash. A few cameras have F sync (5-millisecond delay) or the more common M sync (20-25 millisecond delay). Neither of these sync settings can be used with an electronic flash. Shutter speed is related to sync, but only because most quality focal plane shutter cameras have a 1/50-second X sync speed. Generally speaking, a good focal shutter plane camera is useful up to 1/125 second. Some of the more modern shutters (metal leaves) can be used at any shutter speed, up to 1/500 or 1/1000 second.

Film exposure with different types of film using the electronic flash is calculated from a guide number in the same fashion as with ordinary flash bulbs. You can define guide number as the lamp-to-subject distance times the F-stop. The guide number changes with each ASA film rating There is no filter factor or color correction factor for the electronic flash.

You can determine the guide number for your electronic flash and your most frequently used films in the following fashion:

(1) Load the camera and connect the flash. Set your model exactly 10 feet in front of the lens and be sure the flash reflector is centered on the model.

(2) Be sure that the *Ready* light is blinking before you take a picture.

(3) To determine the guide numbers (usually 40 for Kodachrome II, and 150 for plus-X film), take a picture at all openings (*f4* through *f22*) with your model holding a lettered card calling out the film type and f-stop without changing distance or shutter speed. Develop the film and examine the pictures for best exposure. If the best exposure is say at *f4*, your guide number is 40 (*f4* x 10 feet).

(4) The guide number remains the

same when the flash gun is operated on batteries or house current.

Once the guide number for the film you will most likely use has been established, you will be on the way to much better indoor (or even outdoor) photography. —30—

Experimenter's L Bridge

(*Continued from page* 121)

oscillation. To minimize loading effects on the oscillator, the signal is taken from the junction of *R17* and *R18*. The output transformer delivers approximately 4 volts to the bridge circuit, which varies with the range setting. The lower mh ranges place a heavier load on the output transformer and cause a drop in voltage. The power supply is a conventional full-wave rectifier circuit.

Construction. A 4⅜" x 8" chassis plate is held in place by two angle brackets about 1½" from the bottom of a 4½" x 6" x 8" utility box. The tuning eye socket is secured to the front panel by two *8-32* x 4" rods. A single-terminal lug for the other ends of the five resistors attached to the range switch is mounted on the rod nearest the switch. Connect the circuit leads to *R7* so that the resistance increases as the control is rotated clockwise. (Note: do not connect the *L* control (*R1*) until calibration is completed.)

The *L* dial is a 4" metal disc; a cardboard or plastic dial can also be used. A sheet metal screw positioned below the tuning eye and just above the dial and with the slot in a vertical position serves as an indicator. Paint or ink in the slot on the screw head to make it easy to see. Drill several rows of ¼" or ⅜" holes in the rear panel to allow for ventilation. Wiring is not critical, but keep the leads short in the phase shift network of *V3b*. Terminals X_L should be insulated from the front panel.

Calibration. An ohmmeter or multimeter with an 0-10,000-ohm range is needed for calibration. Rotate the still-disconnected *L* control to the full counterclockwise position. Connect the ohmmeter to the center and right terminals, looking at the control from the rear, the terminals pointed downward. The meter should indicate approximately zero resistance. Now rotate the *L* control clockwise and mark the dial at every 500-ohm point. Number the 1000-ohm positions. Use alternate long and short lines for easier reading, placing the long lines opposite the 1000-ohm points.

Disconnect the meter and hook up the same two terminals of the *L* control to the circuit. The left terminal should be connected to the center terminal for better control action.

Operation. Set the *S* and *Q* controls about midway and allow your newly made inductance bridge to warm up for a few minutes. Connect the coil to be tested to the binding posts and set the range switch to an appropriate range. Adjust the *S* control until the tuning eye is almost closed. Slowly rotate the *L* dial while watching the tuning eye for a sharp change from minimum to maximum and back to minimum again.

