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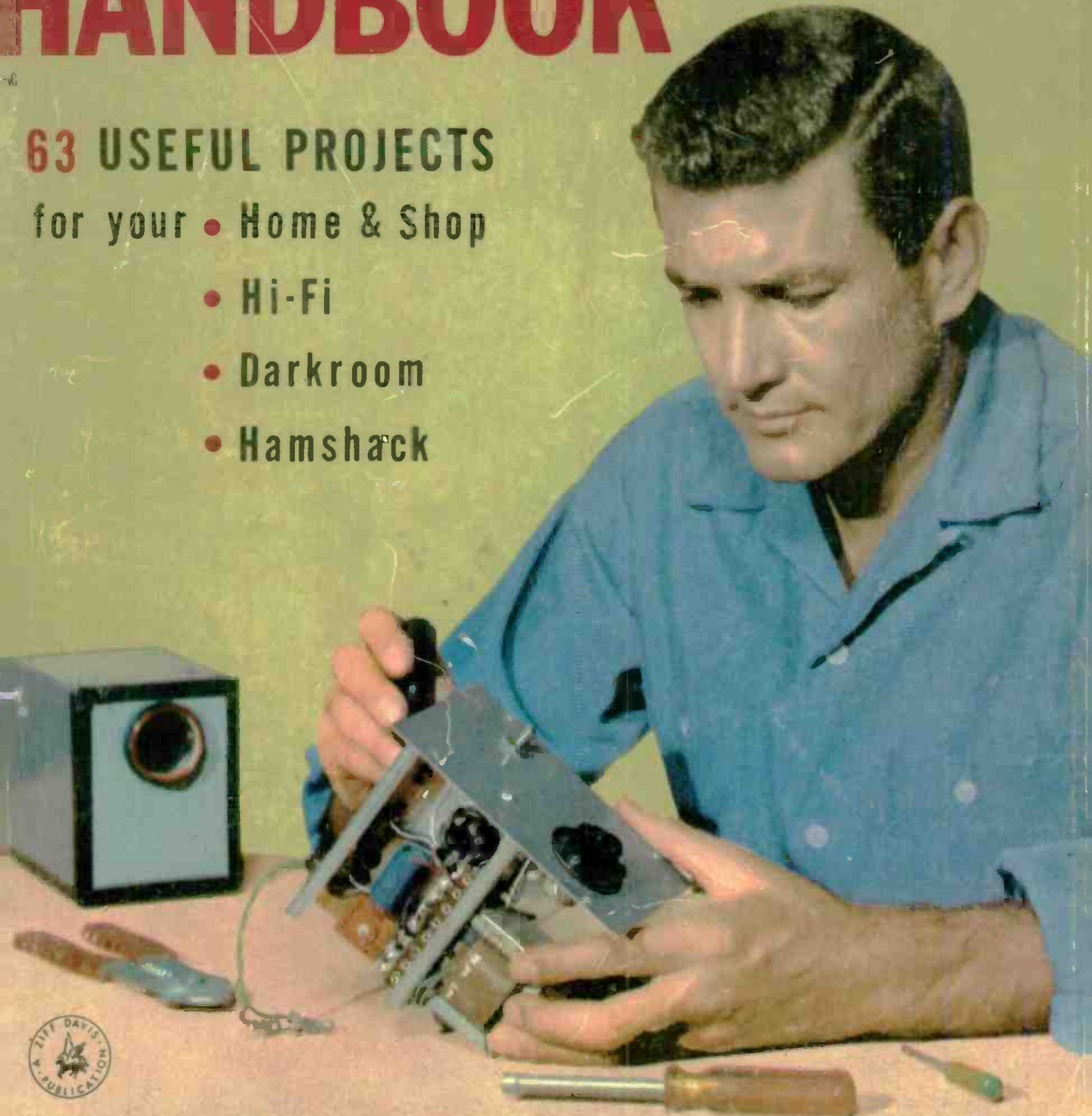

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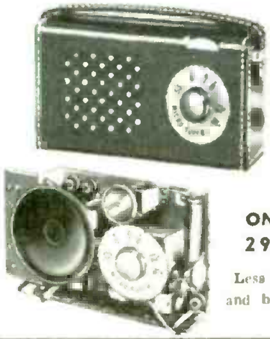

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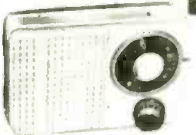

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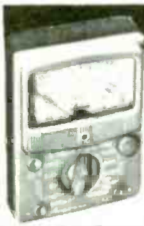

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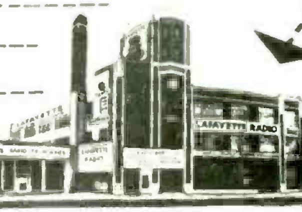

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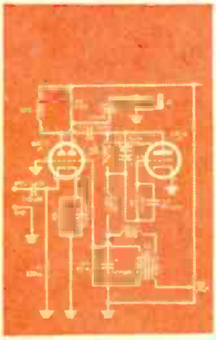

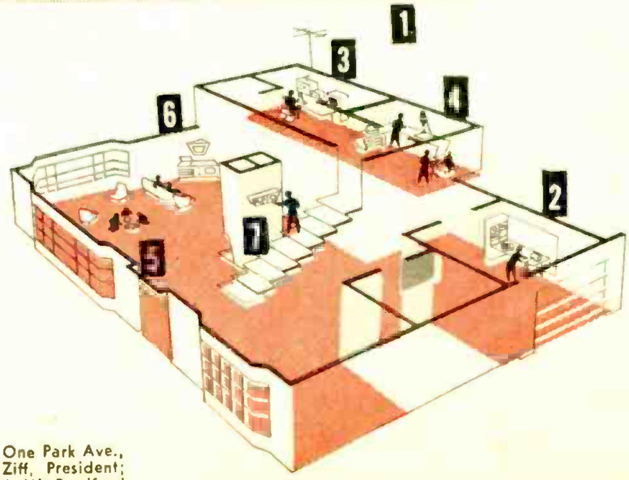

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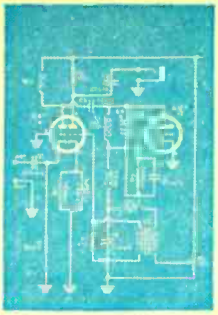

Section 1

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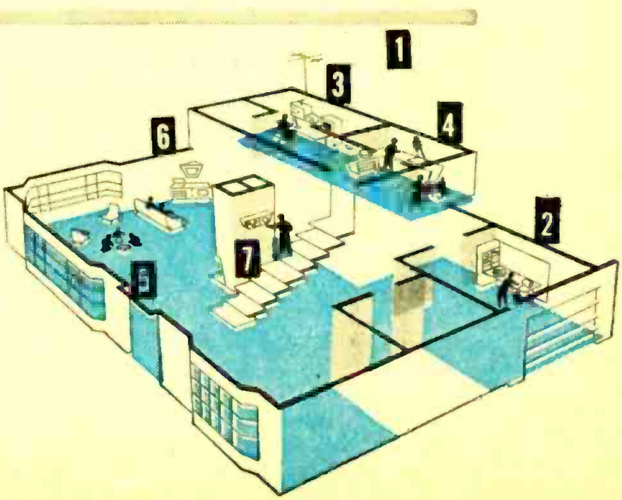
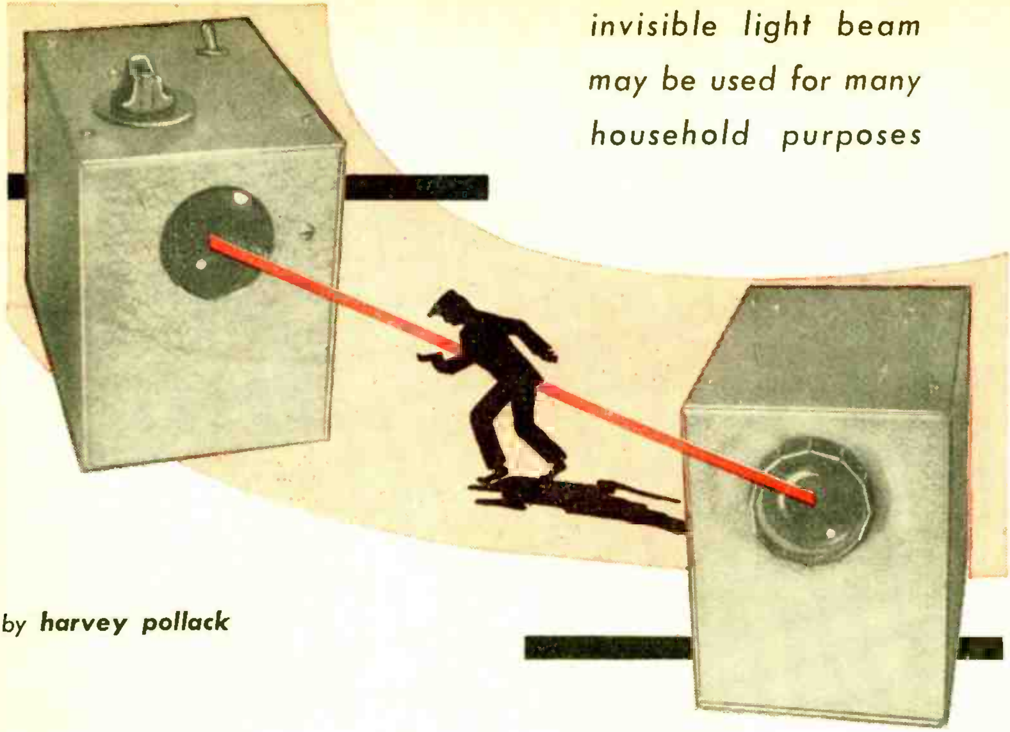




invisible light beam may be used for many household purposes

by **harvey pollack**

Infrared Photocell System

The infrared beam from the light source described in this article is absolutely invisible even in a pitch-black room. Yet, when the beam is broken, it will trigger the transistor-solar cell relay at a distance of 30 feet. This equipment is particularly adaptable as a secret burglar alarm, an invisible lamp-lighter in a child's room, or as a trigger for animal traps. It may also be used for door-openers, overhead garage-door controllers, annunciators in professional offices, and driveway floodlight controllers. Although the photocell amplifier is a.c.-operated, the current drain is so minute that a 22½-volt battery may be substituted for the power supply.

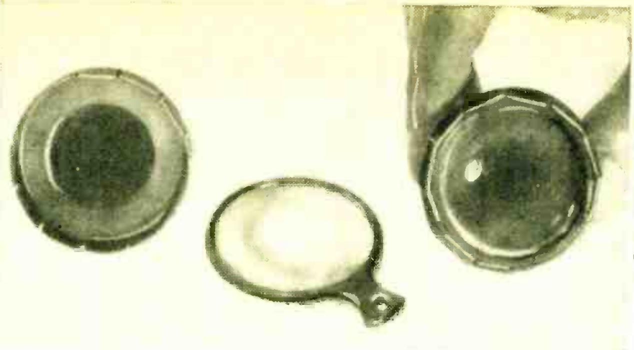
Both the photo-relay and the light source will fit into 4" x 5" x 6" aluminum boxes. Any type of case is suitable for the photocell amplifier since it generates no heat. The automobile lamp used in the light source does give off heat but a metal cabinet dissipates it easily. No ventilation holes are necessary; thus, there are no light leaks to advertise the location of the source in a secret installation.

photo-relay

The chassis selected as the foundation for the relay unit measures 3" x 6⅛" x 1¼". The first step in the construction is to cut it down to fit the Minibox. In the final adjustments, the chassis is slid into a position where the beam received by the photocell lens is focused sharply on the face of the solar cell.

A holding bracket is next on the construction list. It is 2" long and 1⅛" high, and is fastened to the front apron of the chassis by means of two small machine screws. It may be slotted to make chassis movable by drilling small holes side by side and using a file to clean up the lines, or by using a "nibbling" tool starting from a 5/16" hole. The latter procedure was used in the model; it does a very neat, quick job.

Bear in mind, while laying out the chassis, that the light from the lens must have unobstructed passage to the face of the *NATFAB* solar cell. Assuming that you have purchased the lens specified in the parts list, a 1⅜" hole should be punched in the front panel of the photo-relay case with its center about 3½" from the bottom of



Assembly of the infrared optical system. The frame of the lens (center) is snipped off with diagonal pliers, and the lens set into the flange of the infrared filter holder (left). A piece of spaghetti tubing, about 1/8" in diameter, is fitted around the edge of the lens, and the serrations of the flange are then bent inward to hold the lens in place (right).

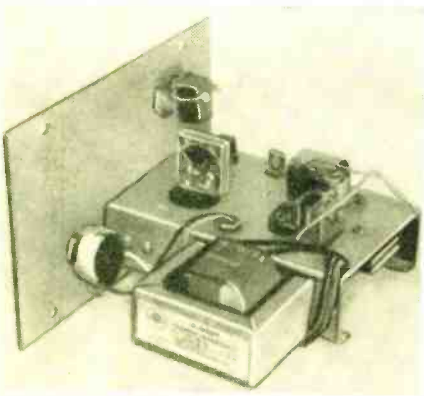
the case. The lens is supplied mounted in a plastic frame which is used as a convenient support. With the lens held over the panel opening, locate the spot for the supporting screw that will go through the hole in the handle of the frame and drill a #27 hole at this point.

The wiring is straightforward, as shown in the schematic diagram. Wire lengths are not at all critical. Particular attention should be given to the voltage polarity on the transistors. Be sure that the minus lead of the power supply connects to the first transistor (*TR1*) collector through the resistors *R2* and *R3* and to the collector of the second transistor (*TR2*) through the relay coil.

This photocell alarm relay, originally designed as a burglar alarm, operates when the beam is interrupted by an intruder. For this kind of application, the *normally open* contacts are brought out to two insulated binding posts at the rear of the case. For the reverse action, the *normally closed* relay contacts may be brought out to the posts.

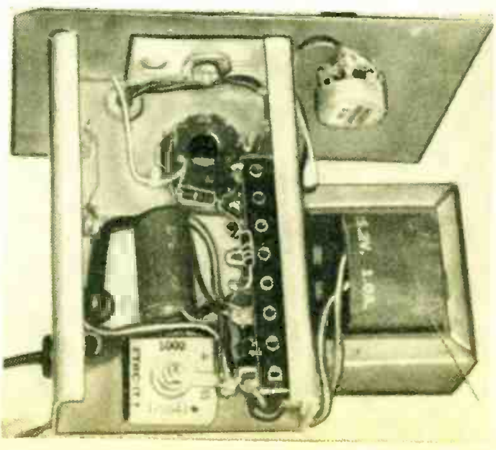
light source

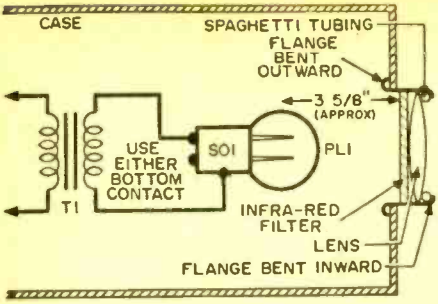
The light source case contains the 6.3-volt, 6-ampere filament transformer and a double-filament 32-candlepower auto headlight lamp. The headlight socket is held between the jaws of a #27 battery clip so that either filament is approximately



The above view of the photo-relay shows the transformer mounting clearly and the relative positions of R3, s.p.s.t. switch S1, and the Sigma relay, RL1. You can also see the front of the solar cell (P-100) which is plugged into holes #4 and #6 of the octal socket.

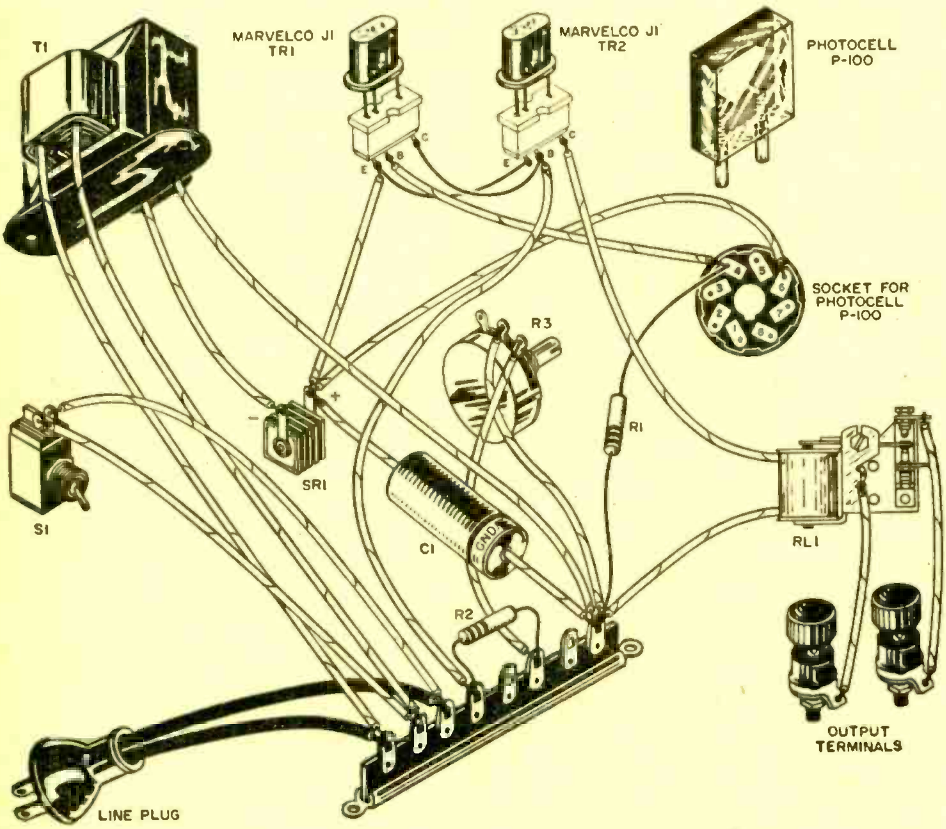
Completely wired chassis of the photo-relay. A seven-lug terminal strip supports the small resistors and serves as a tie strip for transformer wires, etc. Transformer T1 and sensitivity control R3 must be placed so that they do not obstruct the light beam path.





PL1—6-volt auto headlight lamp, double filament, 32 cp each
SO1—Auto headlight socket for double-filament lamp
T1—Transformer, 117-volt primary, 6-volt at 6-amp. secondary (Thordarson 21F11)
1—4" x 5" x 6" grey hammertone aluminum cabinet (ICA #29812)
1—Galvanized iron battery clip, size #27
1—1⅝"-diameter lens, 3⅝" focal length, in plastic frame (Lafayette Radio Corp. Catalog #F-46)
1—Infrared filter in adapter holder (Maurer MC-430—available from Barry Electronics, 512 Broadway, New York 12, N. Y.)

General layout, wiring and parts list for the infrared light source.

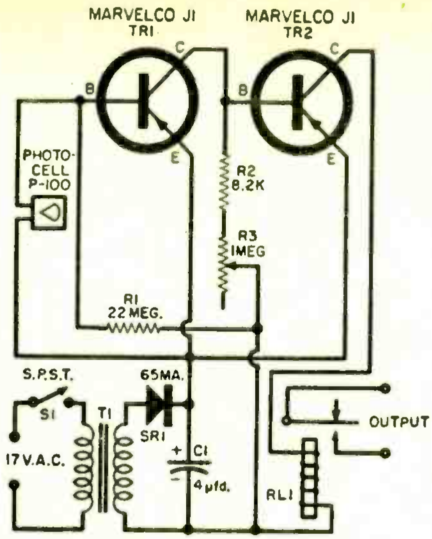


Parts of the photo-relay are interconnected as shown in this pictorial diagram.

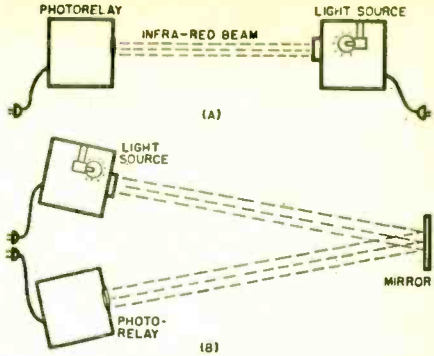
3⅝" from the center of the lens. The distance of the filament from the lens is easily changed by sliding the socket backward or forward between the jaws of the battery clip.

Putting the infrared lens assembly together is a simple matter. Using a pair of diagonal pliers, cut through the plastic frame of the lens in two or three places so that it may be peeled off. Set the lens in the wide portion of the infrared filter holder and lay a piece of thick spaghetti tubing around its edge. Carefully bend the flanges downward to exert pressure all around the circumference. This holds the lens firmly in place without a metal-to-glass contact.

Cut a hole in the front panel of the light-source case the same distance up from the

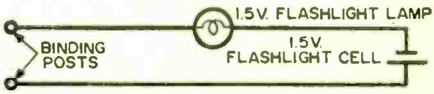


Schematic and parts list for the photo-relay.



If light source and photo-relay are set up at opposite ends of site, as in (A), you will need two different outlets. They may be set up side by side, however, both a.c. plugs then going to the same duplex outlet, as in (B); a small mirror reflects beam back to relay and the total throw distance is doubled.

C1—4-µfd., 150-volt electrolytic filter capacitor
P-100—Silicon solar cell, equipped with prongs for mounting in octal socket (National Fabricated Products)
R1—22-megohm, ½-watt carbon resistor
R2—8200-ohm, ½-watt carbon resistor
R3—1-megohm linear taper potentiometer (Mallory U-54)
RL1—Sigma 4F relay, adjusted to pull in at 2 ma.
S1—S.p.s.t. toggle switch, 120-volt, 3-amp. type
SR1—65-ma., 117-volt selenium rectifier
T1—Transformer, 25.2-volt, 1-amp. secondary, primary 117 volts a.c. (Stancor P-6469)
TR1, TR2—Transistor (Marvelco Type J1 or equivalents such as G.E. 2N76, G.E. 2N45, or RCA 2N109)
1—4" x 5" x 6" grey hammertone aluminum cabinet (ICA #29812)
1—3" x 6⅛" x 1¼" aluminum chassis, miniature open-end type (ICA 29080, cut down to fit)
1—1⅝"-diameter lens, 3⅝" focal length, in plastic frame (Lafayette Radio Corp. Catalog #F-46)



Connections of test lamp setup that may be connected to the relay binding posts during adjustment of photo-relay. These help determine the position of the Sigma 4F relay contacts while the setup is being adjusted.

HOW IT WORKS

An infrared light beam will develop a voltage across a NATFAB silicon cell. The current in the transistor (*TR1*) base-emitter circuit is very small and very little collector current flows. Bias on *TR1* is established by setting the control *R3*, and is adjusted so that the collector current of the second transistor, *TR2*, is too small to pull in the relay.

Interruption of the infrared beam removes the bucking voltage developed by the silicon cell. A current then flows through the base-emitter circuit of *TR1*, increasing the collector current. This current produces a voltage drop across the *R2-R3* combination which reduces the bias on *TR2*. Its collector thus passes enough current to pull in the relay armature.

bottom as in the photo-relay. The hole size should be carefully chosen so that the smaller flange of the infrared filter holder fits into it snugly without light leaks. Finally, bend the inside serrations against the sides of the hole to prevent the assembly from falling out.

If there are objectionable light leaks due to improper fit anywhere on the case, these may be sealed with black vinyl insulating tape.

installation

Line up the light source and photocell relay with the infrared beam sharply focused. Although the beam itself is invisible, a dull red glow may be seen in a slightly darkened room by looking into the lens of the light source. Slide the 32-candlepower lamp back and forth between the jaws of the battery clip until a projected spot is focused on the lens of the photocell.

It is absolutely essential that the infrared beam be focused sharply on the solar cell. It may be necessary to shift the box slightly laterally or up or down to get proper alignment. Experiment with the setup until you become familiar with the best orientation of the two cases. After that, you can increase the distance between the units up to 30 feet and still obtain positive relay action.

Picnic PowerAmp

by ***louis e. garner, jr.***

power transistor adds pep and volume to pocket radio

Do you own a personal portable radio receiver? If you do, or if you've ever listened to one, you know why they are called "personal" receivers—the output volume is not exactly room-filling. But most pocket receivers are equipped with an earphone jack. Earphone listening is possible under background noise conditions that would make loudspeaker listening impossible with the limited volume available.

If you'd like to provide your receiver with truly "room-filling" loudspeaker volume, you'll find it's a cinch if you use the "Picnic PowerAmp." It can be plugged into the "phone" jack of any piece of equipment designed to power a moderate-impedance (1000 to 8000 ohm) magnetic headset. The instrument takes the low-power signal, amplifies it, and drives a good-sized (6") loudspeaker.

construction hints

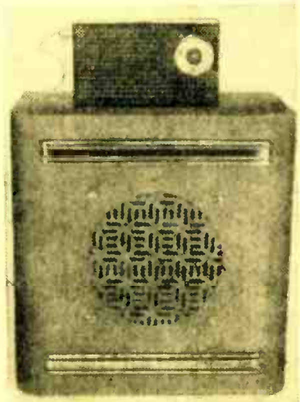
The simple design of the Picnic PowerAmp is made possible by the use of *CBS-Hytron's* new low-cost *p-n-p* power transistor—the 2N255. Aside from the battery, only nine electrical components are required. If you're handy with a soldering iron and other shop tools, you should be able to assemble this project in a single evening . . . even allowing time for a coffee break or two.

You'll need two small chassis. One is used as a heat sink for the 2N255 power transistor . . . it serves to absorb and to dissipate heat generated by the transistor and keeps the transistor's temperature from rising to a dangerous level. The other chassis is for wiring the circuit proper. To insure good heat dissipation, mount the 2N255 flat against its heat sink using small machine screws and nuts. Provide over-sized holes for the base and emitter pins. Transistor pin connections are identified in the sketch on page 16.

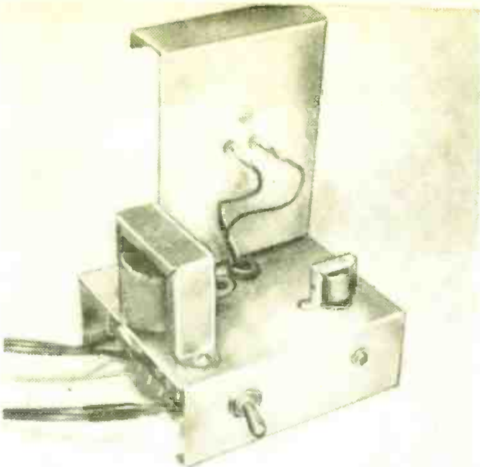
The transistor's collector electrode is connected directly to its outer case, thus insuring an adequate transfer of heat from its junction to the external heat sink. This construction makes it necessary to insulate the heat sink chassis from the main circuit chassis.

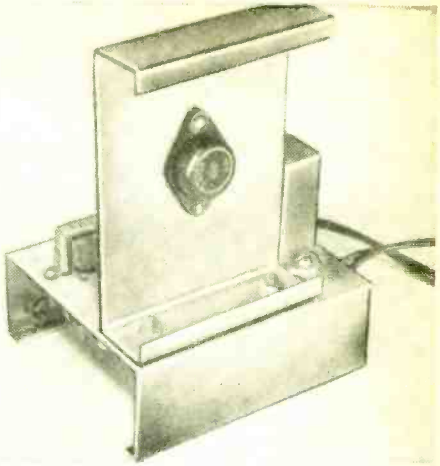
As far as the main chassis wiring is concerned, neither circuit layout nor wiring arrangement is critical. However, keep the input (*T1*) and output (*T2*) transformers reasonably well separated and mounted with the cores at right angles.

The battery power supply may be mounted in the same cabinet with the amplifier chassis and the loudspeaker. Use a secure mounting arrangement to keep the battery from shifting position when the completed amplifier is carried about. You can mount



"Picnic PowerAmp" is shown in photo above ready for operation. The pocket receiver is placed on the amp, and the input for the amp is taken from the headphone jack output of the pocket receiver.



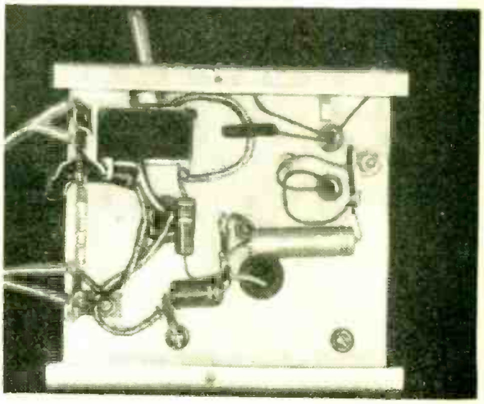


Above are two views showing the mounting details for the heat sink for the 2N255, the power transistor. Four flat fiber washers should insulate the chassis for the heat sink from the amplifier chassis.

the battery securely by using a small "L" bracket.

Don't feel limited to a 6" or 8" loudspeaker. You can use any PM loudspeaker having a 3.2-ohm voice coil—from 3" to 12" in diameter. However, best results are obtained with larger speakers.

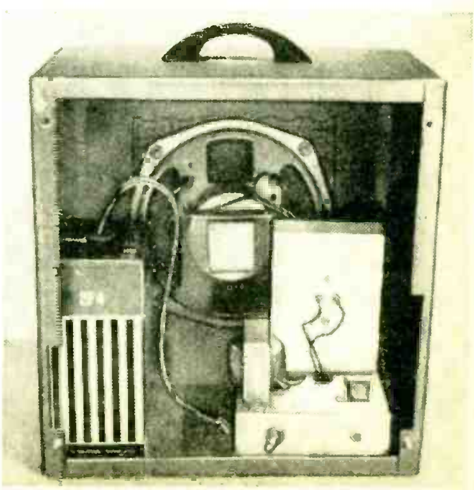
If you want more output power and are willing to accept the penalty of shorter battery life, drop the value of *R1* until collector current—as measured with a milliammeter inserted between switch *S1* and the red lead of *T2*—equals 500 ma. You can determine *R1's* value by experiment, but it should be in the neighborhood of 100 ohms or less. Under these conditions, the circuit will deliver very close to a full watt when driven to maximum output.



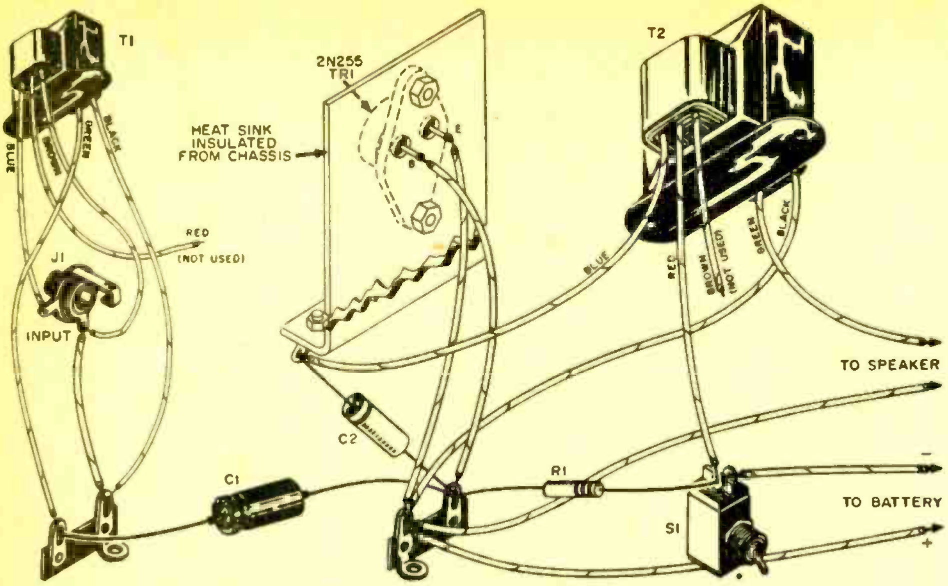
operation and use

You'll need to prepare a short two-conductor connecting cable. At one end, mount a small plug which fits input jack *J1*. The "hot" or signal lead connects to the center terminal . . . that is, with the plug in place, to the blue lead of *T1*. At the other end of the cable, mount a plug which fits the headphone jack of the pocket receiver. Then plug in both ends of the connecting cable to the appropriate jacks and turn on the equipment. Note that no gain control is provided. You simply use the volume control in the receiver.

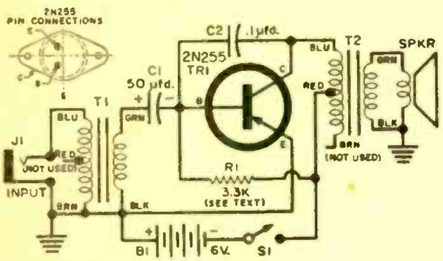
Most builders will ask . . . "how many



Below-chassis view of the wired "Picnic Power-Amp" amplifier (above, right) shows the parts layout. Directly at the right is a rear view of the complete amplifier assembly installed in its cabinet.



Pictorial and schematic diagrams for the amplifier circuit. Transistor pin connections are identified in the sketch at the left of the schematic. See parts list below.



B1—6-volt battery (Burgess No. 2F4)
C1—50-µfd., 25-volt electrolytic capacitor
C2—0.1-µfd., 200-volt tubular capacitor
J1—Input jack
R1—3300-ohm, 1-watt carbon resistor (see text)
S1—S.p.s.t. toggle switch
T1—500-ohm to 8-ohm transistor transformer (Argonne No. AR-164)
T2—48-ohm to 3.2-ohm output transformer (Argonne No. AR-503)
TR1—2N255 power transistor (CBS-Hytron)
PM SPKR—PM loudspeaker, 6" to 8" diameter, 3.2-ohm voice coil
1—Heat sink chassis, 4" x 3⅛" x 1" (ICA No. 29082)
1—Main chassis, 3¾" x 4⅛" x 1½" (ICA No. 29079)
1—Cabinet (ICA No. 3935)
1—Battery plug
Misc. terminal strips, soldering lugs, fiber shoulder and flat washers, rubber grommets, assorted machine screws and nuts

hours can I get from a battery?" . . . whenever they are contemplating a battery-operated piece of equipment. This is similar to asking . . . "how many miles to a tank of gas?" . . . when discussing automobiles. However, if you employ the battery specified in the parts list, and do not attempt to increase the output power by dropping the size of *R1,* you can expect about two hundred (200) hours total operation, assuming you run the Picnic PowerAmp only about six hours per day. If you use it for shorter periods, you can expect longer battery life.

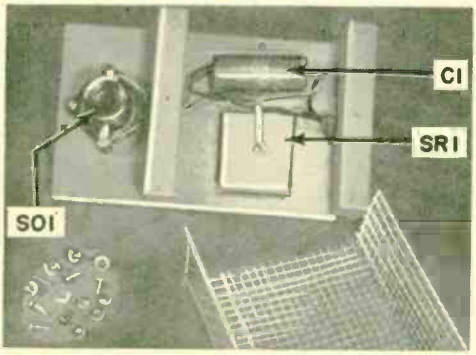
how it works

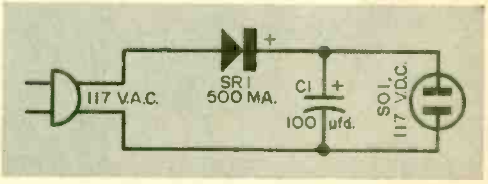
The Picnic PowerAmp uses a *p-n-p* power transistor as a single-stage transformer-coupled Class A power amplifier. The common-emitter circuit configuration is employed.

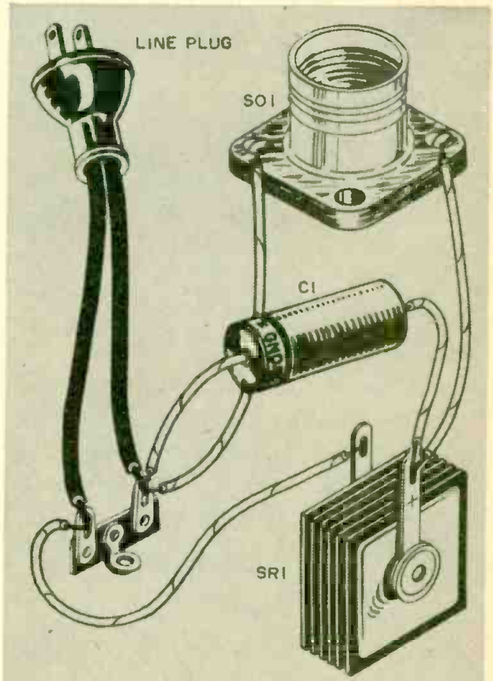
In operation, input transformer *T1* matches the moderate output impedance of the radio receiver or other equipment with which the unit is used to the *low* input impedance of the power transistor. *C1* serves as a d.c. blocking capacitor to prevent the low resistance of *T1*'s secondary winding shorting the base bias current of the transistor, supplied through base resistor *R1.*

Output transformer *T2* matches the output impedance of the amplifier stage to the low impedance of the loudspeaker's voice coil. Feedback capacitor *C2*, between the collector and base electrodes, introduces an out-of-phase feedback signal into the base circuit—which tends to reduce harmonic distortion.

D.C. Supply for Small A.C./D.C. Motors







This power supply can be used to increase a motor's speed and prevent excessive heating. Very simple to construct, it is designed primarily for small high-speed motors used on a.c. or d.c., such as the carving motor shown at the top of this page.

Both the selenium rectifier (*SR1*) and the capacitor (*C1*) can be obtained from your local dealer in electronic parts. Construct the base and uprights from ¾" wood stock, and drill a ¼" hole in each of the upright pieces to pass the electric cord and wiring. The socket (*SO1*), capacitor and rectifier are then mounted and wired as shown in the diagrams.

Cut a protective shield from hardware cloth or wire screen (see photo above); then bend and fasten it with wood screws and washers. As an added safety measure, tape the exposed socket connections.

The d.c. supply must be used with motors drawing less than 0.5 ampere; those drawing more current will burn out the rectifier. It can only be employed with motors using d.c. or a.c./d.c.; motors using just a.c. will not work on the d.c. output of the rectifier.

For a faster, smoother shave, try your electric razor with this power supply. However, be sure that your razor has an a.c./d.c. motor. —*Carleton A. Phillips*

Sensitive Light-Operated Relay

A flashlight beam will pull it in from 20 feet away—without a magnifying lens

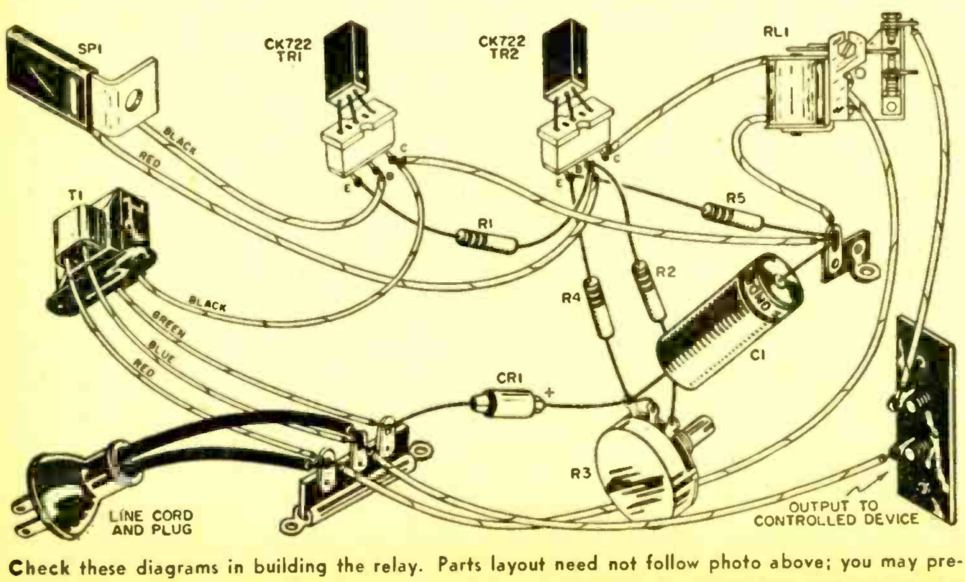
by ***frank h. tooker***

Here is a light-operated relay circuit that has wide application. It uses a pair of inexpensive transistors, yet is so sensitive that the beam of an ordinary flashlight will operate the relay at a distance of 20 feet—without a lens in front of the photocell!

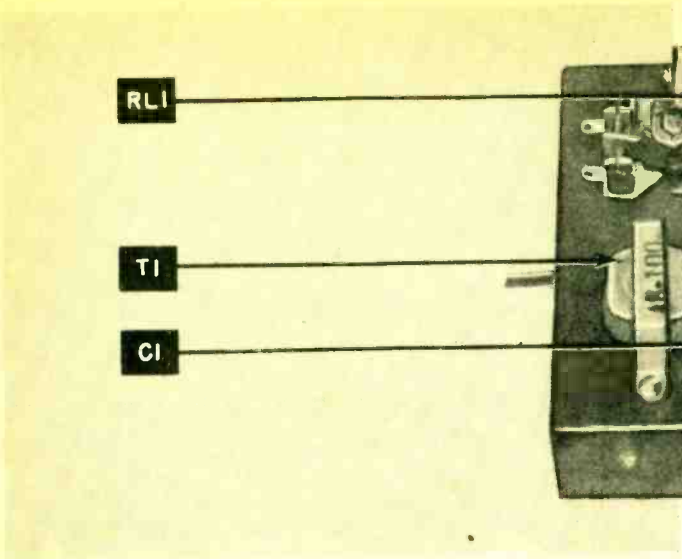
You will probably want to feed a 117-volt power line to the contacts of relay *RL1* to operate a lamp, fire or burglar alarm, bell, gong, or a counter. A miniature power source, employing an Argonne AR-100 transistor transformer (*T1*), a tiny germanium diode (*CR1*), and a miniature filter capacitor (*C1*), is incorporated to supply the operating current.

Since this relay is suitable for many uses, each setup will be best determined by the constructor. The one shown in the photo is an experimental hookup with plenty of open space, although it is assembled on a chassis measuring only 3½" x 3½" x 1". The photocell should be thoroughly shielded by a hood or a suitable length of cardboard tubing to prevent extraneous light from entering the cell.

With the photocell in total darkness, adjust sensitivity control *R3* in the direction of increasing resistance until the relay pulls in. Then, *very slowly and carefully,* rotate *R3* in the opposite direction (decreasing resistance) until the relay just drops out. This



Check these diagrams in building the relay. Parts layout need not follow photo above; you may pre-



is the point of maximum sensitivity. For applications requiring a lower sensitivity, adjust *R3* in the direction of decreasing resistance until the desired sensitivity is obtained.

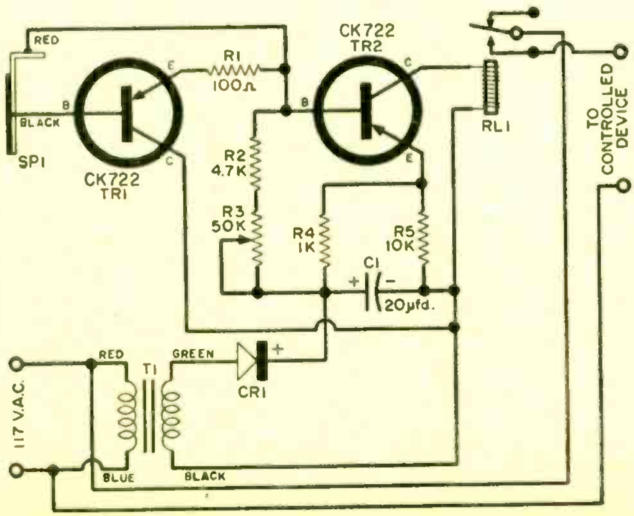
If you want to use a magnifying lens in front of the photocell for weak-light or long-distance operation, choose a lens that is 2" to 3" in diameter and, with the lens aimed at your light source, adjust the spacing between the lens and the photocell until a circle of light just covers the width of the cell. Inexpensive magnifying lenses well suited for this purpose are available from *Edmund Scientific Corp.*, Barrington, N. J.

how it works

The coupling between transistors is actually a Wheatstone bridge. Resistors *R4* and *R5* make up two of the bridge arms. The third arm consists of *R1* in series with the emitter-to-collector resistance of *TR1*, and the fourth is composed of *R2* and *R3* in series.

If the bridge is balanced, the voltage drop across *R2* plus *R3* will equal the voltage drop across *R4*. With the circuit in this condition, the base current of *TR2* will be zero. In actual practice, *R3* is set to allow a small bias current to flow to the base of *TR2*.

When light strikes *SP1*, the base of *TR1* is driven in the forward-current direction, causing the emitter-to-collector resistance to decrease. This further unbalances the bridge. A large part of the current which flows through *TR1* is fed directly to the base of *TR2*. Here it is amplified again and fed to the relay, *RL1*, causing the relay to close.



parts list

C1—20-μfd., 15-volt, miniature, transistor-type electrolytic capacitor (Lafayette)
CR1—1N66 or 1N34 crystal diode
R1—100-ohm, ½-watt resistor
R2—4700-ohm, ½-watt resistor
R3—50,000-ohm potentiometer (sensitivity control)
R4—1000-ohm, ½-watt resistor
R5—10,000-ohm, ½-watt resistor
RL1—8000-ohm sensitive relay (Sigma 4F/8000-S/SIL or equivalent)
SP1—Selenium photocell (International B2M)
T1—Transistor transformer (Argonne AR-100)
TR1, TR2—CK722 transistor
2—Transistor sockets
1—Metal or plastic miniature chassis (if metal is used, insulate SP1 from the chassis)
1—Power cord and plug
2—Terminals (or 1 outlet receptacle) for relay connections to the controlled device
Misc. hardware, wire, solder, etc.

fer more compact construction, depending on the application.

2 intercom projects

Project No. 1 Table Radio Conversion
by r. l. winklepleck

Project No. 2 Transistorized Intercom
by l. e. garner, jr.

Project No. 1

With a bit of judicious rewiring, you can change your mild-mannered little bedroom or kitchen radio into the "master's voice" of your household. What was once a quiet little stick-in-the-corner can summon Dad from his workshop, the children from their TV, or even Rover from his bone. In addition, it will answer the door and question the salesman, all without Mom having to stir a step from her kitchen.

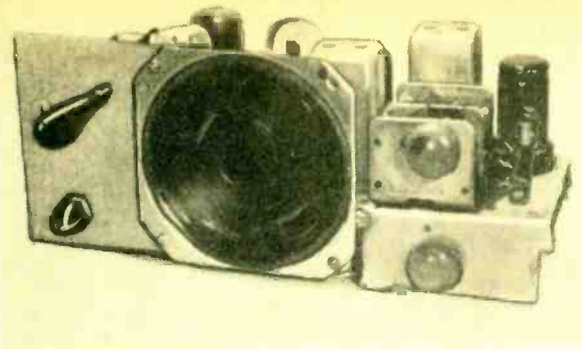
A dual-purpose unit is not an original idea in itself as several intercom models of this type are commercially available. However, the commercial models usually feed the signal into the radio's first audio stage. This works well enough for the high output of a crystal pickup of a record player, but it's woefully weak for amplifying the output of a PM speaker used as a microphone.

What's needed is a little more "soup." This can be easily added by wiring the switching circuit so that a five-tube radio becomes a *three-stage* intercom amplifier instead of a *two-stage* one. The schematic shows a portion of a typical a.c./d.c. radio with the comparatively few alterations necessary to make the change.

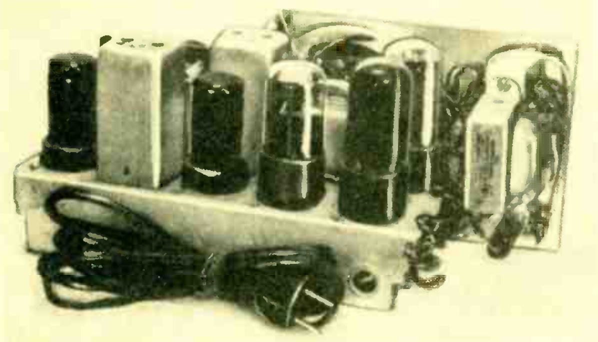
Photo at right shows a.c.-d.c. radio set converted for use as radio-intercom unit.

assembly

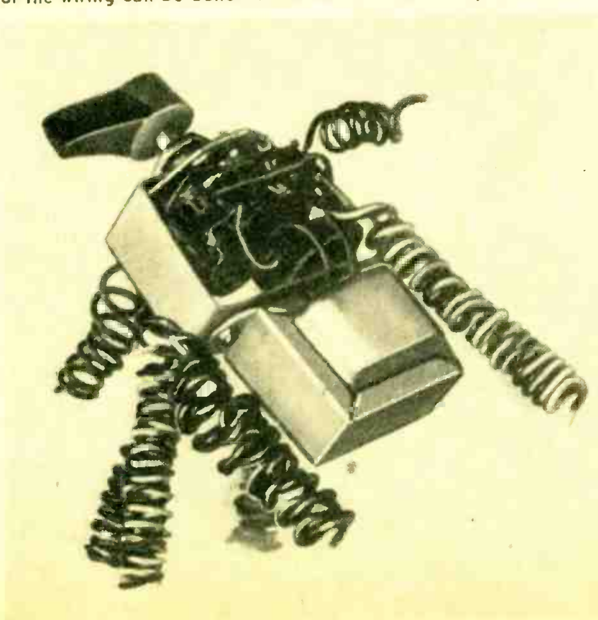
For ease of assembly, a 6-pole, 3-position, non-shorting (spring return to one side) rotary switch was selected. It not only makes the conversion from radio to intercom, but switches the local and remote speakers back and forth for intercommunication. This switch occupies very little space, and it should be possible to find room for it, the input transformer and the intercom volume control (if one is used) in the radio's



Front and back views of the radio-intercom show how the rotary switch may be added to an existing chassis. Switch and intercom volume control are mounted on a piece of scrap aluminum which is bolted to the speaker frame. The assembly will probably fit into your present cabinet, or you can design a new one.



In the close-up view below, you'll see how the input transformer is mounted on the switch with an aluminum strap. Most of the wiring can be done before the switch assembly is installed.



present cabinet. You may, however, wish to design a special cabinet both reflecting the new character of your intercom-radio and providing plenty of space for the added components.

The conversion was made to an old chassis from the junk box. It has the conventional a.c.-d.c. circuit with a 12SK7 i.f. tube, a 12SQ7 detector/amplifier and a 50L6 power output tube. As can be seen, the function switch and new volume control are mounted on a piece of scrap aluminum which is bolted to the speaker frame. This results in a symmetrical arrangement of the controls and is quite attractive.

