1962

POPULAR ELECTRONICS'

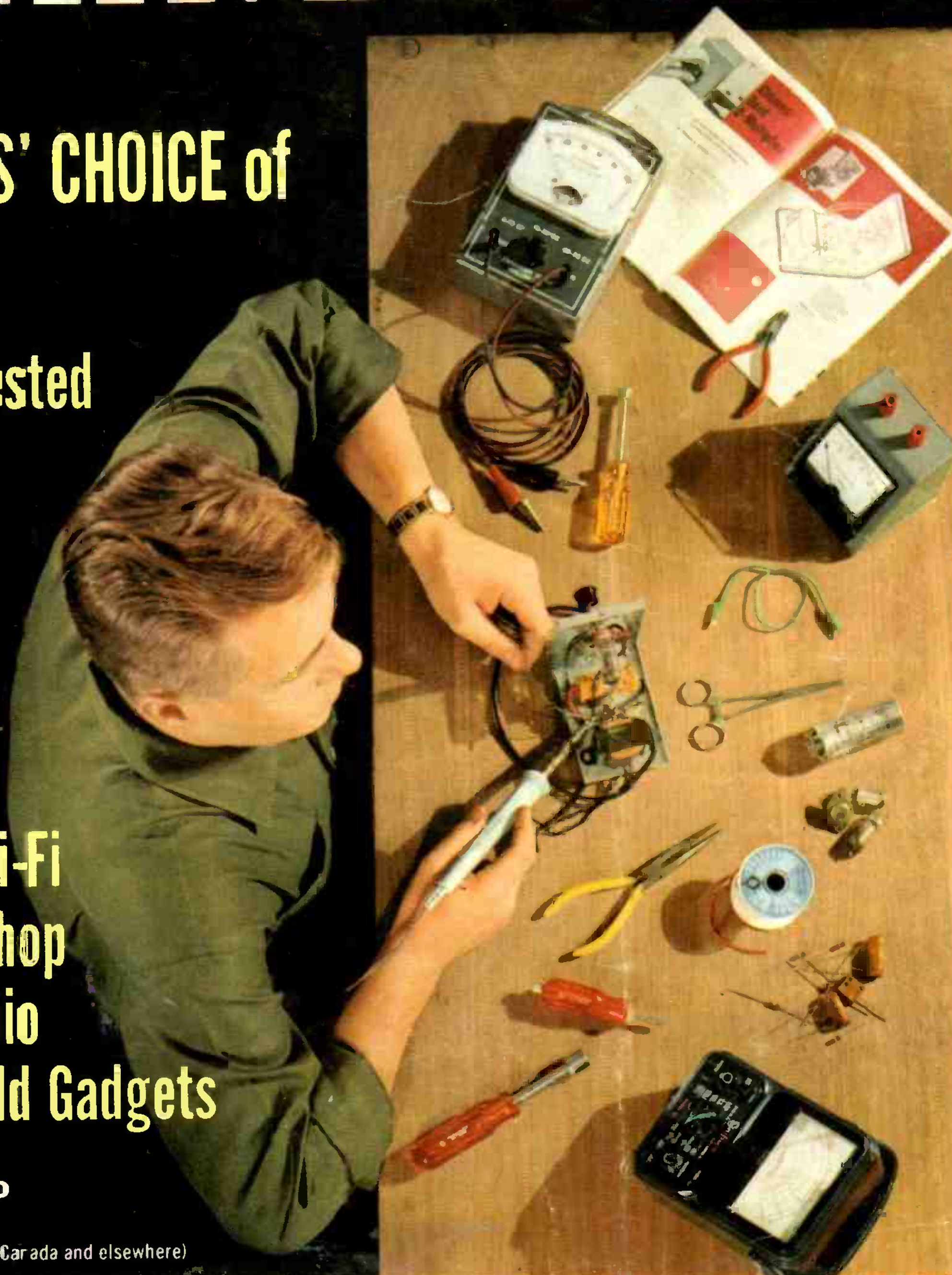
ELECTRONIC EXPERIMENTER'S HANDBOOK

the

EDITORS' CHOICE of

39

Bench-Tested Projects



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1962 POPULAR ELECTRONICS ELECTRONIC EXPERIMENTER'S HANDBOOK

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THIS is the sixth edition of the POPULAR ELECTRONICS "*ELECTRONIC EXPERIMENTER'S HANDBOOK.*" As in the past, it contains a carefully selected group of "bench-tested" experimental electronics construction projects. In addition to the arrangement of these projects in logical groups, all of the material in this book has been thoroughly double-checked and brought up to date; minor errors and misprints have been corrected. Selection of the projects to appear in the 1962 edition was based upon reader response to these articles when they originally appeared in POPULAR ELECTRONICS.

As with previous editions, we are sure that you will find all of these projects entertaining and educational as well as useful.

The Editors

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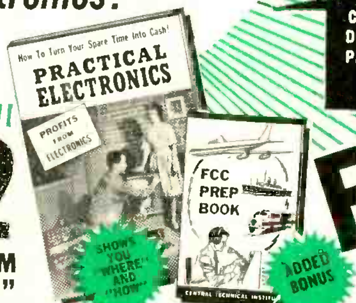

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Superintendent of Communications for the K. C. Southern Railway Company is Central graduate Lawrence D. Fry, with 15 years of railroad communications experience. "Central is a fine school," says Mr. Fry. "I've always recommended it, and have sent several students to Central."

Field Service Representatives for the Bendix Computer Division, L. A., California, are Central graduates E. John Kempf, left, and Robert Young. Mr. Kempf was employed as a maintenance man before he became interested in radio and TV. His first project was building test equipment at home. After enrolling with Central, he began to make extra money repairing radios, auto radios, etc. "The field of Computers is expanding, and there's a real need for trained technicians," he says. "I have found the work to be both profitable and interesting!"

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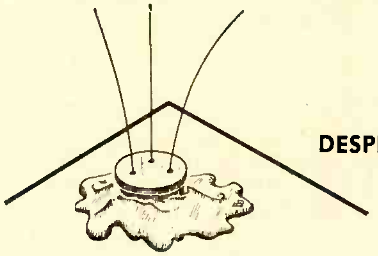
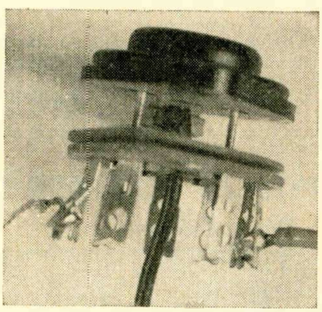
Transistor Mounting Tips



DESPERATION MOUNT

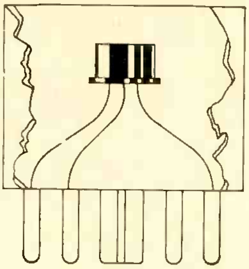
Need some way to shock-mount a lead-type transistor? Simply build a little pool of Duro plastic rubber and stick the transistor—wire leads up—in it. When the latex dries, the transistor will be shock-mounted and the leads readily accessible. —*John A. Comstock*



CONVERTED SOCKET

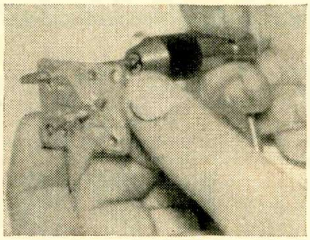
Are you aware that common power transistors, such as the 2N307, 2N255, etc., come in a TO-3 type-approved case and can be inserted in a 9-pin miniature tube socket? But before rushing out and sticking a power transistor in a 9-pin socket, you must make provision for the collector lead. Just pass a machine screw through one of the transistor mounting holes. Take a short wire lead with a solder lug on one end and fasten it to the screw. Bring the lead through the eyelet in the center of the tube socket and solder the free end to one of the unused socket lugs. The photo shows two of the three leads in place.

—*Hartwell M. Hughes*



EASY INTERCHANGE

The one way to find out how transistors really work is to build a lot of small projects. But you will probably not want to keep many of these projects for any length of time, and you *will* want to use the transistors over and over again—making for wear and tear on these delicate parts. A good way to keep your transistors healthy and happy is to mount them in an old octal socket. Every workshop has plenty of old octal glass tubes around. Just break out the glass and clean the solder from the pins. Then carefully solder the wire leads of your most frequently used transistors in a "standard" pin arrangement: base to pin #1, collector to pin #5 and emitter to pin #8. —*Jeff S. Hurlburt*



RETAPPED TRANSISTOR SOCKET

The convenience gained by using a 10-cent Cinch-Jones power transistor socket is often lost due to its *6-20* threading. But you can take a hand tap and retap the hole in the metal contact to accept a *6-32* screw, which you're more likely to have on hand. —*Paul Galluzzi*

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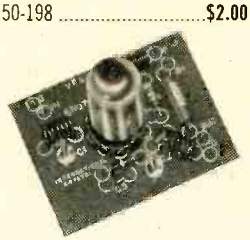
6 Meter	300-171	$5.95
2 Meter	300-172	$5.95
Wired and Tested	**Cat. No.**	
11 Meter	300-164	$9.95
10 Meter	300-165	$9.95
6 Meter	300-166	$9.95
2 Meter	300-167	$9.95

Coupling Section
Cat. No. 150-196 .... $ .95
Mounting Chassis
Cat. No. 150-198 .... $2.00



VFA-1 CASCODE PREAMPLIFIER

For 2 meters or 6 meters. Mounts in standard 3" x 2" x 5" minibox. Power 250 vdc @ 10 to 15 ma, 6.3 vac @ 400 ma. Tube 6BQ7A.

50 mc Kit with tube.
Cat. No. 300-173 .... $4.95
50 mc Wired with tube.
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144 mc Kit with tube.
Cat. No. 300-174 .... $4.95
144 mc Wired with tube.
Cat. No. 300-121 .... $8.95

FO-1L 100 KC OSCILLATOR

Printed circuit oscillator for band edge calibrator and frequency standard use. Power: 150 vdc @ 8 ma, 6.3 vac @ 150 ma.

Kit, complete with tube and crystal.
Cat. No. 200-113 .... $12.95
Wired and tested.
Cat. No. 200-114 .... $15.95

FO-1A FO-1B OSCILLATORS

FO-1A (fundamental operation) 200 kc to 15,000 kc. Tolerances of .01% with appropriate FX-1 crystal. Tolerances of .0025% and .001% available only wired and tested. Power: 210 vdc @ 5 ma, 6.3 vac @ 150 ma. Tube 6BH6.
FO-1B (overtone operation) 15 mc-60 mc in five ranges. Power: 150 vdc @ 8 ma, 6.3 vac @ 175 ma. Tube 6AK5.

	Cat. No.	
FO-1A Kit	200-101	$3.95
FO-1A Wired with tube	200-102	$6.95
FO-1B Kit 15-20 mc	200-103	$3.95
FO-1B Kit 20-30 mc	200-104	$3.95
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FO-1B Wired 50-60 mc	200-112	$6.95

FO-11 CRYSTAL OSCILLATOR

Compact crystal oscillator. Frequency range 2 mc to 15 mc. Fundamental mode crystals. Uses International F-605 or FA-5 crystals. Power: 210 vdc @ 5 ma, 6.3 vac @ 150 ma. Tube 6BH6.
Wired and tested, with tube, less crystal.
Cat. No. 200-130 .... $4.75

TRANSISTOR SUBASSEMBLIES

CONVERTER (TRC-4)

Crystal controlled. Three transistors. RF stage. Available all amateur bands 6 through 80 meters*. 600-1600 kc IF. Power: 12 vdc @ 10 ma.
* See catalog for other frequencies.
Wired and tested with crystal........ $14.50

CONVERTER (TRC-5)

Crystal controlled. Three transistors. Available for any 1 mc band of frequencies between 54 mc and 160 mc. 600-1500 kc. IF. Power: 12 vdc @ 10 ma. 54 mc to 100 mc. Wired and tested with crystal.—Cat. No. 300-153 .... $20.50
100 mc to 160 mc. Wired and tested with crystal.—Cat. No. 300-154...... $20.50

CONVERTER (TRC-1)

Three transistors. Crystal controlled 6 mc IF standard. 10 meters. Power: 15 vdc @ 5 ma. Wired and tested with crystal.—Cat No. 300-132 .... $14.50

AUDIO UNIT (TRA-2)

Three transistors. Input 100,000 ohms and 50 ohms. Speech input for dynamic microphone. Push-pull power amplifier. Power: 15 vdc @ 80 ma peak. Wired and tested.—Cat. No. 400-104 .... $14.50

MIXER IF UNIT (TRB-1)

Six transistors, 2 diodes. Crystal controlled local oscillator. Noise limiter and squelch. 6 mc input. Power: 15 vdc @ 10 ma. Wired and tested with 2 crystals.
Cat. No. 300-131 .... $32.50

TRANSMITTER UNIT (TRT-2)

Three transistors. Crystal controlled. Switch for two frequencies. 10 meter range. Power: 15 vdc @ 30 ma.
Transmitter less transistors.
Cat. No. 200-118 .... $10.00
Transistor Kit.
Cat. No. 150-180 .... $ 9.00

OSCILLATORS

Three separate transistor units with total of 8 frequency ranges (100 kc to 60 mc). Power: 9 vdc @ 3 ma. Prices are less crystals.

TRO-1L 100 kc.
Cat. No. 200-132 .... $4.00
TRO-1H 200-2,000 kc.
Cat. No. 200-133 .... $4.00
TRO-2 2,000-10,000 kc.
Cat. No. 200-134 .... $4.00
10,000-20,000 kc.
Cat. No. 200-142 .... $4.00
TRO-3 Overtone 15 mc-60 mc in 5 ranges.

15-20 mc	Cat. No. 200-135	$4.00
20-30 mc	Cat. No. 200-136	$4.00
30-40 mc	Cat. No. 200-137	$4.00
40-50 mc	Cat. No. 200-138	$4.00
50-60 mc	Cat. No. 200-139	$4.00

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Chapter 1

Electronics Around the Home

THE electronics hobbyist often finds great delight in building things for his "non-electronic" family. The only prerequisite seems to be that the project have a useful function after it is constructed. In this chapter, electronics has been put to work for the performance of a variety of tasks. One, two, or more of these projects cannot help but appeal to the family that is fortunate enough to have an electronics enthusiast among its members.

The "Big Sound" article (page 10) overcomes the tinny, squawk-box audio of transistorized pocket portables. The infrared burglar alarm is a superb protective device, while the "Flea-Power Glow Light" (page 19) is portable and need not be attached to the house wiring lines.

Your fishermen friends will be intrigued by the "Fish Caller" (page 22) which aroused tremendous comment when it first appeared in print over a year ago. And the 3-way intercom—being transistorized—is as up-to-date and modern as many of the more expensive models which sell for almost a hundred dollars.

BIG SOUND FROM PERSONAL PORTABLES

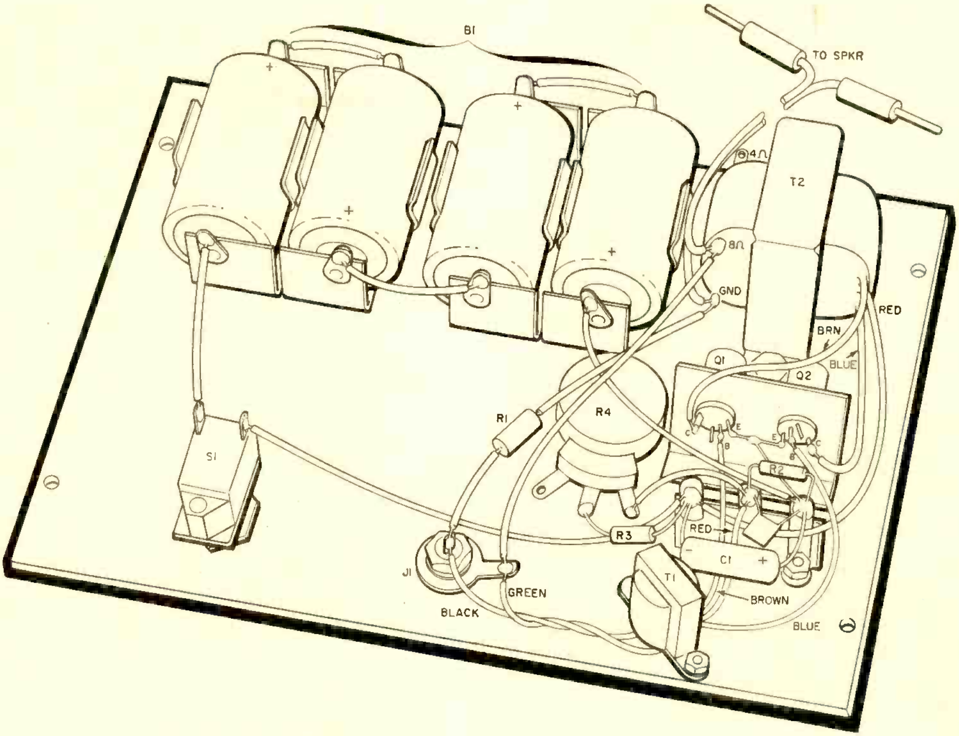
Compact amplifier/speaker combination improves tone and volume of small transistor sets

By JAMES E. PUGH, Jr.

ALTHOUGH a good many people would be lost without their small transistor portable radios, few would deny that these little wonders have their drawbacks—with only 50 to 100 milliwatts maximum output and a tone that is not usually outstanding, they could well stand some "hi-fi'izing." The amplifier/speaker combination shown here is intended to do just that. Called the Transi-Booster, this simple and relatively inexpensive unit will give a worthwhile increase in volume and improve the tone of practically any small portable.

The output of the radio is connected to the input of the Transi-Booster via a plug, jack, and cable arrangement. This makes it possible to enjoy good sound in your radio listening almost anywhere, and you can even control your radio from your favorite chair or sofa. Unplug the connecting cord, and your radio is again its old portable self, ready to accompany you wherever you go.

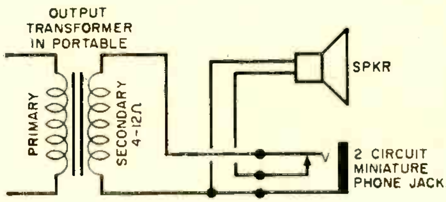
Construction. All parts except the speaker are mounted on one side of a piece of fiberboard, and the whole assembly is attached to the back of a speaker baffle with

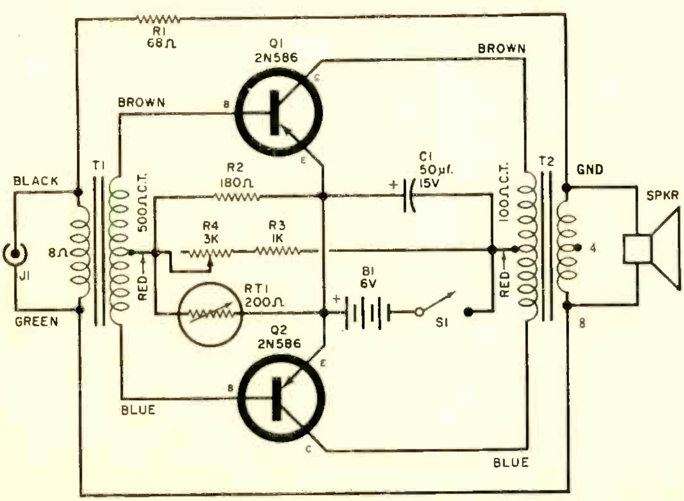


HOW IT WORKS

The Transi-Booster is essentially a push-pull transistor amplifier with overall negative feedback. The primary of transformer *T1* matches the output impedance of the radio at its earphone jack; *T1*'s secondary drives two transistors in Class B push-pull operation. Output transformer *T2* couples the ¾ watt developed by the transistors to a suitable speaker.

Resistor RT1 is a temperature-sensitive resistor (thermistor) which keeps the transistors properly biased over a wide temperature range; resistor *R1* provides negative feedback to improve the Transi-Booster's frequency response and reduce distortion.





Pictorial diagram (above, top) and schematic diagram (left) show simplicity of Transi-Booster circuitry; proper setting of R4 and effect of R1 are discussed in text. Small schematic (above) gives details for adding a phone jack to a transistor portable.

wood screws. To avoid a muffled tone, about ¼ of the back of the baffle is left open.

Begin construction by drilling all required holes in the fiberboard chassis, having first made certain that the parts will clear the edges of the baffle and the rear of the speaker.

Round, 3-pin transistor sockets are mounted on a small aluminum bracket bent to provide a 5/16" lip for mounting to the chassis with two machine screws. If you want to reduce costs by sacrificing a little on appearance and convenience, you can solder the transistors to a six-terminal lug strip instead of using sockets.

Any speaker with a 3.2- to 8-ohm voice coil can be used with the amplifier—simply select the tap on transformer *T2* that corresponds with your speaker voice-coil impedance. The author used a low-cost coaxial speaker (Lafayette SK-97) that works quite nicely, but virtually any unit will be satisfactory.

Actual wiring is very simple and straightforward, following the schematic and pictorial diagrams. Be sure to use a pair of long-nosed pliers or similar heat sink when soldering the transistors and other small parts.

PARTS LIST

B1—6-volt battery (4 size C cells in series)
C1—50-μf., 15-volt miniature electrolytic capacitor
J1—Phono pin jack
Q1, Q2—2N586 transistor (or equivalent)
R1—68-ohm, ½-watt resistor
R2—180-ohm, ½-watt resistor
R3—1000-ohm, ½-watt resistor
R4—3000-ohm potentiometer, linear taper
RT1—Thermistor, 200 ohms at 25°C (Glennite 22TD1 or equivalent)
S1—S.p.s.t. toggle switch
T1—Transistor input transformer; primary, 8 ohms; secondary 500 ohms CT (Argonne AR-164 or equivalent)
T2—Transistor output transformer; primary 100 ohms CT; secondary, 4 and 8 ohms (Triad TY-30X or equivalent)
1—PM speaker, 4- or 8-ohm voice coil—see text
1—Speaker baffle for 5" or 6" speaker
1—5¼" x 7⅜" x ⅛" fiberboard
1—1¼" x 1½" aluminum sheet
1—Subminiature phone plug (Lafayette MS-281 or equivalent)
1—Phono pin plug
1—25' length of 2-conductor miniature parallel cable
Misc.—Transistor sockets, dual C-cell holders, 3-terminal tie point, felt pads, hookup wire, hardware

As a finishing touch, cement small pieces of felt to the four corners of the cabinet bottom to prevent scratches to furniture. Now wax the case and mount the amplifier board to the back with four small wood screws.

Installation. A phono pin jack mounted on the rear of the fiberboard chassis connects with the input cable from the portable. Make the cable any reasonable length, and terminate it with a phono pin plug at one end and a subminiature phone plug at the other.

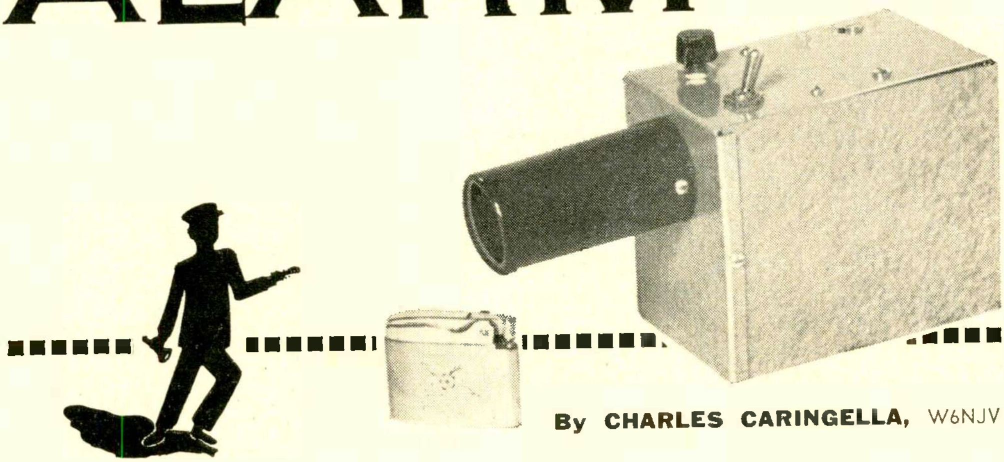
If your radio doesn't have an earphone jack, install one to match the phone plug in some convenient place on its plastic case. Most transistor portables use a low-impedance earphone (4 to 12 ohms) with the output jack connected as shown on page 70. If yours is connected to another point for a high-impedance phone, it can be rewired as shown. Alternatively, transformer *T1* can be replaced with another one which has a primary impedance about the same as the earphone impedance; the secondary impedance should remain the same (500 ohms CT).

One of the features of the Transi-Booster is that it is designed to get the maximum service from its battery. As battery voltage drops with use, it will eventually reach a point where distortion will begin to increase rapidly. Potentiometer *R4* is provided to adjust the base bias voltage (and thus the collector current) as the battery weakens. This makes battery *B1 usable until its output voltage* is down to about 3 volts.

With a new battery, set *R4* to its maximum resistance position. Open switch *S1* and connect a milliammeter across its terminals, then adjust *R4* for about 6 ma. and mark the knob position. Do the same with the negative milliammeter lead connected to the 4.5- and 3-volt battery taps, and again label the knob position to aid in making adjustments later.

To operate the Transi-Booster, push the miniature phone plug into the radio earphone jack, turn volume to a comfortable level, and listen. If the Transi-Booster oscillates, reverse feedback connections by connecting *R1* to *T2*'s "8-ohm" tap and the lead from *T1*'s primary to *T2*'s "GND" tap. Unplugging the phone plug automatically reconnects the radio's own speaker and allows normal operation of the portable. —30—

BUILD AN INFRARED BURGLAR ALARM



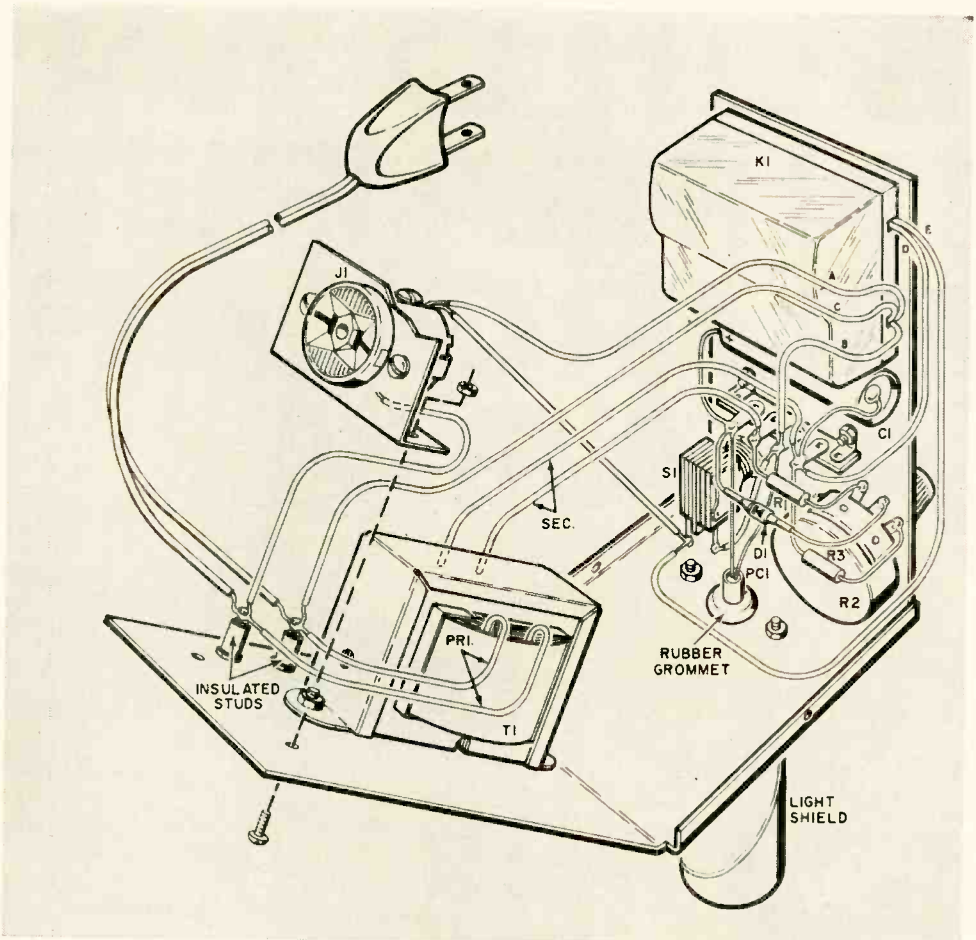
By **CHARLES CARINGELLA,** W6NJV

IF YOU'VE EVER SEEN a photoelectric eye in operation, you've probably noticed its telltale light beam. But the alarm system described here has no visible beam and can thus function undetected—even in total darkness. Its secret: it relies on invisible infrared radiation instead of light.

Although at first glance the infrared alarm system would appear to be quite expensive, you'll find that it can be built for less than $25.00. If you already have some of the parts in your junk box, the cost will be reduced accordingly. In any case, the infrared detector and infrared spotlight are easy to build and their circuitry is quite simple and non-critical.

Construction. The infrared detector is housed in a 5″ x 4″ x 3″ aluminum box. Parts placement is not critical but the pictorial diagram can be used as a guide. The photocell (*PC1*) is pushed through a rubber grommet which is mounted on the box's 3″ x 4″ cover panel and soldered directly into the circuit. Use a heat sink when soldering *PC1* and mount a piece of cardboard tubing around it to keep out extraneous light (see photo); the cardboard should be painted black to minimize reflections. Mount sensitivity-control *R2* and reset-switch *S1* on top of the unit or wherever convenient.

The infrared spotlight is housed in a 6″ x 6″ x 6″ aluminum cabinet (see page 15). Cement the infrared filter across a 5″-diameter opening cut at one end of the box; the filter specified in the parts list is 5⅜″ in diameter and ⅛″ thick. The lamp can be any 117-volt light bulb—its actual wattage



Infrared detector wiring is simple and straightforward, although photocell PC1 requires special consideration. See text for details.

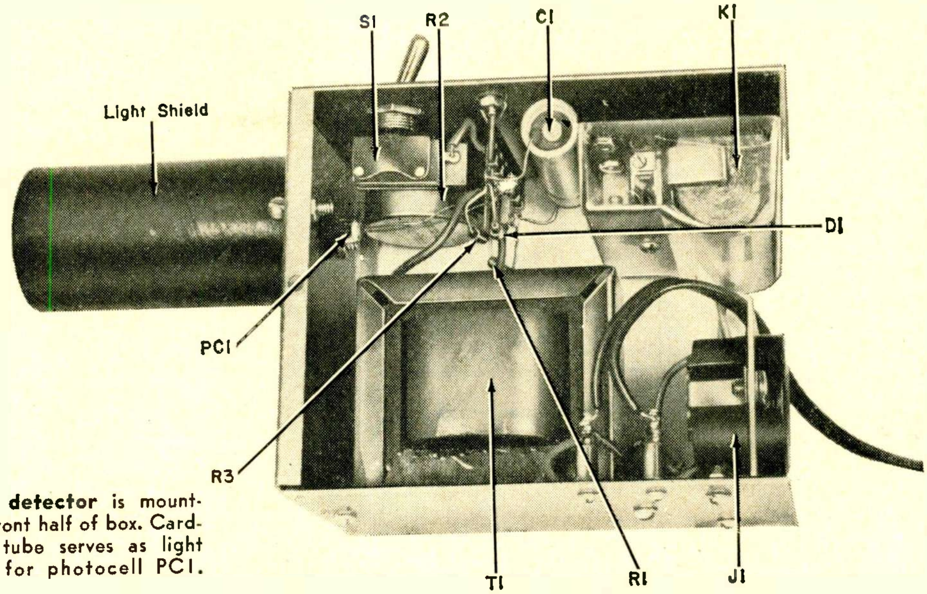
will depend on the distance between the infrared spotlight and the detector.

Use a 5"-diameter parabolic reflector to concentrate the lamp's output in a single beam. The aluminum reflector from a work lamp or spotlight will do nicely. Mount the lamp and reflector directly behind the filter with the lamp's filament at the focus of the parabola.

The focal point of the parabola may be determined by pointing the reflector toward a light source and focusing the light bounced off the reflector onto a piece of translucent white paper. Use a long, narrow piece of paper so as not to obstruct the reflector's pick-up field with your hand. At the focal point, the reflected light should form an intense bright spot.

Operation. You can use the infrared alarm system to guard a single door or window or to cover a large area. To protect a room or store against burglary, mirrors can be used to reflect the infrared beam across all doors and windows. If the beam is broken anywhere in its circuit around the room, the alarm will sound; this "round-the-room" setup is shown on page 16.

If the system is used to keep tabs on people entering and leaving a store, for example, place the infrared spotlight and detector in the store in such a way that the beam passes across the entranceway. Either the door opening or someone entering the store will break the beam between the spotlight and detector's photocell and set off chimes or a buzzer.



Entire detector is mounted in front half of box. Cardboard tube serves as light shield for photocell PC1.

PARTS LIST

Infrared Detector

C1—10-µf., 150-volt electrolytic capacitor
D1—200-ma. silicon diode (Sarkes-Tarzian 2F4 or equivalent)
J1—A.c. power receptacle (Amphenol 61-MIP-61F or equivalent)
K1—Relay, s.p.d.t. contacts, 5500-ohm coil (Advance SV/1C/5500D or equivalent)
PC1—Cadmium selenide photocell (Clairex CL-3 or CL-603)
R1, R3—2200-ohm, 1-watt resistor
R2—5000-ohm, 2-watt, linear taper potentiometer (Ohmite CU5021)
S1—S.p.s.t. toggle switch
T1—117-volt isolation transformer, one-to-one ratio (Lafayette TR-91 or equivalent)
1—5" x 4" x 3" aluminum box (Bud CU-3005-A or equivalent)
Misc.—Hardware, terminal strip, etc.

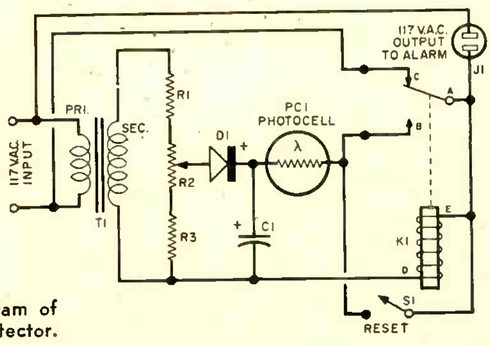
Infrared Spotlight

1—6" x 6" x 6" aluminum utility cabinet (Bud AU-1039 or equivalent)
1—5" parabolic reflector (see text)
1—5⅜"-diameter x ⅛"-thick infrared filter (Edmund Scientific Co., Barrington, N. J., Catalog No. 60,033, $2 postpaid—or equivalent)
1—117-volt lamp (see text)
Misc.—Socket, hardware, etc.

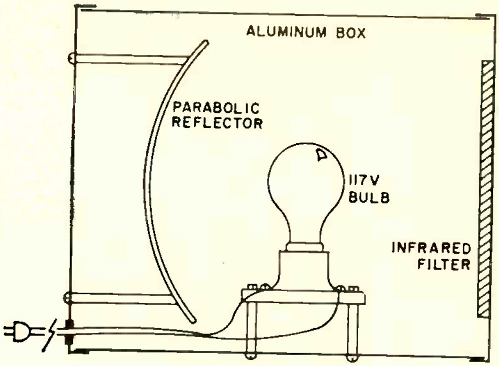
Once the spotlight, receiver, and mirrors are installed, both the reset-switch (*S1*) and the sensitivity control (*R2*) should be set and adjusted for operation as either a burglar alarm or a store "announcer."

First, open switch *S1* and temporarily cover photocell *PC1*. Then power the detector and plug a test alarm—a lamp or buzzer draining less than 100 watts—into 117-volt receptacle *J1*. The test alarm should be on.

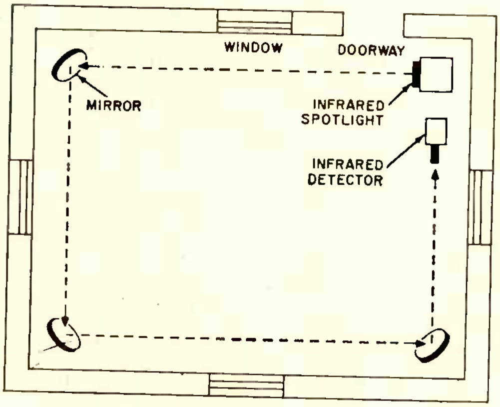
Now, uncover *PC1* and turn on the infrared beam, close reset-switch *S1*, and advance *R2* until the test alarm goes off. If the test alarm does not go off anywhere in *R2*'s range, be sure that the infrared beam is focused on photocell *PC1;* you may have



Schematic diagram of the infrared detector.



Infrared spotlight's box should have lightproof air vents. Use high-wattage lamp for long beam lengths.



Round-the-room setup protects doors and windows. Metal or front-surface mirrors give best results.

HOW IT WORKS

The infrared alarm system consists of two units: the infrared spotlight and the detector. The spotlight contains a lamp, a reflector, and an infrared filter. The lamp is an ordinary 117-volt light bulb. All of the light from the bulb is focused into a single beam by the reflector. The infrared filter removes most of the visible light and allows only the infrared radiation to pass through relatively unimpeded.

The heart of the detector is the cadmium selenide photocell (*PC1*) which is sensitive to red light and to near-infrared radiation. The photocell has a very high ratio of dark resistance to light resistance; it measures well over one megohm with no light falling on it, and only a few thousand ohms in daylight. The photocell behaves very much like a switch, which is its function in the detector.

Transformer *T1* is a one-to-one isolation transformer operating from the 117-volt a.c. line. Resistors *R1* and *R3* and sensitivity control *R2* form a voltage divider to reduce the a.c. voltage on *T1*'s secondary to the operating range of *PC1* and relay *K1*; potentiometer *R2* allows this voltage to be varied from approximately 20 to 80 volts. Diode *D1* rectifies the a.c. and capacitor *C1* filters *D1*'s output.

Photocell *PC1* is connected in series with reset-switch *S1* and the coil of relay *K1*. When no light falls on *PC1*, its resistance remains very high and no current flows through *K1*'s coil, keeping the relay de-energized. When *PC1* is illuminated, its resistance drops, allowing energizing current to flow. With *S1* closed and *R2* properly adjusted, relay *K1* locks up on its own contacts (*a* and *b*) and remains locked until the light or infrared source is removed.

When the infrared beam is broken, *K1* is de-energized and the contacts (*a* and *c*) of *K1* close and apply 117 volts a.c. to alarm output receptacle *J1*. When the infrared beam is restored, *K1* is energized again and the alarm goes off.

With reset-switch *S1* open, relay *K1* remains in its de-energized condition even if the infrared beam is restored. In this case, the alarm can not be silenced until *S1* is closed.

to put a larger lamp in the spotlight for long beam lengths or when mirrors are used.

When the test alarm is turned off by *R2*, open *S1*. The unit is now armed and ready to operate as a burglar alarm. Break the infrared beam and the test alarm will be turned on; the alarm will stay on even though the beam is restored.

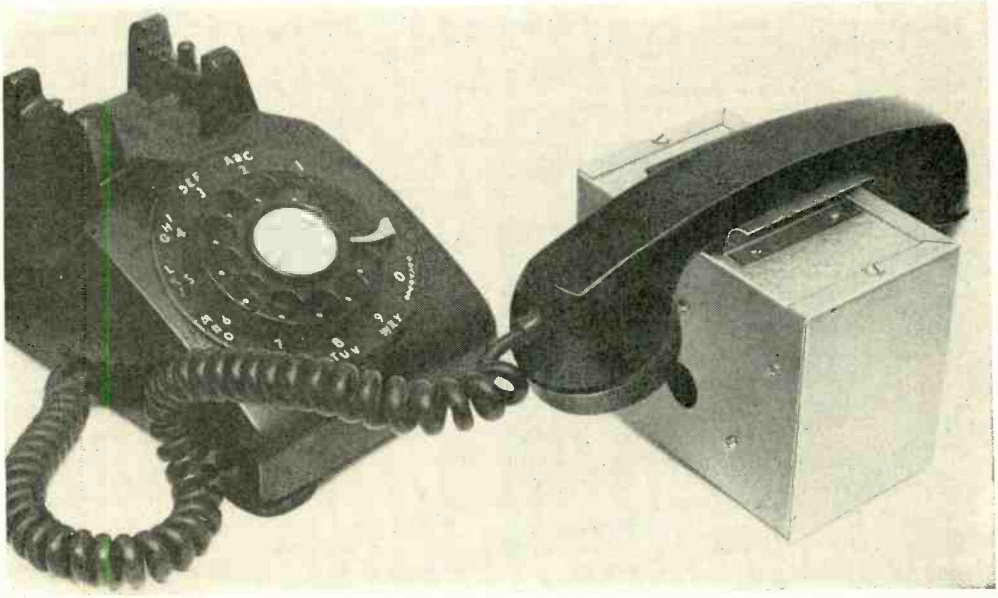
To operate the system as a store announcer, go through the adjustment procedure described for the burglar alarm but leave *S1* closed after sensitivity control *R2* has been adjusted to turn off the alarm. With this setting of *S1*, the alarm is on only while the beam is broken. When the beam is restored, the alarm is silenced.

If you use the system as a burglar alarm, a large gong or other electric noisemaker will be appropriate as the alarm signal. For a store announcer, as mentioned before, chimes or a buzzer will be better. In either case, be sure that the alarm or announcer plugged into *J1* drains no more than 100 watts in order to protect the contacts of relay *K1*. —30—

Musical Telephone Holder

By HERBERT FRIEDMAN

Electric music box "holds the phone" and entertains the caller

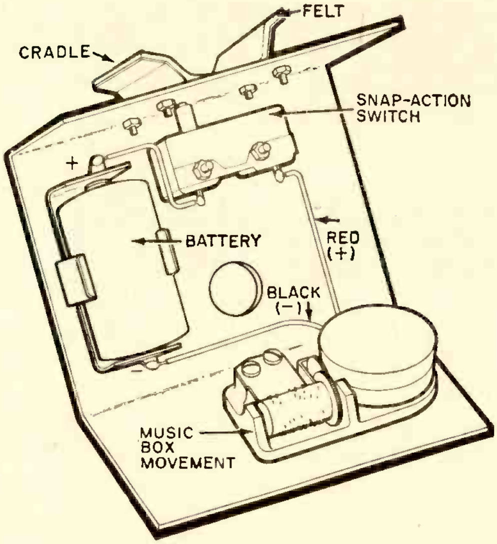


Snap-action switch in box controls music box movement, keeps it playing till phone is removed.

THE inexpensive electrically driven music box movements which have become available in recent years have made possible many interesting applications. These units never need to be wound, can be easily turned on and off by remote control, and will run for hours on a single 1½-volt flashlight cell.

One of these electric music box movements serves as the basis for the musical telephone holder described here. Designed to relieve the tedium of a caller who is "holding the phone," the telephone holder provides a musical diversion while he waits. A snap-action switch in the cradle of the holder, actuated by the weight of the telephone handset, automatically starts the music—and stops it when the handset is removed.

Construction. The movement, flashlight cell, and switch fit neatly into a 3" x 4" x 5" aluminum box. Two pieces of scrap



The parts layout is simple and neat. Optional felt on cradle prevents gear noises from being picked up by receiver. Glue four rubber feet to bottom of box to protect furniture.

Music box movement, flashlight cell and switch fit in 3" x 4" x 5" aluminum box. Inexpensive movements can be found to suit almost any taste; available pieces range from "How Dry I Am" to "Moonlight Serenade."

copper or aluminum are bent into "L" brackets and bolted to the outside of the box, forming a cradle for the telephone handset. Measure the width of your handset before mounting the brackets; dimensions vary from model to model.

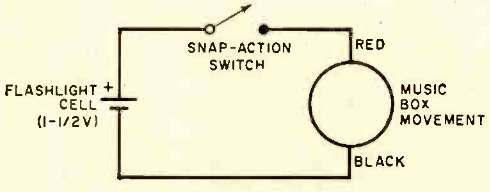
Center the switch plunger under the cradle—before mounting the switch, drill a hole in the top of the box to allow the plunger of the switch to pass through. Then finish the mechanical work by punching a ¾" hole in the side of the box, located so that the sound of the music box movement is directed to the telephone transmitter, and you're ready to wire up the unit.

The wiring couldn't be easier—the battery, switch, and movement motor are simply connected in series—but one precaution is necessary. Be sure to observe the proper polarity when hooking up the motor (its positive lead is usually red). If the motor is connected with reversed polarity, it will run backwards—and the movement may be damaged.

Electric music box movements are available from many mail order parts houses for less than two dollars (Lafayette Radio has a series priced at $1.88). The author used a Unimax 2HBQ-1 snap-action switch, but any s.p.s.t., normally open, snap-action type will do. Use a Bud CU-2105-A Minibox or equivalent for the case. A commercial battery holder, such as the Keystone #175 makes it easy to mount the flashlight cell.

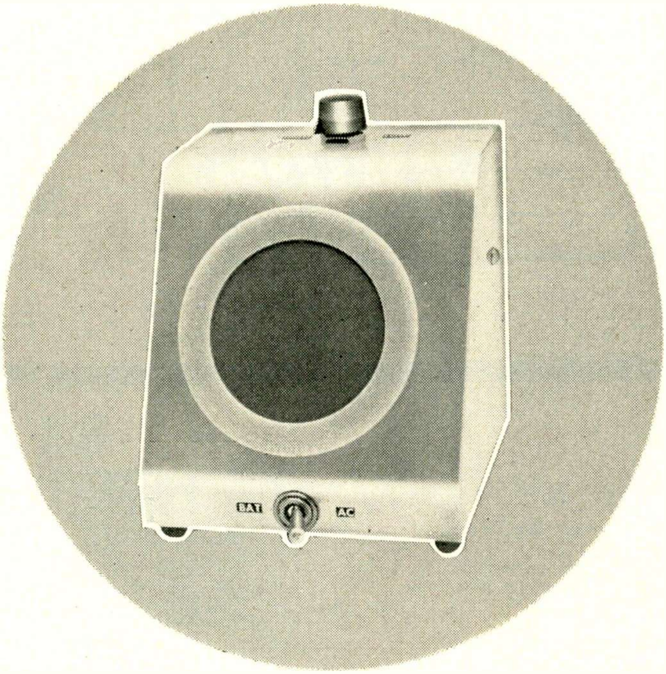
Operation. When it's necessary to ask a telephone caller to wait, place the handset on the cradle (with the transmitter facing the ¾" hole). The music box will start, and continue playing until you lift up the phone again.

If you find that the gears in the movement make noise which is picked up by the telephone, lubricate them with a small quantity of Vaseline or Lubriplate. You might also isolate the handset from the box by lining the cradle with felt. —30—



Flashlight cell, switch and movement motor are connected in series. Battery polarity must be observed in hooking up the motor.

FLEA-POWER GLOW LIGHT



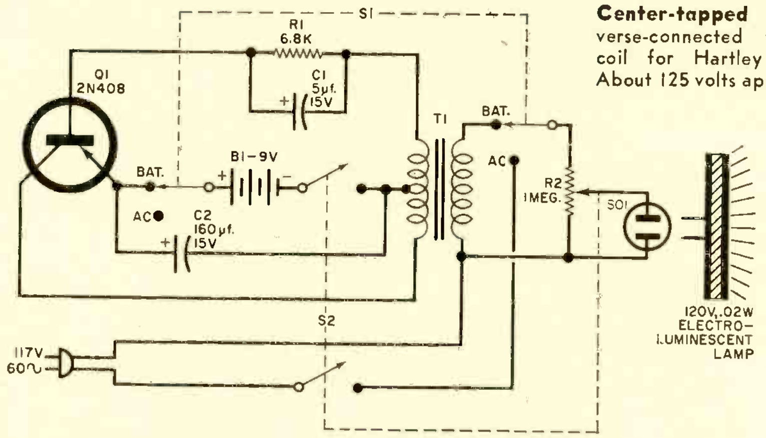
A battery-operated power supply for portable operation of a standard electroluminescent lamp

By JAMES E. PUGH, JR.

THE electroluminescent night-lights now on the market are handy gadgets to have around. Drawing a minimum of current, they'll bathe a room in a soft, pleasant glow—yet can be left burning day and night at a cost of only a few pennies a year. Though designed to work on the a.c. line, the current demand of these units is so small that a battery-powered Hartley oscillator is more than adequate as a power supply.

With the oscillator described here, you can use your night-light on hunting trips; in trains, boats, and cars; or anywhere a soft, low-intensity lamp is needed. A line cord has been included for switching to a.c. when such operation is possible, and a convenient intensity control allows you to vary the brightness.

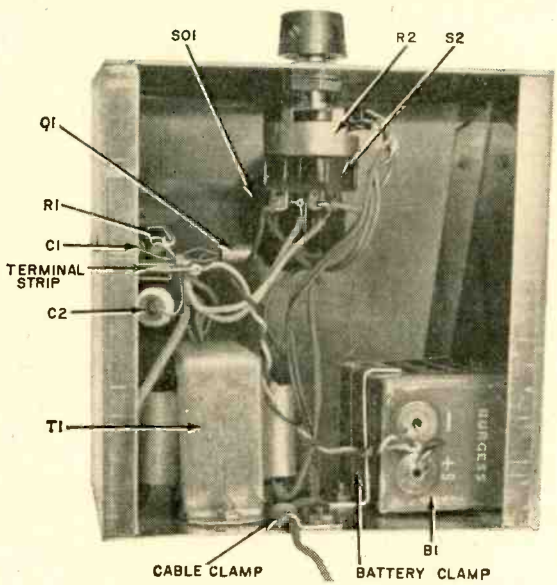
The Circuit. Transistor *Q1* is connected as a Hartley oscillator and powered by battery *B1*. The 6.3-volt secondary of transformer *T1* serves as a tapped oscillator coil. Resistor *R1* and capacitor *C1* determine the pulse rate, which is about 60 cycles with the values specified. When



Center-tapped secondary of reverse-connected transformer T1 is coil for Hartley oscillator circuit. About 125 volts appear across primary.

PARTS LIST

B1—9-volt battery (Burgess 2N6 or equivalent)
C1—5-µf., 15-volt electrolytic capacitor
C2—160-µf., 15-volt electrolytic capacitor
Q1—2N408 transistor
R1—6800-ohm, ½-watt resistor
R2—1-megohm potentiometer (linear taper)
S1—D.p.d.t. toggle switch
S2—D.p.s.t. switch (on R2)
SO1—Chassis-type a.c. receptacle (Amphenol 61-F or equivalent)
T1—Filament transformer; primary, 117 volts; secondary, 6.3 volts @ 1.2 amp. CT (Stancor P6134)
1—4½" x 4³⁄₁₆" x 4¼" sloping panel utility box (Premier ASPC-1200 or equivalent)
1—120-volt, 0.02-watt Sylvania "Panelescent" night light
Misc.—Pointer knob for R2, 7-lug terminal strip, rubber feet, battery connector, cable clamp for line cord, hardware, etc.



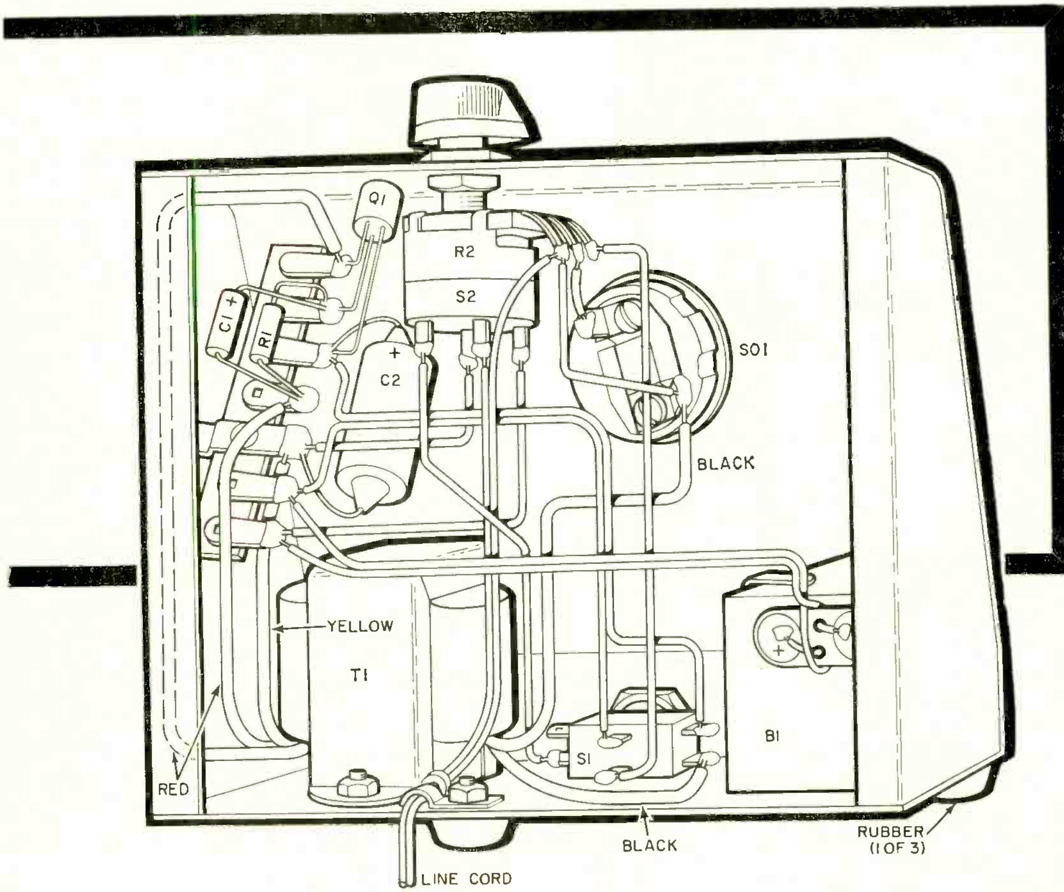
Parts fit neatly in compact utility box. Note that most oscillator components mount on the terminal strip.

the oscillator is in operation, its output is stepped up by *T1*, and approximately 125 volts are available at the primary of this reverse-connected transformer. The primary of *T1* is wired to the night-light socket *(SO1)* through intensity-control potentiometer *R2*.

In the schematic, switch *S1* is shown set for battery operation as described above. When *S1* is in the *A.C.* position, however, battery *B1* is disconnected and potentiometer *R2* and socket *SO1* are switched from *T1*'s primary to the a.c. line. Switch *S2*, which is ganged to potentiometer *R2*, turns the unit on and off regardless of which type of operation *S1* is set for.

Construction. For best appearance and ease of operation, the circuit is housed in a 4½" x 4 3/16" x 4¼" sloping-panel utility box. To avoid damage to furniture, fasten three small rubber feet to the bottom of the box.

Using the photograph as a rough guide,



Pictorial diagram clearly shows parts layout and wiring details. Terminal strip at left is tilted forward for a better view of its connections, and color coding of T1's leads is shown.

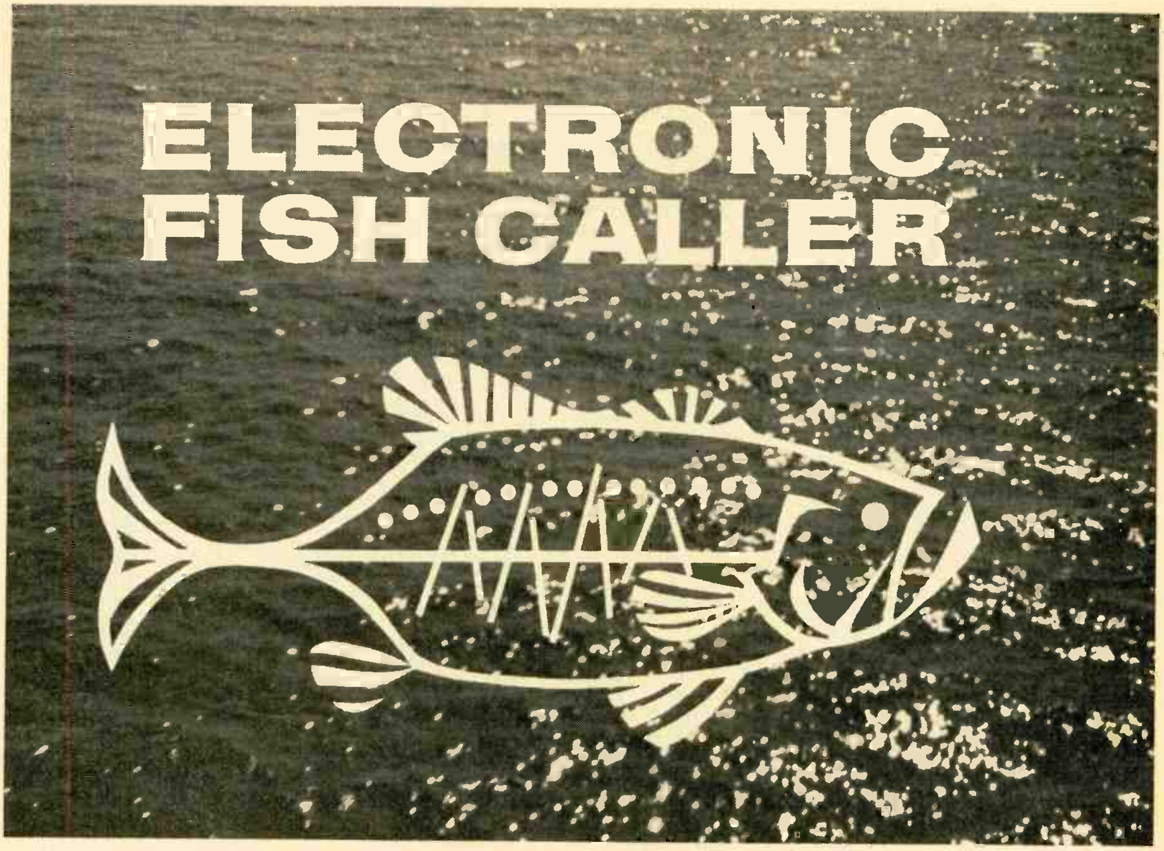
drill all the mounting holes. It's most convenient to make the opening for socket *SO1* with a 1 5/32" punch or hole cutter, but it can be drilled out and filed to size. Now bend a 2¼" x ½" strip of soft steel as shown to form a battery clamp.

With the above construction details carried out, you can proceed to the mounting and wiring of the components. Begin by mounting transformer *T1* and cutting its leads to the lengths needed. Next, solder all wires to switch *S1*, making sure to allow enough lead length to reach the various other components, and fasten the switch in place.

All of the connections to the terminal strip should now be made—take care to avoid heat damage when soldering in the transistor. Then mount the terminal strip, as well as socket *SO1* and potentiometer *R2*/switch *S2*. Finally, install the line cord and battery and complete the wiring.

Using the Supply. For battery operation, set *S1* to the *Battery* position; to operate from the a.c. line, set the switch to *A.C.* In either case, *R2*/*S2* will turn the light on and off and control its intensity. The lamp glows green when operated from the line, but you'll notice that it's blue when the oscillator is being used as the power supply. The color change is caused by a high-frequency component in the oscillator's pulse.