Adjust both the *L* and the *Q* control for maximum opening. Rock the controls to pinpoint the settings. Then rotate the *S* control clockwise to increase tuning eye sensitivity. The shadow will narrow. Again readjust the *L* and *Q* controls for maximum eye opening. The *L*-dial calibration mark multiplied by the range-switch setting indicates the inductance value.

When filter and audio chokes are measured, begin with the *Q* control at the full clockwise position. It will probably have to stay there. Several bridge balance indications may be found with low value r.f. chokes. Use the one with the largest amount of eye opening.

Accuracy of the bridge is determined by the precision of the components used and the *L* dial calibrations. –30–

Swiss Quad Antenna

(Continued from page 105)

in and out to obtain the lowest possible SWR. Move the U's no more than a quarter inch at a time, and keep the ratio between the "director" and "reflector" dimensions constant.

After the SWR is reduced to a minimum by adjusting the U's, vary the length of the *gamma* for a possible further reduction in SWR. It should be a simple matter to reduce the SWR to well below 1.2:1. These adjustments can be made in any reasonably clear space, as long as there is a separation of five feet or more between the antenna and the nearest large object. Be sure to solder all joints and connections.

Results. The front-to-back ratio of the Swiss Quad is about 25 db; its front-to-side ratio is over 35 db. In operation, a moderately strong signal from the front of the antenna will disappear off the back and sides. Indicated gain is a minimum of a solid 6 db over a reference dipole antenna. For its size and cost, the "Swiss Quad" is an excellent performer. By the way, it radiates a horizontally polarized signal. —30—

Transistor FM Multiplexer

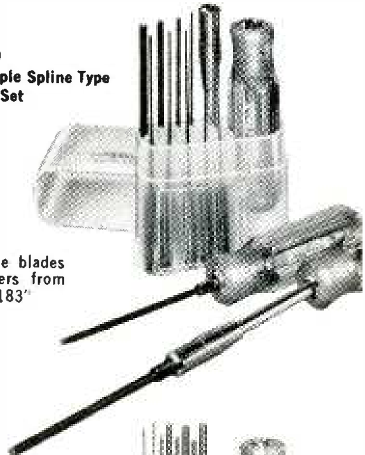
(*Continued from page* 60)

strong signal area, tuner sensitivity is usually not a problem. Some tuners have high-impedance detector circuits which are not suitable for connecting directly to the relatively low impedance transistor circuit in the FM multiplexer. The circuit shown in Fig. 3 can be added to a tuner not equipped with a cathode follower.

Power requirements for the multiplexer are −12 to −17 volts at approximately 25 ma. for stereo, and 11 ma. for mono operation. Less current is needed for mono reception because, in this mode, the stereo indicator lamp is normally off. Various power supplies can be used, but one simple way to get power is to draw it from the tuner's supply as shown in Fig. 4.

The response and separation curves on page 56 were derived from a quality report by Hirsch-Houck Laboratories.

Alignment and Operation. Alignment is begun by removing *Q4* from its socket to kill the 19-kc. oscillator and make it easier to follow the 19-kc. input signal. (See Fig. 1.) Feed into the input jack a 19-kc., ¼-volt signal, and tune *T1* and



T2 for maximum indication on a scope or VTVM attached to point *A*. The indicator lamp should light. Be careful not to overload the circuits with too strong an input signal.

Next, with the generator still set on 19 kc., replace *Q4*, and tune *T4* while looking with a scope at point *C* for the largest 38-kc. signal. Then reset the generator to 67 kc. and tune *T3* for minimum signal at point *B*. If a signal generator is not used, leave *T3* at its factory setting—unless you are bothered by a whistle when tuned to a station broadcasting both stereo and SCA signals; in this case, tune *T3* to eliminate the whistle.

Now, connect the multiplexer into a hi-fi system and tune in a stereo station. The indicator lamp will go on when a stereo program is coming through. Because of the sensitivity of the indicator lamp and bandpass characteristics of the lamp circuit, the lamp will light on interstation hiss and will flicker occasionally on high-frequency modulation in a mono program. If this should happen, ignore it, as it does not create any confusion once you know about it.