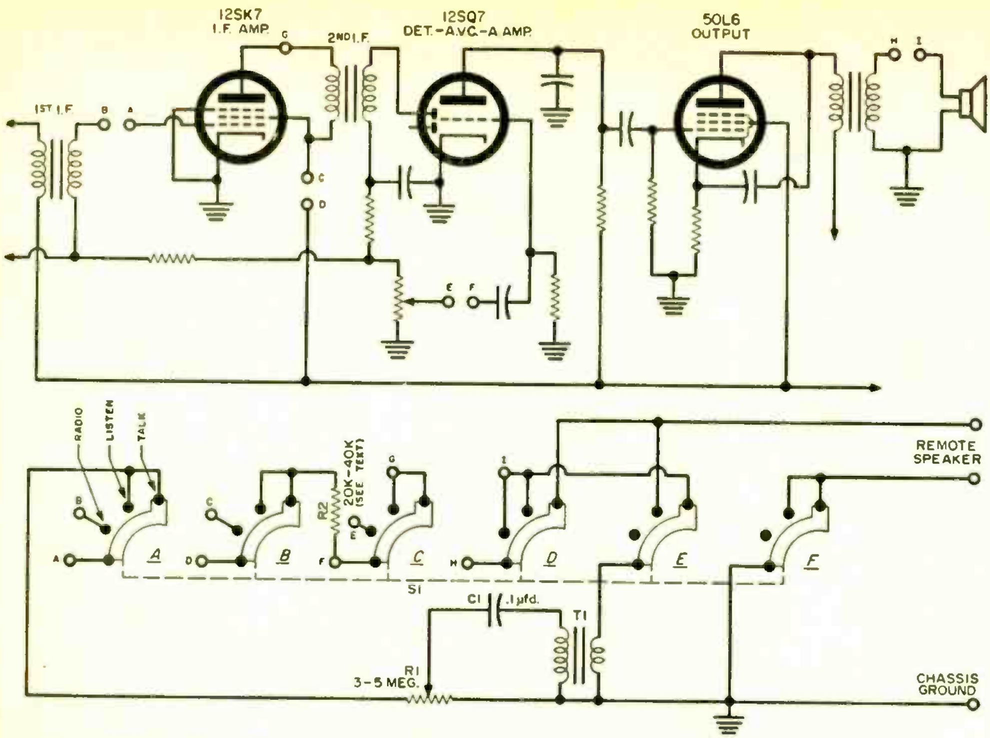
One disadvantage of a switch with 24 contacts is the maze of wires serving it. However, by mounting the input transformer on the switch with an aluminum strap, we find that we can complete 90% of the wiring in the open before the switch assembly is installed. This pre-wiring may look pretty complicated, but the worst is over when you have finished it. At this point, it's only necessary to attach ten color-coded leads to the set and two to the binding posts for the remote speaker leads, and the job is done.

The radio's volume control is deactivated by this conversion; the separate intercom volume control is shown in the schematic.

precautions

Adjustment of the intercom gain is made by using *exactly* the correct plate lead resistance (*R2*) for the preamp/i.f. tube. Because of the circuit employed, the tube manual cannot show the exact load value needed, so it is necessary to connect a potentiometer of at least 100,000 ohms in place of *R2* temporarily. Adjust it until maximum gain with minimum distortion is achieved. Check the pot with an ohmmeter and then replace it with a resistor of the nearest value.

This is a rather tricky conversion in some respects. Wir-



The partial schematic above is of a common type of a.c./d.c. home receiver. The lettered terminals on switch shown beneath it should be connected to similarly lettered points in receiver.

parts list

C1—0.1-µfd. tubular capacitor
R1—3.5-megohm potentiometer
R2—20,000 to 40,000-ohm, ½-watt resistor (see text)
S1—6-pole, 3-pos. non-shorting switch, spring return to one side (Centralab 1449)
T1—Intercom input transformer, speaker voice coil to high-impedance input (Standard Transformer Corp. A-4744)

how it works

The signal from the remote speaker, which can be a 4" or 5" unit like the one in the radio, is fed into an intercom input transformer. From here it passes through a resistor/capacitor network to match the input impedance of the set's i.f. tube, which has been changed into a preamp.

Emerging at the plate of the i.f. tube, the amplified signal passes through a capacitor to remove the d.c., and proceeds through the radio's unmodified first audio and output stages, and thence to the speaker.

The switch, in its first position, restores the original radio circuit. Positions 2 and 3 change the radio into a three-stage amplifier with position 2 for "listen" and 3 for "talk."

Gang A isolates the front end and feeds the intercom input to the control grid of the i.f. tube. Gang B breaks the voltage supply to the i.f. tube and through load resistor *R2* and interaction with Gang C, feeds this voltage directly to the plate of the i.f. tube. Gang C also isolates the radio's volume control and feeds the signal, through a capacitor which removes the d.c., to the grid of the first audio tube.

Gangs D and E merely shift the local and remote speakers from the front to the rear of the amplifier in the customary intercom manner. Gang F is used to isolate the remote speaker leads completely when the unit is being used as a radio.

ing the switch is tedious and can be downright confusing. The leads *must* be color-coded or you'll become hopelessly lost.

If the set's output transformer is mounted directly on the speaker frame, it would be well to move it. On the "talk" position, there might be some feedback between it and the speaker voice coil if they're too close together. Not all sets have one side of the speaker voice coil grounded, and this must be done.

The switch should be mounted as far as possible from the converter tube (which may be a 12SA7, 6SA7, or 12BA7) to reduce noise pickup. Leads from the switch to various parts of the set should be as short as possible. This is particularly true of the lead going from the switch to point "G" in the plate circuit of the 12SK7. A few holes through the chassis may sometimes offer the shortest route.

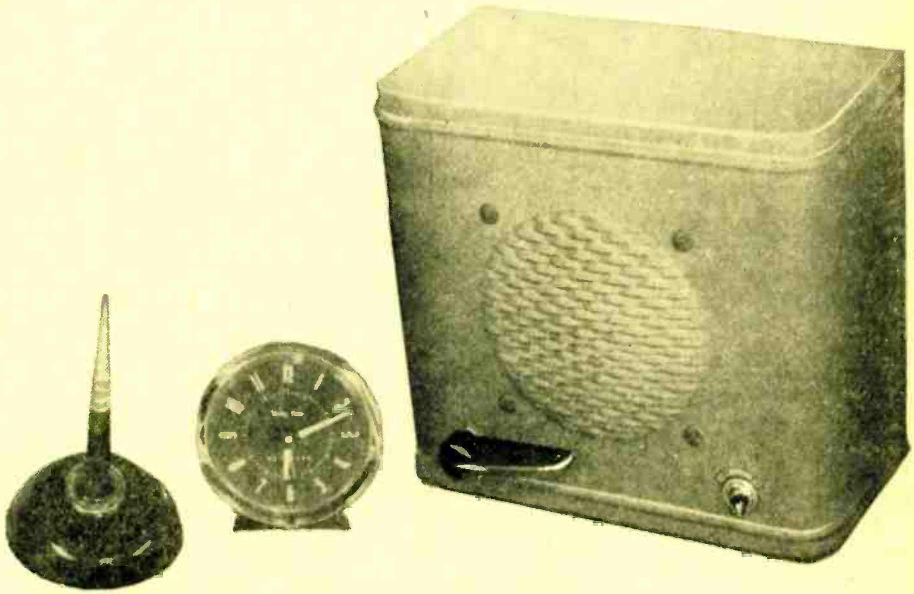
Each conversion presents its own special problems. Because of common tie points, some care and thought must be exercised in selecting the right place to break the circuit. Sometimes leads will have to be relocated to reduce hum pickup or feedback squeals. However, with an understanding of the principles involved, the conversion becomes an interesting and challenging project.

The remote unit consists of an ordinary PM speaker housed in any manner which suits the situation. Since the switching during conversations is done at the master station, and since the sensitivity is excellent, the remote speaker can be inconspicuously mounted high on a wall or on the ceiling.

One of the remote speaker leads may be "hot" in an a.c./d.c. transformerless set. It is important, therefore, to use insulated wire to connect the remote speaker. Shielding should not be necessary. Usually an ordinary twisted pair, such as telephone wire, is satisfactory for this purpose.

Project No. 2

Transistorized Intercom



Our efficient friend, the transistor, is finding new employment opportunities daily. Anywhere that a low-noise, low-impedance, and low current-consuming amplifier is required, there you are apt to find one or more of these little fellows inquiring: "Gotta job for me? I'm light-weight, heavy-duty and willing to travel."

The home intercom system is a natural for "transistorization." By powering it from a 6-volt battery, the possibility of shock or power supply hum can be eliminated. This unit is designed around three old standbys (CK722's or equiv.) and a newer type 2N255 power transistor. The circuit is simple and you should have little difficulty either in assembling the components or raising the cash to buy them.

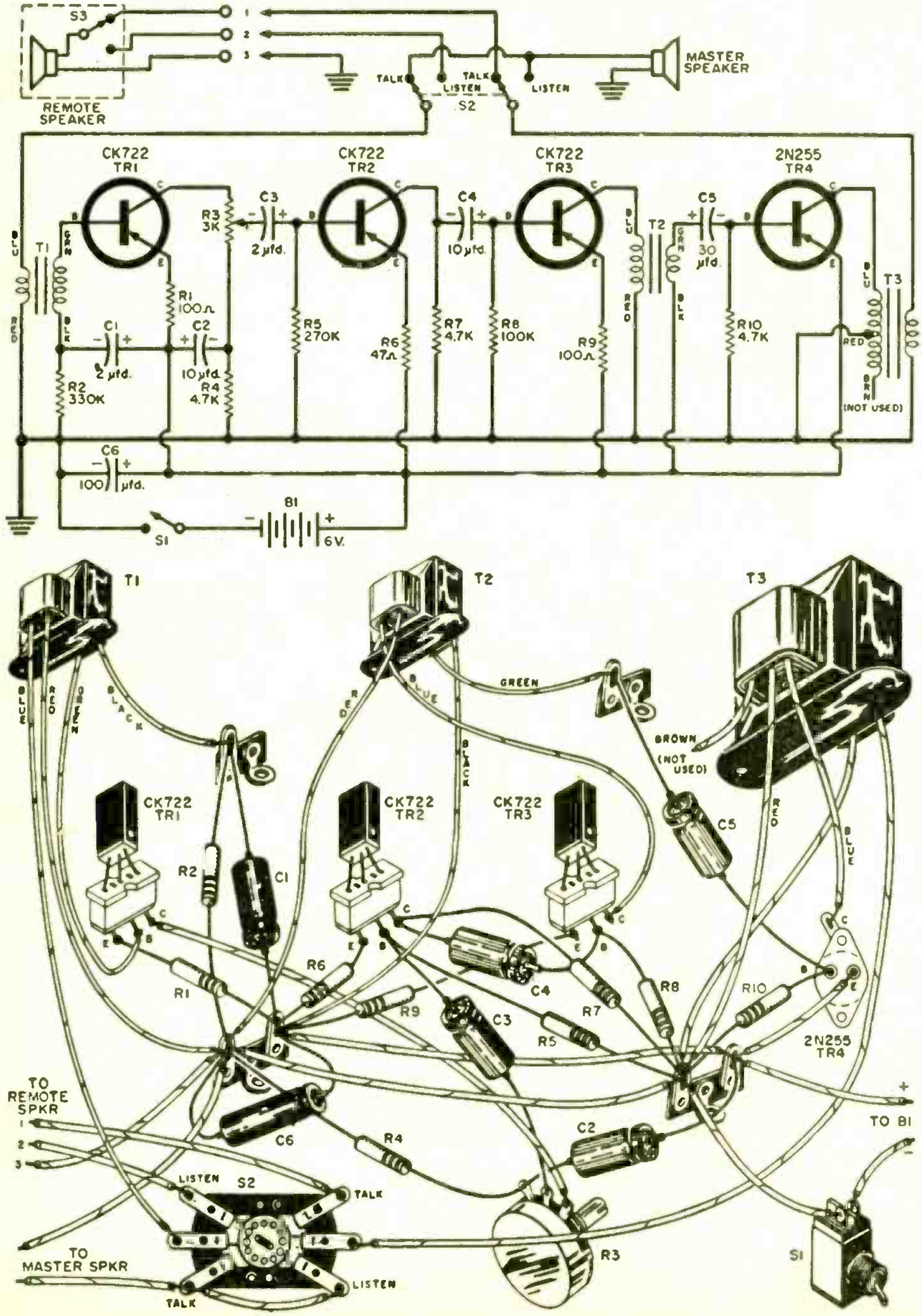
construction

The chassis can be constructed of a scrap piece of perforated Masonite, ¼" plywood (with holes drilled for parts mounting) or even sections of an old cigar box. It's a good idea to apply a couple of coats of acrylic spray to the "chassis" *before* mounting the components. This will prevent moisture from wilting it after installation in the cabinet.

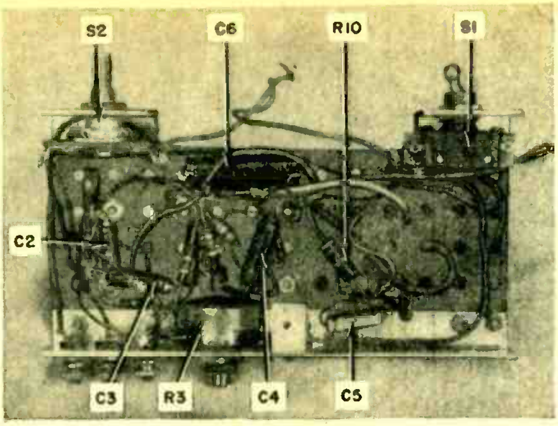
As can be seen from the photos, the power transistor is mounted with *6-32* nuts and bolts, as are *T1, T2,* and *T3*. Place a soldering lug under one of the 2N255 mounting nuts and use it for the collector connections. (The 2N255 has the collector internally connected to its shell and so the shell *cannot* be grounded.) Insert tie points wherever convenient and run the common leads to them. The rear bracket and the brackets mounting the switch and control can be cut from an aluminum angle or shaped from sections of a "tin" can.

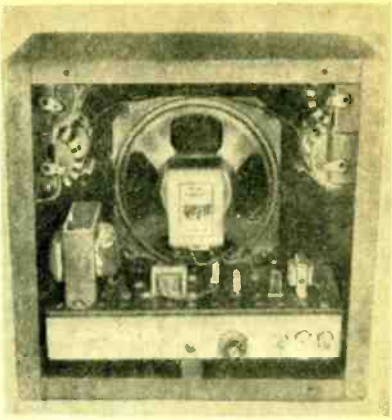
Layout and wiring are not especially critical as long as care is taken to keep input and output circuits well separated, preferably at opposite ends of the chassis. If your intercom shows a tendency to whistle, squeal or howl, the problem is probably due to audio coupling through the power supply or to bad parts layout.

The base resistor (*R10*) of the output stage is of a higher than normal value in order to minimize battery drain. If the circuit shows a tendency to distort or over-



Pictorial and schematic diagrams of the transistorized intercom.





Views of the parts placement layout of the transistorized intercom. In the photo at left, the amplifier chassis is shown from below with major parts identified. Photo at right shows intercom cabinet with all parts installed.

load on strong signals, the value of *R10* can be reduced. With the original 4700-ohm value, the battery drain will be approximately 50 ma. Lowering the value of *R10* will *increase* the amount of current drawn. As far as the input and output connectors are concerned, any convenient three-terminal strip will do. Binding head connectors were used in the model, but other types may be more easily available.

The 6-volt battery can be made up of four 1½-volt "D" flashlight cells mounted in series-wired battery clips. If more convenient, a single 6-volt portable radio type "A" battery can be used.

using the unit

Operation of the master unit can be achieved with any standard PM speaker as a remote. Standard three-wire intercom cable should be used for interconnection of the master and remote. The remote speaker will transmit *only* when its push-to-talk switch is depressed. This feature can be disabled by connecting a jumper wire between output terminals 1 and 2.

After installation, the gain control, which is mounted at the rear of the chassis, should be preset to a standard operating level and should not need readjustment until the batteries age.

This little job's independence of the a.c. power line makes it an ideal companion in areas where power is either not available or unreliable.

parts list

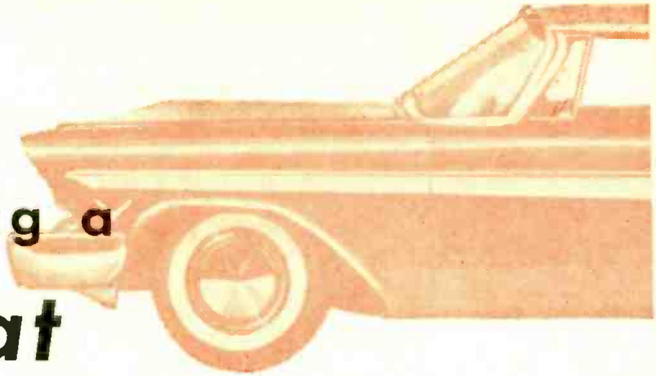
B1—6-volt battery
C1, C3—2-μfd., 6-volt electrolytic capacitor
C2, C4—10-μfd., 6-volt electrolytic capacitor
C5—30-μfd., 6-volt electrolytic capacitor
C6—100-μfd., 6-volt electrolytic capacitor
R1, R9—100-ohm, ½-watt carbon resistor
R2—330,000-ohm, ½-watt carbon resistor
R3—3000-ohm potentiometer (Gain Control)
R4, R7—4700-ohm, ½-watt carbon resistor
R5—270,000-ohm, ½-watt carbon resistor
R6—47-ohm, ½-watt carbon resistor
R8—100,000-ohm, ½-watt carbon resistor
R10—4700-ohm, 1-watt carbon resistor (see text)
S1—S.p.s.t. toggle switch (Power)
S2—D.p.d.t. spring return rotary switch (Centralab No. 1464)
S3—S.p.d.t. normally open push-button switch (Mallory 2003-L)—in Remote
T1—Input transformer; 3-ohm primary, 4000-ohm secondary (Argonne No. AR-125)
T2—Driver transformer; 500-ohm primary, 8-ohm secondary (Argonne No. AR-164)
T3—Output transformer; 48-ohm primary, 3.2-ohm secondary (Argonne No. AR-503)
TR1, TR2, TR3—CK722 transistor (Raytheon)
TR4—2N255 transistor (CBS Hytron)
SPKR.—4" PM speaker, 3-4 ohm voice coil

how it works

Standard intercom techniques are used in the switching circuits. The "push-to-talk" d.p.d.t. spring-return rotary switch (S2) in the "master" interchanges the connections between the master's speaker and the speaker in the "remote" station.

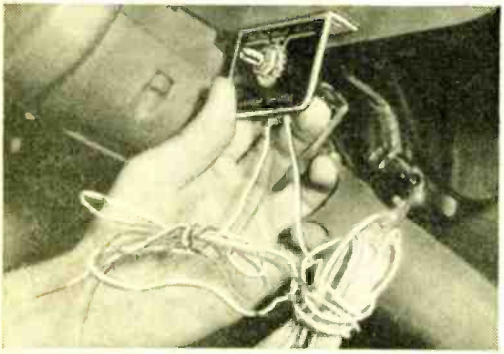
Input transformer *T1* couples the speaker used as a microphone to the first stage by matching the low impedance of the speaker to the 1000-4000 ohm input impedance of the transistor. *R4* and *C2* serve as a decoupling filter and control *R3* serves as the collector load. By having resistor *R1* unbypassed, the input impedance of the stage is raised and enough degenerative feedback is introduced to insure stable operation.

Base bias for the second stage is supplied through *R5*. *R7* serves as the collector load. *R6*, like *R1*, is unbypassed and stabilizes *TR2*. The third (driver) stage uses the interstage coupling transformer, *T2*, to match the output impedance of the driver to the lower input impedance of the power output stage. The 2N255 transistor (*TR4*) is the power output stage; base bias is supplied through *R10*. Output transformer *T3* couples the output of the 2N255 to the loudspeaker voice coil.



Installing a

Back Seat Speaker



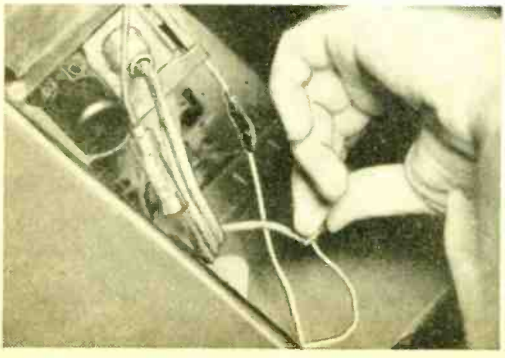
WIRE SWITCH. The switch, with 1 triple, 2 double contacts, taps line from transformer to front speaker, with extension line and ground for rear. Solder long "blue" line to triple "both" contact. Hook 2' "white" line to 2-contact "rear" position, "red" to 2-contact "front" post. Mount under dash.

The car's interior is an almost-perfect listening booth. The upholstery, carpeting and roof lining add up to a tailor-made baffle. But they also account for the usual inaudibility of radios from the rear seat. To overcome this, add a rear-seat speaker—it shouldn't cost you more than $5 or thereabouts.

All you need are a 5" x 7" or a 6" x 9" PM speaker, a three-position switch (*Centralab*), 25 feet of #18 or #22 wire, a speaker baffle, a moulding, four mounting bolts and an escutcheon plate and sheet metal screws for mounting the switch below the dashboard.

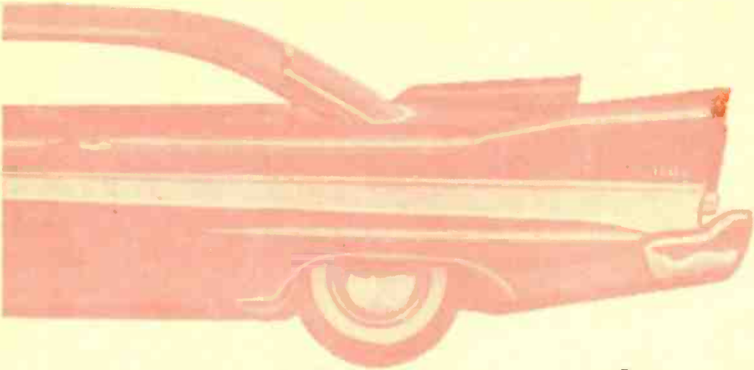
Follow the pictures on these pages for the easy, step-by-step instructions. You'll be amazed at the added listening pleasure you and your passengers will get.

SPLICE TO OUTPUT. Cut line from transformer. Splice "red" to transformer lead, "white" to speaker lead. Run "blue" to trunk under mats and seats.



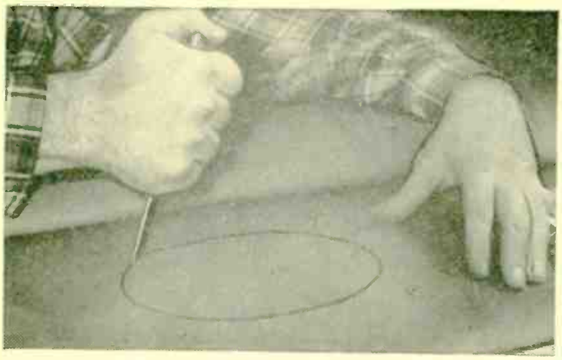
MOUNT SPEAKER. If there's no cutout, trace template on rear shelf. (Use stiff paper to make your own.) Drill holes, hold with bolts, trace speaker.

by
joe petrovec
and
len prokine



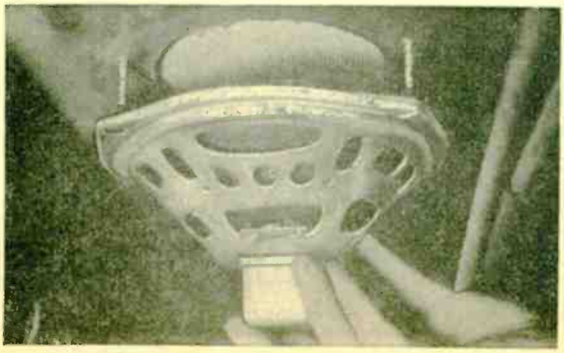
A professional-looking installation of switch and speaker will be the end result for just $5 or so.

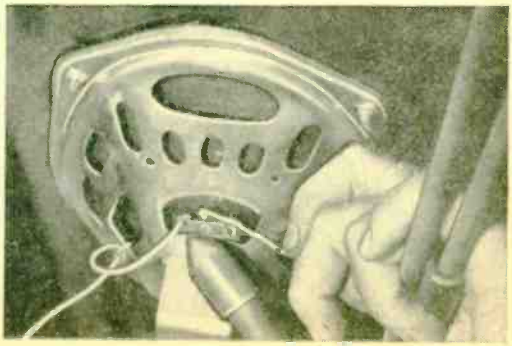
...it's easy and inexpensive



CUT SHELF. Using a sharp knife, carefully follow outline (above). Then lay moulding and baffle in place and drop mounting bolts through holes (above, right). Mount speaker from the trunk, using a weight to hold bolts in place (as shown below).

SOLDER TERMINALS. Hook "blue" line to one terminal. Ground the other with a short line to the body (below). Then turn on radio and check operation of speakers. If one or both don't work, or they are transposed in position, recheck your wiring.





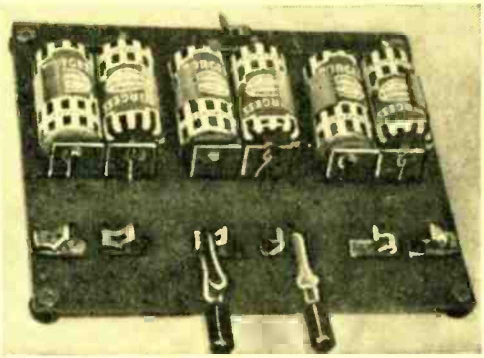
Useful Battery Power Pack

An adjustable-voltage d.c. power source is a real necessity for breadboard tests of transistor circuits and for working with portable radios, test gear, or on experiments with miniature motors. If you've priced the necessary components, you'll know that building an a.c.-operated low-voltage power supply can be an expensive proposition. Here's an inexpensive, easy-to-assemble power pack that should be ample for most of your bench work.

This power pack supplies pure d.c. at voltages ranging from about 1.5 to 9 volts, and at currents up to 500 milliamperes (0.5 amp.) for short periods; and it can be used as a multiple power source. To assemble it, all you will need is a mounting base, a few battery "boxes," batteries, a handful of Fahnestock clips, and some small hardware. A piece of perforated Masonite can serve as a base.

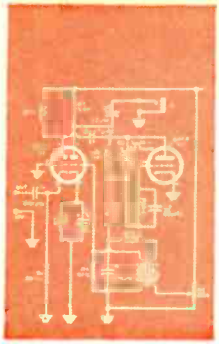
Rubber feet were mounted in each corner of the model built by the author. Three Austincraft No. 144 battery "boxes" were used, connected to supply nine volts from six Burgess No. 1 dry cells. The output leads of each battery box were brought to a separate pair of Fahnestock clips. The frames of all three boxes were bonded together and connected to another clip which is used for grounding.

With this arrangement, you have three independent 3-volt sources. Two sections may be connected in series to furnish six volts or all three sections can be connected in series to supply nine volts. For heavy current drains, over an ampere, for example, the three sections may be connected in parallel. Finally, where you need smaller voltage increments, you can use a clip lead to



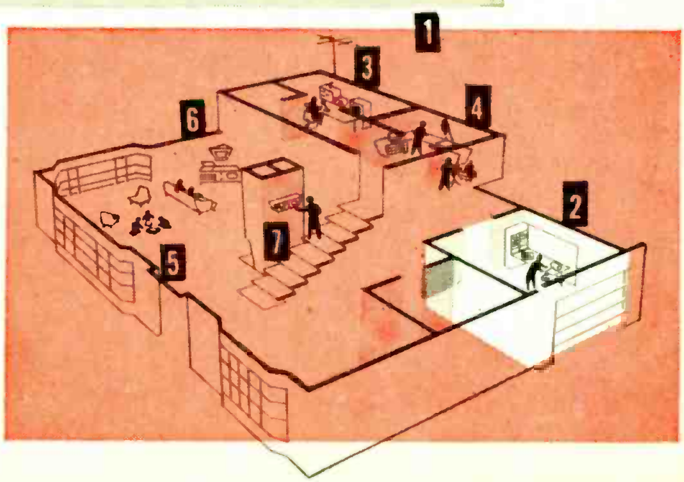
"tap" into the individual battery boxes, obtaining nominal output voltages covering the range of 1.5, 3, 4.5, 6, 7.5 and 9 volts.

—E. G. Louis



Section 2

for your work shop



by ***richard graham***

The "Economy" Transistor Checker

It doesn't take long to accumulate a small but varied stock of transistors once you start experimenting with these little gems. Fortunately, to determine whether a transistor is good or bad requires a tester of extreme simplicity. The "Economy" Transistor Checker performs two sensitive tests which will quickly tell you if a transistor has been damaged due to overload or contamination of the germanium, whether the transistor is shorted or open-circuited, or if it is just excessively leaky.

Construction of the transistor checker should take about one evening. It is housed in a 3" x 2" x 5¼" Minibox. Layout is not critical.

The transistor socket requires a 5/32" x 11/32" rectangular hole. Lay out the hole size carefully on the front panel with a scriber, then drill two ⅛" holes within the rectangle. The remaining aluminum can be readily removed in a few minutes with a variety of small "Swiss Files."

Mount the 6-volt battery on the rear cover of the checker. Bend strap of scrap aluminum so that it fits around the battery and clamp it firmly into place.

Wiring the unit should present no problem if the wiring diagram is carefully followed. If you've worked with transistors at all, you've probably realized that particular care must be exercised regarding battery polarities and short circuits, etc. Usually you get one chance with transistors—unless you're fortunate and fast.

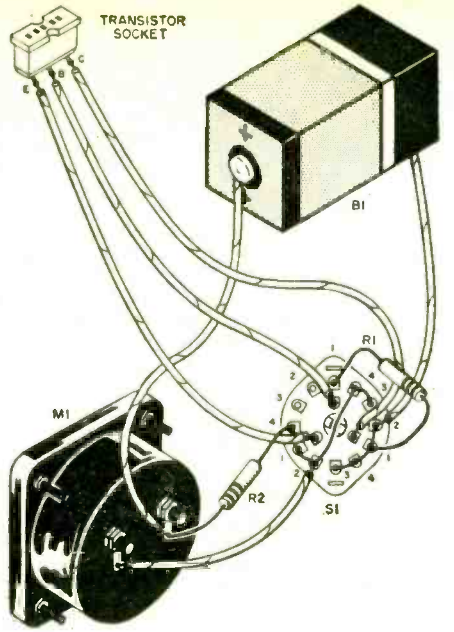
Battery drain is small and intermittent, so solder the wire from the checker directly to the battery terminals. The battery should last for its shelf life.

using the checker

To test a transistor in the checker, it is first necessary to know which basic type of transistor you have, i.e., whether it is a *p-n-p* or *n-p-n* type. You can determine this from the manufacturer's description or from the polarity of the battery connections to the transistor if it is in a piece of equipment. A *p-n-p* transistor always has the collector supplied from the negative pole of the battery and the emitter supplied from the positive pole. The *n-p-n* type is reversed completely, i.e., the collector is supplied from the positive pole and the emitter from the negative pole of the battery.

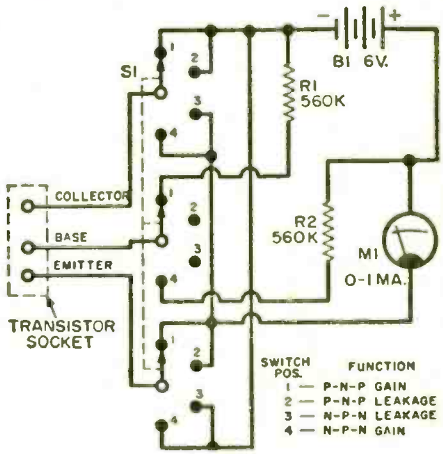
Once this fact is established, it is only necessary to set the switch on the checker front panel to the leakage position for the type of transistor under test. Plug the transistor in the socket provided and observe the reading on the meter. The data in Table 1 give representative readings for several transistor types (see page 31).

In general, the lower the leakage, the better the transistor. It can then be noted that the inexpensive low-frequency types usually exhibit higher leakage than the more expensive low-frequency types.



Pictorial and schematic diagrams show how parts are interconnected. See parts list below.

B1—6-volt battery (Burgess Z4 or equivalent)
M1—0-1 ma. meter (Shurite, Electro Mech, or equivalent)
R1, R2—560,000-ohm ½-watt resistor
S1—3-circuit, 4-position switch (Erie #612-08 or equivalent)



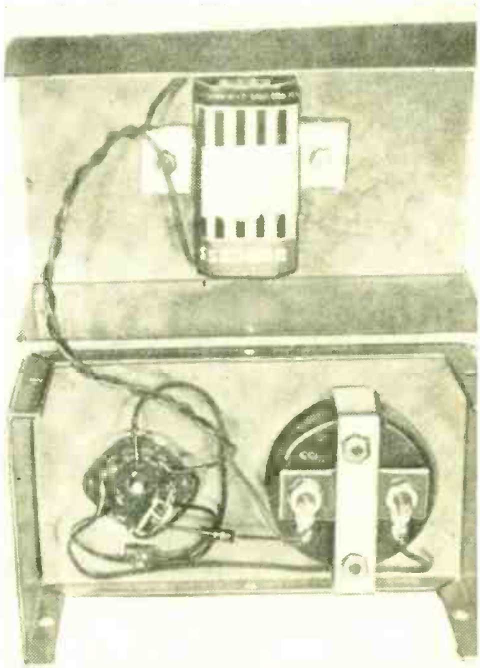
To check the common-emitter current gain, merely set the switch to the gain position. An upward swing indicates a current gain. If the leakage reading was very low, the meter reading, multiplied by 100, can be called the approximate beta (β) for the transistor. At any rate, the meter reading can be checked against Table 1.

If the transistor has an appreciable amount of leakage, the current gain (β) can be obtained by observing the change in meter reading when switching from the leakage to gain positions. The difference between these two readings divided by the change in base input current which occurs when switching between leakage and gain positions will give the common emitter current gain. For example, in the transistor checker, the base input current is 10.7 microamperes. Thus, if the meter reads a change of 0.5 milliampere in going from leakage to gain positions, the approximate current gain would be 0.0005 divided by 0.0000107, or 46.7.

Many manufacturers rate transistor gain as alpha (α) which is the common-base current gain. This is a number always less than "1" for junction transistors and is generally of the order of 0.98.

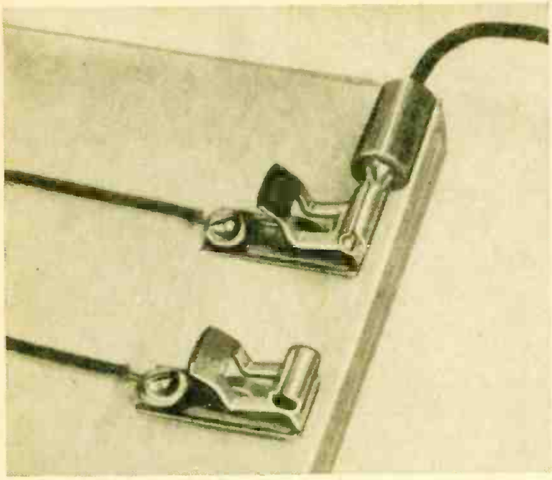
Transistor Type No.	Leakage Reading	Gain Reading
CK722	0.1	0.3
2N107	0.1	0.5
2N45	0.2	0.4
2N78	0.05	0.55
2N94	0.0	0.3
2N137	0.1	0.7

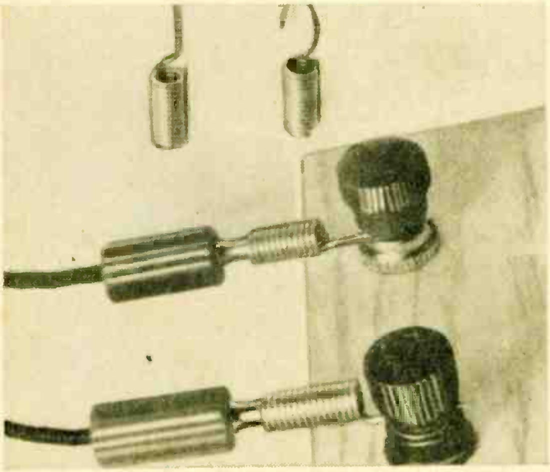
Table 1. Typical leakage and gain readings obtained for several different types of transistors.

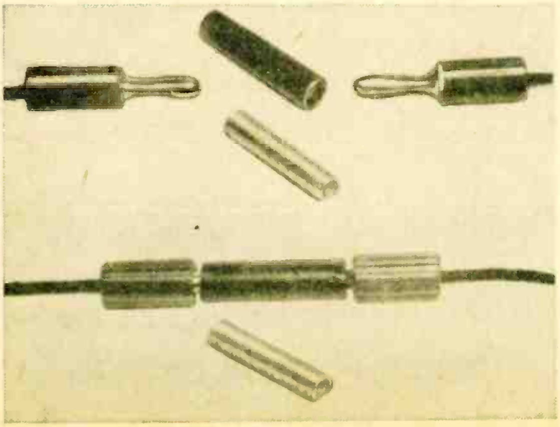


Looking into the transistor checker from the back, you can clearly see the layout of the parts. This unit will check any junction-type transistor.

Tricks with Banana Plugs and Adapters







It's a tough job to fit standard banana plugs onto Fahnestock clips without bending either the clips or the split noses on the plugs. Try soldering short lengths of metal tubing onto some of your clips, as shown at left, to enable firm connections to be made between the clips and plugs. Obtain some steel, brass, or copper tubing having the correct inside diameter, and cut it up into ⅜" or ½" lengths; then solder the sleeves onto the Fahnestock clips. If you have trouble locating metal tubing of the right inside diameter, you can bend your own sleeves using tin salvaged from a tin can. Another trick is to cut a lengthwise slot in the metal sleeve so that you can spread or pinch it to the correct inside diameter to fit the banana plug snugly.

When you want to connect standard banana plugs to apparatus using various types of binding posts, the simple adapters at left center will help you out. Obtain a No. 42-S spring sash rod (10 cents at all dime stores), and clip off a few ⅝" lengths with a pair of sidecutters. Uncoil one end of each piece of spring and straighten it out. Bend a ½"-long hook on some of the springs, and leave a ½"-long straight pin on the others, as shown. The binding post nearest top of photo is of the standard variety, such as is found on "hot-shot" batteries, etc., and it uses the hook type of adapter. The one at the bottom is the "Eby" type having a hole to receive a wire lead, and it uses the straight-end adapter.

With simple, insulated, dual receptacles (below, left), you can quickly and economically extend test leads which use standard banana plugs on the ends. Cut off a few 1"-long pieces of the spring sash rod with your sidecutters and smooth the sharp edges of the cut wire with a file. To insulate your couplers, and to color-code them, half may be covered with black Mystik tape (see top coupler), and the others with red tape. The inside diameter of the No. 42-S rod is just right to make a snug fit with standard banana plugs, but any other spring stock or metal tubing of the correct inside diameter can be used instead. —*Art Trauffer*

Building an "ECONOMY" Signal Generator

by richard graham

A signal generator means as much to the electronics experimenter and serviceman as a hammer does to the carpenter. It is considered an essential tool of the trade. This particular signal generator is tailored for the experimenter with "good tool" taste, but without the financial resources to back it up.

The "Economy" signal generator is fairly straightforward in electrical design. Although it uses only one tube, it offers a frequency range that can be spread or tailored to one's individual requirements. This is achieved by the use of plug-in coils. It also results in a general cost reduction . . . particularly since the coil forms are free!

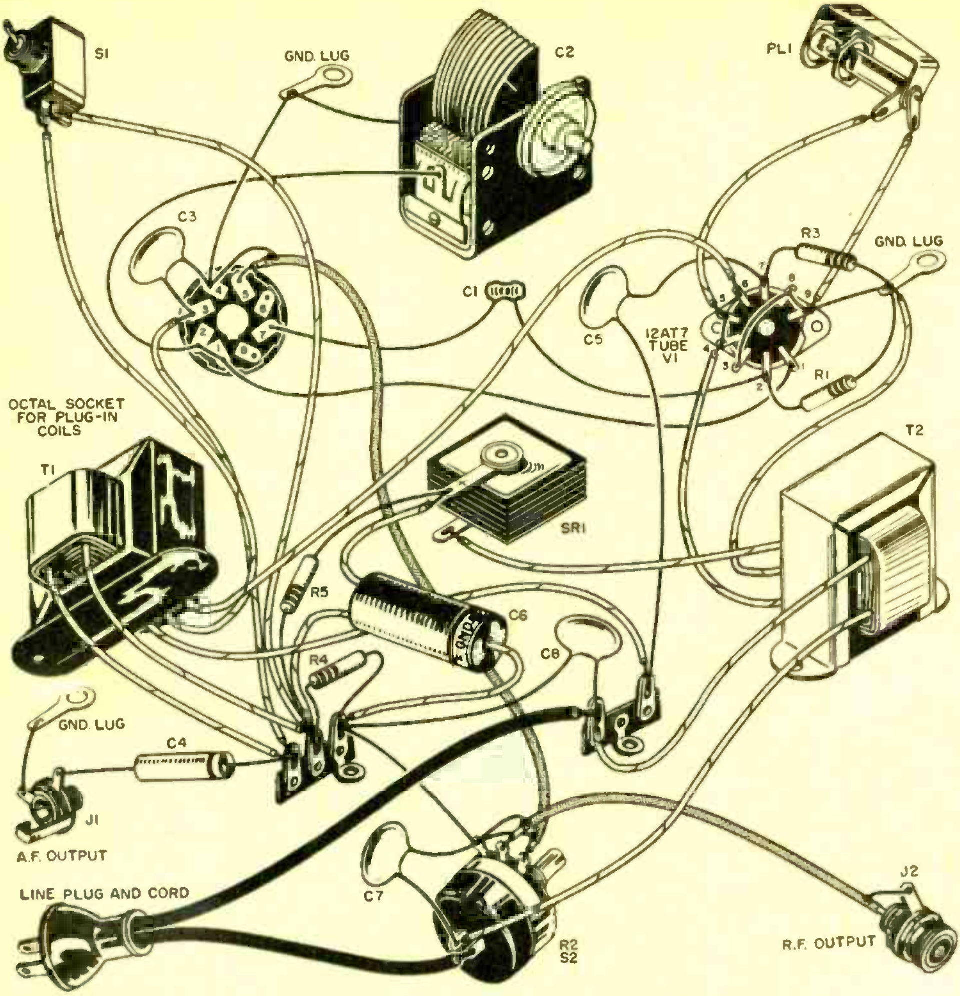
Four plug-in coils cover the range of 375 kc. to 65 mc. The generator incorporates an internal 400-cycle audio modulation. The audio tone is made available through the front panel to check audio systems, amplifiers, etc.

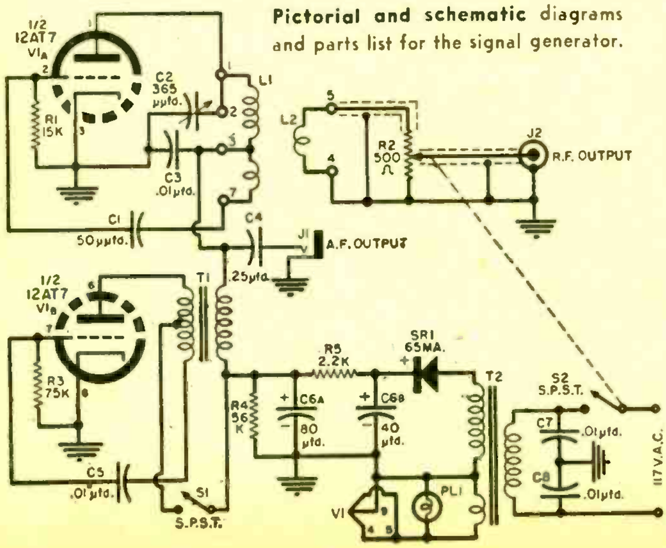
Mechanical considerations involved in building a signal generator are as important as the electrical design. Ever try to lift a high-quality laboratory unit? It often takes two men to transport it across a room. Mechanically rugged and rigid construction is a primary aim in these generators.

While the "Economy" generator can certainly be lifted by a very small boy, it has this same philosophy of good mechanical design in its layout. A steel chassis and box are used purely for mechanical rigidity. The rear edge of the chassis has a metal post stand-off and the plug-in coil bracket has a special metal post to hold it to the cabinet. These precautions make a fairly rugged unit in which the output is reasonably immune to pounding and vibration.

construction

The unit is housed in a black crackle 6" x 6" x 6" steel utility box with a 4¾" x 5½" steel shelf. The 12AT7 is mounted vertically under the chassis, and the coil socket is mounted on a right-angle bracket formed from a 1¾"x2½" piece of steel. If short

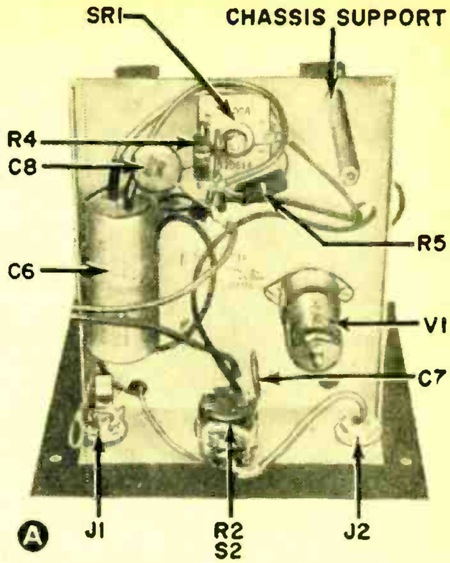


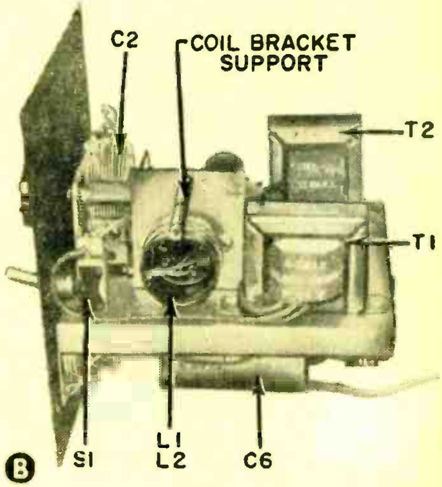


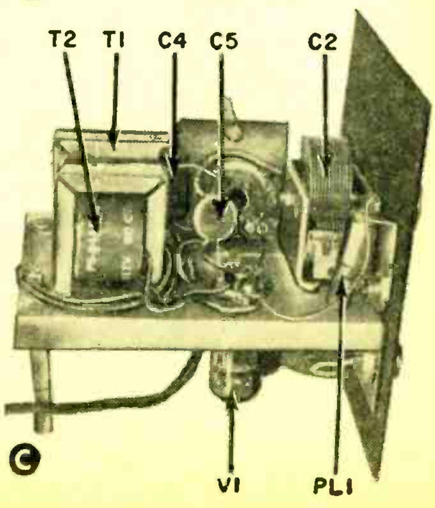
Pictorial and schematic diagrams and parts list for the signal generator.

C1—50-μμfd. ceramic capacitor
C2—365-μμfd. variable capacitor
C3, C5, C7, C8—0.01-μfd., 600-volt disc ceramic capacitor
C4—0.25-μfd., 400-volt paper capacitor
C6—80-40 μfd., 150-volt electrolytic capacitor
J1—Open-circuit jack
J2—Coaxial jack
PL1—Pilot light
R1—15,000-ohm, ½-watt resistor
R2—500-ohm carbon potentiometer
R3—75,000-ohm, ½-watt resistor
R4—56,000-ohm, 1-watt resistor
R5—2200-ohm, 2-watt resistor
S1—S.p.s.t. switch
S2—S.p.s.t. switch on R2
SR1—65-ma. selenium rectifier
T1—Modulation transformer, 4000-ohm secondary, 10,000-ohm center-tapped primary (Stancor A3812)
T2—Power transformer, 125 volt @ 15 ma., 6.3 volt @ 0.6 amp. (Stancor PS8415)
V1—Type 12AT7 tube

Three views of the "Economy" signal generator chassis show placement of the major components: Ⓐ bottom view; Ⓑ right side view; and Ⓒ left side view. Layout is very critical.







leads are maintained in the coil (*L1*) and variable capacitor (*C2*) circuitry, you will find that there is nothing critical in the wiring.

The coil forms can be salvaged from defective octal tubes. Just make sure that the coil is wound on the diameter base specified. Break a tube in a paper bag with a sharp hammer blow. The base can then be cleaned out with a pair of cutters. A screwdriver will pick or scrape out the cement. Remove wires from the pins by heating the pins with a soldering iron. After the solder has melted, give the base a sharp rap and the hole in the pin will be clear of both wire and solder.

The post providing support between the rear chassis edge and cabinet and the post between the coil socket and cabinet are made up of standard 1" threaded metal spacers. They are fastened together by cutting the head off a screw and using the threaded portion to hold the two posts together.

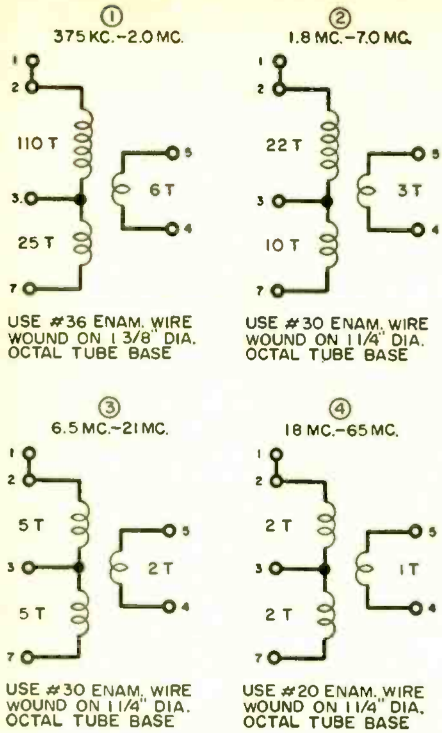
calibration

This poses a more interesting challenge than building the generator, but an accurate and reliable calibration can be worked out with a good communications receiver. An "all-wave" receiver of undetermined accuracy can be used if it has a short-wave coverage up to approximately 22 mc.

The calibration method to be described uses broadcast-band stations of known frequencies. These are made to beat against the generator fundamental and harmonics up through the highest frequency received by the receiver. The lowest frequency of the generator is around 375 kc.

Let's assume that there is a broadcasting station at 800 kc. in your locality, and that the receiver is tuned in to this station. Place the receiver antenna close to the generator output lead. If the low-frequency coil is plugged in the unit, and the generator is set to the lowest frequency (i.e., the variable plates of *C2* are all in), as the generator is slowly rotated toward the higher frequencies a beat note or whistle will be heard.

As the dial is rotated, the beat note will first be noticed as a high-pitched whistle which decreases in frequency as the dial is rotated further. This continues until zero frequency difference is reached, known as "zero beat." As the dial is rotated still fur-



Four plug-in coils, such as the one shown here, cover the basic frequency range. Data for each coil is given in the box above. You can salvage the coil forms from defective octal tubes as described in the text.

how it works

This signal generator utilizes a series-fed Hartley circuit, with stability being achieved through rigid mechanical construction. Oscillation occurs through feeding the signal appearing in the plate circuit back into the grid with the proper phase change.

The generator is plate-modulated through a small Stancor modulation transformer. This method is unusual in signal generator design but is capable of rendering a higher percentage of modulation, and so has the effect of giving a louder audio signal output when used during receiver alignment.

The primary of transformer *T1* is connected as an audio oscillator in the same type of Hartley oscillator circuit as the r.f. oscillator. Audio output for test purposes is coupled from the secondary of *T1* through capacitor *C4* to block d.c. from the output test lead.

ther, the frequency will again increase until it is inaudible. However, when we were "zero beat" with the broadcast station at 800 kc., it really meant that the generator was exactly set to 400 kc. Thus, the first calibration point has been obtained.