If you'd like to experiment with different oscillator frequencies, you can change the values of *R1* and *C1*. Reduce either or both to increase the frequency, or increase them to decrease the frequency. For greater light output at very low frequencies, the pulse should be broadened by making *C1* much larger. —30—



ELECTRONIC FISH CALLER

Unique "beeper" lures fish with underwater sound

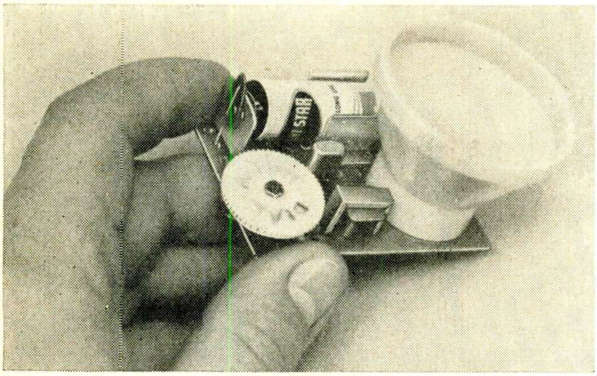
ANY sailor who has worked around sonar gear will testify to the fact that fish are attracted by certain man-made noises. The fish may believe that the sounds come from some source of food, such as another aquatic animal or a trapped insect, or their motivation may simply be curiosity. At any rate, the technique of calling fish with underwater sound really works, and has been successfully used by fishermen.

You can put together this neat little fish caller with a minimum of work and expense, and it should be well worth your while. The device produces a repeating, high-pitched "beep" which is attractive to many kinds of fish.

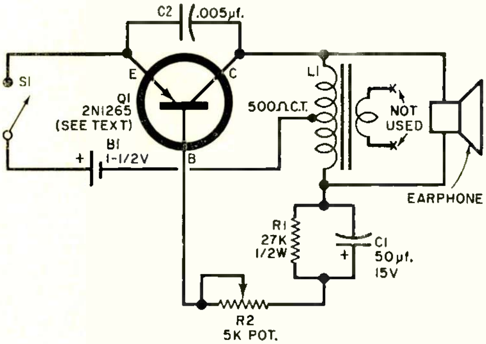
The Circuit. A single transistor *(Q1)* is used in a Hartley oscillator circuit (feedback produced by tapped inductance). Although the author used a Sylvania 2N1265, most *pnp* audio transistors will work just as well. The tone and basic repetition rate are fixed by capacitor *C1* and resistor *R1*, and potentiometer *R2* varies the repetition rate over the small range required. The crystal earphone is simply connected in parallel with the inductance *(L1)*. Power is provided by battery *B1*, a penlight cell.

Construction. Begin by mounting the battery holder, earphone, transformer, transistor socket, and potentiometer on one side of a suitable perforated board. Fasten the earphone in place with cement, first removing the screw and back plate, and passing the leads through two convenient holes in the board. You may not want to use a transistor socket, in which case transistor *Q1* can be mounted by simply pushing its leads through three holes in the board; these leads are later soldered directly into the circuit.

Mount potentiometer *R2* by bolting it down through the holes in its switch terminals—it will be necessary to use spacers between these terminals and the board or to bend the terminals down and



Miniature components make completed unit extremely compact. Tiny potentiometer (R2 in diagram) includes built-in on-off switch (S1).



PARTS LIST

B1—Penlight cell
C1—50-µf., 15-volt subminiature electrolytic capacitor
C2—0.005-µf., 75-volt subminiature ceramic capacitor
L1—Subminiature output transformer; 500-ohm CT primary, secondary not used (Lafayette TR-99 or equivalent)
Q1—Audio-frequency pnp transistor (Sylvania 2N1265 or equivalent)
R1—27,000-ohm, ½-watt resistor
R2—5000-ohm miniature potentiometer with switch S1 (Lafayette VC-62 or equivalent)
S1—S.p.s.t. switch (on R2)
1—Miniature high-impedance crystal earphone (Lafayette MS-439 or equivalent)
1—1¾" x 2⁷⁄₁₆" perforated board (half of Lafayette MS-304, or equivalent)
Misc.—Battery holder, transistor socket (if used), hardware, etc.

By JAMES J. BUCHER

out, forming mounting brackets. Install soldering lugs between the mounting nuts and the bottom of the board for making connections to the switch *(S1)*.

Only the three primary leads of the transformer are used, and the leads from the secondary may be cut off or taped up. The end of the battery holder nearest *R2* will be positive; mark it with a dab of red nail polish. When the battery is installed, its brass center terminal should be placed at the marked end; reversed polarity would damage the transistor.

The earphone specified in the Parts List comes with an interchangeable ear plug and mouthpiece (it may be used as a microphone in other applications). Discard the ear plug and finish the mounting job by cementing the mouthpiece (which will act as a speaker horn—amplifying the sound) in place.

The wiring is a simple job, but be sure to observe the proper polarity when hooking up the battery holder and electrolytic capacitor *C1*. If you install the transistor without a socket, be careful when soldering the leads; use a six-watt (or smaller) soldering iron—and use it sparingly.

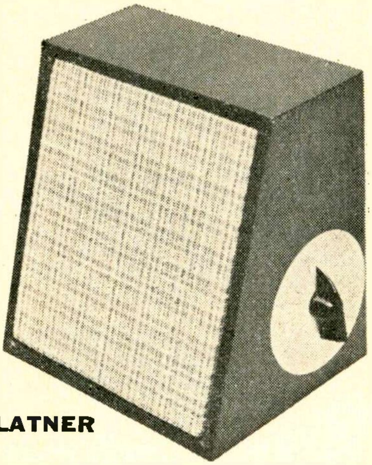
Now install battery *B1*, flick on the switch, and your unit should operate. The author's model is adjustable from about 100 to 250 repetitions per minute. You can get more power output by substituting a 2N255 transistor for *Q1*, but this will mean increasing *B1* to 3 volts. To do so, simply wire another 1.5-volt battery in series with *B1*.

How to Use It. To operate the fish caller, turn it on and seal it in a Mason jar or waterproof can, adding enough weight to make the assembly sink into the water. (A weighted plastic bag with the air squeezed out of it will also do.)

Suspend the device at fishing depth from a float or a hand line, drop in your bait, and await results. If nothing happens, try a different repetition rate. —30—

TRANSISTORIZED METRONOME

Portable timekeeper works while you play



By NORMAN LATNER

ALMOST anyone who plays a musical instrument has at least an occasional need for a metronome. Commercial units are sometimes costly, but this reliable transistorized metronome is inexpensive enough to be practical for even the most casual user.

Completely portable, the instrument is powered by a small, but long-lasting, 9-volt battery. The tempo range (about 40-215 beats per minute) and sound are comparable to those of a commercial mechanical unit. Three low-cost transistors and a minimum of other components are used in the circuit.

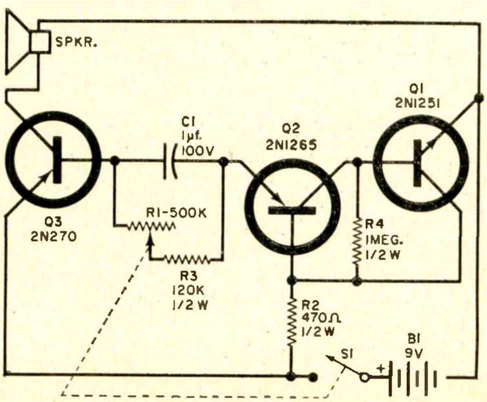
Construction. The loudspeaker baffle serves a dual purpose—it also houses the electronic section of the unit. Mount the speaker in the baffle, then proceed with the wiring of the electronic section.

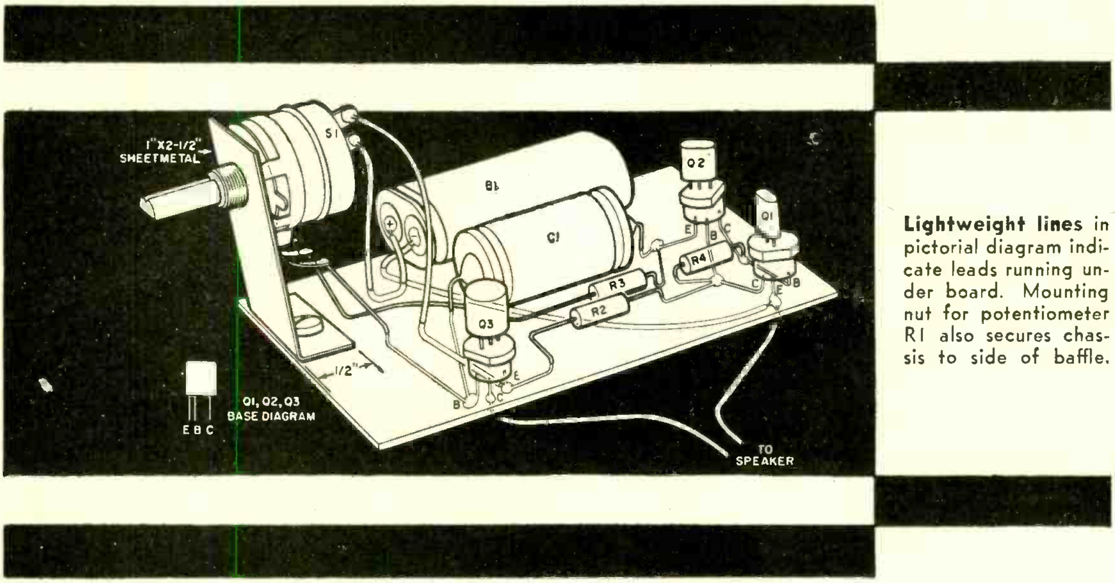
A 2-7/16" x 3⅜" piece of perforated board is used for the chassis. The tempo control potentiometer *(R1)* is secured to the chassis by means of an "L" bracket made from a 1" x 2½" piece of sheet metal. Make a 90° bend along the short dimension ½" from one end, then drill a ⅜" hole for the potentiometer shaft ⅝" from the other end. (See pictorial diagram.) Now bolt the bracket to the chassis and temporarily mount *R1*.

The transistor sockets are mounted by inserting their terminals through holes in the perforated board—bend the terminals slightly to hold the sockets in place. Resistors *R2, R3,* and *R4,* and capacitor *C1* are mounted in the same way; leave one lead from *R3* at the top of the board, since it will be soldered to the potentiometer. Use a strip of plastic or friction tape or a commercially available clip to hold the battery in place.

Now you're ready to complete the wiring. The battery connections may be soldered, or you can use a set of commercially available snap terminals—but make sure you observe the proper polarity. A pair of leads should be provided which can be connected to the loudspeaker when you are ready to mount the chassis in the baffle.

Drill a hole in the baffle large enough for *R1*'s shaft. If the threaded portion of the shaft is too short to pass through the bracket and the baffle, you'll have to





Lightweight lines in pictorial diagram indicate leads running under board. Mounting nut for potentiometer R1 also secures chassis to side of baffle.

countersink the hole. Make the countersunk area large enough in diameter to accommodate the potentiometer mounting nut and the tool which will be used to tighten it. Finally, the potentiometer-chassis assembly is mounted and the speaker connected.

Calibration. Make a paper dial for potentiometer *R1*'s pointer knob and rubber-cement it in place. Then turn on the metronome and allow about 30 seconds for it to stabilize. A clock or watch with a second hand is used to determine the number of beats per minute at appropriate settings of *R1*, and the dial is marked accordingly.

After you've finished the calibration, add a final touch to the instrument by putting a protective coat of clear nail polish or Krylon spray on the dial. —30—

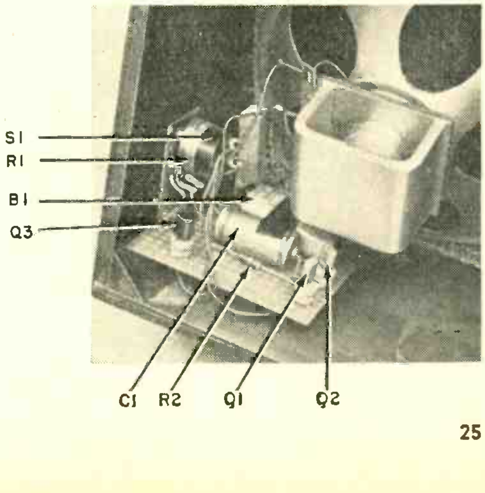
HOW IT WORKS

Transistors *Q1* and *Q2*, *npn* and *pnp* units respectively, are arranged to form a composite *pnp* transistor with a common base current gain greater than one. This composite transistor acts as a switch which closes when the voltage on *C1* is high enough. Capacitor *C1* charges through *R1*, *R3* and the base resistance of *Q3*. The "charge-discharge" pattern is a sawtooth wave and is fed to *Q3*, which acts as a common emitter stage. The speaker serves as the load resistance.

Almost any *pnp* transistor with a common emitter current gain of over 20 and a collector voltage rating of over 10 volts will do for *Q2*. Any *npn* unit with a current gain of over 45 and a voltage rating of over 10 can be used for *Q1*. Transistor *Q3* can be almost any *pnp* transistor, though some units will give lower sound output. If transistor substitution causes a change in the tempo range, the value of *R3* should be raised or lowered to correct the condition; a change of the order of 10,000 or 20,000 ohms should be sufficient.

PARTS LIST

B1—9-volt battery (Burgess 2U6 or equivalent)
C1—1-µf., 100-volt Mylar capacitor (Mallory Type 11 or equivalent)
Q1—2N1251 transistor }
Q2—2N1265 transistor } *see "How It Works"*
Q3—2N270 transistor }
R1—500,000-ohm potentiometer (with S1)
R2—470-ohm, ½-watt resistor
R3—120,000-ohm, ½-watt resistor
R4—1-megohm, ½-watt resistor
S1—S.p.s.t. switch (on R1)
Spkr.—6" PM loudspeaker (Lafayette SK27 or equivalent)
1—Speaker baffle
1—2 7/16" x 3 3/8" perforated board (Lafayette MS304 or equivalent)
Misc.—Transistor sockets, knob, sheet metal, hardware, etc.



LIGHT CONTROL FOR BATTERY POWERED TOYS

Flashlight-actuated photoelectric relay circuit gives new life to Junior's electric toys

By **MARTIN H. PATRICK**

HERE'S a good way to add some life to to that electric toy which may be beginning to bore Junior. The transistor-amplified photoelectric relay described here will allow him to turn the toy on and off from a distance merely by pointing a flashlight beam at it. Although the model shown is used on a battery-operated truck, the device is adaptable to almost any gadget which runs by electricity.

The Circuit. A self-generating photocell *(PC1)* is coupled through a two-stage transistor amplifier to a sensitive, normally open relay *(K1)*. The simple direct-coupled amplifier is made up of transistors *Q1* and *Q2;* resistor *R1* serves as a collector load for *Q2*. Potentiometer *R2* and relay *K1* also pass part of the collector current, but only enough to operate the relay; *R2* is set at its maximum value and decreased until satisfactory operation is achieved.

Power for the circuit is supplied by two penlight cells in series *(B1)* through switch *S1*. When the surface of *PC1* is illuminated, an electric current is generated which is amplified and passed through the coil of *K1*, closing its contacts and activating the toy.

Transistors *Q1* and *Q2* may be almost any inexpensive *pnp* and *npn* (respectively) transistors. Experiment with various units if you like, but be sure that the one you choose for *Q2* has a collector current rating of at least 65 milliamperes.

Construction. The components for the model were housed in a 2½" x 3" x 2½" homemade wooden box. The size and ma-

The author's model was designed to "ride" in the back of a small toy truck. Your version could be built right into the toy itself —if enough space is available.

terial of the housing are not critical, however. Any container which fits either on or inside the toy can be used. You can even build the circuit right into the toy itself.

Photocell *PC1,* which comes unmounted, is installed in a frame made of some pieces of scrap metal and Bakelite (see photo). The two vertical metal clamps touch the negative contacts located at each end of the front of the photocell. These contacts are shorted together through the mounting screws of the clamps and the metal bottom of the frame. Make the negative connection to the cell via a solder lug secured to one of the mounting screws.

The positive contact of the photocell is located on its rear surface. A metal plate placed between the photocell and the Bakelite back of the frame touches this contact, and a lead soldered to the plate is brought out to the rear of the frame through a hole drilled through the back. This lead is connected to one of a pair of solder lugs bolted together at some convenient spot on the Bakelite. Use the extra lug to make the positive connection to *PC1.*

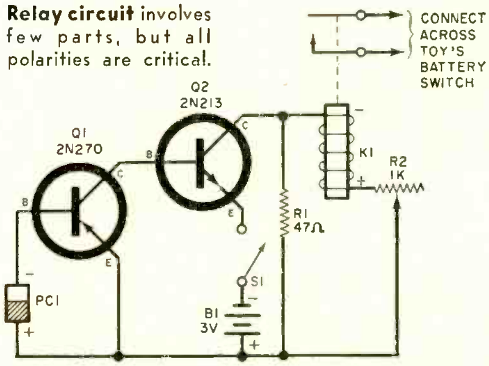
In the model, the mounted photocell was

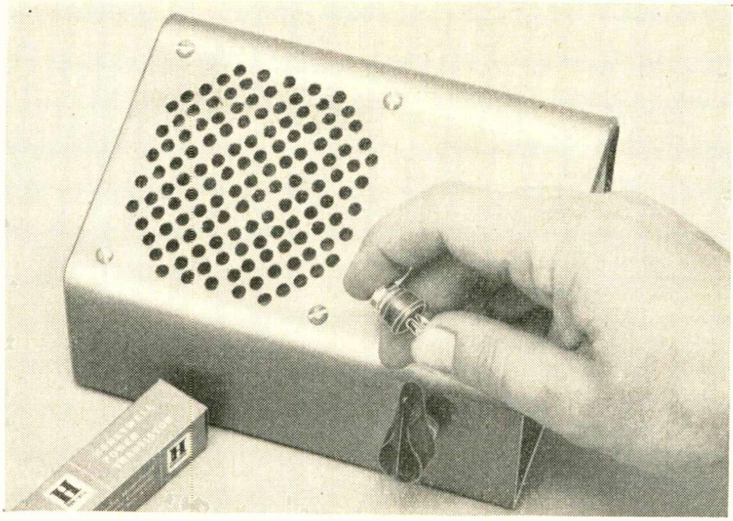
(*Continued on page* 137)

PARTS LIST

B1—Two 1½-volt penlight cells in series (Eveready #912 or equivalent)
K1—High-sensitivity meter relay (Lafayette F-482)
PC1—Self-generating photocell (International Rectifier B-5 or A5PL)
Q1—2N270 transistor—see text
Q2—2N213 transistor—see text
R1—47-ohm, ½-watt resistor
R2—1000-ohm screwdriver-adjusted potentiometer
S1—S.p.s.t. switch

Relay circuit involves few parts, but all polarities are critical.



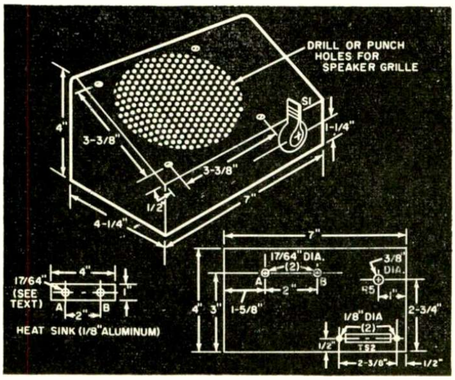


3 WAY INTERCOM

By **JULIAN M. SIENKIEWICZ**
Managing Editor

Unique circuit uses two 2N1502 power transistors for instant communication at the flip of a switch

Detail 1. Location and sizes of chassis holes. Check hole centers against parts for accuracy before drilling; be sure all holes are drilled before starting assembly of intercom unit.

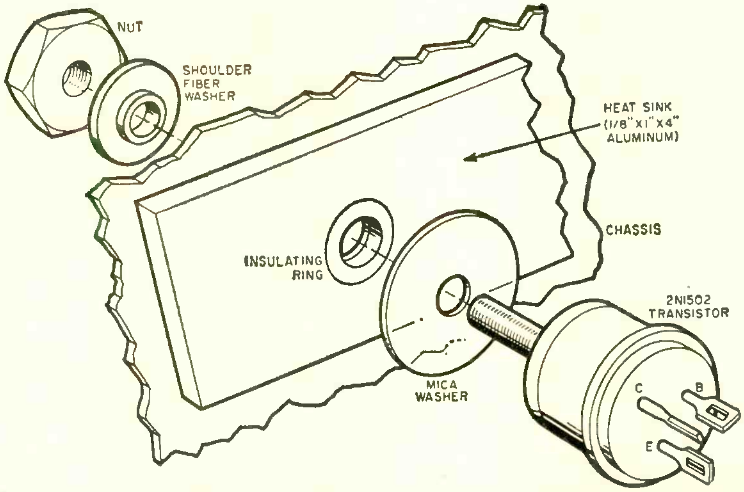


COMPACT and easy to build, the three-way intercom described here* has a number of outstanding design features. For one thing, it's battery-operated—which means that it can be used anywhere without the need for an a.c. line. For another, it's completely transistorized, and consumes no power until the "talk" switch is pressed.

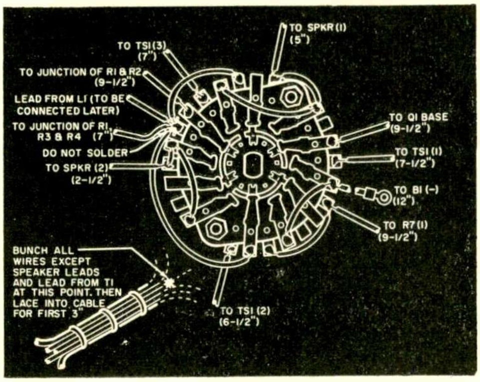
Even more important, any one of the three stations in the system can "talk" to either of the other two. In addition, each station is identical, and each has its own amplifier to amplify your voice and pass it on to the desired station. This way, even though the other two stations are "off," you will still be able to get your call through.

Construction. Assembling and wiring the intercom should present no problems either to the advanced experimenter or to

* *Designed by engineers of the Minneapolis-Honeywell Regulator Company, Semiconductor Products, 2747 Fourth Ave. South, Minneapolis 8, Minn.*



Detail 2. Transistor mounting technique uses heat sink to radiate transistor heat yet electrically isolates transistor from chassis.



Detail 3. Prewiring "talk" switch S1 greatly simplifies wiring and reduces construction time. Check wiring carefully when completed.

the beginner. However, to avoid any possible trouble, even the experienced builder should follow the detail drawings carefully, as well as the construction procedure outlined below. Since the three units are identical, all of the drawings show details for one station only.

The first step is to drill the chassis—Detail 1 gives the location and the sizes of the holes. Before drilling, be sure that the parts you have purchased will mate correctly with the planned holes. The only critically located holes are those marked *A* and *B* on the back surface of the chassis and the mating holes in the heat sink as shown in Detail 1; when the heat sink is mounted, its holes must line up with holes *A* and *B* on the rear panel.

The first components to be mounted are power transistors *Q1* and *Q2*. It is important that neither the studs on the transistors nor the transistor cases touch the metal heat sink or chassis. To prevent this, the holes in the heat sink should be enlarged so that small insulating rings can be cemented in place to line them—the rings can be fabricated from phenolic tubing or stiff spaghetti. (See Detail 2.) A mica washer, shoulder fiber-washer, and nut come with each 2N1502 transistor.

Mount both transistors as shown in Detail 2 and turn the nut one-quarter-turn after it is finger-tight. If you did the job right, an ohmmeter across the mounting nut and the heat sink or chassis will indicate an open circuit. If the ohmmeter indicates a short circuit or some finite resistance, don't go any further until you manage to locate the trouble.

The "talk" switch, *S1,* should be wired as shown in Detail 3. Before you start, be sure the notch on the shaft of the switch faces to the right when the back of the switch is towards you. Use different colored wires so they can be identified easily after they are cabled together. Make all the connections necessary, then bring the leads around the edge of the switch and bunch them together at one point as indicated in Detail 3. Lace the bunched wires for a distance of three inches and tie off the lacing cord tight.

Switch *S1* can now be mounted to the front panel of the chassis—refer to Detail 1. Use a lock washer and nut to secure the switch in place loosely, and observe where the notch on the shaft is located. Rotate the switch until the notch points to the right side of the front panel, then tighten the mounting nut.

Next, mount *L1* (the filament transformer used as a choke) on the speaker bracket; then mount the speaker in the chassis. Also mount potentiometer *R5* and terminal strip *TS1*.

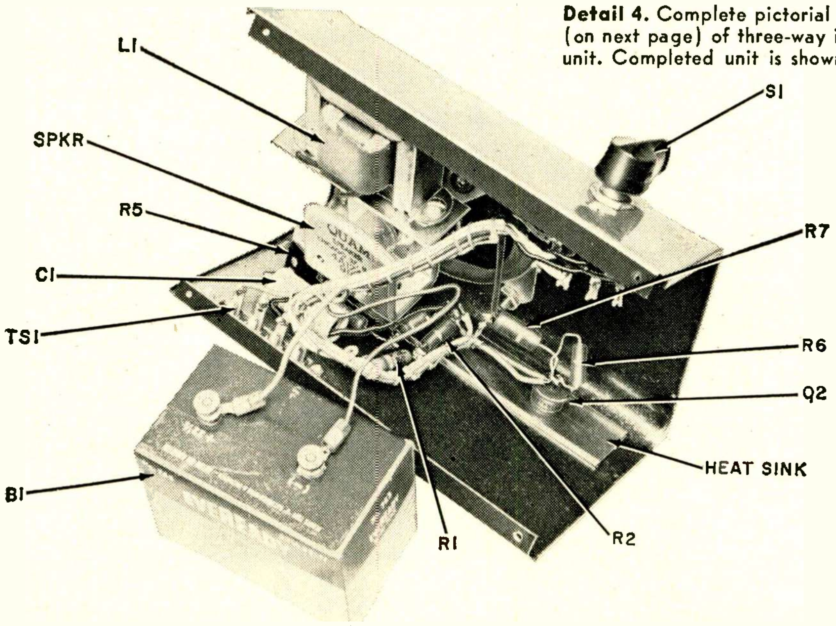
Detail 4 is the complete pictorial diagram for one station. As you wire it, constantly recheck your work; it will pay in the long run, since the wiring is quite dense. When the unit is completed, a final wiring check should be made. If you use different colored wires throughout, checking will be comparatively easy. And you'll have a neater-looking unit if you take time to lace wires which group together.

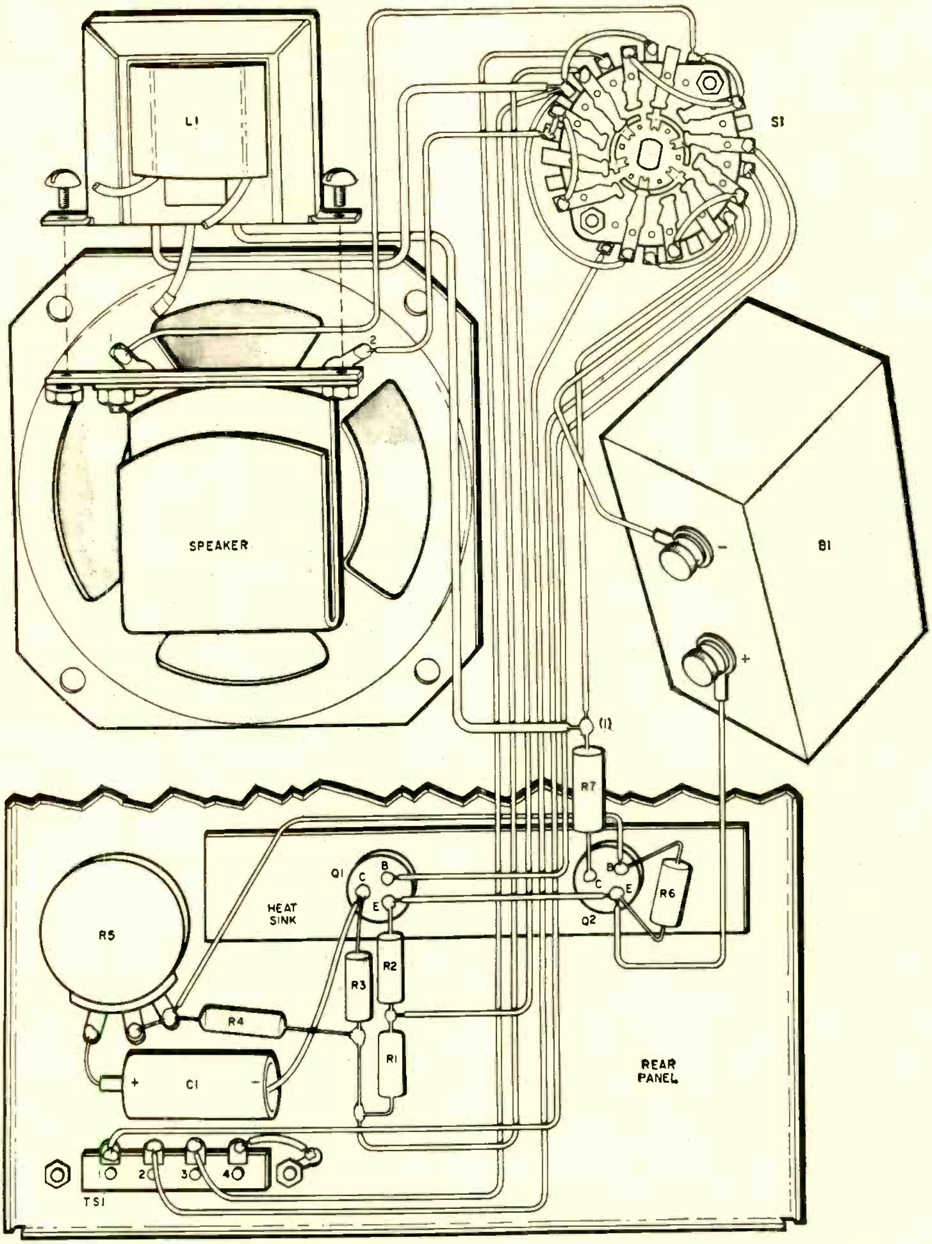
Finally, secure battery *B1* to the bottom plate. Using masking tape, fix the battery to the bottom plate and fit the chassis together. If the battery does not butt against anything, mark its position on the bottom plate and install an aluminum strap bracket to hold it in place. If the battery butts against one or more parts, loosen the masking tape and try a new position.

Installation. A three-wire twisted cable is all that is needed to connect the three stations to each other. See interconnection diagram on page 32. Although shielding isn't necessary, you can use three-wire shielded mike cable if you happen to have some on hand—it will reduce hum picked up from the a.c. line. After the three wires are connected to *TS1* on each unit, wire the shields of the two cables together and ground to a water pipe. Then, at each station, connect the shield to terminal 4 of *TS1*.

To operate the intercom, throw switch *S1* to the left or right, depending on which station you want to contact. Release the switch at the end of your message and wait for a reply. The spring-loaded talk switch always returns to the "listen" or "off" position when not held down. In the event you wish to monitor the children's bedroom, for example, the spring can be removed from *S1* and the switch set to "talk"—the switch has a "detent" which will hold it in position

Detail 4. Complete pictorial diagram (on next page) of three-way intercom unit. Completed unit is shown below.





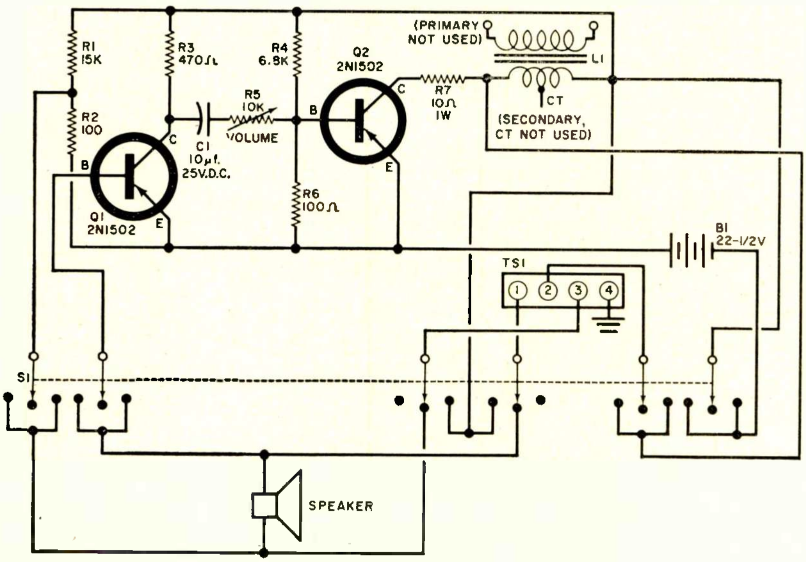
PARTS LIST FOR ONE STATION

B1—22.5-volt battery (Eveready #763 or equivalent)
C1—10-µf., 25-volt d.c. electrolytic capacitor
L1—Filament transformer used as choke; primary, 117 volts (not used); secondary 6.3 volts @ 1.2 amperes (Stancor P-6134 or equivalent)
Q1, Q2—2N1502 power transistor supplied with mounting hardware by Minneapolis-Honeywell (available from Allied Radio)
R1—15,000-ohm, ½-watt resistor
R2, R6—100-ohm, ½-watt resistor
R3—470-ohm, ½-watt resistor
R4—6800-ohm, ½-watt resistor
R5—10,000-ohm potentiometer, linear-taper
R7—10-ohm, 1-watt resistor
S1—3-position, 6-pole spring-return switch (Centralab #1448)
TS1—4-lug, screw-type terminal strip
SPKR.—4" PM speaker, 45-ohm voice coil (Quam #4A1Z45 or equivalent)
1—7" x 4" x 4¼" aluminum universal sloping-panel cabinet (Bud AC-1613 or equivalent)

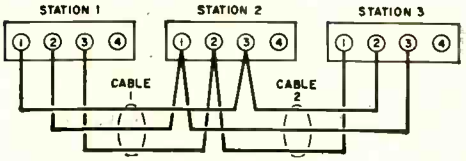
when the spring is removed. To obtain the desired volume, simply adjust potentiometer *R5*.

About the Circuit. The schematic diagram shows the wiring for one station only. Transistor *Q1* amplifies the signal picked up by the PM speaker in the same unit. When "talk" switch *S1* is thrown to either position, the speaker's voice coil is connected to *Q1*'s base and, through *R2*, to its emitter. Resistors *R1* and *R2* provide the d.c. bias for the base of *Q1* to obtain the operating point for this amplifying stage. The amplified audio signal is developed across *R3* and coupled to the next stage through capacitor *C1* and volume control *R5*.

Note that *R5*, unlike volume controls in vacuum-tube circuits, is connected in series between transistors *Q1* and *Q2*. Since transistors are current amplifiers, the signal current supplied to a transistor amplifier stage must be decreased or increased in order to decrease or increase the output signal from it.

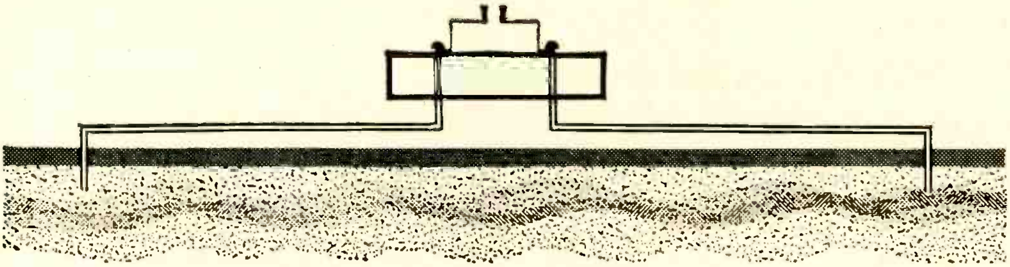


Two-stage transistorized amplifier above is heart of each of the three-way intercom units. External cable connections are made to terminal strip TS1.



Interconnection diagram shows how to hook up stations. If cables are shielded, connect shields to terminal 4 on each unit and to water pipe ground.

Resistors *R4* and *R6* provide the bias level for transistor *Q2*. The output signal for *Q2* is developed across *R7* and *L1*. The d.c. resistance of *L1* causes most of the a.c. signal to drop across it. Resistor *R7* functions mainly as a current limiter for the second stage. The remote speaker in the intercom selected by switch *S1* is connected across *L1*; hence, it will convert the audio signal to sound. Using this technique to couple the speaker to the second amplifying stage limits the d.c. current passing through the voice coil of the remote unit's speaker to almost zero. —30—



Build a SOIL MOISTURE METER

By RONALD WILENSKY

Simple ohmmeter circuit takes guesswork out of lawn watering

HAVE you ever wondered whether you were watering your lawn or garden more than necessary—or not enough? This handy "moisture" meter will help you determine just how much water the soil needs at any time—it will take some of the guesswork (and the unnecessary work) out of the job.

Essentially a simple ohmmeter, the unit works on the principle that the wetter the soil gets, the lower its resistance becomes. A miniature 0-1 milliampere meter *(M1)* is the heart of the device. Wired in series with a transistor battery *(B1)*, calibrating potentiometer *R1*, resistor *R2*, and a special probe, the meter functions as an effective soil resistance indicator.

Construction couldn't be simpler. The ohmmeter circuit will fit in an aluminum Minibox with plenty of room to spare. Lead length and component placement are not critical. The simplest way to make the 1½"-diameter hole for the meter is to use a Greenlee chassis punch, but the light aluminum is easily cut, and a few minutes work with a ¼" drill and a half-round file will yield the same results. The battery is mounted in a holder made of 1" sheet-metal or aluminum strip.

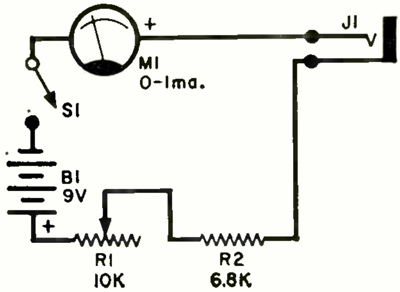
The probe is made from two lengths of coat hanger wire (paint removed) and a piece of scrap plastic or other insulating material. Construction details are shown in the pictorial diagram. A six-foot or longer length of zip cord, terminated in a phone plug, connects the probe to the meter box.

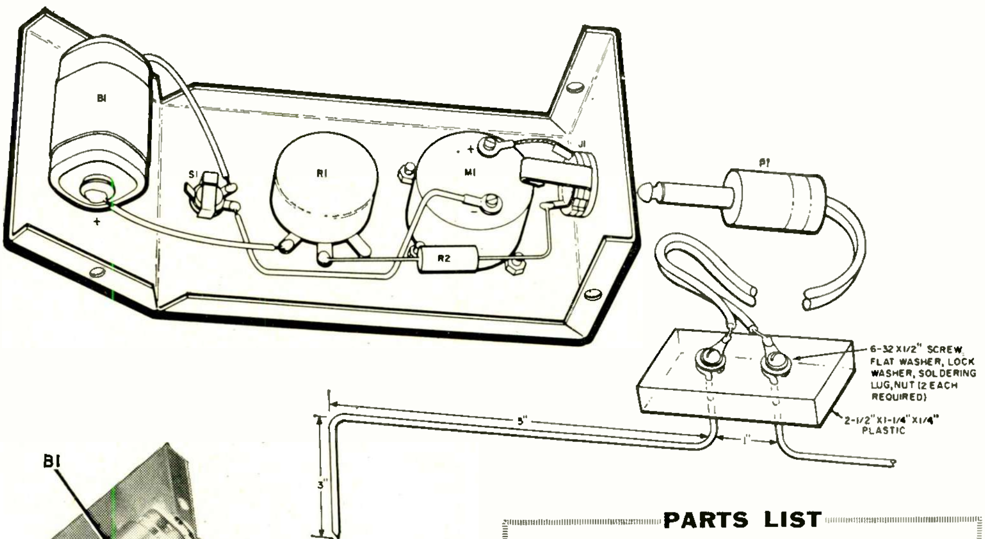
To use the soil moisture meter, you must first calibrate it. When your lawn or garden has been freshly watered, insert the prongs of the probe two inches into the ground; then adjust *R1* until the meter reads eight-tenths of full scale (0.8 ma.). You may want to mark *R1*'s position with a pencil in case the shaft is accidentally moved.

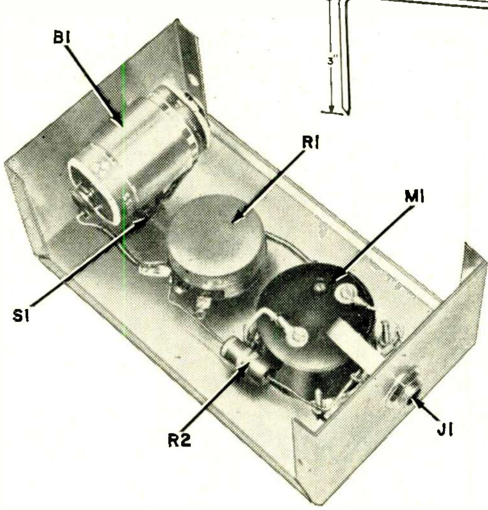
When you think the ground should be watered again, insert the probe at several different points on your plot and take readings by depressing *S1*. If most of your readings are much less than 0.8 ma., the soil needs water. If they're over 0.8 ma., hold off the watering for a day or so. (Exact scale readings will vary for different types of soil.)

If you'd like to use the moisture meter on several kinds of soil, or in garden areas,

Wiring the moisture meter is easy but be sure to observe proper polarities when connecting meter M1 and battery B1.







All components fit nicely in a 5¼" x 3" x 2⅛" aluminum box. The battery holder shown here is handmade, but a commercial unit may be used.

PARTS LIST

B1—9-volt transistor battery (Burgess P6 or equivalent)
J1—Open-circuit phone jack
M1—0-1 ma. miniature d.c. milliammeter (Lafayette TM-400 or equivalent)
P1—Phone plug
R1—10,000-ohm potentiometer, taper not important, slotted shaft (Mallory SU-20 or equivalent)
R2—6800-ohm, ½-watt resistor
S1—Miniature push-button switch (Lafayette MS-449 or equivalent)
1—5¼" x 3" x 2⅛" aluminum box (Bud CU-3006-A or equivalent)
Misc.—Hardware, zip cord, 2½" x 1¼" x ¼" plastic block, coat hanger wire, etc.

requiring varying amounts of water, you'll probably need more than one calibration point. In this case, it might be handier to use a potentiometer with a pointer and scale rather than the screwdriver-adjusted type shown, and jot down the different calibration readings on the side of the box. -30-

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J. Stataitis, of 25 Poplar Pl., Waterbury, Conn., writes: "I have repaired several sets for my friends, and made money. The "Edu-Kit" paid for itself. I was ready to spend $240 for a Course, but I found your ad and sent for your Kit."

Ben Valerio, P. O. Box 21, Magna, Utah: "The Edu-Kits are wonderful. Here I am sending you the questions and also the answers for them. I have been in Radio for the last seven years, but like to work with Radio Kits, and like to build Radio Testing Equipment. I enjoyed every minute I worked with the different kits; the Signal Tracer works fine. Also like to let you know that I feel proud of becoming a member of your Radio-TV Club."

Robert L. Shuff, 1534 Monroe Ave., Huntington, W. Va.: "Thought I would drop you a few lines to say that I received my Edu-Kit, and was really amazed that such a bargain can be had at such a low price. I have already started repairing radios and phonographs. My friends were really surprised to see me get into the swing of it so quickly. The Trouble-shooting Tester that comes with the Kit is really swell, and finds the trouble, if there is any to be found."

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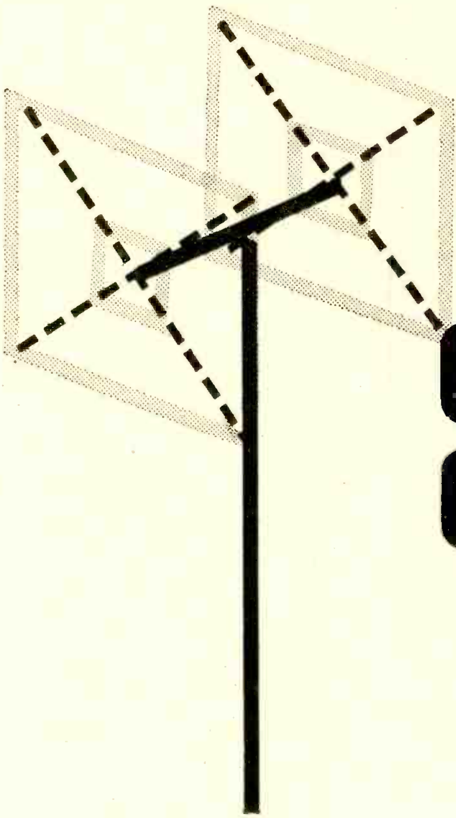
Chapter 2

CITIZENS BAND

AS thousands of new CB stations go on the air each month, the problem of maintaining effective two-way communication is magnified. Limited by Federal Communications Commission rules to five watts input, CB operators must make use of the best possible techniques. In this chapter, a world-famous beam antenna is described. Simple to erect, this antenna has been used for the past fifteen years by commercial short-wave broadcasting stations and thousands of amateur radio operators. Dubbed the "Cubical Quad," it represents one more way of achieving maximum use of the low CB power input.

Many of the earlier CB transceivers lacked sufficient selectivity and effective "squelch." On page 44, we describe a simple circuit that may be added to any CB transceiver having a single i.f. stage—it will solve the problem of adjacent channel interference. On page 53 we present the most effective squelch control we have ever seen added to a superregenerative receiver.

Two other useful gadgets are also described in this chapter—a power output meter, and a channel "spotter." Both will afford a wealth of applications at your CB station.



By **WILLIAM I. ORR,** W6SAI

CUBICAL QUAD for CB

Popular directional antenna makes its Citizens Band debut

INTERFERENCE on the crowded Citizens Band channels in urban and industrial areas is often so high that the efficiency of the CB service is severely impaired. The use of a good, directional beam antenna will do much to reduce or eliminate the interference.

First, the beam antenna will concentrate the transmitted r.f. energy in one direction. Secondly, the beam will improve reception by picking up signals from one direction only and greatly attenuating all others, thus providing a bonus feature over nondirectional antennas such as the simple ground plane. Two CB stations employing beam antennas can enjoy reliable communications over distances far beyond the usual range of single-element antennas.

An efficient and inexpensive beam antenna that has enjoyed great popularity among radio amateurs is the "Cubical Quad" array. The Quad is simple to construct, made of easily obtainable components, and provides a power gain of approximately 6 db (four times). No tuning adjustments are necessary; you build it, put it up, and *it works!* If you are a good "scrounger," you should be able to construct the Quad for ten dollars or less!

Framework Assembly. The Quad consists of two square loops of #14 enameled wire (each loop is about 37 feet in length) supported on a simple lightweight bamboo frame. (See Fig. 1 on p. 41.)

One loop of wire is coupled to the CB equipment via a twin-line lead-in, while the second loop acts as a parasitic reflector element requiring no connections to the lead-in. The antenna can be supported by a center pole and rotated by a heavy-duty "TV-type" antenna rotor. Directivity—the direction in which the antenna beams transmitted waves and best picks up r.f. signals—is in a plane parallel to the plane of the loops and *through* the driven element.

A suitable framework can be made up of bamboo "arms" and a wooden supporting structure. (See Fig. 2.) Four poles are re-

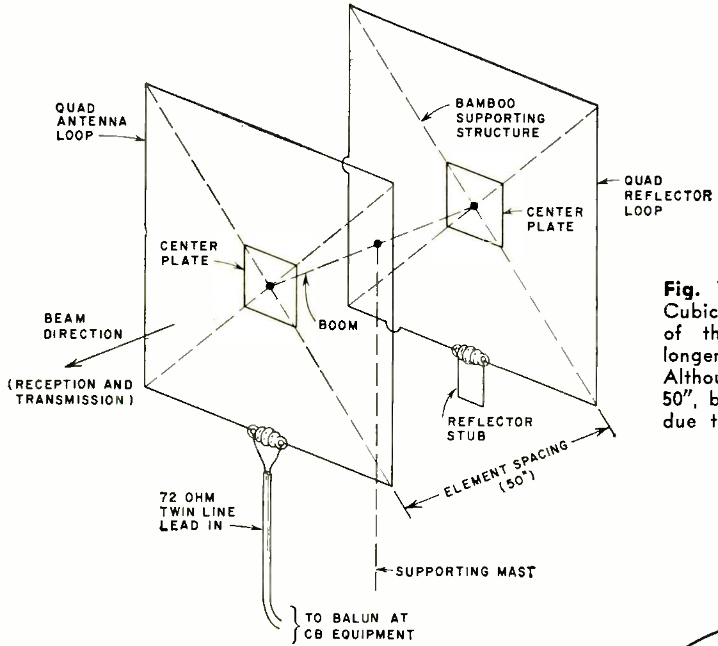
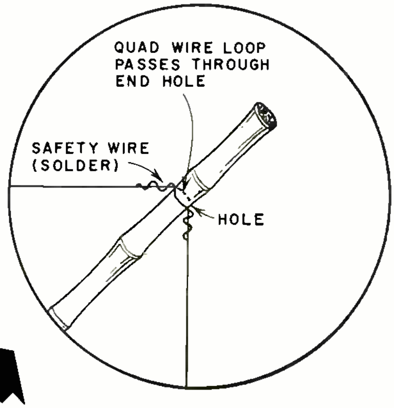


Fig. 1. Designer's "eye view" of Cubical Quad antenna. Each side of the square loops is slightly longer than one-quarter wavelength. Although spacing between loops is 50", boom will be about 1" shorter due to thickness of center plates.

BILL OF MATERIALS

8—8'-long bamboo poles—see text
1—80' length of #14 enameled wire—see text
2—12" x 12" plywood plates, 5/8" thick
1—49" section of dry 2" x 2" lumber
8—4" galvanized steel angle brackets
16—Galvanized U-bolts with nuts and washers
1—Random length of TV-type 72-ohm "ribbon" line (Belden #8222)
2—2" glass or ceramic insulators
1—77" length of 3/8"-diameter braided shield (Belden #8661 shielded loom)
1—Coaxial plug (to mate with CB antenna jack)



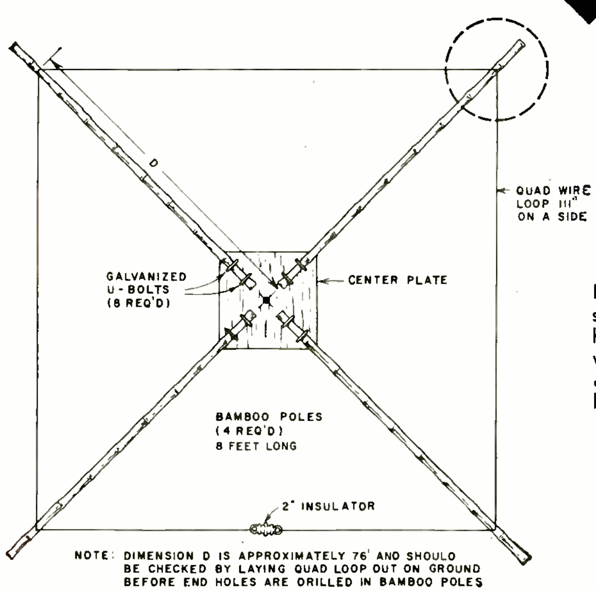


Fig. 2. Two square loops are necessary. Quad wire is strung through holes in ends of poles and secured with safety wire. (See details above.) To eliminate wire slack, loosen U-bolts and extend the poles.

quired for each Quad loop, and are bolted to a wooden center plate with galvanized U-bolts, commonly used in TV installations. The center plates in turn are bolted to opposite ends of a wooden boom. Choose bamboo poles that are clean, straight, and free of splits and cracks between the rings; use 96"-long poles so that the small tips may be cut off and discarded to provide an overall length of 7 feet. The poles should be wrapped firmly with electrical vinyl tape

BOOM ASSEMBLY

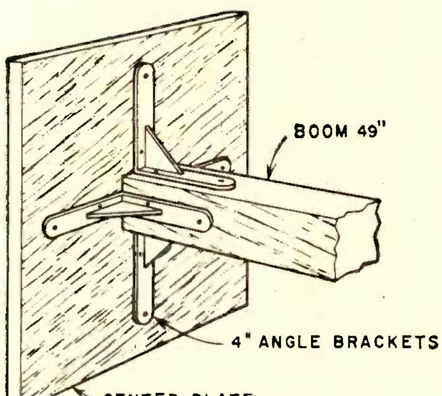


Fig. 3. Weakest parts of Cubical Quad are at junctions of center plates to boom, so be sure plates are securely mounted before installing the antenna. Boom dimensions are 2" x 2" x 49".

between the joints to retard splitting and then given two coats of outdoor varnish or shellac to protect them from the weather.

Plywood is ideal material to use for the two center plates, which measure 12" on each side and are cut from ⅝" stock. (See Fig. 3.) It is necessary to seal the plate edges against moisture to prevent the plywood from cracking or splitting—two liberal coats of outdoor house paint will do the job. The center plates are drilled to pass U-bolts which clamp the bamboo poles along the diagonals of the plates.

Galvanized or plated hardware is used in the assembly to retard rust and corrosion, and the butt ends of the poles are wrapped with electrical tape for added strength at the points where the U-bolts contact the bamboo. Two U-bolts are required for each pole, and the poles are positioned so that there is a gap of about 1½" between the butt ends. Washers are placed under all nuts to prevent them from digging into the soft surfaces of the plywood.

The boom is made of a 49" section of dry 2" x 2" lumber, well painted to protect it from moisture. ("Green" lumber would tend to warp as it gradually dries out, imparting a nasty twist to the symmetrical Quad design.) Sand the boom before you paint it, as this precaution will protect you from slivers and splinters during the assembly process.

The center plates are attached to the ends of the wooden boom by means of eight galvanized steel angle brackets. (Refer to Fig. 3.)

Wiring the Quad. You'll find that the bamboo framework is a flimsy and unwieldy structure, having as much stability as a jellyfish. However, once the antenna wires are strung in position, the assembly will magically become neat and amazingly rigid.

The next job is to string the wires on the bamboo frameworks. (See Fig. 2.) Remove the frameworks from the boom and lay them on the ground. Since the Quad loops are 111" on a side, you cannot take up slack by shortening the wire loops. Rather, the slack in the wires (if any) must be absorbed by expanding the bamboo framework until the wires are under tension. Final tension may be adjusted by spreading the poles equally apart at the center plate before the U-bolts are tightened.

Begin by cutting the two wire loops; there will be enough extra wire on each loop to make the end connection and the reflector stub. Make one loop assembly first.

When everything is "ship-shape," wire each bamboo pole to the loop. Scrape the enamel covering from the loop wire for an inch on each side of the poles and pass a short piece of copper wire over each pole, wrapping it securely about the Quad wire. Then solder the points. This safety wire will prevent the loop from shifting about on the framework. (Refer to Fig. 2.)

The second loop assembly may be made by laying its components atop the first one and making a "Chinese copy." When it is completed, the reflector stub (Fig. 4) should be soldered across the center insulator of one of the loop assemblies.

Finally, mount the bamboo frameworks to the center boom with the angle brackets.

Feed System. The Quad is a symmetrical, balanced antenna, and for best results should be fed with a balanced trans-

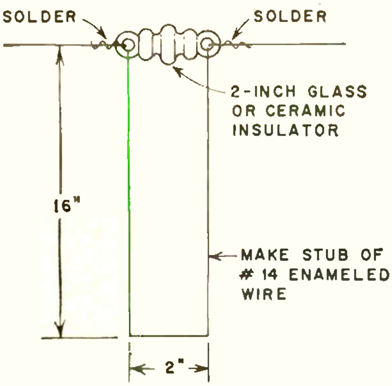


Fig. 4. Shorted stub on reflector loop serves to tune element for maximum rejection of CB signals at rear of Quad antenna. Inspect soldered joints at insulator before installing antenna.

mission line. Two-wire, 72-ohm "TV-type" transmission line (Fig. 5) is used at a considerable savings in cost over common coaxial line. The line may be of any length required to reach from the antenna to the CB equipment. Most CB rigs are designed

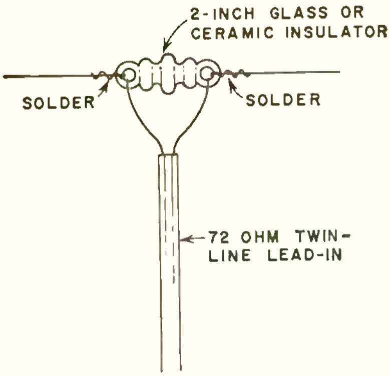
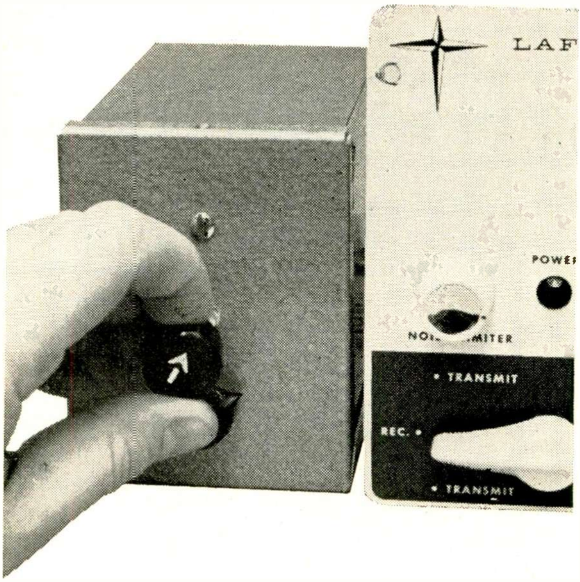


Fig. 5. Install 72-ohm line as you would a TV twin-lead. Fix lead-in to mast a few feet below the connections, to prevent wire's weight from bending loop.

for use with an unbalanced (coaxial) transmission line. Therefore, some sort of balance-to-unbalance device must be placed near the CB rig's antenna jack for a correct impedance match between the lead-in line and the equipment. A *balun sleeve* made of flexible, metal braid will do the job.

A 77" length of braid is slipped over the line and trimmed to the correct dimension. (See Fig. 6.) Tape the braid's free end to (*Continued on page* 158)



Citizens Band Q-Multiplier

. . . gives any superhet razor-sharp selectivity

. . . cuts out adjacent channel interference

By DONALD L. STONER, 11W1507

CITIZENS BANDERS, hams, or SWL's plagued by interference on the crowded bands can pep up their receivers with an easy-to-build Q-Multiplier.* The unit improves a set's selectivity by narrowing its i.f. bandpass, thus eliminating interfering stations and reducing static and noise pickup.

Since the Q-Multiplier operates on the receiver's intermediate frequency, it can be used with any superhet receiver, including CB, ham, or SWL sets, regardless of its tuning range. However, the receiver must have an i.f. near 455 kc. or between 1300 and 1800 kc.

Completely self-contained, the Q-Multiplier has its own a.c. power supply and requires only a two-wire connection to the receiver. Operation is simple, too; using only two controls, you select the desired station and reject the ones you don't want.

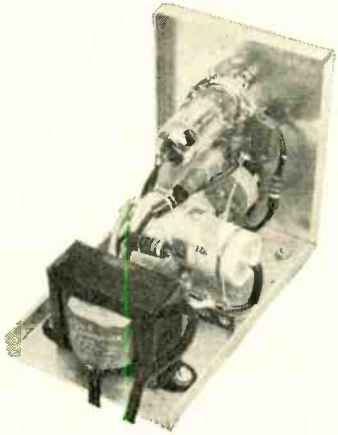
As for construction, there are no expensive parts; with all parts purchased new, you can build the unit in an evening or so for around $10.00. The wiring is not critical.