If possible, tune in a station known to broadcast portions of its program on one channel only, and during such a broadcast retune *T4* very carefully to reduce the audio output from the unused channel to an absolute minimum. Decrease the volume level of the in-use channel and raise the volume of the unused channel to get the best possible setting for this critical adjustment.

Now all you need is a pair of slippers, a pipe, an easy chair, and a stereo FM disc jockey who shares your taste. —30—

Module Pocket Receiver

(*Continued from page* 100)

this station is heard at maximum level. Now find a station at the high end of the band on the standard radio. Rotate the knob until the plates are fully open.

(Note: whether the plates should be fully open or less than fully open depends upon the actual position on the dial occupied by the station. The same is true for the position of the plates and the radio station at the low end of the band. If the standard radio has, say, 10% rotation from maximum, adjust the radio you have just built to 10% from maximum in a similar manner. Unless you are working with a premarked tuning dial, the exact position of the variable capacitors is not critical, so long as you can tune in all the stations.)

When the plates are fully open, the trimmer capacitors on *C1a* and *C1b* have their maximum effect. Adjust the trimmer on *C1b* until the station on the upper end of the band comes in, then adjust the trimmer on *C1a* for maximum volume.

Now go back to the low end of the band and repeat the entire procedure. "Rock" and peak all the adjustments. You can align the set in less than five minutes. If desired, either the case or a small dial mounted under the tuning knob can be marked to show the location of the stations in your area.

As the volume level goes up during the alignment procedure, reduce the level with the volume control to enable you to more easily detect variations in signal level. —30—

Exalted Pot

(*Continued from page* 124)

brated also, because both pots are of the linear type. Simply switch *S1* to *10K* and multiply readings by 1000. With *S1* in the *1K* position, you would of course multiply the readings by 100.

To calibrate a capacitance scale, find the capacitance value and mark the appropriate resistance point. At 836 ohms, mark 1.9; at 800 ohms, mark 2; etc. No further calibration for capacitance is required. The other three ranges of capacitance fall into line because the controls are linear. With a 100-cycle test signal, the *C* or *C/10* scale applies, depending on *S1*'s position. With a 10,000-cycle signal, the ranges become *C/100* and *C/1000*. Simply flip *S1* to the desired range. Consult the calibration charts on page 124 as you work.

An inductance scale is calibrated similarly. At 62.8 ohms, mark 1; at 125.6 ohms, mark 2; etc. Refer to the first two columns in the calibration table. Here again, because the controls are linear, the other ranges do not require further calibration. With a test signal of 10,000 cycles, and with *S1* at position *L*, you can read 1 to 15 mh. directly. With *S1* in the *Lx10* position, multiply readings by 10 and read 10 to 150 mh. The ranges at 100 cycles are: *Lx100* for readings from 0.1 to 1.5 henrys, and *Lx1000* for values from 1 to 15 henrys.

Operation. Connect the generator output to jack *J1* and the unknown component to terminals *C* and *Gnd*. Connect your VTVM first to *C* and *Gnd*, and then to *B* and *C*. Adjust the knob to obtain the same voltage readings. When the voltages are equal, the scale can be read. Keep in mind that the applicable scale depends upon using the correct test frequency and position of the range switch. Also remember that electrolytic capacitors are polarized and are designed for d.c. operation—you may not be able to determine their values with this technique.

To use the "Exalted Pot" as a variable resistor, terminals *B* and *C* are employed. For 0-1000 ohms, set *S1* to the *1K* position. For 0-10,000 ohms, set *S1* to the *10K* side.