The generator frequency is increased until a carrier is heard, indicating that the generator is set at 800 kc. That point is then calibrated on the generator. Now, with the generator set at 400 kc., previously calibrated, the third and fourth harmonics of the generator can be picked up on the receiver at 1200 kc. and 1600 kc. They will be considerably weaker.

With these frequency points calibrated on the receiver, more calibrated points on the generator can be determined as follows: Set the receiver to the newly calibrated frequency of 1200 kc. on the dial. Continue increasing the generator frequency until a strong carrier (no whistle) is heard. This frequency will be 1200 kc. and is so calibrated on the generator dial. The receiver is then set to 1600 kc. and the generator adjusted until the new carrier is heard, which would be at 1600 kc. Thus, we have determined four frequencies with good accuracy.

With the generator at 1600 kc., scan the receiver frequencies starting at 1600 kc. for generator harmonic points. The first should be heard at 3.2 mc., then 4.8 mc., and a weaker one at 6.4 mc. Now set the receiver at the 6.4-mc. spot and double-check the lower generator frequencies. For example, as the generator frequency is increased, the next signal heard in the receiver will be when the generator is set at 3.2 mc. This point is calibrated on the generator dial, then the carrier at 6.4 mc. Such a boot-strap process can be repeated to the highest frequency covered by the receiver.*

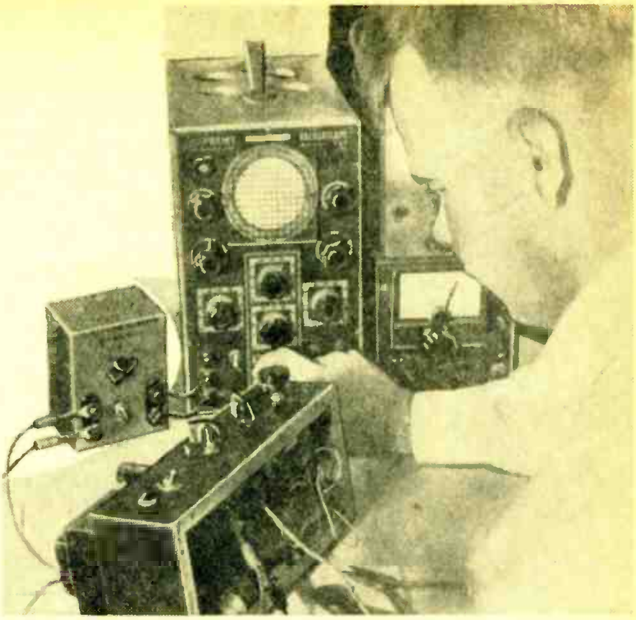
The generator frequencies beyond the highest frequency received by the shortwave receiver can be calibrated by means of an FM tuner. As generator harmonics will lie in the FM and TV band, the procedure described above can also be used to extend the calibration of the generator.

* Something to watch in calibrating by this method is that, since each calibration point is based on the previous calibration, extreme care must be used.

Also, feed as little signal from the generator into the receiver as possible to avoid the false responses that would result if the generator signal were too strong. Such responses are always weaker than the desired response and spaced twice the intermediate frequency away. For example, if a receiver has a 455-kc. i.f., the image response might appear 910 kc. higher or lower (only one or the other) than the stronger desired frequency.

The above statements are not meant to confuse but rather to serve as words of caution to enable the successful calibration of the generator. After the method is understood, calibration can be completed quite rapidly.

double the value of your oscilloscope with this simple easy-to-build unit



Economy Oscilloscope Calibrator

by richard graham

We can all agree that the oscilloscope tells more about the operation of a piece of equipment than any other test instrument. But what do you do when you need more than just a picture? Suppose you want to know the actual peak voltage of the waveform under observation? This economy oscilloscope calibrator can give you this information in a fraction of time, conveniently and accurately.

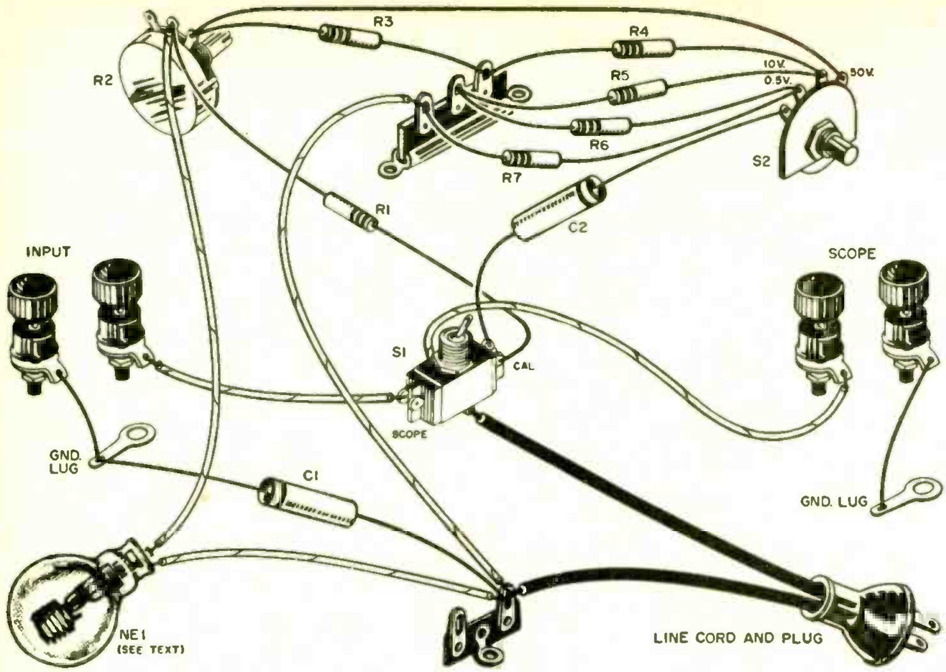
Price-wise, the construction cost of the calibrator shouldn't exceed $4.50 for the unit complete as shown. If you've invested in an oscilloscope, which probably cost upward of 10 times this amount, you're cheating yourself out of a large part of the utility and versatility inherent in the oscilloscope if you don't build the calibrator. Looking at it this way, you almost can't afford *not* to build it.

Basically, the calibrator is a device that will put out a standard a.c. voltage. This a.c. reference voltage is unaffected by variations in the 117-volt a.c. line voltage. Switching is provided in the calibrator to select either the waveform under observation or the standard voltage signal from the calibrator. Further provision is made so that any of three standard a.c. voltages can be obtained.

construction

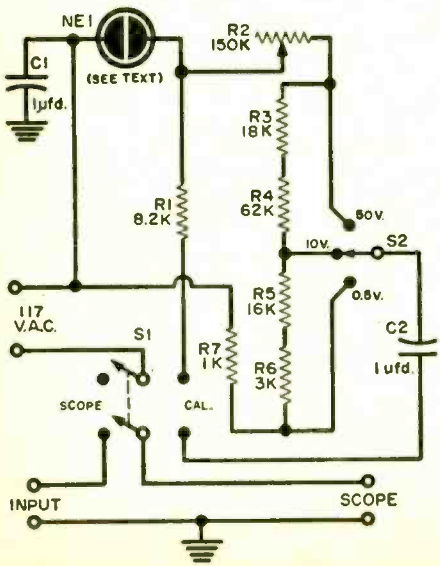
The oscilloscope calibrator is housed in a 5" x 4" x 3" aluminum utility box. Since nothing is critical in the layout or construction of the unit, any other size and shape box may be used. Preferably, the housing should be made of metal to act as shielding.

The heart of the calibrator is the one-watt neon lamp (*NE1*), the odd-shaped glass object you can see in the rear view photo. This is a standard one-watt type NE-30 neon lamp, which can be obtained at most electrical distributors, from which the screw base and internal resistor has been removed and which has been mounted with the lead end up. Care must be used in removing the base from the lamp; since the brass screw base is very thin, however, only a pair of cutters is required.



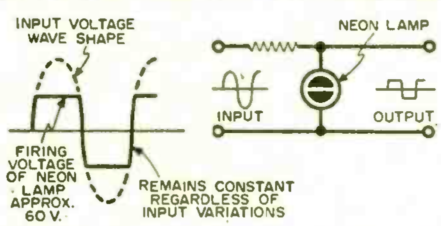
Follow the pictorial and schematic diagrams in putting the oscilloscope calibrator together. The parts list and a description of how the unit operates are given below.

C1—1.0-µfd., 200-volt paper capacitor
C2—0.1-µfd., 200-volt paper capacitor
NE1—Neon lamp (NE-30 or NE-32; see text)
R1—8200-ohm, 1-watt, 10% resistor
R2—150,000-ohm potentiometer
R3—18,000-ohm, ½-watt, 5% resistor
R4—62,000-ohm, ½watt, 5% resistor
R5—16,000-ohm, ½-watt, 5% resistor
R6—3000-ohm, ½-watt, 5% resistor
R7—1000-ohm, ½-watt, 5% resistor
S1—D.p.d.t. toggle switch
S2—S.p. 3-pos. rotary switch



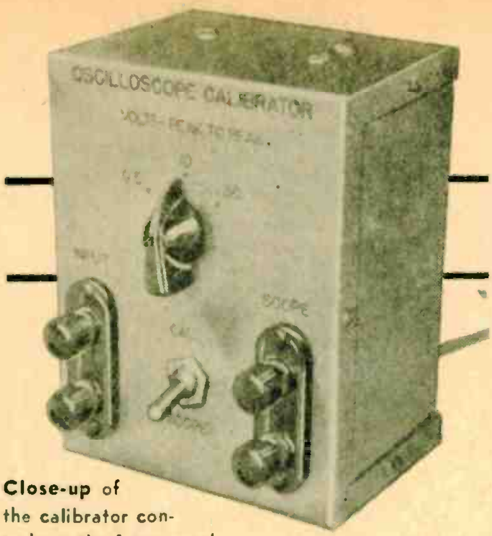
how it works

The calibrator is an a.c. voltage regulator capable of supplying a constant, known voltage to the oscilloscope. The regulator utilizes a one-watt neon lamp (*NE1*) that will conduct whenever the voltage across

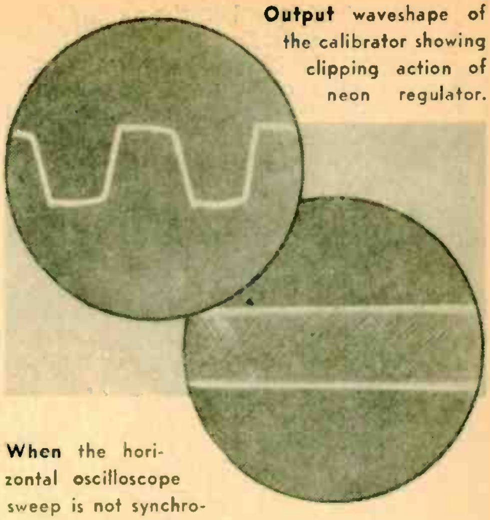


the lamp exceeds its firing voltage, which is on the order of 60 volts. When the lamp "breaks down," it will start to conduct, but the voltage across the neon will remain constant. Thus, as the 60-cycle voltage waveform exceeds the firing voltage, the lamp begins to conduct, effectively clipping the voltage waveform to a maximum of 60 volts. It does this for both halves of the 60-cycle waveform, since the lamp will conduct equally well in either direction. The drawing above shows the regulating action.

To make the calibrator more versatile, a voltage divider is connected across the lamp. Potentiometer *R2* is used to adjust the voltage across resistors *R3* through *R7* to exactly 50 volts peak-to-peak. The divider drops this to 10 and 0.5 volts peak-to-peak. These three standard voltages are usually adequate. Switch *S2* selects the standard voltage to be fed to the oscilloscope, and switch *S1* is used to feed either the calibrator output or the signal to be observed and measured to the oscilloscope input. Capacitors *C1* and *C2* isolate the oscilloscope input from the power line.



Close-up of the calibrator controls on the front panel.



Output waveshape of the calibrator showing clipping action of neon regulator.

When the horizontal oscilloscope sweep is not synchronized with the calibrator, a waveform like the one at the right is obtained. This is easier to use in calibrating the calibrator.

In the photograph on page 37, the calibrator is shown in action—being used to test an amplifier.

If your radio parts distributor is well stocked, try and get a type NE-32 neon lamp. It has the same characteristics as the NE-30 except that the base is a double-contact bayonet base and does not include an internal resistor.

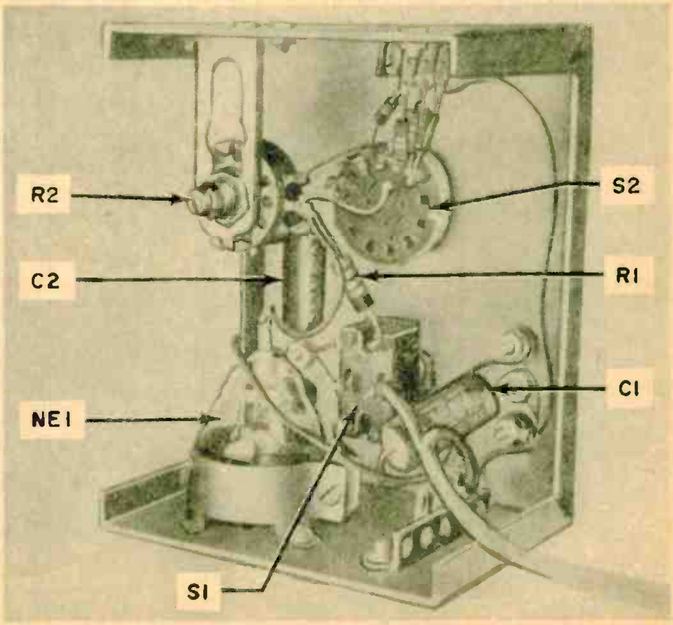
Mount the lamp in an electrolytic capacitor mounting clamp. To reduce the possibility of breaking the glass, first wrap the bulb with a few turns of tape. The clamp can then be tightened, remembering that it's a piece of glass we're clamping, not a piece of steel.

After the calibrator is completed and the wiring checked out, hook up the *scope* terminals on the calibrator to the vertical input terminals of your oscilloscope. Turn everything on, and place the calibrator switch in the *cal.* position of switch *S1*. The oscilloscope can be adjusted until a waveform similar to that shown in the photo above (the top one) is seen. This indicates that the calibrator is working properly. Now all that is needed is to perform the calibration of the calibrator.

calibration

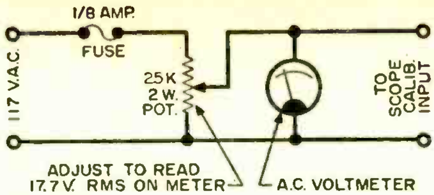
The setup is shown in the drawing on page 40. A reasonably accurate a.c. voltmeter is required. Since the full a.c. line voltage will be across the potentiometer, some caution should be exercised. A small ⅛-amp fuse is in series with the incoming line to prevent any serious short circuits.

Adjust the potentiometer until a reading of



Rear view of the unit in which the major components are identified.

17.7 volts is obtained on the a.c. voltmeter. This voltage reading corresponds to a peak-to-peak voltage of 50 volts used to calibrate the oscilloscope. Place switch *S1* in the *scope* position. Adjust the oscilloscope vertical gain for a specific number of boxes on the face of the oscilloscope. Let's use ten boxes for our example.



Setup for calibrating the calibrator.

Once this is done, do not touch the vertical gain setting for the remainder of the calibration procedure. Now place switch *S1* in the *cal.* position and the volts peak-to-peak switch in the 50-volt position. Adjust potentiometer *R2* in the calibrator to produce the same ten boxes of deflection.

To check the accuracy of the voltage divider, set switch *S2* to 50 volts peak-to-peak. Adjust the oscilloscope vertical gain to produce a deflection of ten boxes. Then set switch *S2* to the 10-volt peak position. The deflection on the screen should now equal two boxes.

Similarly, to check the 0.5-volt peak-to-peak position, first set the switch *S2* to the 10-volt peak-to-peak calibrating position and then adjust the oscilloscope gain for ten boxes of deflection. When switch *S2* is placed in the 0.5-volt peak-to-peak position, the deflection should be one-half box if the divider is accurate.

During actual use of the calibrator, the unit is left connected to the vertical input of the oscilloscope and the signal waveforms under observation are fed into the *input* terminals of the calibrator. With the switch *S1* in the *scope* position, the oscilloscope input terminals are merely transferred to the input terminals of the calibrator.

using the calibrator

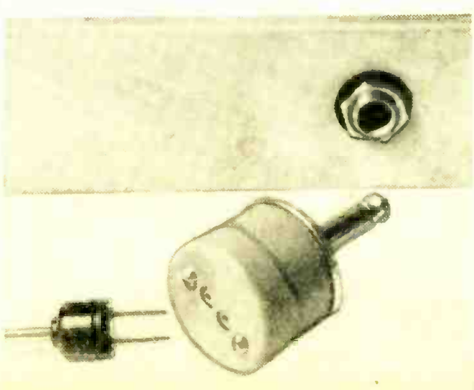
To measure the voltage of a waveform being fed into the oscilloscope, use a reverse procedure to that of the calibration just described. To measure a peak-to-peak voltage, first calibrate the screen of the oscilloscope in terms of volts with the calibrator. This is done by placing switch *S1* in the *cal.* position. Then set switch *S2* to one of the voltage settings on the calibrator. For our discussion, let's use the 10-volt position.

Adjust the vertical gain of the oscilloscope to produce a signal of a specific number of boxes on its face. If you make the calibrator signal ten boxes high, then each box on the oscilloscope face will represent one volt. If you adjust the oscilloscope vertical gain so that a 10-volt calibrator output is only one box high, then ten boxes on the oscilloscope face will represent one hundred volts. Thus, it can readily be seen that the three ranges included in the calibrator will cover any voltage normally encountered with the oscilloscope.

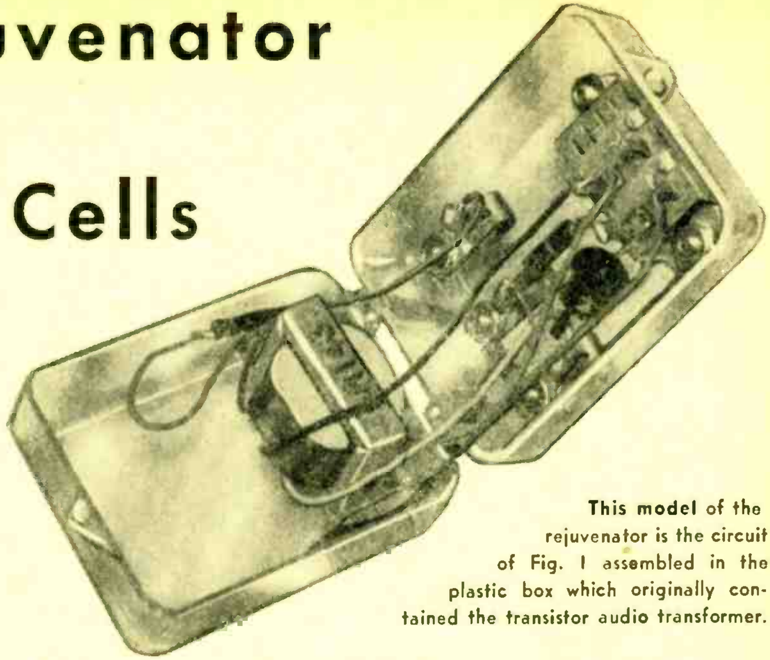
Adapter Connects "Tiny Plug" to Standard Phone Jack

You can make a simple adapter that will connect a "tiny plug" (Lafayette MS-283) to a standard phono jack in a jiffy. Just obtain a metal can at least 1" in diameter having a friction lid (such as a bouillon cube can), and saw it off to a length of ¾". Drill or punch a ⅝" hole in the bottom center of the can. Then twist an Amphenol 75-MC1P phone plug into this hole and solder the plug to the bottom of the can.

Drill four small holes for a "tiny jack" (Lafayette MS-284) in the lid of the can; the two outside mounting holes are 1/16" in diameter, but the two center holes should be about 3/32" in diameter to prevent shorting of the plug's prongs. Mount the "tiny jack" to the inside of the lid. Now solder a short flexible insulated lead from the center electrode of the phone plug to one lug on the "tiny jack," and solder another lead from the rim of the plug to the remaining lug on the jack.



Rejuvenator For Dry Cells



This model of the rejuvenator is the circuit of Fig. 1 assembled in the plastic box which originally contained the transistor audio transformer.

by
frank h. tooker

If you use an average number of ordinary zinc-carbon dry cells in flashlights and transistorized devices around your home, you'll find that either of the convenient rejuvenator circuits described in this article will soon pay for itself.

The rejuvenator shown in the photo is the assembled circuit of Fig. 1. Appearance of the setup for Fig. 2 would be identical except for the additional rectifier and resistor. Either unit may be assembled in the handy little plastic box in which the transformer, *T1*, is purchased.

using the rejuvenator

Always make sure that the positive terminal (brass cap) of the dry cell is connected to a positive terminal of the rejuvenator. The bottom of the zinc can is the negative terminal of the dry cell. It should always be connected to the negative (center) terminal of the rejuvenator.

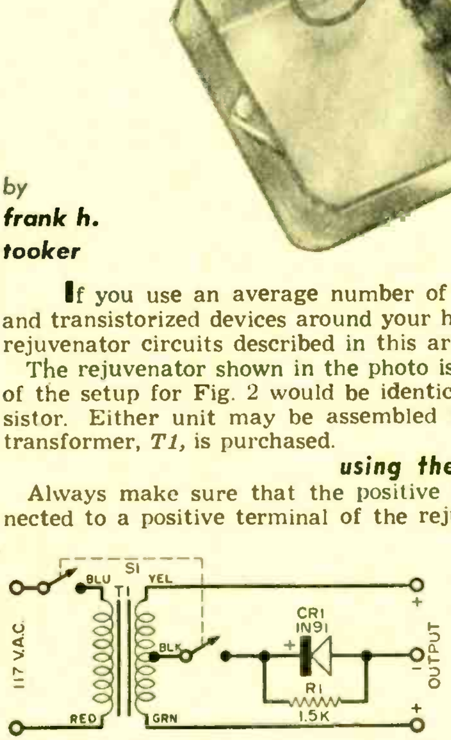


Fig. 1. Circuit for rejuvenating one dry cell.

Don't try to rejuvenate two cells simultaneously with the circuit of Fig. 1. It won't work. The two positive terminals are provided on this unit merely for convenience. If you want to charge two cells at once, use the circuit of Fig. 2.

Connect a voltmeter, at intervals, across the dry cell being rejuvenated. If the cell voltage tends to go above 1.7 volts, turn the rejuvenator off and allow the cell to rest. If the potential is 1.6 volts after several hours of rest, cell is fully rejuvenated.

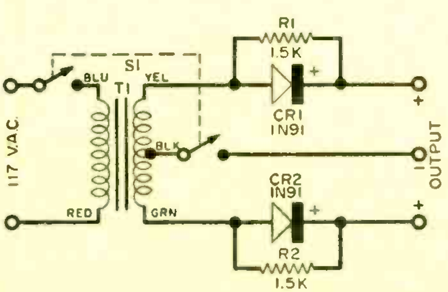


Fig. 2. Circuit for rejuvenating two dry cells of the same or different size and type simultaneously. It will also accommodate single cells.

parts list

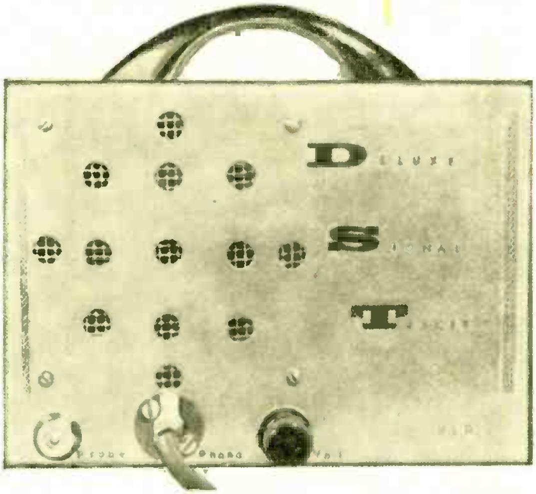
CR1, CR2*—Type 1N91 diffused junction germanium rectifier (General Electric)
R1, R2*—1500-ohm, ½-watt resistor
S1—D.p.s.t. slide switch
T1—Transistor audio transformer used as voltage step-down transformer (Argonne AR-143)
3—Miniature Fahnestock terminal clips
1—Lightweight power cord and plug
1—Plastic box
Misc. hardware, plastic cement, wire, solder, etc.
* CR2 and R2 are required only for the circuit of Fig. 2

Two Transistor Signal Tracers

battery operated transistorized tracers avoid the noise problems associated with older models. One model provides a watt of audio output. The other costing less than $5 to assemble will give you an inexpensive start in the radio servicing business.

Power Transistor Signal Tracer

by ***homer l. davidson***



With the possible exception of a volt-ohm-milliammeter, signal tracers are perhaps the most useful test instruments in the home workshop. However, a.c.-operated signal tracers have always been handicapped by their sensitivity to 60-cycle pick-up. And battery-powered models, using vacuum tubes, have the disadvantages of high-battery drain, tube fragility and low audio output.

The "de luxe" model tracer shown here incorporates four transistors and a self-contained 6-volt battery and has almost 1 watt of audio available at the output of the CBS 2N255 power transistor!

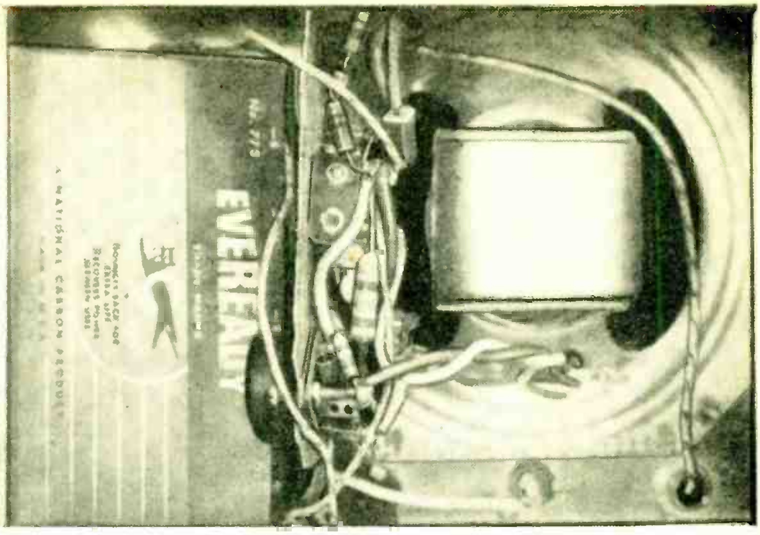
Construction is simplified by using a standard aluminum chassis as a cabinet. A small individual subchassis for parts mounting is cut from a scrap piece of aluminum and bolted directly on the speaker. The power transistor is insulated from the chassis and plugged into a 9-prong miniature socket. All other transistors and parts are soldered directly into place as the circuit is wired.

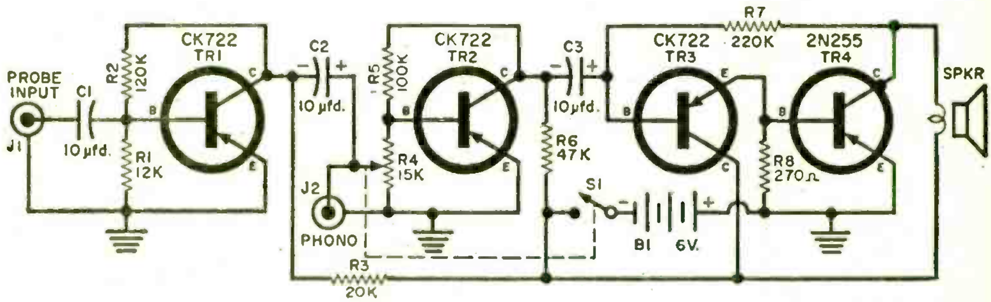
Spaghetti is placed on the collector and base leads of each transistor to prevent shorts to other components or to the chassis. Parts placement is not particularly critical, but try to keep the input components away from the output circuit.

Note that this model tracer has two separate input jacks labeled respectively "phono" and "probe." The "probe" jack (*J1*) is the input for the r.f. detector lead. This probe contains a crystal diode which demodulates the r.f. signal and allows the transistor audio amplifier to build up the signal to audible level.

When testing in audio stages where less gain is required, use the "phono" jack input. This jack (*J2*) is fed by a shielded cable terminated on one end by a standard type phono plug and on the other by an isolating capacitor. For audio applications, such as crystal phono cartridge testing or hi-fi amplifier servicing, this input is best.

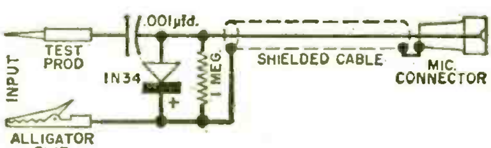
Using the tracer for trouble-shooting is simplicity itself. First turn the radio receiver





parts list

B1—6-volt midget battery (RCA VSO68)
C1, C2, C3—10-µfd., 50-volt elec. capacitor
J1—Chassis-mounting microphone connector (Amphenol 75-PC1M)
J2—Phono jack (RCA type)
R1—12,000-ohm, ½-watt carbon resistor
R2—120,000-ohm, ½-watt carbon resistor
R3—20,000-ohm, ½-watt carbon resistor
R4—15,000-ohm volume control
R5—100,000-ohm, ½-watt carbon resistor
R6—47,000-ohm, ½-watt carbon resistor
R7—220,000-ohm, ½-watt carbon resistor
R8—270-ohm, ½-watt carbon resistor
S1—S.p.s.t. switch (on R4)
TR1, TR2, TR3—CK722 transistor (Raytheon)
TR4—2N255 transistor (CBS)
Spkr.—4" PM speaker, 45-ohm voice coil (Operadio—DuKane Corp., St. Charles, Ill.)
1—7" x 5" x 3" aluminum chassis with back plate (Bud AC-429)



DETECTOR PROBE

AUDIO PROBE

These special probes should have all elements well shielded. The detector probe components can be built into a small tube shield. All capacitors should be 600 volt miniatures. Thin lapel microphone cable can be used for utmost flexibility.

how it works

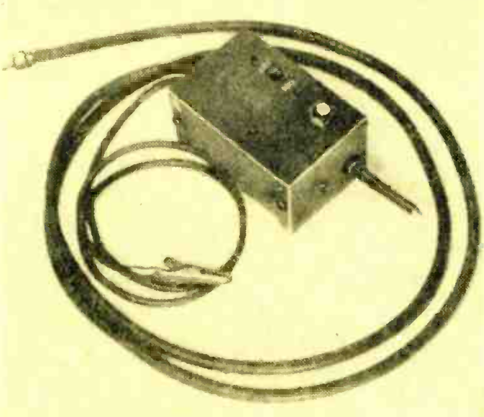
Signal tracing is a "dynamic" test in that the equipment under test is in operation and has a signal going through it. The tracer is used to follow the path of the signal from input to output. The signal in the case of a broadcast receiver is a tuned-in station or an r.f. oscillator. For amplifier tracing, you can use an audio oscillator or phono player as a signal source.

The input signal is coupled to the base of the first audio stage by a 10-µfd. capacitor (*C1*). The collector of *TR1* is coupled to the base of the second audio stage through a 15,000-ohm volume control, *R4*. A phono jack (*J2*) installed at this point enables pickup from a crystal phono pickup head.

A 270-ohm resistor (*R8*) is used as an emitter load resistor, common to both *TR3* and the output stage, *TR4*. The collector of *TR3* is tied directly to the 6-volt power supply. As the output impedance of a 2N255 transistor is approximately 48 ohms, a 45-ohm voice coil speaker provides the proper collector load.

on and tune it to a strong local station. Connect the signal tracer's ground lead to the receiver's chassis or "ground." Then turn the signal tracer on, adjusting gain control *R4* for full volume. Starting at the receiver's antenna, the probe may be touched to the "input" and "output" of each stage to check individual stage operation. If the program is heard at one stage but not at another, check the circuit between. Defective radios, hi-fi amplifiers, p.a. systems, TV receivers and intercom circuits should present no problems for this little transistorized signal tracer.

Bargain Basement Signal Tracer



by **r. l. winklepleck**

Signal tracers are useful in troubleshooting radio receivers since they permit checking a circuit under operating conditions and use the received signal itself as the common denominator. They quickly and easily check for the presence, strength and distortion of the signal at various points in the circuit. Here is a junior-grade signal tracer which performs on a par with the best, yet is so cheap and so simple to construct that anyone who ever probes the innards of an ailing radio will really treasure it.

Actually, the gadget isn't a complete signal tracer: it's just the front end. It's a very compact detector/preamplifier. Plug it into the phono jack of a working radio or a small amplifier, and you'll have an r.f. or a.f. tracer which will pick up the signal from the antenna of the set under test and follow it through to the speaker voice coil.

This unit won't tell you the amount of gain in each section with a meter or magic-eye tube. You must operate strictly by ear. But a five-dollar bill will buy all the parts if you shop around a little, and the junk box probably will provide enough parts to leave some change for another project.

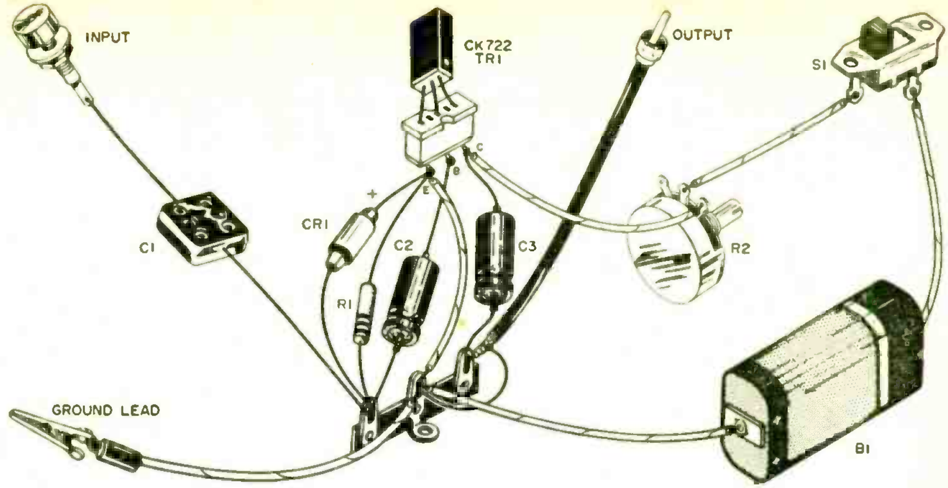
construction

The tracer consists of a crystal detector using a 1N34A diode. The detector feeds into a single-stage, grounded-emitter transistor preamplifier using a CK722. A potentiometer (*R2*) between the battery and the collector is adjusted once for maximum gain with minimum distortion, and then touched up only occasionally as the battery ages. All this is fitted into one of those small aluminum boxes and connects, via a length of microphone cable, to the phono jack of a convenient radio receiver.

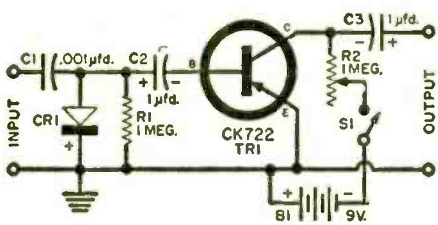
Most of the components are hung on a 3-point tie strip with the center point grounded. These are all soldered in place before being installed in the box. The input connection is an insulated banana jack, so it's easy to substitute an alligator clip for the simple probe—both of which are soldered to banana plugs—when you want to clip the tracer to the section being examined.

A strip of aluminum or tin can stock holds the battery in place. And the transistor can be soldered directly into the circuit, thus eliminating the socket. Remember not to overheat the diode and transistor while soldering.

The tracing technique is very fast and simple. Tune the set under test to a strong local station or feed a modulated signal into the set from an r.f. signal generator.



Hook up the "bargain basement" signal tracer's components as shown in the pictorial diagram above; schematic and complete parts list for this simple test unit are given below and at right.



B1—9-volt mercury transistor battery (Mallory TR-146R)
C1—0.001-µfd. mica capacitor
C2, C3—1.0-µfd. miniature electrolytic capacitor
CR1—1N34A crystal diode
R1—1-megohm, 1/2-watt resistor
R2—1-megohm linear potentiometer with stub shaft
S1—S.p.s.t. slide switch
TR1—CK722 transistor
1—1 5/8" x 3 1/4" x 2 1/8" aluminum case
1—Three-point tie strip
1—Insulated banana jack
2—Banana plugs
1—4' length of microphone cable
1—1' length of limp test lead wire (for ground lead)
1—Phono plug
2—Alligator clips

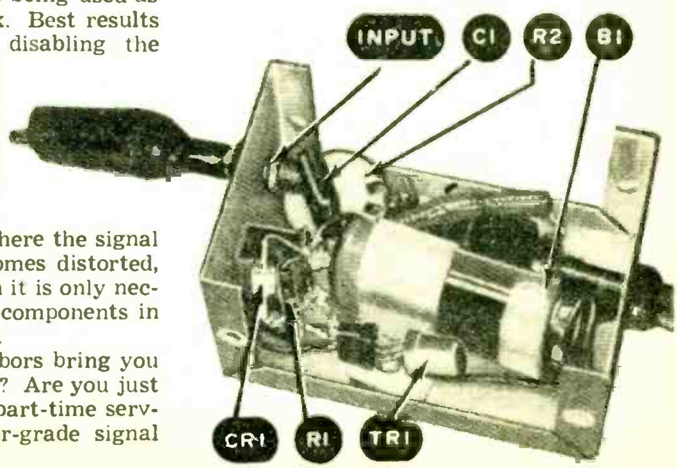
Plug the tracer into the phono input of a working radio and turn the volume clear up. Then clip the ground lead of the tracer to the chassis of the test set.

Starting with the antenna, pick up the signal at the input and output of each stage. This is easily done at the input grid and the plate of each tube. As you progress through the set and signal strength increases, the gain of the radio being used as an amplifier can be cut back. Best results may be obtained through disabling the a.v.c. of the set being tested by grounding the black lead from the first i.f. coil; this isn't strictly necessary but it will give you a better idea of the gain contributed by each stage.

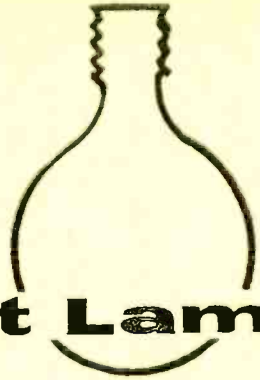
When a stage is reached where the signal disappears, weakens, or becomes distorted, the trouble is localized. Then it is only necessary to check out the few components in this stage to find the trouble.

Do your friends and neighbors bring you their old radios for you to fix? Are you just getting started with a little part-time service work? If so, this junior-grade signal tracer is for you.

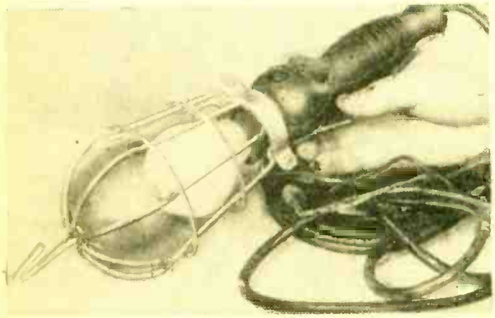
Interior view of tracer. All components—except B1, C3, R2 and S1—are attached to three-point tie strip before being installed in box. An insulated alligator clip is used in input jack.



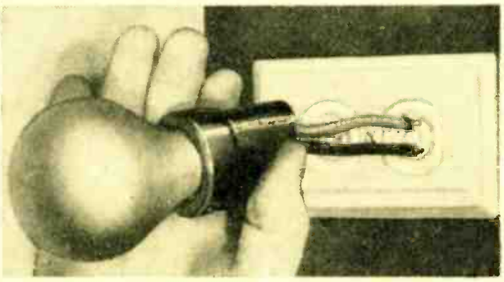
Test lamps come in a variety of sizes and shapes. Included in the photos below are manufactured neon lamps, drop lights, and homemade test lamps and sockets. Any of these can be used to check fuses and mysterious a.c. grounds.



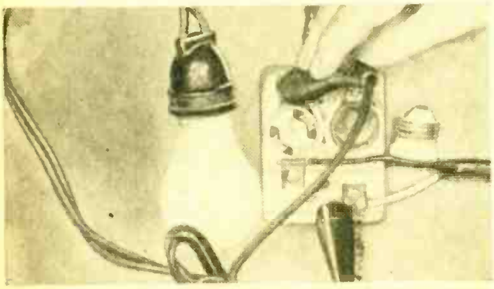
Using a Test Lamp

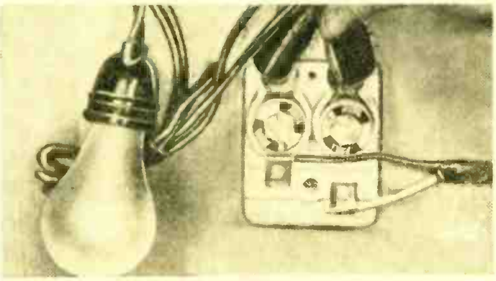


Drop lights with extension cords should be well insulated with a shade and heavy wire screen protecting the bulb (left). Some of these drop lamps will have a built-in switch, a handy item if the light is to be used regularly.

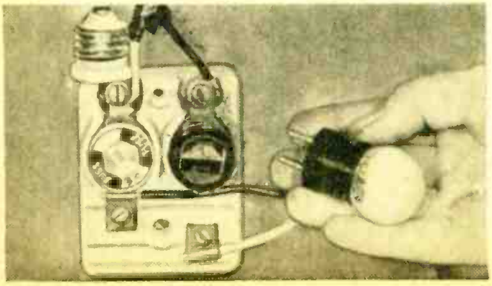


You can buy a general-purpose "test lamp" in most electrical appliance stores for a few cents. It consists of a socket and short lengths of heavy wire leads which are bared. Using a low-wattage bulb, check a.c. availability by sticking the leads into an a.c. outlet (above, right). The author extended his socket leads with sealed-in lengths of wire (below, right). The rubber-covered alligator clips shown provide a safe method of contacting hot a.c. lines. A two-fuse line is being checked out here.





Occasionally it is difficult to see whether a fuse has blown. To "cross-check" fuses, remove one and tap the test lamp from the input to appliance side of fuse (above, left). If the light glows, the fuse removed is burnt out.



A low-amperage ground often eats up current without notice. To check for such a ground, turn off all electrical gadgets in the house, and insert the connector plus bulb (left). If bulb glows, the ground indicated should be located quickly to prevent a fire hazard.

Make Your Own "Economy" Multitester

by *richard graham*

Usually the first piece of test equipment to be acquired by the electronic experimenter is a multitester or VOM. Once in a while, though, this acquisition is delayed while the necessary capital accumulates. The multitester described here isn't intended to replace any of the VOM's or VTVM's available in finished or kit form, but it will enable you to have the fun of electronic experimenting while you're waiting for the "real thing." Best of all, it's guaranteed not to deflate any but the most meager of pocketbooks.

The neon tester will measure a.c. voltages between 40 and 200 volts, d.c. voltages between 60 and 300 volts, and resistances between 10,000 and 250,000 ohms.

construction

Only a minimum amount of time is necessary to construct the tester. As a matter of fact, to duplicate the unit described requires only the drilling of seven holes. The tester was housed in a 3" x 4" x 5" metal utility box. As there are no critical components or wiring in the unit, successful operation is practically guaranteed after construction and calibration.

Power transformer *T1* is wired to the panel but mounted inside the box. Since the transformer leads aren't quite long enough to mount the transformer and then wire it, first wire the unit, including the transformer, and then mount the transformer inside the bottom of the box. The neon bulb (*NE1*) is mounted by forcing it into a rubber grommet on the panel of the instrument. Be sure to mount the grommet on the panel first, then gently slide the bulb into it. Also, don't forget to use insulated tip-jacks through the metal panel of the instrument. If you make your own box out of Masonite or plywood, however, this won't be necessary.

The filament winding on the power transformer is not used. Taping up these leads is a better practice than simply cutting them off, for you may eventually want to use the transformer for another purpose.

calibration

The voltage calibration of the neon tester is best accomplished by direct comparison with another multimeter. Meters of this type are about in such great profusion that you should have little difficulty in borrowing one temporarily. If a friend with a VOM is not immediately available, you might try the local radio/TV service shop. Most of these people are pretty friendly and helpful about things like this. The calibration can be done "on the spot" in just a few minutes if the procedure and necessary test setup are prepared beforehand.

Before beginning the actual calibration, prepare a finished blank scale. It should consist of three concentric circular scales without calibration marks. For best results and greater durability, use India ink in preparing the scale and later in making the calibration marks and figures. The scale can be made on a white file card.

Put the blank scale in place on the front panel of the tester. Since you'll want to remove it later on for the finishing touches, fasten it in place with two small tabs of Scotch tape.

Voltage calibration can be effected with the setup shown in the diagram below. The transformer, which can be any common receiver-type power transformer, supplies the voltage necessary to calibrate the upper end of the scale. With the 500K pot adjusted so the "standard meter" reads 40 volts, adjust the neon tester control (*R1*) until the neon just ignites and begins to glow. The voltage at this point (as read on the "standard meter") should be marked on the blank scale in pencil. The pencil mark will be inked over later.

Adjust the 500K pot to 45 volts, and the neon tester control until the neon just glows. Then mark this new point on the scale. Continue until the scale is completely calibrated with as many points as desired. This one procedure calibrates both the a.c. voltage scale and the d.c. voltage scale.

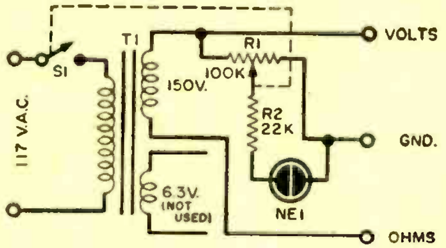
Ohms calibration is best accomplished by digging around in the junk box and finding as many different resistor values as possible between 10,000 and 250,000 ohms. If you are missing any essential values, they can be made up by series or parallel combinations of available resistors.

To calibrate the ohms scale, simply place the known resistance between the common and ohms lead of the neon tester and adjust *R1* until *NE1* just begins to glow. Mark this point on the scale with the resistance value of the resistor. Continue the procedure until sufficient resistance points have been obtained.

Remove the pencil-calibrated scale from the neon tester. Now, simply multiply the a.c. scale by 1.41, and you can mark in the d.c. voltage calibration. For example, the a.c. voltage calibration of 100 volts would correspond to the d.c. calibration point of 141 volts. The reason for this becomes apparent when we realize that an r.m.s. a.c. voltage of 100 volts, as read on any meter, has a peak value of 141 volts. Since the neon lamp in the tester responds to the peak voltage applied, a d.c. voltage (which of course has a peak voltage corresponding to its average value) will read 1.41 times the a.c. voltage.

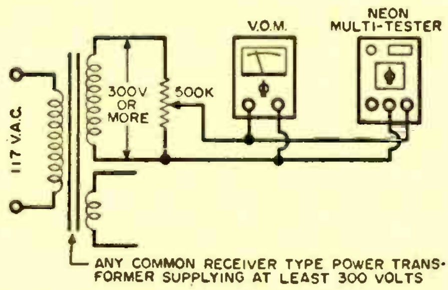
Then go over the pencil-calibrated scale with the more permanent India ink. The surface of the scale can be coated with polystyrene Q dope to give it a hard glossy finish. If the lettering is carefully done, the results will look quite professional.

The neon tester is now ready for operation. When you use it, adjust *R1* to the point where the neon lamp lights up.



NE1—NE-51 neon lamp
R1—100,000-ohm potentiometer
R2—22,000-ohm, 1/2-watt resistor
S1—S.p.s.t. switch (on R1)
T1—Power transformer, primary 117 volts; secondary 150 volts, 25 ma. (Stancor P8181 or equivalent)
1—3" x 4" x 5" utility box

Schematic diagram of the unit, with parts list.



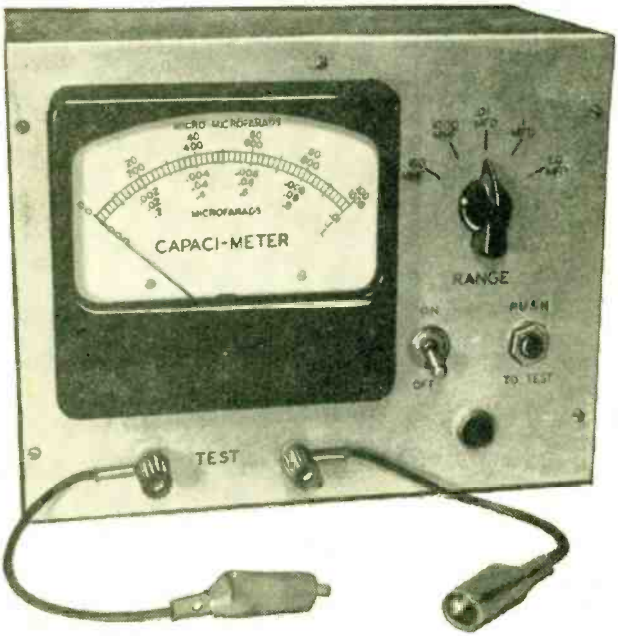
Voltage calibrating setup for the multitester.

how it works

This tester utilizes the firing voltage of a NE-51 neon lamp to measure both voltage and resistance. When the tester is used to measure voltage, the unknown voltage is applied across calibrated potentiometer *R1*. This resistance is adjusted to divide the unknown voltage and apply some of it to the neon lamp (*NE1*). For the NE-51 model, this is approximately 60 volts. Thus, the setting of *R1* at which the neon just fires will then denote the value of the voltage being measured.

When the tester is used to measure resistance, the transformer secondary voltage is effectively placed in series with the external unknown resistance and calibrated potentiometer *R1*. Now the voltage is divided between the unknown resistor and *R1*. Voltage across *R1* is actually a measure of the unknown external resistor. The higher the external resistance, the less voltage drop appears across *R1*. Conversely, the lower the external resistance, the higher will be the voltage drop across *R1*. This voltage drop is measured by the same action just described for the voltmeter. However, in this case, the voltage being measured is calibrated in terms of resistance.

"Capaci-Meter" Salvages Unmarked Capacitors



by r. l. winklepleck

Stop wondering whether or not those capacitors are good or bad

Probably every reader of ELECTRONIC EXPERIMENTER'S HANDBOOK who builds his own projects has a VOM. It's of the first test instruments an electronics fan buys, and it is used constantly. How else can one determine voltages, tell if a resistor is open, discover the value of an unmarked resistor or know whether a marked one has changed in value?