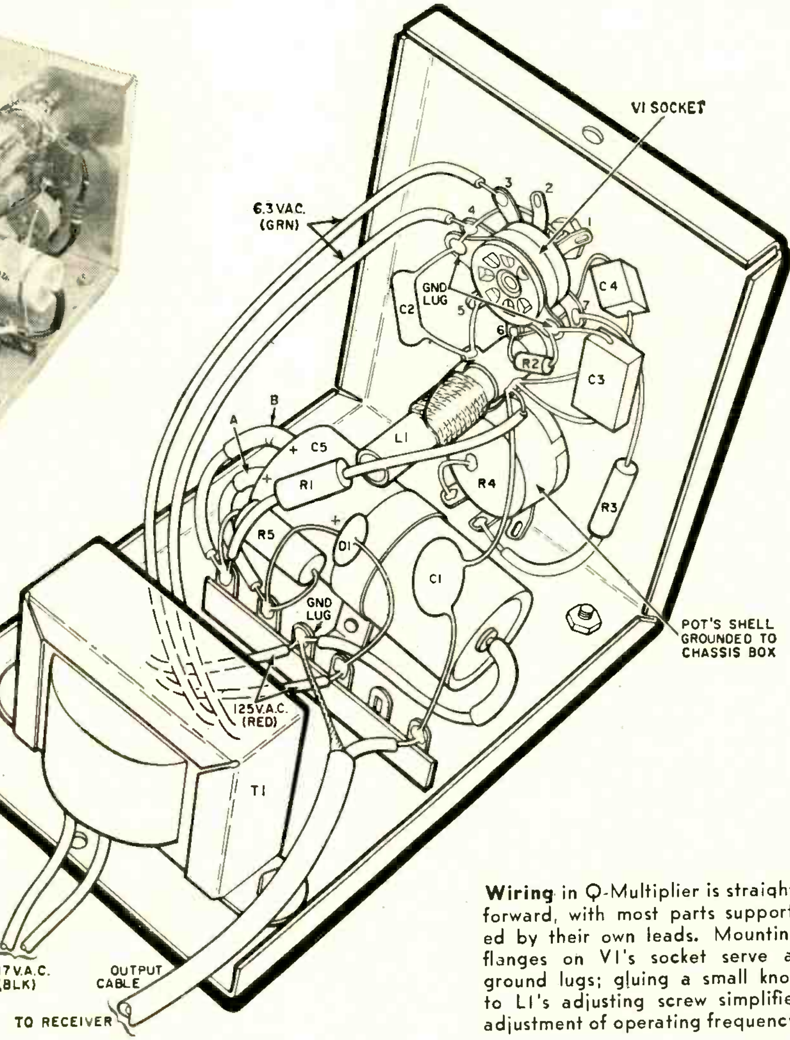
Construction. Build the unit following the layout shown in the pictorial diagram. The tube socket, tuning coil *L1*, and potentiometer *R4* are fastened to the front panel of the box; however, each requires soldering or modification before mounting.

Bend out the solder lugs on the tube socket before fastening it to the front panel. Then solder a bare wire jumper through the socket's ground sleeve, pin 4, and the socket's mounting flange. Mount the socket so that pins 1 and 7 are pointing to the left when viewed from the front of the box. The socket is fastened to the box by soldering its ground sleeve to a machine screw mounted on the front panel with a nut and lock washer.

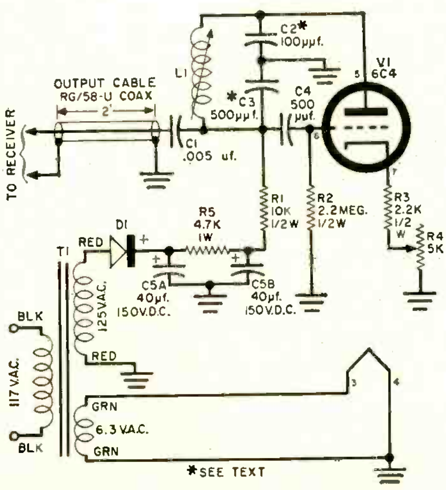
If the Q-Multiplier is to be used with a receiver having a 1300- to 1800-kc. i.f., remove 100 turns of wire from the winding of tuning coil *L1*, which is a Miller 2007 ferrite loopstick. For sets with 455-kc. i.f.'s, do not modify *L1*, but change capacitors *C2* and

* *Developed by O. G. Villard, Jr., the original Q-Multiplier was first described in the engineering monthly "Electronics" in April, 1952.*



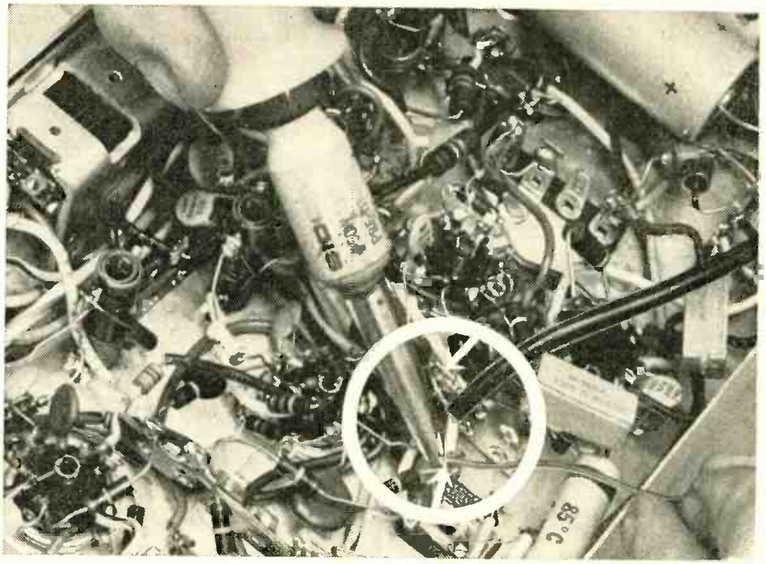


Wiring in Q-Multiplier is straightforward, with most parts supported by their own leads. Mounting flanges on V1's socket serve as ground lugs; gluing a small knob to L1's adjusting screw simplifies adjustment of operating frequency.



PARTS LIST

C1—0.005-μf., 500-volt ceramic disc capacitor
C2—100-μμf., 500-volt mica capacitor—see text
C3—500-μμf., 500-volt mica capacitor—see text
C4—500-μμf., 500-volt mica capacitor
C5a/C5b/—40/40 μf., 150-volt electrolytic capacitor
D1—Silicon diode, 200 P.I.V., 200 ma.
L1—Ferrite loopstick (Miller 2007—see text)
R1—10,000-ohm, ½-watt resistor
R2—2.2-megohm, ½-watt resistor
R3—2200-ohm, ½-watt resistor
R4—5000-ohm potentiometer, linear taper (Mallory U-14 or equivalent)
R5—4700-ohm, 1-watt resistor
T1—Power transformer; 117-volt primary; 125-volt, 15-ma., and 6.3-volt, 0.6-amp secondaries
V1—6C4 tube
1—4" x 3" x 5" aluminum box (LMB 435EL or equivalent)
Misc.—Hardware, RG-58/U coaxial cable, 7-pin tube socket, etc.



Hot lead of Q-Multiplier's output cable can be connected to plate of first i.f. tube at i.f. transformer (lower arrow in photo). Cable's shield should be soldered to ground lug nearby (upper arrow).

C3 to 680 $\mu\mu$f. and .0025 μf., respectively.

Ground one lug of potentiometer *R4* to the shell of the control with a short bare-wire jumper, as shown in the pictorial diagram. Then mount the control.

The remaining wiring is straightforward. However, take care to watch polarities on diode *D1* and filter capacitor *C5*. Note that the output cable shown on the schematic is a 2′ length of RG-58/U coaxial cable.

Connection and Adjustment. If you build the Q-Multiplier to operate on 455 kc., it should be adjusted when you connect it to the receiver. The 1300- to 1800-kc. model requires a preliminary adjustment before being connected. To make the preliminary adjustment, tune the receiver or any broadcast-band set to approximately 1600 kc., and place the hot lead of the Q-Multiplier's output cable near the receiver's antenna. Set selectivity control *R4* to its minimum resistance position and adjust tuning coil *L1* until you hear a whistle in the receiver's speaker.

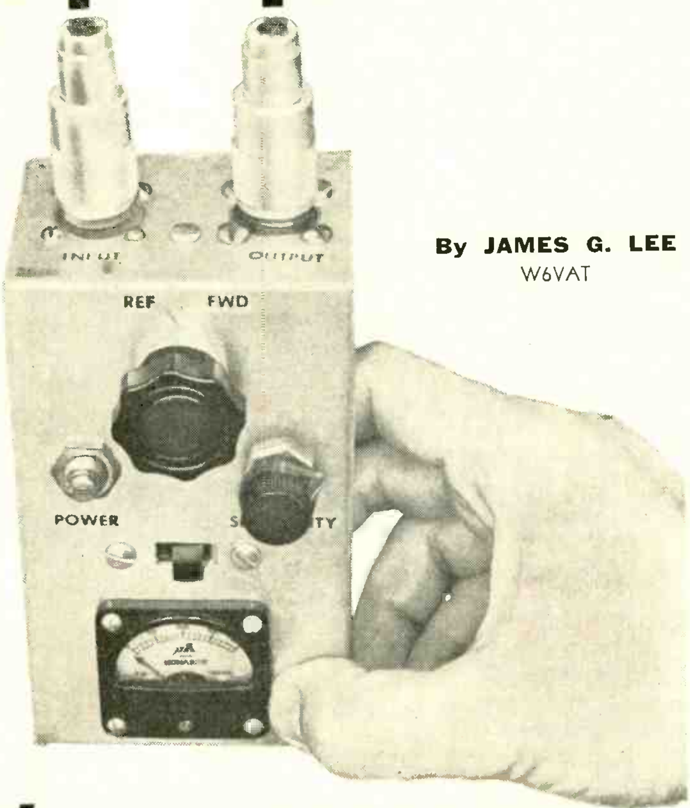
Before hooking up either model to your set, turn off both the receiver and the Q-Multiplier. Then connect the hot lead of the output cable to the plate of the first i.f. tube in the receiver, and solder the output cable's shield to the nearest ground point. If you use the Q-Multiplier with a dual conversion superhet, you must connect the hot lead to the plate of the i.f. tube which operates in the frequency range of the Q-Multiplier.

Now power the receiver and Q-Multiplier, and set selectivity control *R4* to its maximum resistance position; this is the point where the Q-Multiplier does not oscillate. When you tune in a station on the receiver in the normal manner, you should notice a considerable reduction in the volume of the received station.

To adjust the 455-kc. Q-Multiplier and to touch up the tuning on the 1300- to 1800-kc. model, set *R4* to its minimum resistance position. Adjust *L1* until a strong whistle is heard from the speaker. Now reset *R4* to maximum resistance. For maximum output, you can repeak the plate tuning adjustment on the first i.f. transformer; a quarter turn in either direction is all that is needed.

Operation. Starting with *R4* at maximum resistance, slowly decrease the resistance; you will find that the volume of the received station starts to increase as you do so. Soon the volume will increase noticeably, and voice signals will begin to sound rather bassy. Any further decrease in *R4*'s resistance will cause the Q-Multiplier to oscillate and the received station will be blotted out.

Back off *R4* until the oscillation just stops; this is the most selective point in *R4*'s range. Now adjust both *L1* and *R4* slightly, for best results. Once adjusted, these controls should need no further attention when you tune in other channels on the band. —30—



By JAMES G. LEE
W6VAT

Want to know just how much you're putting out? Then build this . . .

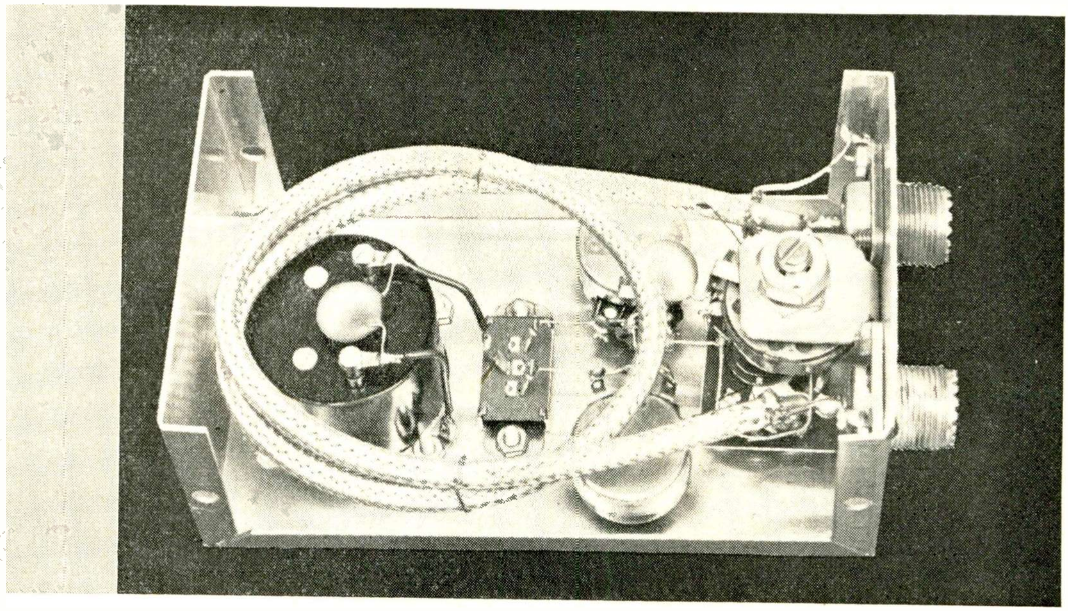
SWR/POWER METER FOR CB

"LET'S face it," groaned one CB'er to another a few weeks ago, "it's getting so I can almost never cut into that hubbub on 11 meters!"

The other nodded knowingly. "I had the same trouble," he returned, "until I built a little SWR/power meter for my rig."

CB'er number two had a point: with the five-watt input allowed by the FCC, every CB'er needs some means of insuring that he's getting peak efficiency from his transmitter. And one of the best ways of doing so is to provide some means of measuring actual power delivered to the antenna.

You can leave the SWR/power meter described here in the line at all times to measure actual power. In addition, it can be used for initial transmitter and antenna tuning adjustments for best standing-wave ratio (SWR). The circuit consists of a di-



Parts layout of power meter is highly symmetrical and reflects arrangement of schematic diagram on page 157 very closely. See text for details of pickup loop.

rectional coupler which is switched to sample either forward or reflected voltage, and a voltmeter.

Although this unit can be used on other than CB frequencies, its power-handling capability is sufficient only for transmitters rated at 5 watts input or less.

Construction. The unit is housed in a Bud CU-3006-A Minibox. Photo above shows the general layout and should answer any questions regarding parts placement.

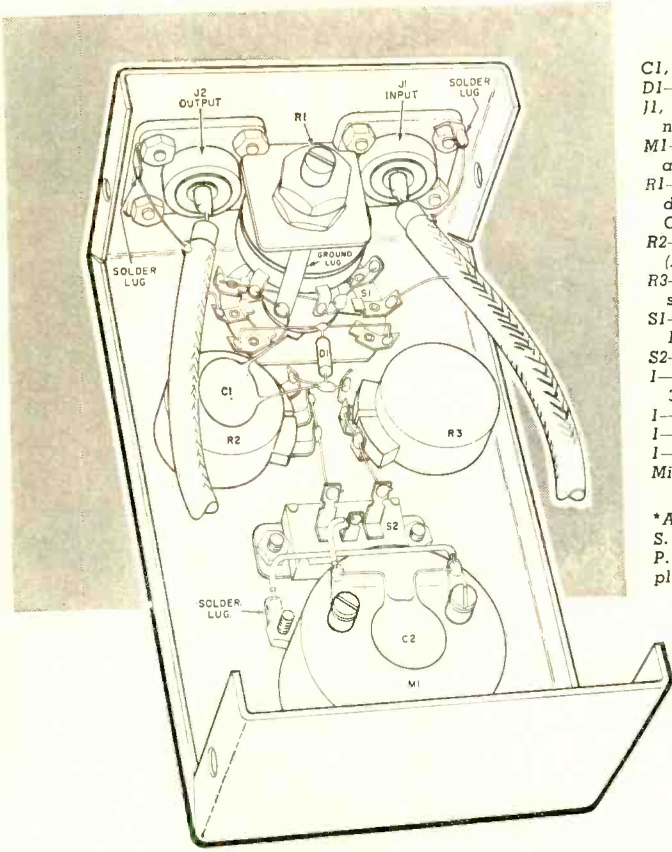
The coax directional coupler is made from an 18" length of RG-58/U. Slit the outer covering lengthwise with a knife and peel it off. Bunch the woven braid toward the center to loosen it so that a length of #28 enameled wire can be threaded between the braid and the inner insulation. The enameled wire is then brought out through the braid about 1" from each end.

Next, smooth the braid back to its original position on the inner insulation without scratching the enameled wire. With this done, a few turns of #20 tinned wire should be wrapped around the braid about ½" from each end of the cable.

About 1" of this tinned wire should be left free on each end; then solder the wire to the braid and trim off any excess braid. Finally, cut the inner insulation so as to expose about 3/16" of the inner conductor at each end. The coax line and coupler can now be set aside, and the rest of the meter assembled.

Note that the metal cover on potentiometer *R1* is removed to lower circuit capacity and the potentiometer carefully positioned for shortest leads. Diode *D1* requires special handling when soldering —a pair of long-nose pliers held close to the rectifier will serve as an effective heat sink. The last item to be soldered in place is the coax coupler—avoid scratching the enamel insulation where the wire comes out of the braid.

Calibration. Although there are a number of ways to calibrate the unit, the simplest involves your CB transmitter and a suitable dummy load. (If you use an r.f. source other than your CB rig, make sure its frequency is between 25 and 30 mc.) The easiest dummy load to make is a 2-watt, 50-ohm resistor mounted in a male coax plug; all leads should be as short as possible,



PARTS LIST

C1, C2—.005-µf., 1000-w.v.d.c. ceramic capacitor
D1—1N66 diode
J1, J2—Coaxial jack, chassis-mounting (Amphenol 83-1R or equivalent)
M1—0-200 µa. meter (Monarch PM-4 or equivalent)*
R1—250-ohm potentiometer, linear taper, screwdriver adjustment, with locking shaft (Ohmite CLU2511 or equivalent)
R2—100,000-ohm potentiometer, linear taper (IRC PQ11-128 or equivalent)
R3—100,000-ohm potentiometer, linear taper screwdriver adjustment (IRC RQ11-128)
S1—2-pole, 2-position rotary switch (Centralab 1462 or equivalent)
S2—S.p.d.t. slide switch
1—5¼" x 3" x 2⅛" aluminum box (Bud CU-3006-A or equivalent)
1—18" length of RG-58/U coaxial cable
1—20" length of #28 enameled wire
1—12" length of #20 bare copper wire
Misc.—Wire, solder, plugs to match J1 and J2

**Available from Arrow Electronics, Inc., 2534-38 S. Michigan Ave., Chicago, Ill., or RPJ Sales, P. O. Box 1252, Studio City, Calif., for $4.95, plus postage.*

Top half of box holds all components; wiring is point-to-point, with small parts supported by their own leads. Solder lugs should be mounted at jacks J1, J2, and at meter M1, as indicated.

and the resistor should ideally be of the non-inductive type.

With the back off the unit, attach the dummy load to output jack *J2* and set *S2* to *Sensitivity, S1* to *Fwd*, and *R2* at its maximum resistance position. Next, attach the transmitter (or other r.f. source) to the input connector with a short length of coax and turn on the transmitter. Adjust *Sensitivity* potentiometer *R2* until a full-scale reading is obtained on the meter. Now, switch *S1* to *Ref*; this should result in a lower reading on the meter.

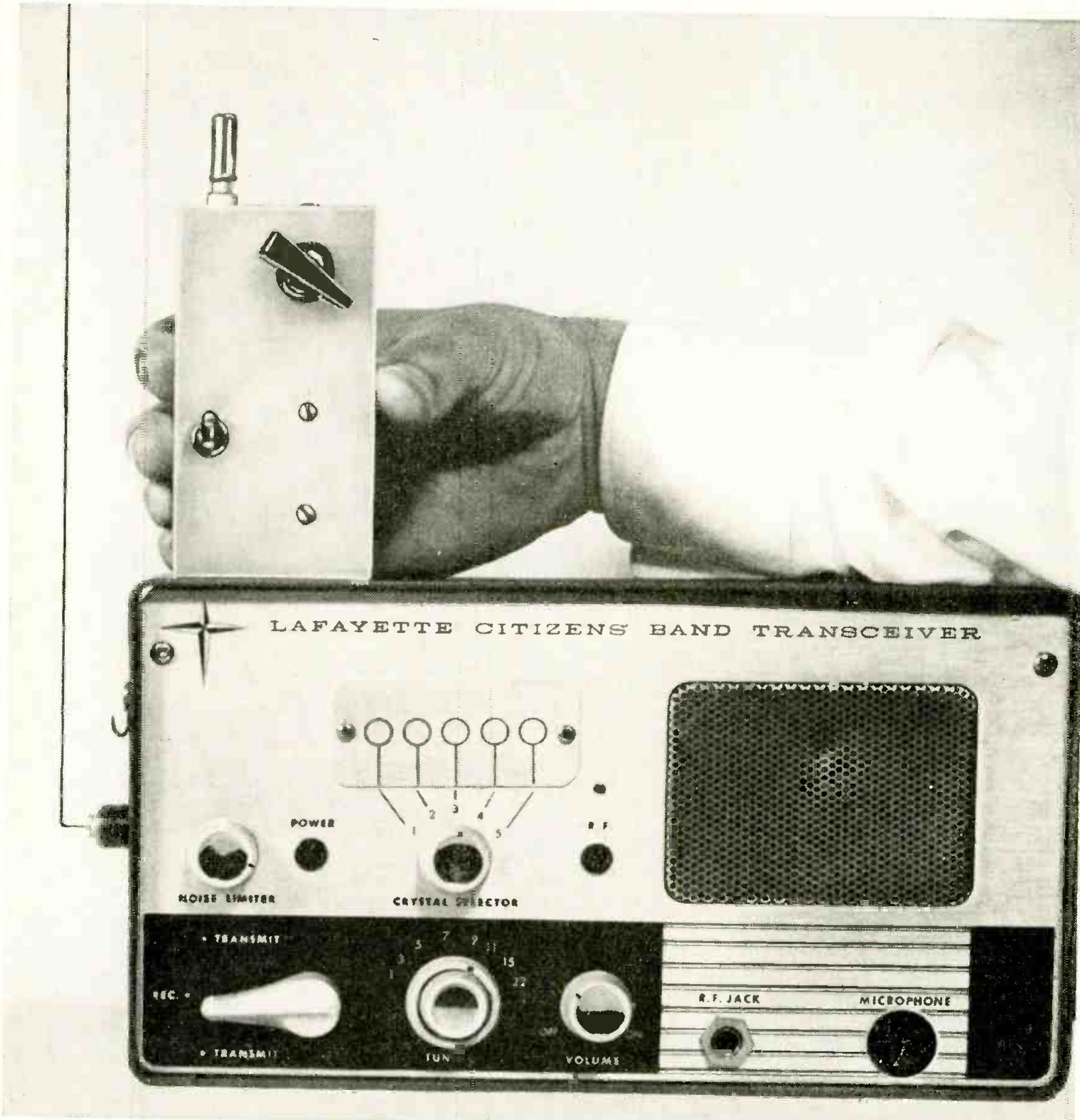
Potentiometer *R1* should then be adjusted for a minimum meter reading. Using the above dummy load, you will not get a complete null, but the meter should read 30 µa. or less with full-scale *Fwd* deflection. Once the null is obtained, the locking nut on *R1* is tightened and the cover replaced.

For *Power* calibration, a VTVM with a high-frequency detector probe is necessary—the author used a Heathkit V7-A. Replace the dummy load with a T-connector and screw the load on one arm of the T. Set *S2* to *Power* and *R3* at its maximum resistance position. Now apply power and measure the voltage at the open arm of the T with the VTVM and probe.

Once the voltage is known, the power can be calculated from the standard E^2/R formula. For example, 10 volts across 50 ohms equals 2 watts; *R3* can be adjusted to give any meter deflection desired.

Operation. The meter is now ready for use and can be inserted in the line between the antenna and the transmitter at any convenient point. For SWR measurements, switch *S1* to *Fwd* and *S2* to *Sensitivity*. Turn on the transmitter and adjust *R2* for full scale; then switch *S1* to *Ref* and read

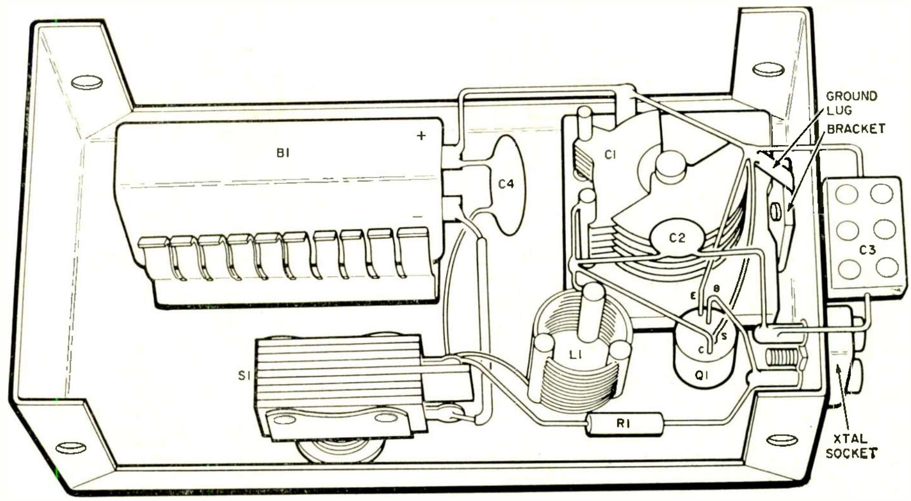
(*Continued on page* 157)

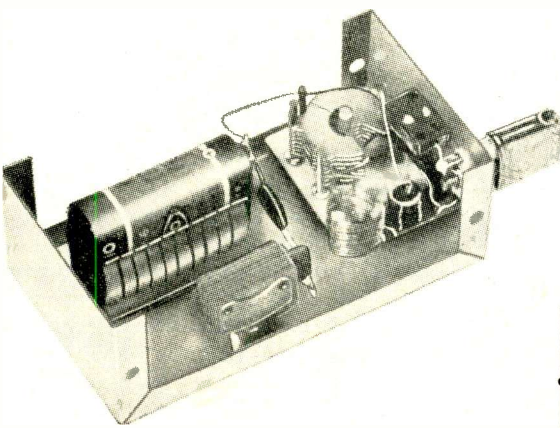


CB CHANNEL SPOTTER

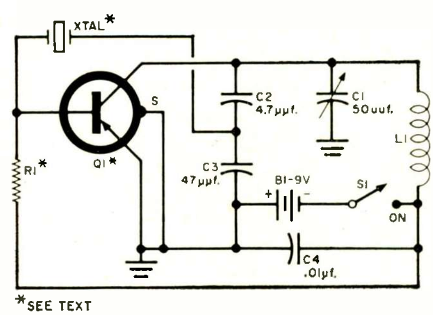
Handy home-built calibrator pinpoints operating frequency on tuning dial

By DONALD L. STONER, W6TNS





Follow the parts layout shown here as closely as possible to minimize changes in stray capacitances.



THE INCREASING USE of tunable receivers in the Citizens Band calls for a device to "spot" your frequency on the receiver tuning dial. Just in case you're not crystal-controlled on the *receive* channel, it's handy to have a gadget that will help you pick out the exact dial setting when the channel is unoccupied.

The "CB Calibrator" will do just that. Essentially, it is a low-power crystal-controlled transistor oscillator for the Citizens Band. When a transmitter crystal for your CB rig is placed in the calibrator's crystal socket, the instrument will generate a signal on the appropriate channel. When accurately calibrated CB crystals are used,

PARTS LIST

B1—9-volt transistor battery
C1—50-μμf. variable capacitor (Hammarlund HF-50 or equivalent)
C2—4.7-μμf. NPO disc or silver mica capacitor
C3—47-μμf. NPO disc or silver mica capacitor
C4—0.01-μf. disc ceramic capacitor
L1—11¾ turns of No. 18 wire, air core (B & W 3003 Miniductor or equivalent)
Q1—2N274 drift transistor—see text
R1—½-watt resistor—see text
S1—S.p.s.t. toggle switch
1—4¼" x 2¼" x 1½" chassis box (Bud CU-3016A or equivalent)
Misc.—Crystal socket, battery holder, solder lug, etc.

the signal should be within the 0.005% limits specified by the FCC for CB equipment.

Using all new parts, you should be able to construct this handy little calibrator for less than $8.50.

Construction. The unit is housed in a 4¼" x 2¼" x 1½" aluminum box. The only other components required are a few capacitors, a resistor, one transistor, a coil, a battery, a switch, and a crystal socket.

Mount the tuning capacitor *(C1)* by its shaft nut and a screw through its bracket. A solder lug placed between the chassis and *C1*'s bracket serves as a common ground for the entire unit. The crystal socket is mounted alongside the tuning capacitor. Transistor *Q1* and coil *L1* are held in place by their leads with no other external support.

Most of the space in the box is taken up by the battery and switch. They may be mounted wherever convenient. The battery is wired directly into the circuit. Also wire in the three fixed capacitors *(C2, C3* and *C4)*, keeping their leads as short as possible. Do not wire in resistor *R1* until after the adjustments are made.

Adjustments. There are just two adjustments needed to put the calibrator in operating condition. The first is to set the transistor's collector current at about 0.4 ma.; the second, to set *C1* properly.

The author used an RCA 2N274 drift transistor. Another transistor in the same family can be used if you wish. A preferred substitution is the brand-new Philco 2N-1745. Some of these transistors will oscillate while drawing as little as 0.1 ma.; others may need as high as 0.5 ma. With the minimum drain (0.1 ma.), the battery should last almost its entire shelf life. With a drain of 0.4 ma., the battery will last six months to a year under normal service.

HOW IT WORKS

The calibrator uses a single drift transistor, connected in the common-emitter arrangement as an oscillator. When switch *S1* is turned on, a pulse is fed to the transistor's base through resistor *R1*. The pulse is amplified and appears at the transistor's output—tank circuit *L1-C1*.

Part of the pulse is fed back to the base through the crystal. The crystal sets the operating frequency and acts as a feedback path. Although the crystal is cut for approximately 9 mc., the circuit oscillates at its third harmonic—about 27 mc.

Base bias is determined by *R1*, with the exact value depending on the transistor used.

Connect a 1-ma. milliammeter in series with one of the battery leads. Substitute a 1-megohm potentiometer (wired as a variable resistor) for *R1*. With the pot at maximum resistance and no crystal in the socket, turn on the switch. The meter should read zero. (Current is actually less than 1 microampere.) Decrease the pot's resistance until the meter reads about 0.2 ma.

Insert a crystal in the socket and slowly tune *C1* while listening for the signal on your CB receiver. If the unit is oscillating, remove the pot, measure its resistance, and place a fixed resistor with the same value (or as near to it as possible) in the circuit. If the calibrator is not oscillating, decrease the pot's resistance a little more and try again. The unit should "take off" with less than 0.5 ma. collector current.

Only third-overtone crystals intended for the Citizens Band are suitable. Fundamental-type crystals will *not* work in this circuit since they operate at a low frequency that is later multiplied to a CB channel frequency.

Operation. To use the calibrator, simply place a CB third-overtone crystal in the socket and flip on the switch. Normally, capacitor *C1*'s plates will be about one-quarter meshed and will need no readjustment (unless crystals for widely separated parts of the band are used).

The calibrator's high degree of accuracy enables it to be used for aligning CB equipment. For example, with suitable crystals, it will indicate the band ends much more accurately than will the conventional signal generator. It can, therefore, be used for setting receiver tracking.

If you normally operate on only one channel most of the time, select a crystal suitable for that channel and place it in the calibrator. Turn the unit on and set it down near your antenna. Adjust the antenna's length and matching network (if there is one) for maximum pickup. When this is done, you can be sure your antenna will deliver maximum performance, both receiving and transmitting, on the band you use most often.

And don't forget the original reason for building the calibrator—it will point out your transmitting frequency quite accurately on your receiver's dial. After operating the unit for a while, you will probably come up with several additional useful applications for it. —30—

ADD A SQUELCH TO THE CB-1

Simple diode circuit eliminates superregenerative hiss

By R. L. HAWBAKER, 1ØWØ975

IF YOU OWN one of the popular Heathkit CB-1 Citizens Band transceivers, here's a neat way to add an efficient squelch circuit to the receiver section. The squelch will block almost all of the "between-stations" superregenerative hiss and man-made noise—yet, if set properly, it will pass the weakest r.f. carrier. Installation involves adding only a few components and making some simple wiring changes.

About the Circuit. The changes to be made center around the plate circuit of detector *V1b*. This circuit, before and after modification, is shown in Figs. 1 and 2 respectively. In both diagrams, all original components are marked with their Heath part numbers. In Fig. 2, all new components are designated by numbers beginning with *"50"* (i.e., *V501, R502,* etc.). Portions of the circuit which are left unchanged have been drawn with dotted lines.

Tube *V501* is a 6AL5 dual diode, only half of which is used. Its plate voltage is taken from dropping resistor *R501* and filtered by a network consisting of *R503* and *R504* and capacitors *C502* and *C503*. The cathode is biased through resistor *R502* and potentiometer *R106*; it receives the audio output of tube *V1b* through capacitor *C501*. Capacitor *C504* couples *V501*'s audio output (by way of volume control *R108*) to the grid of the first audio amplifier (*V2b*).

Potentiometer *R106*, formerly the regeneration control, serves to control the

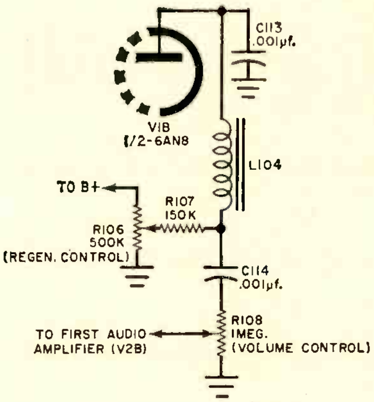


Fig. 1. Plate circuit of Heathkit CB-1's detector before modifications are made. Regeneration control R106 will become the squelch control.

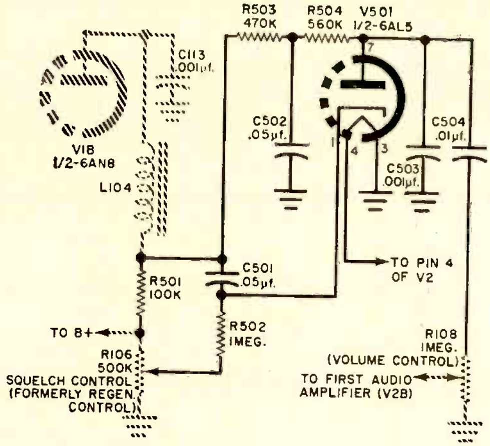


Fig. 2. The circuit in Fig. 1 after it is modified. Dotted portions of the schematic represent sections which have been left unchanged.

squelch. Resistor *R501* sets the regeneration at a fixed value, and the author found that this causes no inconvenience—the model shown has operated over the entire Citizens Band with no noticeable loss in sensitivity.

Squelch control *R106* is normally set so that the cathode of diode *V501* is slightly more positive than the plate. In this condition, the tube will not conduct and no signal will pass through to *V2b*. When a carrier is received by detector *V1b*, however, the diode's plate voltage will rise until the plate becomes more positive than the cathode. The tube then conducts and the signal passes through.

With *R106* set so that *V501* is just on the threshold of conducting, a rise in plate voltage of only one volt will "break" the squelch. The average readable signal causes a rise of 3 to 5 volts, but superregenerative hiss and/or most man-made noise will not increase the voltage to the value necessary for conduction.

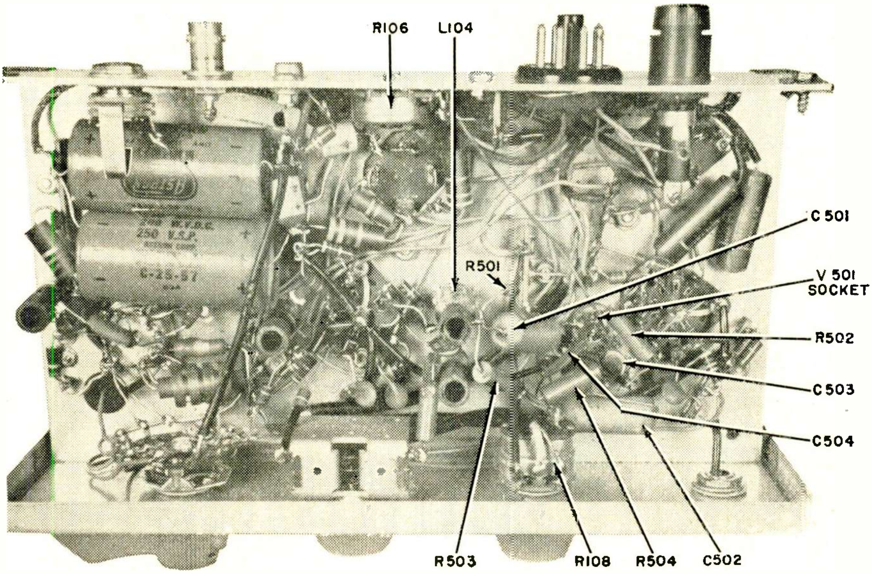
Remember, though, that this device is not a noise limiter. It serves mainly to squelch the hiss which is characteristic of a superregenerative receiver when no signal is being picked up. Man-made noise is also suppressed when no signal is present, but once a carrier causes the tube to conduct, any noise will ride through as well.

Installation. The only mechanical changes which must be made in the CB-1 are the addition of a socket (*SO1*) for *V501* and an extra terminal strip (*TS1*). The pictorial diagram (Fig. 3), which shows the corner of the chassis (wiring eliminated) where these parts are located, will help you with the placement. The original parts are marked with their Heath designations.

The author installed a 5-terminal (one grounded) terminal strip, even though a 3-terminal unit would have worked, to get good spacing of the parts. Only the terminals marked 1, 2, and 3 are used. Notice also that, to conserve space and avoid drilling an extra hole, one side of the new socket is held in place by one of the mounting nuts for *V2*'s socket. Place a solder lug under the mounting nut for the other side of the socket.

Wiring Steps. Once *SO1* and *TS1* are in place, you're ready to go ahead with the wiring. The steps are itemized on page 56—carry them out in order and check off each one as you have completed it. An asterisk appearing after a terminal means that the last connection has been made to it and it's okay to solder.

All of the terminal numbers mentioned in the following instructions refer to Fig. 3, and the photo of the underside of the chassis will give you an idea of the relative positions of the components. When wiring, be sure to route all component leads so that they are as short and direct as possible. In this way, undesirable effects, such as



Bottom view of CB-1 chassis shows some of the components to be added. Extra terminal strip (not visible) makes for a professional-looking installation.

PARTS LIST

C501, C502—0.05-μf., 400-volt capacitor
C503—0.001-μf. ceramic disc capacitor
C504—0.01-μf. ceramic disc capacitor
R501—100,000 ohms
R502—1 megohm } *all ½-watt resistors*
R503—470,000 ohms
R504—560,000 ohms
SO1—7-pin miniature tube socket
TS1—5-lug terminal strip (center lug grounded)
V501—6AL5 tube
Misc.—Tube shield for V2, solder lug, hardware, etc.

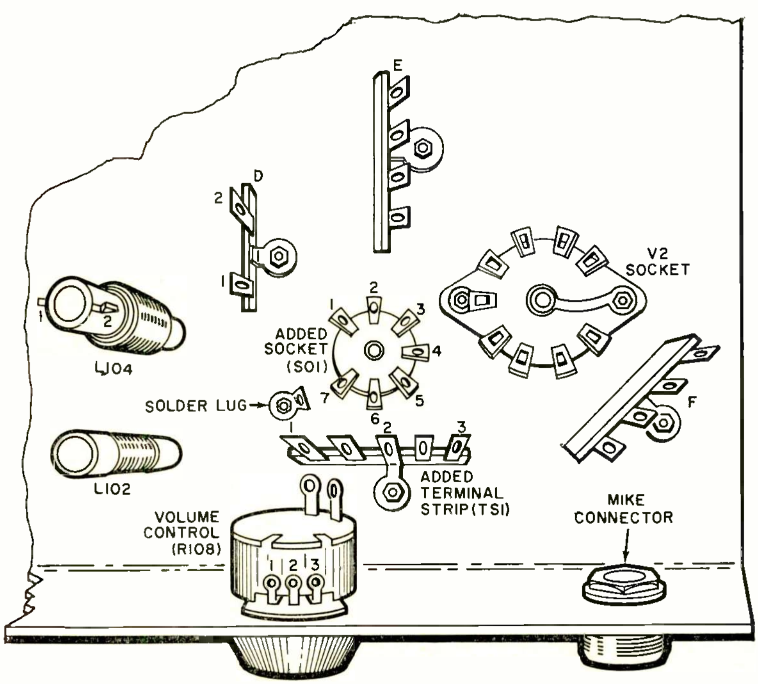
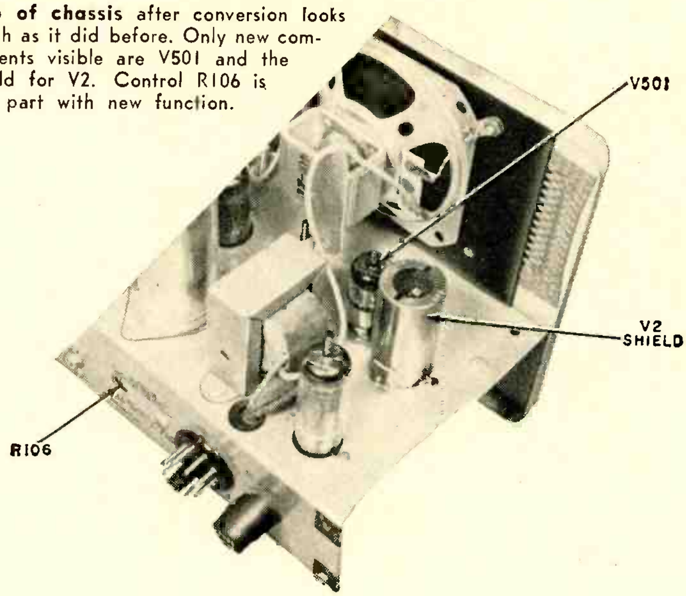


Fig. 3. Components in area of chassis where changes are made. Part and terminal numbers are keyed to installation and wiring instructions in text.

Top of chassis after conversion looks much as it did before. Only new components visible are V501 and the shield for V2. Control R106 is old part with new function.



hum pickup or the introduction of feedback will be avoided. In addition, you'll have a neater-looking job.

(1) Remove the 150,000-ohm resistor (*R107*) connected between terminal 2 of choke *L104* and terminal 1 of terminal strip "*D*."

(2) Remove and save the 0.001-μf. capacitor (*C114*) connected between terminal 2 of *L104* and terminal 1 of volume control *R108*.

(3) Connect a 100,000-ohm resistor (*R501*) between terminal 2 of *L104* and terminal 1* of terminal strip "*D*."

(4) Disconnect the lead from the center terminal of regeneration control *R106* (not shown in Fig. 3) and move it to the ungrounded end terminal.*

(5) Connect the center terminal* of *R106* to terminal 3 of terminal strip *TS1*.

(6) Connect pin 3* of socket *SO1* to *SO1*'s center shield terminal.

(7) Connect *SO1*'s center shield terminal* to the solder lug* installed under *SO1*'s mounting nut.

(8) Connect pin 4* of *SO1* to pin 4* of *V2*'s socket.

(9) Connect *R502* (1,000,000 ohms) from terminal 3* of *TS1* to terminal 1 of *SO1*.

(10) Connect *C501* (0.05 μf.) from terminal 2 of *L104* to terminal 1* of *SO1*.

(11) Connect *R503* (470,000 ohms) from terminal 2* of *L104* to terminal 1 of *TS1*.

(12) Connect *C502* (0.05 μf.) from terminal 1 of *TS1* to terminal 2 (ground) of *TS1*.

(13) Connect *R504* (560,000 ohms) from terminal 1* of *TS1* to terminal 7 of *SO1*.

(14) Connect *C503* (0.001 μf.—formerly *C114*) from terminal 7 of *SO1* to terminal 2* of *TS1*.

(15) Connect *C504* (0.01 μf.) from terminal 7* of *SO1* to terminal 1* of volume control *R108*.

With the wiring completed, the only work remaining is to install a shield on *V2*. Tube *V2*'s socket could be changed to the type having a fitting for a shield, but the author found it more convenient simply to slip the shield over *V2* and solder it to one of the socket mounting screws.

Using the Squelch. After all of the wiring has been double-checked, turn on the receiver and let it warm up. Start with *R106* at its maximum resistance position, rotating it until the superregenerative hiss just stops. The control is now set for proper operation and need not be readjusted until the set has been shut off and turned on once more. After you've used your new squelch circuit for a while, you'll wonder how you ever got along without it. —30—

Chapter 3

Short-Wave Listening and Amateur Radio

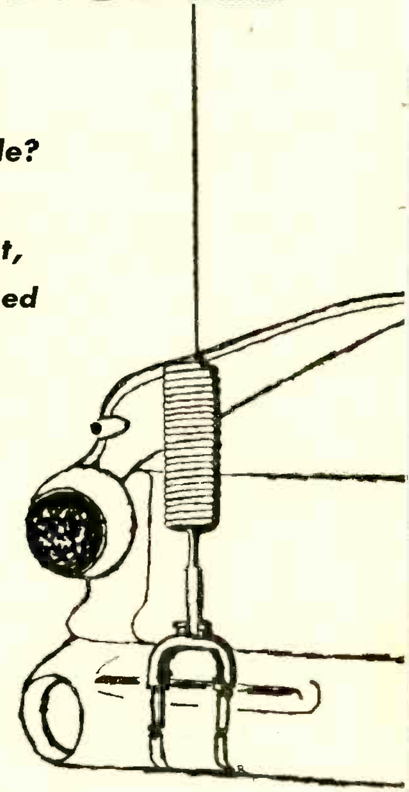
ALTHOUGH the sunspot cycle is past its peak and has started on the downward side of its 11-year cycle, short-wave receiving and transmitting conditions are expected to be nothing short of terrific in 1962. At the same time, many listeners are turning to new fields. Broadcast band DX, for instance, is beginning to boom, and in case you want to try it out, we suggest building the "Booster" on page 74; it can add unexpected life to any BC receiver.

You may be intrigued by the number and variety of stations (police, aircraft, fire, taxicab, FM, ham, etc.) transmitting between 70 and 160 mc. The simplified single-tube Compactron receiver (p. 65) is ideal for covering this range and is also economical to construct.

Our amateur radio friends will not want to miss the cathode modulator (p. 62) and the compact 50-mc. mobile unit (p. 58).

6 METERS and MOBILE

Thinking of going mobile? Then make this compact, self-contained transmitter the heart of your rig



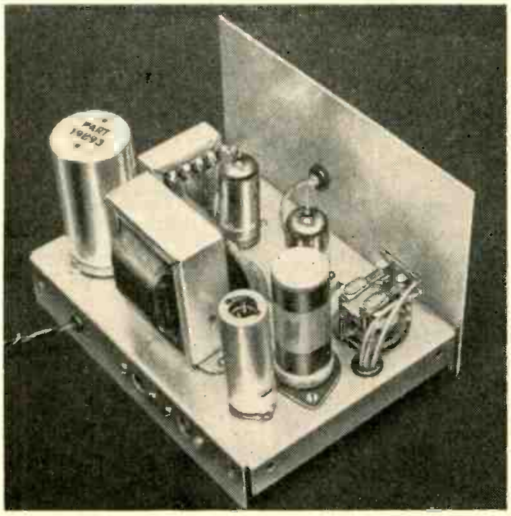
By **LEN BUCKWALTER,** K1ODH

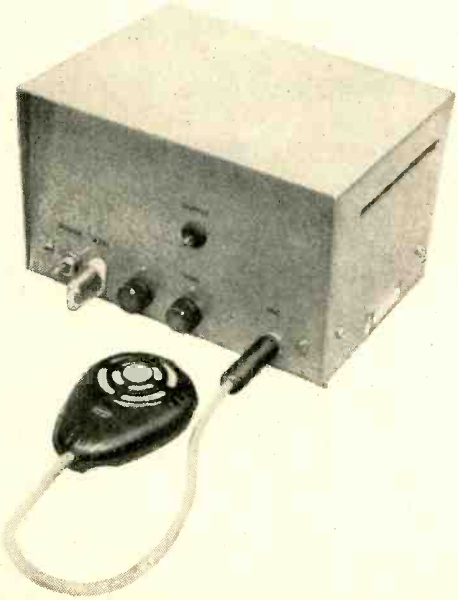
INTEREST in the 6-meter band has been running high ever since the FCC opened the band to Technicians. The remarkable performance of even low-power transmitters on 50 mc. makes a mobile rig especially attractive. There's plenty of opportunity for local contacts, with an occasional taste of DX when the band "opens up."

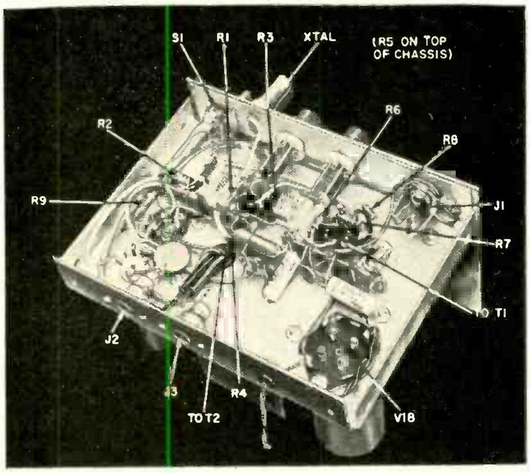
The transmitter described here offers several advantages, especially for the new ham who is anxious to abandon the code key in favor of a microphone. For one thing, it's a self-contained rig, complete with power supply. Then, too, there's a built-in "Send" to "Receive" relay. Further, chassis layout is "open" (you'll find no "rat's nest" of wires), thus easing the problems of critical wiring at the high (50-mc.) frequency. And finally, the circuit is easily wired for either 6- or 12-volt cars. In fact, the only other components needed to round out a mobile station are a receiving converter and a whip antenna.

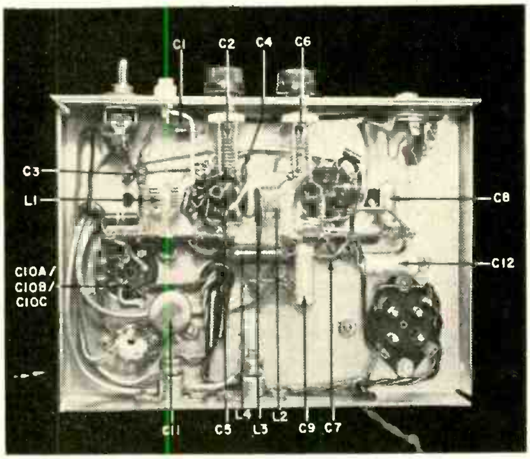
Construction. After drilling and punching the chassis, make certain that the major

Inexpensive transmitter puts out approximately five watts with power supply shown. Crystal-controlled, the rig can be constructed for either 6- or 12-volt cars.









Two views of underside of chassis, showing location of principal parts. Leads should be as short as possible.

parts are oriented properly before fastening each one in place. The lugs on the tube sockets, for example, should be positioned as shown in order to keep leads short. Note that the center lugs on the two large terminal strips serve as both mounting feet and grounds.

The neon bulb (*I1*) is simply pushed through a rubber grommet on the front panel and held in place by friction. Be sure to install a ground lug on top of the chassis under one screw which holds the socket for tube *V1* (this screw is nearest the front panel). The lug receives one lead of resistor *R5;* the other lead is soldered directly to one of the leads on neon bulb *I1.*

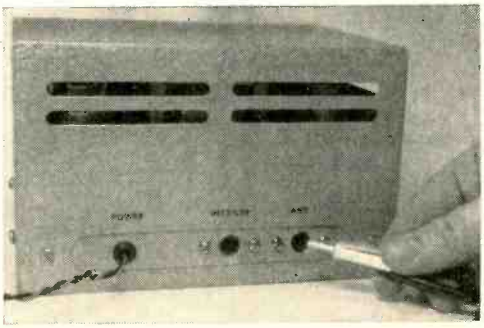
Standard #20 hookup wire is suitable for most of the wiring, although coil *L3* in the antenna circuit is a 1½-turn pickup link fashioned from a short piece of #20 enameled magnet wire. Wind it around a ½"-form (the author used a tubular capacitor), slip it off, and solder it in place. When properly mounted, it should *almost* touch *L2.*

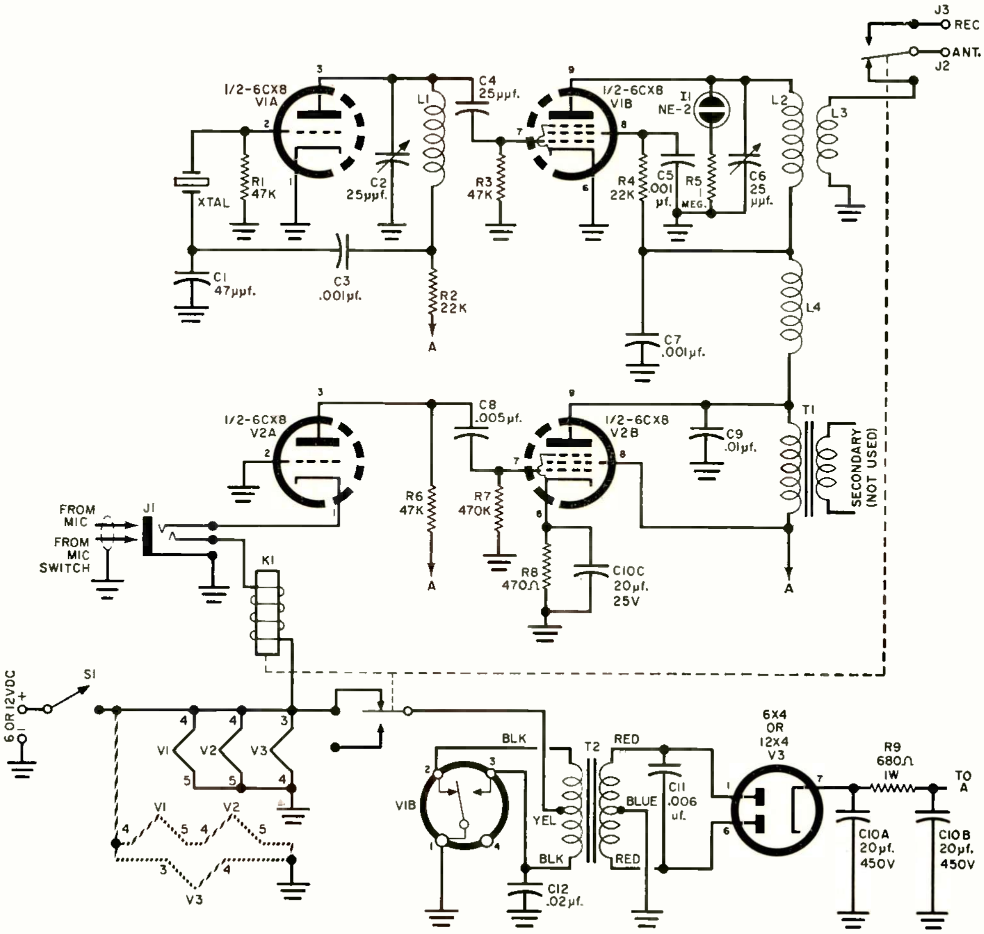
The three cables coming from relay *K1* are shielded; ordinary phono cable will serve very nicely. Note that in each case the shield grounds at only one end of the cable (at the underside of the chassis).

6 or 12 Volts. The rig as shown is wired for a 6-volt auto ignition system. The alternative, 12 volts, is achieved by one wiring and four component changes—simply substitute the parts given under the heading "For 12-Volt Operation" in the Parts List. The wiring change is to connect the heaters of tubes *V1* and *V2* in series instead of in parallel (see schematic). Otherwise, everything remains the same—pin numbers, layout, etc.

Checkout and Tune-Up. After checking carefully for possible wiring errors, plug

Almost any carbon microphone equipped with a press-to-talk switch is satisfactory, but its plug must be wired to match jack J1. Due to switching by relay K1, only one antenna is needed.



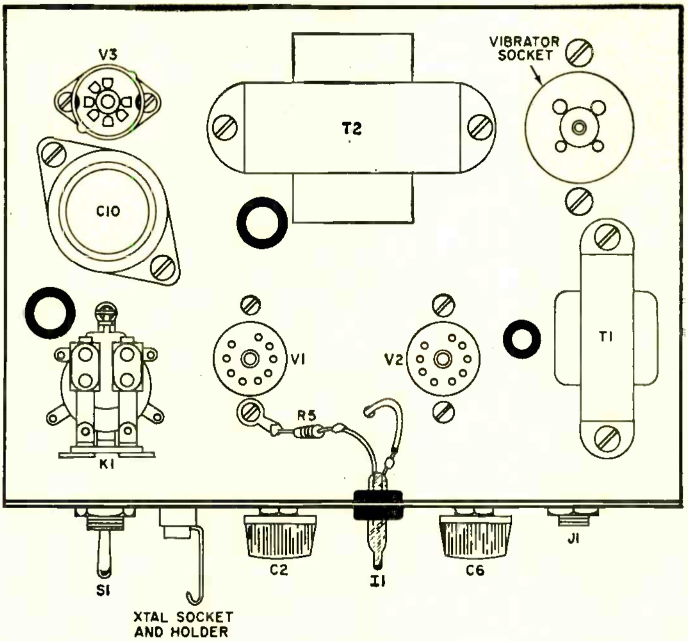


PARTS LIST

C1—47-μμf., 600-volt disc capacitor
C2, C6—25-μμf. variable capacitor (Johnson 160-110 or equivalent)
C3, C5, C7—0.001-μf., 600-volt disc capacitor
C4—25-μμf., 600-volt disc capacitor
C8—0.005-μf., 600-volt paper capacitor
C9—0.01-μf., 600-volt paper capacitor
C10a/C10b/C10c—20/20/20 μf., 450/450/25 volt d.c. electrolytic capacitor (Mallory FP345.8 or equivalent)
C11—0.006-μf., 2000-volt disc capacitor
C12—0.02-μf., 600-volt paper capacitor
I1—NE-2 neon bulb
J1—2-circuit phone jack
J2, J3—Auto-type antenna jack
K1—D.p.d.t., 6-volt d.c. antenna switching relay (Potter & Brumfield KT11D-6VDC or equivalent)
L1—6 turns of B & W 3003 coil stock
L2—5 turns of B & W 3003 coil stock
L3—1½ turns of #20 enameled wire, ½" diameter—see text
L4—7-μh. r.f. choke (Ohmite Z-50 or equivalent)
R1, R3, R6—47,000 ohms
R2, R4—22,000 ohms, 1 watt
R5—1 megohm
R7—470,000 ohms
R8—470 ohms
All resistors ½-watt unless otherwise noted
R9—680 ohms, 1 watt
S1—S.p.s.t. toggle switch
T1—Universal output transformer (secondary not used) (Lafayette TR-12 or equivalent)
T2—Vibrator transformer; primary, 6 volts d.c. CT; secondary, 200 volts CT @ 55 ma. (Lafayette TR-77 or equivalent)
V1, V2—6CX8 tube
V3—6X4 tube
Xtal—6-meter crystal, overtone type
1—6-volt, 4-prong vibrator (Lafayette MS-14 or equivalent)
1—7" x 5" x 4½" aluminum utility enclosure (LMB W-1A or equivalent)
1—Carbon microphone—see text
1—2-lug terminal strip, one lug grounded
2—5-lug terminal strips; center lug grounded
Misc.—Shielded cable, sockets, etc.