To operate the unit as a low-current voltage divider, apply the voltage to terminals *B* and *T*. Take the divided voltage from terminals *B* and *C*. Either the 1000-ohm or 10,000-ohm potentiometer can be used depending upon the position of *S1*. Do not exceed the ½-watt rating of *R1* and *R2*. —30—

Simple Voltage Calibrators

(*Continued from page* 116)

type rated at 0.6 ampere, *D1* is a silicon diode rated at 50 PIV, 100 ma., or better, *S1* is a d.p.d.t. unit, and *S2* is a single-pole, 17-position rotary switch. Potentiometer *R2* serves both as an a.c. and a d.c. voltage adjuster, while *R3* controls only the applied d.c. voltage. Resistor *R1* insures a certain amount of minimum resistance in the circuit to protect the diode against current surge. Electrolytic capacitor *C1* can have a working voltage rating of 150 volts or as low as 20 volts.

A voltmeter at the output jacks can be used to set up the desired input voltage on the 100% range. All the other positions will, without further adjustment, provide the indicated voltage steps; accuracy is limited only by the initial meter reading and the variations in values of the resistors. Both the meter reading and output voltage are taken from *J1* and *J2*.

One precaution to observe when taking voltage readings is to avoid the loading effect of a low ohms-per-volt meter. A simple check on the accuracy of your reading on the 100% level is to measure the voltage on the next lower step, which is the 50% level, and then multiply your reading by 2. If the answer is the same, you are on firm ground; otherwise, you should accept the reading on the lower scale as being the more accurate one. -30-

2 Halos for 2 Meters

(*Continued from page* 103)

nidirectional pattern of the stacked halos is particularly desirable for net control stations and for automobiles facing in different directions.

Construction. The two halos are spaced ½ wavelength apart, horizontally leveled and oriented in the same direction. See the diagram on page 103 for actual dimensions.

Carefully form the halos to prevent flat spots, kinks and just plain out-of-roundness. There are machines for this purpose and for a small fee you can get a sheet metal shop to form the halos.

Bolt the halos securely to the mast cutouts as shown in the halo mounting detail diagram. Do not tighten enough to distort the mast or halo tubing, and use lock washers. Connect the halos to each other with 52-ohm coaxial cable. Stranded internal conductor transmission line is preferable to the solid conductor type to reduce breakage from vibration.

Two lengths of cable, each about 21″ long, connect the halos. The center conductor on one end of each cable is attached to the terminal connected to the small mica capacitor on each halo. Connect each outer shield to the adjacent ground terminal. The other end of each cable is terminated in a PL-259 or equivalent type coaxial connector and screwed into an appropriate coaxial "T" fitting. The transmission line from the antenna to the transmitter is also screwed into this fitting.

Gamma Match. To construct the gamma match, install a clamp on each halo at a point 4½″ to the right of center. The gamma match on each halo should be located on the same side of the mast.

The capacitors should be shielded from the weather. As a matter of fact, a coat of acrylic paint over the entire antenna and fittings will protect it from the elements. The wire forming the gamma match should follow the outside curvature of the halo. About #13 AWG tinned copper bus wire will do. Place nothing within the center of the halo.

An easy way to tune the antenna is with the aid of an SWR meter or field strength meter. Another method is to connect the halos to a receiver and adjust the gamma match for maximum volume or reading of an "S" meter if available. —30—

The Dymwatt

(Continued from page 52)

an ohmmeter to be sure there is no electrical connection.

An aluminum case will help the heat sink do its work. Do not use a smaller box than the one specified—it might get too hot to touch and could damage the Triac. The case used by the author remains relatively cool for all but the heaviest power loads; above 400 watts it becomes noticeably warm.

See Fig. 4 for parts layout. The heat sink on the inside and a dial plate on the outside of the case are held in place with a "Pop" rivet and the mounting nut of the potentiometer. Avoid overheating either *Q1* or *D1* when you are soldering. If you wish, a NE-83 neon lamp can be substituted for *D1* to reduce cost, but it will also reduce the control range.

As long as the Dymwatt is used within its ratings and only for its intended types of loads, it is capable of long life and trouble-free service. -30-

Electric Fence Charger

(*Continued from page* 32)

find out if the fence is being charged, connect the neon tester between the ground and the fence. The higher the intensity of the flash, the greater the charge. To minimize the possibility of shock, first connect the tester's lead to ground.