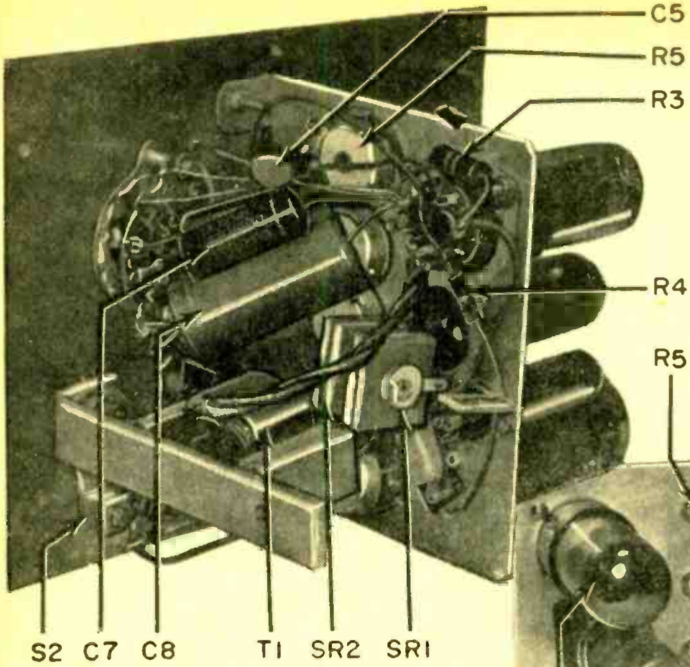
Every day similar questions arise concerning capacitors, but only a few experimenters have the necessary test instrument to supply the answers. The pile of resistors in the junk box represents a definite use potential; the small capacitors, so often unmarked, continue to accumulate and are seldom used. Worse yet, small radio servicing jobs take forever when a bad capacitor is found only by replacement.

This easily built "Capaci-Meter" will accurately read values as small as 5$\mu\mu$fd. It can be used to measure the values of small trimmers, the interelectrode capacitance of vacuum tubes, and the lengths of rolls of shielded cable. Its real worth, however, lies in checking out the values of capacitors in ailing radios and TV sets, and putting on the "ready shelf" the unknowns from the junk box. You'll use it almost as frequently as your ohmmeter.

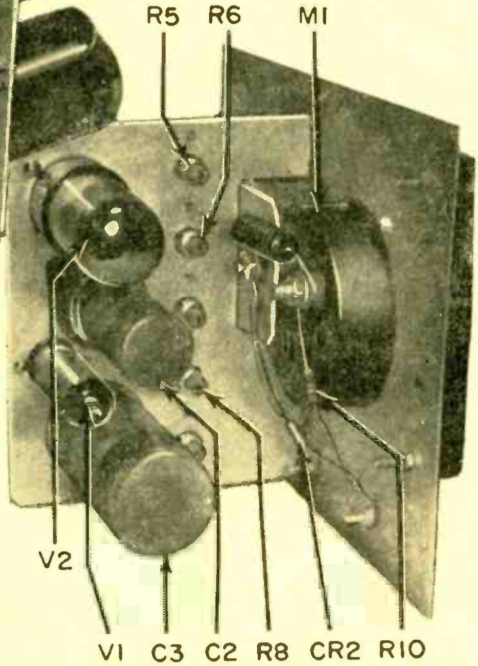
construction hints

The photographs show a suggested layout of components, but modification—when using other parts either to reduce the size or change the shape of the Capaci-Meter—can be made without altering its accuracy. Changes can be made in the power supply to utilize components from the junk box in the best way possible; remember, however, that a regulated 150 volts at 60 to 70 ma. is needed. The cost of the meter can be reduced by selecting one of smaller size, or one may occasionally be found in war surplus sales.

Components can be arranged quite compactly to permit short, direct wiring. Insulating the chassis from the panel, as is done here with insulating shoulder washers,



Suggested layout of the "Capaci-Meter" components is shown below and at left. Physical modifications may be made without altering its accuracy.



eliminates any danger of shock in using this particular type of power supply. It should be noted that the test posts are "hot" when a reading is being taken.

Be sure and grasp the crystal diode leads with a pair of pliers when soldering to prevent heat damage to the sensitive crystal. Check the wiring very carefully before turning the instrument on to avoid any possibilities of mistakes which might damage the meter. If all seems correct, turn the five potentiometers to the position which places maximum resistance in the circuit. Plug in the unit and turn it on.

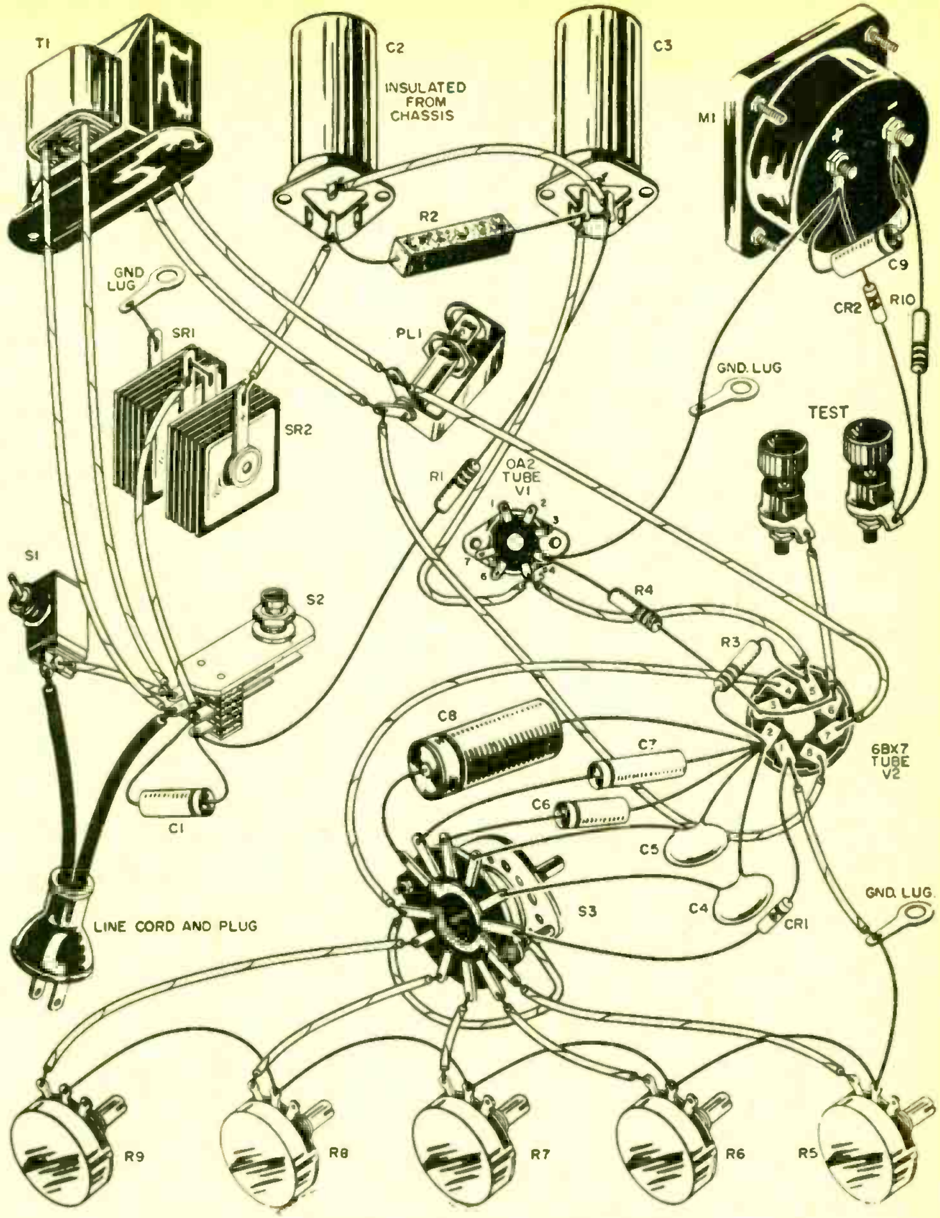
Allow it to warm up for a few minutes. Then, with nothing connected to the test posts, depress the test switch; the regulator tube should glow on every range switch position. If it fails to glow on one or more positions, the line voltage is probably low and the 2500-ohm, 10-watt resistor (*R2*) should be replaced with one of 1500 ohms.

calibrating the unit

Calibration is accomplished with the aid of five accurate capacitors, one for the maximum reading on each range. As the Capaci-Meter can be no more accurate than the calibrating capacitors, it is advisable to use only those with the best possible tolerance. Capacitors which are accurate to $\pm 1\%$ in values of 100 $\mu\mu$fd., 1000$\mu\mu$fd., and 0.01 μfd. are available at quite reasonable prices. However, the two larger capacitors (0.1 μfd. and 1.0 μfd.) are both hard to find and very expensive when very close tolerance is desired. Usually it is sufficient to consider the purchase of only the three smaller precision capacitors.

First attach the 100-$\mu\mu$fd. standard capacitor to the test posts and turn the range switch to the position which places *C4* and *R9* in the circuit. Press the *Read* switch and adjust *R9* until the meter needle is deflected to full scale. Make this adjustment going toward full deflection rather than returning from beyond full scale. Follow this same procedure with each of the other standards (1000 $\mu\mu$fd. and 0.01 μfd.) for the respective range positions, and the calibration is complete.

After calibrating the 0-0.01 μfd. range, a search of your junk box should turn up at least five 0.01-μfd. capacitors whose values can be individually measured. Connect these capacitors in parallel to the test posts, and calibrate the meter on the 0-0.1 μfd. range at a value representing the sum of the five



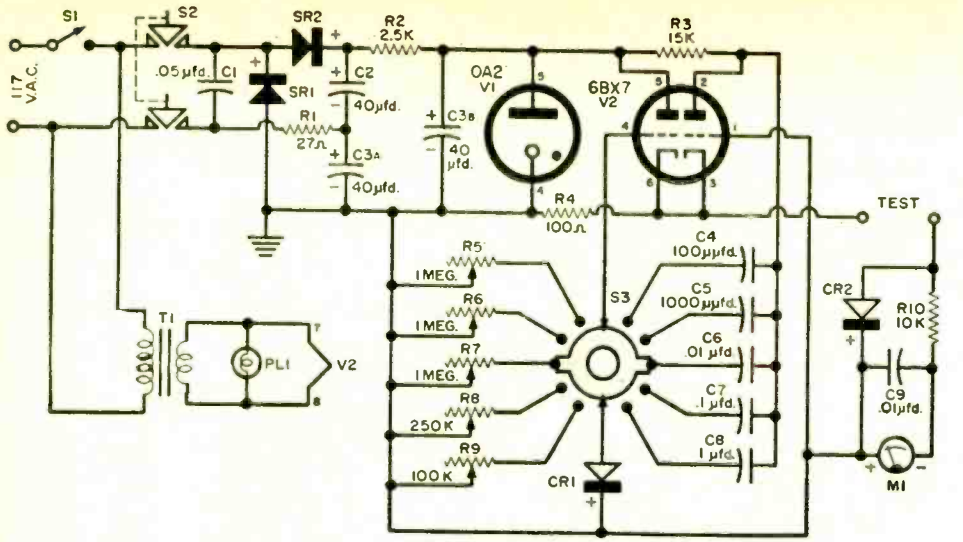
Pictorial of the "Capaci-Meter." Schematic and parts list are on page 52.

capacitors. Follow this same procedure with a group of 0.1-μfd. capacitors to calibrate the 0-1 μfd. range.

During calibration, the capacitors should be fastened directly to the test posts. Two short test leads connected to the test posts and terminating in alligator clips will be very convenient for rapidly attaching and detaching capacitors after calibration has been completed. Such leads contribute a slight capacitance and may have significance on the lowest scale. This value can be determined by taking a reading before connecting a capacitor, and the amount then subtracted from the final reading.

testing capacitors

Attach the capacitor to be tested and start with the high range. If the needle goes off scale, the capacitor is larger than the meter can measure—or it is shorted. If the needle is only slightly deflected, drop down to a smaller capacity range until a point is reached which gives a significant needle deflection.



Schematic and parts list for the "Capaci-Meter".

C1—0.05-µfd., 200-volt tubular capacitor
C2—40-µfd., 350-volt electrolytic capacitor
C3a/C3b—40-40 µfd., 350-volt electrolytic capacitor
C4—100-µµfd. mica capacitor
C5—1000-µµfd. mica capacitor
C6, C9—0.01-µfd. tubular capacitor
C7—0.1-µfd. tubular capacitor
C8—1.0-µfd. tubular capacitor
CR1, CR2—1N34 crystal diode
M1—0-50 microampere meter
PL1—Pilot light assembly
R1—27-ohm resistor
R2—2500-ohm, 10-watt resistor
R3—15,000-ohm, 2-watt resistor
R4—100-ohm resistor
R5, R6, R7—1-megohm linear potentiometer
R8—250,000-ohm linear potentiometer
R9—100,000-ohm linear potentiometer
R10—10,000-ohm resistor
S1—S.p.s.t. toggle switch
S2—D.p.s.t. push-button switch
S3—2-pole, 5-position wafer switch
SR1, SR2—100-ma. selenium rectifier
T1—6.3-volt, 1.2-ampere transformer
V1—0A2 tube
V2—6BX7 tube

how it works

The conventional bridge method of measurement (not used here) is accurate but inconvenient, and requires a signal generator for best results. The impedance method of measuring capacitance is a suitable alternative. Basically, an a.c. voltmeter or ammeter, in series with a resistor, is connected in series with the capacitor to be measured and then connected across a source of alternating current. The reading of the meter will be inversely proportional to the capacitor's impedance which, for non-electrolytics, we'll call its reactance at the measured frequency.

In other words, advantage is taken of the fact that the flow of current through a capacitor connected to an alternating voltage source is directly proportional to its capacitance. By calibrating the meter with a standard capacitor, the capacitance of the unknown can be read directly from the meter. This method cannot be used for capacitors with an appreciable resistance component or leakage, such as electrolytics.

The design of the Capaci-Meter utilizes a multivibrator circuit as a square-wave signal generator. In such a circuit, two triodes are connected as a two-stage, resistance-coupled amplifier with the plate of one section controlling the grid potential of the other. The fundamental frequency of the multivibrator is determined by the time constant of the grid resistor and capacitor. Provision is made for switching five different capacitor-resistor combinations into the circuit to produce five different fundamentals.

By bridging the 100-ohm resistor (*R4*), a portion of the square wave is diverted through the capacitor to be measured and the meter circuit. However, five capacitance ranges are possible since five fundamental frequencies are individually generated and impressed on the capacitor to be measured—and since as much current at high frequency will flow through a small capacitor as through a much larger capacitor when the frequency is lower.

Each of the five resistor-capacitor combinations is designed to produce full-scale meter deflection through each of five capacitor standards. Each resistor is variable to permit the slight adjustment necessary to deflect the meter exactly to full scale. The 0-1 µfd. range requires a frequency of only about 8 cps, so the meter needle vibrates somewhat; the midpoint of the needle swing, however, provides a reasonably accurate reading. The other ranges require frequencies progressively higher to approximately 80 kc., and on these ranges the needle is quite stable.

Buzzer-Type Power Supply

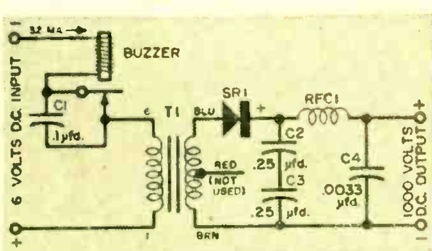
maintain high voltage for your geiger counter at low cost

This 1000-volt power supply will deliver 60 to 70 microamperes d.c. It is a vibrator-type supply using a high-frequency buzzer as the vibrator and an output transformer connected backward to give a high step-up ratio. Cost of parts is $13.00.

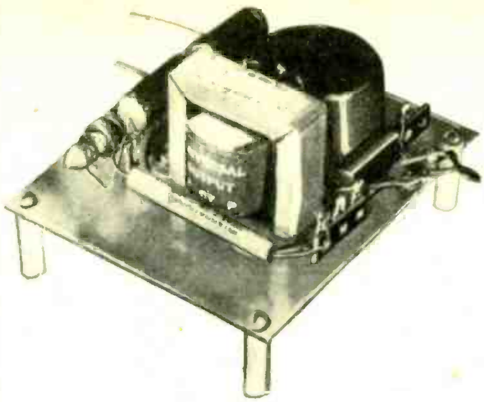
The unit is driven by a 6-volt battery comprised of four jumbo-size flashlight cells connected in series. Battery drain is 32 ma. You can expect the following operating life range if you use Eveready No. 950 Size D cells: 150 hours at 2 hours per day, 90 hours at 8 hours a day, and 60 hours at 24 hours a day.

There are no hard-and-fast rules for building this power unit, except to keep the entire circuit well insulated. The author mounted his on a 1/16"-thick polystyrene panel 5" long and 4" wide.

Adjust the buzzer for the highest-pitched



C1—0.1-μfd., 600-volt metalized paper capacitor
C2, C3—0.25-μfd., 600-volt metalized paper capacitor
C4—0.0033-μfd., 1000-volt mica capacitor
RFC1—2½-mh. r.f. choke (National R-100)
SR1—High-voltage, cartridge-type selenium rectifier (International Rectifier U50HP)
T1—Universal output transformer (Stancor A-3823)
BUZZER—High-frequency buzzer (Johnson Type 114-400)



Small enough to be mounted in the same case with a Geiger counter, the power supply weighs one pound.

sound so that you will obtain the highest possible output voltage. Further adjustment may be necessary after you wire the buzzer into the circuit.

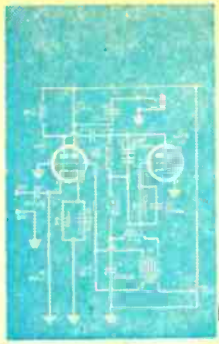
When the wiring is completed, connect the 6-volt battery to the input terminals through a s.p.s.t. switch. Connect a VTVM (switched to its 1000-volt range) to the output terminals. Now close the switch and note the voltmeter reading. Adjust the buzzer, if necessary, then tighten firmly each of the two lock nuts on the adjustment screws and replace the cover.

Danger, High Voltage! A word of caution is in order regarding the handling of the unit. Remember that a 1000-volt supply is not a plaything. This one can give a nasty sting. Guard against coming into contact with the exposed portions of the circuit. —*Rufus P. Turner*

how it works

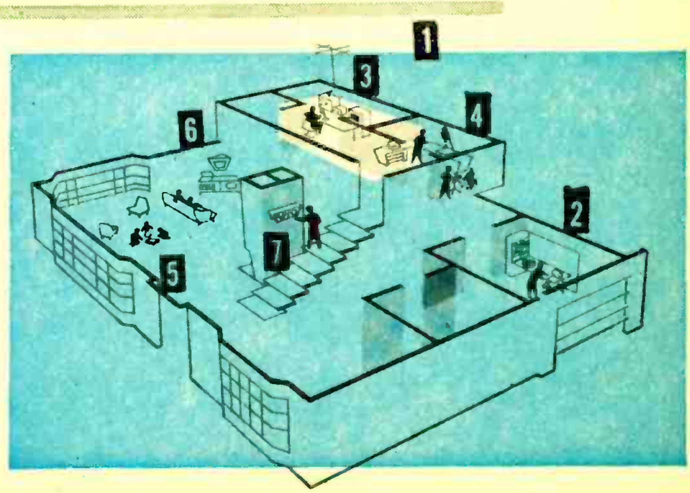
The operating principle is fairly simple. Transformer *T1* is connected so that its normal low-turns secondary output winding is used as the primary. The entire center-tapped normal primary winding serves as the secondary. The buzzer, connected in series with the transformer primary and the battery, chops up the battery current flowing through the primary. This interrupted current sets up a high a.c. voltage across the secondary, which is converted to d.c. by the high-voltage selenium rectifier, *SR1*.

Capacitor *C1*, connected directly across the buzzer contacts, eliminates hash which, if it were not removed, would set up electrical noise in the counter circuit. Capacitors *C2* and *C3* provide filtering action, and stabilize the d.c. output voltage against fluctuations in the current through the buzzer. The choke, *RFC1*, and capacitor *C4* provide additional filtering to minimize the small amount of buzz remaining in the d.c. output of *C2* and *C3*.

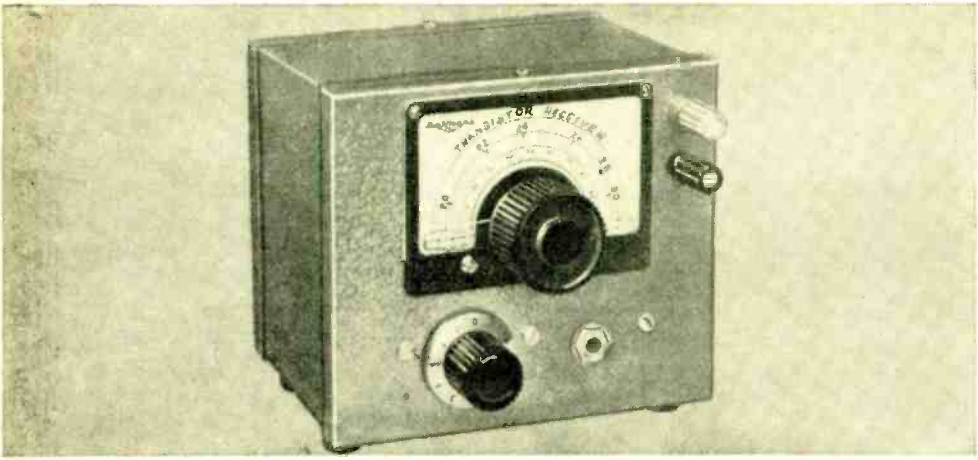


Section 3

for your ham shack



Transistorized



Short-wave "Two-Lunger"

introducing RCA's new 2N247 in a two-transistor receiver for the 10-meter band

by donald l. stoner, W6TNS

Back in the good old days of ham radio, one-tube radio receivers were affectionately referred to as "one-lungers." Although this phase in the development of amateur radio will never return as such, we are now at a similar point in time with respect to the development of transistors. So it seemed quite apropos that this high-frequency transistorized receiver be tagged a "two-lunger."

Some of you may recollect the year 1932 when the first screen grid tube—the revolutionary 24A tetrode—was announced. The tetrode transistor is just as spectacular today as the first screen grid tubes were in those bygone days.

The "two-lunger" utilizes an amazing semiconductor, the *RCA* 2N247 drift transistor. All of the 2N247's tried worked well beyond 50 mc. By replacing coil *L1* (as will be described later), it is usually possible to receive signals as high as 40 or 45 mc. However, if your 2N247 doesn't "cut the mustard" near 40 mc., don't sue the company. Anything above 30 mc. is par for the course.

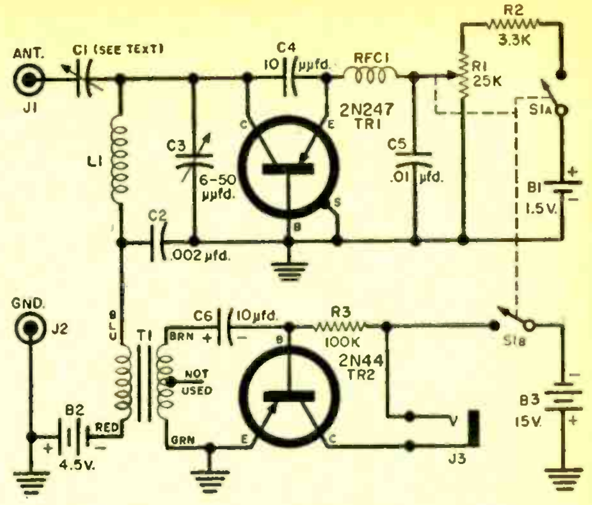
putting it together

Chassis layout is straightforward and the circuits are not critical. The chassis in the model was constructed from a sheet of 6" x 5⅞" 18-gauge aluminum. This size is neatly accommodated by an LMB box, UC-972. The midget 15-volt battery (*B3*) located on top of the chassis supplies power to the 2N44 audio amplifier stage.

Components are arranged so that there is only one terminal strip, located between the 2N247 and the battery holders. The primary and secondary leads of transformer T1, the disc capacitors *C2* and *C5*, and one end of *L1*, *RFC1* and *C6* are all secured to this terminal strip. Note from the bottom view of the receiver that *T1* is held in place with an aluminum bracket and a single screw.

parts list

B1—1½-volt penlite cell
B2—4½-volt battery, three penlite cells
B3—15-volt hearing-aid battery (Eveready 411)
C1—1-5 μμfd. adjustable "gimmick" capacitor (see text)
C2—0.002-μfd. disc ceramic capacitor
C3—6-50 μμfd. variable capacitor (Johnson 50R12)
C4—10-μμfd. mica or disc capacitor
C5—0.01-μfd. disc ceramic capacitor
C6—10-μfd., 25-volt electrolytic capacitor
J1, J2—Binding posts (Johnson 111-102 red and 111-103 black)
J3—Open-circuit headphone jack
L1—14 turns #20 wire wound on ½" form, spaced the diameter of the wire (14 turns of Air Dux #416 or B & W 3003 "Miniductor")
R1—25,000-ohm potentiometer, linear taper
R2—3300-ohm, ½-watt resistor
R3—100,000-ohm, ½-watt resistor
RFC1—Homemade choke consisting of 50 turns #34 wire scramble-wound on a 1-megohm, 1-watt resistor
S1a/S1b—D.p.s.t. switch (part of R1)
T1—Transistor interstage transformer, 20,000 ohm to 1200 ohm (Triad TZ-15 or equivalent)
TR1—2N247 drift transistor (RCA)
TR2—2N44 transistor (General Electric)
1—Case (LMB #UC-972)
1—Vernier dial (National MCN)
1—Knob (National HRS-3)
1—3-pin transistor socket
1—4-pin transistor socket



Although the receiver is very sensitive, you'll find it simple to construct if you follow the schematic diagram above.

how it works

The "two-lunger" uses two transistors to form a complete 10-meter receiver. A single *p-n-p* RCA drift transistor, Type 2N247, functions as a tunable superregenerative detector and the common base configuration is employed. Incoming r.f. signals are applied to the collector and at the same time coupled to the emitter through internal transistor capacity and capacitor *C4*. The signal is amplified in the transistor and again appears in the collector circuit, this time highly amplified. With the 2N247 functioning in this manner, a feedback loop is created and oscillation takes place.

In addition to the oscillation at the incoming signal frequency, another oscillation occurs at approximately 17 kc. due to the time constant of C5 and *R1*. This secondary oscillation tends to pulse the high-frequency oscillations off and on at just the right instant for maximum sensitivity. This type of circuit is also known as a superregenerative oscillating detector.

Transformer *T1* is used to couple the audio and match the impedance between *TR1* and *TR2*. *TR2* is wired as a high-gain class A amplifier and uses a Type 2N44 *p-n-p* transistor. Resistor *R3* provides base bias for the transistor and, in effect, controls its operating point. The audio output is direct-coupled to the headphones and provides more than adequate volume.

One word of caution regarding earphone jack *J3*—be sure to use the insulating shoulder washers that are supplied with the jack and check to see that there are no burrs around the mounting hole that could short through to the jack frame.

In the photograph of the top of the chassis, you will see another aluminum bracket, fabricated to secure *B3*. This photo also shows the "gimmick" capacitor (*C1*) used to control antenna coupling. A 2" piece of busbar wire (stiff and tin-plated) was soldered to the left terminal of the capacitor and bent parallel to the chassis. Around this were wound approximately 13 turns of insulated wire, and the free end was soldered to the antenna binding post. The turns of wire are free to slide on the busbar, and the amount of wire in proximity with the busbar controls the degree of coupling between the antenna and the receiver.

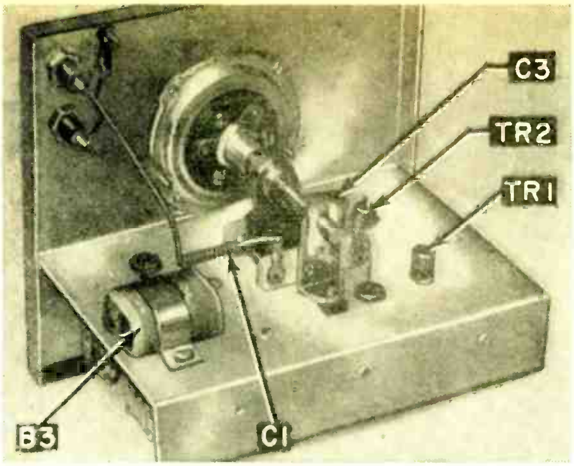
firing it up

If you follow the schematic faithfully, the receiver will probably work the first time around. However, you may be too eager to hear it perform and rush the job a wee bit. So it's a good idea to make a few checks just to protect the transistors and batteries. There's nothing like a molten mass of germanium to put a damper on one's spirits. And that's just what will happen to the transistors if you hook them up wrong.

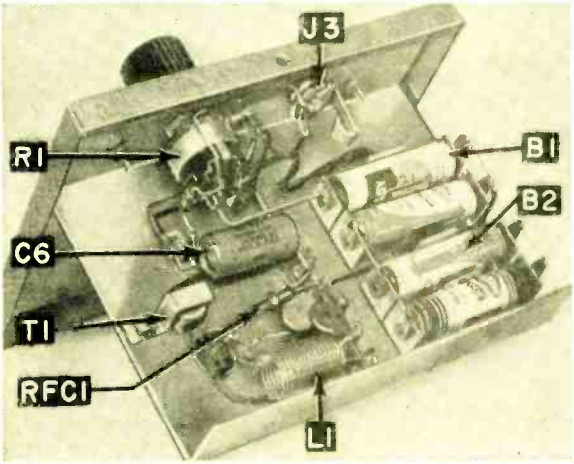
First, insert the batteries *but not the transistors*. Check with the schematic to make sure that you get the polarities correct. Once you are sure they are right, place some plus and minus marks on the chassis for future reference. With the switch *off*, measure the resistance between the chassis and the frame of *J3*. It should be extremely high. If the resistance is low, the jack is shorted.

Next, couple the negative lead of the voltmeter on coil *L1* and the positive lead on the chassis. With good batteries, the meter should read 4.5 volts. If it does not, see if the coil is shorted to the chassis, or if the transformer leads are shorted. Then place the positive lead of the voltmeter on the emitter connection of *TR1*. Turn the switch on and rotate *R1*. The meter should read a little over a volt. Now, insert the phones in the jack and again check from the frame (negative meter lead) to the chassis. With a fresh battery, the voltage should be 15 volts. Then check the voltage between the base terminal of the 2N44 socket (negative meter lead) and the chassis. It should be below 15 volts.

If the meter reads down scale during any of the above checks, it means that a battery is reversed. Assuming that all the checks are satisfactory, turn *off* the power switch and insert the transistors correctly. It is possible to pop a transistor if it is inserted when the power is turned on.



Top and bottom views of the "two-lunger." C1 is a "gimmick" capacitor which allows a wide range of frequencies to be received. Aluminum brackets hold T1 and B3 in place.



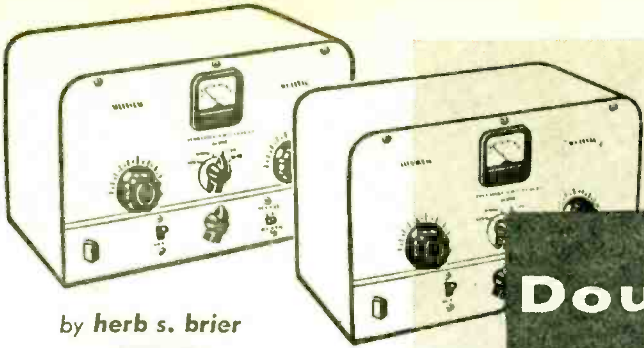
With the headphones inserted in the jack and the antenna disconnected, turn on the power switch and slowly advance the regeneration control, *R1*. You should hear a scratchy sound as the control is turned, and at about half rotation the 2N247 will start to oscillate. The oscillations are heard as a sizzling sound known as hiss. When you hear this sound you have arrived. It is time to connect an antenna.

As you tune capacitor *C3*, you will probably hear stations across the dial. Their strength can be increased by sliding more turns of wire on the busbar. If you get too much coupling between the two wires, the detector will quit oscillating, or else it will pop in and out of oscillation across the dial. If it quits as soon as the antenna is connected, you have too much coupling to start with.

making replacements

If you don't like winding your own r.f. chokes, you can purchase commercial units in the form of television peaking coils. Any choke in the vicinity of 70 microhenries will work. However, the handmade one wound on the 1-megohm resistor will be more than satisfactory, although not quite as pretty as a commercial unit.

As mentioned earlier, replacing coil *L1* with one containing less turns will usually allow you to receive signals almost up to the six-meter amateur band. The technique goes something like this. With the plates of *C3* one-quarter meshed, remove a turn at a time from coil *L1* until the detector refuses to oscillate. For use on the six-meter band, the 2N247 can be replaced with a *Philco* SB-103 which features an alpha cutoff of 90 mc. You pocketbook pinchers will be very happy to know that the 2N247 is available at your *RCA* distributor for approximately $3.29.



Double Your Heathkit AT1 Output

by **herb s. brier**
W9EGQ

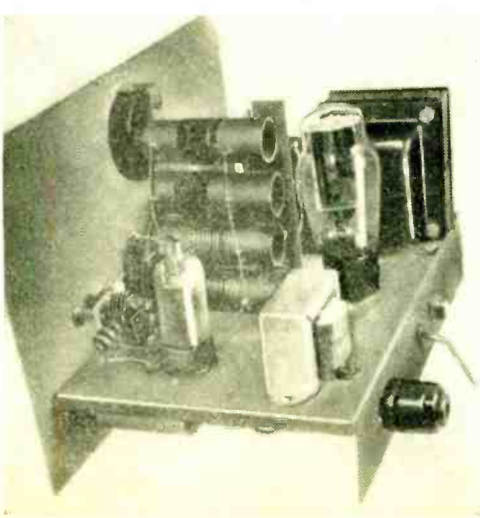
Probably the most popular low-power transmitter available to radio amateurs in recent years has been the Heathkit AT1. Thousands of them are in daily use. Covering the amateur bands from 80 to 10 meters, the AT1 uses a 6AG7 crystal oscillator to drive a 6L6-G amplifier-frequency doubler to about 30 watts input. To insure stability, the 6L6 is operated as a frequency doubler on the bands above 80 meters and power output is no more than 10 watts on the 40-, 20-, 15-, and 10-meter bands.

This article tells how to substitute a 2E26 tube for the 6L6 in the AT1 transmitter and thus double its power output on the 40-, 20-, and 15-meter bands. The entire job can easily be completed in one evening at a cost of approximately $6.00.

amplifier stage

If the Heathkit instruction manual is handy, it will help in making the following changes. Start at the output tube socket (socket *B* in *pictorial 1* in the manual). First remove the 100-$\mu\mu$fd. capacitor and the 1.1-mh. r.f. choke connected to pin 3 of the socket from the circuit. Put the capacitor and choke aside temporarily. Then transfer the 22,000-ohm resistor and the 0.001-μfd. fixed capacitor from pin 4 to pin 3 of the socket. Transfer the connections of pin 8 to pin 1 and connect pin 8 to the nearest ground lug.

Remove the leads from the 0.5-μfd. capacitor and the 100-ohm resistor from pin 6 of the socket. Solder these two leads together, but clear of the socket pins. Replace the 47,000-ohm resistor connected to pin 5 of the socket with an 18,000-ohm, 2-watt resistor. This completes the rewiring of the socket.

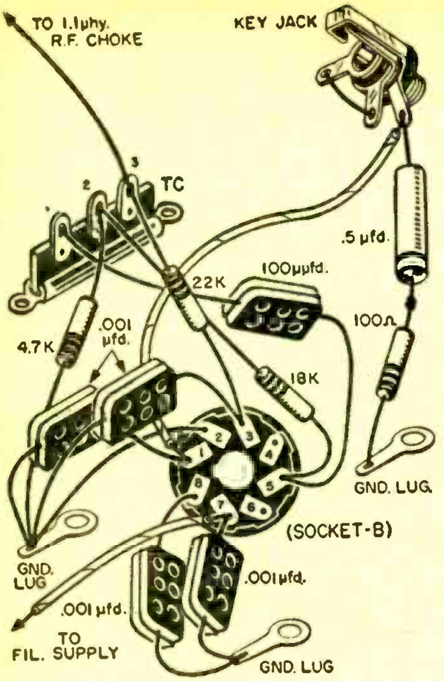


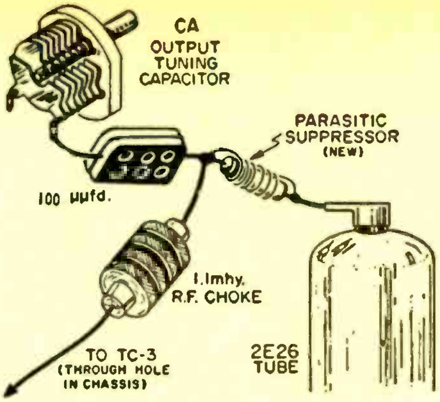
In revised circuit, 2E26 (in foreground) is substituted for 6L6-G.

Now make a "parasitic suppressor" by winding six turns of No. 16 or No. 14 wire around a pencil, spacing the turns, so that the coil is about ¾" long. Slip the winding off the pencil and insert a 100-ohm, 2-watt resistor through it. Solder the ends of the coil to the leads of the resistor close to the resistor body.

Cut one lead of the suppressor to a length of about ⅜" and solder it to one lead of the 100-$\mu\mu$fd. capacitor previously removed from the circuit. Then solder the other lead of the capacitor of the stator terminal of the *Output* tuning capacitor to which is was previously soldered (*2A* of *CA, pictorial 2* in the manual). Bend this lead so that the fixed capacitor and the parasitic suppressor are standing upright.

Temporarily insert the 2E26 into the





Fixed capacitor and r.f. choke formerly connected to pin #3 (plate) of the 6L6-G tube socket are moved above the chassis for connection to plate cap of the 2E26. Pictorial is shown at left.

1—100-$\mu\mu$fd. midget variable capacitor (Bud #1875 or equivalent)
1—18,000-ohm, 2-watt composition resistor
1—100-ohm, 2-watt composition resistor
1—2E26 tube
1—3/8"-diameter tube cap connector (National #24 or equivalent)

tube socket. Bend the wire from the parasitic suppressor towards the plate cap of the tube and solder a tube cap connector to it. Leave the lead just long enough to permit putting the connector on the tube cap without strain.

Next, connect one end of the 1.1-mh. r.f. choke to the junction of the fixed capacitor and the parasitic suppressor. Position the choke so that it extends over the ½" hole in the AT1 chassis. Take about a 4" length of stiff, well-insulated wire and run it from the other end of the choke, through the hole in the chassis, to the same terminal on the three-terminal tie strip to which the choke was previously connected (terminal *3* of *TC, pictorial 1* of the manual). Center the wire in the chassis hole to prevent the possibility of a short circuit developing at this point.

Viewed from the rear, the changes to the bandswitch now to be described are made to the terminals on the right side of the rear switch wafer. These terminals are numbered for identification: top terminal, *1*; the next one down, *2*; the third one down, *3*; and the bottom one, *4*.

Transfer the wire on switch terminal *3* to switch terminal *4*. Do not remove the wire already connected to terminal *4*. Transfer the wire on terminal *2* to terminal *3*. Then connect a wire jumper between terminals *1* and *2*, without disturbing the wire already connected to terminal *1*.

Replace the *Driver* (oscillator) tuning capacitor with a 100-$\mu\mu$fd. midget variable capacitor, mounting it on the panel by means of its shaft bushing and panel nut. Wire the new capacitor into the circuit so that its connections are the same as those of the old one.

Finally, unsolder the end of the oscillator coil winding from the top front lug on the coil form and unwind four turns. Cut off the excess wire and resolder the end of the winding to the same terminal.

Eighty-meter crystals are required for 80-meter operation of the transmitter, and may be used on 40 and 20 meters. Forty-meter crystals may also be used for 40- and 20-meter operation, and are required for 15 and 10 meters.

Maximum power output from the modified transmitter is obtained with a maximum grid current of approximately 2.0 ma. to the 2E26. On 80 and 40 meters, over 5.0 ma. of grid current can be obtained. It is controlled by detuning the *Driver* control on these bands.

The power output from the modified AT1 is approximately double its former value on the 40-, 20-, and 15-meter bands. Substituting a 6146 tube for the 2E26, without additional circuit changes, will give slightly more output (and input), but the 6146 costs somwhat more than the 2E26.

V.H.F. Explorer's Receiver

by richard graham

tune in on emergency broadcasts, FM and TV sound—and aircraft frequencies too

Exploring the many services using the v.h.f. band can provide real excitement in listening. Not only are the familiar FM and TV broadcasting services found in this region, but a host of others, such as: Police, Fire, Public Utilities, Taxi, Aircraft, Amateur, etc.

The *Explorer's Receiver* has three plug-in coils and will pick up all these services in the range of 28 to 175 megacycles. The receiver has excellent sensitivity although it uses only two tubes. This is accomplished by using a superregenerative detector. This detector circuit has long been famous for its sensitivity, as well as for some of its less desirable traits. A superregenerative detector is basically an oscillator. So it's only natural for it to cause interference. The problem is overcome in this receiver by preceding the detector with an r.f. isolation stage.

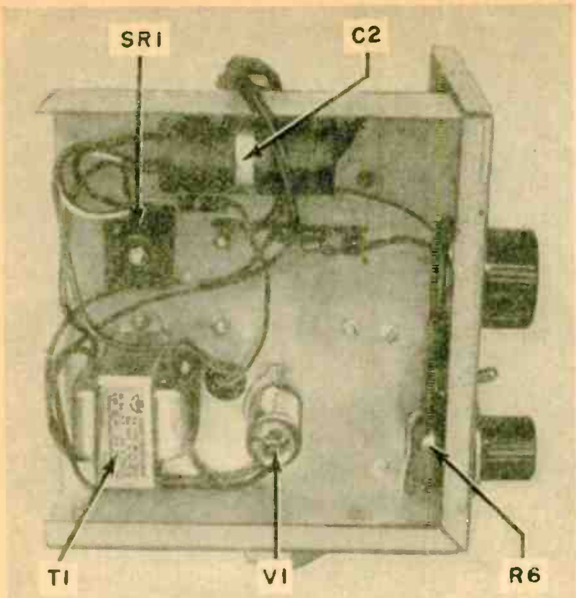
construction

This receiver requires some care in building. The lengths of leads play an important part in successful operation. For this reason it is recommended that the photographs of the receiver be carefully studied. If possible, copy the parts layout exactly.

The receiver itself is constructed in a 6" x 6" x 6" LMB box in which the chassis is mounted vertically. There is a good reason for this unorthodox approach. It permits very short leads between the antenna input and the detector. Note that the r.f. stage is mounted horizontally from one side of the chassis so the bottom of the socket will face the 6AF4 socket.

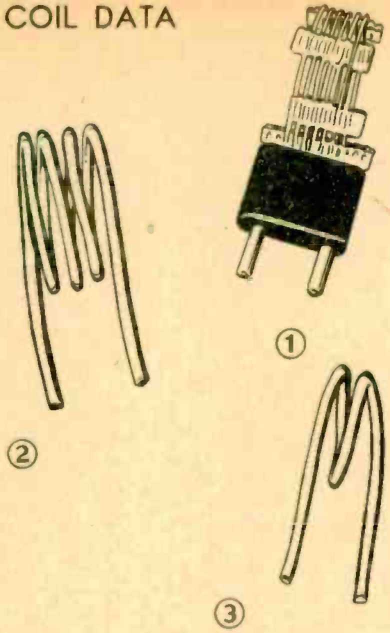
The detector tube socket is mounted on the variable capacitor *C5*, which is made specifically for this application and has brackets for mounting a tube socket. The coil socket is a ceramic (or other high quality material) crystal socket. All sockets, couplings and capacitors used in the r.f. and detector stages should be of similar high-quality material.

The *National* VHF-1-S tuning capacitor *C5* is different from the type of variable capacitor commonly used at lower frequencies. There are two stators and two rotors, but the capacitor wiring terminals are connected to the two stators while the rotors are fastened to a common shaft. Thus, two variable capacitors are effectively placed in series.



Interior view of left side of the receiver showing location of power supply components and the combination r.f. and audio amplifier tube, mounted horizontally.

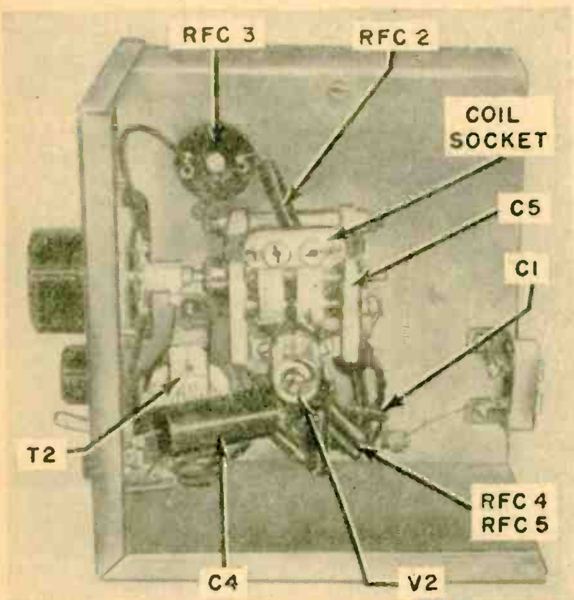
COIL DATA



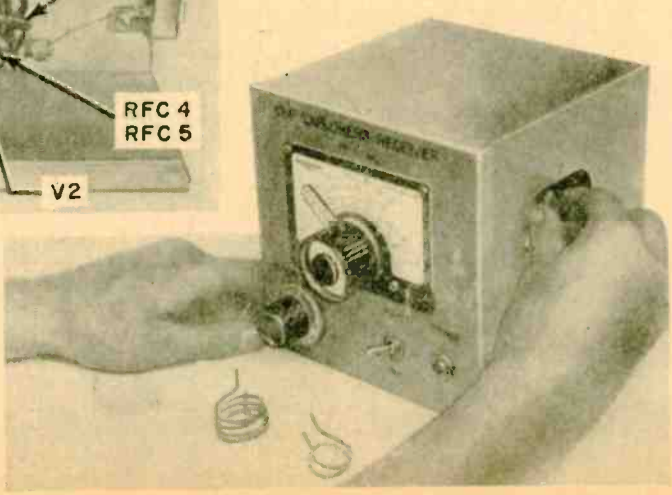
① For the 28-50 mc. band: six turns of Barker & Williamson Miniductor No. 3015 coil stock (16 turns/inch), soldered into Millen No. 37412 plug.

② For the 48 to 90 mc. band: four turns of No. 12 wire, tinned, 1/2" long, 1" in diameter.

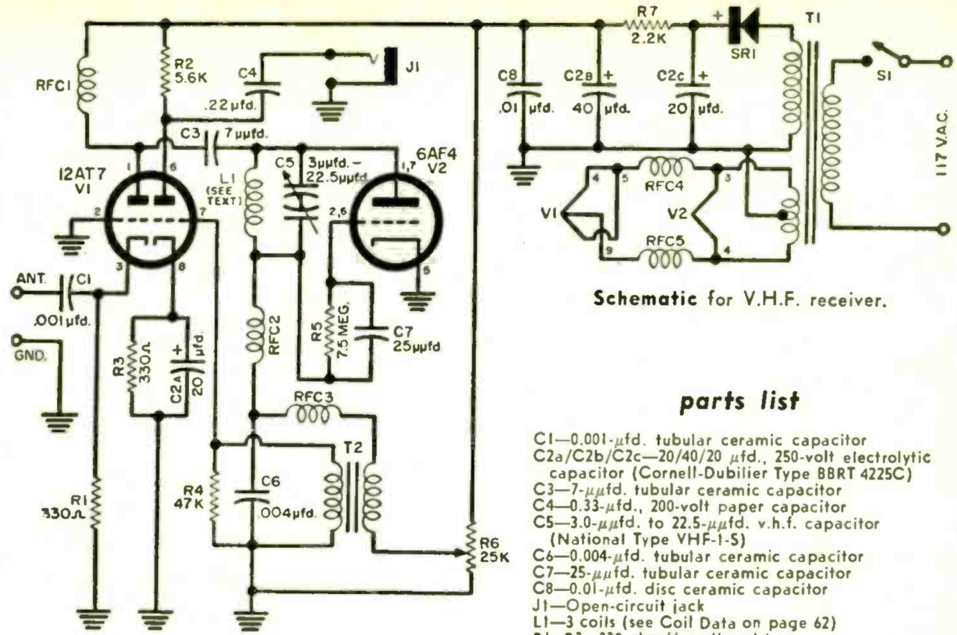
③ For the 90 to 175 mc. band: two turns of No. 12 wire, tinned, 1/2" long, 3/4" in diameter.



Right side of receiver (at left) contains oscillator tube and coil socket into which band coils are plugged. Point-to-point wiring and short leads are used.



Exterior view of the receiver (at right) shows cutout in the right side through which the various coils are inserted into the coil socket to obtain the desired frequency band. In this photo, the coil for the 28-50 mc. band has been inserted; coils for the other two bands are also shown.



Schematic for V.H.F. receiver.

The power supply section is located on the chassis opposite the r.f. wiring.

Before the unit is assembled, the cabinet will need a large hole cut through the side to comfortably allow the plugging in of the three coils. The hole in the model shown is 1¼" by 2⅜".

trying it out

After the receiver is completed, including the coils, turn on the a.c. switch and advance the regeneration control *R6* until a loud hissing sound is heard in the headphones. Now tune the receiver for a signal —always remembering to adjust the regenerative control for the proper level.

The last step is to calibrate the three bands. If you have access to a signal generator, this is no problem. It becomes more difficult, but not insurmountable, if no signal generator is available. Generally there are enough signals of known frequency, such as TV and FM stations, to enable a rough calibration.

There is no single antenna that will produce top performance over the complete range covered by the receiver. An outdoor TV antenna will perform fairly well. However, this type of antenna is directional and horizontally polarized. Most mobile services use vertically polarized antennas. The writer has found that for general listening a plain random length piece of wire does as well as anything.

For top performance, a dipole cut to the desired frequency will produce superior results. The antenna can then be hung vertically or horizontally.

parts list

C1—0.001-µfd. tubular ceramic capacitor
C2a/C2b/C2c—20/40/20 µfd., 250-volt electrolytic capacitor (Cornell-Dubilier Type BBRT 4225C)
C3—7-µµfd. tubular ceramic capacitor
C4—0.33-µfd., 200-volt paper capacitor
C5—3.0-µµfd. to 22.5-µµfd. v.h.f. capacitor (National Type VHF-1-S)
C6—0.004-µfd. tubular ceramic capacitor
C7—25-µµfd. tubular ceramic capacitor
C8—0.01-µfd. disc ceramic capacitor
J1—Open-circuit jack
L1—3 coils (see Coil Data on page 62)
R1, R3—330-ohm, ½-watt resistor
R2—5600-ohm, 1-watt resistor
R4—47,000-ohm, ½-watt resistor
R5—7.5-megohm, ½-watt resistor
R6—25,000-ohm potentiometer
R7—2200-ohm, 2-watt resistor
RFC1, RFC2—Z50 Ohmite choke
RFC3—25-mh. choke
RFC4, RFC5—Z144 Ohmite choke
S1—S.p.s.t. toggle switch
SR1—65-ma., 160-volt selenium rectifier
T1—Power transformer, sec. 150 volt, 25 ma.; 6.3 volt @ 0.5 amp. (Stancor P8181)
T2—Audio transformer, interstage 1:3 ratio (Stancor A-53)
V1—12AT7 tube
V2—6AF4 tube
1—Crystal socket (Miller No. 33102)
1—6" x 6" x 6" cabinet (LMB)

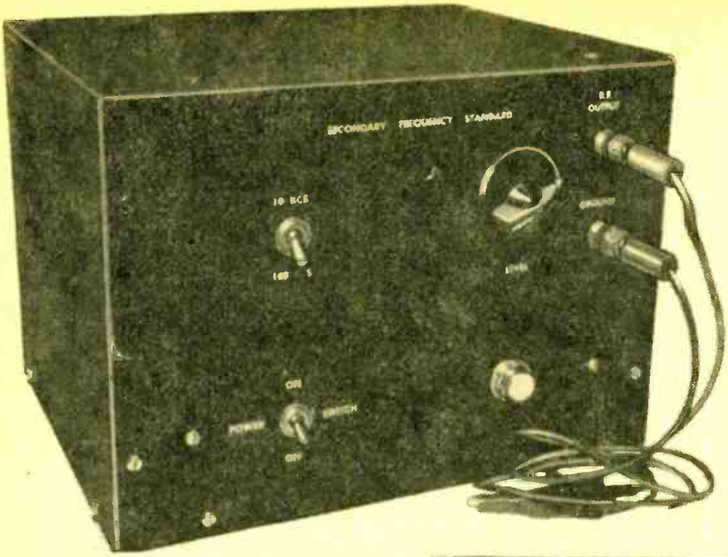
how it works

A 12AT7 double triode serves as a grounded grid r.f. stage preceding the detector. The second half of this tube serves as an audio amplifier. The detector is of the super-regenerative variety and uses a 6AF4 triode.