Alternate Parts for 12-Volt Operation

K1—D.p.d.t., 12-volt d.c. antenna switching relay (Potter and Brumfield KT11D-12VDC or equivalent)
T2—Vibrator transformer; primary, 12 volts d.c. CT; secondary, 200 volts CT @ 55 ma. (Lafayette TR-78 or equivalent)
V3—12X4 tube
1—12-volt, 4-prong vibrator (Lafayette MS-128 or equivalent)



Drawing of top of chassis, with case removed. Neon bulb I1 serves as a tuning indicator and is held in place by a rubber grommet; R5 is soldered directly to one lead and attached to a solder lug under a screw at V1's socket.

HOW IT WORKS

The 6-meter mobile transmitter is comprised of three sections—a transmitter, a modulator, and a power supply. In the transmitter section, tube *V1a* oscillates at the crystal frequency due to feedback through capacitor *C3;* tuned circuit *C2/L1* selects the fifth overtone of the crystal output, which, with a "6-meter" overtone crystal, falls in the 6-meter band. Tube *V1b* is an r.f. amplifier, boosting the oscillator output and delivering it to tuned circuit *C6/L2*. The *L2/L3* combination matches the high impedance of the plate circuit to the low impedance of the antenna.

In the modulator section, tube *V2a* amplifies the weak signals generated by the carbon microphone. Since the microphone is in series with the cathode of the tube, current passing through the tube supplies excitation current for the microphone. In addition, this hookup eliminates the necessity of using an impedance-matching transformer.

The audio signal is further amplified by tube *V2b*. Inasmuch as modulation "transformer" *T1* is in series with the B+ voltage to the r.f. amplifier *V1b*, audio voltage in *T1* will affect the output of the r.f amplifier. This creates the characteristic envelope of amplitude modulation.

In the power supply, the vibrator interrupts the d.c. input, enabling transformer *T2* to step it up to about 200 volts; rectifier tube *V3* and a filter network consisting of *C10a*, *R9*, and *C10b* furnish a smoothed B+. The vibrator is powered when relay *K1* returns the *T2* primary center-tap to the battery, and this occurs whenever the microphone button is depressed, energizing the relay coil. The remaining relay contacts switch the antenna from "receive" to "transmit."

in the crystal and microphone. The circuit is designed for a carbon mike equipped with a push-to-talk button. A Monarch MC-63 is shown here, but there are numerous bargains to be had in army surplus units—the T-17, for example. Just be certain that the button connects the relay coil to ground (through the shield of the mike cable) when it is depressed.

Next, hook a 54" piece of wire to the jack marked *Ant* and apply power. The most important aspect of the initial tune-up is to determine the approximate positions of the two tuning capacitors; unless this is done, you might find yourself operating on the wrong overtone of the crystal. A grid-dip meter is valuable for tuning up, but a near-by receiver equipped with an S-meter will also do the trick.

Tune the receiver to your transmitting crystal frequency, press the mike button, and rotate the oscillator capacitor *(C2)* for a peak on the S-meter. Now tune the final for peak output.

With the vibrator transformer listed, input power of the transmitter is five watts (B+ at *C10a* is about 200 volts). If desired, power input can be boosted by selecting a transformer with a higher rating—up to about 270 volts. No other parts changes are necessary.

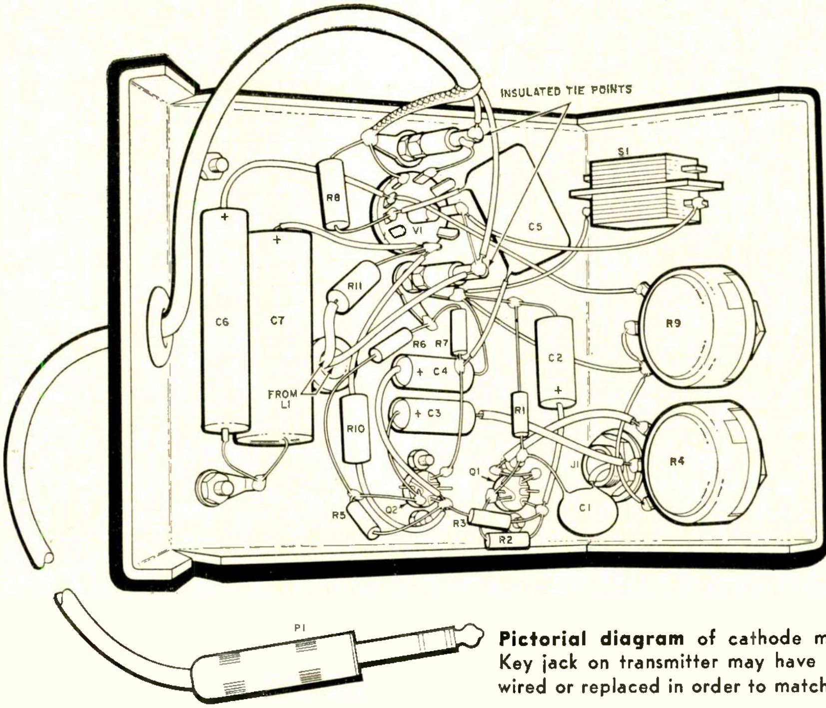
(*Continued on page* 159)

HYBRID CATHODE MODULATOR

By **MARTIN L. KAISER,** W2VCG
Electron Tube Division
RCA Laboratories

Two transistors and a single tube team up to make a low-cost modulator for low-powered amateur rigs

HERE'S a simple modulator specifically designed for amateur transmitters whose plate current during c.w. operation is 120 ma. or less. Compact in size as well as easy to install and remove, it can be used with almost any small transmitter having a keyed final amplifier. Powering the modulator is no problem, since the entire unit —with the exception of the 6BQ5 heater—



Pictorial diagram of cathode modulator. Key jack on transmitter may have to be rewired or replaced in order to match plug P1.

receives its power from the cathode circuit of the transmitter final.

Because the modulator needs no output transformer or bulky power supply, it is well within financial reach of any amateur —Novice and old pro alike. And it's just the thing to turn a Novice or standby c.w. rig into a fine amplitude-modulated transmitter.

Construction. The modulator is built in a 5" x 4" x 3" chassis, with gain control *R4*, level-set control *R9*, microphone jack *J1*, and modulate/test switch *S1* mounted on the front panel. For connection to the transmitter, a two-conductor shielded cable is run through the rear of the chassis to a three-conductor plug (*P1*).

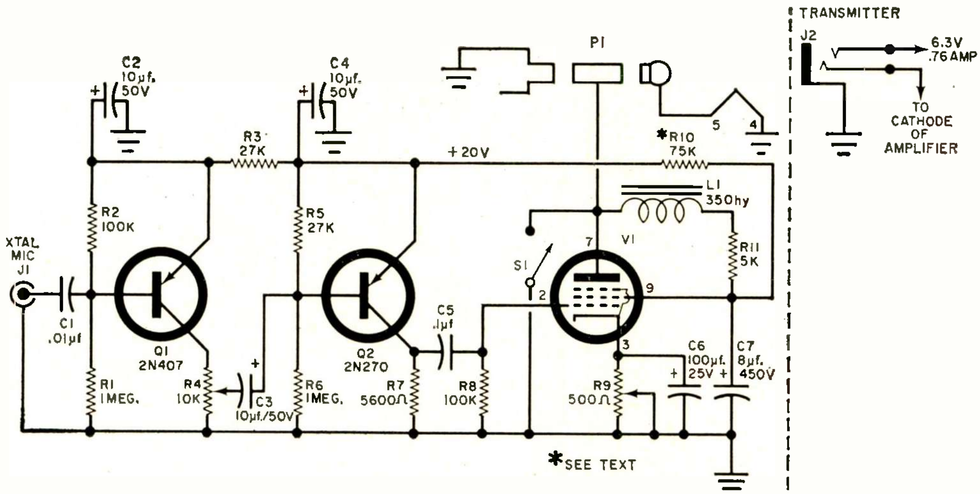
To match this plug, you may have to replace the key jack in your transmitter with a three-contact jack; if you do, a Switchcraft 12B jack should serve nicely. The tip contact should be connected to a 6.3-volt, 0.76-ampere source; the center contact to the cathode of the final; and the other contact should be grounded. Be sure to check connections to the jack and plug with an ohmmeter or other continuity tester to avoid possible damage to the equipment.

Wiring is straightforward and should proceed smoothly; full details appear in the pictorial diagram. Make ample use of spaghetti, and be certain to employ a heat sink when soldering to the transistors.

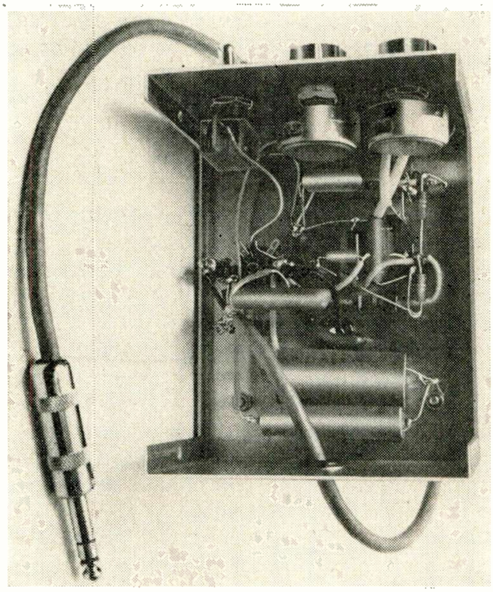
Operation. With the transmitter turned off, plug in the modulator, turn gain control *R4* to zero, set level-set control *R9* at mid-range, and throw switch *S1* to *"Test"* (this will ground the cathode of the transmitter final). Turn on the transmitter and tune it up under c.w. conditions.

Now throw *S1* to *"Modulate,"* and adjust level-set control *R9* until the plate current meter on the transmitter final reads one-half its c.w. value. Next, speak into the microphone at a normal level and turn up gain control *R4* until the meter starts to "kick" heavily. This is the point of maximum modulation, and you are now on the air with amplitude-modulated phone.

About the Circuit. Even though the modulator is connected in series with the cathode of the transmitter final, it is basically of the grid-bias type. Since the audio signal controls the cathode voltage of the final, the modulator effectively governs the final's plate current.



Schematic diagram of modulator. Modulate/test switch S1 is shown in "modulate" position; resistor R10 should be selected to produce about 20 volts at the emitter of Q2.



PARTS LIST

C1—0.01-µf., 50-w.v.d.c. ceramic capacitor
C2, C3, C4—10-µf., 50-w.v.d.c. miniature electrolytic capacitor
C5—0.1-µf., 75-w.v.d.c. ceramic capacitor
C6—100-µf., 25-w.v.d.c. electrolytic capacitor
C7—8-µf., 450-w.v.d.c. electrolytic capacitor
J1—Microphone jack
J2—3-conductor phone jack (Switchcraft 12B or equivalent)
L1—350-henry, 5-ma. choke (Thordarson 20C50 or equivalent)
P1—3-conductor phone plug (Switchcraft 297 or equivalent)
Q1—2N407 transistor
Q2—2N270 transistor
R1, R6—1 megohm
R2, R8—100,000 ohms
R3, R5—27,000 ohms
All resistors ½ watt unless otherwise noted
R4—10,000-ohm potentiometer, linear taper
R7—5600 ohms
R9—500-ohm potentiometer, linear taper
R10—75,000 ohms, 1 watt (see text)
R11—5000 ohms, 1 watt
S1—S.p.s.t. toggle switch
V1—6BQ5 tube
1—5" x 4" x 3" aluminum box (Bud CU-3005A or equivalent)
Misc.—Sockets, wire, solder, hardware, etc.

The speech-amplifier section of the modulator, using cascaded 2N407 and 2N270 transistors (*Q1* and *Q2*), provides sufficient gain to drive the 6BQ5 power amplifier (*V1*). Resistor *R10* drops the incoming voltage to about 20 volts for the transistor stages, while capacitors *C2* and *C4* provide adequate regulation and decoupling. Resistor *R10,* by the way, is a 75,000-ohm unit in the model, but its actual value is best determined by test; the voltage at *Q2*'s emitter should be about 20 volts.

In the 6BQ5 modulator stage, audio voltage is developed across choke *L1* and bias is set by a variable cathode-bias resistor (*R9*). During peak carrier conditions, the only bias on the final is a small drop across the modulator tube, plus the drop across *R9*. This is a very small percentage of the full voltage. —30—

COMPACTRON

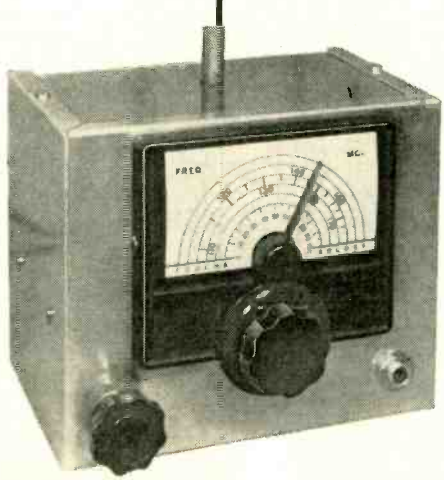
Listen to

- **POLICE**
- **ONE-WAY SIGNALING**
- **HAMS**
- **BUSINESS SERVICES**
- **AIRPLANES**
- **FIRE**

on a triple-purpose single-tube . . .

V.H.F. RECEIVER

By RALPH M. DORRIS, Receiving Tube Department
General Electric Company



THE BAND OF FREQUENCIES (108 to 174 mc.) lying between the FM band and television Channel 7 offers the experimenter a variety of exciting and informative listening—aircraft communications and navigation signals, messages from ships at sea, and so on. Here, too, are "on the spot" reports from police and fire department emergency crews, and even the two-meter ham band.

Commercially available receivers for these frequencies are generally priced beyond the reach of the experimenter or casual listener. But the v.h.f. receiver shown here tunes the entire range, is easy to construct, and can be assembled for less than \$20.00. It uses the General Electric 6D10—one of the new multi-function "Compactron" tubes—as a combination r.f. amplifier, detector, and audio amplifier. And the detector is of the superregenerative type, long noted for its simplicity, extreme sensitivity, and ability to detect either AM or FM signals.

Construction. Although construction of the Compactron v.h.f. receiver is simple and straightforward, keep in mind that v.h.f circuits are critical as to parts placement and lead lengths. For this reason, it's best to follow the layout shown in the pictorial and photographs very closely.

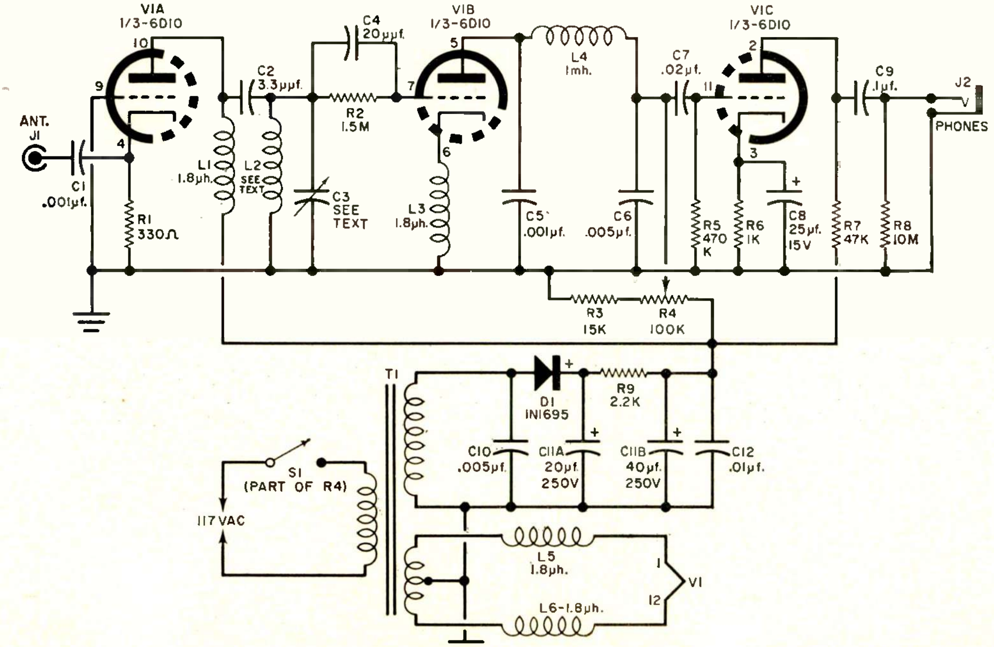
Begin by forming the subchassis. The author used a brass plate and soldered component leads directly to it; however, a printed-circuit board can be substituted if a suitable brass plate is not readily available. In this case, the subchassis would have no lips and could be supported in the cabinet with angle brackets.

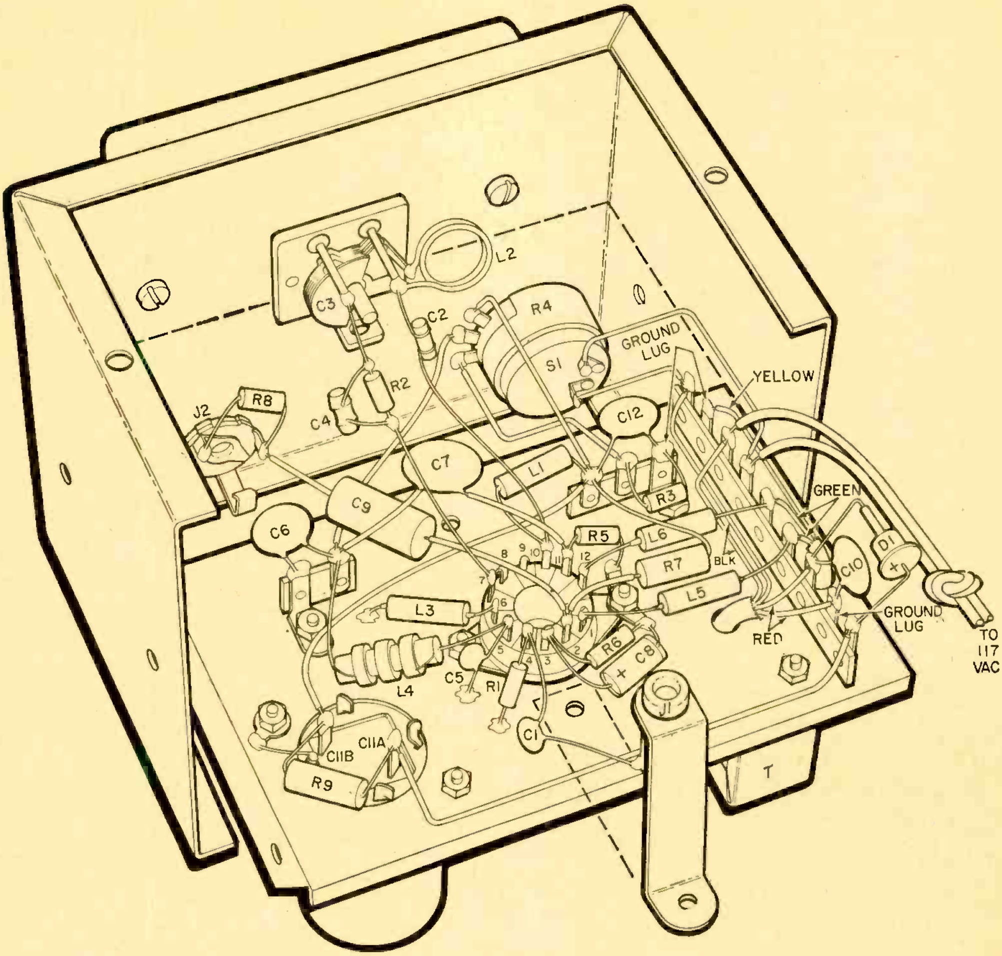
To insure proper fit of the subchassis and correct mating of the tuning capacitor and dial, first drill the required holes in the front of the cabinet as shown in the pictorial

PARTS LIST

C1, C5—0.001-µf. disc capacitor
C2—3.3-µµf. ceramic capacitor
C3—Tuning capacitor (Hammarlund HF-50 or HF-35—see text)
C4—20-µµf. ceramic capacitor
C6, C10—0.005-µf. disc capacitor
C7—0.02-µf. disc capacitor
C8—25-µf., 15-w.v.d.c. electrolytic capacitor
C9—0.1-µf., 400-volt paper capacitor
C11a/C11b—20/40 µf., 250-w.v.d.c., can-type electrolytic capacitor (General Electric XC2-22 or equivalent)
C12—0.01-µf. disc capacitor
D1—1N1695 silicon diode
J1—Insulated banana jack
J2—Open-circuit phone jack
L1, L3, L5, L6—1.8-µh. r.f. choke (Ohmite Z-144 or equivalent)
L2—Tuning coil—see text
L4—1-mh. r.f. choke
R1—330 ohms
R2—1.5 megohms
R3—15,000 ohms
All resistors ½ watt unless otherwise noted
R4—100,000-ohm potentiometer, linear taper
R5—470,000 ohms
R6—1000 ohms
R7—47,000 ohms, 1 watt
R8—10 megohms
R9—2200 ohms
S1—S.p.s.t. switch (on R4)
T1—Power transformer; primary, 117 volts a.c.; secondaries, 150 volts @ 25 ma., and 6.3 volts @ 0.5 amperes (Merit P-3046 or equivalent)
V1—6D10 tube
1—6" x 5" x 4" aluminum chassis box (Bud CU-3007A or equivalent)
1—4" x 7" x 1/32" brass plate (subchassis—see text)
1—Midget panel dial (Millen 10039 or equivalent)
1—Miniature telescoping antenna (Lafayette F-343 or equivalent)
Misc.—Tube socket, wire for L2, hookup wire, line cord and plug, solder, hardware, etc.

The v.h.f. receiver uses a hand-wound tuning coil (L2) and a modified tuning capacitor (C3), as explained in text. If the unit specified for C11 proves difficult to obtain, a 20/20/20-µf., 250-w.v.d.c. electrolytic may be employed instead, with two of the sections wired in parallel.





Parts layout shown in pictorial diagram above must be followed closely for optimum results.

HOW IT WORKS

The v.h.f. receiver employs a single, multi-function tube as an r.f. amplifier, superregenerative detector, and audio amplifier. Its power supply is a conventional transformer-fed, half-wave rectifier.

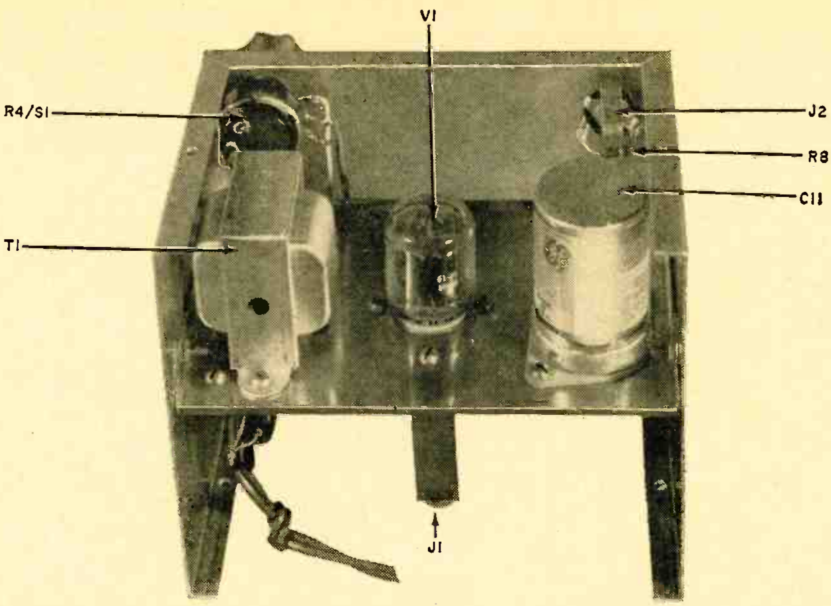
Signals from the antenna are fed through capacitor *C1* to the cathode of *V1a*, connected as an untuned, grounded-grid r.f. amplifier. While this stage provides some gain, its principal function is to isolate the detector from the antenna; the grounded-grid circuit is particularly effective for this purpose, since the grid acts as a shield between input and output.

The output from *V1a* is coupled to the detector *(V1b)* through *C2* and tuned by *L2/C3*. A superregenerative detector of the "hot-cathode" type, *V1b* is brought in and out of oscillation at a supersonic rate determined principally by *R2* and *C4*. This is known as the "quench frequency" and enables the detector to develop tremendous gain without instability.

The last stage *(V1c)* is a conventional resistance-coupled audio amplifier which is fed from the plate of the detector through *C7*. The output, fed to *J2*, is used to drive high-impedance headphones or an external amplifier.

and mount the dial assembly. Second, temporarily insert the shaft of the tuning capacitor (*C3*) into the dial plate. Third, slip the subchassis into the cabinet, then mark and drill the tuning capacitor mounting hole, and fasten the capacitor to the subchassis. Finally, square up the subchassis and—in the case of a brass plate—drill the required holes through the sides of the cabinet and the lips of the subchassis in one operation.

With this done, all holes in the subchassis should be drilled or punched and the remaining parts mounted. The wiring can now be completed (except for the connec-



Inverted view of receiver with cover removed shows placement of major components. All parts are mounted on subchassis except regeneration control R4 and phone jack J2.

tions to regeneration control *R4* and phone jack *J2*) with the subchassis removed from the cabinet. Pins 8 and 9 of the Compactron socket should be grounded by bending them over sharply and soldering them to the metal rim of the socket; then, after the socket is mounted, solder should be allowed to flow between the socket rim and the subchassis.

The tuning capacitor (*C3*) is a Hammarlund HF-50 or HF-35 with all but three stator and three rotor plates removed by twisting them back and forth with a pair of pliers until they break. Tuning coil *L2* consists of two turns of No. 14 tinned copper wire, ½" in diameter and approximately ¼" long.

When all of the subchassis wiring has been completed, the mounting bracket for the antenna jack (*J1*) should be fashioned from a piece of scrap metal and bolted in place. Finally, the subchassis should be fastened into place in the cabinet and connections made to *R4* and *J2*. Drill holes in the cabinet for the power cord and jack *J1* and the unit is finished.

Adjustments and Operation. After carefully double-checking all wiring, insert the antenna, plug in a pair of headphones, and turn the receiver on. When the set has had time to warm up, advance the regeneration control; you should pick up several stations.

If the tuning range is a bit lower than expected, some stations in the upper end of the FM band may be heard; alternatively, if the range is too high and there is a Channel 7 station in your locality, TV signals may be heard. The tuning range can be altered by adjusting the spacing between the turns of *L2*. Squeezing the turns closer together increases the inductance of the coil and thus lowers the frequency range, while spreading the turns farther apart raises it. Once the range is centered, the dial can be calibrated with the aid of a signal generator or by logging several stations of known frequency and plotting a curve of dial readings vs. frequency.

An outside antenna is not recommended for a number of reasons. For one thing, such an antenna might pick up too much signal and overload the detector. Then, too, even though the r.f. stage provides a good degree of isolation, there is always the possibility that the detector will radiate some signal and thus create interference. Even more important, the receiver is so sensitive that the small telescoping antenna is all that is required. —30—

THE MONITOR METER

. . . . checks percent modulation and audio quality, also serves as a sensitive field strength meter

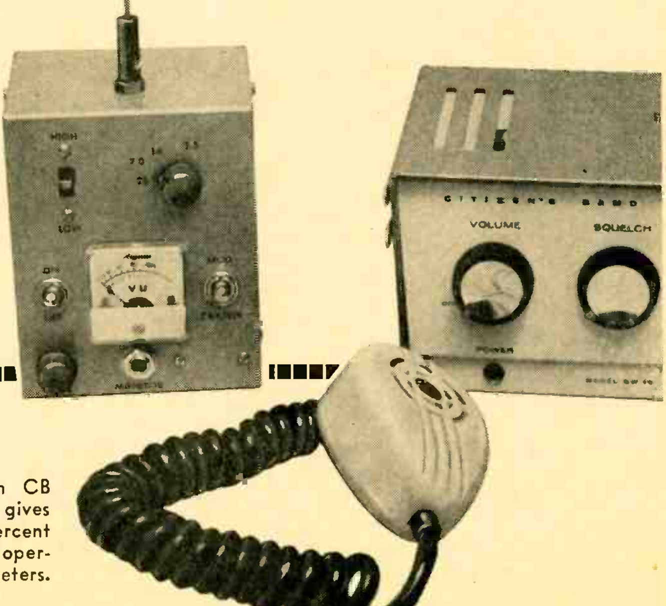
By HERBERT FRIEDMAN
W2ZLF

ALTHOUGH "phone men"— amateurs using phone and all Citizens Band'ers—are usually interested in improving their audio, their checking is generally limited to the reports of stations they contact. And, as most hams and CB'ers have learned, the best of signals can sound pretty bad to some individuals. Even worse, the poorest can sound "good" to others.

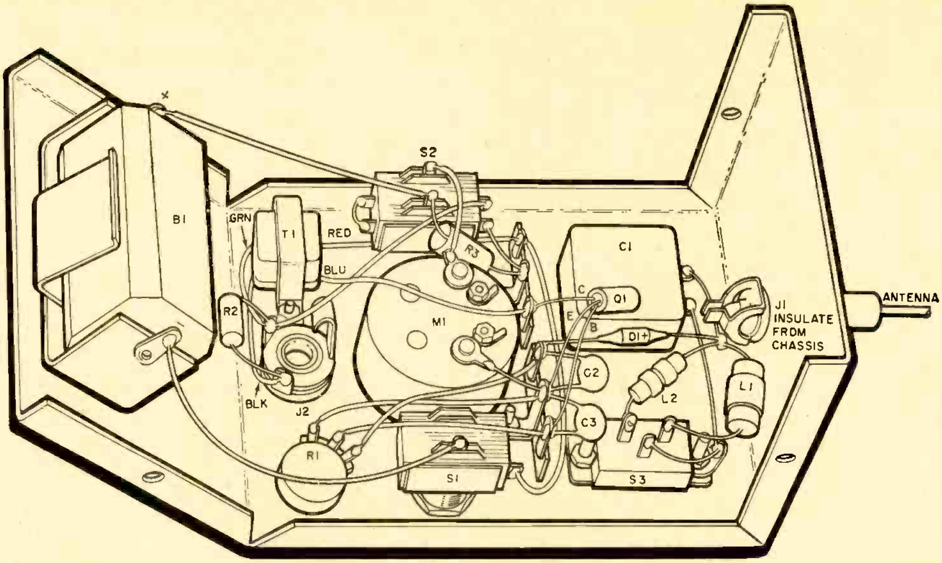
Actually, after all transmitter adjustments have been made and the antenna tuned, it is audio quality alone which can beat interference and static—QRM and QRN. And audio quality goes hand-in-hand with the percentage of modulation. If a modulator having good frequency response and low distortion overmodulates a transmitter, the result is distortion and sideband splatter. And if the audio is crisp and clean but the transmitter is undermodulated, the signal will hardly get through the second layer of QRM—let alone the fifth!

A percent modulation meter with a provision for monitoring will help the "phone man" realize the maximum potential from his transmitter. The "Monitor Meter" described here differs from the usual modulation meter in that it requires no connection to the antenna feedline, thereby eliminating the problem of the meter coupler changing the length of the feedline. Also, no power is removed from the feedline. This may seem unimportant, but at the low output of CB or portable transmitters, even 1 watt is an appreciable loss.

The Monitor Meter is basically an amplified field strength meter. Not only will it function as such, but it will also indicate percent modulation on a VU type-B meter scale, and it has a monitor jack for checking audio quality. Its cir-

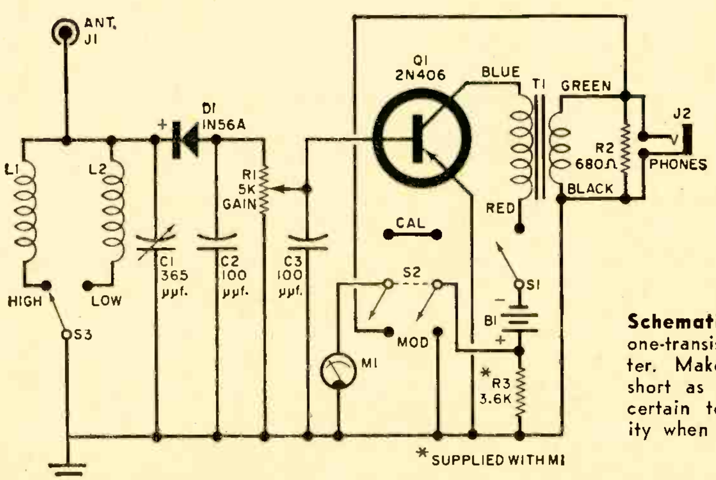


Particularly useful with CB rigs, the Monitor Meter gives continuous indication of percent modulation for transmitters operating between 80 and 10 meters.

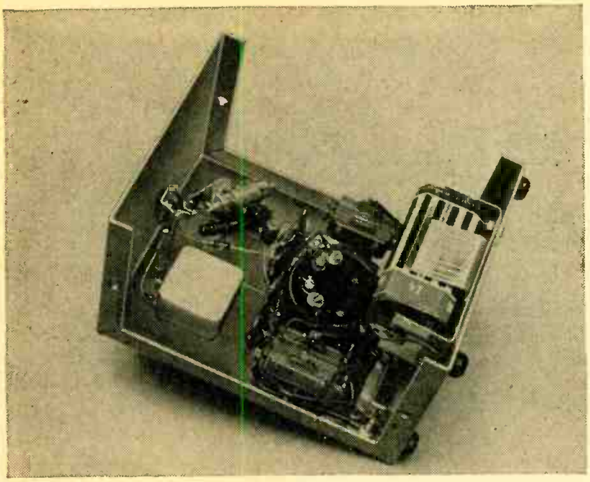


PARTS LIST

B1—6-volt portable radio battery (Burgess Z4 or equivalent)
C1—365-μμf. midget variable capacitor (Lafayette MS-274 or equivalent)
C2, C3—100-μμf. ceramic disc capacitor
D1—1N56A diode
J1—Banana jack
J2—Open-circuit phone jack
L1—0.8-μh. TV filament choke (Miller 6175 or equivalent)
L2—10-μh. r.f. choke (National R-33 or equivalent)
M1—VU meter (Lafayette TM-10 or equivalent)
Q1—2N406 transistor
R1—5000-ohm miniature potentiometer (Lafayette VC-33 or equivalent)
R2—680-ohm, ½-watt resistor
R3—3600-ohm, ½-watt resistor (supplied with meter M1)
S1—S.p.s.t. toggle switch
S2—D.p.d.t. toggle switch
S3—S.p.d.t. slide switch
T1—Miniature driver transformer; primary, 20,000 ohms; secondary, 1000 ohms (Argonne AR-104)
1—5" x 4" x 3" aluminum utility box (Bud CU-3005A or equivalent)
Misc.—Battery holder, wire, solder, hardware



Schematic diagram of one-transistor Monitor Meter. Make all r.f. leads as short as possible, and be certain to observe polarity when wiring diode D1.



Completed unit, with side of box removed. Rubber feet on base lend a professional touch.

The Monitor Meter, which can be used indoors or out, needs no direct connection to transmitter.

cuit is so designed that use of the monitor output does not disable the VU meter, and the unit is tunable from below 80 meters through 10 meters using "stock" coils.

Construction. The meter is built on the main section of a 5" x 4" x 3" aluminum box, with the r.f. components—coils, bandswitch, tuning capacitor, and antenna jack—mounted close together at the top. Before wiring, mount all parts except switches *S1* and *S2*. Complete as much wiring as possible, and then mount *S1* and *S2*. Although all r.f. leads must be extremely short, the audio and power sections can be wired in any convenient manner.

Since most of the components are rather delicate, you'll save yourself some headaches by avoiding the use of a high-wattage soldering iron or gun; a 25- or 50-watt pencil iron should be more than adequate. Use a heat sink when soldering the diode and transistor leads.

Although most components, including transistor *Q1*, are non-critical, the Monitor Meter is designed to operate with the transformer *(T1)* specified. For this reason, no substitution for *T1* should be attempted.

The antenna is made from a section of an unpainted metal coat hanger, 8" to 12" in length, with a solderless banana plug for the connector. Since a solderless plug utilizes a setscrew for connection, it makes a very firm contact with the antenna.

With the wiring completed, you're ready to label the front-panel controls. The position of *S3* which places *L1* in the circuit should be labeled *High;* the other position, *Low*. Label the position of *S2* which places the meter across the transformer's secondary *Mod* (modulation); the other position, *Cal* (calibrate). Potentiometer *R1* is the gain control and should be marked *Gain*.

Check-out and Calibration. Place the battery in its holder and set *S2* to the calibrate *(Cal)* position. Turn the unit on; if

(Continued on page 160)

HOW IT WORKS

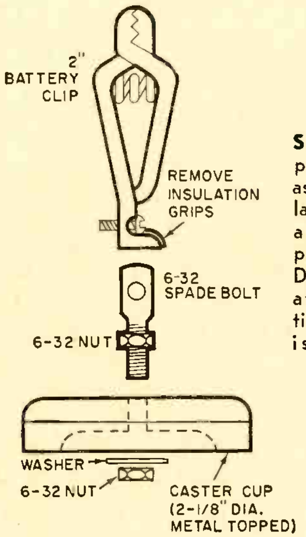
The unmodulated r.f. carrier picked up by the Monitor Meter's antenna is tuned by either *L1/C1* or *L2/C1* (depending on the position of switch *S3*) and rectified by diode *D1*. The resultant d.c. component is applied to the base of transistor *Q1* through gain control *R1*. The applied base current is adjusted so that the collector circuit will develop 1 milliwatt of audio when modulation is applied to the transmitter. In practice, the actual power developed in the collector circuit is slightly greater than 1 milliwatt in order to compensate for losses in transformer *T1*.

The secondary of *T1* is terminated in a 680-ohm resistor (*R2*). Since the VU meter is designed to read 100% when connected across a 1-milliwatt, 600-ohm circuit, the 100% modulation mark represents the collector current which will produce 1 milliwatt in *T1* when modulation is applied.

Plugging a pair of earphones into jack *J2* permits monitoring the signal and thus enables you to check the audio quality.

MIKE STANDS FROM LAMP SOCKETS

By **ART TRAUFFER**

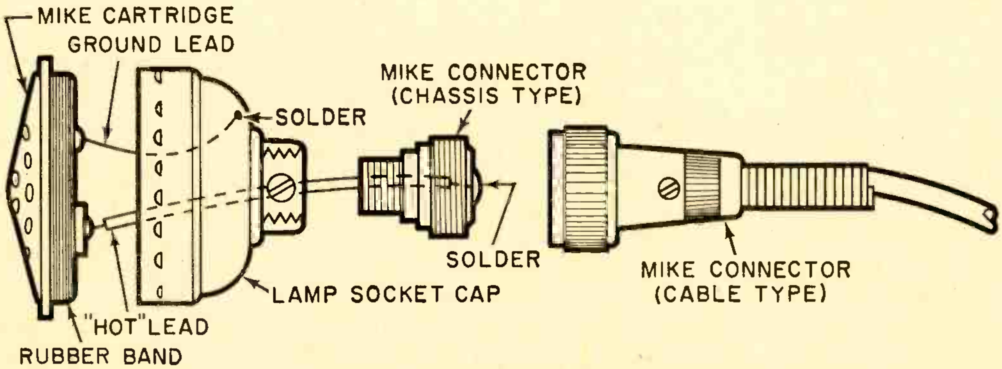


Swivel desk mike pictured above is assembled from a lamp socket cap plus a few other common pieces of hardware. Diagram of stand is at left; construction of microphone is shown below.

THE VARIETY OF inexpensive microphone cartridges now on the market is a challenge to the experimenter's ingenuity. Many of them are sensitive units with good frequency response. Mount one in an appropriate housing and you'll have a useful microphone at little cost.

The author has found that the metal enclosure from an old lamp socket makes an almost ideal housing. Its dimensions are just about right and the threaded mounting collar will accept a chassis-type mike connector. Illustrated here are three designs for lamp-socket microphones.

Swivel Desk Mike. Just the cap of a lamp socket enclosure was used as the basis for the handy desk mike shown on this page. A Lafayette MS-108 crystal cartridge (with a rubber band slipped around it to provide a cushioned press-fit) mounts neatly in the 1½"-diameter mouth. The cartridge's ground lead is soldered to the interior of the cap and the "hot" lead brought



out to a mike connector (Amphenol 75-PC1M) screwed into the cap's mounting collar.

The base is made from a 2⅛" diameter metal-and-rubber caster cup. A 6-32 spade bolt fastened to the cup serves as a swivel mount for a 2" battery clip. The clip, in turn, is clamped to the mike's cable connector.

Desk or Floor Mike. A complete enclosure (with socket and switch removed) houses the mike at right, top. The cartridge used here is a Western Electric magnetic unit (Model MC-253-A), cemented into the front opening of the enclosure. Any cartridge that will fit can be used, of course, and there's even room for a subminiature impedance-matching transformer if necessary.

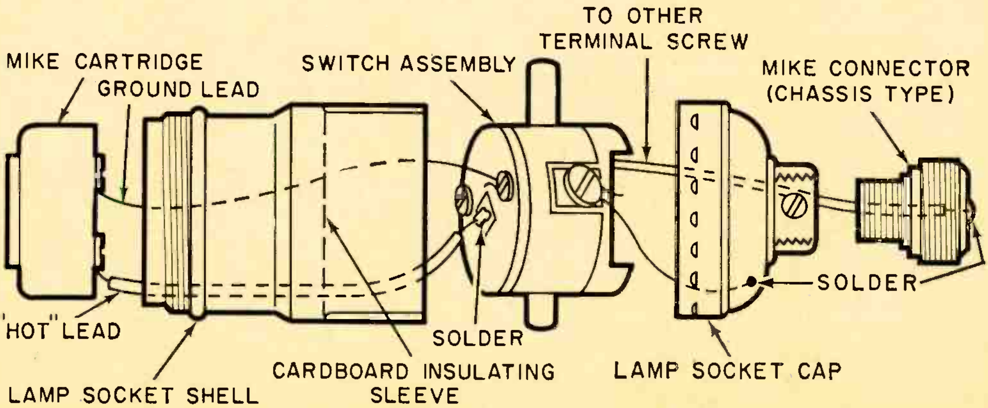
A threaded retaining ring (removed from a cable connector) is soldered to the side of the enclosure to act as a socket for a standard desk or floor stand. Refer to the swivel desk mike diagram for wiring and connector installation.

Hand Mike with Switch. In the hand mike shown directly at right, the socket switch was left in place for use as a microphone control. The threaded lamp holder is removed from the switch assembly and the cartridge ground lead soldered to one of its mounting screws (an ohmmeter check should be made to see which one connects to a terminal screw). The "hot" lead is soldered to the old center lamp contact.

Other wiring and construction details for the hand mike are given in the diagram below. Be sure to use the original cardboard insulating sleeve (cut down so that it just fits the switch) to prevent any possibility of the screw terminals shorting to the enclosure. —30—

Desk or floor stand model utilizes a complete lamp socket enclosure. Retaining ring from cable connector is soldered on to serve as socket for microphone stand.

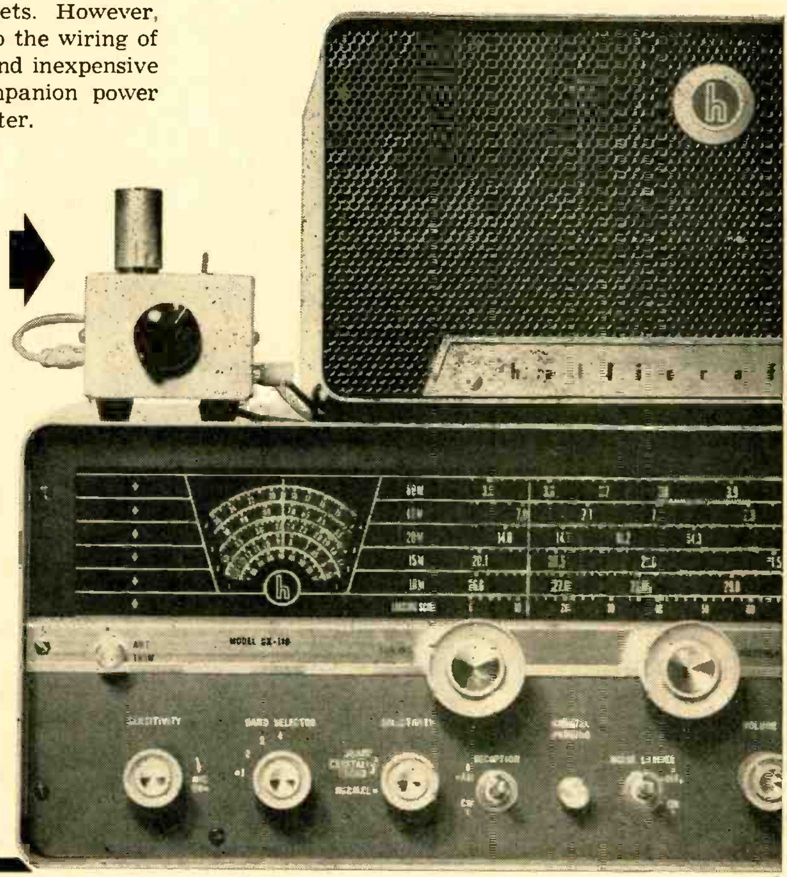
Hand mike below, a variation of the unit above, is turned on and off by original lamp-socket switch. See construction details at bottom of page.



BROADCAST-BAND DX BOOSTER

High-gain r.f. stage brings pepped-up performance to almost any receiver

By MIKE SWINK
KØVVR



DID YOU EVER WISH that your receiver was sensitive enough to pull in DX stations from other states or countries on the broadcast band? Well, here's a one-tube r.f. booster designed to pep up those weak BC-band DX signals. It will give your signal a boost of about seven "S" units if you use a communications receiver. With entertainment-type broadcast receivers, which are normally poor performers, it will have even more spectacular results.

The booster can be powered by stealing plate and heater current from your receiver. If you have a communications set with an accessory socket, you can easily tap the power off there. It will be a little more trouble to borrow power from sets not equipped with accessory sockets. However, if you don't like to delve into the wiring of your receiver, it's a simple and inexpensive job to make the small companion power supply designed for the booster.

Parts needed for the booster alone will cost only about $5 or so. The power supply, if you decide you want to build it, will cost slightly under $10.00. Construction time depends on your skill with tools, but even a rank beginner should have little difficulty with the booster's simple circuit.

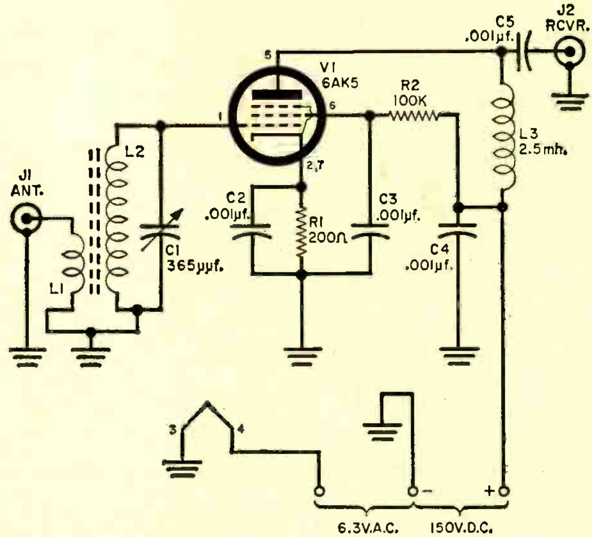
Construction. The booster shown here was built in a 4" x 2¼" x 2¼" aluminum chassis box. A larger box can be used if you wish. In any case, follow the layout in the pictorial. Be sure to mount jacks *J1* and *J2* on opposite sides of the box; both jacks are grounded to the box through their ground strips.

BOOSTER PARTS LIST

C1—365-µµf. midget variable capacitor (Lafayette MS-445 or equivalent)
C2, C3, C4, C5—0.001-µf., 600-volt disc capacitor
L1—30 turns of enameled wire—see text
L2—Ferrite broadcast-band loopstick (Lafayette MS-11 or equivalent)
L3—2.5-mh. r.f. choke
R1—200-ohm, ½-watt resistor
R2—100,000-ohm, ½-watt resistor
V1—6AK5 tube
1—7-pin miniature tube socket, shield base (Amphenol 147-913 or equivalent)
1—1⅜" 7-pin miniature tube shield (Amphenol 5-401 or equivalent)
1—4" x 2¼" x 2¼" aluminum box (Bud CU-2103A or equiv.—see text)
Misc.—Hardware, grommet, rubber feet, knob, etc.

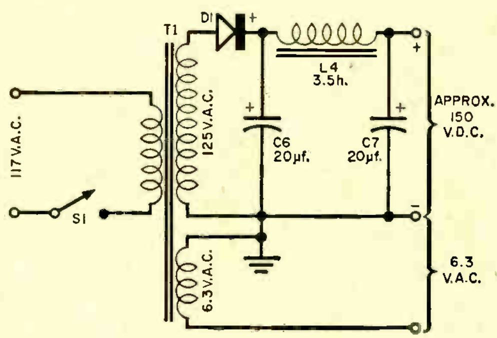
POWER SUPPLY PARTS

C6, C7—20-µf., 250-volt electrolytic capacitor
D1—50-ma., 200-volt P.I.V. silicon rectifier
L4—3.5-henry, 50-ma. choke (Stancor C1080 or equivalent—see text)
S1—S.p.s.t. switch
T1—Power transformer; primary 117 volts a.c.; secondaries 125 volts at 15 ma., 6.3 volts at 0.6 amp. (Stancor PS-8415 or equivalent)
1—2" x 6" x 4" chassis (Bud AC-431 or equivalent)
Misc.—Hardware, binding posts, etc.



The DX booster uses a ferrite loopstick, tuned by capacitor C1, as its antenna coil. Capacitor C5 couples output to receiver.

Small power supply can be built for the booster if no other power source is readily available. Parts list is shown at left.



Coil *L2* is a standard ferrite antenna loopstick; any readily available unit will do, but make certain it fits inside the box you choose. Coil *L1* is made up of about 30 turns of insulated wire wound over *L2*. The exact diameter of wire used for *L1* is not important; anything from No. 28 to No. 32 is fine, and the wire can have either enamel or cotton insulation.

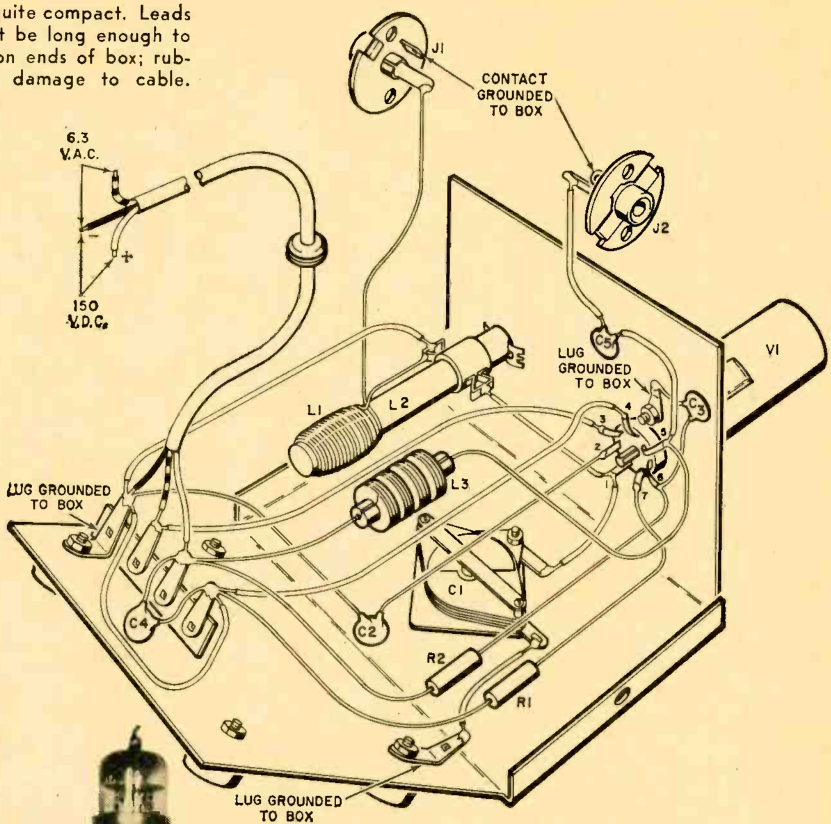
Mount the polyethylene insulated variable capacitor *(C1)* near coil *L2;* be sure to mount coils *L2* and *L3* at right angles to each other and well spaced. Location of the other components is not as critical.

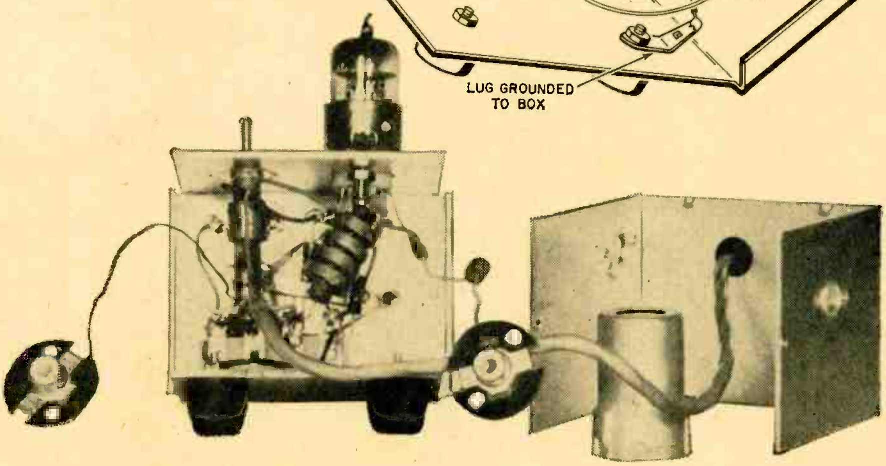
The power supply is built on a separate chassis following the schematic diagram. Parts placement here is not at all critical. For economy's sake, a 1000-ohm, ½-watt resistor could be used instead of filter choke *L4*. Note that a single binding post is used as a common ground for B- and one of the 6.3-volt a.c. output terminals.

Operation. Do not use the booster with an a.c.-d.c. set unless you use the power supply. If you are powering the booster from an a.c. (only) communications receiver, connect the booster's three-wire power cable to a plug that matches the set's accessory socket, if it has one. The exact "B" supply voltage for the booster should be about 150 volts d.c., but *no more than* 170 volts d.c. If your receiver has a 12-volt a.c. heater supply, connect a 36-ohm, 2-watt, 5% composition resistor in series with the booster's *ungrounded* 6.3-volt a.c. heater lead.

With power applied, the booster is ready for operation. Connect a dipole antenna to

Layout of booster is quite compact. Leads to jacks J1 and J2 must be long enough to permit mounting jacks on ends of box; rubber grommet prevents damage to cable.





jack *J1* and connect the receiver's antenna terminals to jack *J2*. For operation with a long-wire antenna, connect only the center (hot) terminal of *J1* to the antenna with a good ground connected to *J1*'s ground.

Tune in stations on your receiver in the usual manner. Then adjust the booster's tuning capacitor *(C1)* for best reception. The slug on coil *L2* can also be adjusted to give operation over the entire broadcast band. Since the bandwidth of tuned circuit *C1-L2* is quite sharp, *C1* will need resetting whenever the receiver's frequency is changed more than 100 kc. If your receiver sports an antenna trimmer, don't forget to use it whenever you tune in a new station; repeak it each time along with *C1*.

Using the booster with a National NC-173 receiver in Kansas, the author has picked up a station on 900 kc. in Mexico City (XEW) 1600 miles away with good results on many nights. Other intermediate-range stations have also been heard with only a 30-foot antenna connected to the booster. —30—

Hi/Low POWER RELAY

Use only the power you need for local or DX contacts

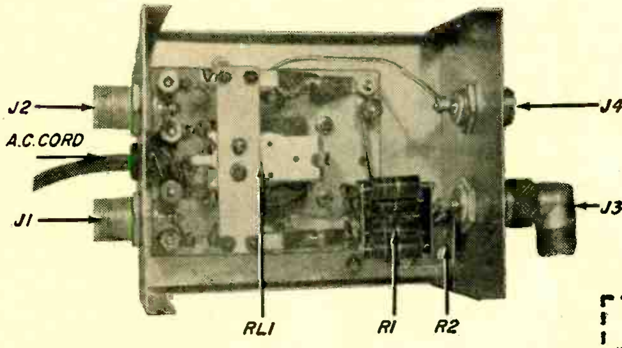
By HERB S. BRIER, W9EGQ

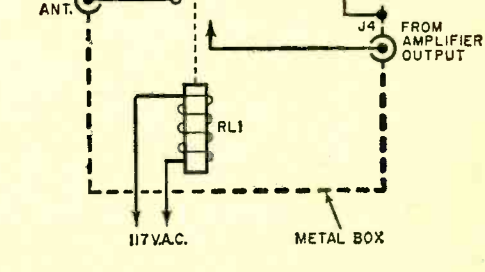
THIS construction project, a low-power/high-power relay, was built by Jim Manning, K9RUH, to permit feeding his antenna directly from his exciter for local contacts or from his power amplifier for DX contacts. It's an easy-to-build unit which lets you comply with FCC regulations by using the minimum transmitter power necessary for satisfactory communications.

When the relay is not energized, the exciter feeds the antenna directly. In the energized position, the output of the exciter is transferred to the amplifier input circuit (either directly or through the optional power attenuator) and the antenna is switched to the amplifier output circuit. The relay is connected to the 117-volt primary circuit of the amplifier's power supply and the switching takes place automatically when the amplifier is turned on.

Construction. Mount the 117-volt, d.p.d.t., antenna changeover relay (*RL1*) on one-half of a two-piece 3" x 4" x 5" utility box, using ½" spacers to center it. Then mount two coaxial connectors on each end of the box, keeping each set of connectors at least two inches apart; in this way, the chance of r.f. feedback between the input and output connectors is mini-

(*Continued on page* 156)





Relay circuit for automatically switching r.f. power amplifier in and out of transmitter. If attenuation is not required, substitute a short bus wire for R1 and omit R2.

PARTS LIST

J1, J2, J3, J4—Chassis-type coaxial connectors (Dow-Key DK-60-P or equivalent)
**R1—Ten 330-ohm, 2-watt, composition resistors connected in parallel*
**R2—Five 150-ohm, 2-watt composition resistors connected in parallel*
RL1—D.p.d.t., ceramic-insulated antenna changeover relay; approx. 2" spacing between poles; 117-volt a.c. coil (Ameco Type 51 or equivalent)
1—5" x 4" x 3" two-piece aluminum utility box (Bud CU-2105A or equivalent)
**4—Squares of "flashing" copper; two 1½" and two ¾"*
Misc.—⅜" grommet, ½" spacers (four), #14 or #12 solid copper wire

**Parts used for optional attenuator*

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Chapter 4

Hi-Fi and Stereo

THE MOST LIKELY AREA for experimental electronics in the field of hi-fi/audio is the speaker system. In this chapter some 12 pages have been devoted to two unusual speaker system designs. One of them—the "Sweet Sixteen"—uses 16 small 5" speakers to achieve broad sound distribution at low distortion levels. The idea behind the design of this speaker system dates back to the 1930's. We don't claim that it is an original design, but only that it is intriguing and many audiophiles find it equal to systems costing three or four times as much.