To keep a garbage can from being raided, place a small sheet of thin plastic material (the kind that plastic bags are made of) under the can. The plastic sheet should be just large enough to insulate the garbage can from the ground.

If the can is to be placed on a dry cement or gravel walk, first lay down a piece of metal screen, about 2′ x 2′, to serve as a ground. It should be big enough so that a dog will have to stand on it when he reaches out a paw for the can. Cover the screen with a piece of cardboard, then place the sheet of plastic over the cardboard, and then place the can over this "sandwich." The cardboard keeps the screen from puncturing or tearing the plastic. Both the cardboard and the piece of plastic are just a little bit bigger than the can but not big enough to prevent the dog from standing on the bare screen.

Run an insulated wire from the garbage can to the red post on the charger, and either a bare or insulated wire from the ground to the black binding post. (Better turn off the charger before the garbage collector arrives, or he may decide to take you in along with the garbage.)

One shock per invader should be enough. You will probably see some of the most surprised pooches you ever saw in your life. -30-

Best Meter Face Forward

(*Continued from page* 118)

top arc. Then lay out each minor division by dividing each major division into a suitable number of parts. Guide lines are drawn through each of these division points, aimed radially toward the meter pivot point. Add the actual scale markings using ⅛"-wide black printed circuit tape for the major divisions, and 1/16"-wide tape for the minor ones. Carefully cut the tape squarely across each arc with a razor blade or a sharp knife.

Transfer the scale numerals into place, being very careful about centering. Note that the center of a *20* is exactly between the "2" and "0," while the center of a *10* is just inside the "0." The center of each numeral group should exactly correspond to the axis of that major division. The title baseline is drawn parallel to the original baseline, and the title pressed into place. To center the title, add up all the space required for each letter and space, and then start the lettering *half* this distance away from the centerline.

Nonlinear Scales. Nonlinear scales require more thought. If the scale is clearly defined mathematically, the scale divisions may be determined by suitable algebra or geometry. An ohmmeter scale is started with infinity and ends with a zero at full scale. The exact center of the scale is equal to *R*, the internal resistance of the ohmmeter; *2R* is located one-third of the way up the scale; *3R* is one-fourth, *4R* is one-fifth of the way up the scale, etc. For a 1-10 log scale, lightly lay out a linear 0-10 scale. Divisions for each log point are then placed on the log of each desired number. This means the 1 goes at 0, the 2 at 3.01, the 3 at 4.77, etc. Decibel scales work in much the same manner.

Photolith Negatives. Most towns have at least one photolithographer who can make a 5:1 reduction of your art work in the form of a photographic negative. The cost of this service is about $1.00. Don't go to an ordinary photographer, as it will cost much more, and the film used will not have nearly the contrast ratio that lithography film has (the negative is either perfectly transparent or else jet black). Take the negative to a photo store and have semigloss contact prints made; the cost of each print should be about 15 cents.

To mount a new meter face, cut the print to size, align it carefully, and cement it with rubber cement to the *back* of the original meter face. If you ever need the original again, you'll have it handy. —30—

Strobelight Slave

(*Continued from page* 45)

150 and less than 180, turning *S1* on will make the slave more sensitive to low light levels without danger of damaging the strobe.

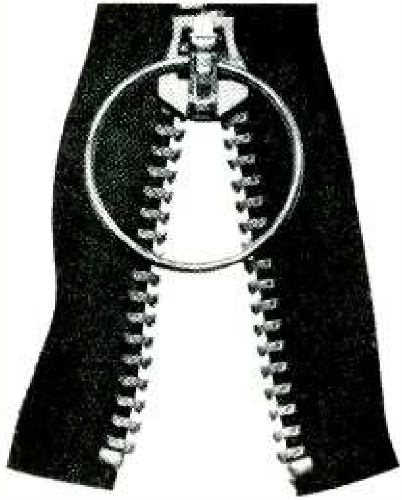
Construction. To determine which Strobelight Slave you should build, turn on the strobe you intend to use with it, and carefully measure the d.c. voltage *across the contacts of the shutter socket* when the "ready" light comes on. While you're at it, observe the polarity of the voltage at the shutter socket, and permanently mark the positive contact with a plus sign.