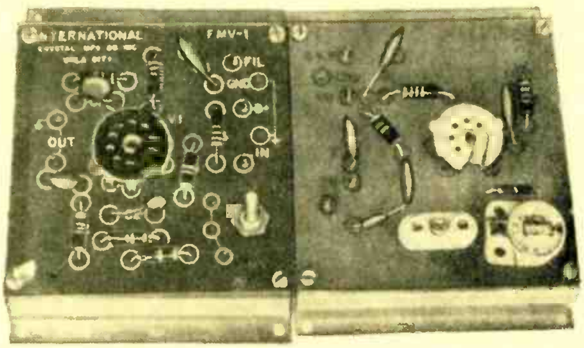
A grounded grid r.f. amplifier serves to isolate the oscillating detector from the antenna. Since the grid is grounded and the signal is fed into the cathode, it is necessary to feed the filament through r.f. chokes. The output is very loosely coupled to the detector.

The detector is an ultraudion type of oscillator that is brought in and out of oscillation at a low frequency rate. This low frequency is called the "squelch" or "quench" frequency. Feedback for the oscillator is accomplished through the circuit wiring and the internal capacities of the tube. These capacities are not shown as such on the schematic diagram, although they are adequate at the frequencies used in the receiver to enable oscillation.

The detector output is fed to a conventional audio stage which feeds the headphone jack. D.c. power is obtained from a transformer-fed half-wave selenium rectifier supply. To enable the use of resistance filtering in the supply, the transformer selected has a higher output voltage than the usual transformer of this type. This eliminates the use of a filter choke.



Front panel view of the spot frequency injector (left) which is designed around two printed-circuit kits. Below are the printed-circuit boards shown with all small parts mounted.



by *paul harvey*

Spot Frequency Injector

kits simplify crystal calibration for ham operators and SWL'S

The utility of any short-wave receiver can be enhanced by pairing it off with a reliable frequency standard. If you take advantage of commercially available printed-circuit kits and the economy of a homemade power supply, you can build an accurate crystal calibrator that performs right up to 30 mc.

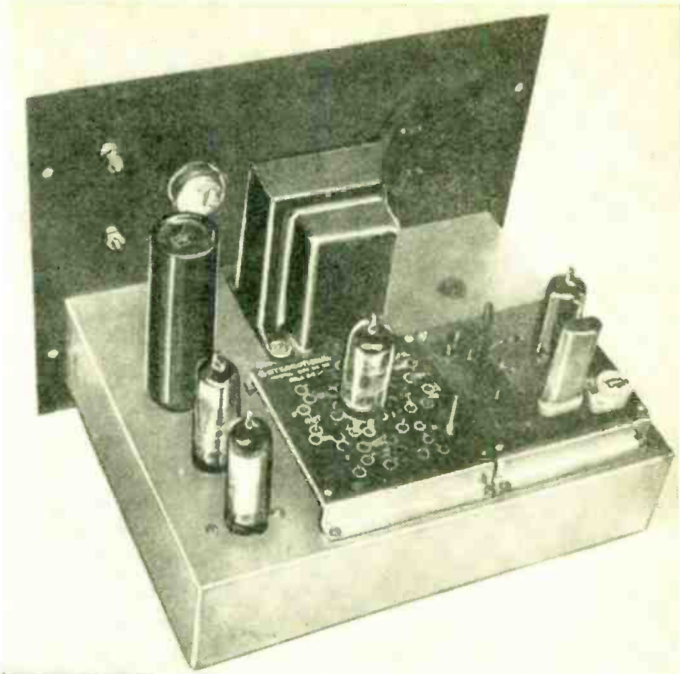
The unit pictured here is designed around two kits manufactured by the *International Crystal Manufacturing Co., Inc.,* 18 N. Lee St., Oklahoma City, Okla. The first of these is a 100-kc. crystal oscillator and the other is a 10-kc. multivibrator. With the proper power supply and housing, 100-kc. and 10-kc. markers may be obtained right up to the limit of the high-frequency end of most short-wave receivers.

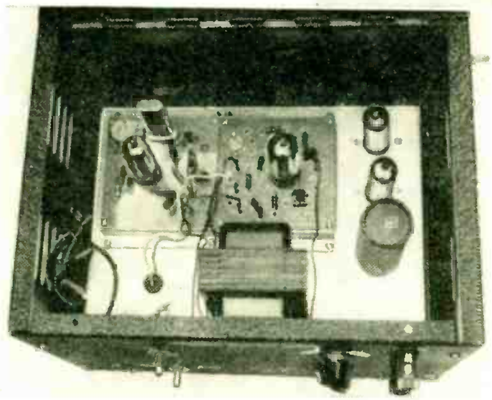
construction

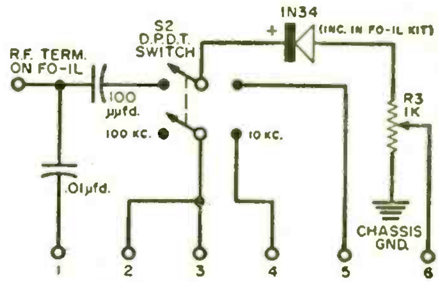
After obtaining the kits and accessory parts given in the "bill of materials," you will find it easy to follow the constructional steps below.

Step 1: Locate all the components in the positions indicated in the manufacturer's assembly instructions except for one modification: connect both the 100-$\mu\mu$fd. capacitor that comes with the FO-1L 100-kc. oscillator and the 0.01-μfd. capacitor accompanying the FMV-1 multivibrator to the common r.f. terminal on the FO-1L board. This leaves two free wire ends, one on each of the capacitors. The free end of the 0.01-μfd. capacitor will later join the input terminal on the FMV-1 board while the 100-$\mu\mu$fd. capacitor will be connected to the switch that selects *either* the 100-kc. or 10-kc. output. Solder

Layout of components above the chassis is shown at right; the OA2 regulator tube is in the left-hand corner, while the 6X4 rectifier is located between the filter capacitor and the OA2. In the photograph below, you can see the interconnecting wires and how the chassis looks installed in the cabinet, viewed from the top.







1. INPUT POST ON FMV-1
2. TO B+ TERMINAL ON FO-1L
3. TO 150V. REG. TERMINAL OF POWER SUPPLY
4. B+ TERMINAL ON FMV-1
5. OUTPUT TERMINAL ON FMV-1
6. R.F. OUTPUT TERMINAL ON MAIN PANEL

NOTES: 1. ALL GROUND CONNECTIONS ARE MADE THROUGH MAIN CHASSIS AND SUPPORTING BRACKETS OF PRINTED CIRCUIT BOARDS.
2. 6.3 V. LEAD FROM POWER SUPPLY IS DIRECTLY CONNECTED TO THE 6.3 VOLT TERMINAL ON FO-1L AND TO THE FIL. TERMINAL ON FMV-1.

Changeover switching system for 100 or 10 kc.

the components according to instructions.

Step 2: Lay out and mark the positions of the printed-circuit boards on the aluminum chassis. Group the power transformer *(T1)*, filter capacitor *(C1)*, OA2 regulator tube *(V2)*, and 6X4 rectifier tube *(V1)* around the boards and mark their positions. Drill the cabinet panel for the two output terminals, the level control *(R3)*, pilot light assembly, and the two switches *(S1* and *S2)*. One additional grommeted hole should be drilled in the chassis between the panel and the FO-1L board to permit passage of connecting wires from the parts beneath the chassis to those aboveboard.

Step 3: Wire the power supply. The filter resistor *(R1)* and series resistor *(R2)* for the regulator are supported by solder lugs on the tube sockets and filter capacitor.

Step 4: Secure the printed-circuit boards to the chassis with the small screws and brackets that accompany the kit. Complete all the aboveboard wiring at this time. Insert the crystal in the FO-1L board socket, the 6BH6, and the 12AT7; be certain that the 6X4 rectifier and the OA2 regulator are in the correct sockets.

With the power off, couple the output terminal of the frequency standard to the antenna post of your short-wave receiver and join the ground terminal of your receiver to the ground post on the calibrator. Tune your receiver to the National Bureau of

Standards transmitter at Station WWV; this station can be heard at any time of the day on 2.5, 5.0, 10, 15, 20. and 25 mc., and may be recognized by ticks that resemble those of a clock.

100 kc. operation

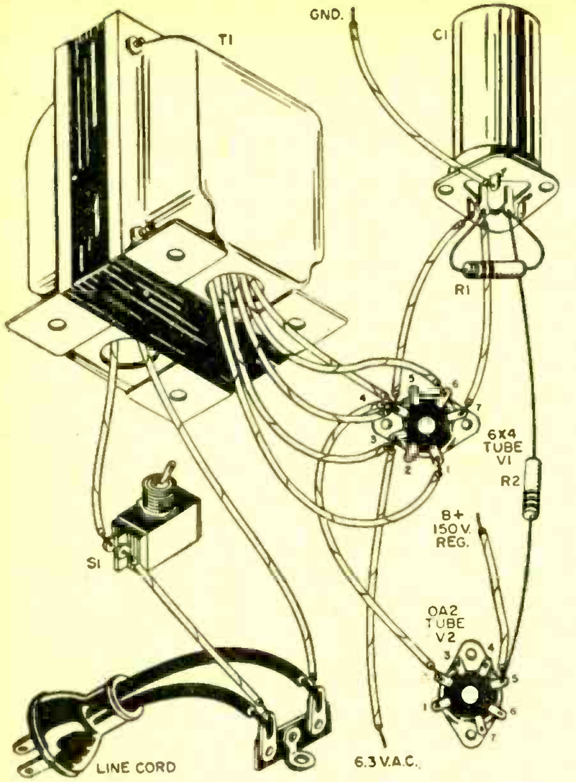
Set the changeover switch on the calibrator to "100 kc.," and turn the level control up to maximum. With proper operation, an audio beat note will be heard indicating that the 100-kc. oscillator is emitting a harmonic close to WWV's frequency. Adjust the trimmer capacitor on the FO-1L board for zero beat.

Now your BFO may be turned on while you check for the presence of 100-kc. marker signals throughout the band. After the initial test. you will want to reduce the output level of the crystal calibrator using potentiometer *R3*; it may also be advisable to loosen the coupling between the calibrator and the receiver.

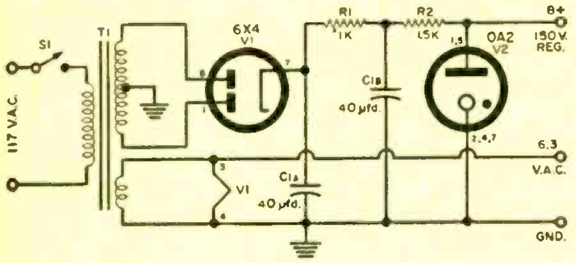
10 kc. operation

To test the 10-kc. multivibrator section, set the changeover switch on "10 kc." and adjust the tiny potentiometer on the FMV-1 board for a locked-in condition. This is accomplished by rotating the shaft while listening to the beat note of the harmonic of the FMV-1 with either WWV or any standard broadcast station. The potentiometer is adjusted until the multivibrator locks at 10 kc. and produces a beat signal with the broadcast station of a few cycles per second. An S-meter is useful here because its slow visible oscillation tells you when zero beat is being approached.

Precise frequency measurements and receiver calibration procedures are outlined in the literature which forms a part of each of the kits. The success and satisfaction you have with this instrument depends in part on the way you handle it. The setting of *R3* is important to avoid overloading your receiver and "swamping" the incoming signal. More output is required for the higher order harmonics, of course.



Pictorial and schematic diagrams for the power supply.



bill of materials

1—100-kc. crystal oscillator kit supplied with 6BH6 tube (Int. Crystal Co. Model FO-1L)
1—10-kc. multivibrator kit supplied with 12AT7 tube (Int. Crystal Co. Model FMV-1)
C1—40-40 µfd., 250-w.v., dual filter capacitor
R1—1000-ohm, 5-watt resistor
R2—1500-ohm, 5-watt resistor
R3—1000-ohm linear taper potentiometer
S1—S.p.s.t. toggle switch
S2—D.p.d.t. toggle switch
T1—Power transformer, primary 117 volts, 60 cps, secondaries 250 volts @ 25 ma, 6.3 volts @ 1.0 amp. (Stancor PS-8416 or equivalent)
V1—6X4 tube
V2—OA2 tube
1—7" x 9" x 2" aluminum chassis
1—Black crackle steel cabinet, hinged top
2—5-way type binding posts, one black and one red
2—7-pin miniature Bakelite sockets for subchassis mounting
Misc.—Bakelite pointer knob, Dialco 81410 pilot assembly, #47 bayonet-base, 6-volt pilot lamp, two-lug terminal strip, a.c. line cord, decals for trim.

the 21 SPECIAL

here's a 70 watt transmitter designed for today's novice, tomorrow's general class ham

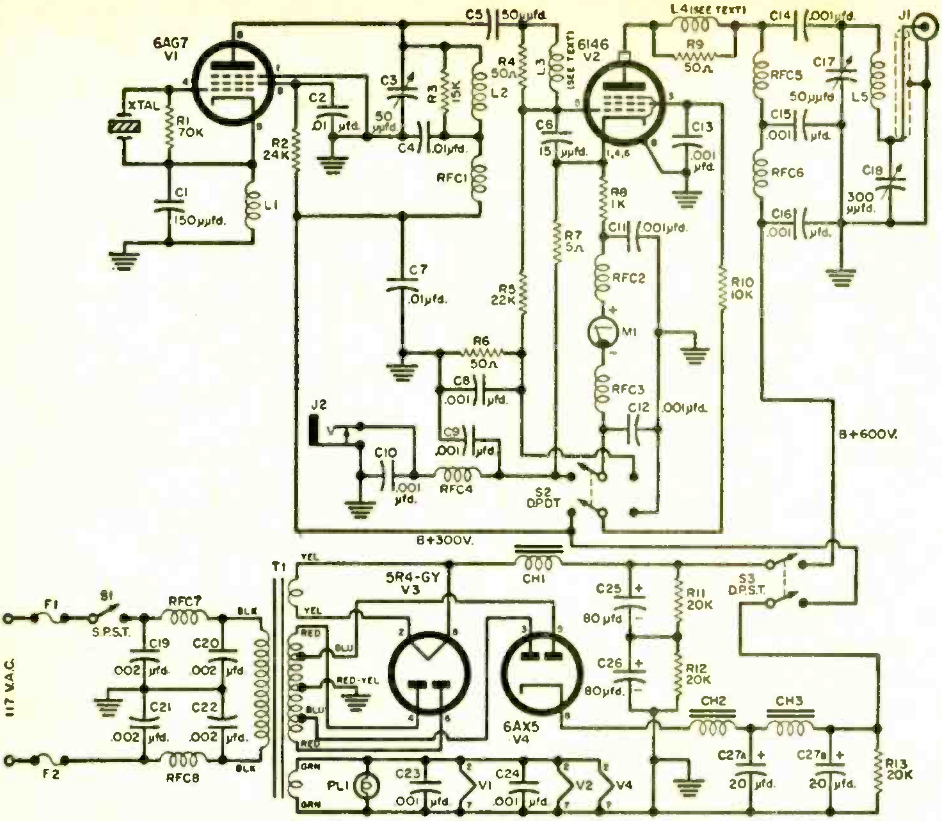
by ***william i. orr***

Intended for the Novice or the newly licensed General Class amateur, the "21 Special" is capable of 70 watts input on the 21-, 27- and 28-mc. amateur bands. World-wide DX can be worked on these interesting, long-distance bands, and the "21 Special" is designed particularly for those amateurs who have had some experience in building their own equipment. It is completely TVI-suppressed, and delivers over 50 watts to the antenna on each of the three bands.

A 6AG7 (*V1*) harmonic oscillator employing inexpensive 7-mc. crystals is capacity-coupled to a 6146 (*V2*) beam tetrode, working as a class C amplifier. The correct harmonic of the crystal is selected by the resonant circuit *C3-L2*. In the plate circuit of *V2* is a pi-network coupler capable of matching the amplifier to either a 52-ohm or a 75-ohm coaxial transmission line. The pi-network tunes from 20 mc. through 32 mc., eliminating the necessity of coil switching. Amplifier tuning is done by capacitor *C17*, and antenna loading is controlled by capacitor *C18*. Stable operation of the class C amplifier is insured by complete parasitic suppression in the grid and plate circuits of

notice We do not suggest that the Novice Ham construct this unit as his "first" transmitter. Before tackling such a project, the Novice should attempt to gain wiring experience and knowledge on how to tune up a transmitter. While the circuit is foolproof, a little extra know-how—principally gained through experience—should be sought first.

The Editors



the 6146 beam tetrode (V2) using components *R4, L3* and *R9, L4*.

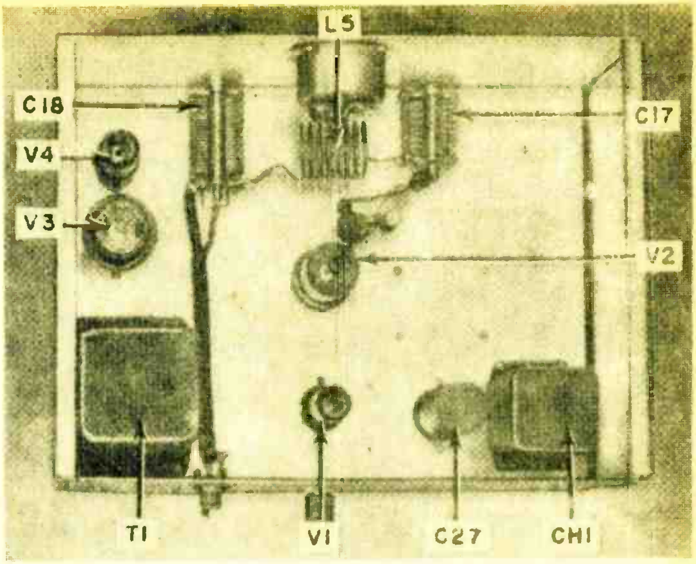
Plate power for both stages is provided by a dual-voltage supply utilizing a new Chicago-Standard transformer. The oscillator stage requires 300 volts, and the amplifier requires 600 volts. A 6AX5 (*V4*) is employed for the low-voltage rectifier, and a 5R4-GY (*V3*) is used for the high-voltage rectifier. For standby purposes, the two high-voltage circuits are broken by *S3*, permitting the transmitter to come on as soon as the switch is closed.

Grid and plate current of the 6146 amplifier tube are measured by a unique multiplier circuit, permitting both readings to be made on a single 0-1 d.c. milliammeter. Full-scale reading of the meter in the grid (*Ig*) position of *S2* is 3 ma., and full-scale reading in the plate (*Ip*) position is 200 ma. Normal grid current should read about 0.5 on the meter (1.5 ma.), and normal plate current should read about 0.6 on the meter (120 ma.).

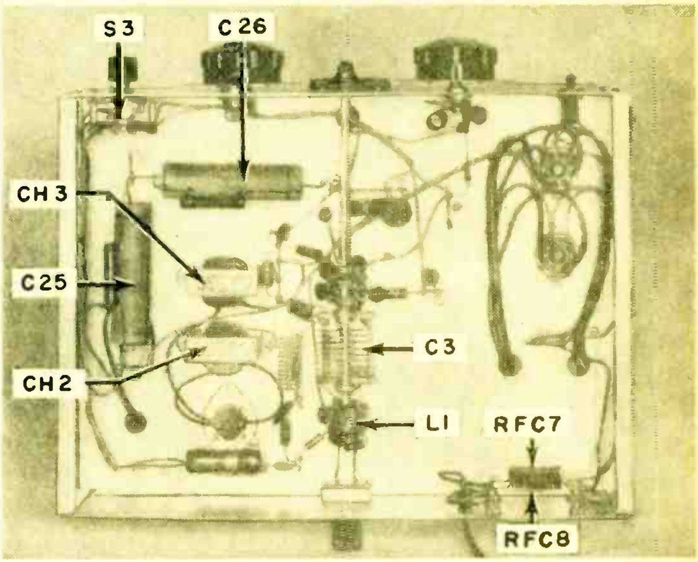
You can achieve maximum TVI-suppression by placing r.f. filters in the main power

parts list

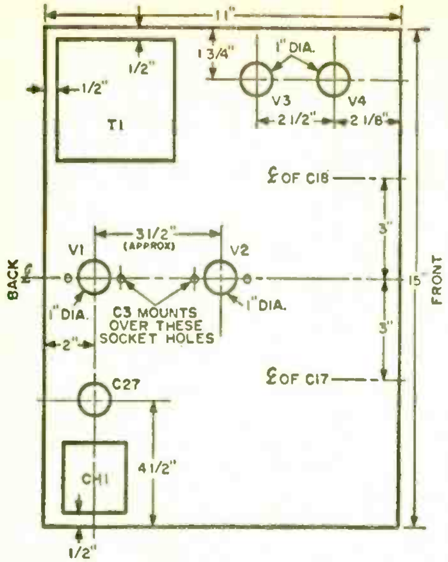
C1—150-μμfd. mica capacitor
C2, C4, C7—0.01-μfd. ceramic disc capacitor
C3, C17—50-μμfd. variable capacitor (Bud MC-1863)
C5—50-μμfd. mica capacitor
C6—15-μμfd. ceramic disc capacitor
C8, C9, C10, C11, C12, C13, C23 C24—0.001-μfd. ceramic disc capacitor
C14, C15, C16—0.001-μfd., 1-kv. capacitor
C18—300-μμfd. variable capacitor (Bud MC-1860)
C19, C20, C21, C22—0.002-μfd. ceramic disc capacitor
C25, C26—80-μfd., 450-volt electrolytic capacitor (Sprague TV-1716)
C27—20-20 μfd., 450-volt electrolytic capacitor
CH1—10-hy. @ 150 ma. choke (Chicago-Standard C-2335)
CH2, CH3—7-hy. @ 50 ma. choke (Chicago-Standard C-1227)
F1, F2—2-amp. fuse in 117-volt line plug
J1—Coaxial receptacle (S0239)
J2—Closed-circuit jack
L1—8 turns of No. 16 wire, 1" diameter, ½" long (B&W 3015)
L2—12 turns of No. 16 wire, ⅝" diameter, 1½" long (B&W 3006)
L3—3 turns of No. 18 enameled wire wound on 50-ohm, ½-watt resistor (R4)
L4—3 turns of No. 18 enameled wire wound on 50-ohm, 1-watt resistor (R9)
L5—8 turns of No. 10 wire, 1⅜" inside diameter, 2" long
M1—0-1 d.c. milliammeter, 55-ohm resistance (Triplett 221, 2" square)



Top and bottom views of the chassis are shown in the photos at right. No effort has been made to economize on space nor is special shielding required to insure foolproof TVI-free operation. Principal components are identified to assist you in assembling the transmitter along the lines described in the text. The only really critical dimension is the spacing between the sockets of V1 and V2, as the oscillator tuning capacitor, C3, is mounted on spacers and long bolts through the socket mounting holes. Schematic diagram of the "21 Special" is given at left; parts list appears below.



PL1—6.3-volt pilot light with holder (Johnson 147-300)
R1—70,000-ohm, 1-watt resistor
R2—24,000-ohm, 1-watt resistor
R3—15,000-ohm, 1-watt resistor
R4, R6—50-ohm, ½-watt resistor
R5—22,000-ohm, 2-watt resistor
R7—5-ohm, ½-watt resistor
R8—1000-ohm, 1-watt resistor
R9—50-ohm, 1-watt resistor
R10—10,000-ohm, 2-watt resistor
R11, R12, R13—20,000-ohm, 10-watt resistor
RFC1—2.5-mhy. r.f. choke (National R-60)
RFC2, RFC3—20 turns of No. 28 enameled wire close-wound on 1-megohm, ½-watt resistor
RFC4, RFC6, RFC7, RFC8—20 turns of No. 18 enameled wire, close-wound, ½" diameter
RFC5—2.5-mhy. r.f. choke (National R-100U)
S1—S.p.s.t. toggle switch
S2—D.p.d.t. slide type switch (Carling S-316)
S3—D.p.s.t. rotary switch (Centralab 1404)
T1—Transformer, to deliver 650 volts @ 150 ma., 315 volts @ 60 ma., 6.3 volts @ 3.5 amperes, and 5 volts @ 2 amperes; 117-volt primary (Chicago-Standard PC-8307)
V1—6AG7 tube
V2—6146 tube
V3—5R4-GY tube
V4—6AX5 tube
Xtal—7-mc. crystal
1—9" x 11" x 15" TVI-suppressed cabinet (LMB #159-11)
Misc. tube sockets, line cord, hardware, etc.



Suggested chassis layout for transmitter.

leads to the r.f. stages, in the keying circuit, and the 117-volt a.c. power line. Housing the transmitter in the new LMB shielded cabinet will provide complete shielding.

Plug all the tubes in their proper sockets, and place *S2* in the grid position. This removes screen voltage from the 6146 stage for tune-up purposes. Attach a 75-watt lamp bulb to the terminals of *J1* to act as a dummy antenna. Open *S3*, and place *C3*, *C17*, and *C18* at maximum capacity. Insert a 7-mc. crystal (frequency between 7031 kc. and 7082 kc. for the Novice 21-mc. region) in the crystal holder. Turn on *S1*. The pilot lamp should light, as well as all tubes.

Close *S3*, and note that a reading should be observed on the grid meter as *C3* is varied. Grid current should be observed at maximum and minimum settings of *C3*, corresponding to the third (21-mc.) and fourth (28-mc.) harmonics of the 7-mc. crystal. Set *C3* near maximum capacity, keeping the meter reading below 0.6 ma.

Next, open *S3* and switch *S2* to the plate current position. Close *S3*, and adjust the plate tuning capacitor, *C17*, for minimum current. Capacitor *C18* may be adjusted to bring the minimum plate current to 0.6 on the meter (120 ma.). Antenna loading and minimum plate current are both increased in value as the capacity of *C18* is decreased. Always re-resonate *C17* for minimum plate current after any adjustment is made to *C18*.

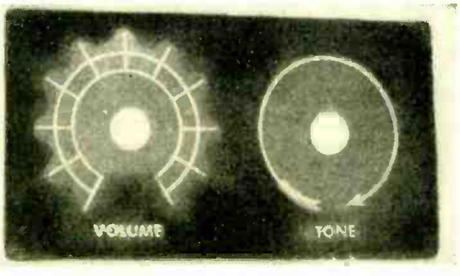
Now remove the lamp bulb, and attach the transmitting antenna to *J1*. The amplifier should be returned for proper loading with this new load. Plug a key in *J2*, and the transmitter is ready for operation on 21 mc. Never switch *S2* to the grid current position when the key is open. The key should be closed during all tuning operations.

Both the oscillator and amplifier tuned circuits cover the range of 20 mc. to 32 mc., inclusive. It is possible, therefore, to tune to any frequency in that portion of the spectrum. For 10-meter operation, resonate *C3* to 28 mc., which is near minimum capacity. At this point, grid current may be observed on the meter when *S2* is in the grid position.

Adjust *C3* for about 0.5-ma. current reading. Set *C17* near minimum capacity and *C18* at maximum capacity. Attach the 10-meter antenna, and place *S2* in the plate position. Close *S3* and resonate *C17* for minimum plate current. Adjust antenna loading by means of *C18* until the plate meter reads 0.6 ma., corresponding to a plate current of 120 ma.

Make Your Own Professional-Looking Dial Plates

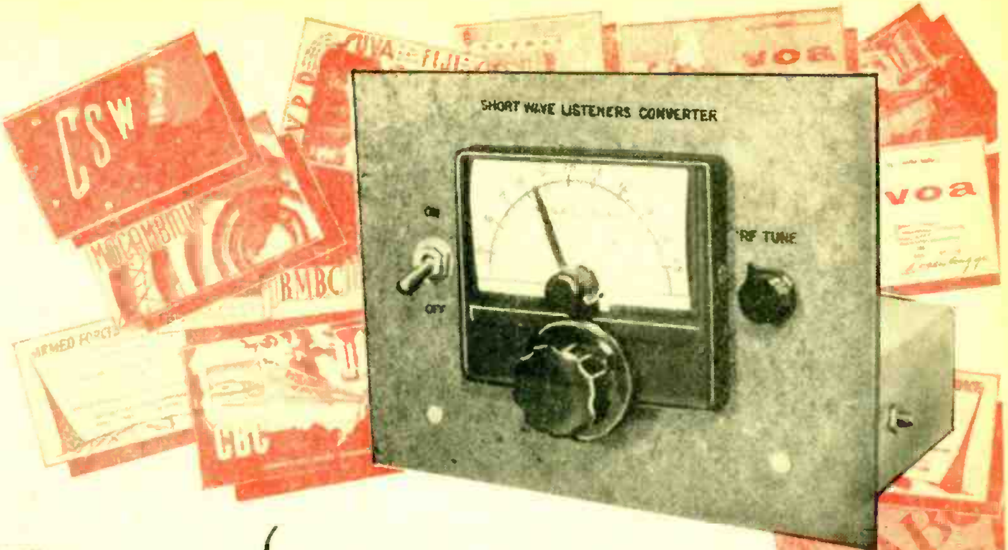
A professional-looking dial plate can be made from a strip of flashing copper and a few dial decals. Cut the copper strip to the desired size, flatten it, and then polish the best side to a bright finish. Rinse the plate well, dry it, and give it two coats of clear plastic spray to prevent it from tarnishing.



When the plastic has dried, lay out and apply the dial and lettering decals carefully, then put the plate aside for about 24 hours to allow the decals to dry thoroughly. At the end of this time, cut the necessary dial-center and mounting holes, and give the plate a second coat of plastic spray.

Dials can be made in a strip, as shown in the photo, or individually, as preferred or as necessity dictates. Small brass escutcheon pins, available from almost any hardware store, may be used to affix the dial plate neatly to a wooden hi-fi or receiver cabinet.

—*B. W. Blachford*



The 5:15 Simplicity in a Short-Wave Converter

by *richard graham*

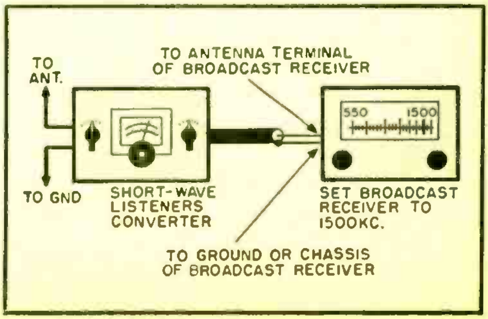
Although great strides have been made in the field of radio and electronics, one thrill which has consistently held the interest of all generations is that of short-wave listening. This thrill can be yours if you construct a simple converter which, when it is attached to any standard broadcast receiver, will enable you to receive short-wave signals from all over the world.

This converter covers all the major short-wave broadcast bands in the 5 to 15 mc. range. Its construction is only slightly more involved than that of a typical one-tube receiver.

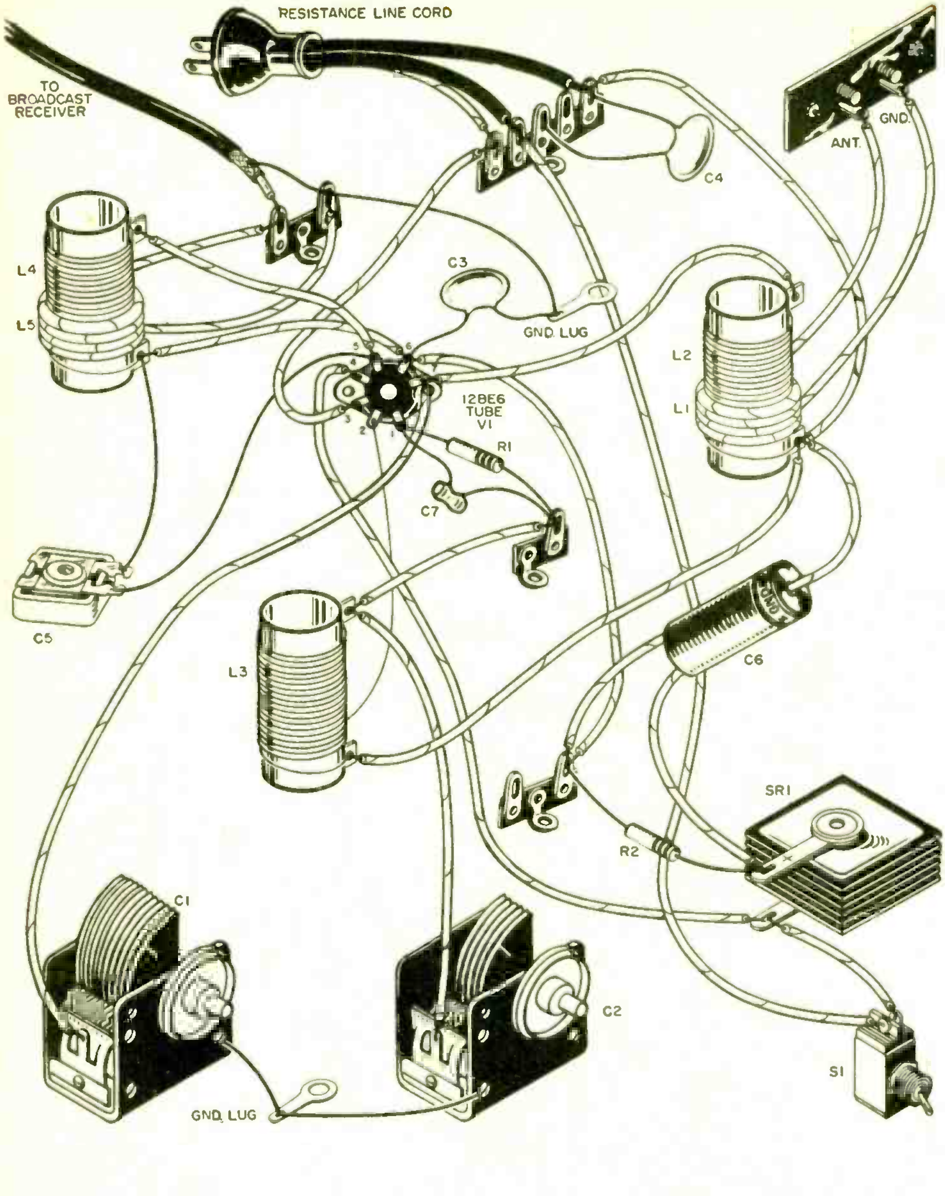
construction

The "5:15" is assembled on an aluminum chassis measuring 7" x 5" x 2". It is recommended that the general layout in the photographs be followed to insure adequate isolation between the coils *L1/L2* and *L4/L5*. Coil *L2* and oscillator coil *L3* are placed on opposite sides of the chassis. The output coil, *L4*, is also located under the chassis but is placed on the opposite corner. This coil arrangement is essential.

As an economy measure, the coils can be wound on a ¾"-diameter dowel. After winding, apply a coating of either polystyrene cement or colorless nail polish. A third alternative is to let the coils soak



How to hook up the converter, which covers all major short-wave broadcast bands in the 5 to 15 mc. range, to a standard broadcast receiver.

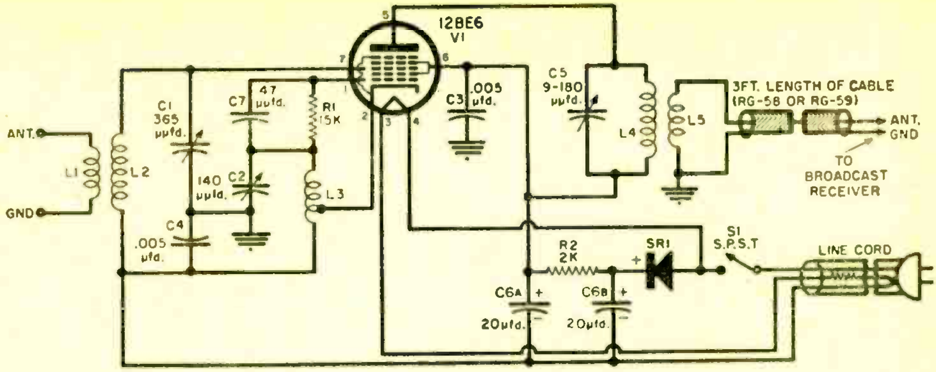


Pictorial layout of components for simple low-cost short-wave converter.

in melted paraffin. They are then securely installed on the chassis by small wood screws.

There is no power transformer in the "5:15" converter. To eliminate the possibility of dangerous electrical shocks, the a.c. line is not grounded to the chassis. The 0.005-μfd. capacitor, *C4*, grounds the chassis for r.f. only.

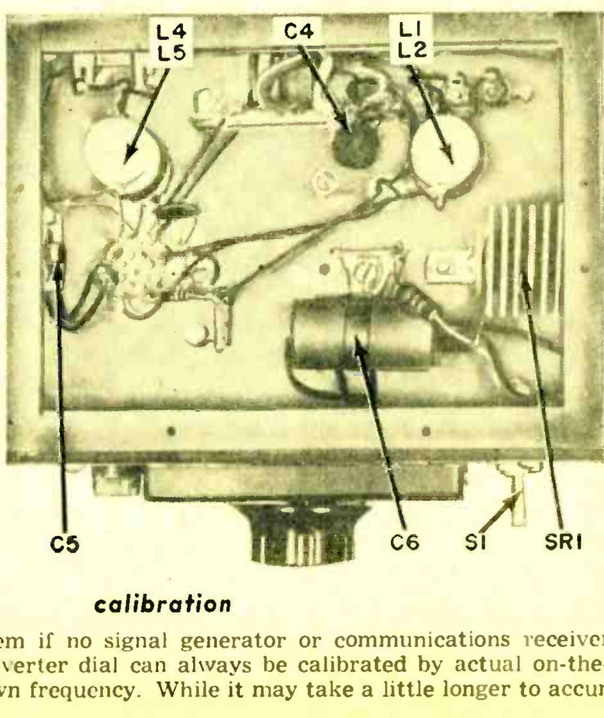
Only one fixed adjustment needs to be made when you initially put the "5:15" into operation. Hook up the converter to the broadcast receiver as shown in the diagram. Adjust the main tuning dial to any signal on the air that can be found, simultaneously adjusting the "RF Tune" control for maximum strength. Now merely adjust trimmer capacitor *C5* for maximum signal volume from the receiver.



parts list

C1—365-μμfd. variable capacitor
C2—140-μμfd. variable capacitor
C3, C4—0.005-μfd., 600-volt fixed ceramic capacitor
C5—9-180 μμfd. variable trimmer capacitor
C6a/C6b—20/20 μfd., 150-volt d.c. dual electrolytic capacitor
C7—47-μμfd., 600-volt fixed ceramic capacitor
L1—4 turns of hookup wire wound over bottom end of L2
L2—12 turns of No. 30 DSC wire, close-wound on ¾"-diameter form
L3—11 turns of No. 30 DSC wire, close-wound with tap at 3 turns from bottom (r.f. ground end) on ¾"-diameter form
L4—76 turns of No. 30 DSC wire, close-wound on ¾"-diameter form
L5—4 turns of hookup wire over bottom of L4
R1—15,000-ohm, ½-watt resistor
R2—2000-ohm, 1-watt resistor
S1—S.p.s.t. toggle switch
SR1—65-ma. selenium rectifier
V1—12BE6 tube
1—560-ohm resistance line cord
1—3' length of cable (RG-58 or RG-59)

Below-chassis view of unit (at right) shows placement of coils on opposite sides of chassis. Adequate isolation must be maintained between coils L1/L2 and L4/L5. The "RF Tune" control is located at the left of the main tuning dial; when you adjust the dial, this control must be adjusted simultaneously.

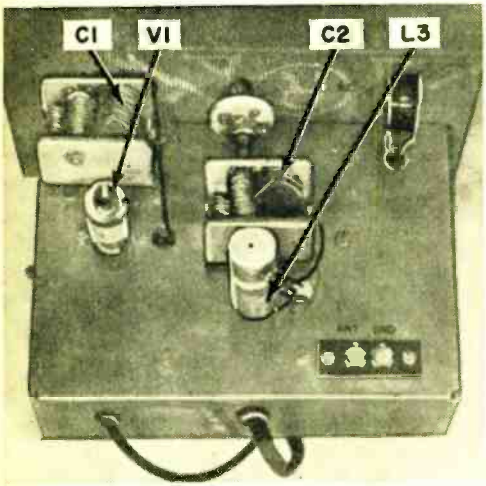


calibration

This can present a problem if no signal generator or communications receiver is available. However, the converter dial can always be calibrated by actual on-the-air signals from stations of known frequency. While it may take a little longer to accumulate enough calibration points that way, such a method is just as valid as either of the two following methods requiring more complex equipment.

To use a signal generator for calibration, it is only necessary to hook the generator up to the input antenna and ground terminals of the converter and set the generator at various known frequencies from 5 to 15 mc., meanwhile tuning in each signal on the converter as if it were an actual on-the-air signal.

Using this technique, points can be plotted at regular intervals across the entire range of the tuning capacitor. Accuracy of this calibration is dependent on the accuracy with which the signal generator can be set.



Top view of the "5:15" (above), assembled on a 7" x 5" x 2" aluminum chassis. Variable capacitors C1 and C2, coil L3 and the 12BE6 tube are identified. Frequency changing is accomplished by adjusting the oscillator frequency by means of capacitor C2, which is driven by the main dial of the converter.

alternate method

A third method of calibrating the converter is to use a communications receiver which covers the frequencies from 6 to 17 mc. Place the communications receiver antenna lead near the oscillator coil *L3*. Set variable capacitor *C2* to maximum capacity. Now tune the communications receiver around 6.5 mc. Somewhere in the vicinity of this frequency, a strong steady signal will be heard. This is the oscillator signal in the converter. Note the frequency on the dial of the communications receiver, then subtract 1.5 mc. from this reading. The resulting number will be the frequency to which the converter main tuning dial is set. This frequency can be marked on the dial. The main tuning dial may then be set at various spots throughout its range and the procedure repeated to calibrate the dial completely.

In using the converter, always keep adjusting the "RF Tune" control as the main tuning dial is adjusted. If you are searching for a signal, adjust the "RF Tune" control for maximum background noise. The position of this control will always roughly correspond to the position of the pointer of the main tuning dial.

how it works

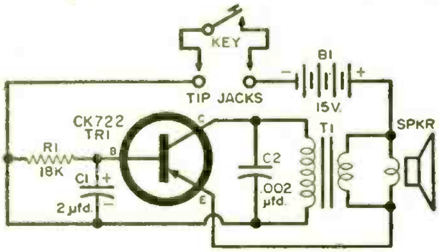
You will notice that the converter is actually a receiver "front end," i.e., it comprises the r.f. mixer and oscillator circuits. It serves as a means of converting any frequency between 5.0 and 15 mc. to 1500 kc. The 1500-kc. signal can then be fed into any broadcast receiver tuned to that frequency.

When a 5.0-mc. signal is applied to grid No. 3 of the 12BE6 and the oscillator portion of the converter is applying a 6.5-mc. signal to grid No. 1 of the 12BE6 (pin No. 1), the output signal at the plate of the 12BE6 will be the original two input signals of 5.0 and 6.5 mc., and two new frequencies—11.5 mc. and 1.5 mc. This last resultant frequency is the one which we can use in our broadcast receiver.

We have just converted a signal from 5.0 mc. to 1.5 mc. This same reasoning would apply if we chose any other signal frequency besides 5.0 mc. All that would have to change would be the oscillator frequency. In the converter, frequency changing is accomplished by adjusting the oscillator frequency by means of the variable capacitor C2. This is the capacitor that is driven by the main dial of the converter.

Subminiature Code Practice Set

by *e. g. louis*



Simple single transistor circuit provides enough output to drive loudspeaker. Entire circuit can be mounted in small plastic box.

Whether you're a prospective Novice or an old hand at pounding the brass, here's a versatile code practice oscillator which you should enjoy assembling and using. Pocket-sized—actually smaller than a package of cigarettes, it is completely self-contained, requiring neither external headphones, speaker, nor batteries. In fact, the only "accessory" needed is a standard hand key. What's more, the unit provides ample volume for both personal study and small class instruction through its own built-in subminiature loudspeaker.

mounting and wiring

Neither parts arrangement nor wiring is critical, and you can follow your own inclinations in assembling your model. Try to choose a layout which will permit easy replacement of the battery.

I mounted the transistor socket, resistor *R1*, and capacitors *C1* and *C2* on a piece of perforated Bakelite, which serves as a chassis. This chassis board, in turn, is fitted over the ends of the phone tip jacks which serve as the hand key terminals. Transformer *T1* is mounted on the subminiature loudspeaker's frame.

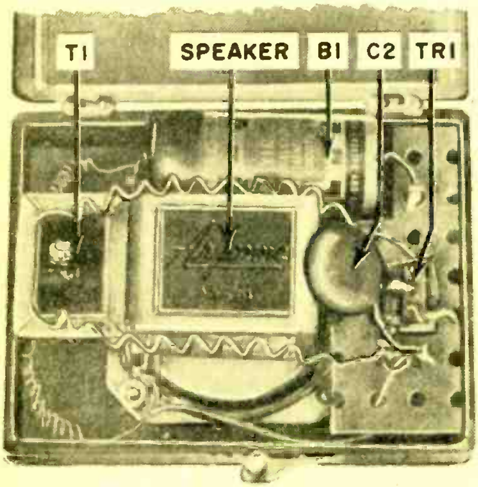
An opening in the case is needed for the loudspeaker. One technique is to drill a number of small holes in the case (as shown on the preceding page) arranged in a decorative pattern.

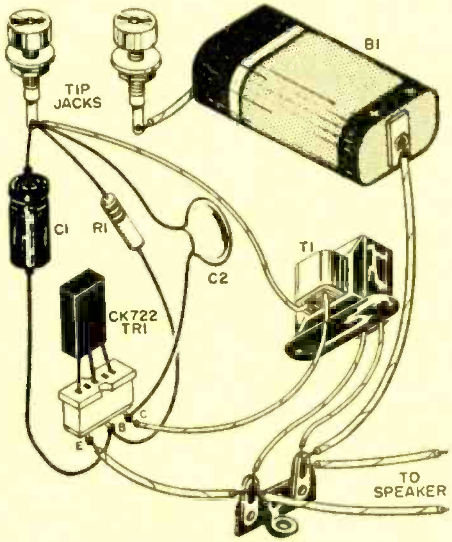
Mount the 15-volt hearing-aid-type battery, *B1*, by soldering a heavy piece of wire to its negative terminal and attaching this wire, in turn, to one of the phone tip jacks. Use care when soldering to the battery and complete each joint as quickly as possible to avoid excessive heating. The connection to the positive terminal is made with a small flexible wire.

operation and use

With the wiring completed and checked, depress the key. You should hear an audio note from the speaker. If no sound is heard other than, say, a "click," reverse *either* the primary *or* the secondary leads of transformer *T1*. Proper phasing is necessary for oscillation to take place, and this must be determined experimentally. Do *not* reverse both of the windings.

Although designed specifically for use as a code practice oscillator, chances are that you'll find many other uses for this gadget. For example, it can serve as a portable source of an audio tone . . . in this capacity, it's handy for checking microphones or for "one man" checks of p.a. installations and paging systems.





Layout of parts is not critical, but if you want to color the plastic case, don't mount the parts until after the paint has dried. Check all wiring before connecting the hand key or trying the unit.

parts list

B1—15-volt miniature battery (Burgess No. Y10)
C1—2-μfd., 15-volt electrolytic capacitor
C2—0.002-μfd. disc ceramic capacitor
R1—18,000-ohm, ½-watt carbon resistor
T1—Miniature transistor transformer, 2000 ohms to 10 ohms (Argonne No. AR-96)
TR1—CK722 transistor (Raytheon)
SPKR—10-ohm v.c. subminiature PM loudspeaker (Argonne No. AR-95)
KEY—Standard hand key (accessory)
2—Phone tip jacks
1—Small plastic box
1—Transistor socket
1—Perforated Bakelite mounting board
Misc. machine screws, nuts, wire, solder, etc.

how it works

A CK722 *p-n-p* junction transistor is wired as a "tickler feedback" audio oscillator. The oscillator is powered by a single battery, *B1*, with base bias current established by resistor *R1*, and bypassed by electrolytic capacitor *C1*. Capacitor *C2*, across the primary of transformer *T1*, forms a tuned circuit with the transformer's winding and helps determine the frequency of operation. *T1* provides a feedback path between collector and emitter circuits necessary to sustain oscillation.

The hand key connected to the phone tip jacks takes the place of a switch. When the hand key is depressed, the battery circuit is closed and oscillation can take place.

Soup Up Your DX
. . . with an Antenna Tuner

cost is small, but results will amaze you

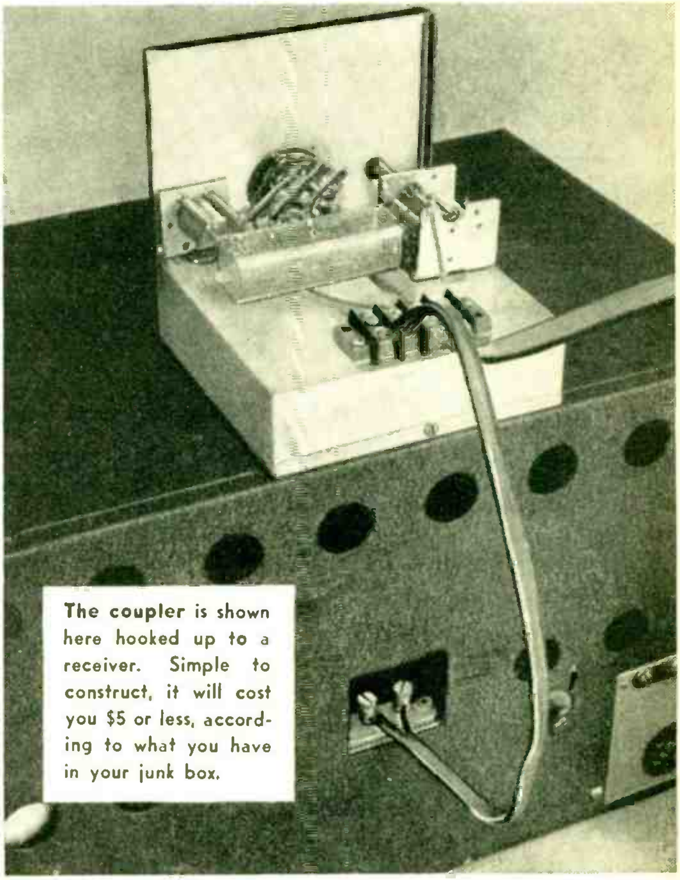
by ***joseph w. doherty***

Do you have to strain to hear that shortwave broadcast? Do you fret and fume because London fades, or Paris just never shows up? Calm down. The answer to your problem will cost you peanuts ($5 or less) and just a couple of hours of your time. It's called a Receiver Antenna Coupler, Low Cost, Mark I.