This chapter also includes plans for a space-saving speaker system. In this design, the speaker faces upward and the treble notes are dispersed by a special conical reflector. It is unusual in that the bass resonant point has been damped and flattened out so that the overall frequency is quite uniform.

In addition, there is a low-cost, conservatively-rated monaural power amplifier construction project (page 92) plus suggestions on stereo testing techniques, stereo headsets, speaker and equipment mountings, etc.

Sweet Sixteen

Compact enclosure delivers solid sound from sixteen 5-inch speakers

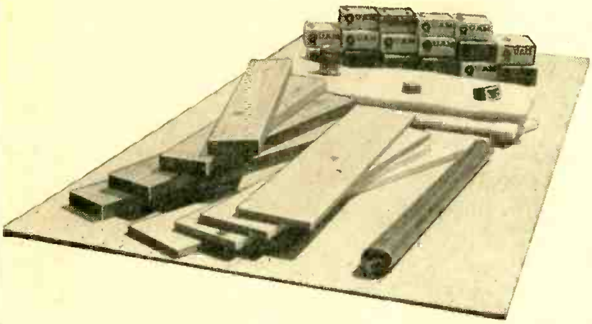
By JIM KYLE, K5JKX/6

CRISP, solid, bass reproduction—a hallmark of highest fidelity—can be yours for a little over $50 and a week-end's work. And there's no catch, even though $250 is a more likely price for a full-range speaker system capable of delivering useful output to 30 cycles and below.

The classic method for providing good bass response calls for big speakers, heavy magnets, low resonant frequencies, and carefully matched enclosures. This approach provides superlative sound in the bottom octaves, but its price tag is pretty super, too.

The performance of the "Sweet Sixteen" system is virtually unbelievable to those who haven't heard it. Coloration of sound—characteristic to some degree of almost every system—is conspicuous only by its absence. Useful response extends to 20 cycles—well below audibility—and is reasonably flat from that point up to just below 10 kc.

Unlike many hi-fi systems, this setup requires little driving power. Five "clean" watts applied to the system will drive all



Required parts are few, but it's best to gather all of them together in one place before you start to work on the system.

but the most hardened hi-finatics out of the room. And the system will handle more than 30 watts without audible distortion.

Multiple Speaker Setup. The secret of the setup is hinted at in a good many reference books, and several similar systems have been built and described. (See September, 1960, POPULAR ELECTRONICS, for one of the most recent and most elaborate systems, built for the Wright Air Development Center.) Yet the idea appears to have been almost completely ignored by most audiophiles.

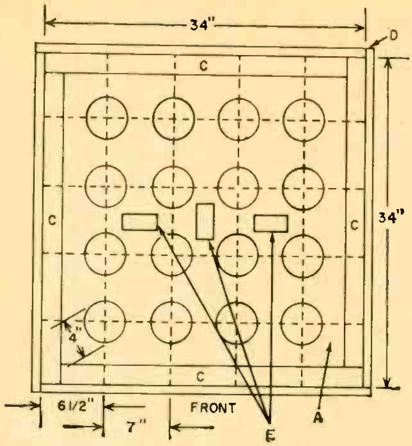
Here's how it works. Instead of mating a big woofer (to handle the bass) with a specially designed tweeter (for mid-range and treble), a large number of small speakers are made to work in unison. At low frequencies, the small cones acting together move the air just as if they were one huge unit. In the mid-range, their low mass and high efficiency produce results not attainable with a single larger speaker.

By using many speakers together, the peaks and valleys in each individual unit's frequency response tend to be statistically averaged into a smooth characteristic, difficult to attain with a single unit. The price tag is kept down, surprisingly enough, by the use of inexpensive replacement-quality speakers. Operated at extremely low power levels, these speakers are capable of hi-fi response even though the output from each speaker is so low that it can barely be detected at close range in a quiet room.

With enough of the small speakers working together, sound output comes up to a more-than-usable value. It's theoretically possible (and based on observations made with this unit, perhaps practical) to build a system which will reproduce frequencies as low as one cycle if you just use enough speakers.

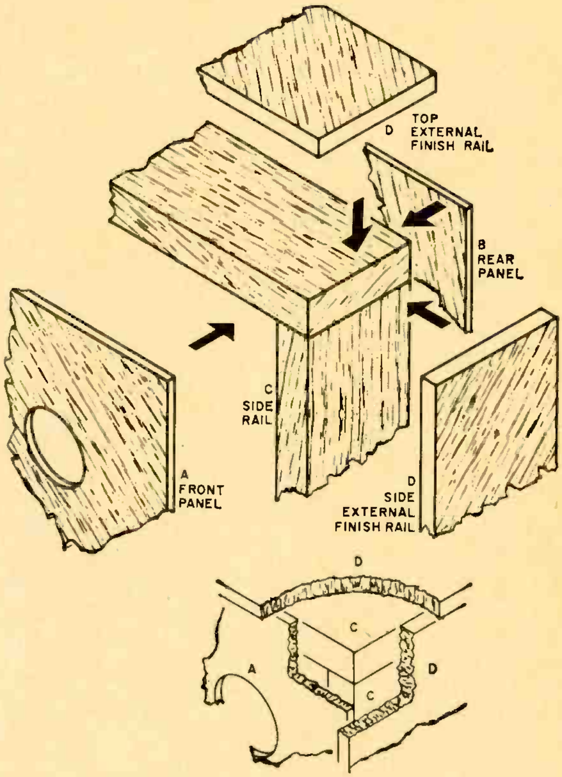
Interconnecting the speakers insures that the power fed to each remains small—each cone's movement is in the neighborhood of

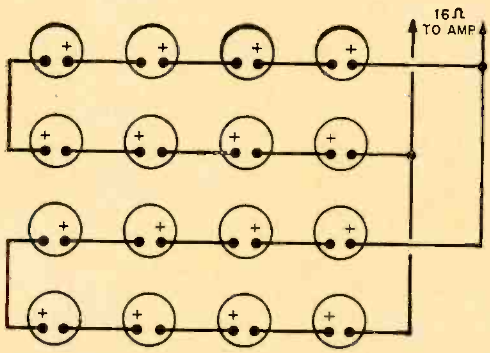
Speaker holes in front panel should be 4" in diameter and can be drilled most easily with a circle cutter mounted in a large electric drill. Side rails are intentionally designed to overlap at corners so they can be trimmed off to size.



Front panel (A) is drilled following layout at left before side rails (C) are attached. Spacers (E) can be cut to fit from pieces sawed off from side rails.

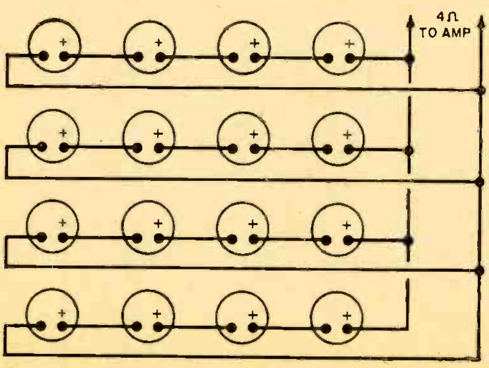
Final assembly is easy following pictorial below. External finish rails (D) hide joints in side rails (C); finish rails are covered with "Contact" material.





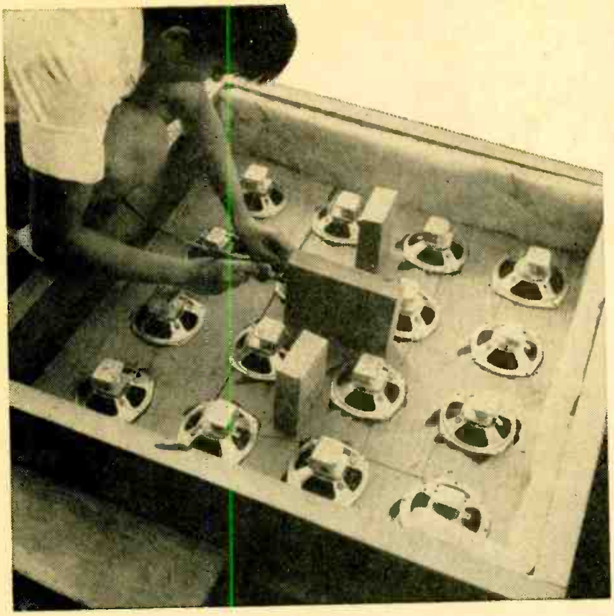
Wiring diagram for use with a 16-ohm amplifier output. See text for instructions on how to phase speakers properly.

Speaker hookup for 4-ohm amplifier. Other series/parallel hookups are possible and should appeal to experimenters.



BILL OF MATERIALS

2—34" x 34" x 5/16" plywood sheets (cut from a 3' x 6' sheet)
4—2" x 6" x 38" side rails
4—1" x 8" x 38" external finish rails
5 doz.—No. 8 flathead wood screws, 1¼" long
64—No. 6 sheet metal screws, ⅜" long
1 sq. yd.—Grille cloth
1 sq. yd.—Acoustic padding or Fiberglas insulation material
16—5" PM speakers (Quam 5AO7 or equivalent)
6 ft.—No. 18 hookup wire
1 sq. yd.—"Contact" table-top material
Misc.—Black screen enamel, staples or tacks, solder, lamp cord, etc.



Connecting individual speakers is easy once you know the impedance you require. Simply use ordinary hookup wire and follow the appropriate schematic on page 82.

only 0.01″ at top volume. Even loud drum passages reproduced at 30 watts cause no visible cone movement.

Simple Enclosure. Resonance problems and tricky enclosures are automatically eliminated in this approach, since they are important only when a speaker is being operated near its power limit. The baffle used with this system is a simple padded box to enclose the sound radiated from the rear of each speaker cone.

Two items are of prime importance for good results with this system. The speaker box must be solid, so don't try to skimp on the side braces or internal supports specified. Important, too, is speaker phasing—individual units must be connected with one another in such a way that all the cones move in the same direction at the same time.

If all of the units are identical, you'll have no trouble. But if you must mix models and manufacturers (and it's sometimes hard to find 16 of these speakers in stock at the same supply house), you'll have to check the phasing before making connections. This process will be described later.

Layout and Construction. The first step, naturally, in building the system is to gather all the materials and components called for in the bill of materials. The only tools required are conventional ones—a ruler, saw, hammer, screwdriver, and soldering iron—but a ¼″ electric drill equipped with an adjustable hole cutter and with woodscrew speed bits will simplify construction.

Begin by laying out and cutting the front and rear plywood panels (*A* and *B* in the diagram) to size. Mark the location of the 16 speaker holes on the front panel (*A*) and cut them out. The hole diameter will be exactly four inches for a 5″ speaker.

If you're using a hole cutter in an electric drill, check the setting by cutting a hole in scrap lumber first. Then drill the hole halfway through the panel from one side, turn the panel over, and complete the cut from the other side. This will prevent the plywood from splintering when the cutter breaks through.

The next step is to attach the side rails (*C*) to the front panel. Note that the rails are overlapped at the corners in such a manner that each can be easily cut to length after assembly. Tack each rail in place with small nails before drilling holes for the assembly screws. Place screws at 6″ intervals down the side, turning them in tightly, and proceed around the square in this manner until all four rails are attached firmly to the front panel.

Cut the extending ends of the side rails off flush. Be sure that the cut edge is even so that the external finish railing (*D*) will fit properly as shown in the illustrations. Save the pieces of 2″ x 6″ you cut off for use in the next step.

Internal bracing is provided by the short pieces of 2″ x 6″ (*E*). Attach them as shown in the photo, at the center and two other spots on the inside of the front panel, using at least two screws in each bracing block.

Now paint the entire front panel black with screen enamel so that the speakers won't show through the grille cloth. Let the paint dry—it shouldn't take more than 30 minutes—before proceeding.

In the meantime, you can attach the acoustic padding to the inside surface of the back panel (*B*), being sure to leave a 2″ clearance at each side for the side rails. Use carpet tacks or a stapler to attach the padding.

After the paint dries, it's time to apply acoustic padding to the inside surface and attach the speakers. Center each speaker over its hole and secure it with No. 6 sheet-metal screws through the mounting holes in the speaker frame. Tighten the screws lightly, and be careful not to damage the cones.

Wiring the Speakers. With all speakers attached, you're ready to wire them up. If phasing must be checked because of mixed models, connect a 1.5-volt flashlight cell to the terminals of each speaker in turn and note whether the cone moves in or out. If necessary, reverse the connections to make the cone move out. Then mark the speaker lug which is connected to the positive terminal of the cell, using a crayon or china marking pencil.

If all your speakers are identical, phasing is not necessary. Simply mark one terminal of each speaker, marking the corresponding terminals on all speakers. Consider the marked speaker terminals to have positive polarity, and wire the speakers together as shown in the diagram. Standard No. 18 hookup wire is satisfactory for connecting the speakers, but it's best to use a generous length of lamp cord for the wire (see diagram) which runs from the system to the amplifier.

(It is not recommended that this system be used with amplifiers that have low damping factors—2.0 or less. When the "Sweet Sixteen" is coupled to a power amplifier that has a low damping factor, the system will sound "boomy.")

At this point, only one step remains to complete the system so far as sound is concerned—attaching the back panel (*B*). Drill a small hole near one corner of the panel and thread the wire from the amplifier through the hole. Then position the back panel on the speaker box and tack it in place temporarily with small nails. Use wood screws at 6" intervals for permanent attachment.

Dressing Up the System. All subsequent construction steps deal with the decorative finish of the system. First, the grille cloth must be attached. It's best to lay it in place, tack the center of one side, stretch the opposite side and secure it, then work from the center to each corner. When two sides are secure, repeat the process on the other two sides. A stapler works well for tacking the cloth in place, and if all tacks or staples are driven into the sides rather than into the front panel, they will be hidden when the external finish railing is attached.

Decorative touch for finished system is furnished by wood-grained covering material purchased from a department store. Cut material to size before applying it.

The 1" x 8" external finish rails (*D*) should be attached in the same "ring" fashion as the side rails—secured by six-penny finishing nails hammered flush, then cut to final length after assembly. Note that they mount flush with the rear of the box, leaving an overhanging lip around the grille cloth. Fill any cracks or knotholes with "Plastic Wood," let it dry, and sand smooth with a fine grade of sandpaper.

Now you're ready to apply the furniture finish, which consists of a square yard of "Contact" table-top material available from larger department stores (usually in the "notions" department). This material, a photographic replica of hand-rubbed wood grain in a number of patterns, is self-adhesive. Simply cut it to size, smooth it down carefully on the finish railing, and your "Sweet Sixteen" speaker system is ready to go! Want to try another for stereo? —30—

Step-by-step instructions for adding a super-tweeter to the POP'tronics "SWEET SIXTEEN" speaker system

Sweet Sixteen

Sweeter with a Tweeter

By JIM KYLE, K5JKX/6

WANT to turn your "Sweet Sixteen" into a speaker system second to none? With an evening's work and an investment of less than $20, you can do it—by adding a super-tweeter.

Response of the basic Sweet Sixteen, described in the preceding article (pages 80 through 84), extends from below audibility to just less than 10,000 cycles. As a basic unit, it's hard to surpass. But for the more sophisticated listener, addition of a super-tweeter to extend the range up past 16,000 cycles can add a whole new dimension of sound.

One of the best comparison tests is to play a record of snare drums through the system. With response flat to 10,000 cycles the drums sound real but somewhat muffled. With the super-tweeter added, the drums seem to move out through the speakers into the room! This test, incidentally, is used by a number of professional critics and equipment reviewers to compare speakers, since the sound of snare drums is one of the most difficult to reproduce.

Hold That Transient! While the addition of the tweeter will sweeten the sound of the entire system if done properly, it can destroy system performance if you're not careful. Here's why:

As explained in the previous article, the Sweet Sixteen acts in different ways at the two ends of the audio spectrum. At the lower end, it behaves like a single, large cone moving a mighty mass of air. In the upper octaves of its range, it becomes 16 independent speakers moving together, preserving transient response because of the small mass of each individual cone. This excellent transient response in the mid-range is the major reason for the system's sweet sound.

Haphazard addition of a tweeter can completely destroy this characteristic, producing muddiness in the mid-frequencies. Conventional crossover networks made up of inductors and capacitors are major offenders in this respect, since the inductance and capacitance usually resonate at some one frequency and reflect an unrealistic load back into the amplifier.

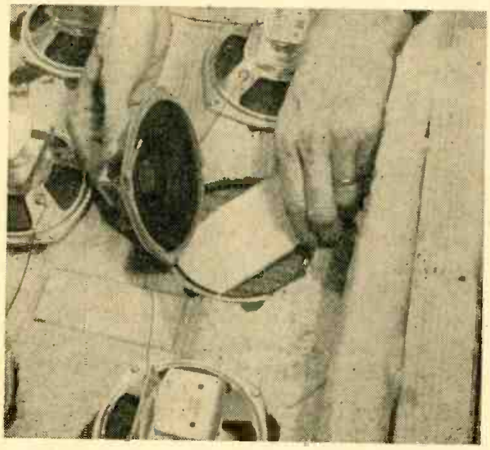
However, if you use capacitance-only high-pass crossovers, the excellent transient response of the system will be preserved. In addition, since frequency response will now extend beyond the limits of hearing in both directions, the result will be almost complete removal of the "loudspeaker wall" between the music and the listener.

Any tweeter used with the Sweet Sixteen must be a high-efficiency unit to be able to blend with the rest of the system. A Calrad Type CT-3 was chosen by the author, but the S-307 (Olson Radio), R90LX762 (Radio Shack), HK-3 (Lafayette) are also suitable; other possibilities include the Electro-Voice T35B and University T202. The procedures described here are based on the use of the CT-3, so the size of the mounting

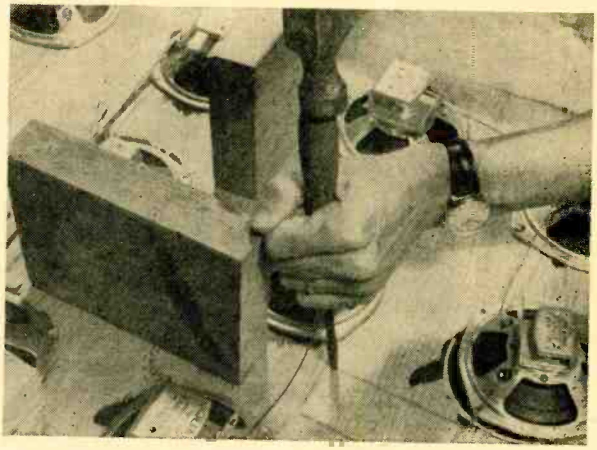
the plywood acting as a "backup," it was then possible to cut the new hole with a sharp wood chisel.

Dimensions and placement of the new hole are shown on the drawing at right—don't forget to remove the backup block and to replace the speaker after the hole is cut.

Since the original Sweet Sixteen used 5/16" plywood for front and rear panels, adding the CT-3 will cause the tweeter horn to project approximately 7/16" in front of its mounting lips. To avoid this projection, cut shims from scrap pieces of 1/4" plywood and place two shims under each mounting lip. (If your Sweet Sixteen uses a 3/8" or thicker front panel, you won't need the shims.)



Backup block slid under front panel protects grille cloth from damage as tweeter hole is cut.



Chisel and hammer combination is best for making required cutout, tweeter placement is not critical.

hole and manner of installation may have to be altered slightly if you choose a different tweeter.

Mounting the Tweeter. Place the Sweet Sixteen face down and remove the back, disconnecting the amplifier leads if necessary. To mount the tweeter on the front panel, it's necessary to cut another hole in the plywood.

Since the panel is already covered with grille cloth which cannot be removed without damage, this new hole can pose a problem. The author solved it by removing one speaker from the panel and sliding a small piece of plywood through the hole thus exposed into the space between the panel and the grille cloth (see photo at left). With

Tighten the tweeter down with the four 3/4" screws specified, and the job is half finished.

Crossing Over. The next step is assembly of the crossover network and presence control. Before this can be done, you must pick the proper value of crossover capacitor, and this value will be determined by the impedance for which your system is built. With a 16-ohm unit, use a 3-μf. capacitor. If your Sweet Sixteen is connected for a 4-ohm impedance, use a 12-μf. capacitor. For other impedance levels, divide 48 by the impedance level in ohms and the result will be the capacitor value in microfarads. Paralleled metallized-paper units will serve very nicely, but do *not* use an electrolytic. Voltage rating of the capacitor does not have to be greater than 50 volts.

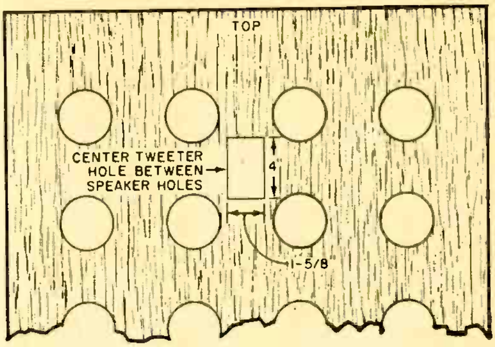
Solder the capacitor to one of the outside terminals of the 50-ohm wire-wound "presence control" potentiometer as shown in photo below, right. Connect 2-foot wires to the other capacitor lead and to the central terminal of the potentiometer.

Next, decide where on the rear panel you want to locate the presence control (the author chose the top center) and drill a ⅜" hole from the outside of the panel. Cut away just enough of the acoustic padding to allow space for the potentiometer, and mount the control on the panel.

Connect the wire from the capacitor to one terminal of the tweeter, and attach another length of wire to the other tweeter terminal. Connect this new wire to one of the amplifier leads, and solder the wire from the presence control to the other lead as shown in the wiring diagram. Phasing is immaterial. Now replace the rear panel.

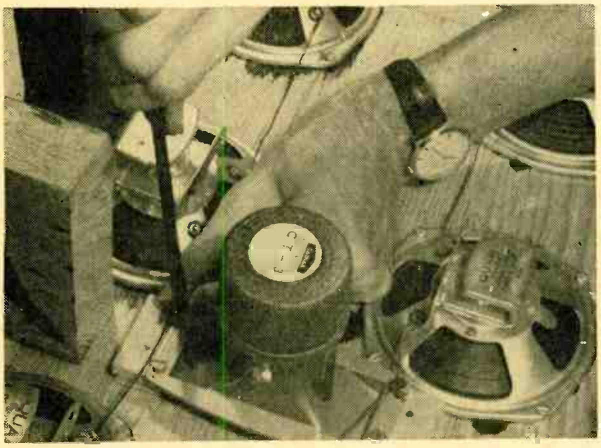
Final Touches. The only thing left to be done is to balance the super-tweeter with the 16 basic speakers. With the presence control at one end of the range, high notes will sound shrill; at the other end, the modification will not be detectable. The proper balance is somewhere in between.

The procedure is simple. Play a record with drums, trumpets, or vocal performances. Set the presence control for least treble, then gradually increase it (amplifier tone controls should be in the flat position).

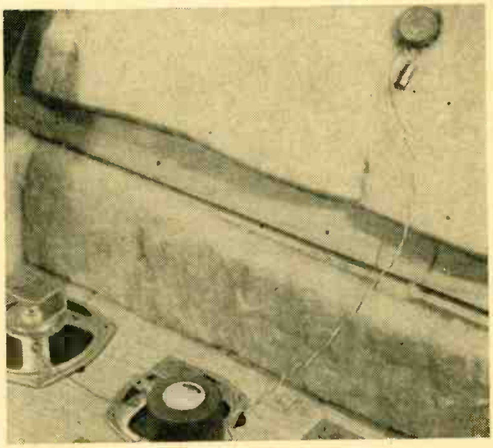


Cutout for tweeter should measure 4"x1⅝" as shown if a Calrad Type CT-3 is used; other tweeters may require a different size hole.

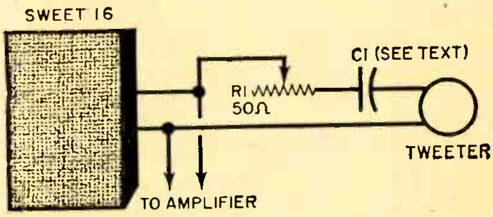
Photos by John Kedroff



Screws hold tweeter securely to front panel; shims prevent unsightly bulge due to projections on horn.



Potentiometer and capacitor are added to prevent low frequencies from reaching tweeter cone.



Schematic diagram of a recommended hi-pass filter for use with super-tweeter.

PARTS LIST

C1—Paper capacitor—see text
R1—50-ohm, 2-watt wire-wound potentiometer
1—Super-tweeter (Calrad CT-3 or equivalent)
4—No. 8 wood or sheet-metal screws, ¾" long
4—¼" x ⅝" x 1½" plywood shims—see text

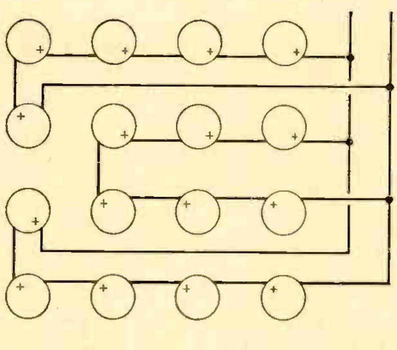
When the drums *just begin* to sound "live," the trumpets "raspy" (like live trumpets), or the vocalists "breathy," you have the proper balance. Further adjustments should be made with your amplifier tone controls.

Some experimenters prefer to test for proper balance with the background hiss audible between stations on their FM tuners. The correct balance between highs and lows is achieved when the higher audio frequencies of the hiss just barely become audible. Technically speaking, this test relies on the use of the so-called "white noise." —30—

MORE ABOUT THE "SWEET SIXTEEN"

Enthusiastic reader response to the original "Sweet Sixteen" speaker system (which was described on pages 80 through 84) has exceeded our wildest expectations. Our offices have been deluged by literally hundreds of letters, and we've done our level best to answer each one individually. Since some of the points raised are of general interest, we thought you might like to hear about them, too.

One of the most frequent questions we have received concerns impedance—many speaker systems are rated at 8 ohms and readers want to use the Sweet Sixteen with existing systems. Several different arrangements will fill the bill, and a hookup which produces an impedance of 7 ohms is shown in the diagram. But we recommend wiring the Sweet Sixteen for 4 ohms as shown in the original article and paralleling it across the existing 8-ohm speaker; don't worry



about the slight apparent mismatch since speaker impedance ratings are only nominal anyway.

An allied question is that of which impedance to use with an amplifier when you have a choice. In this case, the 16-ohm hookup is recommended, since amplifier feedback taps are usually taken from the 16-ohm output. Connecting the system there will bring the speakers more under control of the amplifier's feedback loop.

The next most frequent inquiry has to do with the dimensions of the enclosure. They're not critical; in fact, hardly anything connected with this system is critical—and that's one of its greatest advantages. The box need not be square, and its depth can be whatever you like. Just be careful not to have the cones farther apart than twice their own diameter, or they may fail to couple properly to the air at very low frequencies. Wood thickness can be whatever is handiest, and the final decor can naturally be changed to suit your own taste. However, use of extra-heavy front and rear panels is unnecessary, since the internal bracing and 2" x 6" side rails provide all the physical strength needed.

Although the original article specified Quam Type 5A07 speakers, any similar unit should give equal results. Theoretically, using speakers from a number of different manufacturers should give a smoother response—slight differences in construction would tend to fill in "valleys" and to level "peaks." But using speakers from the same manufacturer does simplify the problem of speaker phasing.

Magnet weight isn't critical. In fact, the 0.65-oz. magnet of the 5A07 is heavier than needed. The only time magnet weight becomes important in a speaker is when the cone is traveling over a long path, and cone movement is imperceptible in the Sweet Sixteen.

Several readers have inquired about using a larger number of smaller speakers or fewer but larger units, and many have asked why the number 16 was chosen. The answers to these questions are interwoven.

If a speaker much larger than 5" is used, cone mass will be larger and transient response will suffer in the upper mid-range. However, bass response will remain good and fewer speakers will be necessary (the author's first system of this type used two 8" and one 12" unit, giving response to 30 cycles and below). If a speaker much smaller than 5" is chosen, many more will be needed for adequate bass response, but treble response will be slightly better. The best compromise is obtained with 5" or 6" speakers, and the 5" unit was chosen so that holes could be cut with a drill rather than with a saber-saw.

Why 16 speakers? Without going into deep theory, it has been determined by experiment that bass response goes down approximately one octave every time the number of speakers is doubled. Thus, with response flat to 320 cycles for a single 5" speaker, two speakers are flat to 160 cycles, four to 80 cycles, 8 to 40 cycles, 16 to 20 cycles, 32 to 10 cycles, 64 to 5 cycles, and so on. To reach 1 cycle, you would need at least 256 speakers. Since true response to 20 cycles will meet all musical needs, 16 speakers were chosen.

By the same token, splitting the Sixteen for stereo use probably wouldn't give the results you would expect. The formula holds true only when all the speakers are close together, so a Split Sixteen would be flat only to 40 cycles, thus losing some of the essential bass.

FM TABLE RADIO TURNS TUNER

By ART TRAUFFER

Improve the sound of your FM receiver by feeding it into your hi-fi system

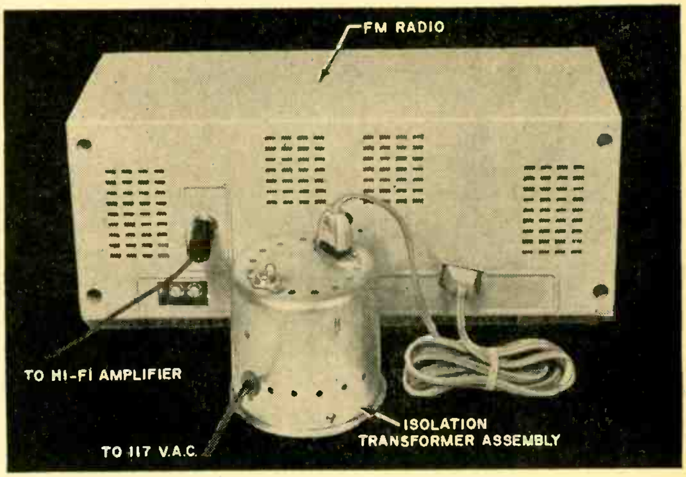
CUSTOM HAS IT that most hi-fi fans start out with an amplifier, a speaker or two, and a changer or a record player—tape decks and tuners seem to come a little later, since the necessary cash is often lacking. As a temporary arrangement, though, the FM section of an FM or an AM/FM table radio can make a fine little tuner for budget hi-fi systems.

Why turn an FM table radio into a tuner? Simply because the performance of such sets is often surprisingly good—prior to the discriminator or detector, at least. But in the audio section, the cost of installing hi-fi circuitry is prohibitive. The result is often a small, replacement-type speaker, inadequately baffled, fed by an inexpensive amplifier that probably produces almost as much hum and distortion as anything else.

The addition of a closed-circuit phone jack can change all this, however, allowing you to turn your table radio into a tuner at will.

Closed-Circuit Jack. All you do is tap into your radio at the output of its FM "detector," and feed the signal into your

The pretty miss at left is listening to the fine sound of FM over a hi-fi setup. The simple modifications made to the FM receiver are shown at right.



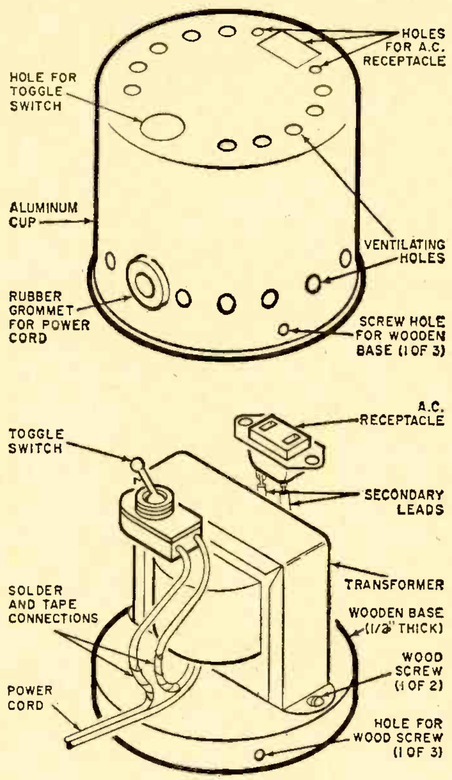
hi-fi amplifier and speaker system. The jack is wired across the radio's de-emphasis capacitor, as shown in the schematic diagram. Although the exact mounting details will vary from set to set, the jack can usually be placed at some convenient spot at the rear of the radio.

A phone plug and a few feet of phono or mike cable feed the tuner output into the input of your hi-fi amplifier. Use low-capacitance cable, and keep it as short as possible to preserve the "highs." If the capacitance of the cable is large and you want to compensate accordingly, the de-emphasis capacitor in your set can be reduced in value in order to produce the required 75-μsec. de-emphasis characteristic.

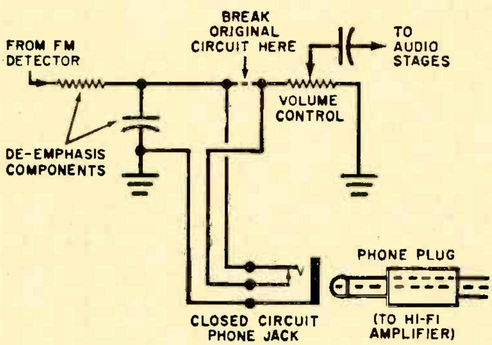
As you can see from the schematic, the table radio's audio section is severed from the "tuner" section whenever the cable from the hi-fi amplifier is plugged into the closed-circuit jack. Since this is the case, volume and tone must be controlled from the hi-fi amplifier or preamplifier whenever you use your receiver as a tuner.

Isolation Transformer. If your FM or AM/FM table radio is of the a.c. type (i.e., containing a power transformer), there is no danger of electrical shock. But if your radio is of the a.c./d.c. type (i.e., without a power transformer), it's almost imperative that you use an isolation transformer between the line and your radio.

Details for constructing a suitable isolation transformer unit appear at right. The



Isolation transformer assembly makes it safe to operate any a.c./d.c. receiver with a hi-fi set.



Schematic diagram shows how a closed-circuit phone jack can be added to your FM radio to permit it to function either as a tuner or as a receiver.

transformer—a Lafayette Type TR-91 or equivalent—is mounted on a round, wooden base, approximately 3$\frac{3}{16}$" in diameter and ½" thick. An aluminum drinking cup, 3½" wide and 3" deep, hides the wiring and improves the appearance of the assembly; a power switch and an a.c. receptacle are provided for convenience.

Although the parts shown here are those selected by the author, construction details are largely a matter of individual choice and will depend to a great extent on what you are able to uncover in your spare parts box. Then, too, individual receivers may necessitate some changes in design. If your radio requires a larger and heavier-duty isolation transformer than that specified, for example, you will naturally have to use a larger cup than the one shown here.

All holes and cutouts in the cup—including those for the s.p.s.t. toggle switch and the Amphenol Type 2R2 a.c. socket—were made with the small blade of a pocket knife and a few small round and flat files. To pass the transformer's power cord through the rubber grommet in the cup, you'll probably have to clip off the plug and put on another. In any case, be sure to provide plenty of ventilating holes in the cup, since the transformer warms up after a few hours' use.

—30—

EASY DOES IT when you're MOUNTING Hi-Fi SPEAKERS

THE audiophile who can set up his own hi-fi system usually knows just what to do with each component. But equally important is knowing what *not* to do.

Take the matter of mounting a speaker in a baffle for instance. To the uninitiated, it looks like little more than tightening a few nuts with a wrench. But to those in the know, proper installation of a speaker in its baffle is as important to good sound as a cleanly shaped point on a diamond stylus.

According to Al Altenhof of Utah Radio & Electronics Corp., the thing to remember is that a speaker is a precision item held to dimensions of several thousandths of an inch. Screwing a speaker to a warped mounting board or tightening the nuts too tight can easily throw most speaker cones out of alignment. Mr. Altenhof recommends following these three easy steps when mounting a speaker:

1. Check the mounting board to be sure it isn't warped.

2. Slowly place speaker on the screws, carefully aligning its holes with the screws to avoid damaging the cone.

3. Tighten the mounting nuts by hand, then use a wrench to give each nut one additional turn. —30—

Utah Radio & Electronic Corp. photos

Check mounting surface before putting the speaker in place to be sure that the surface is not warped.

Be careful to avoid overtightening the nuts. Too much muscle may result in damage or distortion.

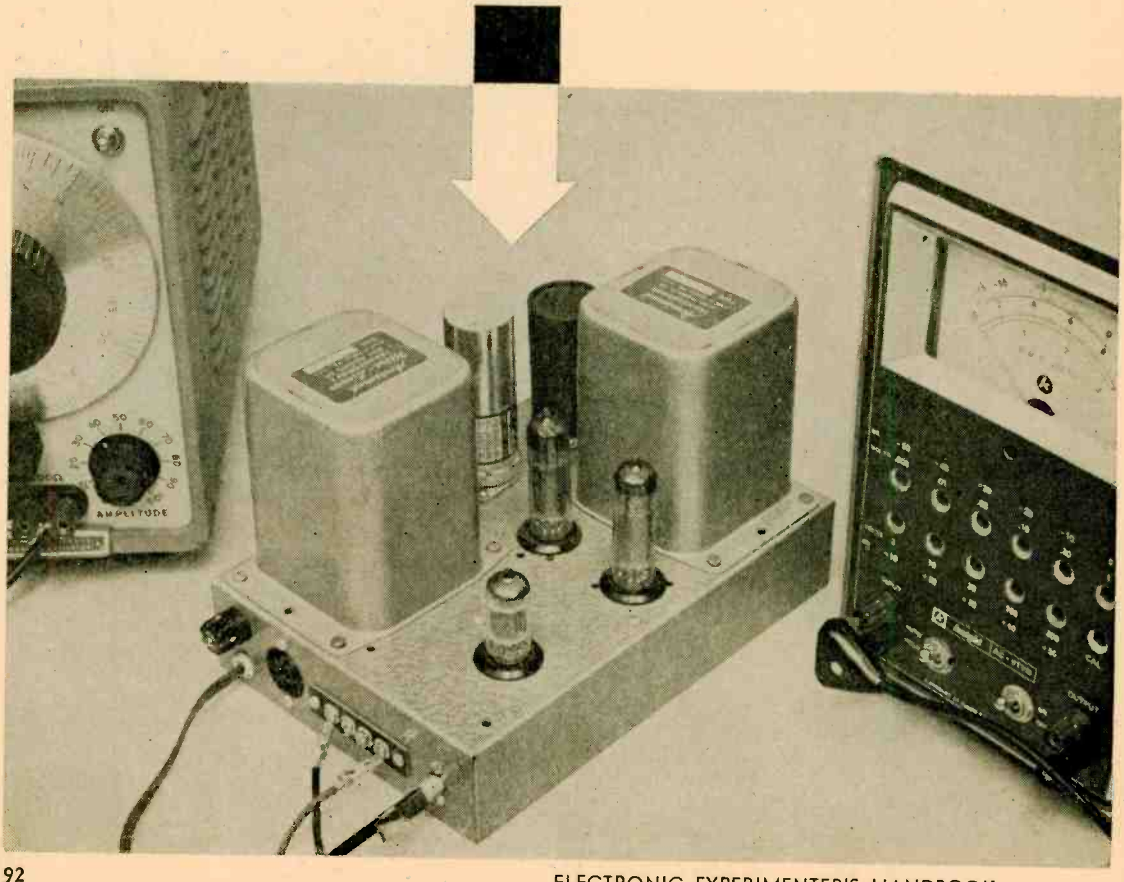
DIRECT-COUPLED

Complete construction details for a superior-quality 18-watt power amplifier with excellent frequency response and low transient distortion

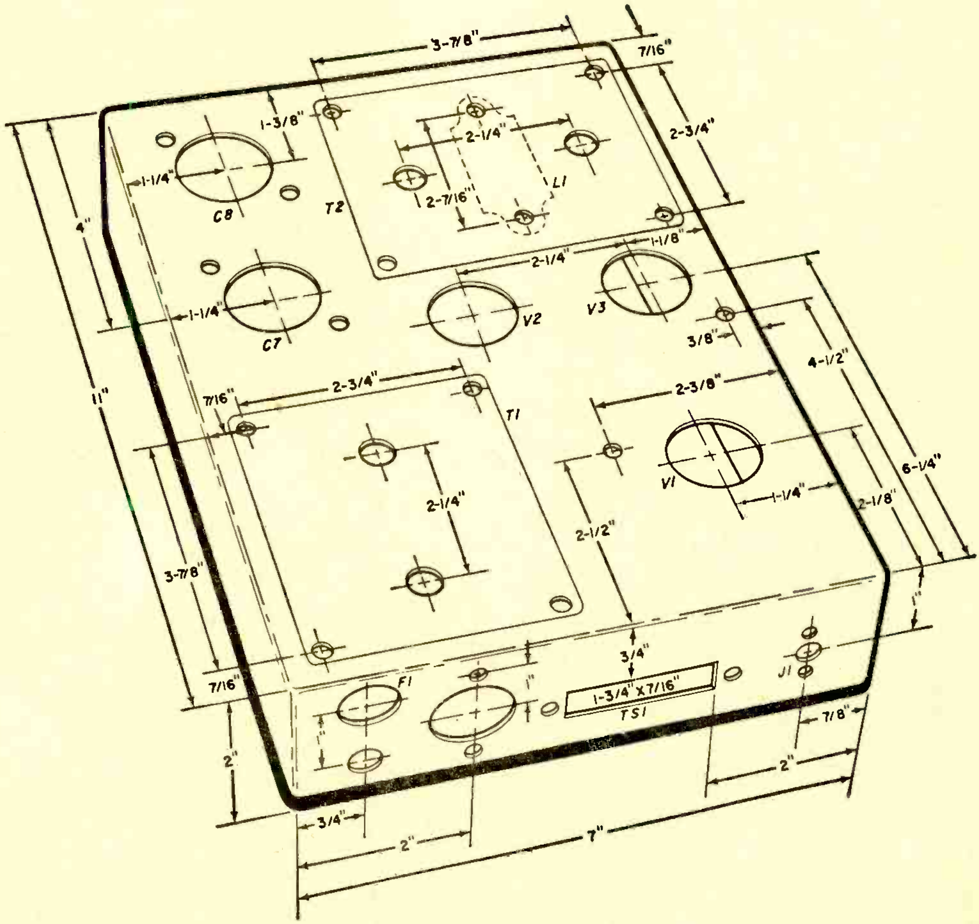
By HERBERT I. KEROES

YEARS AGO, before the hi-fi era, an audio power amplifier was built that sounded better than any other then in existence. This unit was called the Loftin-White amplifier, after its designers, and had many ingenious features. It used direct coupling and a method of bias stabilization that was probably the first application of inverse feedback in an audio amplifier. Overall, it had distinctly better sound—noticeably reduced distortion and better bass response.

The modern theory of feedback amplifiers provides a ready explanation for the improvement brought about by the Loftin-White circuit. Direct coupling reduced the low-frequency attenuation and phase shift, and improved the stability of the amplifier so far as low-frequency transients were concerned. Today we know that an amplifier lacking low-frequency stability sounds weak and puny compared to one that is more stable but less powerful.



HI-FI AMPLIFIER

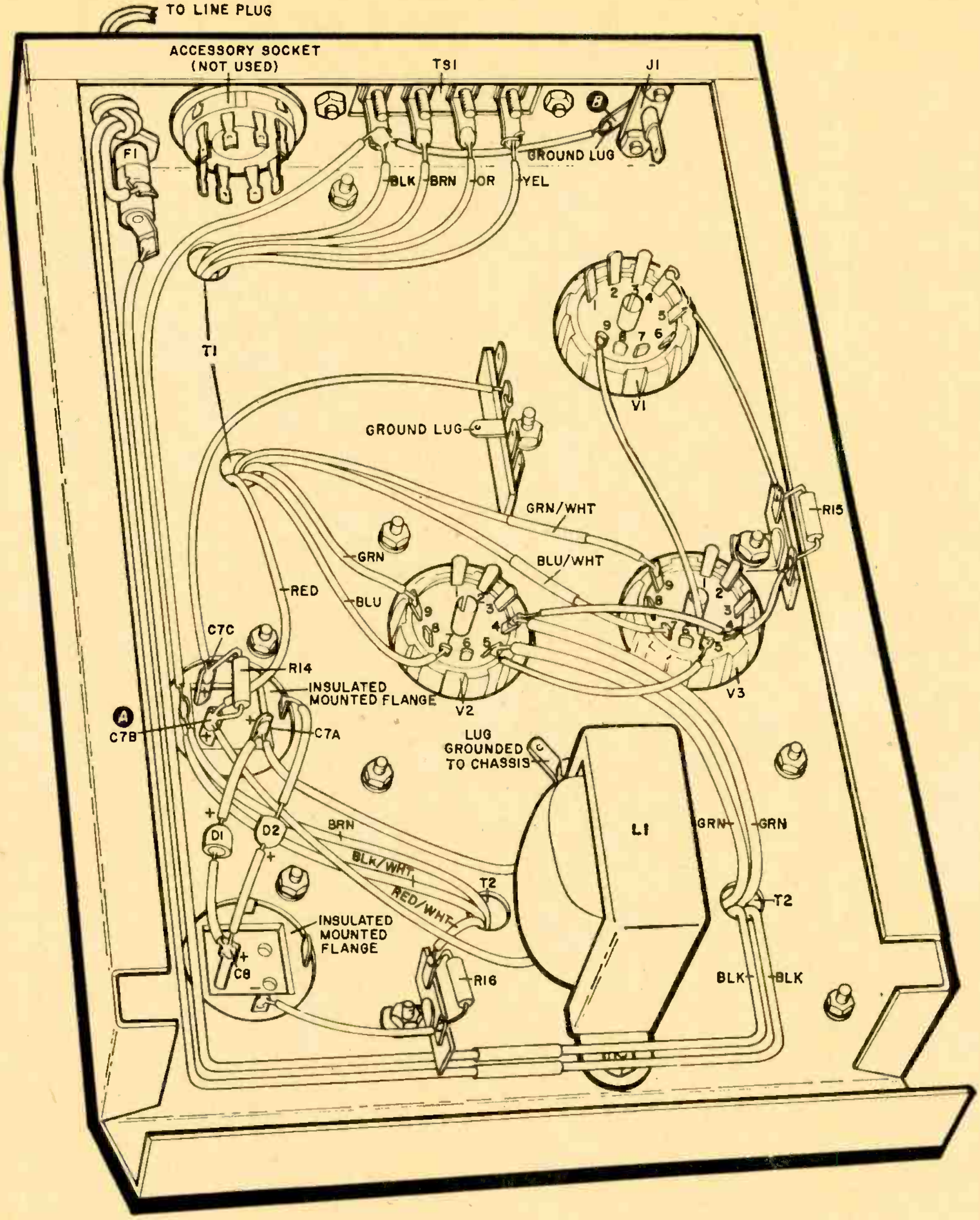


Drill and punch the amplifier's chassis before mounting any components. Filter choke L1 (dashed line) mounts under chassis below transformer T2.

Here is a modern version of the Loftin-White amplifier that is free from distortion, is exceptionally stable, and has excellent frequency response. (See power output and frequency response curve on page 96.) With a push-pull ultralinear output stage and a voltage feedback of 20 db, the resulting amplifier is nominally rated at 18 watts but will actually outperform many amplifiers of considerably higher power.

Printed Circuit Optional. Building the amplifier is exceedingly simple if you follow the pictorial and schematic diagrams. If desired, you can purchase a pre-wired and pre-tested printed-circuit board which contains all of the circuit wiring and components with the exception of the power supply, tubes, and output transformer. The circuit board, the Acrosound Model 20, can be ordered through Allied Radio, 100 N. Western Ave., Chicago 80, Ill.; Lafayette Radio, 165-08 Liberty Ave., Jamaica 33, N. Y.; or Radio Shack Corp., 730 Commonwealth Ave., Boston 17, Mass.

Both the audio output and power transformer used in the amplifier can also be obtained from the above-mentioned suppliers. When ordering ask for the Acro-

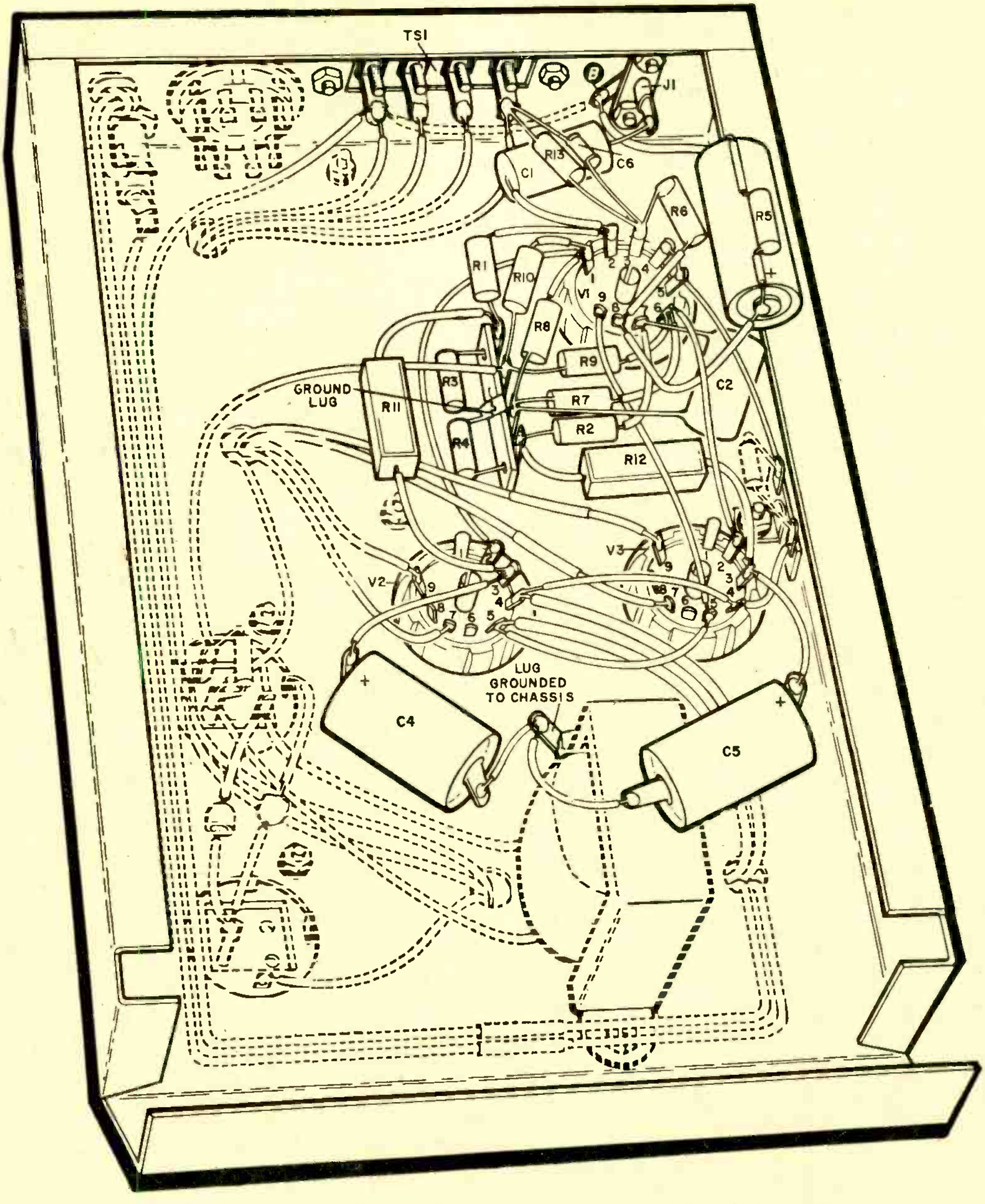


Power supply section of amplifier is completed before audio stages are hooked up. Rectified output appears between points A (positive) and B (negative).

sound TO-370 audio output transformer, (*T1* in the schematic) and the Acrosound TP535 power transformer (*T2*).

If you build the amplifier from scratch without the aid of the printed-circuit board, you will find it helpful to pre-drill the 2" x 11" x 7" chassis following the pictorial diagram shown on page 93. Once the chassis is drilled, the amplifier is built in two steps: first the power supply is wired and tested; then, when the power supply is operating properly, the audio stages are wired.

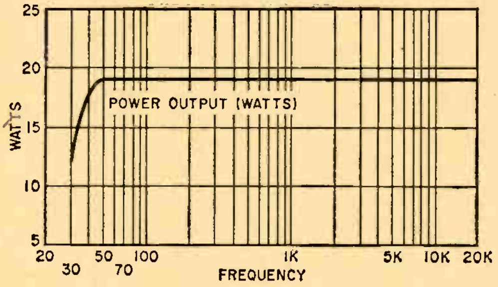
Wiring the Power Supply. Start by mounting all the components shown in the pictorial diagram above and hook up the power supply and output transformer, be-



Audio stages of amplifier are wired last; power supply wiring is indicated by broken lines. Note that circuit is grounded to chassis at only three points.

ing careful to follow the wiring shown. Note that the power supply is grounded at point *B* only and that filter capacitors *C7* and *C8* are both mounted on the chassis with insulated mounting flanges. It is also important to use an insulated fiber sleeve on capacitor *C8*'s can, since both terminals of *C8* are "hot" with respect to ground. And be sure to polarize silicon diodes *D1* and *D2* correctly.

Although an octal accessory socket is mounted on the chassis, it need not be wired unless you wish to power auxiliary equipment such as a preamplifier. If you do, connect point *A* to pin 3 of the octal socket and point *B* to pin 8; these are the 390-volt



Power response of amplifier is shown above for a harmonic distortion of 2%. Note that due to use of a special output transformer the output is flat from 48 to 20,000 cycles. Harmonic distortion at 18 watts output at 30 cycles is less than 3%.

B+ and ground terminals, respectively. You should also connect pins 4 and 5 of *V2*'s tube socket to pins 2 and 7 of the octal socket to supply 6.3-volt heater current for your accessories. Do not ground either heater lead at the accessory socket since the power transformer has a grounded center-tap on the 6.3-volt winding.

PARTS LIST

C1, C2—0.047-µf., 600-volt paper or ceramic capacitor
C3—250-µf., 6-volt electrolytic capacitor
C4, C5—40-µf., 150-volt electrolytic capacitor
C6—100-µµf., 500-volt ceramic capacitor
C7a/C7b/C7c—60/40/20-µf., 450-volt electrolytic capacitor with insulated mounting flange (Cornell-Dubilier C0365 or equivalent)
C8—100-µf., 300-volt electrolytic capacitor with insulated mounting flange (Cornell Dubilier A0340 or equivalent)
D1, D2—Silicon diode, 750 ma., 600 P.I.V. (Motorola 1N1096 or equivalent)
F1—3-amp. slow-blow fuse
J1—RCA phono jack
L1—2-henry, 200-ma. filter choke (Stancor C2325 or equivalent)
R1, R2, R7, R8, R9, R10—1-megohm, ½-watt, 1% resistor
R3, R4—10-ohm, ½-watt, 1% resistor
R5—2200-ohm, ½-watt, 10% resistor
R6—330-ohm, ½-watt, 10% resistor
R11, R12—1500-ohm, 10-watt, 5% resistor
R13—5600-ohm, ½-watt, 10% resistor
R14—220,000-ohm, ½-watt, 10% resistor
R15—6.8-ohm, 1-watt, 10% resistor
R16—22-ohm, 2-watt, 10% resistor
T1—Output tranformer (Acrosound TO-370)
T2—Power transformer; 117-volt, 60-cycle primary; 185-volt, 200-ma., and 6.3-volt CT, 4.5-amp. secondaries (Acrosound TP-535)
TS1—4-lug, screw-type terminal strip
V1—12AX7 tube
V2, V3—EL84/6BQ5 tube
1—Fuse holder
1—2" x 11" x 7" aluminum chassis (Bud AC-407 or equivalent)
1—1⅜" x 3" fiber insulating sleeve for C8 (Mallory CE-6 or equivalent)
Misc.—Nine-pin sockets, octal socket, terminal strips, hardware, etc.

HOW IT WORKS

Input stage *V1* is used as a combination voltage amplifier and phase inverter. This tube operates with "starved" plate current to achieve maximum amplification, a condition created by the 1-megohm plate resistors (*R9* and *R10*). To obtain best linearity and maximum driving voltage, the heater of the tube is also "starved" by means of dropping resistor *R15*.

Direct coupling is used between *V1* and the push-pull output tubes *V2* and *V3*. The cathode current of each output tube flows through a separate resistor, *R3* and *R4* respectively, which is coupled to the corresponding grid of *V1*.

The current feedback through *R3* and *R4* accomplishes several purposes. First, it stabilizes the cathode current of each output tube under quiescent operating conditions. Secondly, the cathode current is also stabilized under dynamic operating conditions to the point where the stage operates almost completely as class A, resulting in minimum distortion. Finally, the stabilized direct coupling produces an amplifier which has only one principal source of low-frequency phase shift, output transformer *T1*; this provides perfect low-frequency stability.

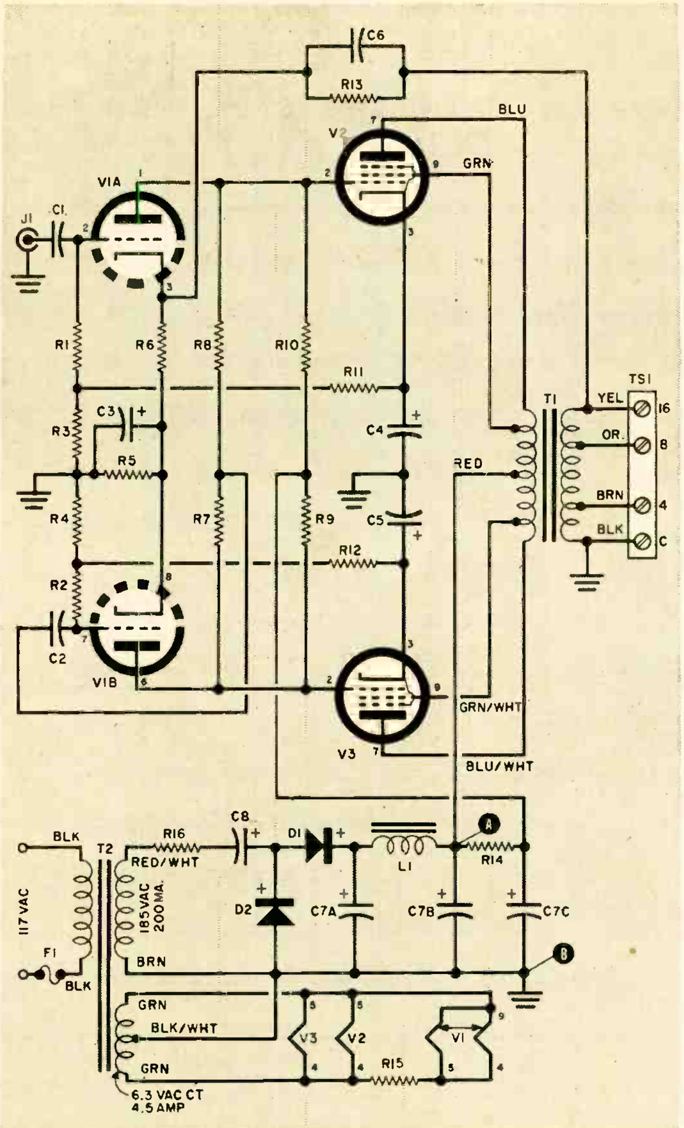
In addition to the current feedback, 20 db of voltage feedback is provided by the capacitor-resistor combination *C6-R13*. The voltage feedback circuit is connected between the secondary of *T1* and the cathode of *V1a*.