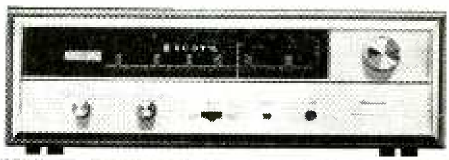
The assembly of both slave units is simple and straightforward; the basic Strobelight Slave is housed in a 2¼" x 2¼" x 4" box, while a 3" x 4" x 5" box is used for the booster model. Simply mount the parts as shown in the photographs, using spacers to hold *V2*'s socket away from the bottom of the box. With the booster slave, be sure to mount the parts so that the batteries can be secured in the back of the case; a battery retaining strap can be made from scrap aluminum.

Make a shield can with a window in it for *V1* to minimize triggering of the slave by stray light. A tube shield or cover from an old i.f. transformer can be used for this purpose. For some applications, however, it may be desirable to remove the shield to obtain greater sensitivity.

Both versions of the Strobelight Slave are designed to work without any modifications to the strobe unit itself. Just make sure that the connecting cord between the two is properly polarized by marking a plus sign on the positive contact of the socket on the strobe and the positive contact of the socket on the slave. In Figs. 2 and 3, the positive contact of *SO1* is the upper one, and is connected to *V2* or *D1* respectively. *Damage may result to one or both units if the cord is incorrectly polarized.*

The basic slave shown in Fig. 2 can be built for about $6, and the booster slave for about $16, the primary increase being in the cost of the batteries. -30-





Tachometer Calibrator

(*Continued from page* 40)

lamps can be mounted in grommet-lined holes on the front of the case, or in regular small sockets.

Substitutions of components can be made. However, two things should be kept in mind: (1) the peak inverse voltage rating of the diode must be at least 300 volts and (2) the transformer voltage should be well over any possible difference in firing voltage of the two neon lamps, but not so high as to fire the lamps unaided by the ignition pulses. Transformer voltage on the order of 24 volts works very well.

Operation. To calibrate the tachometer, connect the newly made calibrator as shown in Fig. 1, one wire going to any convenient chassis ground and the other going to the coil's terminal which is connected to the distributor points. Plug the power cord into any 117-volt, 60-cycle a.c. outlet.

Start the car, and adjust the motor speed until the lamps indicate synchronism. Note the tachometer reading, then adjust the motor speed until the lamps indicate synchronism for the second point, and again note the tachometer reading. You now have two accurate calibration points for the tachometer. The difference between each reading and the corresponding true figures (450 and 900 rpm for an 8-cylinder engine and 600 and 1200 rpm for a 6-cylinder job) is the tachometer error.

No trouble should be encountered in identifying the two points of synchronization. The lower speed is a slow idle, and the upper speed is much faster than idle. As either point is approached from either a higher or lower engine speed, the blinking rate of the lamps will slow down, indicating that you are approaching the calibration speed.

In the event your car specifications show that one of the calibration speeds is the proper idling speed, the calibrator can be used to set the idle adjustment without the aid of a tachometer. Many V-8's with automatic transmission idle at 450 rpm when the transmission is in *Drive* and the *parking brake is on.* —30—

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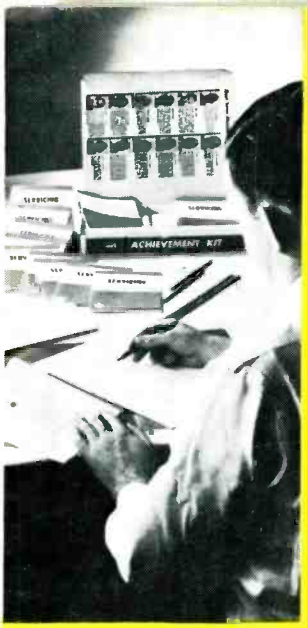
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