The device is the missing link between antenna and receiver. It will not only couple them together at the desired frequency, but it will automatically "uncouple" many types of interfering signals. It will be found particularly effective ahead of receivers which do not have a preselector stage ahead of the mixer tube, typical of many low-cost short-wave receivers.

Technically, it is a pi-section filter. There is no complicated switching involved from series resonance to parallel resonance, and it is simplicity itself to construct. Total cost will depend on how many parts you can salvage from your junk box.

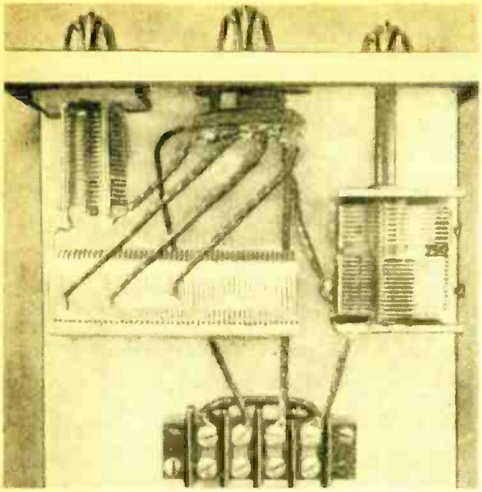
Note that if your antenna, transmission line and receiver impedances are already closely matched, no antenna coupler will greatly increase the signal. But for the system which uses tuned feeders or an end-fed antenna, or a random-length antenna, this coupler will give results that will probably surprise you.



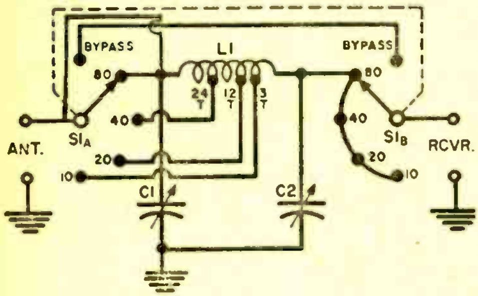
The coupler is shown here hooked up to a receiver. Simple to construct, it will cost you $5 or less, according to what you have in your junk box.

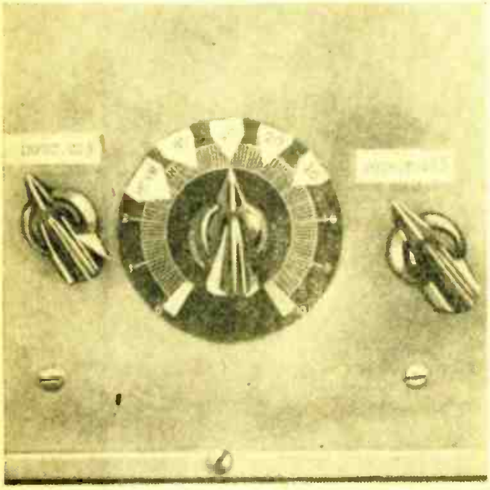
switching operation

The values shown will provide good matching over a wide range of impedances from about 2 mc. to 30 mc. Taps on the coil enable you to peak on the 80-, 40-, 20- and 10-meter amateur bands by rotating switch *S1* through its five positions. Position 1 is a bypass position which automatically removes the antenna coupler from the circuit and shorts the input to the output terminals. Position 2 is for the 80-meter band; 3 is for 40 meters; 4 for 20 meters, and 5 is for 10 meters.



Top of unit shows placement of capacitors. Follow the schematic shown below for proper wiring.





Front panel should be marked with proper identification for various bands and for identification of input (C1) and output (C2) capacitors.

Frequencies which lie between these amateur bands can easily be tuned with capacitors *C1* and *C2*. Generally, as the frequency increases, the tuning becomes more critical; and on the 20- and 10-meter positions, care must be taken not to tune the coupler to the image frequency.

The tap switch is of phenolic material and the terminal block is of molded Bakelite. They could be replaced with ceramic types, if desired. Miniductor coil #3015 was chosen because it is easily tapped, due to the spacing between the windings, and because of its rigidity, which contributes to the ruggedness of the unit.

Note that the windings adjacent to the windings on which the taps are made are slightly depressed, making it easier to solder the connection. You can make these depressions with a screwdriver, but be careful not to let the tool slip, or the coil may be damaged. It is recommended that the windings be depressed before mounting the coil. Because of the rigidity of the coil, no separate mounting is needed. It is connected directly to the stator terminals of capacitors *C1* and *C2* as shown.

Tap the coil as follows: for 80 meters, the full 48 turns; for 40 meters, 24 turns; for 20 meters, 12 turns; 10 meters, 3 turns. Follow the switch wiring exactly as shown in the schematic diagram.

now to the chassis

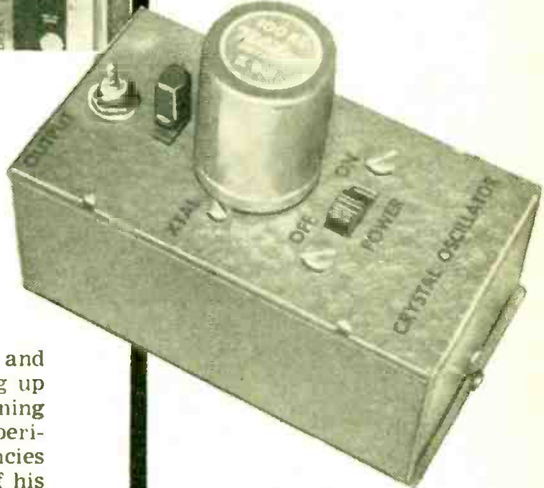
The chassis may be of any type. The one illustrated was a can which contained a small reel of 16-mm. film; its shape and dimensions made it ideal for a lightweight chassis. (Even a coffee can may be used, if necessary.) Looking at the top of the chassis from the rear (above at left), the input capacitor, *C1*, is at the right, *C2*, the output capacitor, is at the left.

One note of caution: If the receiver is of the a.c./d.c. type, do not—*repeat*—do not connect the coupler chassis to the receiver *chassis*. Both your receiver and antenna coupler chassis would then be connected to one side of the a.c. line. In the case of a two-wire feeder, one side of the feeder and, therefore, one side of the antenna might be "hot" to your roof gutters or vent pipe. This could result either in a blown fuse or a severe jolt—depending on how lucky you happen to be.

parts list

C1—360-$\mu\mu$fd. variable capacitor
C2—140-$\mu\mu$fd. variable capacitor
L1—B&W Miniductor #3015 (3" x 1" x 48 turns, tapped at 24 turns, 12 and 3 turns)
S1—2-pole, 5-position shorting switch (Centralab #1404)

Crystal-Controlled Receiver Calibrator



by *luis vicens*

Novices and SWL's can check received frequencies with this midget 100-kc. oscillator

Nearly everyone who works with radio signals should be able to check frequencies with fair accuracy. The amateur radio operator is responsible for the operation of his transmitter within assigned frequency bands. The SWL may want to check the calibration of his receiver and make sure that he doesn't miss picking up a particularly interesting station by tuning to the wrong frequency. Even the experimenter must be able to check frequencies with a reasonable degree of accuracy if his r.f. projects—receivers, tuners, etc.—are to be successful.

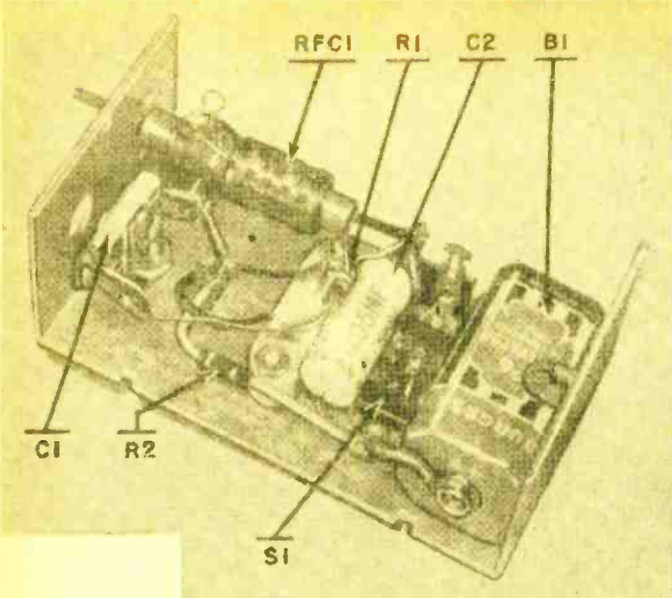
One of the best techniques for checking the frequency of a signal is to compare it with another signal of known frequency, such as the signal from an AM broadcast station or from the Bureau of Standards Station WWV. Since this provides only a limited number of known frequencies, the next best thing is to use a crystal calibrator. A 100-kc. crystal-controlled oscillator is particularly valuable for frequency checks. The output signal of such an oscillator can be made rich in harmonics, and so used to establish "check points" on a communications receiver well into the shortwave bands.

The instrument described in this article operates from a self-contained, long-life battery. With no connection to the a.c. power line, it is free from shock hazard and its output is free of hum and line noise. Only standard, readily available components are used, and although its external appearance is that of a "factory-built" instrument, its assembly and wiring should be within the capabilities of beginners.

construction

You can obtain the components from your local radio parts distributor or from one of the large mail order supply houses. Not all distributors will have the 100-kc. crystal in stock, but most can obtain it for you on order.

You can make substitutions for some of the electrical components if you wish. *R1* may have values ranging from 180,000 ohms to 240,000. Any value from 0.05 μfd.



Open-chassis view of the transistorized calibrator shows wiring details clearly. Only standard, readily available components are used. The major parts are identified here, but neither the circuit nor chassis layout is critical. Be sure to mount the battery securely.

to 0.25 μfd. is satisfactory for *C2*. Output capacitor *C4* may be any value from 270 $\mu\mu$fd. to 470 $\mu\mu$fd. Either mica, ceramic, or paper capacitors may be used throughout the circuit.

The chassis layout is not critical and you can either duplicate the model, as shown in the photographs, or make up a new layout. Lead dress is also completely non-critical. Just make sure you observe the battery's polarity.

Of course, if you decide to solder the transistor permanently in position instead of using a socket, you'll have to take the usual precautions to avoid heat damage. Use fairly long leads and grasp the lead you are soldering with a pair of pliers at a point between the body of the transistor and the connection point. The pliers will absorb excess heat.

adjustment

Install the battery and adjust the slug on *RFC1* about three-quarters of the way "in." Adjust *C1* to a setting about two or three turns back from "fully closed."

An insulated lead is connected to the calibrator's *output* terminal and the free end wrapped tightly around a receiver's antenna lead-in wire, forming a small "gimmick" capacitor. Five or six tight turns should be ample. The "gimmick" capacitor coupling technique will *not* work if your receiver uses a coaxial lead-in cable. In such a case, connect a 25 to 100 $\mu\mu$fd. capacitor between the free end of the *output* lead and the receiver's antenna terminal.

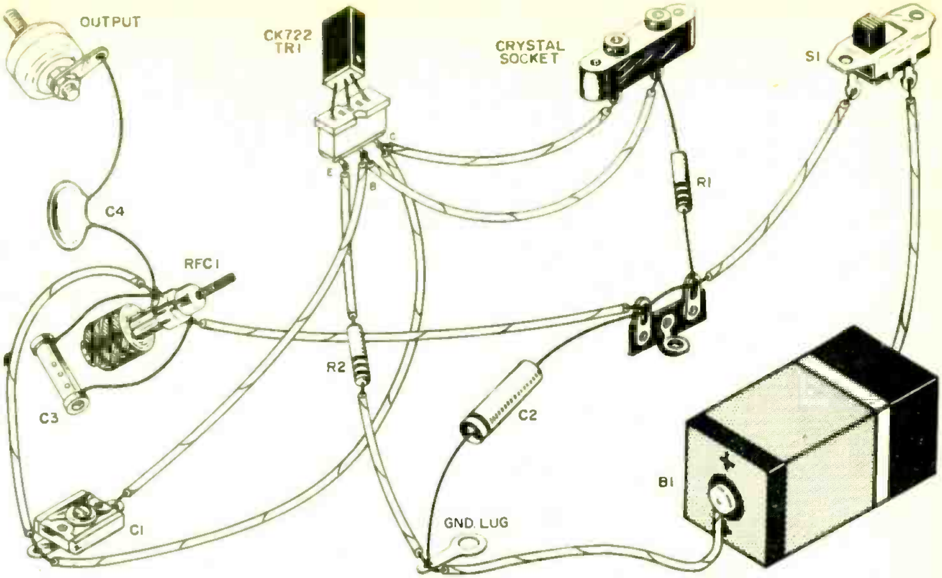
If you have a local AM broadcast station with a frequency which is an even multiple of 100 kc. . . . such as 600 kc., 700 kc., 800 kc., etc. . . . you can make a preliminary test against this station. Simply tune to the station frequency and listen for an audio beat note indicating that the signal from the calibrator is interfering with the reception of the AM station. You can identify it by switching the calibrator off—the audio note should disappear.

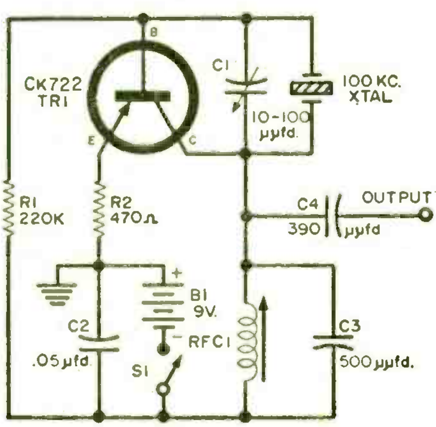
If you cannot obtain an audio note, try readjusting *RFC1* and *C1*. If you are very lucky, you may have immediately set the 100-kc. calibrator on the exact frequency and be "zero beat" (meaning no audible beat note) with the broadcasting station. By juggling *RFC1* and *C1*, you should get a "zero beat" with a good 100-kc. crystal.

operation

Now switch on the receiver's BFO and tune the receiver. You should obtain beats at 100-kc. intervals up to several megacycles. The beats will become fainter at higher frequencies as the strength of the 100-kc. harmonics falls off.

On the upper bands of your receiver, and especially if your set has only moderate sensitivity, you may have to connect the calibrator's lead directly to the receiver's antenna terminal instead of using capacitor coupling. The maximum frequency at





Follow these diagrams when you build the crystal calibrator. Parts list is given below.

B1—9-volt transistor battery (Burgess No. P6)
C1—10-100 μμfd. trimmer capacitor
C2—0.05-μfd., 200-600 volt paper capacitor
C3—500-μμfd. tubular ceramic capacitor
C4—390-μμfd. disc ceramic capacitor
R1—220,000-ohm, ½-watt carbon resistor
R2—470-ohm, ½-watt carbon resistor
RFC1—5-35 mhy. adjustable r.f. choke (Superex No. V-25)
S1—S.p.s.t. slide switch
TR1—CK722 p-n-p transistor (Raytheon)
XTAL—100-kc. crystal (Bliley No. KV3)
1—Small "Channel-Lock" aluminum case (ICA No. 29400)
1—Transistor socket
1—Crystal socket (Millen No. 33102)
4—Rubber feet
1—Insulated feedthrough terminal
Misc. wire, solder, battery clips, ground lug, small brackets, terminal strips, etc.

which you can still obtain beats depends primarily on the sensitivity of your receiver. Used on a low-sensitivity a.c.-d.c. "communications type" receiver, the model supplied beats up to 7 mc. On a better receiver, you should obtain beats at 100-kc. intervals up to 20 or 30 mc.

double-check

To double-check the calibrator, it should be adjusted with Station WWV at either 2.5 mc., 50 mc., 10 mc., or 15 mc. Operating 24 hours a day at these four frequencies, Station WWV (Beltsville, Md.) provides an accurate standard for checking out your equipment.

how it works

A single *p-n-p* junction transistor is used as a crystal-controlled r.f. oscillator, and the common-emitter circuit configuration is employed. Because of the low frequency (100 kc.) and circuit efficiency, a low-cost audio-type transistor—instead of the more expensive r.f. type—is specified.

Base bias current is supplied through *R1*. Adjustable coil *RFC1* and fixed capacitor *C3* serve as collector load, with the feedback obtained through the 100-kc. crystal. A small trimmer capacitor, *C1*, across the crystal, permits a slight control over operating frequency, providing the operator with the means to adjust the output frequency to exactly 100 kc.

Unbypassed emitter resistor *R2* helps stabilize circuit operation by adding a slight amount of negative (degenerative) feedback. The output signal is obtained through blocking capacitor *C4*.

Make Your Own Dynamic Mike

by luis vicens

Except for its low output impedance. a PM loudspeaker makes an excellent dynamic microphone. But by teaming up a PM speaker with a transistor, we can assemble a true dynamic mike which has the high output impedance needed by most audio amplifiers, coupled with a high output level comparable to that obtained from carbon microphones.

construction

The author's model of the dynamic microphone was assembled in a small plastic box. Some type of protective opening is needed for the subminiature loudspeaker. This may be a decorative pattern of drilled holes, or a piece of plain or flocked metal screening mounted behind a circular cutout in the case.

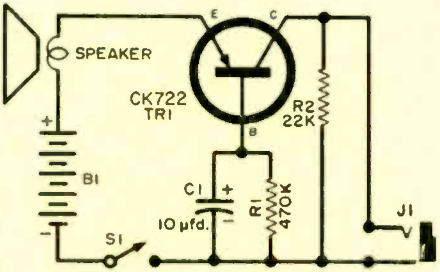
The chassis is a small piece of perforated Bakelite. The transistor socket and small electrical components are mounted on it. Although a transistor socket was used in the model, this component may be eliminated and the transistor wired permanently in place if desired. A single 15-volt battery is used; a small lug is soldered to one of its end terminals, and is attached to the case with a machine screw and nut.

The simple "on-off" push-button switch *S1* is made up from a short machine screw, a small compression spring, a hex nut, and a piece of flexible hookup wire, arranged so that the nut presses against one battery terminal when the screw is depressed.

installation and use

The dynamic microphone is used just like any other microphone equipped with a "push-to-talk" switch. Connect a shielded cable from *J1* to the input jack of the amplifier, recorder or transmitter with which the instrument is to be used. To use the mike, simply depress *S1* and speak in a normal voice, holding the instrument a few inches from your mouth.

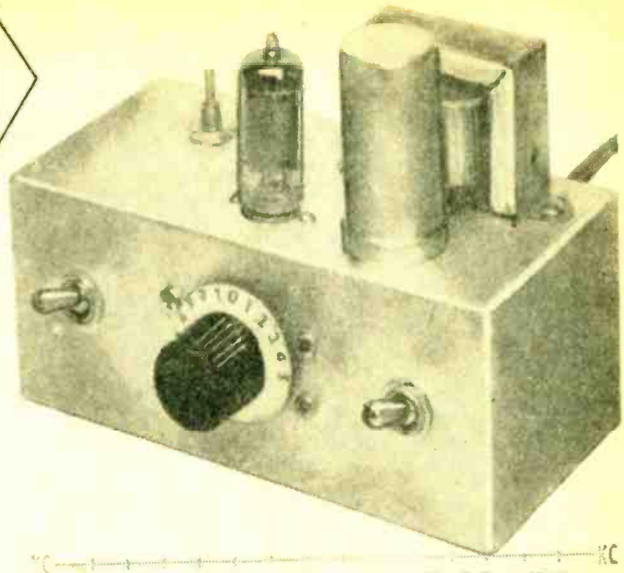
There is no d.c. isolation in the output circuit of the dynamic microphone—note that the transistor's collector electrode connects directly to the "hot" terminal of jack *J1*. Isolation is not needed in the microphone if it is used with equipment having a "blocking" capacitor in the input circuit.*



B1—15-volt miniature battery (Burgess No. Y10)
C1—10-µfd., 15- or 25-volt electrolytic capacitor
J1—Phono jack
R1—470,000-ohm, 1/2-watt carbon resistor
R2—22,000-ohm, 1/2-watt carbon resistor
S1—S.p.s.t. switch (see text)
TR1—CK722 transistor (Raytheon)
Speaker—Subminiature PM loudspeaker, 10-ohm voice coil (Argonne No. 95)
1—Transistor socket
1—Small plastic box
1—Perforated Bakelite mounting board
Misc. machine screws, nuts, wire, solder, etc.

* If there is a chance that the mike will be used with equipment having no d.c. isolation, a blocking capacitor should be added to the microphone's output circuit. Simply connect a moderate-sized capacitor (0.1 to 1.0 µfd.) between the transistor's collector and the "hot" terminal of *J1*. The capacitor's voltage rating is not too important—a 50 to 100 volt (or higher) unit will be ample.

This oscillator will set inexpensive receivers for best bandspread



INEXPENSIVE DIAL SETTER

by *robert j. murray, W1FSN*

Many short-wave listeners and hams-to-be experience difficulty in properly setting the general coverage dials so that the bandspread dials are properly calibrated according to their markings. Sometimes an error in setting the general coverage dial by as little as the width of the pointer results in a 25 to 100 kc. error on the bandspread dial.

The gadget described in this article is a simple high-stability self-excited oscillator with its own power supply. It was deemed necessary to include the power supply because many less expensive receivers are a.c./d.c. with no provision for accessories.

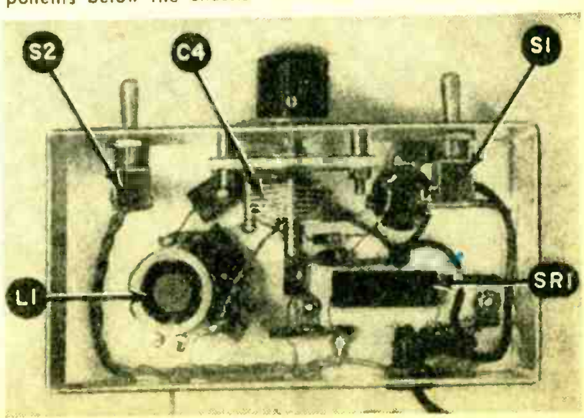
Basic frequency of the oscillator is 1000 kc. It is roughly set to this frequency by tuning in a broadcast-band station. Of course, if there should be a local broadcast station operating on 1000 kc., it may be set on the nose. Leeway is provided on the front control for more precise measurements of frequency if slightly more or a little less than 1000 kc. is required.

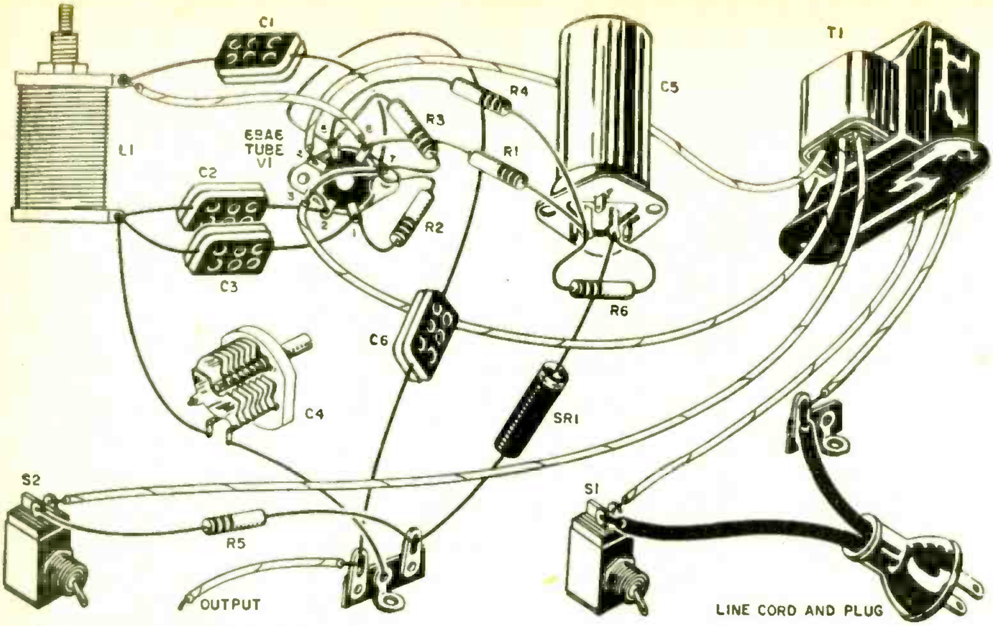
The layout of the calibrator should be followed as closely as possible as all major heat-producing components are mounted above the chassis, while the frequency-controlling components are mounted below the chassis where the heat is least apt to affect them. In operation it is recommended that the unit not be placed on top of the receiver or other equipment which will add to the temperature rise within the calibrator itself.

To place the calibrator in operation, both switches should be turned on and the tube allowed to come to operating temperature. It is well to allow it to run for about fifteen minutes before setting the frequency of the oscillator. Capacitor *C4* is then set at half capacity. The receiver is tuned to 1000 kc. on the broadcast band and the slug in *L1* is turned in or out until a strong unmodulated carrier is heard on the receiver.

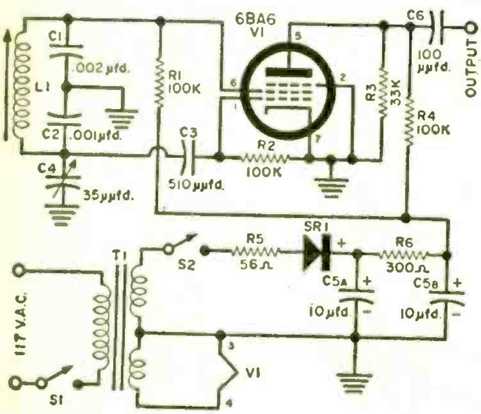
The calibrator is now roughly set at 1000 kc. and will provide strong harmonics at every multiple of 1000 kc. throughout most of the short-wave spectrum, i.e., 2000 kc., 3000

All major heat-producing components are mounted above the chassis (see top photo), and all frequency-controlling components below the chassis where heat will least affect them.





Follow the pictorial and schematic diagrams in building the dial setter. Note that C5 is grounded through its metal mounting plate.



parts list

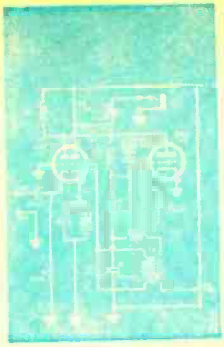
C1—0.002-µfd. silver mica capacitor
C2—0.001-µfd. silver mica capacitor
C3—510-µµfd. silver mica capacitor
C4—35-µµfd. air variable capacitor (National UM-35)
C5a/C5b—10/10 µfd. (or 20/20 µfd.) dual 150-volt electrolytic capacitor
C6—100-µµfd. mica capacitor
L1—40 turns of No. 26 Formvar on National XR-62 ceramic coil form
R1, R2, R4—100,000-ohm, ½-watt resistor
R3—33,000-ohm, ½-watt resistor
R5—56-ohm, ½-watt resistor
R6—300-ohm, 1-watt resistor
S1, S2—S.p.s.t. toggle switch
SR1—20-ma. selenium rectifier (Sarkes Tarzian #026-28H-Q or National T657-1)
T1—Power transformer (Stancor PS 8415)
V1—6BA6 tube
1—6" x 3" x 2½" aluminum chassis
1—Knob (National HRS-5)

kc., 4000 kc., 5000 kc., etc. At this point the calibrator may be set exactly on one of the Bureau of Standards' stations (WWV) at either 5.0 megacycles or 10.0 megacycles. The receiver should be tuned to WWV at either of the above frequencies and the tuning slug in *L1* adjusted carefully for zero beat with the station.

calibration precautions

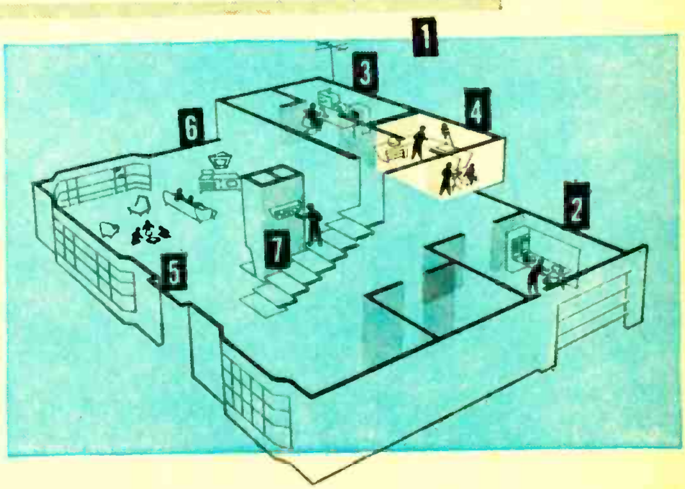
As a final word of caution, it should be pointed out that some simpler superheterodyne receivers have a relatively poor signal-to-image ratio at the higher frequencies and it is possible for the operator to mistake an image for the true signal. Images are signals that are heard at a frequency twice the i.f. removed from the true signal. In other words, if your receiver has an intermediate frequency of 455 kc. and its local oscillator frequency is above the signal, the image of any one signal heard will be found 910 kc. lower in frequency on the dial. If the receiver's oscillator is lower in frequency than the signal, the image will be found 910 kc. higher in frequency on the dial.

These 910-kc. points are very close to the next 1000-kc. calibrator harmonics; therefore the operator should be careful to differentiate properly between a true signal and an image. This problem will not present itself on the lower frequencies but should be looked for and recognized for what it is when you are operating on the higher frequency ranges.



Section 4

for your darkroom



Front view of the "Audio Photometer." Note size comparison with conventional light meter shown at its right.

Transistorized Audio Photometer

by *luis vicens*

In scientific research, one of electronics' most important jobs is converting energy from one form to another so that it can be conveniently measured by standard instruments. Most electronic instruments use a meter as the indicating device. But here's a really off-beat instrument—a light meter or "photometer" which employs *sound* to indicate the light level. In use, light falling on a sensitive photocell is converted into an audible signal, heard from a subminiature loudspeaker. The more intense the light, the higher the frequency (pitch) of the audio note.

The "Audio Photometer" has many potential applications. You'll find such an instrument valuable for scientific demonstrations or as an electronic toy. An experienced photographer could learn to approximate his camera settings on the basis of the audio note heard, a paint salesman could use the instrument for demonstrating the difference in the "whiteness" of different samples and so on.

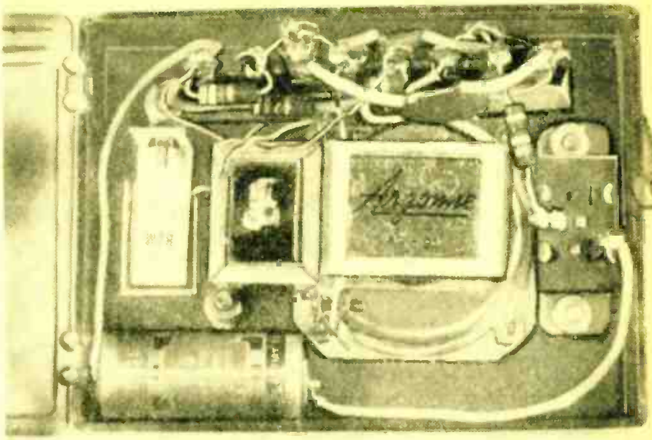
construction

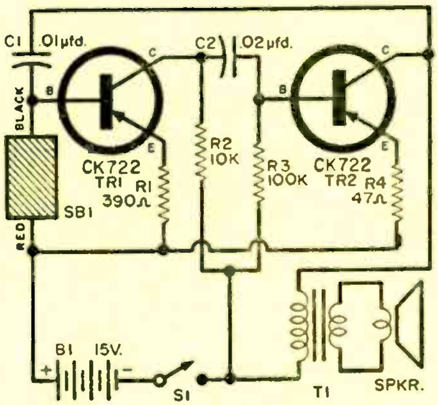
Circuit details are given in the schematic diagram. Only standard, readily available components are needed, and neither parts arrangement nor lead dress is critical.

A transparent plastic case was used in assembling the model. You can obtain a professional appearance by spraying colored Krylon plastic on the *inside* of the case. A "window" for the selenium photocell may be made by covering a small area with masking tape before spraying.

Construction and wiring are simplified by mounting all small components along an eight-position terminal strip. The transistors are wired permanently in position.

At the right is an interior view of the photometer with small parts and transistors wired directly to the terminal strip. Also see schematic and parts list below.





You can use a similar scheme, or provide separate transistor sockets. Make the connections to the battery by soldering leads directly to its terminals. Avoid overheating the battery.

using the photometer

Hold the unit so that the light to be measured falls on the photocell. Close *S1*, and listen to the audio tone produced. The lower limit may be determined by operating the instrument in the dark. The upper limit may be determined by exposing the photocell to an extremely strong light . . . that is, by holding it close to a lamp bulb or by exposing it to full noon sunlight. Do *not* hold the unit close to a "spotlight" type bulb or other source of heat, however. Overheating would probably damage components.

parts list

B1—15-volt miniature battery (Burgess Y10)
C1—0.01-μfd. disc ceramic capacitor
C2—0.02-μfd. disc ceramic capacitor
R1—390-ohm, 1/2-watt carbon resistor
R2—10,000-ohm, 1/2-watt carbon resistor
R3—100-000-ohm, 1/2-watt carbon resistor
R4—47-ohm, 1/2-watt carbon resistor
S1—S.p.s.t. slide switch
T1—Transistor output transformer, 2000 ohms to 10 ohms (Argonne No. AR-96)
Spkr—Subminiature PM loudspeaker, 10-ohm v.c. (Argonne No. AR-95)
Sun Battery—Selenium cell (International Rectifier Corp. No. B2M)
TR1, TR2—Type CK722 transistor (Raytheon)
2—Transistor sockets
1—Perforated Bakelite board
1—Small plastic case
1—8-position terminal strip
Misc. machine screws, nuts, soldering lugs, wire, solder, etc.

how it works

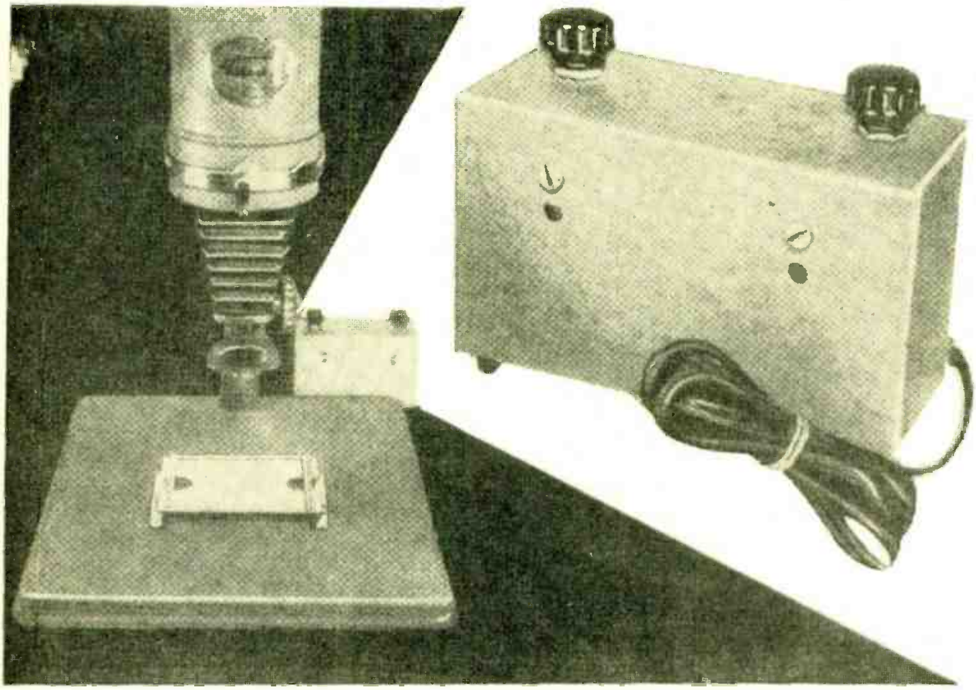
The audio photometer uses two *p-n-p* junction transistors as common-emitter amplifiers. The first stage is coupled to the second stage through capacitor *C2*. Output of the second stage is coupled back to the input of the first stage through capacitor *C1*, which supplies the in-phase signal feedback necessary to sustain oscillation. Unbypassed emitter resistors *R1* and *R4* raise the effective input impedances of their respective stages. Base bias for the second stage is supplied through *R3*.

In operation, the bias for the first stage is determined by the selenium Sun Battery connected between the base electrode and circuit ground. When the Sun Battery is dark, a low bias is applied to the first stage and the oscillator operates at a low frequency. As more light falls on the photocell, first stage bias increases, and frequency of operation goes higher.

Low Cost
Darkroom Timer

the "blinks" of the neon bulbs will tell you when your print is properly exposed

by **e. g. louis**



After you've done some photographic work, you will realize that the success of each operation depends on proper timing. The exposure of the film must be accurately timed and, when making prints, the paper exposure depends on such factors as paper "speed" (sensitivity), intensity of the light used for exposure, and the density of the negative. The exposing interval may be several seconds—or perhaps approach a full minute or more in some cases. Thus, the photographer must rely on special mechanical, electrical or electronic timing devices which are accurate to a second.

Most commercially manufactured photographic timers are rather expensive; some cost as much as small cameras. So the photographer with a thin pocketbook either has to do without or to build his own. Here's a reliable timer you can build for only a few dollars—one that doesn't require a single tube, transistor or relay, yet will provide accurate timing for all your printing and enlarging needs. With no tubes to burn out, no batteries to become exhausted, and no relay contacts to become dirty, burnt or pitted, your first cost will be your last.

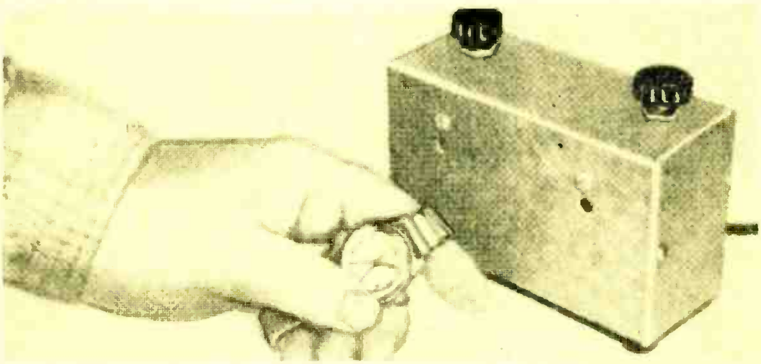
This timer consists simply of a small aluminum box in which two lights are visible. Both glow with a pale orange color that is safe in the typical darkroom. Each light flashes at a periodic rate—one at a rate of one "blink" per second, the other at a rate of one "blink" every five seconds. To time an exposure requiring, say, 19 seconds, it is only necessary to watch for three blinks of the 5-second light and four blinks of the 1-second light. A 27-second exposure would require five blinks of the 5-second light and 2 blinks of the 1-second light.

construction

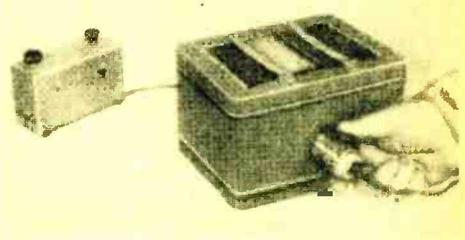
All the components are inexpensive and readily available at radio parts stores. A commercially available aluminum case was used to house the timer shown. However, any similar-size box will serve as well. The unit could be assembled in a plastic, wooden, or even a strong cardboard box.

Neither the circuit layout nor wiring arrangement is at all critical. Just be sure to observe correct circuit polarity when installing the selenium rectifier (*SR1*) and the electrolytic capacitor (*C1*). Use small cable clamps to mount the neon bulbs (*NE1* and *NE2*) behind holes in the case, arranging them so that both electrodes (the wires inside each bulb) are visible from the front.

Since the timer circuit is completely noncritical, quite a number of changes may be



Above illustration shows the darkroom timer being calibrated with a watch. A clock with a sweep second hand may also be used for calibration. At the right, the timer is being used with a contact printer.



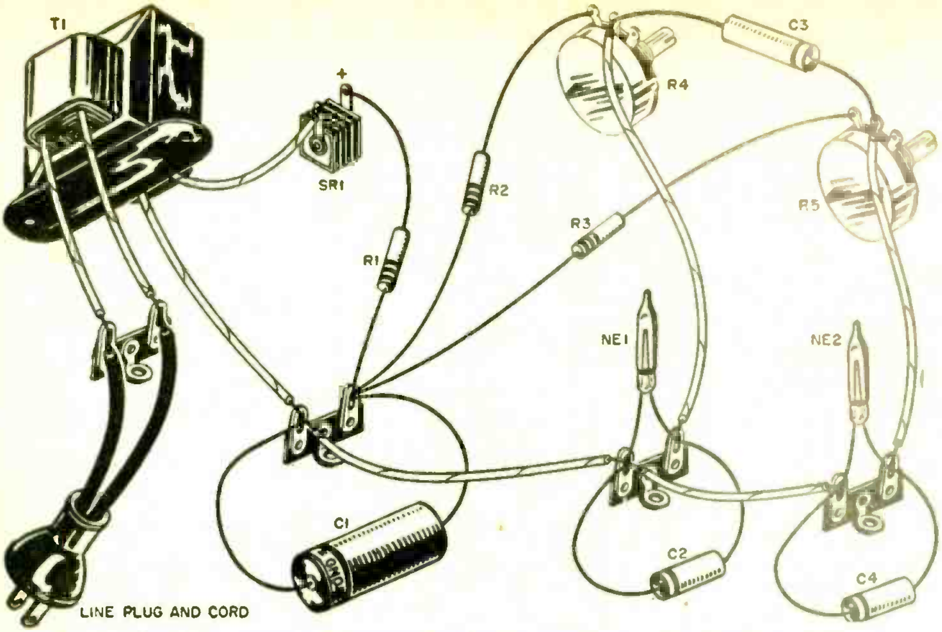
made in parts values without affecting operation. Often, a suitable component from the junk box can be used in place of a specified part. Almost any 117-volt selenium rectifier will serve as *SR1*. You can substitute a larger or smaller resistor for *R1*—values of from 560 to 2200 ohms are satisfactory—and a 1-watt or 2-watt unit will do instead of the ½-watt unit listed. Capacitor *C1* may range from 8 μfd. to 30 or 40 μfd., with ratings from 150 to 450 volts d.c. Type NE-51 neon bulbs can be employed in place of the NE-2 bulbs, if desired.

adjustment

Using a watch or clock with a sweep-second hand, and operating the timer in a partially darkened room, gradually adjust *R4* until *NE1* is blinking at exactly 1-second intervals. Then adjust *R5* until *NE2* blinks at exactly 5-second intervals. Finally, readjust both *R4* and *R5* until the two bulbs are blinking in perfect synchronization.

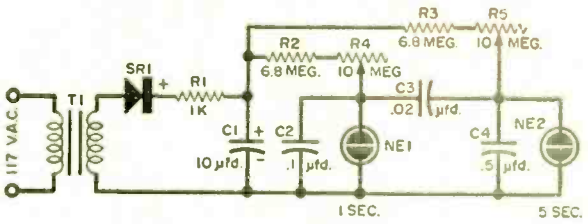
Ideally, the first bulb should blink four times—on the fifth blink, both bulbs should flash together. However, depending on the tolerances of the neon bulbs, it is sometimes possible for one bulb to blink four times, then for the second bulb to supply the fifth—or 5-second—blink. Recheck the timer's calibration adjustment at periodic intervals, especially if you do not use it for extended periods.

Proper timing intervals are determined simply by counting the number of blinks on



Pictorial and schematic diagrams for the darkroom timer. Since the circuit is not critical, other parts may be substituted for those given below in certain cases (see text).

C1—10-μfd., 150-volt elec. capacitor
C2—0.1-μfd., 200-volt paper capacitor
C3—0.02-μfd., 200-volt paper or ceramic capacitor
C4—0.5-μfd., 200-volt paper capacitor
NE1, NE2—Type NE-2 neon bulb
R1—1000-ohm, ½-watt resistor
R2, R3—6.8-megohm, ½-watt resistor
R4, R5—10-megohm carbon potentiometer
SR1—20-ma. selenium rectifier
T1—117-volt isolation transformer
1—5¼" x 3" x 2⅛" "Channel-lock" aluminum case (ICA No. 29410)



the 1-second and 5-second bulbs. For example, an 11-second interval calls for two blinks of the 5-second bulb, one of the 1-second bulb, and a 23-second interval calls for four blinks of the 5-second bulb, three of the 1-second bulb.

how it works

The timer is basically two interlocked neon relaxation oscillators operating with different repetition rates. Transformer *T1*, rectifier *SR1*, resistor *R1* and capacitor *C1* form a simple half-wave rectifier, delivering an output of approximately 150 volts, d.c. Alternating-current ripple is filtered by the L-type filter made up by *R1* and *C1*.

One oscillator circuit comprises series resistor *R2* and *R4*, capacitor *C2* and neon bulb *NE1*. The other oscillator consists of *R3* and *R5*, capacitor *C4* and neon bulb *NE2*. The two oscillators are "locked" together electrically by capacitor *C3*.

In operation, *C2* is charged gradually through *R2* and *R4*. The voltage on *C2* builds up until *NE1* fires (at about 60 to 70 volts). When the bulb fires, it acts more or less like a short circuit, discharging *C2*. When the voltage across *C2* is too low to maintain *NE1* in a "conducting" state, the bulb is extinguished, and *C2* starts to charge again. The entire action is repeated at an interval determined by the time constant of *C2*, *R2* and *R4*.

Each time *NE1* fires, it flashes or "blinks," and at the same time a pulse is delivered to the second oscillator circuit *(R3, R5* and *C4)* through coupling capacitor *C3*. Adjusting *R4* permits the rate to be changed until *NE1* blinks at exactly 1-second intervals. The time constant of the second circuit is made five times longer than that of the first—note that *C4* is five times larger than *C2*—so that *NE2* blinks at exactly 5-second intervals.

Meter Your ENLARGER EXPOSURES

instant reading instrument gives you exposure time for perfect enlargements

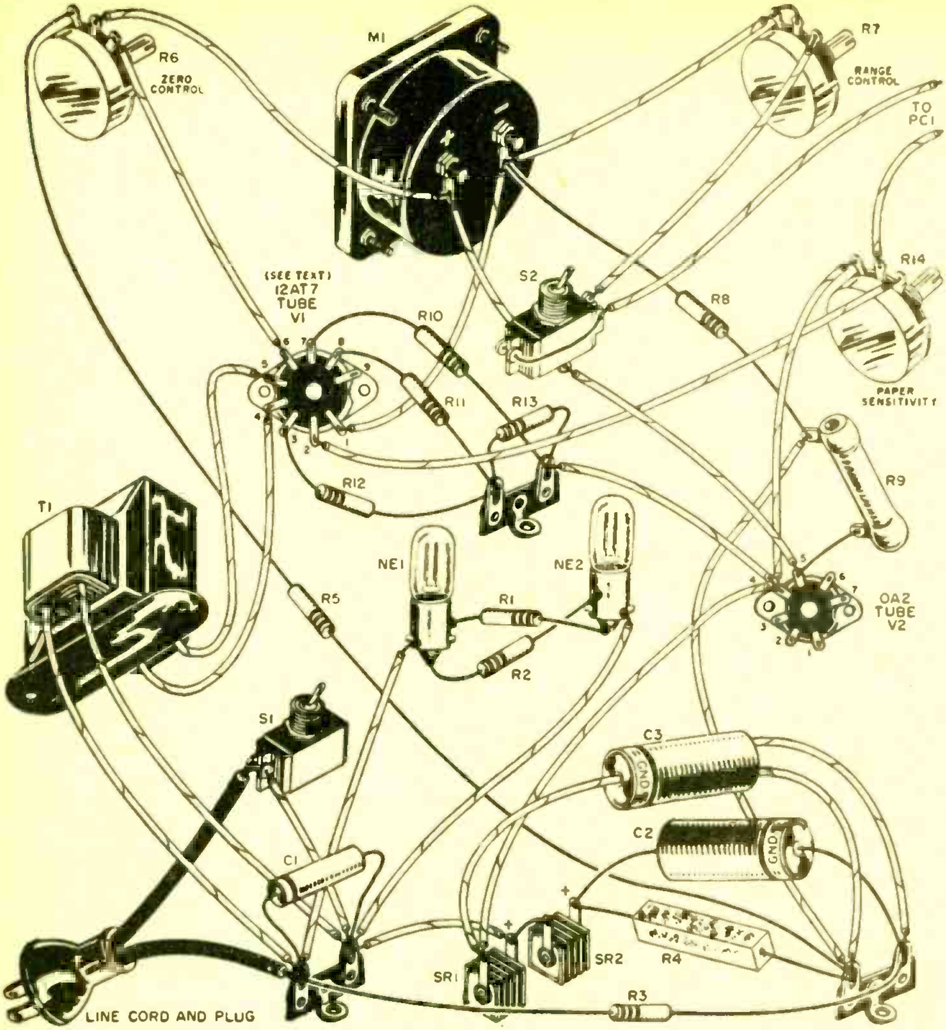
*by **r. l. winklepleck***

One of the few operations in the field of photography which has not yet bowed down to automation is that of determining the precise exposure under the enlarger that will produce a perfect print. We refer to mechanical or electrical gadgets for the distance from camera to subject and for the correct film exposure. We use an automatic timer for our developing. The enlarger automatically focuses the image on the paper and the proper exposure is made for us by a timing mechanism. But to determine this exposure, we still resort to trial and error.

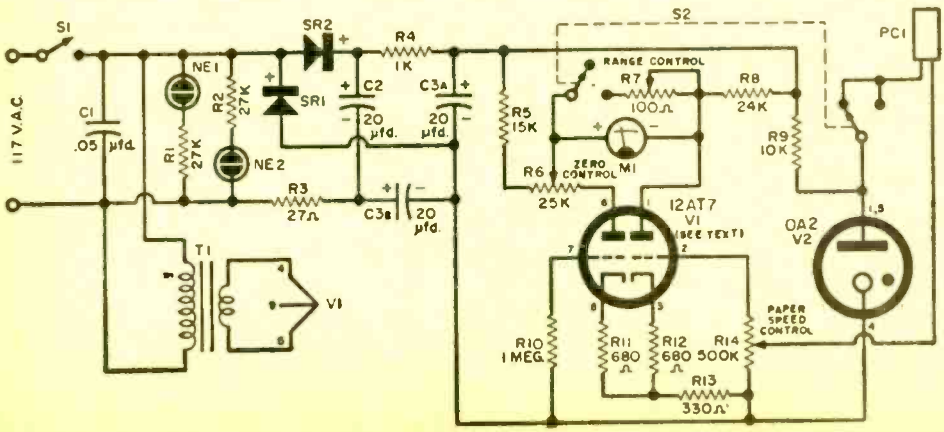
It's true that there are many different pieces of equipment on the market specifically designed to determine the enlarging exposure, but do you and your friends consistently use such equipment? Most of us start off an enlarging session with good intentions. We make a couple of test strips, a practice which is really systematized trial and error, or we use one of the illumination comparison gadgets for a while. We either waste paper or pretend to be satisfied with a lot of prints which are not quite right. We do this because most outfits require tedious adjustment to determine each exposure. What we really want is something as quick and easy to use as the familiar exposure meter.