Response of transformer *T1* drops only 1 db at 5 cps and 60 kc. The primary halves of *T1* are tightly coupled for distortionless high-frequency performance. Ultralinear screen taps are provided at the optimum ratio for the output tubes used.

When the power supply has been wired, test the resistance between points *A* and *B* with a VOM; you should find that it measures well over 1 megohm with the meter connected a few moments. If you get a low reading, reverse the leads to the meter. Should both readings be low, you probably have a defective filter capacitor (*C7*) or have made a wiring mistake; re-check the wiring against the pictorial and schematic diagrams.

Once the power supply checks out with the VOM, you can give it an operating check. Connect a 5000-ohm, 50-watt resistor between point *A* and point *B*. Power the circuit already wired, and test for 390 volts d.c. between points *A* and *B*. If the desired voltage is present, the power supply is operating under a load approximating actual operation.

Wiring the Audio Stages. With the power supply wired and tested, proceed with the wiring of the audio circuitry fol-



In normal operation, voltage from point A to point B is 390 volts d.c. Heater current to tube V1 is "starved" by use of dropping resistor R15.

lowing the pictorial diagram on page 95. The broken lines on this diagram indicate the power supply circuitry.

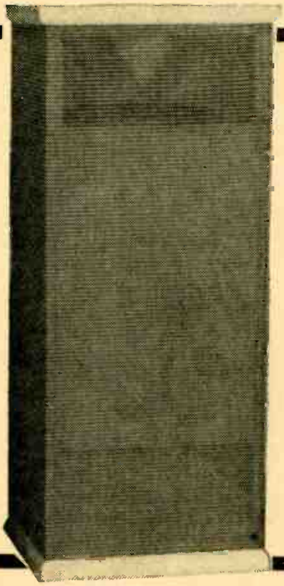
Note that many of the resistors used in the audio stages have 1% tolerance, as mentioned in the parts list. And be sure that the five-lug terminal strip to which most of the resistors are connected has a grounded center terminal. The only other ground connections to the chassis are at the lug under one of choke *L1*'s mounting screws and at the audio input jack *J1* (point *B*).

With all the wiring completed, plug in the tubes and, without powering the amplifier, make a resistance check with a VOM between points *A* and *B*. Any reading of less than 1 megohm after the capacitors charge calls for a wiring check and a test of individual components.

After all tests are completed, connect a signal source with an output of about 1 volt to jack *J1* and hook up an appropriate speaker to the output terminals of *TS1*. The excellent performance of the amplifier should be readily evident. —30—

SPACE-SAVER SPEAKER SYSTEM

By DAVID B. WEEMS



Side view of enclosure, showing its perforated resistive panel. All joints are screwed and glued.

Resonant bass cavity coupled with wide treble dispersion explain this small speaker system's truly amazing performance

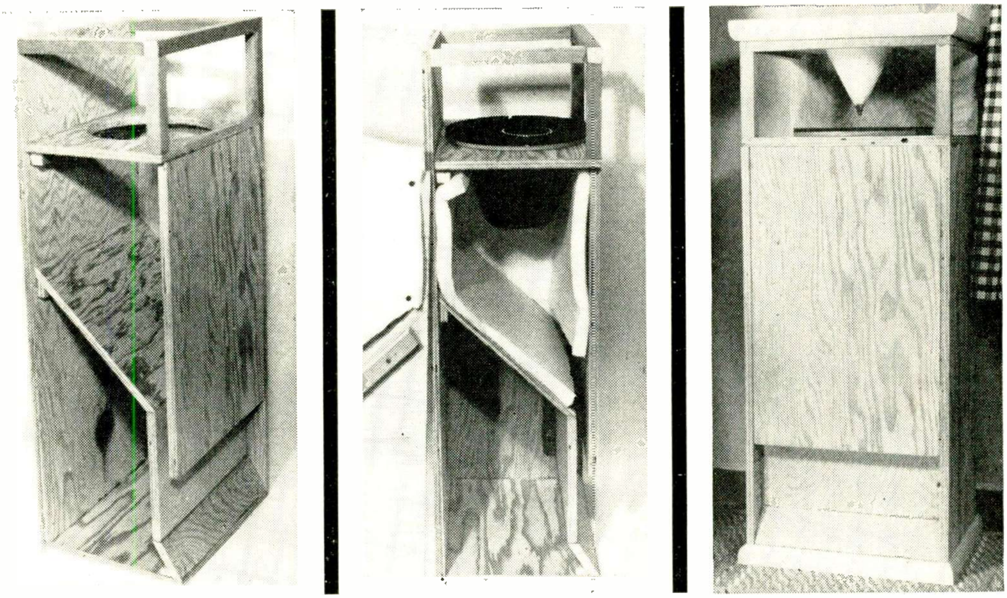
TWO OBJECTS, physicists tell us, can't occupy the same space at the same time. Personally, I've never bothered to find out just *why,* but I'm certain they're right.

You see, the speakers didn't look especially large at the hi-fi showroom—just a little closer to Airedales than Pekinese. At home, the situation boiled down to this: if we moved out of the living room, then the two stereo speakers could move in. But if we stayed . . . well, two objects can't occupy the same space at the same time, like we said!

Looking over the "bookshelf" speaker systems back at the hi-fi showroom, I stumbled across what I think is a rather significant fact: most of them were pretty much the same size and most of them were designed to rest on a "bookshelf" or a table of sorts. As it happened, I had no available space of either kind at the moment.

Further, I reasoned, a bookshelf or table doesn't really add to the performance (although it does raise the speaker to a better level for dispersing sound). What's more, I thought, a speaker/table combination can take up more space than a full-sized enclosure with improved characteristics.

Scratching the old noggin a bit, I finally came up with the solution you see pictured here. It's a speaker-and-baffle combination that occupies only about ¾ sq. ft. of floor space, needs no supporting "table," and yet sounds good from "top to bottom." The basic design is actually British, but it has



Constructing enclosure is actually rather simple, if you follow the step-by-step instructions outlined in text. One side was removed (left and center) to show the internal layout better.

been reworked to fit a full-range 8″ speaker (Lafayette SK-128, Radio Shack "NOVA-3," Knight KN-819, etc.).

If you like your bass with a built-in boom (some people do, and that's their privilege), this cabinet may not appeal to you. And, as with most good speaker systems, your first impression may be that it's a little "shy" at both the low- and high-frequency extremes. But it's not the first impression that counts; it's how well the sound "wears." Lack of boom can be deceptive, and this little system can accept boosting at either end of the spectrum without pain.

Familiar Features. You will note that there are some familiar features in an unusual setting. For one thing, the speaker is pointed upward to avoid "beam" effects at high frequencies and to disperse the sound better. In addition, an angled panel directly behind the speaker is drilled with a number of small holes and offers a resistive path between the speaker cavity and the closed chamber at the bottom. This chamber, incidentally, is intended to counteract resonances in the bass; otherwise, the baffle acts as a conventional ducted-port bass reflex.

Together, these features add up to extremely smooth bass and treble response in a unit whose cost is nominal. The cabinet, for example, is made of ½″ plywood costing less than $3.00, plus about 50 cents worth of foam plastic and some scraps of lumber.

The price of a square yard of grille cloth will vary according to the kind you choose, or you may want to eliminate the cloth altogether and try for a different effect. Another change you might consider is the use of an open grille for the top instead of the closed wood top shown here—more on this possibility later.

The foam plastic used for "padding" the speaker compartment is of the flexible kind. Apparently this material goes under a variety of names, but the warehouse which provided ours called it "poly-ether" foam. It's similar to foam rubber and is used in upholstery work. If you can find a firm which supplies it for that purpose, you can probably get their left-over cuttings for a fraction of what you'd have to pay in most stores.

Basic Enclosure. There are several angled cuts to be made on the pieces of plywood. If you have access to a power saw, you've no problem; but if you don't, it's best to have the parts cut to size at a lumber yard or cabinet shop. You can save some time and material by keeping the pieces left over from cutting the resistive panel and the bottom sloping panel and using them for glue blocks on the back and bottom. And don't forget that for a cut of 30°

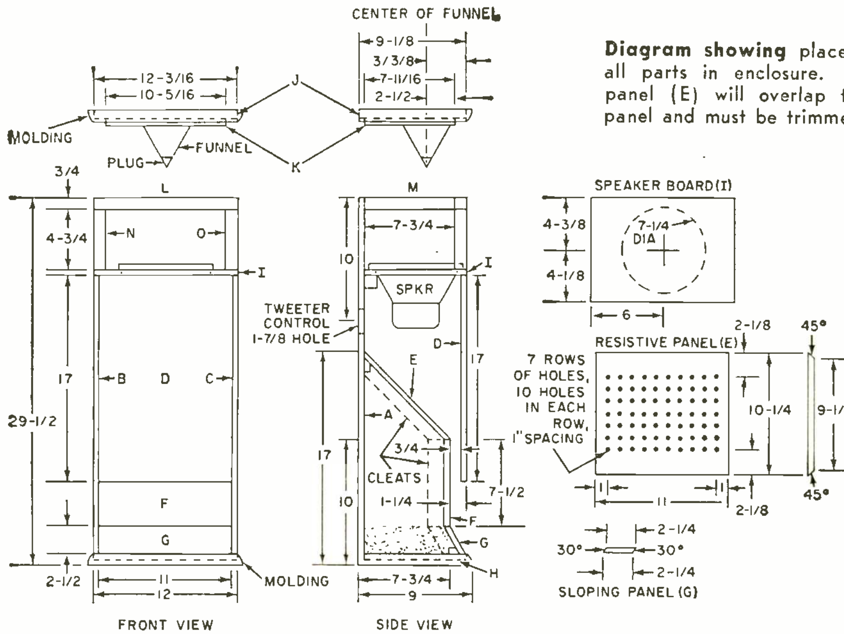


Diagram showing placement of all parts in enclosure. Resistive panel (E) will overlap the duct panel and must be trimmed to fit.

the saw blade should be set at 60°, which is 30° from a vertical setting.

Begin assembly by fixing the cleats in position on the back, bottom, and sides, using plenty of glue and screws. Join these parts and then add the resistive panel, having first drilled it with seventy ¼" holes

(*Continued on page* 142)

STEREO TESTING MADE EASY

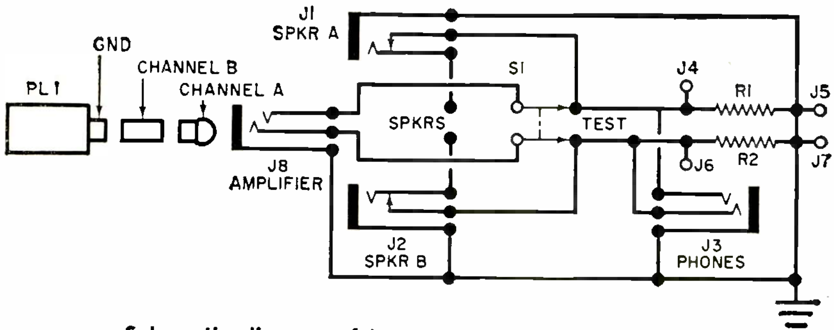
Switch from speakers to test equipment at will with this easy-to-build gadget

By **MILTON OGUR**

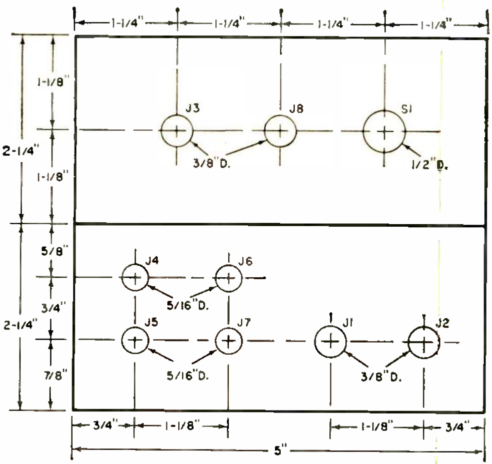
IF YOU'VE HESITATED to test that highly touted stereo system of yours because it meant too much wear and tear on cables, cabinetry, and nerves, this gadget is for you. It's easy to build (only a handful of components are needed), inexpensive (parts will cost you about $5.00), and can be used with monaural amplifiers, too. Furthermore, it's small enough to form a permanent and inconspicuous part of your hi-fi setup.

Comprised of a switch, various jacks, and two resistors, this device should make life easier whenever you want to run frequency response checks, measure distortion, or whatever. Its circuit is built around a single d.p.d.t. toggle switch (*S1*). In normal use, this switch feeds the audio voltage from the input jack, *J8*, to the speaker system, via a pair of 2-conductor, closed-circuit phone jacks (*J1* and *J2*). And for test purposes, it feeds these signals to a parallel combination of the following: banana test jacks *J4*/*J5* and *J6*/*J7* for oscilloscope or VTVM leads; and a 3-conductor open-circuit phone jack, *J3*, for monitoring with low-impedance headphones.

In case the plugs to the speakers are removed from *J1* and *J2*, the amplifiers are automatically terminated in load resistors *R1* and *R2*. For this reason, *R1* and *R2* should possess a power rating in excess of that for each amplifier channel and should roughly match the "nominal" imped-



Schematic diagram of inexpensive stereo test unit. As explained in text, output from stereo amplifier can be fed to speakers A and B, stereo headphones, or test jacks J4 to J7.

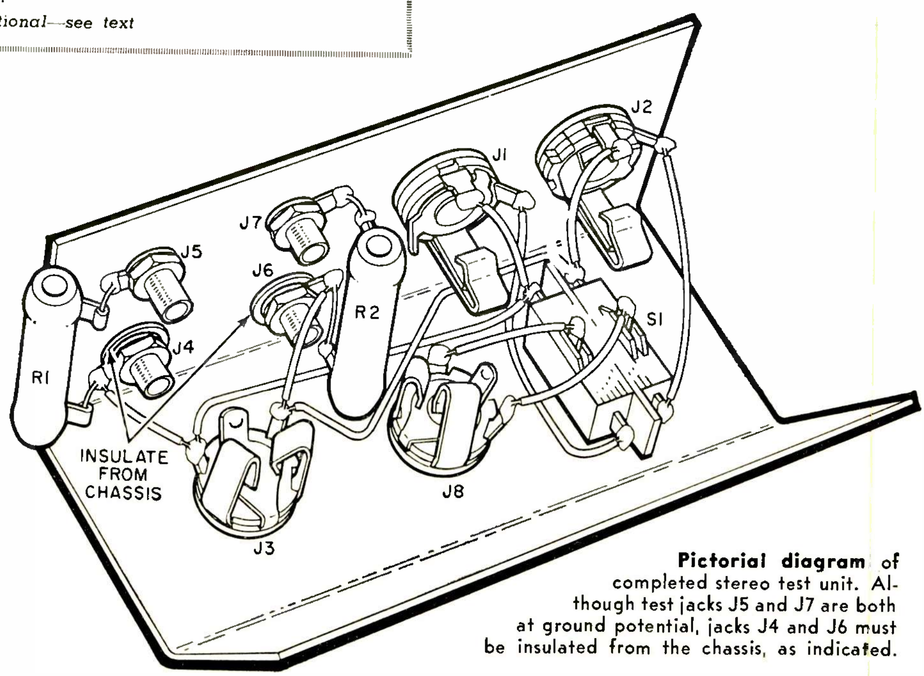


Template at right shows location of holes for jacks J1 to J8 and switch S1. Only two sides of utility box are used.

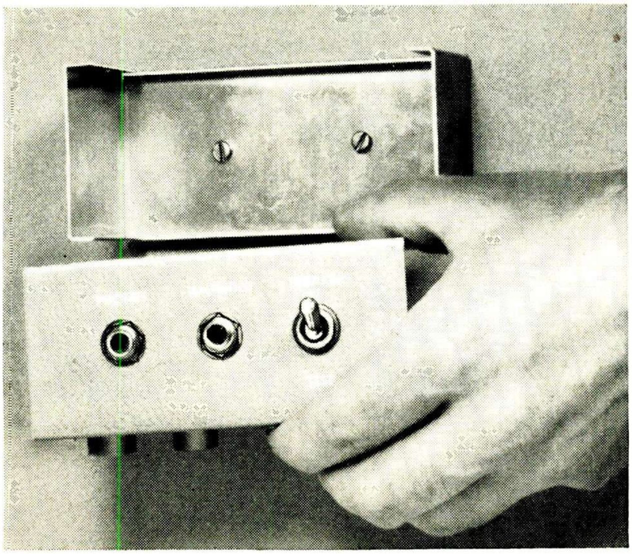
PARTS LIST

J1, J2—2-conductor, closed-circuit phone jack
*J3, *J8—3-conductor, open-circuit phone jack*
J4, J5, J6, J7—Banana jack (2 black, 2 red)
**PL1—3-conductor phone plug (to match J8)*
R1, R2—Wire-wound power resistors—see text
S1—D.p.d.t. toggle switch
1—5" x 2¼" x 2¼" aluminum utility box (Bud CU-2104-A or equivalent)
Misc.—Hookup wire (2 colors, one for each channel), 3-wire cable, hardware, decals, solder, etc.

** Optional—see text*



Pictorial diagram of completed stereo test unit. Although test jacks J5 and J7 are both at ground potential, jacks J4 and J6 must be insulated from the chassis, as indicated.



Aluminum utility box with snap-on cover simplifies mounting of stereo test unit. With cover attached to equipment cabinet, the test unit can easily be removed. If "easy remove" feature is not needed, however, the unit can be mounted in an aluminum box and permanently attached to the hi-fi cabinet.

ance of the taps in use—e.g., 4, 8, or 16 ohms.

Construction is relatively simple, but be sure to use an aluminum utility box with a "snap-on" cover. Begin by laying out the components on the "open chassis"—only two adjacent rectangular sides were used for mounting in the author's model. If the suggested layout shown here is used, the following order of mounting is recommended: (1) *S1*, with leads attached; (2) *J4* and *J6* (both red), with lugs bent slightly in, away from the chassis; (3) *J5* and *J7* (both black), again with lugs bent slightly in; (4) *J3* and *J8*; (5) *J1* and *J2* (rotate until terminals are most accessible); and (6) *R1* and *R2*.

As indicated above, the leads to switch *S1* should be soldered in advance of mounting and made long enough—about 3"—to reach the banana jacks (*J4-J7*). For channel identification, use two colors of hookup wire. All jacks except *J4* and *J6* are grounded to the chassis; these two should be insulated with fiber shoulder washers.

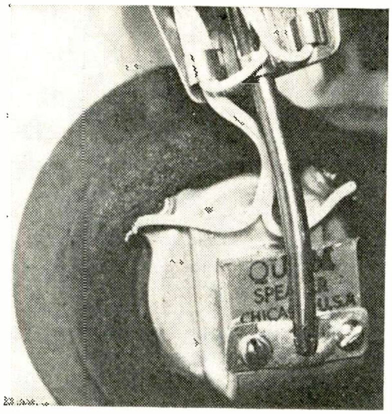
No terminal strips will be needed, and *R1* can be soldered directly to the terminals of *J4* and *J5*, and *R2* to *J6* and *J7*. It may be necessary to loosen the jacks in order to rotate their lugs into positions where wiring will be easiest; in any case, *R1* and *R2* should be dressed to clear all adjacent parts and the chassis for coolest operation.

Jack *J8* is optional. Should you wish to use the unit to check someone else's stereo system, you'll find it helpful; but if the unit is to be anchored to one cabinet, *J8* can be omitted and a rubber grommet inserted in its place to protect the 3-wire cable connecting the unit to the output terminal strip (or strips) of the stereo amplifier. This cable should be long enough to enable the unit to be used outside the equipment cabinet if necessary.

If space is available within the equipment cabinet, drill two holes in the cover to accommodate wood screws, and mount it in the chosen space. With this done, the chassis can be snapped in place as needed.

For regular listening, leave switch *S1* in the *Speaker* position, or, if headphones are preferred, switch to the *Test* position. When distortion rears its ugly head, bring out the audio oscillator, oscilloscope, VTVM, or what have you; snap the test unit out of its cover; and place it in a convenient spot for testing. (This "open chassis" arrangement insures proper ventilation of *R1* and *R2* when full power is being pumped into them.)

With the switch in the *Test* position, plug the meter leads into test jacks *J4*/*J5* or *J6*/*J7*, as needed, and measure distortion or output level. If an oscilloscope is used, simply plug the cable from its "vertical" terminals into the test jacks. —30—



Headband bracket matches tapped holes.

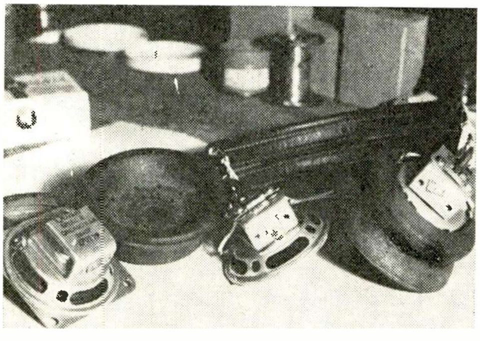
Use separate leads for each speaker, and phase for best bass.

STEREO HEADSET on a BUDGET

By R. F. DRISCOLL

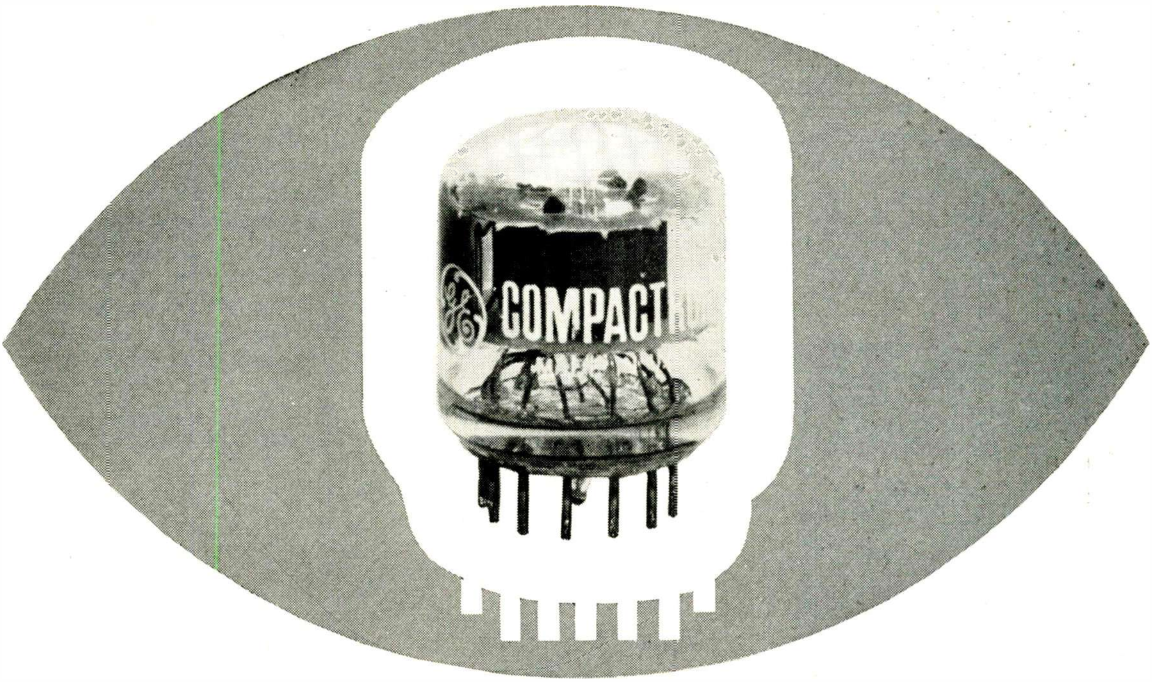
YOU CAN ASSEMBLE your own stereo headset for about half the price of a factory-made product. Pick up a pair of Quam 25A07 replacement speakers (they come with holes tapped in the back plate), a pair of headset cushions, and a Trimm headband. Cut the four flanges off the speakers, and fit the speakers into the headset cushions (be careful of the speaker cones) after attaching some flexible wire leads to the voice coil terminals. Attach the Trimm headband by sweat-soldering a bracket with holes to match the spacing of those already in the speakers. Connect each pair of leads to plugs, reversing the leads to one plug for best bass, then sit back and just listen. —30—

Total cost of the five items you will need to make the stereo headset should be approximately $5.92.



Speaker mounting flanges should be clipped off as shown. Enlarge holes in cushions for best response.

INTRODUCING THE COMPACTRON



multi-section tube gives FM TUNER/RECEIVER three-tube performance

By **PHILIP E. HATFIELD,** W9GFS*

BY NOW, just about everyone has heard of the "Compactron." And you'll be seeing more and more of the Compactron, too, for this new multifunction tube in its many forms will soon appear in TV sets, FM multiplex adapters, and dozens of other products. Actually, the Compactron is just what its name (a General Electric trademark) implies: an extremely compact grouping of a number of different "tubes" in a single envelope. There is almost no end to its applications, but the little FM tuner/receiver pictured here represents an ideal introduction to the device.

Since this one-tube unit can be used with earphones, it is just the thing for listening to FM programs late at night when full-scale operation of your hi-fi rig might cause domestic discord. If you want to boost FM programing to full-room volume, simply feed the output from the combination tuner/receiver into your hi-fi set. Reverting to earphone operation again will entail nothing more than changing plugs.

Although it incorporates its own power supply, this compact tuner/receiver can be

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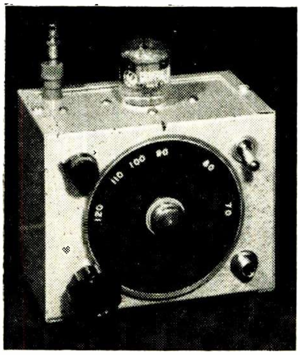
* *Receiving Tube Dept., General Electric Co.*

built for far less than most FM tuners. And it offers the distinct advantage of enabling you to become acquainted with one of the latest developments in the tube field—the Compactron—at the same time.

About the Circuit. You can see from the schematic diagram that the 6D10 Compactron is a triple triode (see page 108). It combines the functions of an r.f. amplifier, superregenerative detector, and audio amplifier—all in one envelope.

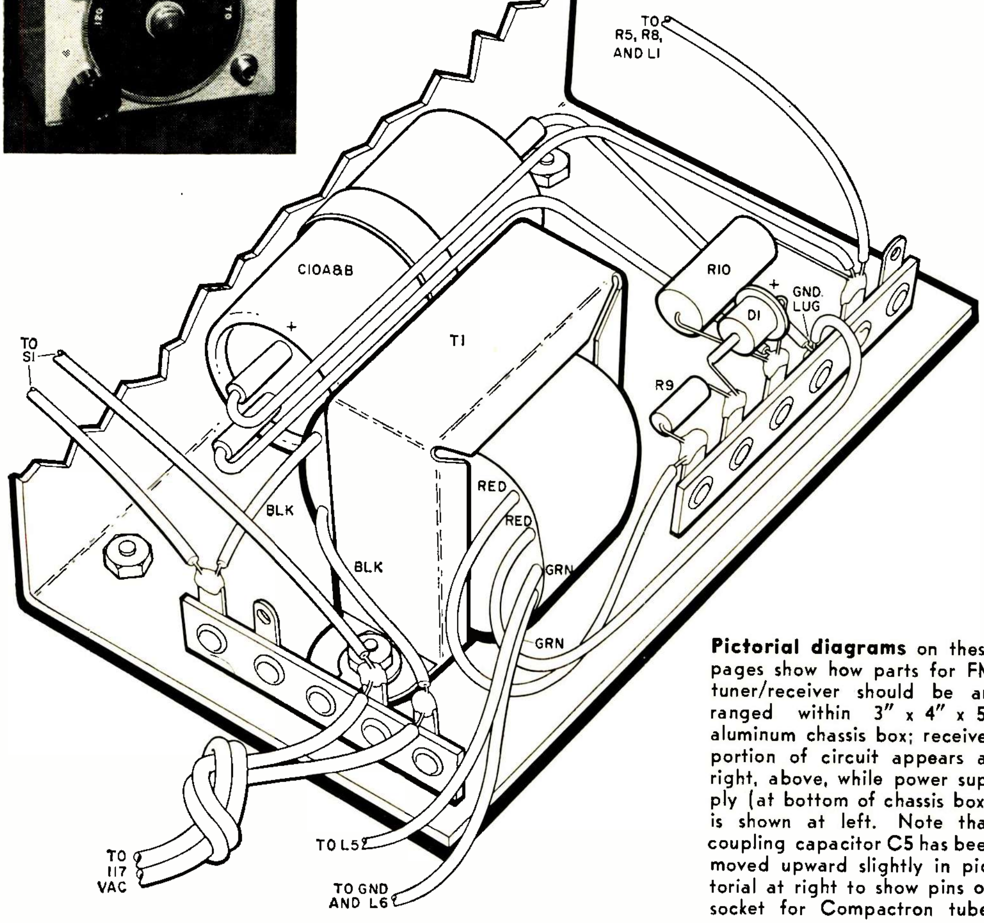
The first section serves as an r.f. amplifier, connected in a grounded-grid circuit. For simplicity, this stage is untuned, since its principal function is to isolate the antenna from the detector.



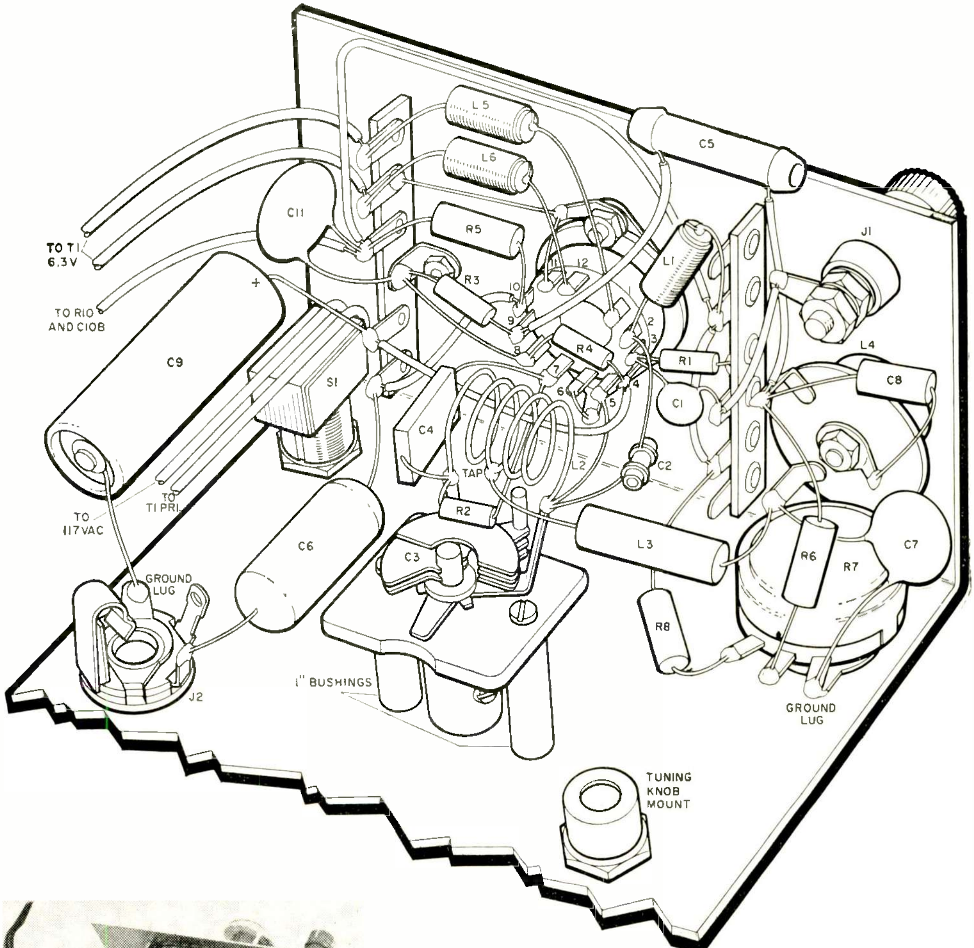
The second stage, a superregenerative detector, oscillates simultaneously at the frequency of the incoming signal and at a frequency slightly above the audible range—the so-called "quench" frequency. If you've ever done much experimenting with ordinary regenerative detectors, it shouldn't take you long to figure out how a superregenerative detector works.

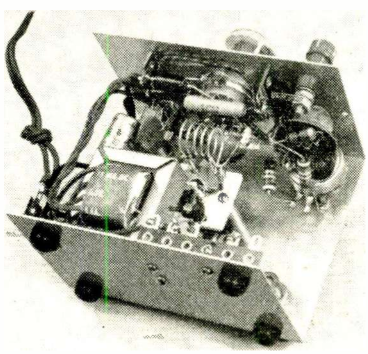
As you no doubt know, an ordinary regenerative detector is most sensitive when it's just on the verge of oscillation. But in the superregenerative circuit, the detector is pulled "in" and "out" of oscillation thousands of times each second at a rate determined by the quench frequency. The result is a circuit so sensitive that you can actually hear the thermal noise of the tube, although this noise disappears when a strong signal is received.

The detector's very high frequency (v.h.f.) oscillation takes place at the same



Pictorial diagrams on these pages show how parts for FM tuner/receiver should be arranged within 3" x 4" x 5" aluminum chassis box; receiver portion of circuit appears at right, above, while power supply (at bottom of chassis box) is shown at left. Note that coupling capacitor C5 has been moved upward slightly in pictorial at right to show pins on socket for Compactron tube.



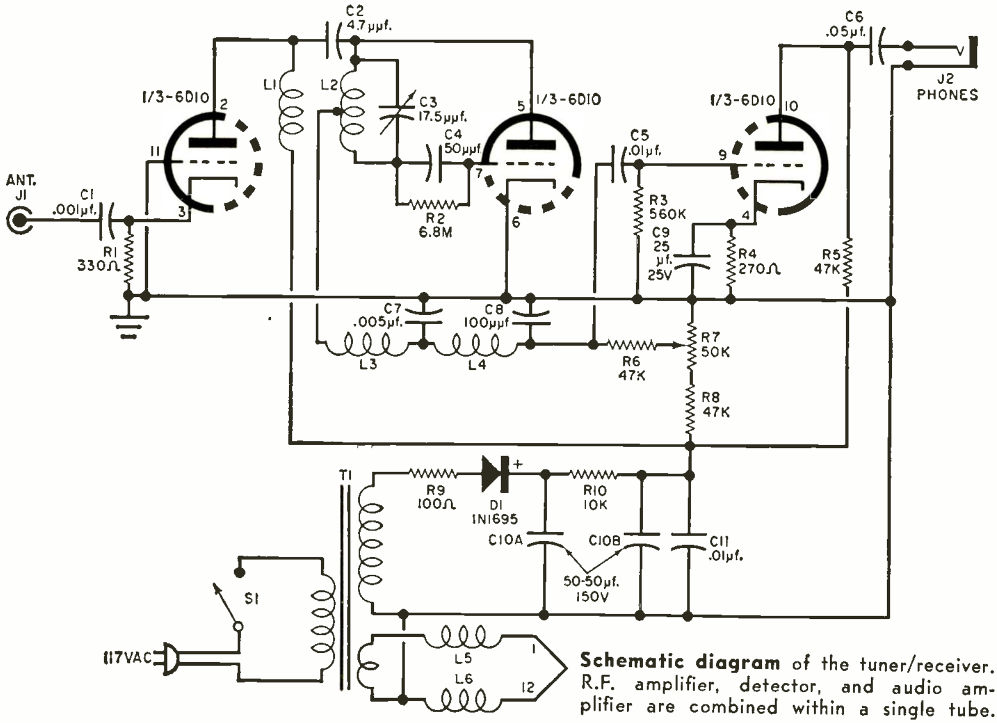


rate as the frequency of the incoming signal; the frequency of this oscillation is determined principally by the values of coil *L2* and variable capacitor *C3*. The lower-frequency oscillation or "quench" frequency is determined chiefly by the values of capacitor *C4* and resistor *R2*, as well as the position of the tap on *L2*. Amplitude of the quench oscillation, in turn, depends on the plate voltage and can be controlled by the setting of potentiometer *R7*.

The output from the detector is fed to a filter consisting of *L3*, *C7*, *L4*, and *C8*, in order to strip the signal of v.h.f. and quench-frequency components. From the filter, it goes to the grid of the Compactron's third triode section, an ordinary resistance-coupled audio amplifier which amplifies the signal to a suitable level for headphone operation. Alternatively, the ouput from this stage can be fed into an auxiliary audio amplifier.

Putting It Together. The box chosen for the cabinet provides plenty of room for all components, but you'll find that assembly is easier if you follow the sequence outlined here.

Begin by punching and drilling all holes, then mount the Compactron socket, the two adjacent 5-point terminal strips, potentiometer *R7*, antenna jack *J1*, and phone jack *J2*. As much wiring as possible should be com-



Schematic diagram of the tuner/receiver. R.F. amplifier, detector, and audio amplifier are combined within a single tube.

PARTS LIST

C1—0.001-μf. ceramic capacitor
C2—4.7-μμf. ceramic or mica capacitor
C3—17.5-μμf. variable capacitor (Hammarlund HF-15 or equivalent)
C4—50-μμf. mica capacitor
C5, C11—0.01-μf. ceramic capacitor
C6—0.05-μf., 200-volt Mylar or paper capacitor
C7—0.005-μf. ceramic capacitor
C8—100-μμf. ceramic capacitor
C9—25-μf., 25-volt electrolytic capacitor
C10a/C10b—50/50 μf., 150-volt dual electrolytic capacitor
D1—1N1695 diode
J1—Screw-type banana jack
J2—Open-circuit phone jack
L1—Single layer of #30 enameled copper wire close-wound on and wired in parallel with 470,000-ohm, 1-watt resistor, 7/32" diameter and 9/16" long
L2—5 turns of #18 tinned copper wire, ½" in diameter, spaced to a length of approximately ⅝", tapped at center turn
L3—7-μh. r.f. choke (Ohmite Z-50 or equivalent)
L4—10-mh. r.f. choke (J. W. Miller 756)
L5, L6—Single layer of #22 enameled copper wire, close-wound on and wired in parallel with 470,000-ohm, 1-watt resistor, 7/32" in diameter, 9/16" long
R1—330-ohm, ½-watt resistor
R2—6.8-megohm, ½-watt resistor
R3—560,000-ohm, ½-watt resistor
R4—270-ohm, ½-watt resistor
R5, R6, R8—47,000-ohm, 1-watt resistor
R7—50,000-ohm potentiometer, linear taper
R9—100-ohm, ½-watt resistor
R10—10,000-ohm, 2-watt resistor
S1—S.p.s.t. toggle switch
T1—Power transformer; primary, 117 volts a.c.; secondaries, 125 volts @ 15 ma. and 6.3 volts @ 0.6 amp. (Stancor PS-8415 or equivalent)
V1—6D10 tube
1—12-pin socket for above (produced by I. H. Mfg. Co., Cinch Mfg. Co., etc.)
1—3" x 4" x 5" utility box (LMB T-F779 or equivalent)
1—Miniature telescoping antenna (Lafayette F-343 or equivalent)
Misc.—Line cord and plug, wire, solder, dial, dial plate, terminal strips, hardware, etc.

pleted before you mount any additional parts. Variable capacitor *C3* should then be mounted and all wiring completed, with the exception of that for the power supply.

Note that both the rotor and stator of the variable capacitor must be insulated from the box, and that an insulated shaft extension must be used with a metal dial. The capacitor specified in the Parts List has two holes in the ceramic end-plate that allow the use of "pillars" for mounting. Other capacitors may require a small plastic plate for mounting, with mounting pillars attached to the plate.

Transformer *T1*, switch *S1*, filter capacitor *C10a/C10b*, and the other two terminal strips should now be mounted on the box

(*Continued on page* 161)

Chapter 5

Electronics in the Workshop

THE newcomer to electronics experimenting may believe that he will soon require a veritable laboratory of test equipment. But before long he finds that this is not so, and that for 1 out of 3 projects a simple 20,000-ohm-per-volt VOM will suffice. Furthermore, he can turn this instrument into a sensitive vacuum-tube voltmeter (which we describe on page 112). A probe to detect and measure radio frequencies with the "adapted" VOM appears on page 122.

The transistor experimenter will probably find the "in-circuit" tester (page 125) of considerable interest and value, while the overall experimenter may want to build the "Universal Workshop Tester" (page 132). Refined voltage measurements are possible with the miniature a.c. voltmeter (page 138) and the very unusual "Expanded Scale Voltmeter" (page 119).

A radio-TV service shop handling electrolytics should investigate the "Restorer" (page 115); it will save "call-backs" galore. This gadget "forms" capacitors to prevent them from popping the insulating film. Such breakdowns are frequent occurrences when electrolytics have been allowed to age and deteriorate.

These, and the other 30 projects in this volume, are only a small sampling of the numerous valuable ideas appearing regularly in the monthly editions of Popular Electronics.

VTVM Adapter for Multimeters

Low-cost adapter converts VOM to a vacuum-tube voltmeter

By **PHILIP E. HATFIELD,** W9GFS

IF YOU NEED a vacuum-tube voltmeter but hesitate to buy one because you already own a good 20,000-ohm/volt multimeter, the little adapter described here may be the answer to your problem. It will convert your meter to a d.c. VTVM having an input resistance of 11 megohms. Since the only connections to the multimeter are made through the existing input jacks, the unit can easily be removed whenever you wish.

The adapter provides d.c. ranges of 0 - 4, 0 - 40, and 0 - 400 volts, and—with the help of a specially built a.c. probe—the two lower ranges can also be used on r.f. voltages at frequencies up to about 10 megacycles. The cost of the unit is low, and you'll be able to check sensitive circuits in which voltages would literally disappear under the load of an ordinary multimeter.

Construction. The parts are housed in a 3" x 4" x 5" metal utility box. Start construction by drilling all the mounting holes and installing all parts except "range" switch *S1* and power transformer *T1*.

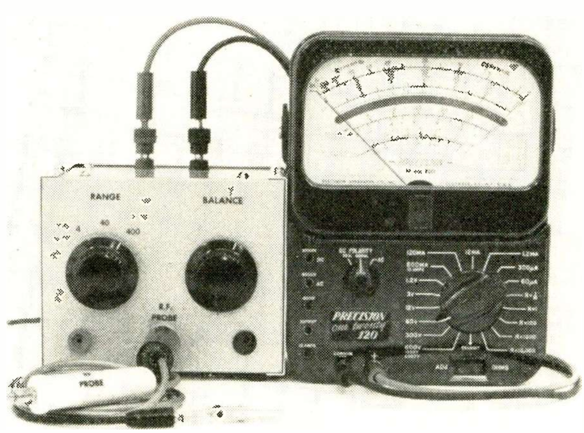
Resistors *R3*, *R4* and *R5* are then mounted on *S1*, the terminal for one of the unused sections of this switch serving as a tie point for the grounded end of *R5*. The switch is now installed and all wiring in the box, except for the transformer connections, may be completed. Finally, mount and connect the transformer.

Before the VTVM adapter can be used, the proper probes must be provided. The d.c. probes are a set of ordinary test leads with one modification: a 1-megohm resistor (*R1*), wired in series with the test lead, is installed in the handle of the positive probe. The r.f. probe circuit is built into the plastic case of a nasal inhaler, in the following manner.

Remove the interior sleeve from the plastic case, and drill holes for the leads and banana plug in the outer shell and threaded cap respectively. Diode *D1*, resistor *R2* and capacitor *C1* are then wired in; these components will be slipped into the shell when the case is closed. Finally, install a phone plug (*P1*) and an alligator clip on the free ends of the appropriate leads. The banana plug may be used as a test prod, or it may be slipped into an alligator clip for attachment to a circuit point.

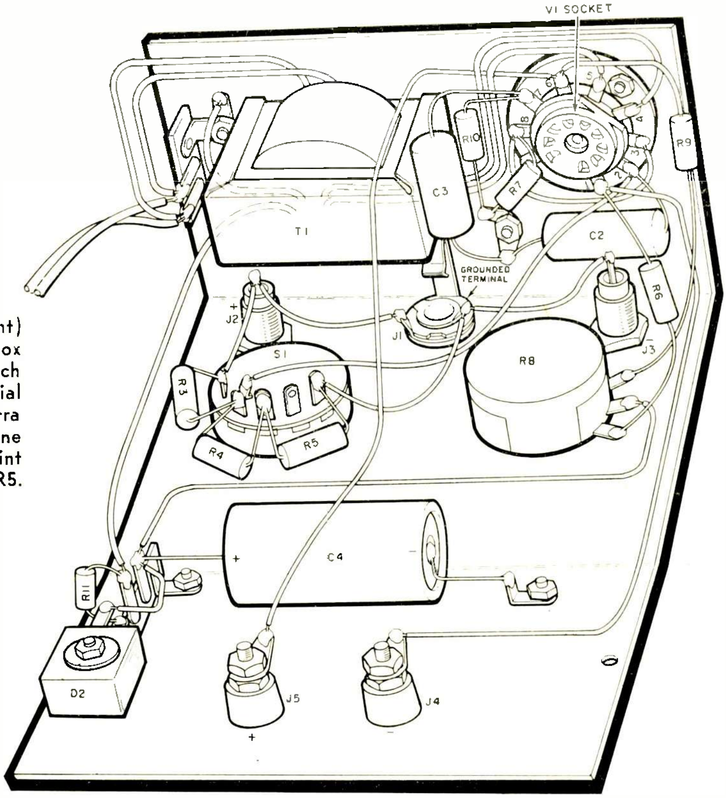
Checking and Operation. Set your multimeter to 50, 75 or 100 volts d.c., connecting its negative lead to *J4* and its posi-

The adapter connects to the multimeter's existing input jacks as shown below. It can be removed at any time if you want to use the multimeter in the normal way.



This VTVM adapter is patterned after one described in the July and August 1954 issues of the "G.E. Ham News." The author wishes to extend his thanks to the General Electric Company for permission to use the idea.

Completed unit (below, right) fits in 3" x 4" x 5" utility box with space to spare. Switch used for S1 (see pictorial diagram, right) has two extra positions. The terminal of one of these was used as tie point for the grounded end of R5.

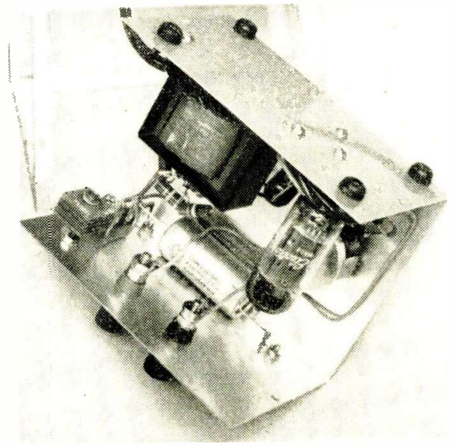


tive lead to *J5*. The adapter is plugged in and, after it has warmed up, balance control *R8* is set for a zero reading on the multimeter. Connect the adapter's d.c. test leads across a 1.5-volt flashlight cell, then several cells in series, and finally a variable voltage power supply—checking several points on the three ranges.

The voltage indicated on the meter will be 10 times the voltage across the adapter's test leads on the 0-4 volt range. On the 0-40 volt range, the meter will indicate the same voltage which is across the leads; while on the 0-400 volt range, the meter reading will be one-tenth that of the voltage across the leads.

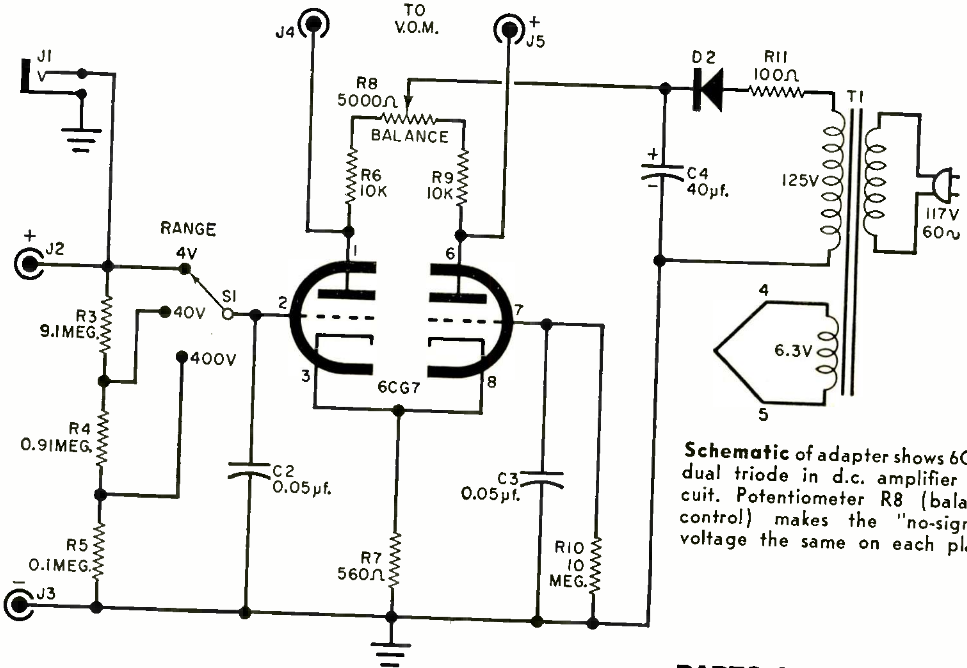
The most accurate readings will be obtained when the resistance of the multimeter used is greater than 50,000 ohms. For this reason, the higher voltage ranges of the multimeter should be employed where possible.

To use the r.f. probe, plug in its cable and disconnect the d.c. test leads. The probe's clip lead is attached to a ground point in the circuit and its tip is touched or clipped to the point where r.f. voltage is to



be read. As mentioned previously, the probe should be used only on the 4- and 40-volt ranges of the adapter; voltages much higher than 40 will exceed the ratings of *D1*.

How It Works. The adapter uses a 6CG7 dual triode as a d.c. amplifier. With no input signal, the two sections of the tube draw currents which are dependent on their



Schematic of adapter shows 6CG7 dual triode in d.c. amplifier circuit. Potentiometer R8 (balance control) makes the "no-signal" voltage the same on each plate.

own characteristics and the values of the resistances in their cathode and plate circuits. If one section draws more current than the other, it will have a greater voltage drop in its plate resistor, and a voltmeter connected across jacks *J4* and *J5* will show this voltage difference.

To zero the meter, the balance control (*R8*) is used to change the relative amounts of resistance in the two plate circuits so the same voltage appears at each plate.

When the positive voltage applied to the grid approaches 4 volts, a linear plate voltage change is no longer obtained. For this reason, a voltage divider has been incorporated to allow higher voltages to be measured without applying more than 4 volts to the grid of the tube.

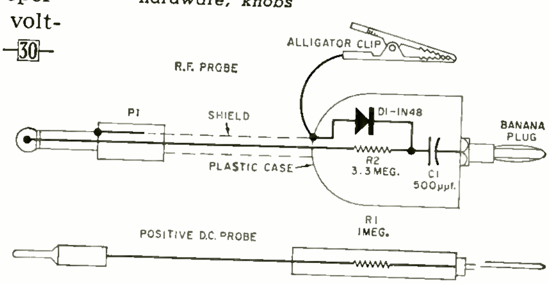
The r.f. probe uses diode *D1* as a shunt rectifier. The diode develops a d.c. voltage across the input voltage divider when r.f. energy is coupled to it through capacitor *C1*. This voltage causes the meter to operate in the same manner as with a d.c. voltage applied to the test leads. —30—

PARTS LIST

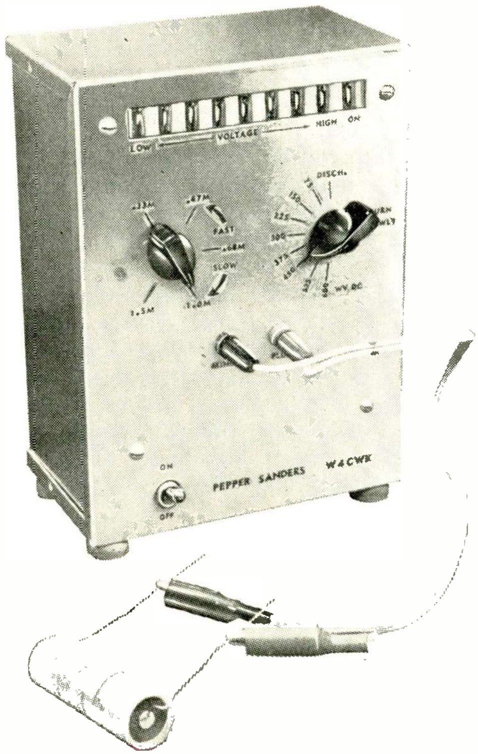
C1—500-µµf. ceramic disc capacitor
C2, C3—0.05-µf., 200-volt paper capacitor
C4—40-µf., 150-volt electrolytic capacitor
D1—1N48 diode
D2—130-volt, 20-ma. selenium rectifier (I.T.T. #1159 or equivalent)
J1—Open-circuit phone jack
J2, J3—Tip jack (one red, one black)
J4, J5—Banana jack and binding post combination (one black, one red)
P1—Phone plug
R1—1.0 megohm
R2—3.3 megohms
R3—9.1 megohms
R4—0.91 megohm
R5—0.1 megohm
R6, R9—10,000 ohms

All resistors 1 watt, 5%, unless otherwise specified

R7—560 ohms, 1 watt, 10%
R8—5000-ohm wire-wound potentiometer
R10—10 megohms, 1 watt, 10%
R11—100 ohms, ½ watt, 10%
S1—Single-pole, 3-position rotary switch (3 positions of Mallory #3215J, or equivalent)
T1—Power transformer; primary, 115 volts; secondaries, 115 volts @ 15 ma., 6.3 volts @ 0.6 amp. (Triad R-54X or Stancor PS8415)
V1—6CG7 tube
1—9-pin miniature breadboard tube socket (Pomona XS-9 or equivalent)
1—3" x 4" x 5" utility box (Bud CU-2105-A or equivalent)
Misc.—D.c. test probes; banana plug, alligator clip and plastic inhaler case for r.f. probe; hardware; knobs



The circuit for the r.f. probe is housed in a plastic nasal inhaler case. The positive d.c. probe is a standard test prod having a 1-megohm resistor in series with its lead.



IF YOU'RE one of the many experimenters who have large stocks of used electrolytic capacitors in storage, you know that such units often break down as soon as they are again placed in service. These capacitors aren't cheap, and you can avoid wasting them by using this efficient automatic restorer. Costing less than $16.00 to build, the device will give the most senile electrolytic in your spare parts box a new lease on life.

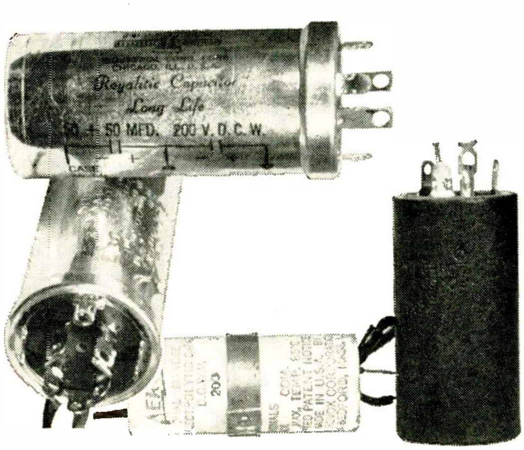
Inside the Electrolytic. Most electrolytic capacitors contain two sheets of thin aluminum foil which are held apart by a layer of electrolyte-impregnated paper or gauze separators and rolled into a cylinder. Each of these sheets is connected to one of the capacitor's pigtail leads, and the positive foil is coated with an insulating (dielectric) film of aluminum oxide. The thickness of this film, which is deposited on the side facing the electrolyte, determines the maximum safe working voltage of the capacitor.

When the capacitor is in service, the thickness of the dielectric film is adequately maintained by the circuit voltage. In storage, however, time and heat cause

THE RESTORER

. . . gives your electrolytics a new lease on life

By H. E. SANDERS, W4CWK



the film to deteriorate. Full voltage placed on an electrolytic that has been idle for some time will almost invariably puncture the weakened dielectric, ruining the unit.

It is possible, however, to electrically restore or "form" a deteriorated dielectric film. One standard forming procedure has been to apply a very low voltage to the capacitor, slowly increasing it over a period of an hour or so, until the normal working voltage is reached.

How the Restorer Works. The unit described in this article has been designed to carry out the forming process described above automatically. The capacitor itself is made to adjust the speed of forming in accordance with its age and the condition of its oxide film. The progress of the forming is observed on a series of neon lamps.

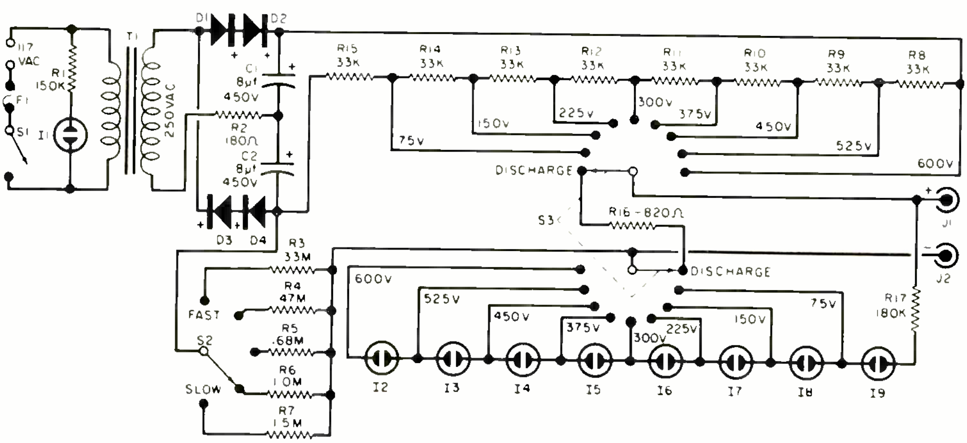
Power for the automatic restorer is provided by transformer *T1* and a voltage-doubling full-wave rectifier circuit consisting of diodes *D1-D4* and capacitors *C1* and *C2*. Resistor *R2* protects the diodes from damage by excess current. The transformer's primary is connected to the line through a ¼-ampere fuse (*F1*) and a toggle switch (*S1*). Neon lamp *I1*, with its associated dropping resistor (*R1*), serves as an "on-off" indicator.

The approximately 720-volt d.c. output

tion of *S3*, an additional neon lamp is connected in series with the original one. Resistor *R17* protects the neon lamps from a current overload.

Voltage applied to the capacitor to be formed, through the series current-limiting resistor (see "Operation" section for appropriate voltage and resistance settings), divides between the two units as if they were both resistors. Since the unformed capacitor has a very low forward—or insulation—resistance, almost all the voltage is initially dropped across the resistor. The small drop across the capacitor begins the forming process, however, and as the deteriorated electrolytic film is restored, the capacitor's resistance gradually increases.