The enlarging exposure meter described here has a small light-sensing element. As soon as the switch is closed, the correct exposure may be read directly in seconds on the meter. Once calibrated for your conditions, less than five seconds is required to determine the right exposure time.

The degree of sensitivity required will vary with the enlarger being used, the degree of enlargement, and the kinds of enlarging paper. So it's difficult to specify the exact tube which should be used. The cathode resistors, therefore, have been selected to



You'll find the pictorial and schematic diagrams helpful in putting the meter together. While V1 is shown here as a 12AT7 tube, your particular needs might call for a 12AU7 or a 12AV7, either of which can be used without circuit modification (see text). Parts list is at right.



permit use of several tubes with different amplification factors. If you customarily use a condenser enlarger, fast paper, and make relatively small enlargements, a 12AU7 will probably perform best. If you want more sensitivity because you use a diffusion enlarger, slow paper, and make big enlargements, you may need the greater amplification provided by a 12AT7. If neither of these extremes seems to fit your condition, a 12AV7 might be best. These three tubes can be used interchangeably without circuit modification.

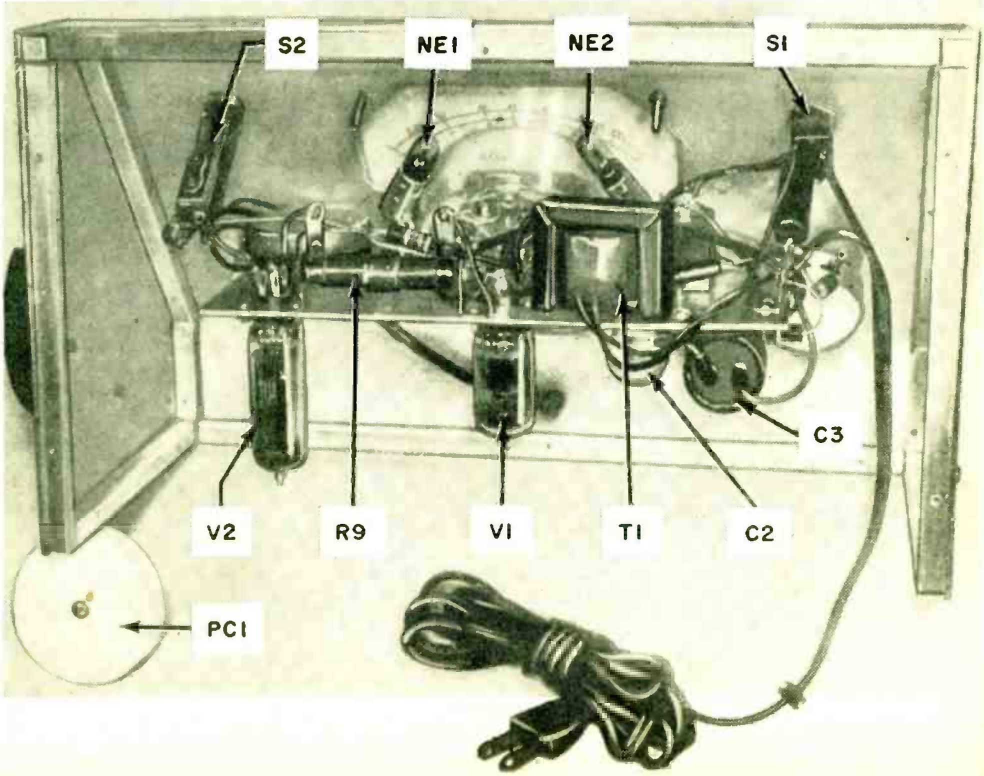
A large meter is desirable for quick and accurate readings and a plastic model can be easily illuminated for darkroom use. In the unit illustrated, the meter opening in the sloping panel cabinet is enlarged; so two neon lamps, mounted behind the meter, adequately illuminate the translucent meter scale. Neon lamps have the advantage of being non-actinic and will not fog enlarging paper.

The size of the cabinet is not critical and the wiring can be point-to-point, using a minimum of tie lugs. If a sloping-panel cabinet is chosen, the inverted chassis arrangement shown makes a compact arrangement possible with very short leads. To eliminate any possibility of shock, the cabinet and chassis are isolated from the circuit.

The light-sensing element is one of the relatively new cadmium sulphide photocells which has a very high dark resistance, decreasing rapidly as light intensity decreases. Such cells are very small, measuring ¼" in diameter and ½" long. This is important since we want to measure the intensity of a very small spot of light on the easel of the

parts list

C1—0.05-μfd., 400 volt tubular capacitor
C2—20-μfd., 300-volt electrolytic capacitor
C3a/C3b—20-20 μfd., 300-volt dual electrolytic capacitor
M1—0-1 ma., 4½" plastic rectangular meter
NE1, NE2—#51 neon pilot light
PC1—Cadmium sulphide photocell (Clairex CL-2)
R1, R2—27,000-ohm, ½-watt resistor
R3—27-ohm, 1-watt resistor
R4—1000-ohm, 7-watt resistor
R5—15,000-ohm, 1-watt resistor
R6—25,000-ohm, wire-wound linear potentiometer (Zero)
R7—100-ohm, wire-wound linear potentiometer (Range)
R8—24,000-ohm, 1-watt resistor
R9—10,000-ohm, 5-watt resistor
R10—1-megohm, ½-watt resistor
R11, R12—680-ohm, 1-watt resistor
R13—330-ohm, 1-watt resistor
R14—500,000-ohm linear potentiometer (Paper Speed)
S1—S.p.s.t. toggle switch
S2—D.p.d.t. toggle switch, spring return to center off (Cutler-Hammer or Switchcraft)
SR1, SR2—65-ma. selenium rectifier
T1—12.6-volt filament transformer (6.3 volts can be used by connecting one lead to pin 9 and the other to pins 4 and 5)
V1—Duo-triode tube (12AT7, 12AU7 or 12AV7—see text)
V2—OA2 tube



enlarger. Also, the resistance of the cell varies significantly and proportionately with light intensity at the low levels with which we are concerned.

Photocell *PC1* is mounted in the center of a wood or plastic disc 2" in diameter and slightly over ½" thick, with the leads soldered to a 3' length of insulated microphone cable connecting it to the instrument. The top of this block should be painted white so that the cell may be more easily centered in the correct position when determining an exposure.

Keep in mind that this is not a thinking, reasoning machine. It is subject to the same restrictions in use as the conventional exposure meter. Best results, therefore, will be secured by using the readings as indicators or guideposts and, where necessary, modifying them slightly to fit specific conditions.

With a perfectly exposed and developed negative, you can accept the readings as gospel truth. Suppose, however, you're working with a negative which was overdeveloped. It has clear shadow areas (in which you'll take your reading) but the middle tones and highlights are too dense. Exposing by meter reading will produce a light print. The same thing is true in reverse if you're working with a very thin negative. In both cases some interpretation is necessary.

calibration procedure

A trial run will show that the *Zero Control (R6)* gives adequate adjustment of the meter and that there is a response when the cell *(PC1)* is exposed to dim light. Now establish the two meter ranges. Remove the OA2 tube *(V2)* to isolate *PC1*. Turn the unit on and let it reach operating temperature. Turn the *Light Intensity* switch *(S2)* to *Low*, and with *R6*, adjust the meter to read some amount near full deflection, 90 for example. Then turn *S2* to *High* and adjust the *Range Control (R7)* to one-third of the *Low* reading (30). This will give you two exposure ranges, one being three times the other. Now replace *V2*.

Final calibration must be done in the darkroom. Select a negative of average contrast which will require an exposure as short as you customarily encounter. Run a series of test strips in the enlarger and determine exactly the correct exposure. Let's say you decide on 3 seconds. Warm up the unit and place *PC1* on the enlarger easel with the sensitive surface in a shadow area of the image. The brightest light on the easel (which is the shadow area of the picture) will give the most consistent readings. Throw switch *S2* to *High* and adjust the *Paper Speed Control (R14)* to provide full meter deflection. This point on the meter will be marked as 3 seconds on the new meter scale.

If full-scale deflection can be secured without approaching the lower end of *R14*, where the cell load would be too low to provide linear readings, you're all set. If this can't be done, you should substitute a new *V1* tube providing more amplification, or change the two scales to 2:1 instead of 3:1 by readjusting *R7*. If *R14* is extremely sensitive, it would be best to substitute a tube with less amplification.

Since the meter reading and the light intensity are directly related, one-half the light intensity giving full deflection should give one-half meter deflection, etc. Thus, if a 3-second exposure deflects the meter fully, a light intensity requiring a 6-second exposure should give half deflection and a 12-second exposure illumination should deflect the meter only to one-quarter of full-scale. Check this out with some additional test exposures. If it checks, the new scale can be made directly from the old one. If there is some variation from this ratio, the exposure times can only be established through the use of test strips and the meter scale made up accordingly.

The new meter scale can be drawn with India ink on a sheet of frosted $^1/_{16}$" plastic cut to the size of the regular scale, or on tracing paper covered with a sheet of clear plastic. Assuming that a calculated scale based on linear response will be essentially correct, multiply the exposure time established as producing full meter deflection by 100. This figure, when divided by any longer time interval, will give the percentage deflection for this time. Thus, if full deflection is 3 seconds, $3 \times 100 = 300$. Four seconds on the scale would be $300 \div 4 = 75\%$ deflection; 12 seconds would be $300 \div 12 = 25\%$ deflection, etc. These points are easily found since the meter scale generally has either 50 or 100 divisions, and the new translucent scale can be made as a simple tracing. The 2x or 3x range, of course, has the same scale points.

The setting of the *Paper Speed Control* should now be noted. This position of *R14* is the one which will always be employed with the particular paper used during this calibration. You can similarly establish a setting for different grades of paper.

With calibration completed, the correct exposure is as quick and easy to determine as placing the light cell in position on the easel and throwing a switch. As components age and sensitivity decreases, the calibration may require slight adjustment.

how it works

The heart of the circuit is a duo-triode tube *(V1)* connected in a balanced-bridge circuit similar to that used in a VTVM. This circuit is also called a difference amplifier. A meter *(M1)* is placed across the two anodes of the tube and a potentiometer *(R6)* in the meter circuit permits zeroing the meter. One triode section has fixed bias with resultant steady current flow, while the other section has a variable grid bias due to the action of a light-sensing cell *(PC1)*. The difference in plate current flow is very much greater than the difference in the bias voltages on the two grids.

A positive voltage, stabilized by a regulator tube *(V2)*, is applied through *PC1* to one of the grids of the duo-triode tube. When the cell is dark, its resistance is so great that it has little effect on the bias voltage; but when light strikes the cell, its resistance decreases, the bias becomes slightly less negative, and increased current flows through only this one section of the tube. This difference between the two sections is read on the meter which is calibrated in seconds to indicate proper exposure.

A filtered selenium-rectifier *(SR1-SR2)* voltage-doubler circuit supplies approximately 250 volts to the plates of *V1*, while *V2* limits the photocell to 150 volts. A potentiometer *(R14)* in the variable grid-bias circuit varies the load on the photocell so that its sensitivity can be varied to match that of different grades of photographic papers. Two exposure ranges are provided to cover a wide range of light intensities; this is necessary since meter response is essentially linear, varying directly with light intensity, which crowds the longer exposures onto the lower end of the meter scale.

Transistorized Slave Flash

by ***r. l. winklepleck***

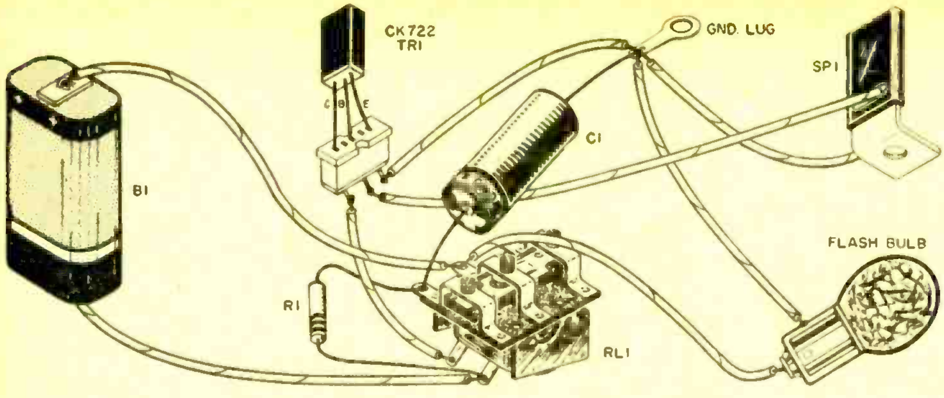
"Multiple flash" is a challenging expression to most amateur photographers. Every serious amateur knows that $99\frac{44}{100}$ % of the flash pictures he takes would be improved by using two or more flash bulbs for illumination. Books have been written expounding the theme of providing fill-in light. Nevertheless, most of us go right ahead using one bulb and getting the harsh, unflattering effect that is associated with flash.

It's a little hard to explain why multiple flash is generally ignored. Probably it's a case of following the course of least resistance. Extension flash is a nuisance with the long, trailing cords from the camera to each light. The "slave flash" is the answer to this entire problem, but most commercial slave units generally consist of a photoelectric cell, a vacuum-tube amplifier and relay to flash the remote bulb. They do eliminate the long cord from the camera to the remote flash, but the outfits are somewhat bulky and expensive.

Inexpensive transistors open up interesting possibilities in this field. The tiny transistor can do the amplifying job which formerly required a vacuum tube. Even more important, it can be operated from a small hearing-aid battery. The long extension cords are eliminated entirely. Couple the transistor with an equally small, self-generating, selenium sun battery and a miniature relay, and you have a very small, light, highly portable unit with no trailing cords. Clip it to or hang it on anything handy at the spot where you want the supplementary light to originate, and you're ready to shoot.

This very simple transistorized BC slave flash circuit is cheap and easy to assemble. The photocell can be salvaged from an old exposure meter or it can be an inexpensive sun battery now on the market. The relay may be purchased cheaply from surplus stocks or it may be a new unit especially selected for small size. All new parts can be used for a total cost of $8, exclusive of flash socket and reflector.

If the components are carefully selected for small size, everything can be easily as-



Pictorial view of the "Transistorized Slave Flash."

how it works

This circuit is designed so that the flash bulb is, in effect, the switch which turns the unit off and on. Until a live flash bulb is placed in the socket, the battery is completely isolated from both the amplifying and flashing portions of the circuit. Placing the flash bulb in its socket charges *C1* with current flowing from the battery through the bulb and resistor, but the rate of current flow is insufficient to flash the bulb. When light from the flash on the camera strikes *SP1*, it generates a small d.c. voltage which permits current to flow through the base-emitter circuit of transistor *TR1*. This current flow, in turn, permits a collector current flow, amplified 10 to 12 times, which is sufficient to operate relay *RL1* dependably. When the relay contacts are closed, the capacitor is discharged instantaneously into the bulb, causing it to flash.

sembled in a small aluminum box. The unit shown was built into a 5¼" x 3" x 2⅛" Minibox cut down to 2½" x 3" x 1¼". The sun battery is mounted inside the box behind an opening the size and shape of the sensitive surface. The socket-reflector assembly is rigidly mounted; although the sun battery must face the camera flash, you can clip the slave unit in place either right side up or inverted, depending upon whether it's to the right or left of the camera.

The transistor can be soldered directly into the circuit using a pair of thin-nose pliers between the transistor body and the soldering gun to drain away the heat. Hearing-aid battery (*B1*) can also be soldered in place, but a mounting clip is inexpensive and permits quick, easy replacement. Be sure to mark the clip with the correct battery polarity.

Some relay adjustment is required. When

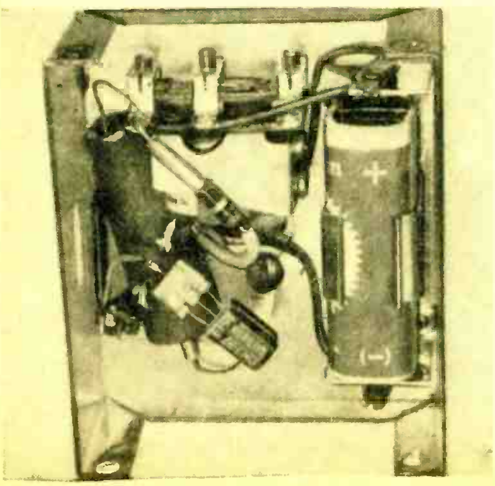
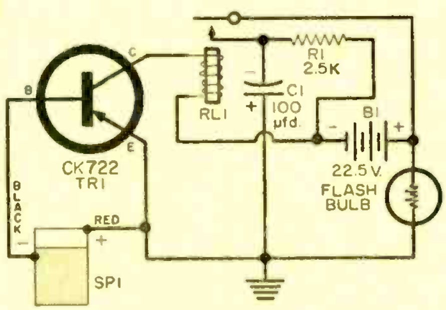


Photo showing all components wired in place.



schematic and parts list

B1—22½-volt hearing-aid battery
C1—100-μfd., 25-volt electrolytic capacitor
R1—2500-ohm, ½-watt resistor
RL1—Relay (Advance Type SO with 10,000-ohm coil)
SP1—Sun Battery (International Rectifier Corp. Type B2M)
TR1—Type CK722 transistor

construction is completed, short the flash socket with a wire and connect a voltmeter across the relay contacts. With the contacts open, a voltage reading will be noted. Adjust the gap between relay contacts to the minimum which will remain open when the unit is shaken.

Now expose the sun battery to the maximum light intensity it will encounter under normal operating conditions. If the relay contacts are still open, gradually reduce armature spring tension until the contacts close as shown by disappearance of a reading on the voltmeter. Tighten the spring very slightly until the contacts open.

At this setting, ordinary room lights should never flash a bulb accidentally, but the unit should be very responsive to the bright burst of light from the camera-mounted flash. (When placing a bulb in the socket, however, it's a good idea to keep your thumb over the photocell to prevent accidental discharge.) Disconnect the meter and remove the short. You're ready to go.

additional notes to camera fans

When similar flash bulbs are used in both the camera gun and the slave, they cannot, of course, reach peak brilliance at exactly the same time. Using Class M bulbs, for instance, which reach their peak light output 20 milliseconds (ms.) after the circuit is closed, the bulbs might peak 20 ms. apart plus the 2 to 4 ms. required for the slave circuit to respond.

Actually, with the relay carefully adjusted and the slave 10 or 15 feet from the camera, the two bulbs peak only 10 or 15 ms. apart, since the slave is generally actuated long before the camera bulb reaches peak output. This small difference is relatively unimportant since at 1/50 second the camera shutter is open for 20 ms., adequate to catch both flashes if the shutter is properly synchronized. However, if you are operating the slave at some distance from the camera and find you are missing the light from the slave, you might try a slower shutter speed.

In practice, it has been found very satisfactory to use a Class M bulb (20-ms. delay), such as a Press 25 or No. 5, on the camera and a Class F bulb (5-ms. delay), such as SF or SM, on the slave. This combination pulls the two flashes 15 ms. closer together and they peak almost simultaneously.

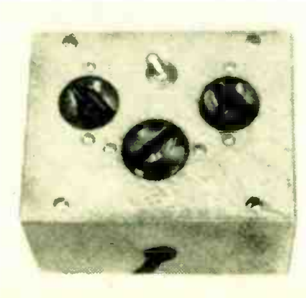
Dimmer Control for Photofloods

Amateur and professional photographers alike make extensive use of #2 reflector photofloods. If you do any portrait work, you will bless this little dimmer control a thousand times. It enables you to adjust your lights while they are generating only one-tenth of the heat that they produce at full brilliance. You can compose and focus without giving your subject a broiling infrared treatment.

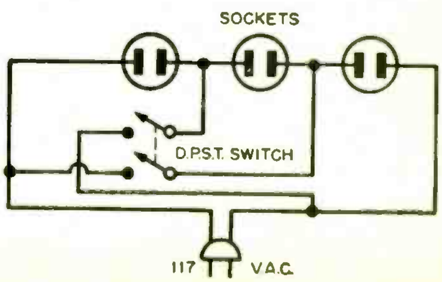
Dimming the bulbs will extend the life of your photofloods because the filaments are not allowed to go cold during a sitting. When cold, the resistance of a bulb is low, and the initial surge of current through this low resistance causes early burn-out.

Most photographers prefer three photofloods for portrait composition. Three receptacles are provided on the control box, one for each of the floods. With the toggle switch in one position, the lamps are all in parallel to produce full brilliance; in the other position of the switch, the circuit is converted to series connection. In this condition, only one-third of the normal current flows through each lamp.

Interconnecting wires between receptacles and switch must not be smaller than #18 gauge and should be tinned for easy soldering. The line cord carries the full load—almost 15 amperes in the parallel connection—and so must not be smaller than #14 gauge. The toggle switch must be capable of carrying 10 amperes.

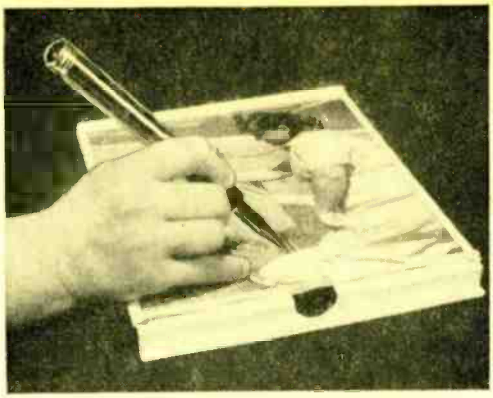


Parts are mounted on Minibox.



Schematic of dimmer control for photofloods.

Photographer's Electric Pencil



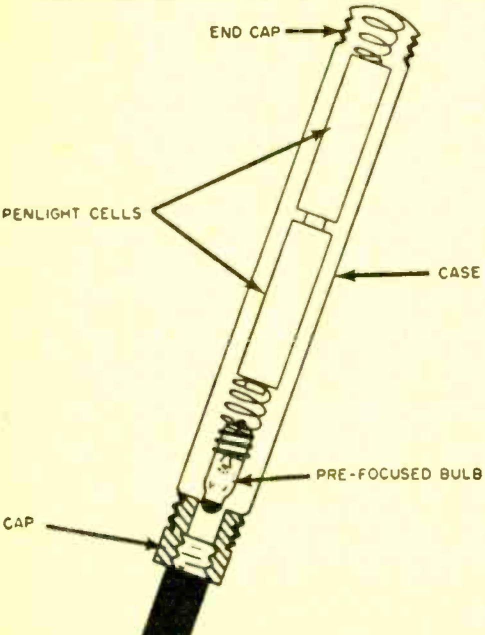
by *louis e. garner, jr.*

With an inexpensive electric pencil you can make your signature a part of your photographs. You can also use it for simple retouching jobs. Approximate assembly details are shown in the cross-sectional sketch. The model in the photograph was made up from a "radiator inspection light" picked up at a local auto supply store: this is essentially a standard penlight equipped with a curved Lucite rod to conduct light "around corners."

To make up the electric pencil, cut off the curved portion of the plastic rod with a small hacksaw and shape the remaining straight portion to a pencil-like form, using a small file and a pencil-sharpener.

For good results, it is extremely important that the tip of the "pencil" be properly shaped . . . *it must end in a flat surface,* though the area covered can be very small. The actual size of the tip will determine the size of the "line" which can be drawn. A small, flat, fine file is useful for shaping the tip.

With the Lucite rod properly formed, coat all of the rod except the extreme working tip with an opaque or deep red lacquer. Deep red fingernail polish is good for this operation. Use at least three heavy coats, allowing the lacquer to dry between each coat.



If you are unable to obtain a "radiator inspection light" as described above, you can assemble your electric pencil from a standard penlight and a short (3") length of Lucite rod.

Using the pencil, you can write with light, exposing undeveloped photographic paper to the pinpoint of light radiating from the flat working tip of the instrument. Thus, the "pencil" line becomes black when the paper is developed.

For proper results, it is important that only the paper directly beneath the working tip be exposed.

Hold the flat working tip against the paper at the point where you want to start writing. Switch the "pencil" on, taking care not to tilt the point. Trace out what you want to write on the paper, then switch the instrument off *before* lifting the tip. The speed at which you move the tip across the paper will determine exposure.

For retouching, you can work with the image projected by your enlarger. First expose the paper in the usual manner. Then move the red safety filter on the enlarger into position and use the pencil to retouch the faint image.

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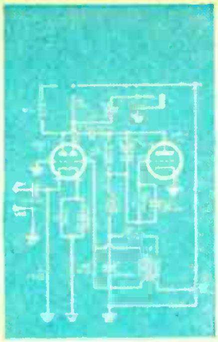
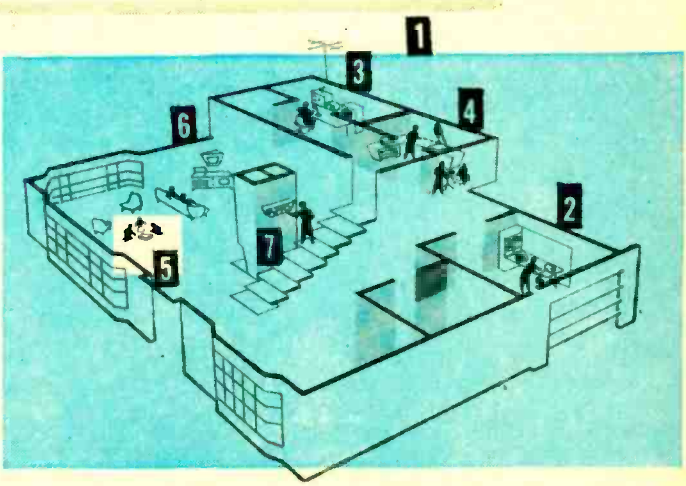
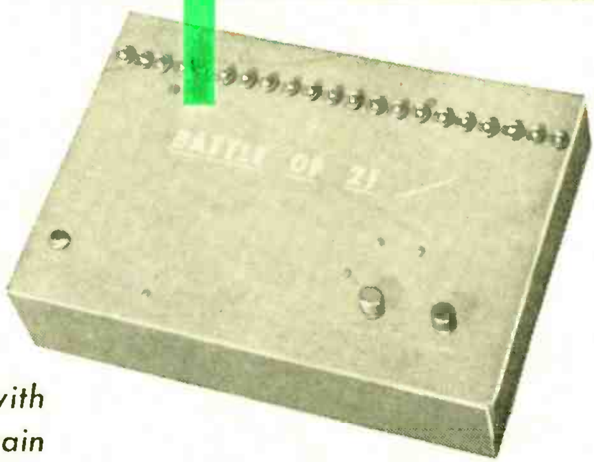


Section 5

for your children



Build the Challenger



and match wits with an electronic brain

by ***harvey pollack***

This machine is a rudimentary computer—complete with a built-in program. It challenges all comers to a battle of wits in a game of numbers. Regardless of whether the player or the machine starts first, the object is not to be trapped into lighting the last—or the 21st lamp. The machine and the player are permitted to light one, two or three bulbs during each turn. The machine and player alternate turns, just as if the player had challenged a "human."

It's fun to play and puzzling in a delightful sort of way the first few times the machine beats you, but then you begin to realize you've got to *think* to outwit the computer. How long it will take before you get the combination is up to you. It's not like taking candy from a baby.

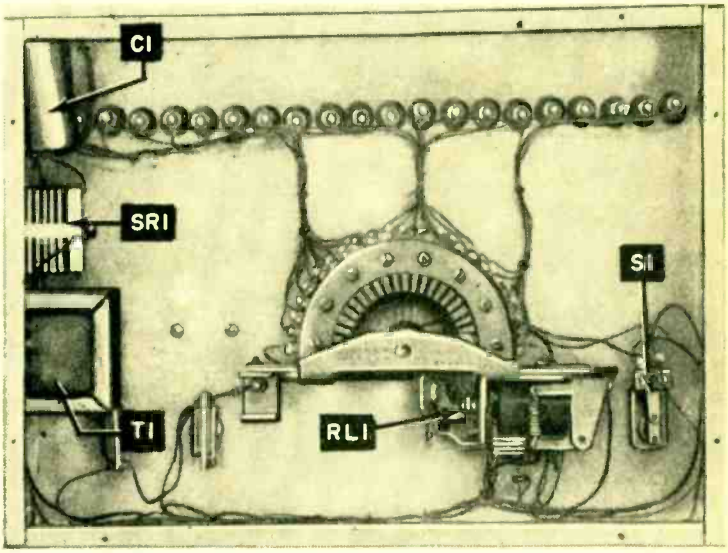
Go ahead and cheat! Just try it. Even if you do, the machine will beat you—unless, of course, you solve the "program."

two versions

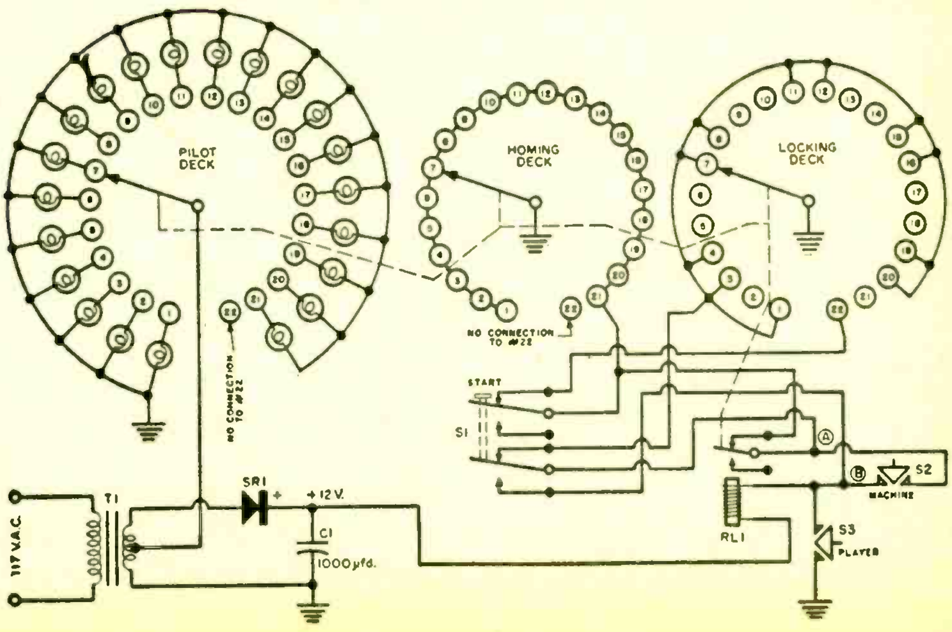
There are two versions of this game. The simpler one should be assembled first. You can then add the remaining parts for the de luxe model if you wish.

In the basic unit, the player must "advise" the machine that its turn has come by pressing the *Machine* button after he has made his move. Either the player or the computer may go first. In the de luxe model, an automatic response circuit makes it unnecessary to use the *Machine* button. It is operated only when the player decides that the machine is to make the first play. After the player has pressed and released his push button, he waits three or four seconds while the machine "thinks" over its strategy, makes its decision, and then waits in turn while the player cudgels his brains to select the next move.

In either model, the game may be interrupted in mid-play to allow the player to start afresh. Operating the *Start* button causes the computer relay to "home" automatically for a re-play.



Basic computer assembly (photo at right) is shown with baseplate removed. Schematic of basic game is shown below and parts list is given on page 104.



basic construction

The model was built on a 10"x14"x3" aluminum chassis. A bottom cover makes it tamperproof. The pilot light bulbs are friction-fitted in rubber grommets. Mount the relay and switches as shown in the photos.

Now hold the relay (*RL1*) so that the coil and spiral spring are on the right side facing you. The terminals will then lie along a semi-circle pointing upward. In this position, the first terminal at the extreme right is the wiper for each deck. The next one up is terminal number 1, then 2, 3, etc. The last terminal on the extreme left is 22.

Of the five relay decks, you use only three. The top one is the pilot light deck and is wired after all other parts are in place. The third deck is for "locking" and should be wired so as to prevent contact of the wire with other terminals. The fifth deck is the "homing" section; terminals 1 through 21 are joined together by a single piece of uninsulated tinned wire spot-soldered to each lug, one after the other. Terminal 22 is left unconnected.

The wipers of the "locking" and "homing" decks are joined by a short jumper and a lead brought out from the common connection for later soldering to a ground (chassis). Solder the wiper of the top ("pilot") deck to a long insulated lead for connection to the center-tap of *T1*.

Cut 21 holes for the pilot lamps with a ½" twist drill. Grommets (½" O.D., ⅜" I.D.) are then forced into the holes. Later on, the pilot lamps will be pushed into place in these grommets. No sockets are used since all connections are made directly to the lamp bases by spot-soldering. Group the 12.6-volt transformer, 500-ma. selenium rectifier, and 1000-µfd. capacitor near each other. The push buttons labeled *Player* and *Machine* should be placed so that they will be easy to operate while the *Start* button is best positioned out of the way where it will not be pressed inadvertently.

Before you begin final wiring, identify the normally closed armature contacts on the stepping relay; also find the coil terminals and remember their location. Operate the relay manually by squeezing down on the armature while you observe the stepping action. Watch how the armature contacts break on each step because this will help you identify the correct terminals.

testing the machine

First check the *Player* button action. With power applied, the light should advance to the right one lamp at a time for each operation of the *Player* button. Check the entire string to be sure that all the lamps are working. If the light does not advance at all, test for B+ at the output terminal of the power supply; the reading here should be between 9 and 12 volts. Check to see that the same voltage appears across the relay coil when the *Player* button is held down.

Then test the *Machine* button action. Each time this button is depressed, the machine should advance the lamps in the sequence shown in the table. Start with all lamps off. Should you find that this sequence is not followed, you may be sure that some part of the wiring of the "locking" bank is incorrect. You may have joined terminals which should not be connected or you may have omitted one or more joints.

Finally, test the *Start* button action. Advance the light to the first lamp using the *Player* button. Now press the *Start* button. You should hear a whirring sound accompanied by a sequential flashing of the lamps from 1 through 21, each lamp lighting briefly as the pulse is automatically transferred from one relay contact to the next. The light should proceed all across the panel but should stop after lamp 21 has lit and extinguished. If this action is not obtained, check the wiring of the "homing" deck

parts list

Basic computer parts list. Parts list for the auto-response circuit is on page 107. The auto-response unit enables the machine to move automatically after each player makes his move.

C1—1000-µfd., 15-volt tubular electrolytic capacitor (C-D Type BR-10001)
RL1—Self-pulsing-type stepping relay, 22 positions, 5 decks, 6-12 volt coil (Type SS-6, available from Lafayette Radio)
S1—D.p.d.t. push-button switch, spring return (Switchcraft #1006 or equivalent)
S2, S3—Push-button switch, spring return, used on s.p.s.t. normally open (Lafayette Type 127-76 or equivalent)
SR1—120-volt, 500-ma. selenium rectifier
T1—Filament transformer, 117 volts to 12.6 volts @ 2 amperes (Stancor Type P-8130)
1—10" x 14" x 3" aluminum chassis
1—10" x 14" aluminum bottom plate for chassis
21—6.3-volt pilot lamps (Type #47)
21—⅜" I.D., ½" O.D. soft rubber grommets

and make sure that all terminals except 22 are joined together. Trace the lead from the wiper of the "homing" deck to be sure it goes to the back or normally closed contact of the armature. In addition, check the connections to the *Start* button since these must be right if proper homing action is to be obtained.

sequence of lights

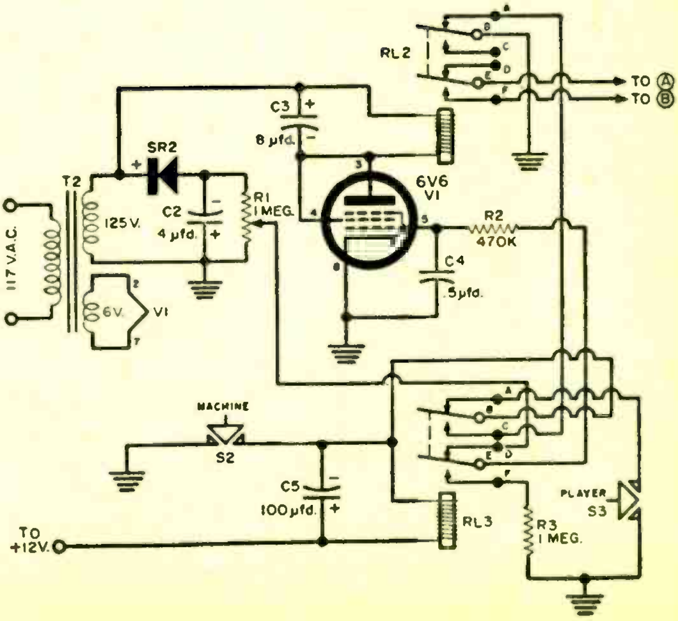
operation number:	1	2	3	4	5	6	7	8	9	10	11
light stops on lamp number:	2	4	5	8	9	12	13	16	17	20	21
light skips by lamp number:	1	3	0	6,7	0	10,11	0	14,15	0	18,19	0

automatic response panel

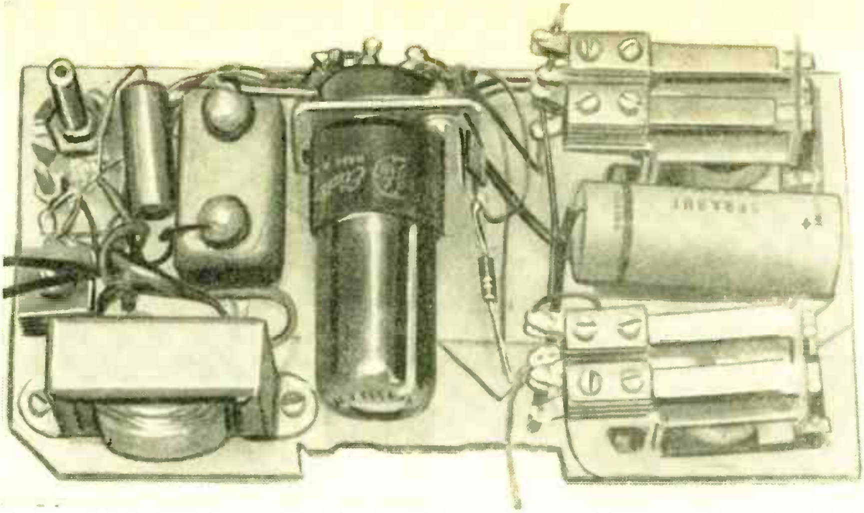
Although your family and friends can have loads of fun with the machine set up in this simple form, the action becomes uncanny when the automatic response panel is added and the computer reacts automatically after each player moves. The auto-response section is simply an ingenious timing circuit.

Layout of the timing parts is not critical. All the wiring is completed before the panel (see photo) is mounted in the machine base. Wire leads (color-coded) of sufficient length are brought out during wiring for later connection to the main circuit.

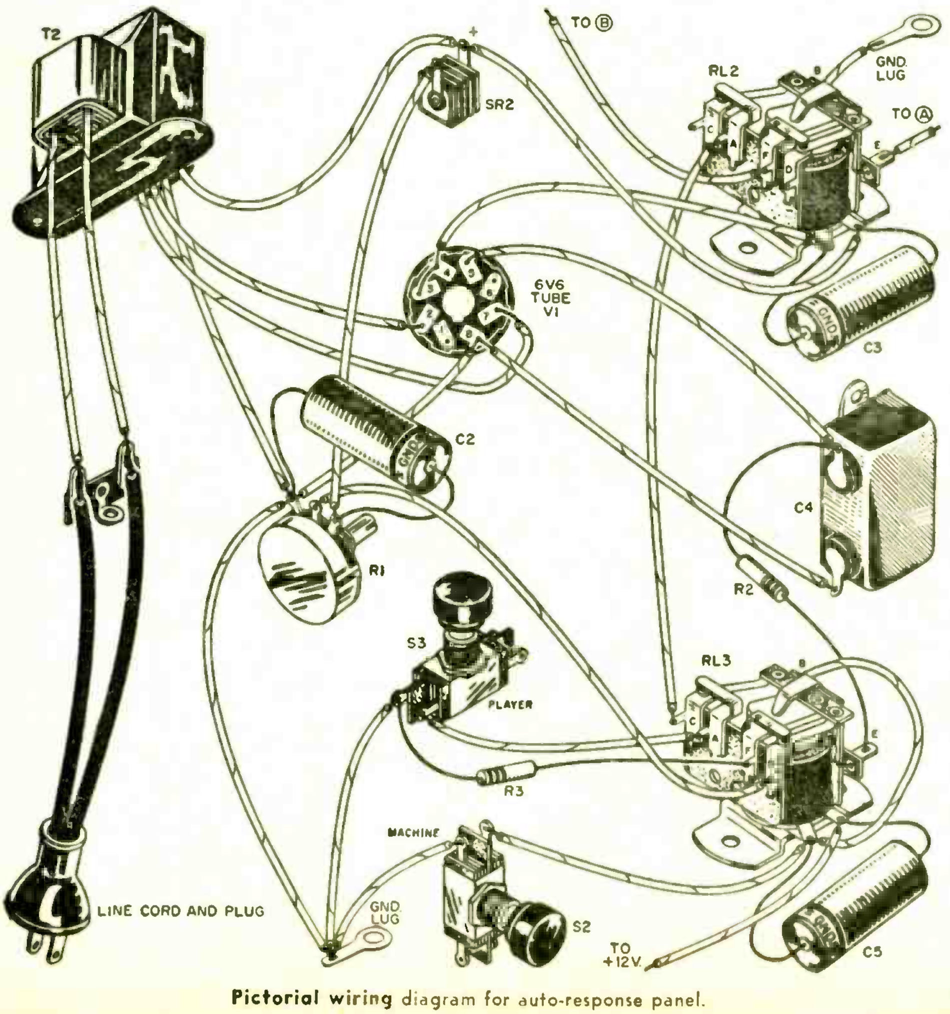
Only two minor changes in the computer wiring are necessary when you install the auto-response panel: (1) disconnect the wires from points Ⓐ and Ⓑ on the *Machine* button and reconnect these wires to points Ⓐ and Ⓑ on the auto-response panel, leaving the *Machine* button free of wires at this point; and (2) connect either side of the *Machine* button to chassis ground and the other side to the negative end of the 12-volt relay coil (*RL3*).



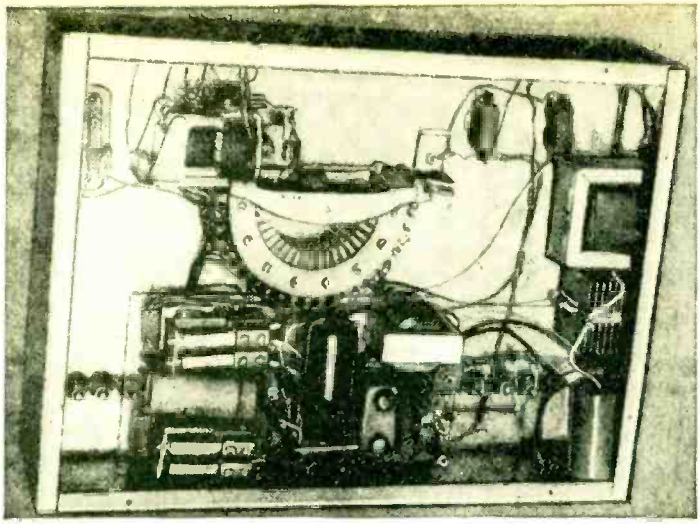
Schematic diagram of auto-response circuit. Placement of parts is shown on the following page. List of component parts is given on page 107.



Recommended placement of parts in auto-response panel.



Pictorial wiring diagram for auto-response panel.



Underside of "Challenger" game with auto-response circuit in place. All wiring on subchassis is completed before unit is installed in cabinet.

parts list for auto-response panel

C2—4-μfd., 150-volt tubular electrolytic capacitor
C3—8-μfd., 150-volt tubular electrolytic capacitor
C4—0.5-μfd., 400-volt paper capacitor, bathtub type
C5—100-μfd., 150-volt tubular electrolytic capacitor
R1—1-megohm linear taper potentiometer (Mallory U-59)
R2—470,000-ohm, ½-watt carbon resistor
R3—1-megohm, ½-watt carbon resistor
RL2—D.p.d.t. relay, 5000-ohm plate circuit type (Guardian Series 200 or equivalent)
RL3—D.p.d.t. relay, 12-volt d.c. coil (Guardian Series 200 or equivalent)
SR2—117-volt, 65-ma. selenium rectifier
T2—Power transformer, 125-volt secondary at 30 ma., 6.3 volts at 0.6 ampere (Olsen Radio Warehouse Type T-173; Stancor Type PA-8421 is also suitable)
V1—6V6 tube
1—Octal socket
1—4" x 6" panel, ⅛" thick (polystyrene, Bakelite, wood, or Masonite)

adjustment of timing

Timing of the machine's response is controlled by the setting of potentiometer *R1*. Allow the unit to warm up and then rotate *R1* until you see relay *RL2* pull in. Back off *R1* until the armature releases in a positive manner, and leave it this way.

To check the operation of the auto-response section, advance the light to any position by pressing the *Player* button three times. On the very first operation of the *Player* button, *RL3* should instantly pull in and latch for about four seconds. At the end of this interval, *RL2* should pull in, advance the lights according to the machine's choice, then quickly drop out. In addition, as *RL2* is activated, *RL3* should instantly drop out, completing the cycle.

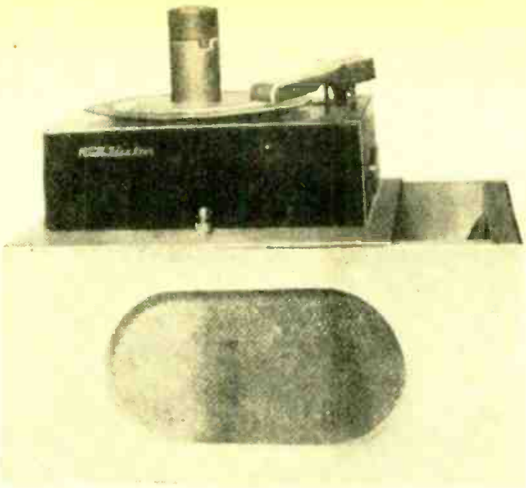
If the machine tends to react too soon after the player's move, the timing interval may be lengthened by adjusting the setting of *R1*.

auto-response circuit

With the *Player* button up in its normal position, *C4* in the grid circuit of *V1* charges negatively on the grid side via the wiper of *R1*, contacts D and E of *RL3*, and through *R2*. This keeps the plate current of the tube at cutoff so that *RL2* is not energized. *RL3* is also de-energized because current cannot flow through its coil while the *Player* button is released.

When the *Player* button is depressed, current flows through the coil of *RL3* to contacts A and B, thence to ground. As *RL3* pulls in, it latches closed due to the continued current through the holding contacts B and C of *RL3* and A and B of *RL2*. When *RL3* pulls in, however, contacts E and F connect the top of *C4* to ground through *R2* and *R3*, causing it to discharge slowly. When the grid potential of *V1* loses enough of its "negativeness," plate current flows through the coil of *RL2* and energizes it.

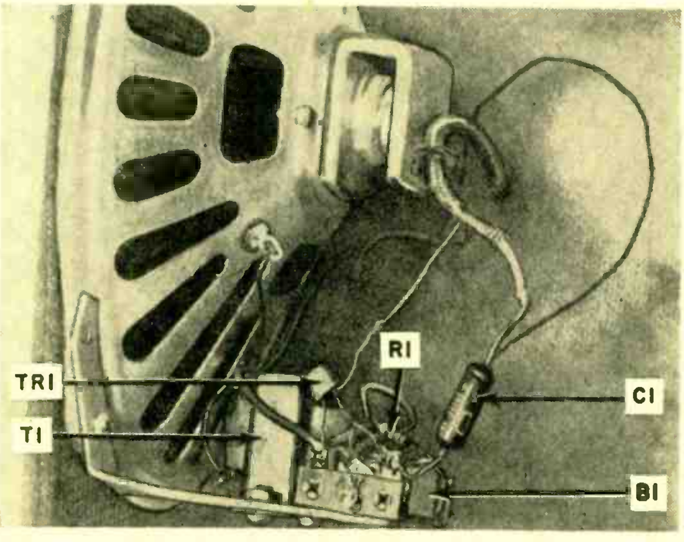
Contacts E and F of *RL2* now operate the machine just as though the *Machine* button had been depressed. At the same time, contacts A and B on *RL2* open up and release *RL3*. A fraction of a second after this release, *C4* again charges to cut-off through contacts D and E of *RL3*, causing *RL2* to open and stop the machine's play. The charging rate of *C4* which restores the cutoff condition is intentionally slowed down slightly by including *R2* in the charging path; this gives *RL2* enough "down time" to complete the machine's move. With the release of both *RL2* and *RL3*, the timing cycle is complete.



by **homer davidson**

ONE Transistor Record Player

Probably the simplest phonograph amplifier ever designed, this *one*-transistor job serves to drive a full 6" x 9" oval speaker. It uses only six components in addition to a standard transistor. You should be able to complete construction in one evening, and there should still be time left over for a couple of hours of TV and a short beer (or long coke).



No volume control is included or necessary in the amplifier shown here. The transistor used may be a CK722, 2N107 or equivalent. The shielded phono lead connected to C1 has its shield grounded to the speaker frame.

The changer used is the same compact *RCA* 45-rpm unit featured in previous construction articles. Costing little more than the price of a separate tone arm, turntable and base, its changing action is almost a free bonus.

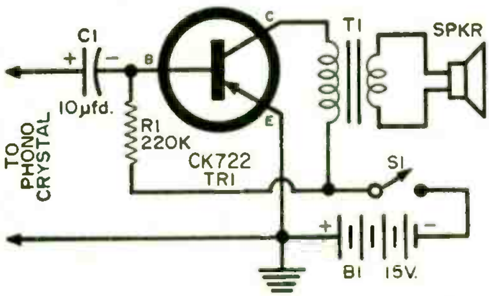
The high output (at least two or three volts) of the original crystal in the tone arm serves to drive the CK722 to an output adequate for quiet listening, but it won't shake the rafters. Don't expect to blast the windows out with this little job. If more power is required, you can try the "Picnic PowerAmp" circuit on page 14.

Any phono player can be used with this midget amplifier. However, the cartridge should be one of the high-output types, such as the *Lafayette* PK-90, *Ronette* TO-222, or *Astatic* L12, having at least a 2-volt output. On the other hand, too high a voltage may overload the transistor.

The amplifier chassis holds the output transformer and the battery clip. The other small components are wired by their leads into the circuit. As no socket is used for mounting the transistor, be very careful when soldering its terminals to the other components. The amplifier is mounted by the same bolts which hold the loudspeaker to the front panel.

A homemade cabinet houses the amplifier as shown. Common pine was used for the sides and cut to the correct dimensions. The oval speaker hole in the front panel was sawed with a jigsaw. One side of the base was designed as a record holder—a dozen records can be stored.