As the capacitor's resistance becomes



Schematic diagram of the "Restorer." Switch S3 taps the power supply's voltage divider, selecting the "forming" voltage, and also controls the indicating lamp circuit. Switch S2 inserts the proper current-limiting resistor.

of the power supply is dropped across a voltage divider made up of resistors *R8* through *R15*. The voltage drop across each of these resistors is on the order of 90 volts. One section of switch *S3* taps the voltage divider, determining the multiple of 90 volts which will be applied (through a series current-limiting resistor) to the capacitor being formed. The current-limiting resistor to be used (*R3, R4, R5, R6* or *R7*) is selected by switch *S2*.

The other section of *S3* controls the automatic indicator circuit. In the lowest-voltage position of this switch, neon lamp *I9* is connected across the capacitor being formed. For each successively higher posi-

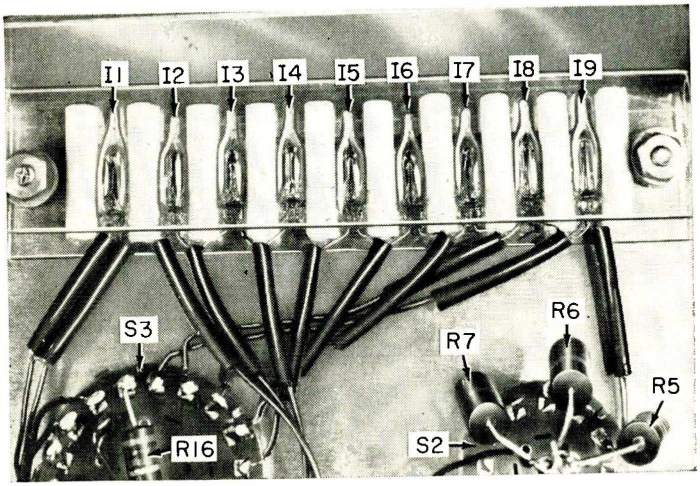
greater, a larger proportion of the voltage is dropped across it. When the voltage across the capacitor has risen to the value at which *S3* is set, the lamp (or lamps) associated with that position of *S3* will fire—indicating that the forming is complete. Switch *S3* is calibrated in 75-volt intervals because the NE-2 neon lamps used at *I2-I9* fire at 75 volts each.

Before disconnecting the restored electrolytic, *S3* is turned to the "discharge" position. In this way the capacitor, its charge drained through *R16*, is made safe to handle.

Construction Details. The restorer is built into an 8"x 6" x 3½" aluminum utility box equipped with an "L"-shaped mounting shelf. The shelf is formed from a 5½" x 4¼" piece of heavy aluminum; make a 90° bend along the long dimension, 1" from one edge. The resulting lip is used to bolt the shelf into the utility box.

Mount transformer *T1* on one side of the shelf and the remainder of the power supply *S2* and *S3*, and the indicating lamps are mounted directly on the box. Before making the front-panel opening for the lamps, construct the lamp holder.

The author made the lamp holder by bending a 2½"x 5½" piece of plexiglass (along its long dimension) into a "U" shape. You can get the same effect, how-



Details of the Restorer's lamp holder can be seen clearly in this photo; the author made his holder from a single strip of plexiglass. Quick-drying cement keeps lamps and rolled-paper separators in place.

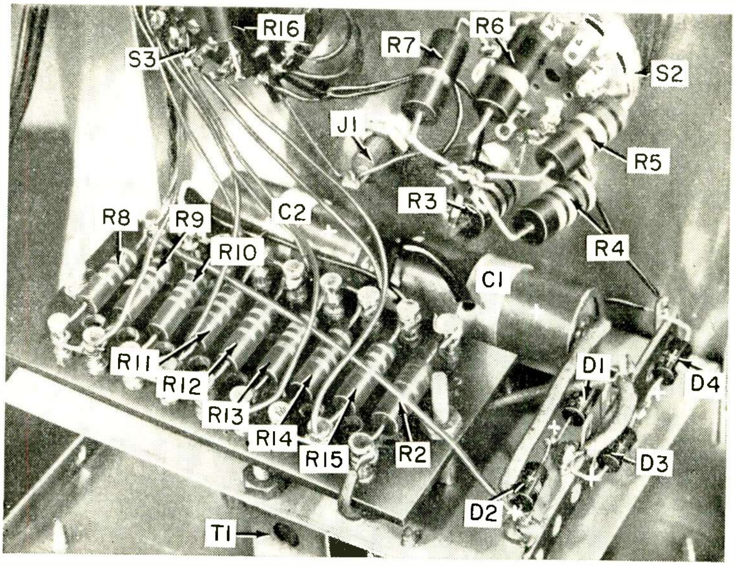
PARTS LIST

C1, C2—8-µf., 450-volt electrolytic capacitor
D1, D2, D3, D4—400-PIV, 200-ma. silicon rectifier (Sarkes-Tarzian 2F4 or equivalent)
F1—¼-ampere, 3AG fuse
I1-I9—Neon lamp (General Electric NE-2 or equivalent)
J1, J2—Banana jack (one red, one black)
R1—150,000-ohm, ½-watt resistor
R2—180-ohm, 1-watt resistor
R3—0.33 megohm
R4—0.47 megohm
R5—0.68 megohm
R6—1.0 megohms
R7—1.5 megohms
(R3–R7) All 2-watt resistors
R8 - R15—33,000-ohm, 1-watt resistor
R16—820-ohm, 1-watt resistor
R17—180,000-ohm, ½-watt resistor
S1—S.p.s.t. toggle switch
S2—1-pole, 5-position, non-shorting rotary switch
S3—2-pole, 9-position, non-shorting rotary switch
T1—Power transformer; primary, 117 volts; secondary, 250 volts @ 25 ma. (Knight 62 G 008 with filament winding and plate winding CT unused, or equivalent)
1—8" x 6" x 3½" aluminum utility box (Bud CU-3009A or equivalent)
Misc.—Sheet aluminum for shelf, line cord and plug, test leads, terminal board and strips, plexiglass strips, cement, hardware, fuse clip, wire, etc.

components (*R2, R8-R15, D1-D4, C1* and *C2*) on the other. To facilitate construction, the resistors are wired onto a terminal board; drill two 3/16" ventilation holes in the board below each resistor. The diodes can be mounted on a long terminal strip.

When installing the shelf, position it so that transformer *T1* is inverted, with its weight resting on the bottom of the utility box. Banana plugs *J1* and *J2*, switches *S1*, ever, by bolting together two 1" x 5½" plexiglass strips, spacing them about ¼" apart. One of the strips, of course, need not be transparent—so you can substitute any non-reflective material you happen to have handy.

The "on-off" indicator lamp (*I1*), as well as voltage indicator lamps *I2-I9*, are inserted between the strips. Use only new NE-2 lamps; old ones may have drawn

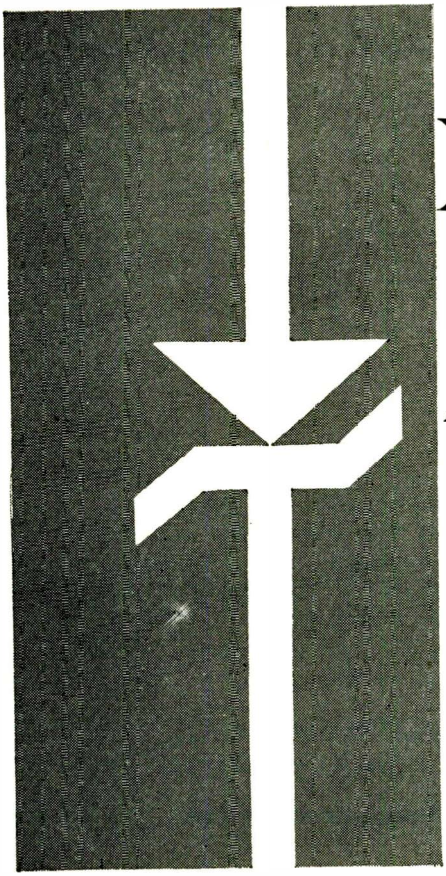


The Restorer's "L"-shaped mounting shelf is fastened to the rear of the front panel. Transformer T1, though fastened to the shelf, is really supported by the bottom of the box.

heavy currents in prior usage, causing them to fire at a voltage which is too low. The NE-2's are separated with ¼"-diameter x 1"-long cylinders made of rolled paper, and both the lamps and cylinders are held in place with quick-drying cement.

When the cement has dried, measure the assembly to determine the proper dimensions for the front-panel opening. The same screws that hold the unit together may be used to fasten it to the front panel.

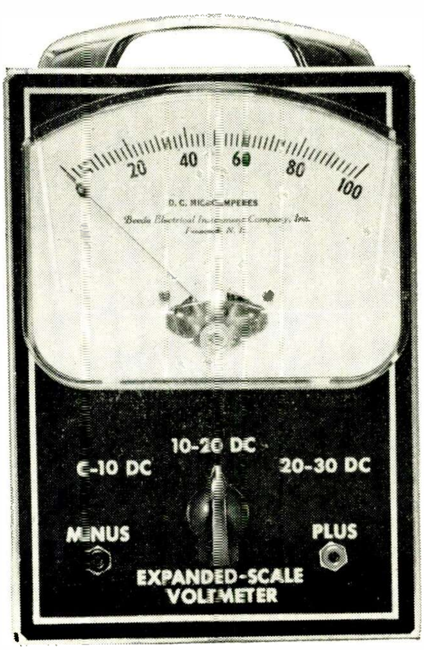
(*Continued on page* 154)



EXPANDED SCALE VOLTMETER

Ingenious circuit employs three zener diodes, makes possible accurate, low-voltage d.c. measurements

By DOROTHY LOUISE ZACHARY

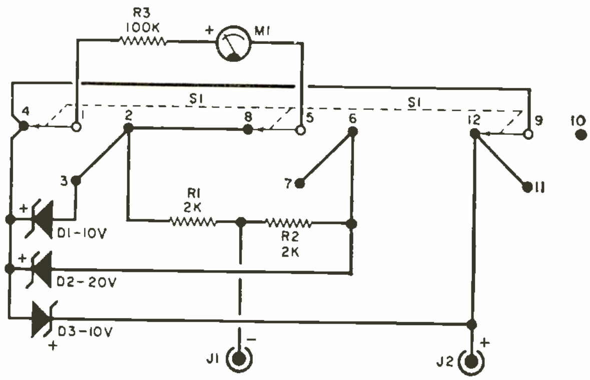


NOT SO LONG AGO, an expanded-scale voltmeter was a piece of equipment too expensive for the average experimenter to consider buying. Recent developments in semiconductors have changed the situation, however. The 0-30 volt expanded-scale voltmeter described here, designed around the now-familiar zener diode regulators, can be built at moderate cost—even though it rivals in performance commercial models costing much more. Each of the unit's three ranges (0-10, 10-20 and 20-30 volts d.c.) is spread out over the full scale of the 4½"-wide panel meter.

The Diodes. The design of the voltmeter is based on the properties of the zener or "breakdown" diode. When a voltage source is connected to such a diode in the reverse direction (positive to cathode), current flow through the diode is negligible as long as the voltage is below a certain critical point.

If the source voltage is raised above this point, the diode "breaks down," passing a current which is determined by the value of the excess voltage and the resistance of the rest of the circuit. As the source voltage is further increased, the current flow through the diode increases proportionally

The three zener diodes in the expanded-scale voltmeter (D1, D2 and D3) are protected from excess current by resistors R1 and R2.



PARTS LIST

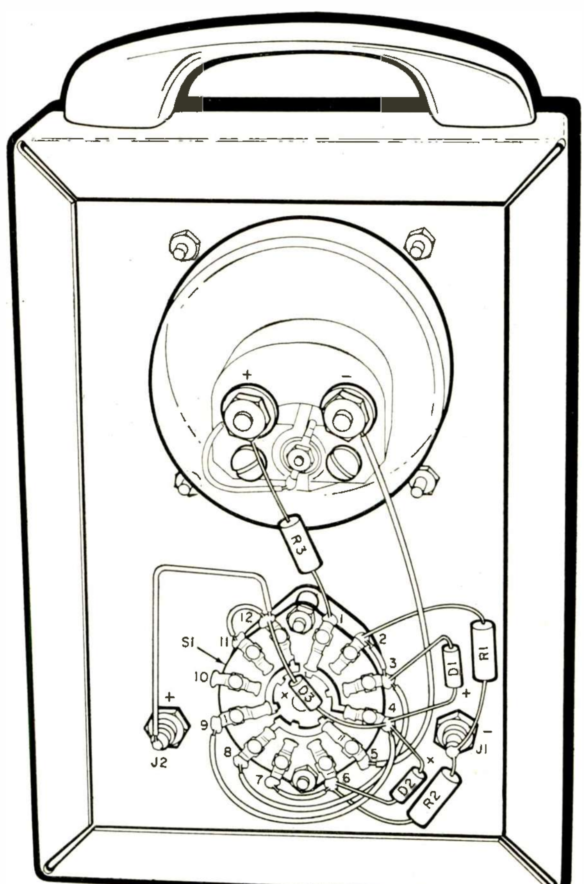
D1, D3—10-volt zener diode, 1-watt, 5% (Motorola 1N3020B or equivalent)
D2—20-volt zener diode, 1-watt, 5% (Motorola 1N3027B or equivalent)
J1, J2—Insulated tip jack (one red, one black)
M1—0-100 d.c. microammeter (Beede Model 230 or equivalent)
R1, R2—2000-ohm, 1-watt, 1% precision resistor (either deposited-carbon or wire-wound)
R3—100,000-ohm, 1-watt, 1% precision resistor (either deposited-carbon or wire-wound)
S1—3-pole, 3-position rotary switch
1—2" x 7" x 5" aluminum chassis (Bud AC-402 or equivalent)

to the excess voltage, but the voltage across the diode remains at the breakdown point—as long as the diode's rated power-handling capacity is not exceeded.

Zener diodes are available with breakdown ratings ranging from under 3 to about 200 volts. The two types used in this instrument are rated at 10 and 20 volts. (For more complete information on zener diodes, see the article beginning on page 76 of the June 1961 issue of POPULAR ELECTRONICS.)

The Circuit. Meter *M1*, a 0-100 d.c. microammeter, is converted to a 0-10 d.c. voltmeter by means of a 100,000-ohm series resistor (*R3*). Resistors *R1* and *R2* are current-limiting units, serving to protect diodes *D1*, *D2* and *D3*; the 2000-ohm resistance of *R1* or *R2* is low compared with that of *M1* with its series resistor—so *R1* and *R2* have a negligible effect on the meter reading. The equivalent circuit for each of the three positions of range switch *S1* is shown at the bottom of page 121.

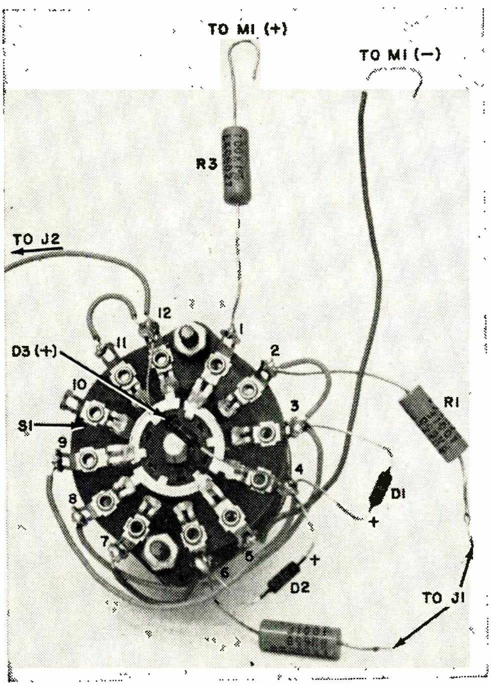
When switch *S1* is in the 0-10 volt position, *M1* (neglecting the very small voltage drop across *R1*) reads the voltage across input jacks *J1* and *J2*. Diode *D1* has no effect on the circuit for voltages below 10, since it does not conduct. At voltages higher than 10, *D1* "breaks down," maintaining a 10-volt drop across its leads and locking *M1* at a reading of 10 volts. Resistor *R2* and diode *D2*, though in the circuit, have no effect because *D2* is a 20-volt



diode—remaining a non-conductor throughout the 0-10 volt range.

With the switch in the 10-20 volt position, no current flows through meter *M1* for voltages less than 10 appearing across *J1* and *J2*, since neither diode conducts. For voltages between 10 and 20, *D1* is in its "break-down" state and maintains a 10-volt drop across its leads, although *D2*, the 20-volt diode, is still in a non-conducting state; the meter, therefore, reads the excess over 10 volts across *J1* and *J2*. When voltages of 20 or higher appear across the input jacks, diode *D2* also "breaks down" and maintains a 20-volt drop; in this case, *M1* sees only the voltage difference between *D1* and *D2* (10 volts) and remains locked at its maximum reading.

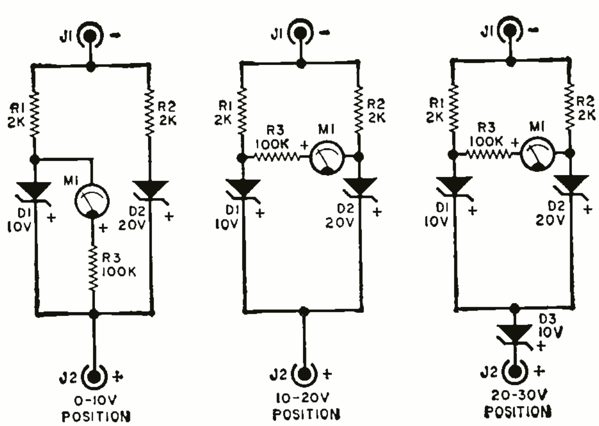
When *S1* is in the 20-30 volt position, the circuit is the same as in the previous case except that an additional 10-volt diode (*D3*) is placed in series with the lead from *J2*. This has the effect of "offsetting" the measurement by 10 volts. In other words, no current flows through *M1* for input voltages of less than 20, while for voltages between 20 and 30, the meter reads the excess over 20 volts. When the input voltage reaches 30 or above, *M1* locks at its maximum reading.



Hook up range switch S1 as shown in photo above before installing it in the chassis according to pictorial diagram shown at left.

Construction. There's room to spare in the 2" x 7" x 5" aluminum chassis used to house the parts, but you'll find it convenient to make all connections to switch *S1* before mounting it. And although parts layout and placement are not at all critical, it's essential to observe the proper polarity when wiring in the diodes (*D1*, *D2* and *D3*) and meter (*M1*). A chromium handle of the type used for kitchen cabinet drawers may be screwed to the top of the meter, making it easier to carry around.

Reading the Meter. Since mentally converting *M1*'s 0-100 scale to measure 0-10 volts is a simple matter (you just divide all readings by 10), it's not really necessary to make a new meter scale for this application. Remember to add 10 volts to all measurements taken on the 10-20 volt range and 20 volts to all measurements on the 20-30 volt range, and you won't have any trouble. —30—

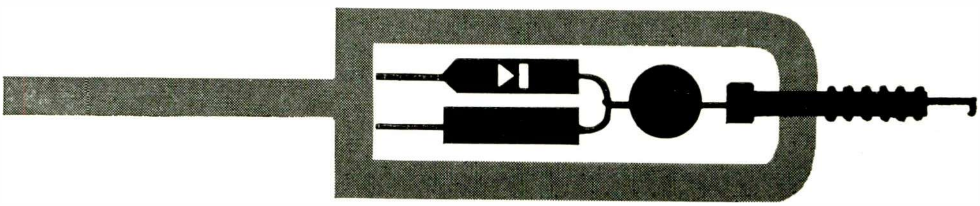


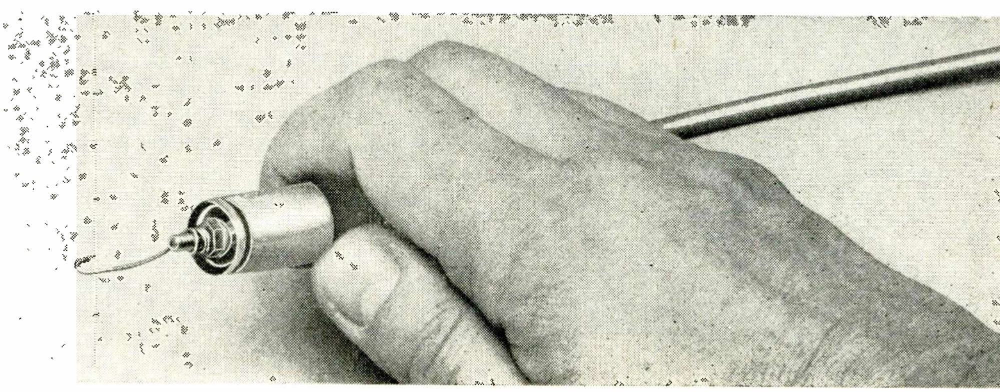
Equivalent circuits for each of the three positions of the range switch. "Offsetting" diode D3 is placed in the circuit only when S1 is in the 20-30 volt position.

R.F. PROBE PEPS UP VTVM

Easy-to-build attachment helps you to trouble-shoot r.f. circuits

By FORREST H. FRANTZ, Sr.



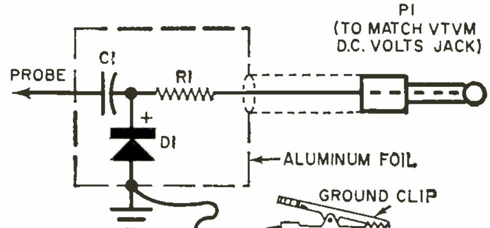


YOU CAN INCREASE the utility of your vacuum-tube voltmeter considerably by building an r.f. probe for it. Although a standard VTVM has an input capacitance which limits its a.c. measurements to frequencies below about 50 kc., an r.f. probe will push this frequency range well into the short-wave region. In fact, the probe described here can boost your VTVM's upper frequency limit into the 6-meter band—a frequency jump of over 1000 times!

What It Is. An r.f. probe is nothing more than an r.f. detector which rectifies r.f. signals and delivers a d.c. output proportional to the voltage applied to the probe's tip.

As shown in Fig. 1, capacitor *C1* passes r.f. signals but blocks d.c. voltages which would contribute to the voltmeter reading and possibly damage diode *D1*. The diode rectifies the r.f. signal by shorting out the negative a.c. pulses, leaving a positive pul-

Fig. 1. Circuit of r.f. probe. Aluminum foil surrounds three components and serves as shield.



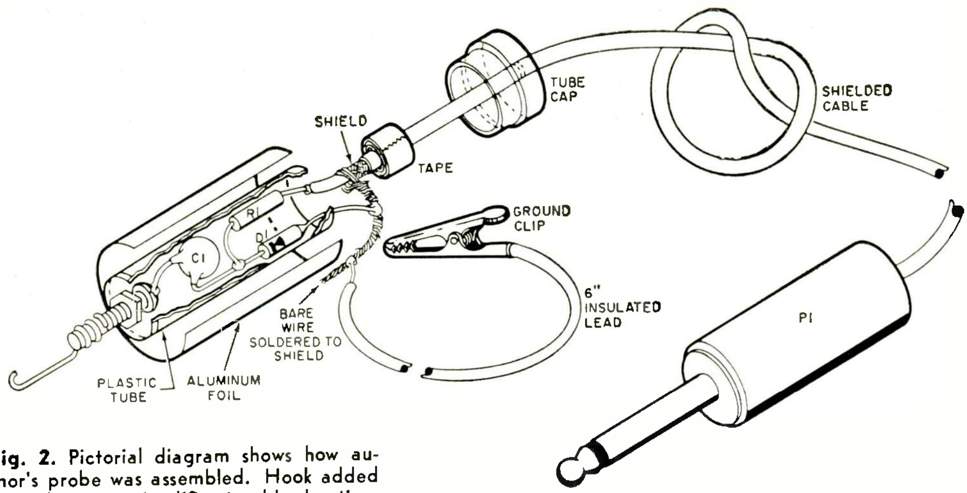


Fig. 2. Pictorial diagram shows how author's probe was assembled. Hook added to probe screw simplifies trouble-shooting.

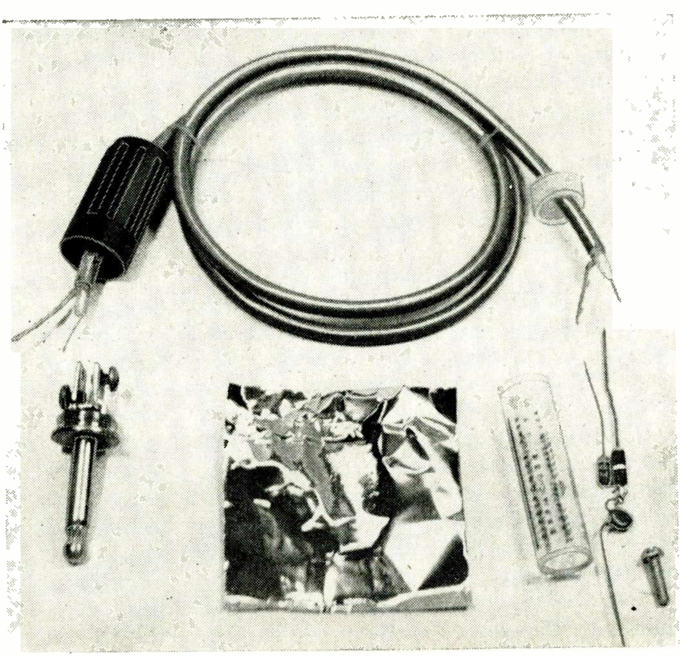
PARTS LIST

C1—0.0002-µf., 1000-volt ceramic capacitor (Sprague 5GA-T20 or equivalent)
D1—1N34A diode
P1—Phone plug (Lafayette MS-455 or equivalent—see text)
R1—4.7-megohm, ½-watt resistor
1—30" length of shielded single-conductor mike cable (Belden 8401 or equivalent)
1—"Mini-gator" clip (Mueller #30 or equivalent)
1—9/16" x 2-1/16" plastic tube—see text
Misc.—Aluminum foil, tape, hardware, etc.

sating voltage which must be filtered to obtain accurate meter readings.

Resistor *R1* is part of the necessary filter. The other part of the filter is the stray capacitance contributed by the shielded cable on the probe and the stray capacitance of the VTVM's internal wiring.

Construction. The probe is built in a plastic tube or bottle about 9/16" in diameter and 2-1/16" long. You can use a larger tube if you wish, but it should be made of



Only a few parts are needed to construct the probe, as shown in the photograph. When soldering, be sure to use a heat sink for diode D1, and to observe the polarity indicated on the schematic diagram.

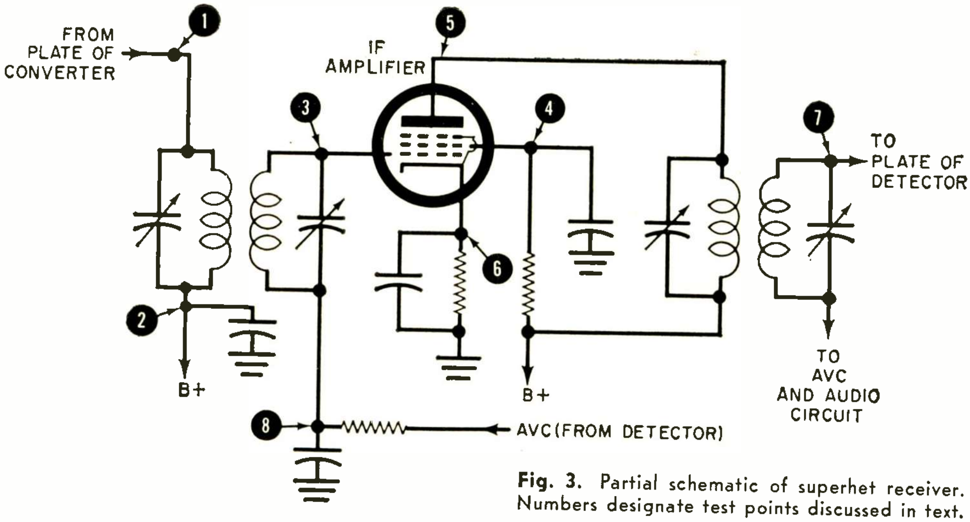


Fig. 3. Partial schematic of superhet receiver. Numbers designate test points discussed in text.

plastic and have a screw-type or force-fit cap. See Fig. 2.

Only the three electronic components already mentioned are used in the probe: *C1* is a 0.0002-μf., 1000-volt ceramic disc capacitor; *D1* is a 1N34A diode; and *R1* is a 4.7-megohm, ½-watt resistor. Before assembling the probe, solder the cathode of *D1* to one end of *R1* and to one end of *C1*; this leaves one end of each component free. Be sure to use a heat sink when soldering *D1*.

Next, solder the free end of capacitor *C1* to the head of a ¾″ *6-32* screw. Solder the free end of resistor *R1* to the center lead of a shielded cable which should first be passed through a ¼″ hole in the cap of the tube. (Use a drill or hot ice pick to make the hole.) Finally, solder the free end of diode *D1* to the cable shield; a short bare wire, about 3″ long, should also be soldered to the shield.

Prepare the probe's body for assembly by drilling a 5/32″ hole in the bottom of the tube. After drilling, glue a piece of aluminum foil to the outside barrel of the probe as shown in the pictorial diagram.

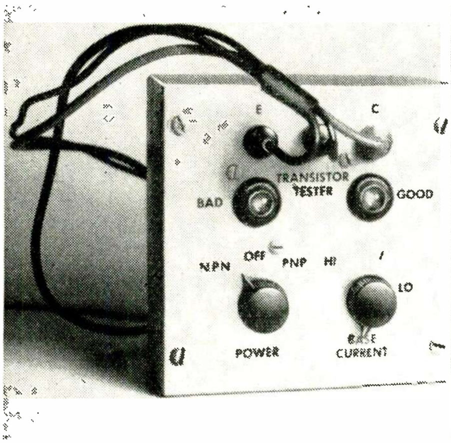
Now push the machine screw connected to *C1* through the hole from inside the tube, and attach a nut to hold the screw in place. The screw serves as the probe's "hot" contact; if desired, a short length of bare wire can be twisted around the screw for more critical "probing."

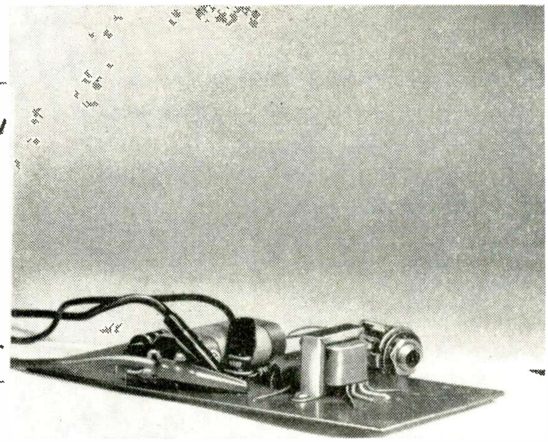
Push the cap over the open end of the tube with the short bare wire passing between the cap and the tube. Then solder a 6″ insulated lead to the bare wire and tape this junction to the aluminum foil so that a good electrical connection is made between the foil and the junction. The tape also serves to hold the cap in place.

Finally, fit the free end of the 6″ insulated lead with a small alligator clip which serves as the probe's ground terminal. The free end of the shielded cable should be connected to a plug (*P1*) that matches your VTVM; be sure to connect the cable's center lead to the plug's "hot" terminal.

Operation. Plug the probe into your VTVM and set the VTVM's range switch to "plus d.c. volts." The d.c. scale will now give a voltage proportional to the r.m.s. value of the r.f. signal. To obtain the r.m.s. value, multiply the scale reading by approximately 1.1. When you use the probe to check the operation of a superhet receiver, for example, ground the probe's alligator clip to the receiver's chassis and touch the probe to selected points in the set.

Shown in Fig. 3 is a partial circuit of a typical superhet receiver; generally, signal voltage should be present at *odd*-numbered test points and should increase as the probe is moved to a higher odd number. However, when proceeding from the plate of one stage to the grid of the next stage, signal voltage should remain about the same. No signal voltage should be present at any *even*-numbered test point; if it is, the bypass capacitor at that point should be checked to see if it is open. —30—





In-Circuit Transistor Tester

Home-brew test instrument checks home-brew projects

By C. L. HENRY

IF you're tired of unsoldering transistors just to test them, and want a dependable transistor tester, this project is for you. With this tester, you'll be able to check most transistors without removing them from the circuit. In one simple operation, it will tell you the quality of the transistor and show up leaky or shorted units.

You don't have to worry about elaborate circuitry, critical wiring, or expensive components. Construction costs are kept down since no meters are used in the tester; a pair of lamps serve as indicators. You should be able to build the unit in an evening—for less than ten dollars.

Construction. The transistor tester is housed in a 4" x 4" x 2" aluminum box which has removable front and back covers. All controls and indicator lamps go on the front cover; mount base-current potentiometer *R1* and power switch *S1* on the lower half, and the indicator lamps (*I1* and *I2*) in the center. The lamps are held in place by rubber grommets and are soldered directly into the circuit.

The collector, base, and emitter jacks (*J1*, *J2*, and *J3*) connect to the transistor under test; these jacks are also mounted on the front cover, near the top. Tip jacks serve as test jacks on the author's model, but universal binding posts might be handier. In addition to the jacks or binding posts, you can also mount an audio and a power transistor socket on one side of the box for rapid testing of transistors which are not wired in circuits.

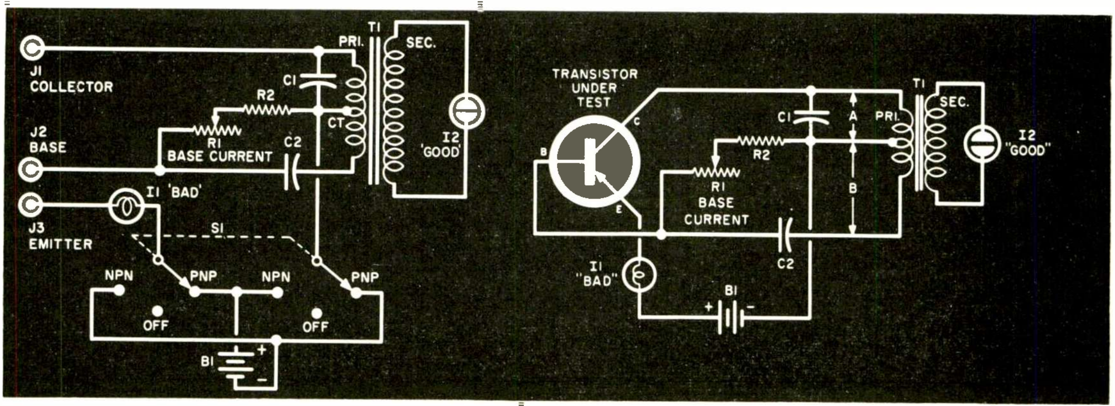
For testing in-circuit transistors, make three test leads from 2' lengths of flexible

PARTS LIST

B1—3-volt battery (two type "C" cells in series)
C1—0.1-μf., 200-volt capacitor
C2—0.068-μf., 400-volt disc capacitor
I1—2-volt, 60-ma. flashlight lamp (GE49 or equivalent)
I2—NE-51 neon lamp
J1, J2, J3—Insulated tip jack (Lafayette PJ-23 or equivalent)
R1—10,000-ohm potentiometer (IRC Q11-116 or equivalent)
R2—220-ohm, ½-watt resistor
S1—Two-pole, three-position rotary switch (Mallory 3223J or equivalent)
T1—Miniature audio transformer, 1500-ohm center-tapped primary, 500,000-ohm secondary (Argonne AR-141 or equivalent)
1—4" x 4" x 2" aluminum utility box (Bud AU-1083 or equivalent)
1—Dual "C" cell battery holder (Lafayette MS-173 or equivalent)
Misc.—Hardware, knobs, grommets, etc.

the transistor is now actually operating as an oscillator in the circuit. If you have another transistor of the same type on hand, you can compare the relative "goodness" of the two transistors by comparing the relative brilliance of the "good" lamps as you test each transistor.

"Bad" lamp *I1* indicates the transistor's collector current. The brighter the lamp, the higher the current. When *R1* is in its minimum resistance position, the collector current should be high and the "bad" lamp should light for most transistors—good or bad. With *R1* in its maximum resistance



Actual schematic of the tester (above) and simplified schematic (right). See How It Works.

wire. Solder an alligator clip to one end of each lead and a phone tip to the other end; the phone tips mate with the tester's jacks.

Operation. Connect each transistor electrode to the tester's jacks (*J1*, *J2*, and *J3*) and rotate base-current potentiometer *R1* to its maximum resistance position. Throw *S1* to either its *p-n-p* or *n-p-n* position, according to the type of transistor under test; if *S1* is in the correct position and the transistor is okay, the "good" lamp (*I2*) will light. (Setting the switch in the wrong position won't harm the transistor, so if you're not sure which type a particular transistor is, try both positions.)

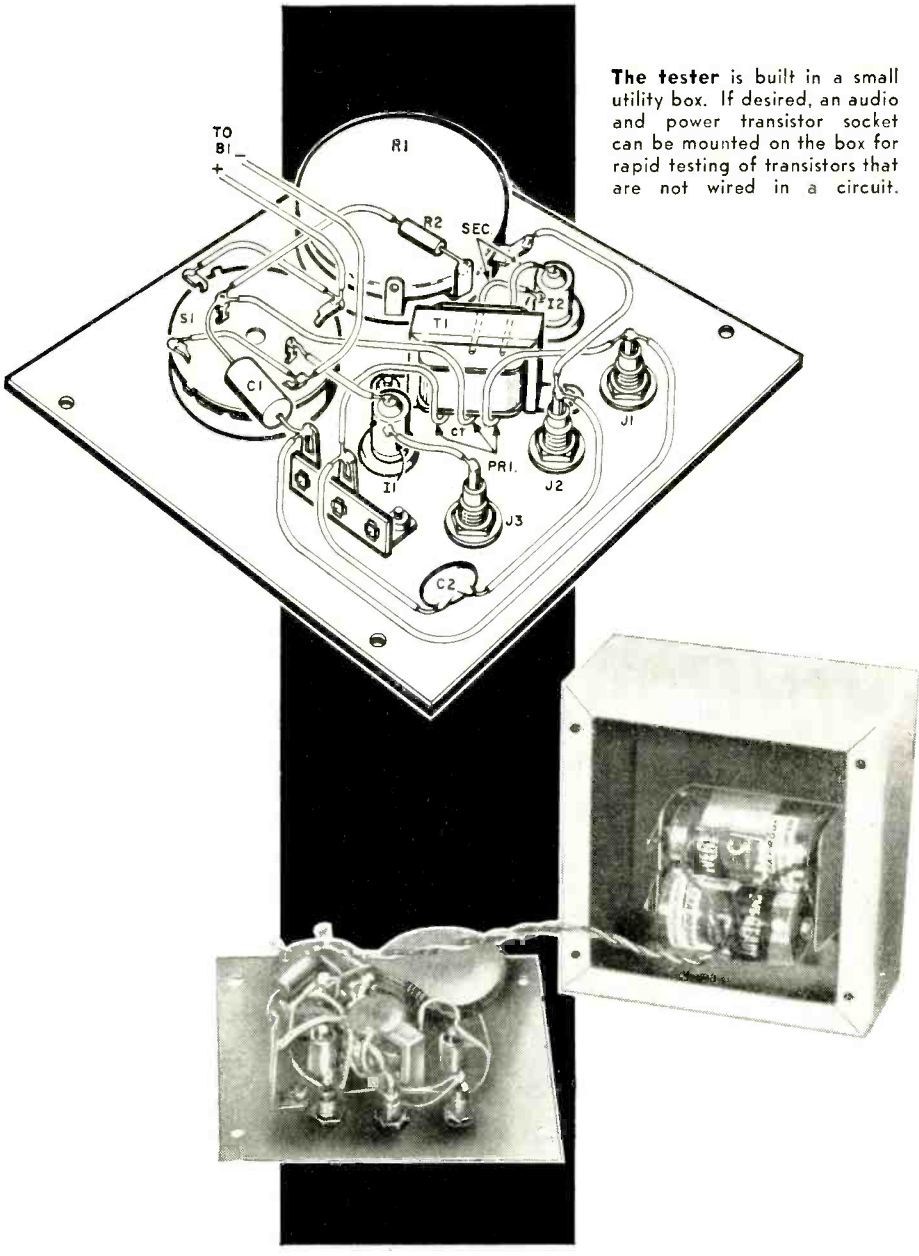
The brilliance of the "good" lamp is an indication of the transistor's quality, since

HOW IT WORKS

The transistor tester is basically an audio oscillator in which the transistor under test becomes an integral part of the circuit. The strength of oscillation provides a relative measure of the transistor's quality.

In the simplified schematic of the unit (above), power switch *S1* has been omitted and the battery is shown connected in the *p-n-p* position of *S1*. Transformer *T1* is used in a Hartley oscillator circuit and as a step-up transformer. One half of the primary of *T1* (A) serves as the transistor's collector load, the other half (B) for audio feedback. Capacitor *C1* tunes *T1*'s primary to raise the oscillator voltage on *T1*'s secondary to the point where neon lamp *I2* will fire. The brightness of *I2* depends on the quality and characteristics of the transistor under test.

Emitter current is measured by the brightness of lamp *I1*, which also serves to limit the transistor's current drain to less than 50 ma. Potentiometer *R1* sets the base current of the transistor; resistor *R2* maintains a minimum resistance in the base circuit. Feedback from the collector to the base passes through capacitor *C2*, which also blocks d.c. from the base.



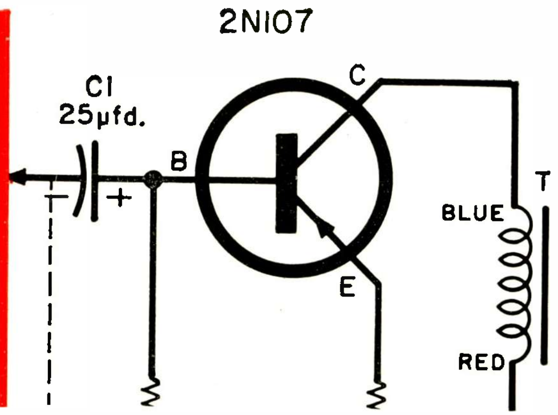
The tester is built in a small utility box. If desired, an audio and power transistor socket can be mounted on the box for rapid testing of transistors that are not wired in a circuit.

position, the "bad" lamp shouldn't light; if it does, the transistor has excessive leakage. If both lamps light when *R1* is at a maximum, it indicates that the transistor is operative but may not work in critical circuits.

If an in-circuit transistor tests "bad," don't condemn it; test it outside of the circuit—some other component may be at fault.

The most common trouble in power transistors is an emitter-to-collector short; if the transistor has this type of short, the "bad" lamp will light in all positions of *R1*. On the other hand, the most common trouble in audio transistors is an open collector or emitter; in this case neither lamp will light. In the last analysis, the "good" lamp must light for a transistor to be rated as "good." —30—

COOKING UP YOUR OWN BLUEPRINTS



By **BOB WRIGHT**

RECIPE: Take one sheet of "Ozalid" paper, top with material to be copied; expose first to light, then to ammonia fumes . . .

Sun lamp provides illumination in this set-up. Drawing lies on top of sensitized paper.

EVER think of making your own "blue-prints"? You can—for little more than the cost of the paper. Of course, there are machines that will duplicate your drawings and other line-type material on photo-sensitive paper very efficiently and with quite uniform results. But if you can do without some of the efficiency, you can still get a fine job—practically free!

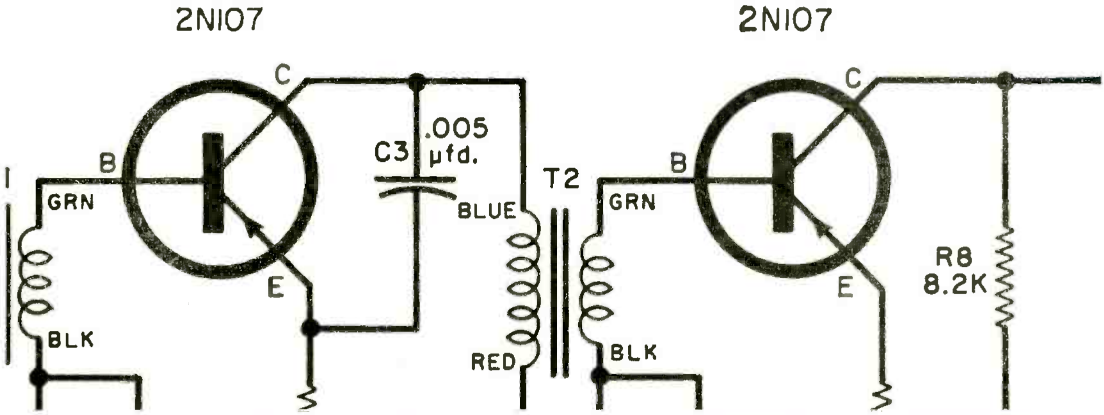
The Paper. The main requirement is sensitized paper, which must be of a type designed for use on an "Ozalid" machine. Such paper is available at office supply houses at a cost of just over one cent a sheet for a package of 250 standard 8½" x 11" sheets. Buy the "Dry Developing" rather than the "Wet Developing" type of sensitized paper.

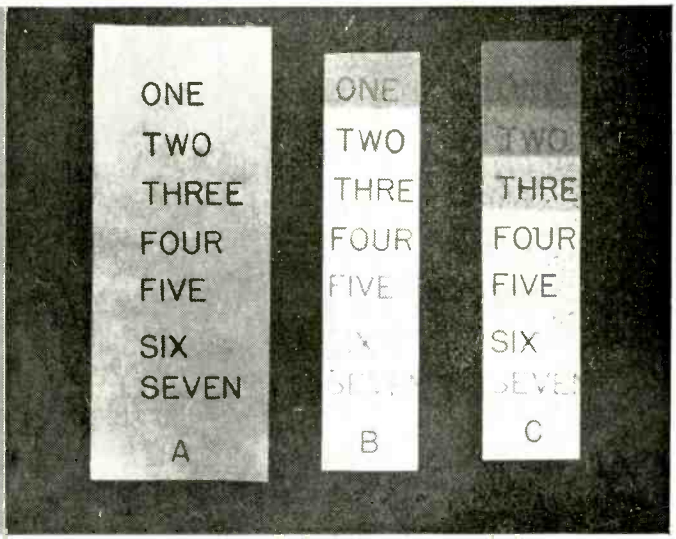
Incidentally, this paper is manufactured in both a "Blue Line" and a "Black Line" variety. As the names suggest, one paper produces drawings with blue lines, while the other makes black-line reproductions. Naturally, the one you choose is simply a matter of your own personal preference.

The Procedure. "For best results, keep in a cool, dry place, away from ammonia and light," reads the warning note on the label of the paper package. Actually, this simple instruction is the key to our duplicating process.

You'll note that the unexposed paper is white on one side, pale yellow on the other. As it happens, the yellow side is sensitive to light, although much less so than photographic paper (it can be exposed to normal room lighting for several minutes at a time without ill effects).

If the paper is subjected to ammonia





After exposure, "blueprint" is developed in glass jar with fumes from ammonia-soaked cloth.

Correct exposure time can be determined with test strips. Strip A is original; B and C are prints.

fumes before it has been exposed to light, it turns a dark color (blue or black). And if it has been exposed to light for a sufficient time, it will be unaffected by the presence of ammonia fumes.

To copy a drawing or other material, take a wide-mouth glass jar with a screw-on lid —a Mason jar or an instant coffee jar, for instance. Then put several drops of household ammonia on a wad of paper or cotton and drop it in the jar.

Place a sheet of the sensitized paper face up on a flat surface, cover with the drawing to be copied (also face up), and place a sheet of glass on top to hold the sensitized paper and the drawing flat. Expose to light for a suitable length of time, and develop in the jar.

Exposure Times. You can see the effects of different exposures in the photograph at right, above. Strip "A" is a piece of ordinary tracing paper with the words "one" through "seven" drawn on it in India ink. This was placed over test strip "B," which was lying on a plate of glass. Another plate of glass was placed on top to hold the tracing against the sensitized paper.

Natural sunshine, of course, can be used for the light source. With a bright sun, the exposure time may be as little as 15 seconds, while on a cloudy day 10 to 20 minutes may be required. You will also notice that, with a little practice, you can judge the degree of exposure by the color of the sensitized paper.

(*Continued on page* 131)

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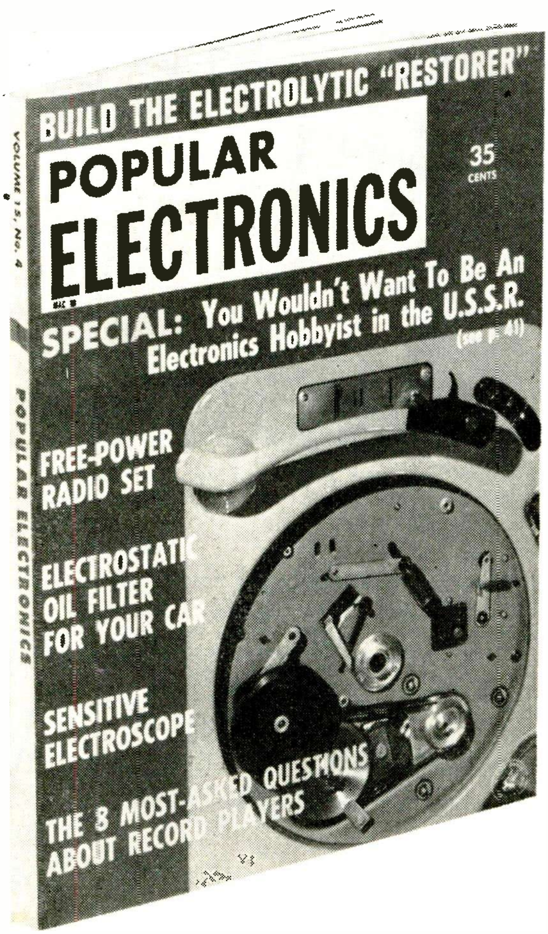

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Cooking Up Blueprints

(Continued from page 129)

Exposure was made 10 inches from a 275-watt, 117-volt Kenmore PS sun lamp. A piece of black cardboard was used to cover the words starting with "one" after the desired exposure time. Total exposure for each section of strip "B" was: "One"—30 seconds; "Two"—1 minute; "Three"—2 minutes; "Four"—4 minutes; "Five"—8 minutes; "Six" and "Seven"—16 minutes.

Strip "C" was exposed in the same manner, although it was placed at a distance of 20 inches from the sun lamp. In addition, the total time was extended to give "Seven" an exposure of 32 minutes. The other sections were exposed exactly as they were on strip "B." On strip "C," the word "Five" has about optimum exposure—8 minutes.

Obviously, the background will be too dark if exposure is insufficient. Similarly, the lines get thin and start to fade if exposure is excessive.

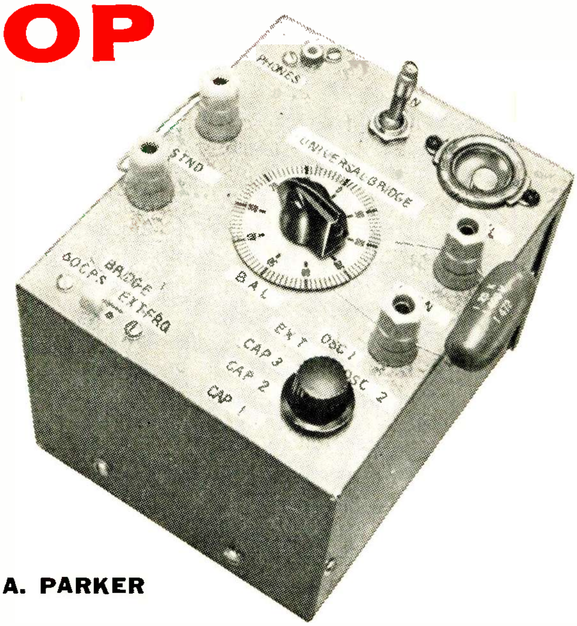
Helpful Hints. When typing material for duplication, place a piece of carbon paper with its coated side against the back of the typing paper. This will make a darker copy, since the type will appear on the front of the sheet with the carbon copy directly behind it on the back of the same sheet. Alternatively, tissue, "onion skin," or tracing paper can be used to reduce the required exposure time, since a thinner paper will pass more light.

In order to get a more even distribution of the ammonia fumes so that developing will take place uniformly at the top and bottom of the jar, you can make an arrangement like that shown on page 129. A vertical wire in the center of the jar was wrapped with a cloth which was then saturated with ammonia. The bottom end of the wire was bent to form a base that would rest on the bottom of the jar.

If you can't find a wide-mouth glass jar that is large enough, try the restaurants. They get pickles and other foods in one-gallon glass jars 10″ high with a screw-on lid approximately 4¾″ in diameter. You'll need more ammonia with these jars, of course, but you'll find that they are almost "made to order" for "cooking up your own blueprints." —30—

UNIVERSAL WORKSHOP TESTER

Versatile instrument measures capacitance and resistance, checks tuning and modulation, also acts as a signal generator



By FRANK A. PARKER

HERE IS an audio generator, resistance-capacitance bridge, and a tuning and modulation indicator all rolled into one. Small in size, this universal tester will take up little room on your workbench and should save you hours in building and adjusting home-brew projects.

With the aid of this instrument, you can easily find values of capacitors from 10 μμf. to 40 μf. with ratings as low as 10 volts. Finding a matched pair of resistors also becomes quite easy. The tuning-eye feature gives you an accurate tuning indicator for AM and FM tuners and tells you the amount of modulation present in the received signal. Added to this, you have an audio generator which puts out a 10- and a 1000-cycle tone for testing audio amplifiers or for signal tracing.

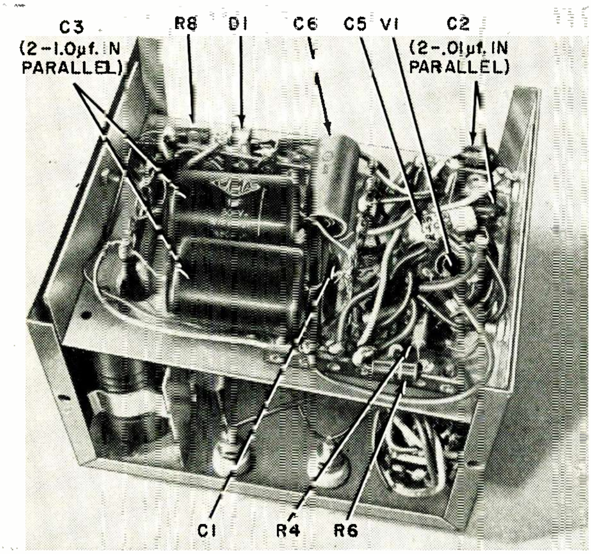
Parts for the tester should cost about $20, but this price can drop drastically if you're lucky enough to be able to find some of the components in your spare parts box.

CONSTRUCTION

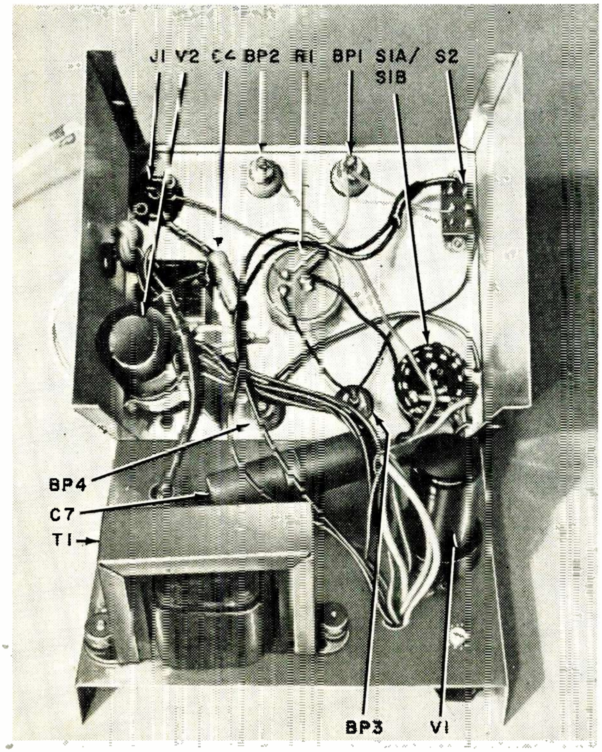
As indicated in the Parts List, the unit is housed in a 4" x 5" x 6" aluminum box; a 1" x 4⅜" x 5⅞" chassis cut from a piece of scrap aluminum fits inside the box and holds most of the components. If you wish, you can use a larger box and chassis—wiring and layout will be easier with the added benefit of a larger and easy-to-read bridge scale.

The entire instrument is built into the front half of the box; the back half serves as a cover. Mount jack *J1*, balance control *R1*, switches *S1*, *S2* and *S3*, and binding posts *BP1* through *BP4* on the box's front panel, as shown in the photos. Capacitor *C4* should be placed just behind the front panel; all the remaining components, including the tubes, fixed resistors, and capacitors, are mounted on the chassis.

The socket assembly for tube *V2* is supplied with a mounting bracket and escutcheon plate which are attached to the front panel of the box; the tube itself clamps onto the bracket. Wire *V2*'s socket to the chassis subassembly using about 7" of the color-coded leads provided (see schematic diagram). Save the excess lengths of wire cut off the socket; they will be handy for connecting the front panel controls to the chassis.



Bottom of chassis, showing placement of parts. Author paralleled two smaller units for both C2 and C3.



View of aluminum box with chassis removed. Operating controls are mounted on top of box, with tube V1, transformer T1, and most small components on chassis.

Balance potentiometer *R1* can be any 2000- to 5000-ohm, 2-watt, linear taper unit; the exact resistance will not affect calibration. Use a standard potentiometer with a 270° rotation or buy a surplus 360° pot of the same value and rating for a longer balance scale; a 360° pot was employed in the model.

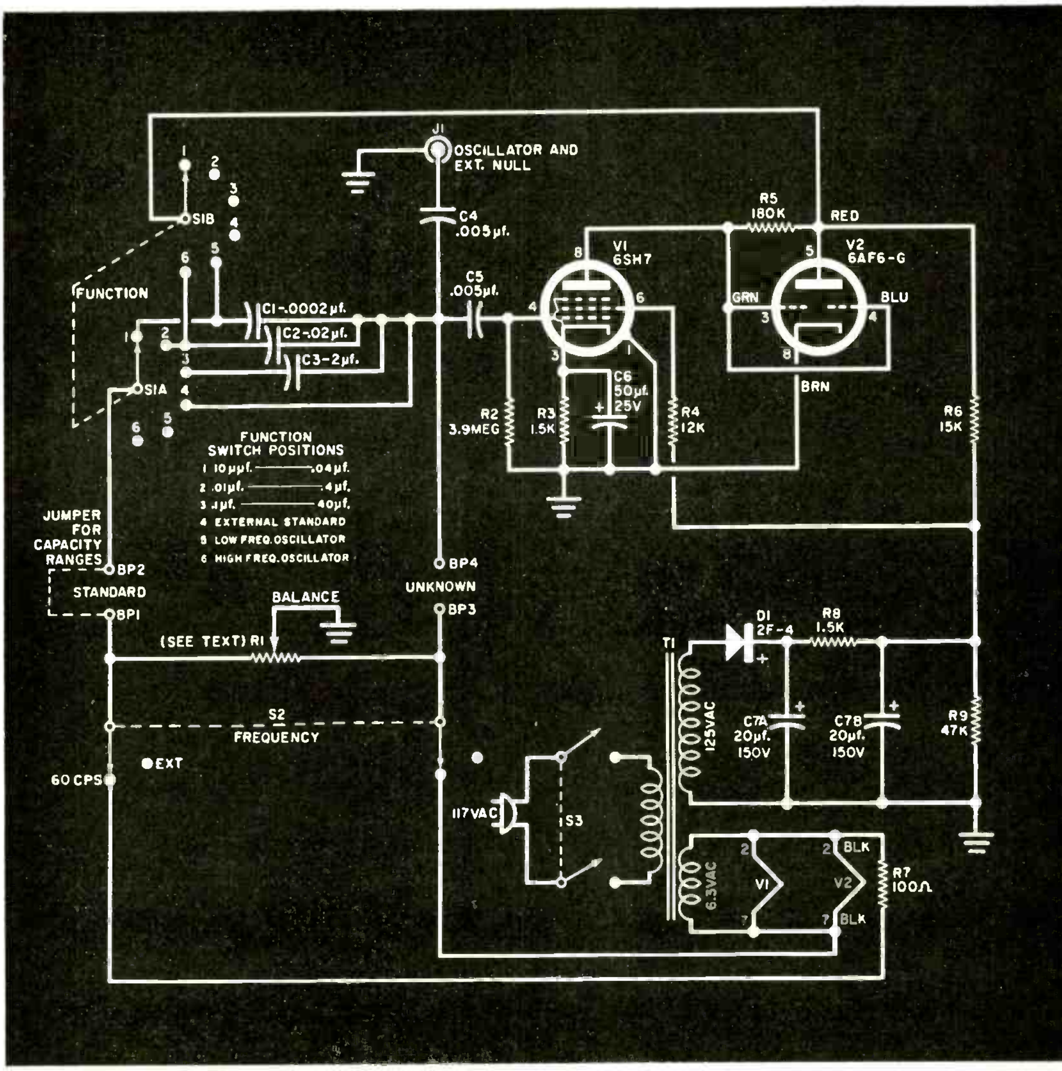
Be sure to use the values specified in the Parts List for capacitors *C1*, *C2* and *C3*; these are the "standard" capacitors and determine the tester's calibration and ranges. Leads between these capacitors and function switch *S1* should be as short as possible. The connecting leads between the binding posts (*BP1* through *BP4*) and balance potentiometer *R1* should also be kept short. Other wiring is not critical.

CALIBRATION

Before applying power to the instrument, check the resistance across resistor *R9* with an ohmmeter. The meter should fall to zero ohms and then slowly climb to about 47,000 ohms; any lower final reading indicates a wiring error or a shorted or leaky filter capacitor (*C7a* or *C7b*). Now disconnect the meter and switch on the unit; tube *V2* should light with a green glow. If *V2* doesn't light, check for about 125 volts d.c. on the plate of *V2* and for 6.3 volts a.c. on *V2*'s heater.

Next, jumper the "standard" binding posts (*BP1* and *BP2*) and set function switch *S1* to capacitance range 1 (*Cap 1*). Rotate balance potentiometer *R1* through its range. The eye of *V2*—the null indicator —should open at one end of *R1*'s range and close at the other end. If the eye doesn't open and close, check for plate and heater voltage on amplifier tube *V1*. When everything checks out, the bridge's balance potentiometer (*R1*) is ready for calibration.

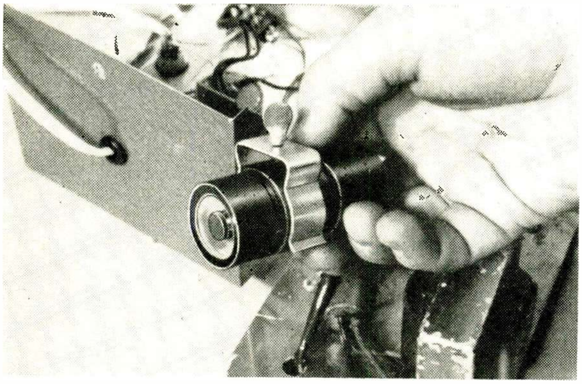
Make a scale for *R1* by marking *V2*'s eye-open position "0" and the eye-closed position "100." This scale is then divided equally, every five units, as shown in the Calibration Chart. You can buy a ready-made scale (such as the Croname 905, designed for 270° rotation pots) or you can make your own scale. If you use a 360° rotation pot and make your own scale, as



Schematic diagram of tester. Potentiometer R1 can be almost any 2000- to 5000-ohm unit.

PARTS LIST

BP1, BP2—Universal binding post (yellow)
BP3, BP4—Universal binding post (blue)
C1—0.0002-µf. silver mica capacitor, 5% tolerance
C2—0.02-µf., 200-volt Mylar capacitor, 10% tolerance
C3—2-µf., 200-volt Mylar capacitor, 10% tolerance
C4, C5—0.005-µf., 600-volt paper capacitor
C6—50-µf., 25-volt electrolytic capacitor
C7a/C7b—20/20 µf., 150-volt electrolytic capacitor
D1—Silicon diode (Sarkes-Tarzian 2F4 or equivalent)
J1—RCA-type phono jack
R1—2500-ohm, 2-watt linear potentiometer—see text
R2—3.9 megohms
R3, R8—1500 ohms
R4—12,000 ohms
R5—180,000 ohms
R6—15,000 ohms
R7—100 ohms, 2 watts
R9—47,000 ohms, 1 watt
All resistors ½ watt unless otherwise noted
S1—Two-pole, six-position rotary switch
S2—D.p.s.t. slide switch
S3—D.p.s.t. toggle switch
T1—Power transformer; primary, 117 volts; secondaries, 125 volts @ 15 ma., 6.3 volts @ 0.6 amp. (Stancor PS-8415 or equivalent)
V1—6SH7 tube
V2—6AF6-G tube
1—6" x 5" x 4" aluminum box (Bud CU-2107-A or equivalent)
1—4⅜" x 5⅞" x 1" chassis—see text
1—Tuning eye assembly (Amphenol 58-MEA-8 or equivalent)
Misc.—Knobs, hardware, octal socket, wire



Socket assembly for tube V2 in workshop tester includes mounting bracket and escutcheon plate.

the author did, you'll find that the "0" and "100" points coincide.

The "0" to "100" scale marked on *R1*'s dial now corresponds to the values of capacitance given in the Calibration Chart, which is valid only if the values of capacitors *C1*, *C2*, and *C3* correspond to the values given in the Parts List. As mentioned earlier, different values for *R1* will not affect the calibration.

OPERATION

Once calibrated, the universal tester is ready to go to work in any one of a number of applications.

Capacitance Bridge. Connect a wire jumper across "standard" binding posts *BP1* and *BP2* and rotate function switch *S1* to a capacity range (*Cap 1*, *Cap 2*, or *Cap 3*). Next, connect the unknown capacitor across the "unknown" binding posts *BP3* and *BP4*. The capacitor's polarity need not be observed and its working voltage can be as low as 10 volts d.c. Set bridge frequency switch *S2* to *"60 cps"* and switch on the unit.

When the null indicator eye (*V2*) lights, rotate *R1* until *V2* gives an "eye open" indication. If the point where the eye opens is at either end of *R1*'s scale (0 or 100), set *S1* to the next higher or lower scale until an eye-open indication is found somewhere between the extremes of *R1*'s range. When the eye-open indication is observed, check *R1*'s reading against the Calibration Chart for the unknown capacitor's value.

Resistance Bridge. To find a matched pair of resistors among a group marked

E90R98083

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with the same value, connect one resistor across "standard" binding posts *BP1* and *BP2*. Connect any resistor you want to match to the "standard" resistor across "unknown" binding posts *BP3* and *BP4*. Set *S1* to *Ext* and place *S2* in the *60 cps* position. Now, rotate *R1* in the vicinity of 50 on its scale, and switch on the tester. If the unknown resistor is exactly the value of the standard, null indicator *V2* will give

CALIBRATION CHART

Balance Pot (R1)	Range 1 (uf.)	Range 2 (uf.)	Range 3 (uf.)
0	—	—	—
5	.00001	.001	.1
10	.00002	.002	.2
15	.00004	.004	.4
20	.00005	.005	.5
25	.00006	.006	.6
30	.00007	.007	.7
35	.0001	.01	1.0
40	.00015	.015	1.5
45	.00017	.017	1.7
50	.0002	.02	2.0
55	.00025	.025	2.5
60	.0003	.03	3.0
65	.0004	.04	4.0
70	.0005	.05	5.0
75	.00065	.065	6.5
80	.0008	.08	8.0
85	.001	.1	10.0
90	.002	.2	20.0
95	.004	.4	40.0
100	—	—	—

an eye-open indication at "50." Should the unknown resistor be a *lower* value than the standard, *R1* will read *above* 50. In the same way, unknown resistors with a *higher* value than the standard resistor will give readings on *R1 below* 50.

Audio Generator. As previously stated, two fixed audio frequencies are available

(*Continued on page* 150)

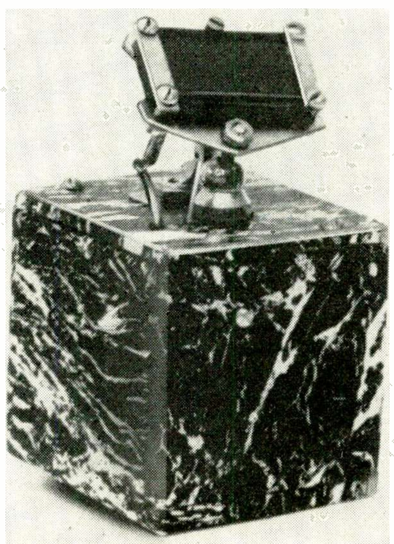
Light Control for Toys

(*Continued from page 27*)

bolted to a swivel joint salvaged from an old desk pen set and attached to the top of the box. This arrangement makes it possible to tilt the cell away from any strong light which might interfere with the operation of the relay.

Installation and Operation. Wire the contact points of relay *K1* in parallel with the switch controlling the toy's power, set *R2* for maximum resistance, and turn on *S1*. A flashlight beam is directed at the surface of *PC1*, and the resistance of *R2* is slowly decreased until the relay contacts close, turning on the toy.

The action should stop when the light beam is shut off or moved away from the photocell. Should the room light level be so high that the relay contacts remain closed, install a cardboard shade on the photocell.



Framed photocell is mounted on optional ball-and-socket joint.

To restore normal operation of the toy, just open *S1;* the toy's original power switch will operate as before.

A word of caution. The contacts of relay *K1* are rated at about 500 ma. (half an ampere). This is more than adequate for most small electric toys, but if you're in doubt, measure the toy's current drain before connecting it to the relay. —30—

ac TRANSISTORIZED VOLTMETER

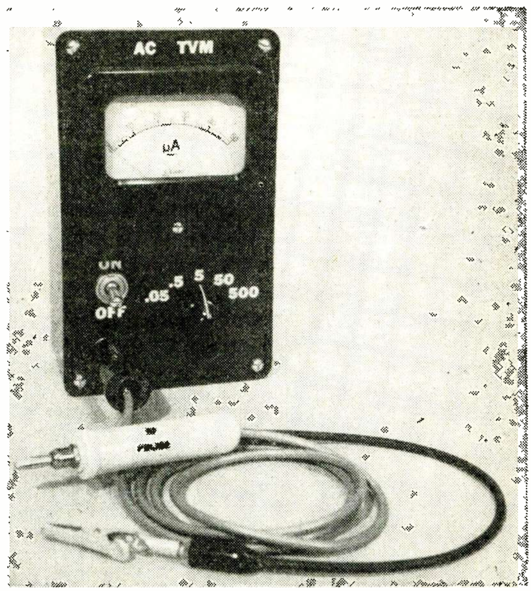
Sensitive pocket-sized instrument, rugged and professional-looking, covers 0.05 - 500 volts in 5 ranges

By FORREST H. FRANTZ, Sr.

THIS versatile a.c. voltmeter is the transistorized counterpart of an a.c. VTVM. Having five input ranges (0-.05, .5, 5, 50 and 500 volts), the battery-operated unit may be used for making any routine a.c. measurements. In addition, its high input impedance (200,000 to 300,000 ohms on the .05-volt range, 2 - 3 megohms on the higher voltage ranges) makes it suitable for a variety of other applications.

The "AC TVM" (transistorized voltmeter) will check relative output levels of microphones and phono pickups, trace and measure audio signals in sensitive circuits. Signal tracing in the i.f. and r.f. sections of radio receivers can also be carried out if a demodulation probe (such as VTVM's r.f. probe) is used.

Rugged and professional-looking, the completed unit is compact enough to fit in your coat pocket. The cost is low for an instrument of this calibre, and it can be built in about a day. All in all, the transistorized voltmeter is a worthy addition to anyone's stock of test equipment.



Construction. Begin by mounting switches *S1* and *S2*, jack *J1*, and meter *M1* on the front panel of the Bakelite box. The exact positions of these parts are not important, but the photograph above will serve as a general guide.

Resistors *R1* through *R5* and capacitor *C1* can now be wired to *S1* and *J1*. Connect the shell of *S1* and the metal frame of *S2* (for shielding purposes) to the frame terminal of *J1*. Leave the connections to this terminal unsoldered, since another wire must be added at a later stage of construction.

Though precision resistors are specified for *R2-R5*, you can save some money by using ordinary, 10%-tolerance, ½-watt units if you have access to a Wheatstone bridge. Use the bridge to measure a number of resistors marked with the value you are looking for, selecting the one which hits it "on the nose" in each case. The author found it convenient, in a few cases, to "make" a resistance of the proper value by combining resistors in series or parallel.

With the front panel wired, you can proceed to the amplifier board. Once again, the exact parts locations are not important—use the component layout shown in the pictorial diagram as a guide. Two ¼" holes should be drilled to accommodate the meter terminal screws (which serve to hold the board in place), and another ¼" hole for mounting *R8*.

The battery is held in place with two pieces of stripped, solid hookup wire looped over it and passed through the perforations. Pull each wire tight and hold it in place by bending its ends back behind the board. Stick a piece of cellophane tape over the wires and the top of the battery to prevent horizontal movement.

All of the other parts are mounted on the board by passing their leads through the perforations. Leads which are to be connected together are run through a common hole or joined with a length of wire running across the back of the board. Do the soldering from behind, using a small, well-tinned iron and rosin-core solder. Heat should be applied for the shortest possible time to avoid damaging the components (the diodes and transistors are most sensitive).

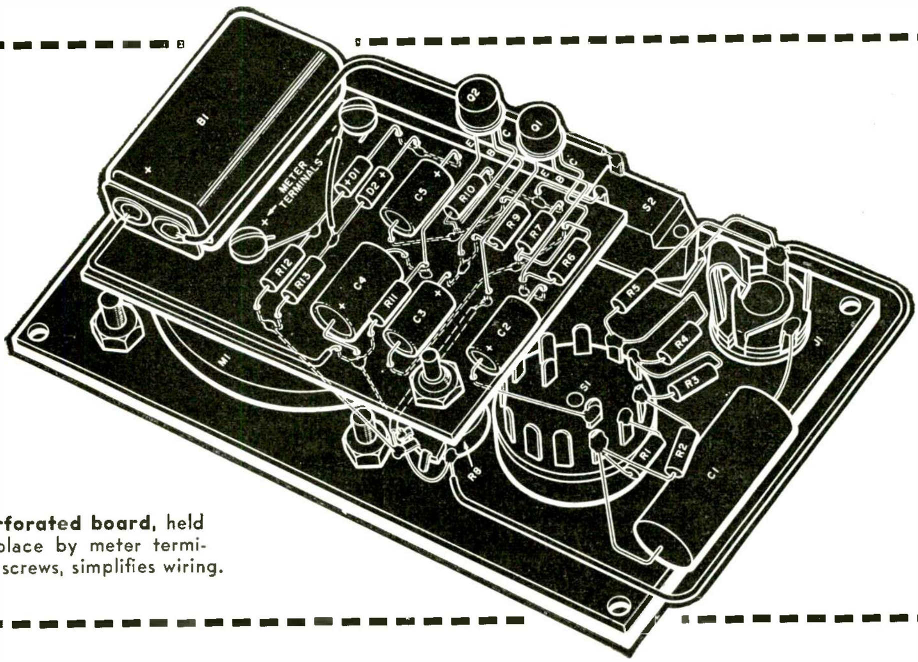
When the amplifier board is completed, it should be fastened to the front panel assembly. Pass the meter terminal screws through their holes in the board, screwing them into the terminals. The meter leads are looped under the screw-heads before tightening.

Finish wiring the voltmeter by making the connections from the amplifier board to switches *S1* and *S2*, and jack *J1*. The terminal of potentiometer *R8* which connects to the frame of *J1* should also be grounded to *R8*'s metal shell, completing the shielding system.

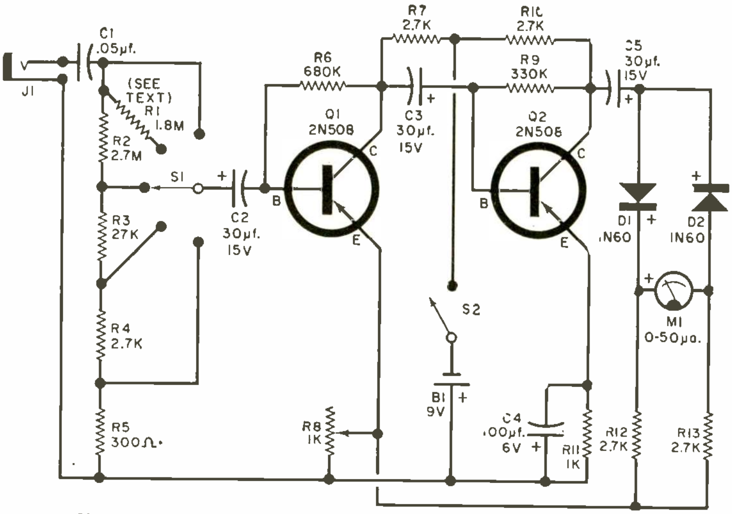
Before moving on to the calibration of your meter, an appropriate input cable must be assembled. Connect one end of a length of single-conductor shielded wire to a phone plug (the braid goes to the plug's "shell" connection), attaching a pair of test prods or a test prod and an alligator clip to the other end. The phone plug is inserted into jack *J1* on the voltmeter's front panel.

About the Circuit. The a.c. voltage to be measured passes through *J1* and capacitor *C1* to a voltage-dividing range-selector circuit consisting of *S1* and resistors *R1-R5*. The output of the voltage divider is fed to a high-gain amplifier employing transistors *Q1* and *Q2*.

Feedback for *Q1* and *Q2*, obtained through resistors *R6* and *R9* respectively, improves the linearity and frequency response of the amplifier. Transistor *Q2*'s output, which is proportional to the voltage



Perforated board, held in place by meter terminal screws, simplifies wiring.

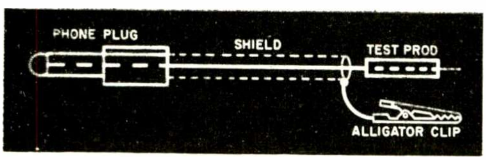


Voltmeter circuit incorporates a high-gain transistorized amplifier.

PARTS LIST

- B1—9-volt transistor battery (Burgess 2U6 or equivalent)
- C1—0.05-µf., 600-volt Mylar or paper capacitor
- C2, C3, C5—30µf., 15-volt miniature electrolytic capacitor (Sprague TE-1158 or equivalent)
- C4—100-µf., 6-volt miniature electrolytic capacitor (Sprague TE-1102 or equivalent)
- D1, D2—1N60 diode
- J1—Open-circuit phone jack
- M1—0-50 microampere meter (Lafayette TM-70 or equivalent)
- Q1, Q2—2N508 transistor
- R1—1.8-megohm, ½-watt, 10% resistor
- R2—2.7 megohms*
- R3—27,000 ohms*
- R4—2700 ohms*
- R5—300 ohms*
- R6—680,000-ohm, ½-watt, 10% resistor
- R7, R10, R12, R13—2700-ohm, ½-watt, 10% resistor
- R8—1000-ohm miniature potentiometer
- R9—330,000-ohm, ½-watt, 10% resistor
- R11—1000-ohm, ½-watt, 10% resistor
- S1—One-pole, five-position rotary switch
- S2—S.p.s.t. toggle switch
- 1—6¼" x 3¾" x 2" Bakelite case (Lafayette MS-216 or equivalent)
- 1—Panel for case (Lafayette MS-217 or equivalent)
- 1—2 7/16" x 3 3/8" perforated board (Lafayette MS-304 or equivalent)
- Misc.—Phone plug, shielded wire, and alligator clips or test prods for input cable

* ½-watt, 1%, deposited-carbon resistor (Aerovox "Carbofilm" or equivalent)



Input cable is made with standard shielded wire; inner conductor connects to tip of phone plug.

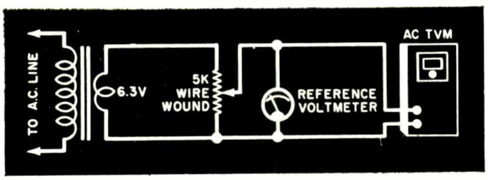
being measured, is rectified by diodes *D1* and *D2* and indicated on meter *M1*. Variable potentiometer *R8* is the meter calibration control.

Power for the transistorized voltmeter is supplied by a small, self-contained 9-volt battery (*B1*). The current drain on the battery is only about 2 milliamperes.

Calibration. Since the scale of meter *M1* reads from 0 to 50, it's a simple matter to mentally convert it for use on any of the transistorized voltmeter's ranges. On the 500-volt range, *M1*'s readings are multiplied by 10; on the 50-volt range, *M1* is read directly; on the 5-, .5- and .05-volt ranges, divide the readings by 10, 100 and 1000 respectively.

The simplest—but least desirable—method of calibrating the voltmeter uses the a.c. line as a reference. Set the instrument to its 0-500 volt range and connect the input cable across a wall outlet. Next, flip on *S2* and adjust *R8* for a reading of 110 volts ("11" on *M1*'s scale). Though the line voltage will be closer to 117 volts in some localities, this discrepancy is minor and will not seriously affect the instrument's accuracy.

A more accurate calibration method involves the use of a reference voltmeter. Connect a good a.c. voltmeter in parallel with input jack *J1,* set the transistorized voltmeter at its 0-5 volt range, and connect the meters to a 6.3-volt filament transformer and 5000-ohm wire-wound potentiometer (see below). The 5000-ohm pot is adjusted for a 5-volt reading on the reference voltmeter, then potentiometer *R8*



Suggested circuit for calibrating the voltmeter.

should be carefully adjusted for a 5-volt ("50" on *M1*'s scale) reading on the transistorized voltmeter.

Either of the methods described above will effectively calibrate the voltmeter for 0 - .05, 5, 50 and 500 volts. The author found, however, that the calibration for the 0 - .5 volt range did not readily fall into line with the others. You can check the accuracy of the 0 - .5 volt reading with the same reference voltmeter circuit discussed above, in the following manner.

After carrying out the calibration, adjust the 5000-ohm potentiometer for a .5-volt deflection on the reference meter and set the transistorized voltmeter to its 0 - .5 volt range. If *M1*'s reading is less than "47" (.47 volt), correct it by decreasing the resistance of *R1* (try other 10% resistors of the same value as *R1* in place of it until you find one which will produce the proper reading).

If *M1* goes off-scale, reduce the setting of the 5000-ohm potentiometer until *M1* reads "50" (.5 volt), and check the reference meter. A reading of less than .47 volt on this meter means that you'll have to increase the value of *R1.* Again try different 10% resistors, repeating the test procedure each time until you find one that works. —30—

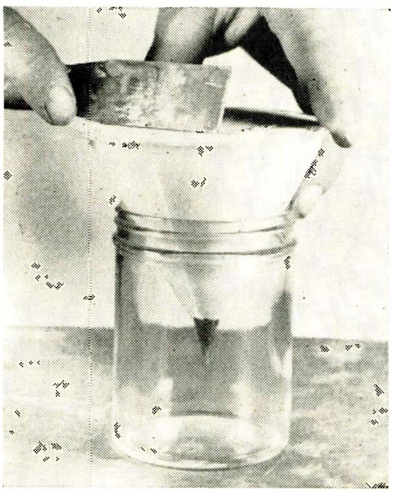
Space-Saver Speaker System

(*Continued from page* 100)

according to the pattern shown. This panel will require trimming from its original 10¼" dimension to prevent its overlapping the duct panel and obstructing the duct.

Next, the duct panel and the bottom sloping panel can be placed in position. By coating the sloping panel edges heavily with glue and putting in its bottom screws last, as shown, the top edge will be forced up against the bottom edge of the duct panel for a good seal.

Plaster of Paris "funnel" serves as a reflector for high frequencies. Author used empty peanut-butter jar as holder.



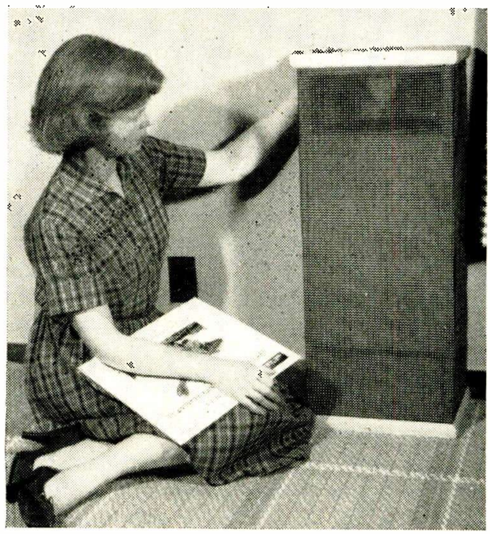
Now the front panel can be set in place, using some small pieces of ¾" stock to insure proper spacing from the duct panel. Place the foam plastic so that it covers the interior surface of the speaker compartment. Last of all, put on the speaker board and the top framework, and the basic enclosure is finished.

Inverted Cone. The reflector for the high frequencies can now be prepared. There are several acceptable means of reflecting highs, including a single convex "mirror," a set of multiple convex surfaces, or an inverted cone. The latter method is used here.

The cone is easily constructed from a funnel by cutting off the narrow tube at the bottom, fitting in a cheap plumb bob for a plug, and filling the funnel with plaster of Paris. Don't mix the latter until you are ready for it.

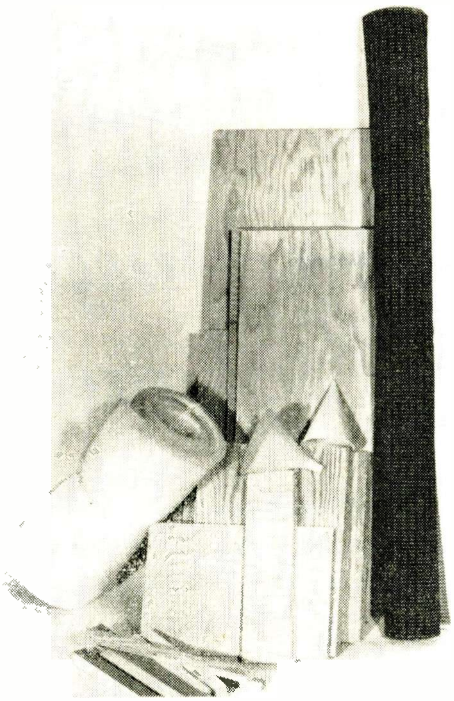
After the funnel is filled with the plaster of Paris, it should be put aside to harden—preferably overnight. Meanwhile, you might want to try out the speaker to make sure everything is working all right and to decide what kind of top you are going to have.

Open or Closed? Connect the speaker leads (it's unnecessary to wire in the tweeter control at this point) and set the speaker in the opening made for it. Now try several kinds of music, both with the top open and with a board across the framework. There will be fewer highs without the reflector in place, of course, but the thing to listen for is the change of quality in the overall sound of the speaker when the board is in place and when it is removed.



Completed "Space-Saver" assembly rests on floor, can be placed almost anywhere in room.

If you like the sound with the board in place, go ahead with the plans as shown here. If, on the other hand, you dislike the slight coloration caused by the top (remem-



BILL OF MATERIALS

Lumber

A—½" x 12" x 29½" plywood (back)
B, C—½" x 8½" x 23½" plywood (sides—2 required)
D—½" x 11" x 17" plywood (front)
E—½" x 11" x 10¼" plywood (resistive panel)
F—½" x 11" x 7½" plywood (duct panel)
G—½" x 11" x 2¼" plywood (sloping panel)
H—½" x 11" x 8½" plywood (bottom)
I—½" x 8½" x 12" plywood (speaker board)
J—¾" x 9⅛" x 12³⁄₁₆" plywood (top)
K—½" x 7¹¹⁄₁₆" x 10⁹⁄₁₆" plywood (sub-top—optional)
L—¾" x ¾" x 12" pine (top/front framing)
M—¾" x ¾" x 7¾" pine (top/side framing—2 required)
N, O—¾" x ¾" x 4¾" pine (front corner framing—2 required)
1—Length of ¾" x ¾" pine (to be cut for cleats)
1—6' length of door stop (top and bottom trim)

Other Parts

1—Plastic funnel, 4" diameter
1—Plumb bob, small (conical plug at bottom of funnel)
1 lb.—Plaster of Paris
5 doz.—Wood screws, #6 x 1"
1 yard—Plastic grille cloth
4 sq. ft.—Plastic foam, ½" thick (acoustical padding in speaker compartment—see text)
1—Speaker—see text
Misc.—Glue, carpet tacks, etc.

Materials for cabinet are readily available at lumber yards and supply houses. Funnel construction is explained in text.

ber, sound quality is largely a matter of individual taste), then mount the funnel on a single ¾" brace and locate it above the tweeter.*

Finishing It. To finish the cabinet, cover the top as well as the sides with grille cloth. Note that the top has about ⅛" overhang at the front and on each side, allowing space for the grille cloth. A piece of ½" plywood is cut to fit inside the top framework of ¾" material. It holds the funnel and provides a guide to hold the top in position.

The top and bottom of the enclosure are trimmed with ordinary door stop (pine molding) and finished to match the top board. Door stop has a width of about 1⅛" and so extends down far enough to cover the edge of the cloth. At the bottom it can be positioned so that it doesn't interfere with the opening of the duct.

The tweeter control is mounted in the back through the 1⅞" hole. Speaker leads are passed through the back panel by means of two ⅛" brass bolts, placed just above the control. When mounting the speaker, follow the instructions supplied with it for hooking up the tweeter control, and don't forget to place the tweeter at the front of the enclosure.

One possible change could be made in the enclosure if you find it too high for your particular installation. The back could be cut 5½" shorter and the entire top eliminated. A ¾" frame around the outside of the top would provide the necessary elevation of a top grille (sub-top) to cover the speaker. This would cut about 6" from the height, but would leave the speaker without a positive method of treble dispersion. Perhaps a plant in an egg-shaped tripod-held pot would provide the answer, if you can bear the thought of water being carried near an upturned, unprotected speaker cone.

But however you finish it and however you use it—for monaural or for stereo—this little speaker system will do its job uncomplainingly. And unlike some of its prima donna competitors, it performs well in any location. —30—

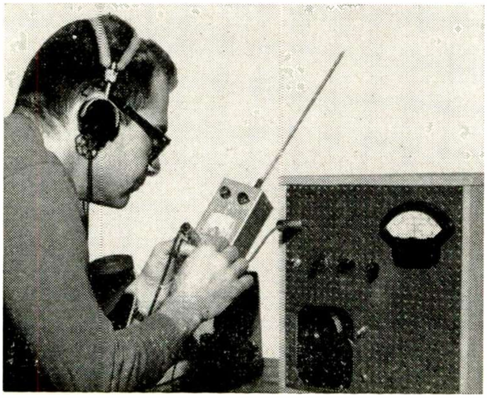
*If you use the ¾" brace, be sure to put it in with removable screws after the speaker is mounted, or access to the speaker will be limited.

SENSITIVE Field Strength Meter

Transistor-amplified unit, bandswitched from 20 to 2 meters, measures field strength, tests for harmonics, and checks transmitter audio quality

By HERBERT FRIEDMAN

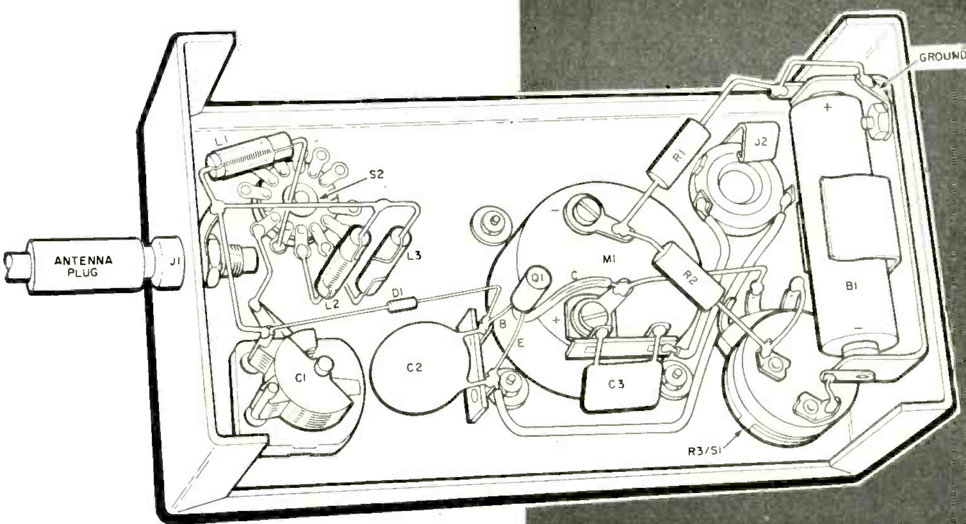
The FSM has headphone output jack for checking transmitter's audio quality. Plugging in headphones does not change sensitivity of instrument.

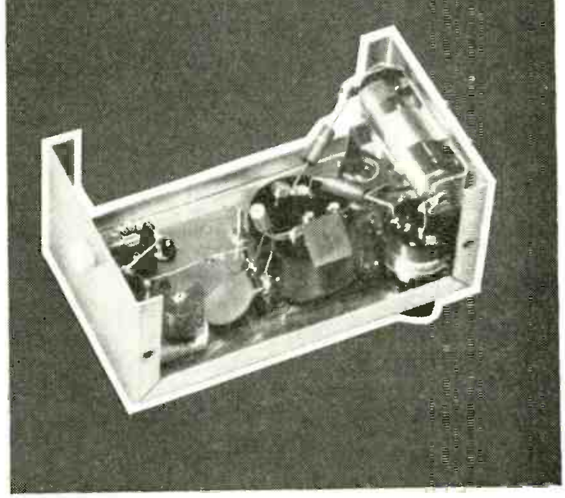


A FIELD STRENGTH METER (FSM) is one of the handiest instruments you can have around your ham shack—it can be used for tuning up and checking transmitters and antennas, or hunting for those TVI-producing harmonics. This transistor-amplified unit combines many of the features most desired in a field strength meter. In addition, its tuned input—which is bandswitched from 20 through 2 meters—makes for high sensitivity and eliminates interference from the transmitter's fundamental frequency when you're checking for harmonics.

The Circuit. A standard tuned circuit with a diode detector picks up and rectifies the r.f. signal. The rectified r.f. is then fed to the base of a common emitter transistor amplifier whose gain is such that a base current of 10 to 20 microamperes, depending on manufacturing variations in the transistor, causes full-scale deflection of the 0-1 ma. meter (*M1*).

This gain is more than adequate for general testing. If greater sensitivity is desired, such as for antenna checking at relatively large distances from the transmitter, a 0-50 or 0-100 μa. meter can be





Small metal utility box houses and shields FSM parts. The leads of coils L1, L2 and L3 should be as short and direct as possible. Notice that the polarity of mercury battery B1 is unusual; the casing is positive and the insulated center disc is negative.

substituted for *M1*. No circuit changes would be necessary as a result of the substitution.

The 2N217 transistor (*Q1*), like all transistors, has a normal leakage current which would ordinarily cause a constant meter indication. This leakage indication is avoided by using the collector-emitter resistance of *Q1* as one arm of a balanced bridge circuit. The bridge is balanced with potentiometer *R3* so that current does not flow through *M1* when no signal is being picked up.

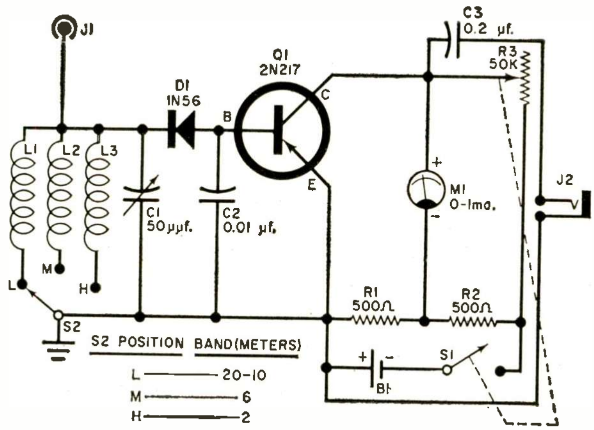
When a signal does enter the instrument, however, rectified r.f. from diode *D1* is fed to *Q1*'s base circuit, and the effective collector-emitter resistance of *Q1* decreases. This unbalances the bridge, causing current to flow in the milliammeter.

Since the transistor amplifies the audio as well as the d.c. component of the rectified r.f., a high sound level is available at the headphone output (*J2*). Isolated from the d.c. circuit, by capacitor *C3*, this output permits the use of crystal headphones for better sound reproduction when checking a transmitter's audio quality. Neither the reading of meter *M1* nor the sensitivity of the instrument changes when the headphones are plugged in.

Construction. The field strength meter is built in a hand-sized (5¼" x 3" x 2⅛") aluminum box; a plastic box should not be used since it would not provide the necessary shielding. The antenna is a 12" piece of stiff wire soldered to a banana plug.

Follow the parts layout in the photograph and pictorial diagram, making sure that antenna jack *J1* is mounted near the rear of the top of the box. This insures that there will be enough room to mount coils *L1*, *L2* and *L3*.

The coils are commercial miniature r.f. chokes (see Parts List) which are modified



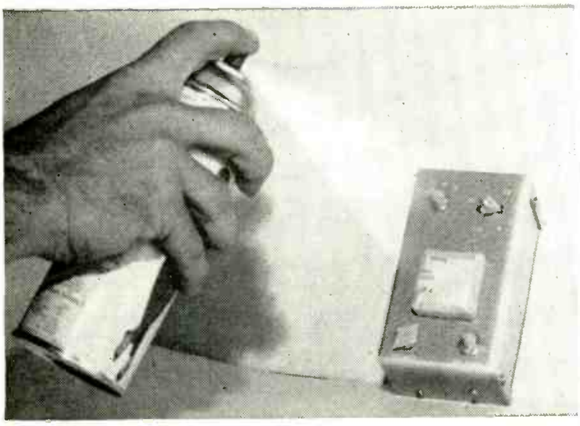
Capacitor C3 isolates headphone circuit from d.c., as shown in schematic diagram, so that high-fidelity crystal headset can be used. Battery B1 could be an ordinary 1½-volt penlight cell, but the mercury battery specified in the parts list has a lower internal resistance, longer life.

by removing turns. Remove five turns from the Miller 4606 to make *L1*, three turns from the 4588 for *L2*, and two turns from the 4580 for *L3*.

Wire coils *L1*, *L2*, and *L3* to switch *S2* so that they are placed in the circuit in that order as *S2* is moved from its extreme counterclockwise position through its first two clockwise positions. Be sure to place the coils so that their leads are as short as possible, especially the 2-meter coil (*L3*).

Use a heat sink, such as a copper alligator clip, to protect the diode and transistor while soldering them in place. The clip, if placed on a lead close to the joint being soldered, will serve to dissipate the excess heat.

Labeling and Calibration. Mark the extreme counterclockwise (*L1*) position of range switch *S2* with an "L" for "low band"



A clear plastic spray such as Krylon is used to protect the panel decals. Front panel parts are covered with tape and cardboard while spraying.

PARTS LIST

B1—1.4-volt mercury transistor battery (Mallory #ZM-9 or equivalent)
C1—50-µµf. trimmer capacitor (Hammarlund MAPC-50 or equivalent)
C2—0.01-µf., 75-volt ceramic disc capacitor
C3—0.2-µf., 75-volt ceramic disc capacitor
D1—1N56 diode
J1—Nylon-insulated banana jack (H. H. Smith #221 or equivalent)
J2—Open-circuit phone jack
L1—2.4-µh. miniature r.f. choke (Miller 4606 or Stancor RTC-8517 } *modified—see text*
L2—0.47-µh. miniature r.f. choke (Miller 4588 or Stancor RTC-8513) } *modified—see text*
L3—0.1-µh. miniature r.f. choke (Miller 4580 or Stancor RTC-8511) } *modified—see text*
M1—0-1 ma. d.c. milliammeter (Lafayette TM-400 or equivalent)
Q1—2N217 transistor
R1, R2—500-ohm, ½-watt resistor
R3—50,000-ohm potentiometer (with switch S1)
S1—S.p.s.t. switch (on R3)
S2—1.p.3.t. switch (appropriate sections of Lafayette SW-78 or equivalent)
1—5¼" x 3" x 2⅛" aluminum box (Bud #CU-2106A or equivalent)
1—Battery holder (Keystone #139 or equivalent)

(20 through 10 meters). The first clockwise (*L2*) position is marked with an "M" for "middle band" (6 meters), and the second clockwise (*L3*) position with an "H" for "high band" (2 meters).

Before proceeding further, check the balancing circuit. First rotate balance control *R3* to the "off" position and insert the battery; then turn the control just enough to switch on *S1*. Meter *M1's* needle will move off the zero mark to some positive or negative value. If the needle moves in the negative direction, disconnect the wire at the end terminal of *R3* and move it to the terminal at the other end. The balance control is now rotated until *M1* reads zero, and the unit is ready for calibration.

To calibrate the FSM, rotate tuning capacitor *C1*'s plates to full mesh and place a pointer knob on the capacitor shaft with the pointer at the nine o'clock position. The range switch is set to "L" and a 20-meter signal from the transmitter or a grid-dip meter is fed to the instrument. Rotate *C1* clockwise until the indicating meter "peaks" and mark this position of *C1*'s pointer "20." Do the same for 15 and 10 meters, marking the appropriate positions "15" and "10."

Range switch *S2* is now set to "M" and a six-meter signal is fed to the field strength meter. Again adjust capacitor *C1* for a peak and mark the new pointer position "6."

Finally, set switch *S2* at "H" and repeat the operation for 2 meters.

If panel decals are used for labeling, they should be protected with a coating of clear plastic spray such as Krylon. Use masking tape to protect the components while spraying.

Operation. To check field strength, turn on and balance the FSM as described above, setting *S2* and *C1* to the transmitter's operating frequency. Meter *M1* will now indicate field strength and can be used to take comparative readings around the transmitter and antenna.

The FSM can be used to test for harmonics by rotating *C1* on the "L," "M" and "H" positions of *S2*. The settings at which *C1* "peaks" meter *M1* show the bands being picked up; the peak readings of *M1* are indications of relative signal strength.

No gain control is provided, since it is unnecessary. The 1-ma. meter can take a considerable overload without damage—but if you want to operate in a high-signal-strength area for more than a few seconds, detune *C1* until the needle rests on scale. Capacitor *C1* may also be used to set meter *M1* at some convenient reference point for comparative signal strength measurements.

When using the headphone output to check the audio quality of a transmitter, adjust *C1* for a meter reading of 0.5 - 0.9 ma. When *M1* is set at this value, the transistor is biased on the linear portion of its operating curve. —30—

Universal Workshop Tester

(*Continued from page* 136)

from the tester. Setting *S1* to *Osc 1* and *S2* to the *Ext Freq* position produces a very low frequency (on the order of 5 to 10 cycles) at jack *J1*. Null indicator *V2* will flicker on and off with the low-frequency oscillation. Switching *S1* to *Osc 2* changes the output frequency to about 1000 cycles. (No jumper should be connected across binding posts *BP1* and *BP2* in either position.)

Tuning Eye. To use the instrument as a tuning eye for an AM or FM tuner, simply connect a shielded cable between jack *J1* and the tuner's auxiliary or tape output jack. Set *S1* to *Ext* and place *S2* in the *Ext Freq* position. No jumper should be connected across binding posts *BP1* and *BP2*. When a station is tuned in properly, the eye of *V2* will open widest. Modulation on the received signal will cause the eye to flicker and wink in accordance with audio peaks.

External Null Detector. The instrument will also work with an external null detector when you want to employ it as a capacitance or resistance bridge. Use a pair of medium- to high-impedance phones for the null detector. Connect the phones (or the crystal phono input of an audio amplifier) to jack *J1*. Whenever a balance is achieved in a capacitance or resistance test, the 60-cycle buzz in the phones or the amplifier's speaker will be at a minimum. Null indicator eye *V2* will also operate in the usual manner.

External Frequency Tests. When you want to test a capacitor with a frequency other than 60 cycles, set *S2* to *Ext Freq.* Connect a low-voltage audio source of about 7 volts in series with a 100-ohm resistor across binding posts *BP1* and *BP3* (NOT *BP2*). For an audio source, use the low-impedance output of an audio amplifier fed by an audio generator; keep the amplifier's gain down so as not to damage the capacitor under test.

Next, place a jumper across binding posts *BP3* and *BP4*. Now, set *S1* to the estimated capacity range and rotate *R1* for a null on *V2* in the usual manner (an eye-open indication on *V2* means that the bridge is balanced). Refer to the Calibration Chart for the capacitor's value. —30—

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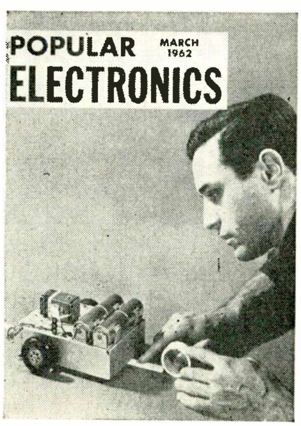


In the March issue of POPULAR ELECTRONICS

(on sale February 27)

EMILY—known in some circles as the "Electro-Mechanical Inebriated Ladybug"—is a robot that will find a white line on the floor and follow it to its destination. Simple to build, "EMILY" is both entertaining and educational.

IDIOT LIGHTS OUT . . . METERS IN—Construction plans on how to wire up thermistors to indicate auto oil, water or cylinder-head temperatures.

430 AND DOWN—A super-sensitive low-frequency converter will tune you in on those long waves where thousands of marine, aeronautical, ship-to-shore and foreign broadcast stations are lurking.

The Restorer

(*Continued from page* 118)

Operation. Plug a set of test prods into *J1* and *J2*, and clip them to the capacitor to be formed—being sure to observe the polarity. If the polarity is accidentally reversed, no harm will come to the capacitor but forming will not occur.

Switch *S2* selects one of the five possible series current-limiting resistors. Faster forming takes place with the lower resistances, but you'll get a higher quality capacitor with the higher ones. Some high-capacitance units, however, will never complete forming at the higher resistance settings. A little experience will soon show you how to use *S2*, but in general you should stick to the 1.0-megohm setting unless you're in a hurry or the capacitance is too high.

Switch *S3* simply selects the d.c. working voltage marked on the capacitor's shell. All possible voltages, of course, are not available, and it may occasionally be necessary to select a slightly higher one. A 20% or 30% excess voltage is not harmful.

After setting switches *S2* and *S3* to their proper positions, flick on power switch *S1* and await results. Relatively new capacitors will form in a few minutes; very old ones may take several hours. When the forming is complete, the appropriate indicator lamps will light.

It's not necessary to disconnect the capacitor from the "former" as soon as the lamps light. The voltage across the restored unit will soon drop to a lower level and remain there, even if you wait all day. When you do disconnect it, though, remember to drain its charge first by turning *S3* slowly to the "discharge" position.

Two electrolytics of the same working voltage may be formed at the same time by connecting them in parallel across *J1* and *J2*. A 330,000-ohm, 1-watt resistor should be placed in series with each one, and the .33-megohm position of *S2* should be used. Under these conditions, one of the capacitors should complete forming before the other. When the indicating lamps light, therefore, disconnect the capacitors and reconnect them individually in the normal way. The unit which requires more forming will not relight the indicators. —30—

Hi/Low Power Relay

(*Continued from page 77*)

mized. A ⅜" hole lined with a rubber grommet accommodates the coil leads.

Use No. 14 or No. 12 solid copper wire to connect the movable contacts of the relay to the connectors (*J1, J2*) on one end of the box. Join together the normally closed relay contacts, and connect the normally open contacts to the remaining coaxial connectors (*J3, J4*), keeping the leads short and well separated. These are the proper connections for driving practically any grounded-grid power amplifier with an exciter having an input power rating up to 200 watts.

Attenuator. To drive a grounded-cathode amplifier using tubes like 813's, 4-250A's, etc., with an exciter delivering much more than 10 watts output, you will need a power attenuator between the exciter and the amplifier to absorb some of the excess power.

To build the attenuator, place two 1½" squares of "flashing" copper together, and drill ten 1/16" holes spaced ⅜" apart. Parallel ten 330-ohm, 2-watt, composition resistors by sandwiching them between the two plates, pushing their leads through the holes, and soldering them. All but one of the leads protruding from each square should be trimmed off, and the remaining two leads used for connecting the resistors into the circuit. Then repeat the operation with two ¾" copper squares and five 150-ohm, 2-watt composition resistors.

The 10-resistor unit (*R1*) should be connected from the relay to the center terminal of the coaxial connector (*J3*) feeding the grid circuit of the amplifier. Connect the 5-resistor unit (*R2*) from the center terminal of *J3* to the metal box.

Operation. Mount the relay unit on or near the power amplifier, and connect it between the amplifier, exciter, and antenna, as shown on the diagram. Use coaxial cables for the connections.

Relay coil *RL1* is connected to the 117-volt circuit of the amplifier, so that the relay will be energized when the amplifier is turned on. Operation of the amplifier and the exciter should be completely normal with the relay unit installed. —30—

SWR/Power Meter for CB

(*Continued from page* 49)

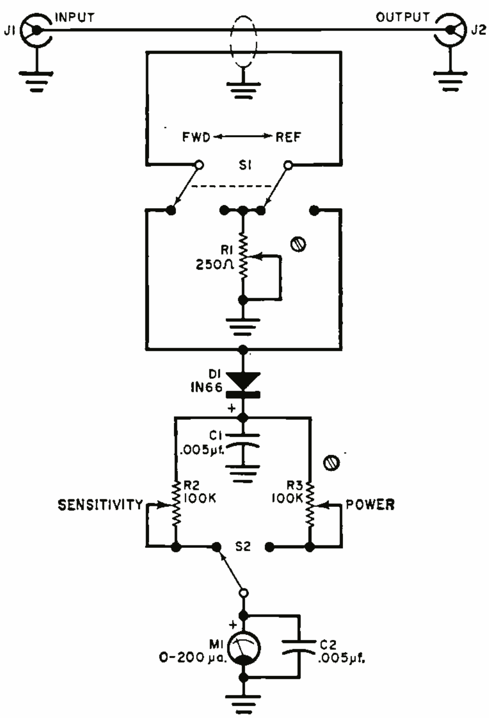
the current.* The SWR can be calculated from the following equation:

$$SWR = \frac{I_{Fwd} + I_{Ref}}{I_{Fwd} - I_{Ref}}$$

For example, let $I_{Fwd} = 200$ μa. and $I_{Ref} = 30$ μa. Then

$$SWR = \frac{200 + 30}{200 - 30} = \frac{230}{170} = 1.36 : 1$$

If precise SWR is not needed, relative indications can be used. Simply keep the *Fwd* reading constant and tune for a minimum



Schematic diagram of CB meter. Potentiometers R1 and R3 should have screwdriver adjustment.

in the *Ref* position. The SWR can then be calculated using the lowest *Ref* value.

To measure r.f. power, set *S1* to *Fwd, S2* to *Power,* and adjust *R3* for a given *Fwd* voltage (representing a given power, since the load resistance is fixed). Once *R3* is calibrated for a given load, it need not be touched again. —30—

* A known voltage (or power) is not really necessary for making SWR measurements. Assuming you have enough "forward" (*Fwd*) voltage available to obtain a half- to full-scale reading, it is only necessary to switch *S1* to *Ref* to obtain a reflected voltage; the ratio between these two readings can then be used to compute the SWR.

Cubical Quad for CB

(Continued from page 43)

prevent unraveling; the opposite end is tinned, and a wire lead is soldered to it.

Now affix a coaxial plug to the end of the line. The leads from the balun sleeve and one side of the transmission line are connected to the outer shell of the plug. The remaining lead of the transmission line is soldered to the center pin of the plug. Make the connections from the line and balun to the plug as short as possible.

Using the Antenna. The pattern of the Quad is quite broad (about 60 degrees), requiring only that the antenna be pointed in the general direction of desired communication. Power gain is about four, so that your transmitter power will be boosted to an equivalent of 20 watts input (about 12 watts output); the same power gain is provided on received signals. Signals from the back of the beam are attenuated by a factor of 10 to 15.

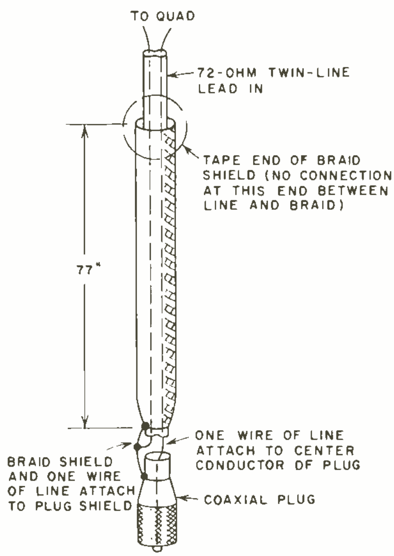


Fig. 6. Neatness counts when wiring up the simple balun. Poor solder joints and incorrect lengths will lessen power gain of Cubical Quad. So do it right!

The antenna should be mounted high and in the clear, free of telephone wires or utility lines. It may be rotated by a heavy-duty TV rotor if communication in various directions is desired. —30—

6 Meters and Mobile

(*Continued from page* 61)

Once you are assured of proper operation on the crystal frequency, mark the knob positions on the front panel. They will act as reference points for future tune-ups and help prevent off-frequency operation. Changing crystals should involve only a slight re-tuning.

Neon bulb *I1* gives two simultaneous indications of the transmitter's performance. The first is a steady orange glow on one of its electrodes, showing the presence of B+ voltage each time the push-to-talk button is depressed. The other electrode serves as an r.f. indicator and should have an orange-purple glow. After the initial settings of both tuning capacitors have been determined and marked on the panel, you can touch up the settings by slowly tuning the knobs for maximum brilliance of *I1*.

Since oscillator tuning is quite broad, and the oscillator is peaked for maximum r.f. output, the circuit may not oscillate each time the rig is switched to "Transmit." The remedy is to choose a compromise setting. Output will be down slightly, but instability shouldn't prove troublesome. Flick the push-to-talk button several times to check for any sign of instability. The receiver S-meter should always peak at the same point during this procedure.

Installation. Two L-brackets bolted to the sides of the transmitter's case provide a secure mounting arrangement. Match the brackets with two holes drilled under the car's dashboard. The power source can be a terminal on the rear of the ammeter. Choose the one that indicates when the transmitter is drawing power (drain during "Transmit" will be about 5 amperes for 6-volt systems, 2.5 amperes for 12-volt systems). The ground lead can be routed to any nearby bolt at car-chassis ground; be certain to determine whether your car has a negative or positive ground, and wire accordingly.

Installation is completed when the antenna cable of a 6-meter receiving converter is plugged into the transmitter jack labeled *Receiver*. Pushing the press-to-talk button automatically causes the relay to switch the whip antenna (at jack *J2*) between the converter input (jack *J3*) and the transmitter output. —30—

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AD INDEX

The Monitor Meter

(*Continued from page* 71)

the wiring is correct, there will be no indication on the meter.

Connect a signal generator to the antenna, or hold the unit's antenna near a grid dip oscillator (GDO) or a variable frequency oscillator (VFO). Advance the *Gain* control *(R1)* halfway, set *S3* to the *Low* position, and feed in any signal between 3 and 7.5 mc. Capacitor *C1* should now be tuned for a maximum reading on the meter, and the gain reduced or increased so that the meter reads 100%.

Next, set the oscillator to the 80-meter band, tune *C1* for maximum meter reading, and mark the dial accordingly. Do the same for the 40-meter band, then set *S3* to the *High* position and repeat the calibration for 20, 15, 11, and 10 meters.

Operation. Set switch *S2* to the calibrate *(Cal)* position. Using *C1*, tune in the transmitter's signal for maximum indication on the meter, and then adjust the *Gain* control (*R1*) so the meter reads exactly 100%. (Move your hand away from the Monitor Meter to eliminate any possible detuning.) Now set *S2* to *Mod* and speak into the microphone. The peak meter reading is the percentage of modulation.

To be certain the transmitter is not overmodulated, adjust the transmitter's modulation control so that the meter peaks at about 85% modulation. As far as the receiving station is concerned, there is no appreciable difference between 85% and 100% modulation (85% modulation is 1.5 db below 100%, and a difference of 1.5 db in speech is barely detectable). However, the 1.5-db reserve will keep the occasional "high peak" from overmodulating the transmitter.

To check audio quality, insert a set of headphones into the monitor jack, throw *S2* to *Cal*, and adjust *R1* for a meter reading of 100%. When high-impedance phones are used, the audio can be monitored simultaneously with the percent reading.

The Monitor Meter can also be used as a sensitive field strength meter (FSM) by simply setting *S2* in the *Cal* position and advancing *R1*. Again, be careful that you don't exceed the 100% mark on the meter scale. —30—

Compactron FM Tuner/Receiver

(Continued from page 108)

and the power supply wiring completed. In order for the whip antenna specified in the Parts List to be used with a jack-top binding post, you'll have to attach a standard banana plug to the whip. In the author's case, a force fit was made between the whip and the plug, although the two could be soldered together.

Hooking It Up. With a pair of headphones plugged in and the whip antenna extended, throw switch *S1* to "on" and allow a few minutes for the tuner/receiver to warm up. Next, turn potentiometer *R7* clockwise until a hissing sound is heard, and then turn the dial over its range. When a station is located, adjust both the dial and the potentiometer until you reach settings which deliver maximum volume with minimum distortion.

If you have trouble obtaining good coverage of the FM band, adjust the inductance of *L2* by stretching the coil or squeezing the turns together, depending on whether you want to decrease or increase the inductance of the coil.

With the whip antenna shown, good signals should be received from all local FM stations. It is possible to use an outside antenna with the tuner/receiver, of course, but this is not recommended. Even though there is an isolating stage between the antenna terminal and the detector, radiation is still possible, and the use of an outside antenna might prove a nuisance to other FM receiver owners.

Almost any dial can be used on the receiver. The one on the model is a National Type K with a scale carrying a rough calibration glued on the front. In the author's case, after the frequency range was determined, the scale was made by preparing a drawing on tracing paper and using this drawing to make a contact print on single-weight photographic paper. The completed scale was cemented to the dial plate and then sprayed with Krylon.

Be sure to make your scale slightly smaller in diameter than the dial plate so that the rim-drive mechanism can work properly. —30—

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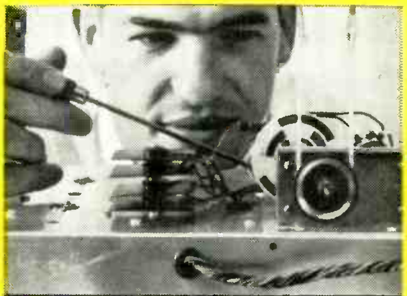

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