Operation of the unit is simplicity itself. But check the wiring several times before throwing the toggle switch. Be sure that the small battery is placed into the holder with the correct polarity. Then throw the toggle switch and slowly rub your fingers over the needle. A scratching sound should be heard. Place a record on the turntable, and your player is ready to go.



Note the simplicity of the phonograph amplifier circuit. The tap on the secondary of the output transformer should be selected for highest volume.

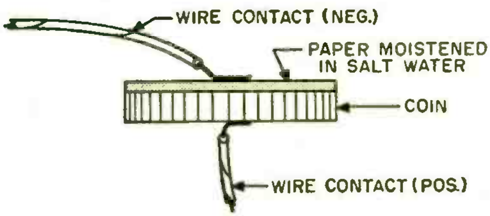
parts list

B1—15-volt, miniature B battery
C1—10-µfd., 15-volt electrolytic capacitor
R1—220,000-ohm, ½-watt carbon resistor
S1—S.p.s.t. toggle switch
T1—Universal output transformer (Merit A 2900 or Stancor A 3822)
TR1—CK722 transistor (Raytheon)
SPKR.—6" x 9" oval PM speaker

how it works

The high output of the crystal cartridge in the phono player is fed through the 10-µfd. capacitor (*C1*) to the base of the transistor. The universal output transformer is connected to the collector terminal with one side of its primary tied to the negative side of the battery supply. The secondary winding of the output transformer is tapped and the connection providing the best impedance match should be used.

Coin-operated Oscillator

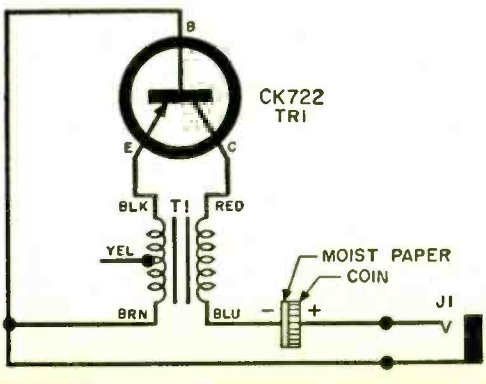


In these days of rising costs, it's hard to get something for nothing. However, Uncle Sam makes you a present of a free battery every time you change a dollar bill.

Take an ordinary piece of white paper and moisten it with warm salt water. Hold it in place on one side of a silver coin with a rubber band, and you've got a battery powerful enough to drive a small transistor oscillator (see schematic at right) or receiver. Transformer *T1* is an Argonne AR-103. The contacts of the coin should be made according to drawing below. Use 2000-ohm headphones.

For best results, the coin should be clean and shiny. The negative end can be held to the wet paper with a rubber band. This type of battery will remain effective as long as the paper is damp.

A dime will deliver 0.5 volt at a current of 50 µa., enough for the oscillator. A quarter will give a bit more voltage at double the current, and a half-dollar will deliver 0.7 volt at 125 µa. Place cells in series for higher voltage. —*William I. Orr*



Home-Built
Model Spaceship

by l. e. garner

ionic drive is demonstrated by high-voltage generator

When men first stood in the night, looking up at the starry sky, ignorantly marveling at its ever-changing, endless mystery—that was the beginning of all science. Astronomy, the oldest of sciences, has always inspired dreams about travels to the moon, to Mars, Venus, and even beyond the planets to distant stars.

Modern technology has transplanted interplanetary travel from the world of dreams to the realm of mathematical calculation and even the engineer's drawing board. Travel to planets within the solar system now seems a sure bet.

interstellar distance

But it's a long way between the stars. On Earth, the mile is a convenient unit. A short voyage may be only a few miles—a longer one, hundreds or even thousands of miles. The distance completely around the Earth is about 25,000 miles.

When we start dealing with the distances between the planets, however, we find that the mile is a rather poor yardstick—distances here are measured in the tens or hundreds of millions of miles. At its closest approach, Mars, for example, is 36 million miles away from Earth. Venus, our nearest planetary neighbor, at its closest point is 26 million miles away.

Distances between stars are generally measured in light-years. A light-year is the distance light can travel in a period of one year—at a speed of approximately 186,000 miles per second, or nearly six million million (6,000,000,000,000) miles. And the nearest star, other than our Sun, is approximately four light-years away!

Such distances raise special problems. Travel in spaceships powered by conventional rockets is impractical because of the fuel loads needed. For example, suppose we had a ship capable of the (today) fantastic speed of 100,000 miles per hour. Such a ship could make the trip from here to the moon and back in about five hours. Yet it would require over 27 thousand years to reach the nearest star.

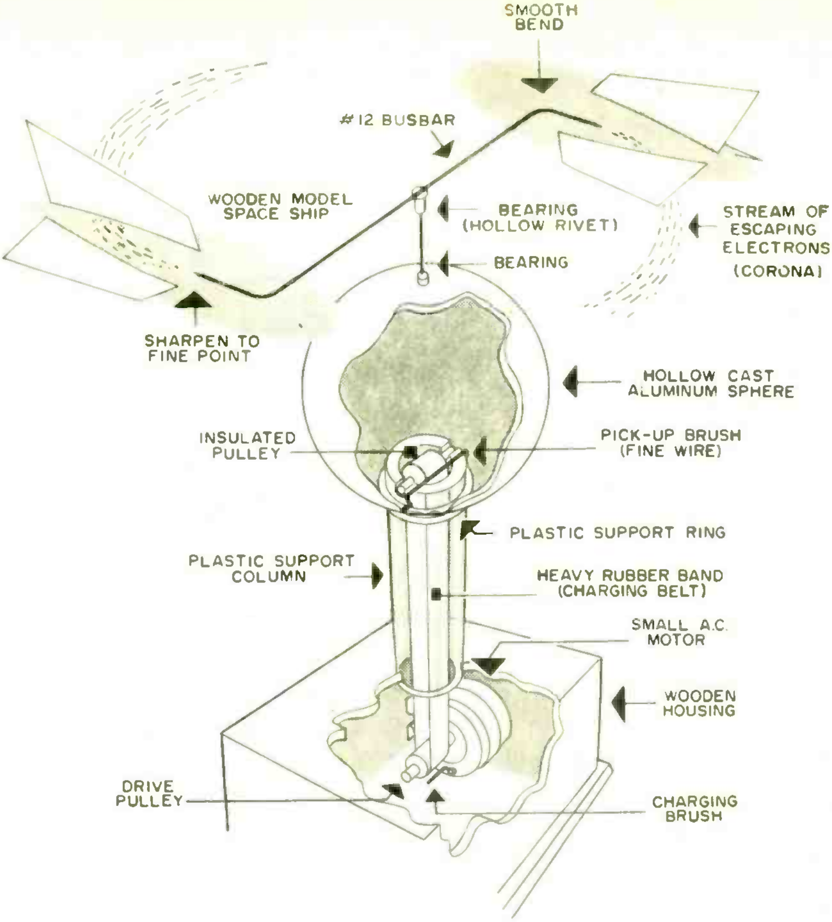
A radically new principle was needed to push our future spacecraft. To go from star to star and complete the trip in a human lifetime, we must develop some transportation close to the speed of light. Such velocity can be attained with a new type of motor, called the *ionic drive reaction motor*.

build it yourself

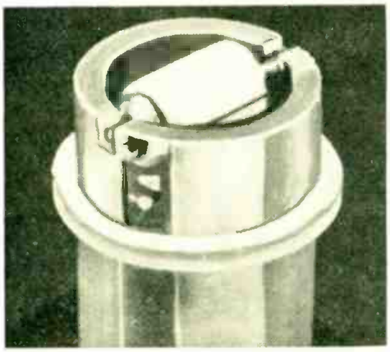
The basic principle of an "ionic drive" reaction motor—that of producing motion by the reaction of an accelerated stream of charged particles—can be demonstrated quite easily in the home. If you wish, you can even assemble your own model spaceship. A "working model" is easy to build.

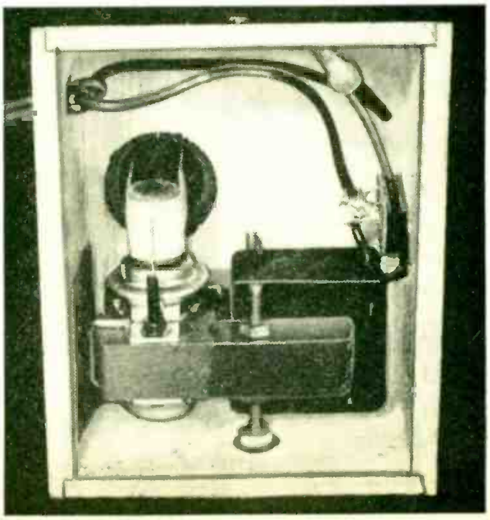
The first thing you'll need is a safe source of high voltage. An Atomotron electrostatic high voltage generator* is suitable and is completely safe to operate, even though

* Available both in kit form and factory-assembled. It may be ordered directly from the manufacturer, *Atomic Laboratories*, P. O. Box 343-C, Berkeley, Calif. It may also be obtained from some jobbers and distributors, e.g., *Lafayette Radio*, 165-08 Liberty Ave., Jamaica 33, N. Y.



Exploded view of model spaceship showing construction details.





The photos above and at right show both ends of the Atomotron's charging belt. See exploded view of model for construction details. Ionic or corona discharge from the sharpened points of the support rod makes the model spaceship revolve rapidly around hollow aluminum sphere.

it may develop voltages on the order of 50,000 to 75,000 volts. Its operation is very similar to that of the early "atom-smashers." The Atomotron consists of a metal sphere about 2" in diameter and insulated above "ground" by a plastic support column. An insulated pulley is mounted at the inside top of the column. At the bottom of the column, a small a.c. motor has another insulated pulley attached to its drive shaft. A rubber belt is affixed between the two pulleys. Small brushes of fine wire are mounted close to the belt. One is mounted at the top and connects to the metal sphere. The second is mounted at the bottom and connects to the motor's frame.

As the motor moves the belt, it picks up a minute electrical charge from the lower brush and transfers it to the upper brush, where the charge accumulates on the metal sphere. The charge on the sphere is built up, bit by bit, until the static voltage between sphere and "ground" is 50,000 to 75,000 volts.

assembling the spaceship

A piece of #12 busbar serves both as the support rod and as the reaction motor. The length is not especially critical—4" to 6" is fine. Form a smooth right-angle bend at each end of the wire, with the bends facing in opposite directions. Use approximately a half-inch of wire for each bend. Both bends should be of equal length.

After forming the bends, use a flat ignition file to shape the two tips to needle points. The support rod is completed by soldering a small rivet to its *exact center*, with the rivet at right angles to the two bends in the wire.

You can make the model spaceship from a piece of dowel or balsa wood approximately ¼" in diameter and 1½" long. Two are needed. Form them to the characteristic torpedo shape with a pocket knife, small file, and sandpaper. Cut a small groove in one side of each ship just wide enough to permit a force fit on the bent ends of the support rod.

The only other thing you'll need is a small bearing to support the entire assembly on the metal sphere of the Atomotron. You'll find that the sphere has a small hole in its top. Select a small nail that just fits this hole and cut off its head with a pair of wire cutters. Sharpen and smooth the nail's point with a small file.

Try the nail in the hole. If it tends to slide through, you can add a small "shoulder" half-way along its length by wrapping on several layers of Scotch tape.

For final assembly, place the nail in the hole of the Atomotron's metal sphere, point upwards. Then place the spaceship assembly on top of the nail, with the small rivet serving as a bearing. Check the balance of the assembly.

"launching" the craft

To operate your completed model ionic drive spaceship, simply switch the Atomotron on and, as the voltage accumulated on the metal sphere starts to build up, the assembly will start to rotate. It will pick up more and more speed as a result of the reaction to an escaping stream of charged particles (electrons) from the sharpened points of the busbar support rod. This electrical discharge is also called a *corona discharge* and is sometimes encountered in the high-voltage section of TV receivers.

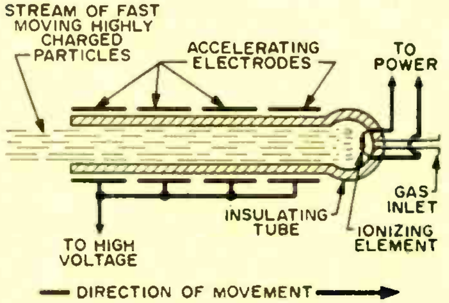
ionic drive

To increase the rate of acceleration of a spaceship, we must develop more thrust in its drive motor. In a reaction motor, we can do this by increasing either the volume (mass) or the speed of the exhaust—or both.

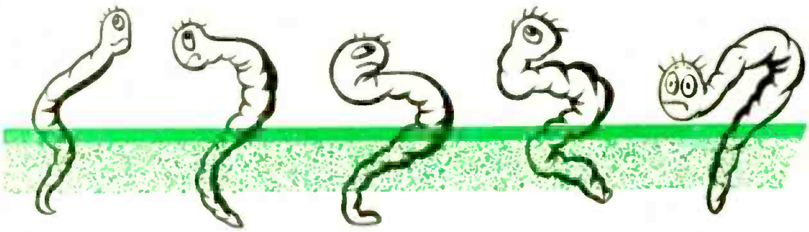
But if we increase the mass of the exhaust, we will use fuel much more rapidly—an undesirable condition, since the greater mass of a typical rocket is already made up in fuel load. The alternative is to increase the exhaust speed—preferably to a velocity approaching that of light.

In giant "atom-smashers," such as cyclotrons, betatrons, etc., charged particles (ions) can be accelerated to velocities close to that of light through the action of electric and magnetic fields. It follows, then, that we should be able to build a rocket motor utilizing accelerated ions instead of a chemical explosion. One possible form of such an ionic drive motor is shown at the right.

In operation, gas atoms are introduced into a chamber where they are ionized by an electric filament. These particles then are accelerated in a steady stream by a series of electrodes carrying high voltages—much in the same manner that the electron beam in a TV cathode-ray tube is accelerated forward to strike the fluorescent screen.



Don't Dig Those Crazy Worms



You can save your back as well as your buck and get fresh worm-bait with no digging and no great expense by using one of the electronic "Worm-Turners" described here. A worm-turner warms the worms—in fact it makes things so hot for them that they quit their earthy diggings and sidle right to the surface where you can snake out an eager hand and scoop 'em up at will. The ladies giggle, the worms wriggle—and you'll have all the fish-bait you'll need.

Before you conclude that your editorial staff has blown its collective cork, take a look at the photos and diagrams shown here. You'll admit there's a new angle for an old angler, and if you'll pardon our puns, you'll see that it's more fun and a lot easier to dig these simple circuits than to break soil as a preface to summer fishing.

All you need is a lawn and a 115-volt a.c. power source. When current from this source passes through a ground probe, the worms in the area of the probe will crawl to the surface. It is assumed that the worms experience a mild shock caused by the IR (voltage) drop in the earth. Regardless of the reason, this method will bring worms to the surface in a jiffy.

worm-turner no. 1

by r. wayne crawford

The safety factor is the biggest problem involved in the use of house current. One side of the a.c. line is "hot" to ground. Obviously, if this side of the line were grounded directly, the house fuses would blow. The circuit used here limits the current flow through the probes. The entire unit is built in a 3" x 3" x 5" wooden box; wood was used in this case because of its insulating properties.

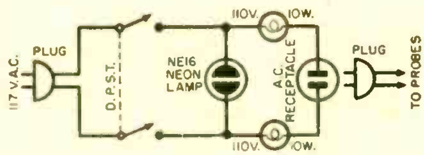
When the d.p.s.t. switch is in the "off" position, both sides of the a.c. line are open. The purpose of the 10-watt lamp bulbs is to limit the current through the ground probes. The neon lamp lights when the switch is in the "on" position, indicating that the probes are "hot." Use of a lamp in series with each line eliminates the problem of trying to identify the "hot" line.

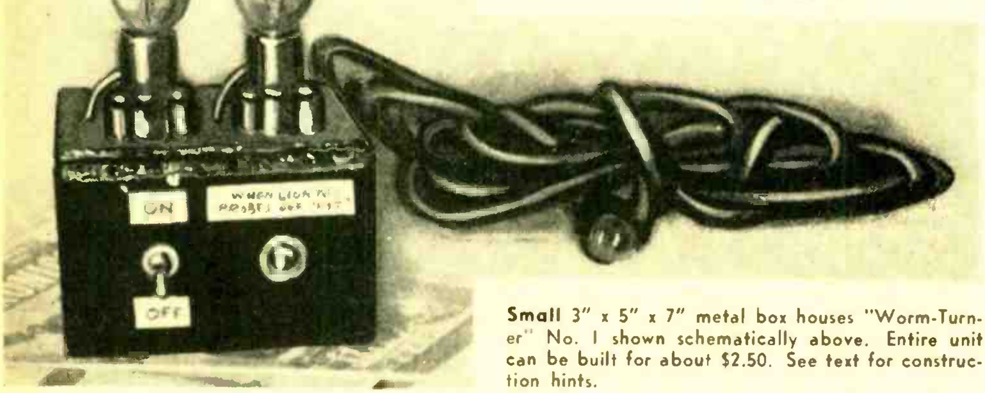
The probes can be constructed from any fairly stiff, thin, metal rod. The writer used two wire coat hangers with the enamel sanded off. Each probe should be about 15" long. One end of each probe should be filed to a point and a 10' or 12' length of rubber insulated wire soldered to the other end. About four inches from the soldered joint, make a 90° bend in the rod. Wrap this section well with rubber tape. It will serve as a handle for forcing the probe into the ground.

A standard a.c. plug and receptacle may be used to attach the wires from the probes to the unit. Connect the unit to the power source with a rubber-covered line cord. A long cord will give you greater freedom of movement about the lawn.

To use this worm-turner, push the probes into the ground to a depth of a foot with the two probes approximately three feet apart. Turn the switch to the "on" position. If the moisture content of the earth is about average, one of the lamps should light. Within a few minutes the worms will start crawling out of the ground in the area of the "hot" probe. When you find that no more worms are crawling to the surface, turn the unit off and move the probes to another location. *Don't take any chances by moving the probes when the unit is turned on.*

If the earth is exceptionally dry, water a section of the lawn before starting. The current flow will now be greater between the two probes and, since the lamps are in series, it may be necessary to use larger wattage lamps to obtain satisfactory results.





Small 3" x 5" x 7" metal box houses "Worm-Turner" No. 1 shown schematically above. Entire unit can be built for about $2.50. See text for construction hints.

worm-turner no. 2

by j. e. pugh, jr.

Worm-Turner No. 2 also depends on a surge of a.c. through the ground to jolt the worms to the surface. Details on its construction may be seen in the accompanying photos and diagram.

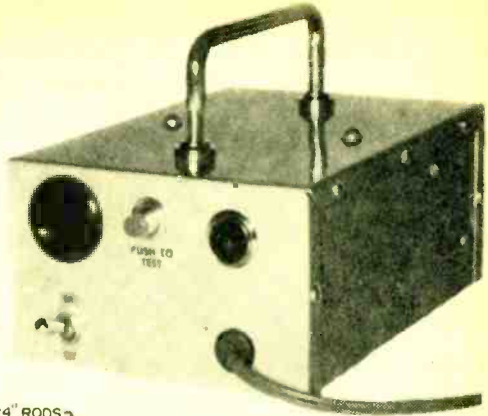
All parts fit nicely in a 3" x 5" x 7" aluminum box, but they should be located with care as they must be closely spaced. The transformer is centered in the box for good balance when the unit is carried. The lamp sockets should be made of Bakelite and their mounting bases must be shortened to about 1/4" thick to provide space for shock mounting. Clip two rubber washers, 1/32" to 1/8" thick, on each mounting screw for this purpose. Use flexible wire such as test prod wire for connecting chassis parts between the two halves of the case. These wires should be long enough to permit the case to be opened if the lamps ever need to be replaced.

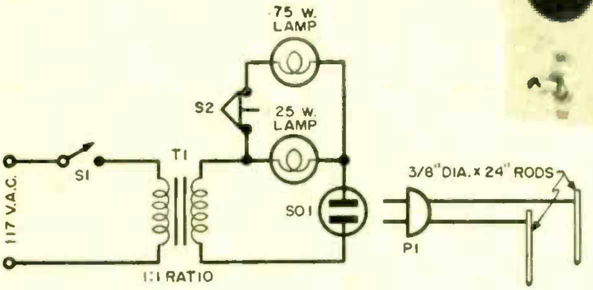
The probes are made of 3/8"-diameter rods about 2 feet long. Fit the upper end of each probe into an inexpensive file handle and then attach the wire (about 10' of test prod wire) near the handle. After this, tape the rod with rubber tape near the handle to lessen the chance of shock. The photo shows the probes both before and after being taped. The end opposite the handle is ground down to a point to make it easy to push into the earth.

When *S1* is closed, line voltage (117 volts a.c.) is applied to isolation transformer *T1*, which in turn supplies 117 volts to output receptacle *SO1*. The two parallel lamps in series with the load will indicate if the probes become accidentally connected together, and under such conditions they place a limit on the maximum current through the

CAUTION

Do not attempt to modify either of these circuits. If wired according to the schematics, they will provide adequate protection from the LETHAL 117-volt a.c. household line.



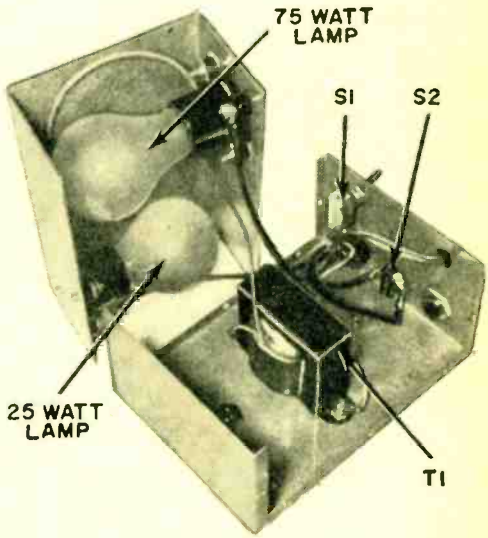


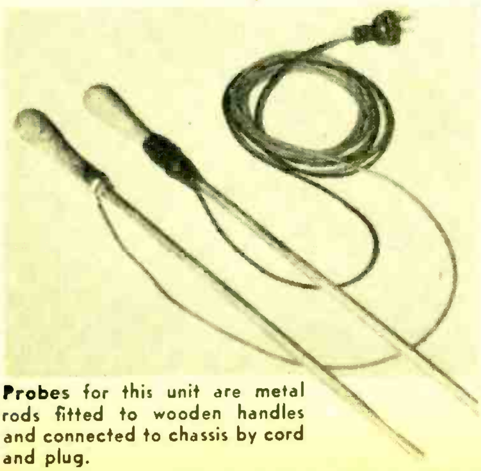
Worm-Turner No. 2 in cabinet, above, and with cover removed, below. Handle is mounted on same chassis section that mounts transformer. Schematic diagram is at left.

transformer. This current is permitted to be somewhat above the transformer rating since excessive loading will ordinarily be only momentary.

In addition to the above, the smaller lamp is used to indicate that the probes are functioning properly. During normal operation, the load current is sufficient to cause the 25-watt lamp alone to glow with a medium brightness, but it is not great enough to light both lamps. Thus, switch *S2* is provided so that the 75-watt lamp can be switched out of the circuit for testing.

To use, push the probes into the earth 5' to 10' apart. Throw switch *S1* on and then press test switch *S2*. The 25-watt lamp should glow dimly, indicating that the system is working. Wait a few moments and then start picking up the worms. As with Worm-Turner No. 1, if the earth is very dry, it may help to spray it with water before inserting probes.



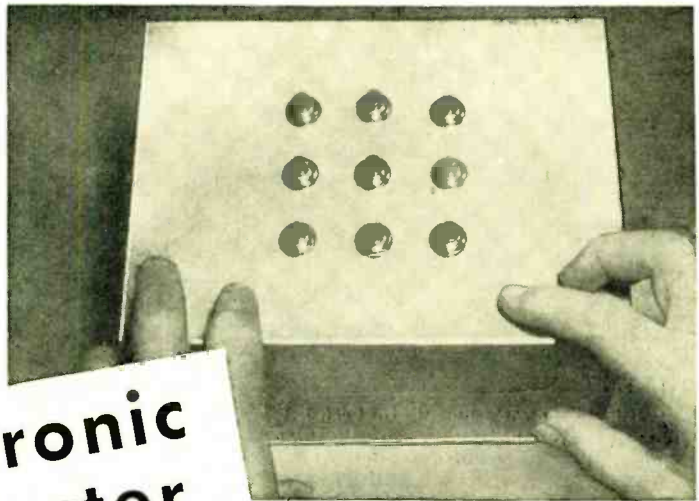


Probes for this unit are metal rods fitted to wooden handles and connected to chassis by cord and plug.

parts list

S1—S.p.s.t. toggle switch, bat handle
S2—S.p.s.t. push-button switch, normally closed contacts (Switchcraft 102 or equivalent)
SO1—Female receptacle (Amphenol 61F or equivalent)
T1—Isolation transformer, 115-volt, 35-va. output (Triad N-51X or equivalent)
1—3" x 5" x 7" aluminum case (Fleximount 29433 or equivalent)
1—Handle (USECO 1020 or equivalent)
1—Pilot light jewel, red, ¾" diameter
1—"On-Off" switch plate
1—4-ft. length of ⅜"-diameter rod
1—20-ft. length of test prod wire
2—File handles
2—Male plugs
Misc. rubber tape, line cord, rubber grommets, hardware

by ed bukstein



Electronic IQ Tester

test your friends' "brain power"

IT seems as though someone is always contriving to place a measure on our powers of reasoning. Most of us have been exposed to the pencil and paper variety of IQ tests, quizzes, etc. But here's a new way to challenge the IQ, electronically. You can build your own surprisingly accurate intelligence tester in just a few hours from a transformer, buzzer and nine push-button switches.

As shown in the photographs and drawing, the secondary of the bell-ringing transformer is connected in series with the buzzer and the nine push buttons. These push buttons have s.p.d.t. contacts, and are so connected that the buzzer will sound when three preselected buttons are pushed at the same time.

The person being tested must discover which three buttons to push. Since intelligence involves the ability to discover relationships, the length of time required to find the right combination of push buttons is an indication of the intelligence of the person being tested.

what's the score?

A "gifted" person will realize immediately that a certain number of possible combinations exist, and will proceed to try them in orderly sequence. A less gifted person will try a few combinations at random, will probably not realize the large number of possible combinations, and may forget and try the same combinations more than once. As a result, he will require much more time to locate the right buttons to make the buzzer sound off.

Standards for grading the test, according to the length of time required to ring the buzzer, might range from less than one minute (Genius) to over four minutes (Dull).

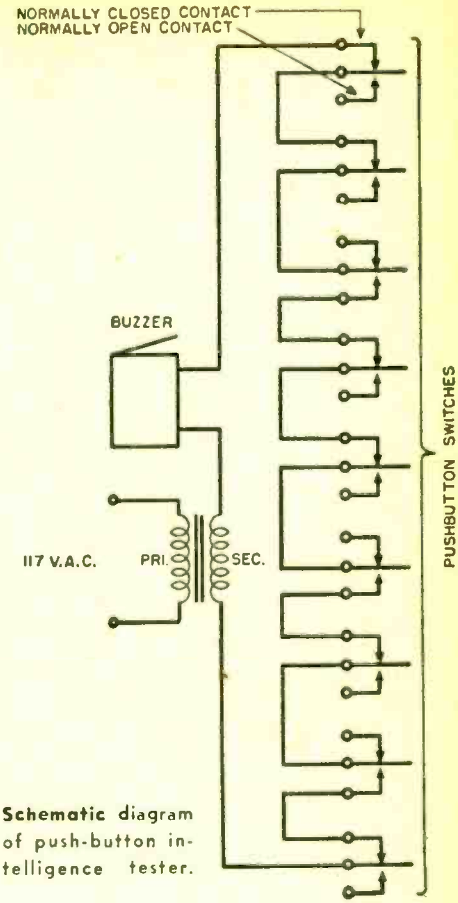
With nine push buttons to choose from, there are 84 possible three-button combinations, and the mathematical probability for hitting the magic three by pure chance is almost nil. Push buttons with s.p.d.t. contacts are used so that the machine cannot be "fooled" by someone pushing more than three buttons at once. Pushing more than the three required buttons will open the circuit.

setting the combination

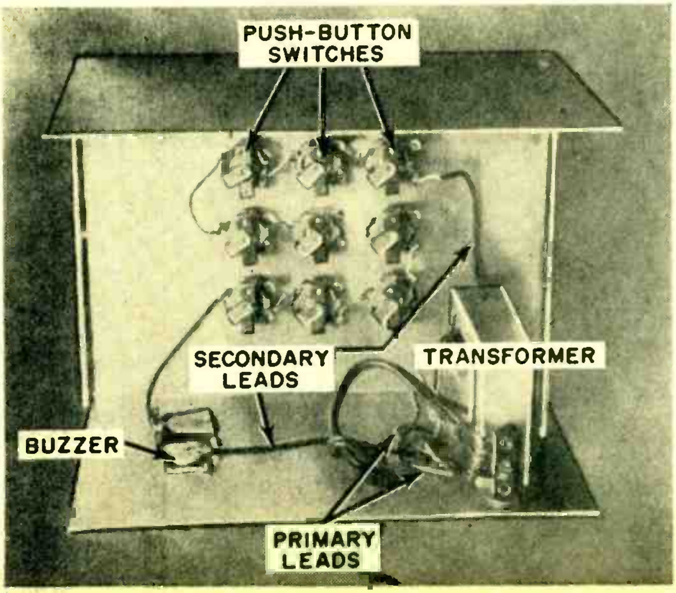
The model is constructed in a 4½" x 6" x 8" metal cabinet. When wiring the push buttons, connection should be made to the normally closed contacts of all push buttons except those which will activate the buzzer. On these three, normally open contacts should be used.

Any three buttons may be used for the "right combination." In the model, the three buttons are (viewed from the front panel), the right-hand button of the top row, the left-hand button of the middle row, and the center button on the bottom.

Once completed, this little "mental gauge" can be used to liven up a party, score your friends' IQ's, or even shed some light on the eternal question of male vs. female intelligence. At any rate, the next time the "little woman" starts proclaiming her superior mental prowess, bring out the push buttons and let her prove it. After all, you have the combination!



Schematic diagram of push-button intelligence tester.



Metal cabinet, doorbell transformer and buzzer, a two-terminal tie-point strip, nine push-button switches, power cord and hookup wire make up the simple parts list for the intelligence tester. Push buttons with s.p.d.t. contacts are employed, and connection is made to normally closed contacts of all switches except the three that will be used to ring the buzzer.

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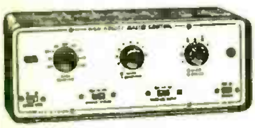

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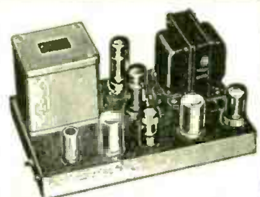

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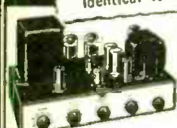

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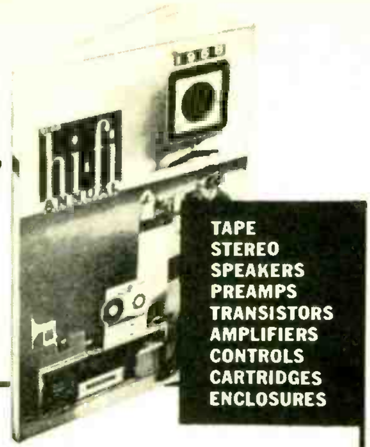

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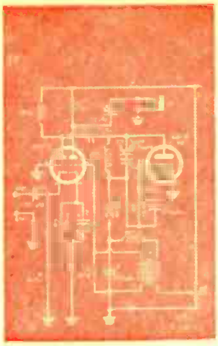
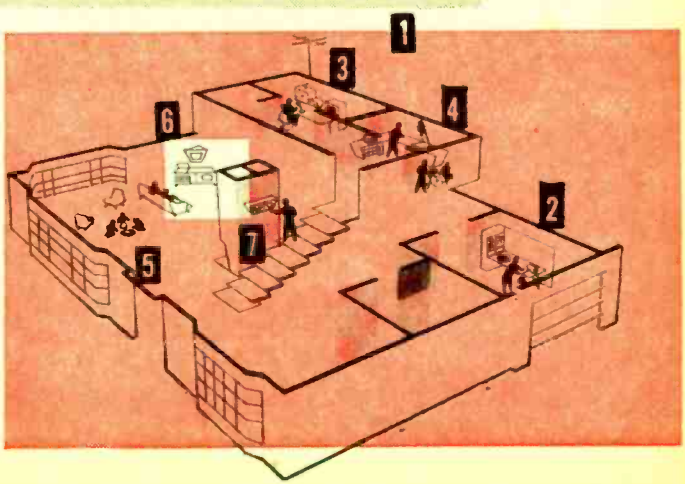
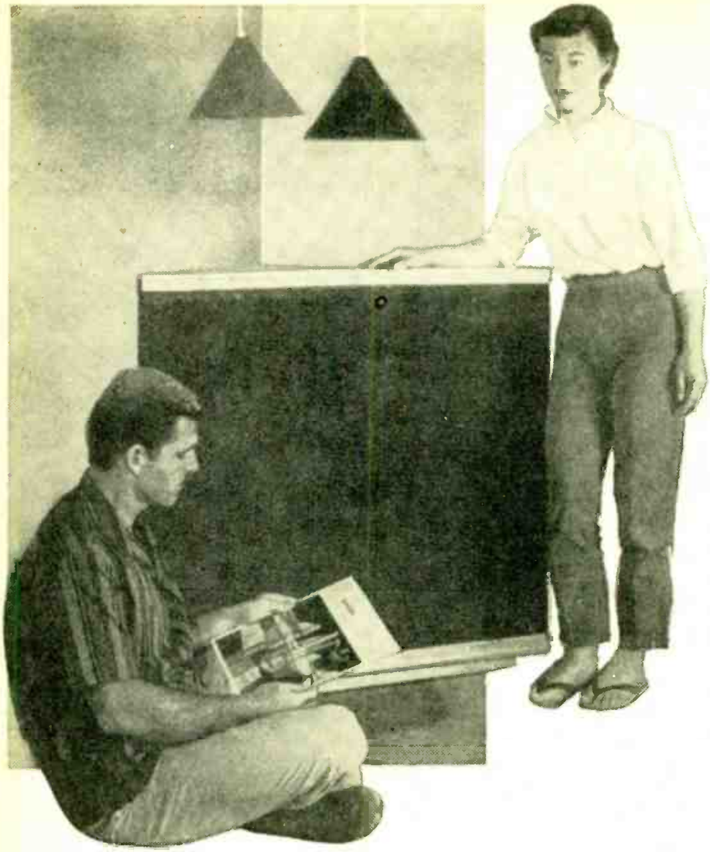


Section 6

for your hi-fi





BUILDING the "Hi-Five"

by *david weems*

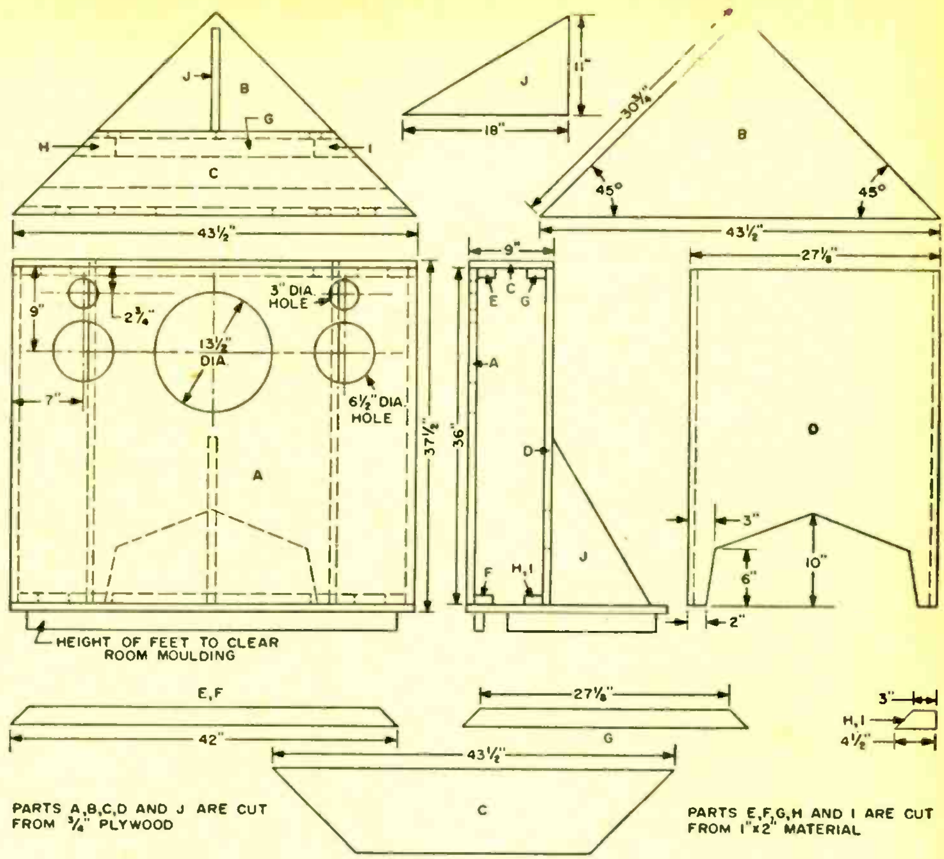
Here's an enclosure and speaker system that will solve a multitude of problems for the hi-fi enthusiast who wants the utmost in flexibility. Once built, it won't go obsolete at the next change in your speaker line-up, nor do you have to mortgage your home to get started on it.

You can begin with a single speaker, if you wish, and add the crossover network and the other speakers later. When you get all five speakers working, the spread of sound, as compared with a single coax or ordinary woofer-tweeter combination, will amaze you. It does for sound what the wide screen has done for movies.

The secret of the system's versatility lies in the special advantage of the folded labyrinth design. Other types of enclosures are particular about the speakers you mount in them. A large infinite baffle will sound wonderful when you use an expensive low resonance woofer in it, but with an ordinary speaker you'll wonder where the bass went. A reflex is even more critical. Change speakers on one of those, and you've got a woodworking job ahead of you. But our friend, the labyrinth, will tolerate just about any speaker that will pass for high fidelity. Of course, the labyrinth doesn't alter the facts of life. Good speakers still sound better than cheap ones.

three-channel system

Distortion is kept low by splitting the sound three ways with a *Sherwood* SFX-35 crossover network. It provides rather sharp crossover points at 300 and 5000 cycles. In the final version, a single 15" woofer handles the bass, two 8" squawkers fill in the mid-range, and two 3" tweeters take over from there. Because the ear perceives direction chiefly through mid-range and treble, the sound source will appear to be as wide as the placement of the small speakers.



Construction plans for building the "Hi-Five." The entire cabinet can be built from a single 4′ x 8′ sheet of plywood. The home builder will find this project is economical and requires no power tools.

There may be a parallel here to the history of "3-D" movies. First came the glasses, which amazed everyone; but after the novelty had worn off, people didn't want to sit through every film wearing the things. Next, we saw the effects of multi-channel pictures and sound, but they were too expensive for the average Hollywood production. In audio, we've gone through the headphone stage of binaural and are just now learning about two-channel reproduction. For most of us, an inexpensive and satisfying answer to the problem is simply to use a wider sound source, and so simulate the effect. Obviously, the final judgment of the arrangement depends on individual taste, but if you're tired of hearing a full orchestra crowded into a radius of a few inches, you're sure to like the change.

The cost of the system is pretty much up to you. The cabinet can be built from a single 4′ x 8′ sheet of ¾″ plywood. For attractive appearance, the top should be cut from a piece of hardwood or hardwood plywood and the front trimmed with hardwood. Select an open weave of cloth for the grille; the special plastic materials manufactured for the purpose are best because they don't restrict the movement of air around the cones or damp the highs. Without the hardwood, the cabinet can be built for about $15.00, including the grille.

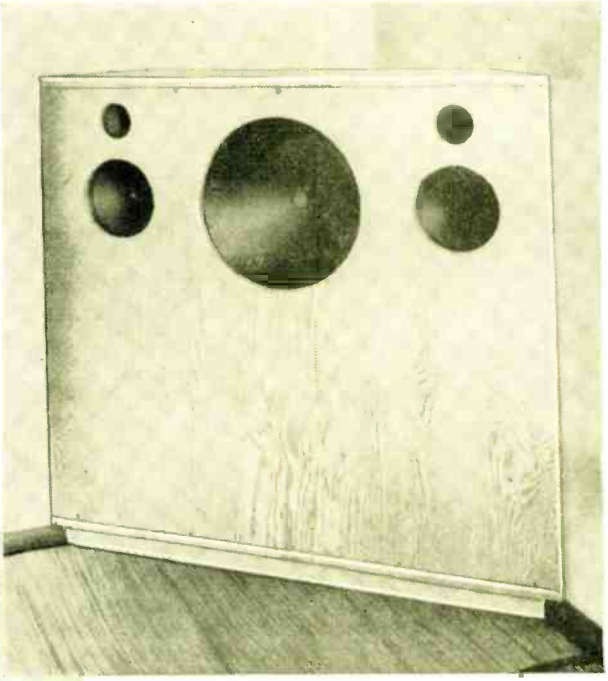
assembling the parts

The entire cabinet can be made without power tools. All you need is an ordinary hand saw, a keyhole saw for the speaker holes, a screwdriver, a hand drill, and a hammer. If you have a power saw and want to bevel the edges of the front panel (*A*), fine, but don't forget that will change the dimensions. To maintain the same inside measurements, you should add 1½″ to the long width of all parts beveled, such as panels

A and *D,* and bring out *B* and *C* to points instead of chopping off the corners as shown. Actually, beveling is unnecessary and mainly a matter of taste.

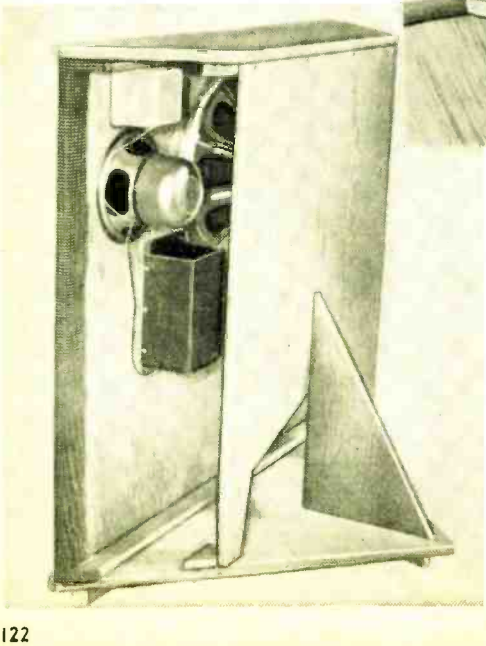
After you have marked and cut out the parts, begin assembly by mounting the glue blocks, glued and screwed, to the bottom (*B*) and the top (*C*). This is also a convenient time to mount the feet, which may be made any height to clear the room moulding. Next, glue and screw the front panel to the top and bottom. Then mount the speakers and crossover network, using either bolts or screws.

It is necessary to isolate the tweeters acoustically as well as electrically. A convenient method is shown in the photo on page 123. Remove the top of the soft plastic freezer cartons and cut a central hole to match the tweeter diameter. A sharp knife will cut the material very easily. Then, using the tweeter as a guide, drill the mounting holes and screw the assembly to the baffle. The connecting wires from the tweeter may be brought out through the box by means of small bolts and lugs. Each hole drilled through the plastic should be of the same diameter as the bolt or screw put through that hole in order to prevent air leaks. Carefully seat the box edges in the grooves, and you'll have an airtight compartment that provides ready access to the tweeters at any time.

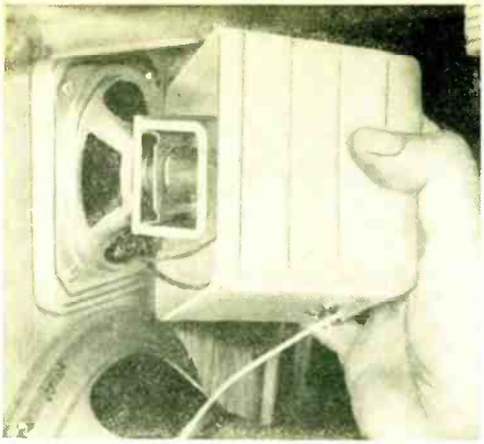


bill of materials

1—4' x 8' x ¾" sheet of plywood
2—1" x 2" x 48" pieces of material
1—1" x 2" x 30" piece of material
1*—1" x 10" x 43" piece of hardwood
1*—84" strip of hardwood moulding
48—#8 x 1¼" screws
1—36" x 48" speaker grille
1—Box of staples or carpet tacks
1—36" x 48" cotton batting, Fiberglas, etc.
2—4"-square, soft plastic freezer containers
Misc. bolts or screws for mounting speakers
* Optional

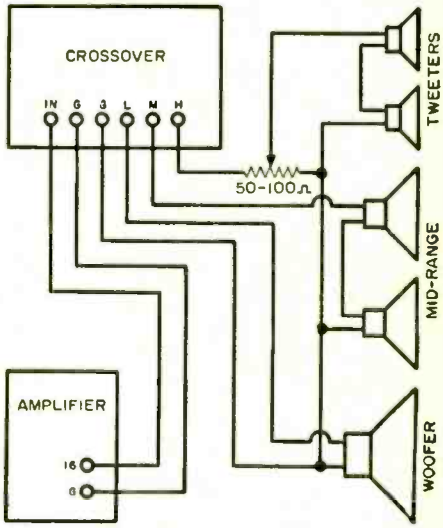


The baffle is shown above without grille to illustrate location of the five speakers. Side view shows construction details; note that the crossover network is mounted where it interferes least with the cross-sectional area of the labyrinth. See the illustration on the opposite page for details on providing acoustical isolation for the tweeter.



At left is view of plastic freezer container being mounted over the tweeter to isolate the back wave from the woofer. If a horn-type tweeter is used, this precaution is not necessary.

Wiring diagram of the speakers. The brilliance control indicated for the tweeter is optional.



Accessibility to the other speakers may be accomplished by not using glue on panel *D* or on the rear brace *J*. The brace may be cut from any convenient leftover, specifically from the excess of *C* if you cut *C* from a triangular section. Screw the brace to *D* from the inside before *D* is in position. Then, after screwing *D* to the top and bottom glue blocks, put the final screws up through the bottom to fasten *J* in place. If you haven't planned the location of *J* and the rear foot so that they are offset from one another, you may have trouble getting screws to go in both directions.

This completes assembly of the cabinet except for the grille, moulding, and internal padding. The labyrinth should be padded, but the amount of padding depends on several factors—mainly on how you like it. Keep the padding symmetrical with regard to the mid-range speakers.

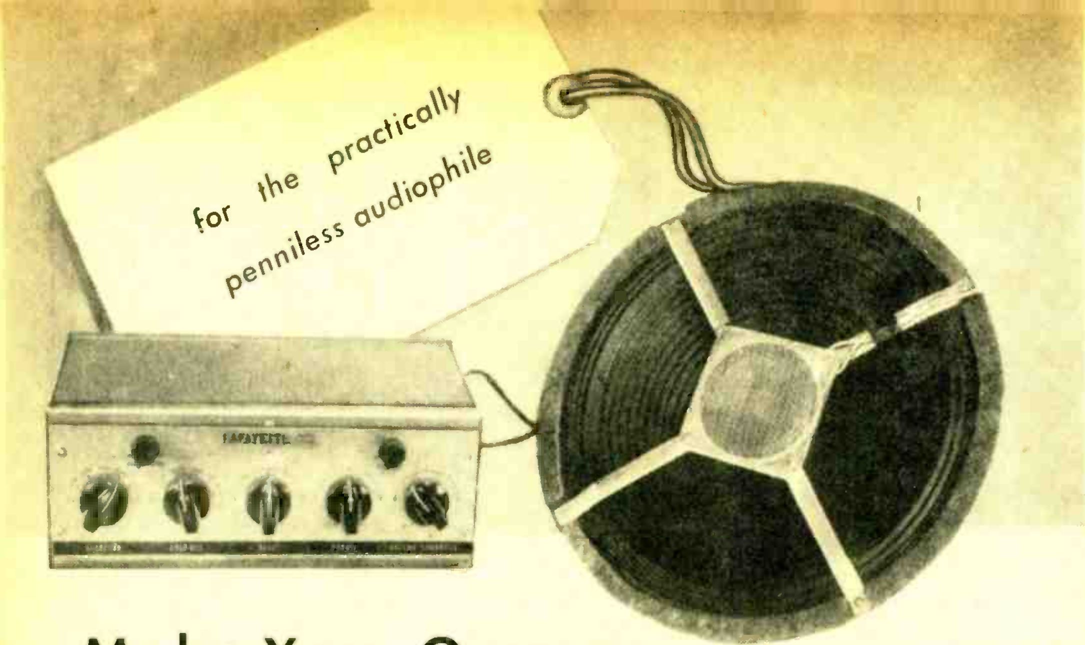
selecting speakers

The *Sherwood* crossover network was designed to be used with 16-ohm speakers, but a slight mismatch will not be noticeable with most modern amplifiers (especially if they have damping controls). Actually, the use of an 8-ohm woofer will result in a few db of boost in the range below 300 cycles, producing an effect that many people will like. The 8" speakers should be 8-ohm units—to make 16 ohms when wired in series—but again perfect matching isn't essential.

This network has a rather sharp cutoff of 12 db per octave beyond the crossover points, but the manufacturer recommends that the speakers selected should have undistorted response at least one octave beyond the crossover frequencies. Thus, the requirements for the 8" speakers include undistorted response from 150 to 10,000 cycles, which shouldn't be hard to meet. Use of two speakers for the mid-range and treble reduces the distortion still further.

substitutions

For best results, a 15" woofer is recommended for this enclosure, but there is no reason why you can't substitute a 12" speaker if you have one on hand. Or two ten's or twelve's might be used for the bass. If you're starting from scratch, you can begin by purchasing a couple of eight's and using them until you're ready to add the tweeters, woofer, and crossover. An alternate crossover network which is quite satisfactory is the *Lafayette Radio* LN-3. Whatever you begin with, you'll end up with "wide-screen" as well as wide-range sound after you have finished your "Hi-Five."



Make Your Own
$5 COAX SPEAKER

A wise philosopher once said: "Money isn't everything." This may be true, but it helps to have the long green when you're planning a de luxe hi-fi installation. Unfortunately, most of us don't have the legendary money tree growing in our backyards, so we have to be satisfied with something less than the most expensive—at least at the beginning.

But this doesn't mean you can't enjoy the good music a hi-fi system will bring you. Instead, you can start with a less expensive system, perhaps assembling many of the components. While there are a large variety of amplifier, speaker enclosure and tuner kits offered, no one markets a "do-it-yourself" speaker kit. Yet the speaker cost represents an important item in any hi-fi budget. If you're handy in the workshop, you can assemble your own coaxial speaker at a cost of $5 to $10, depending on how well you shop for bargains and the status of your junk box.

the woofer

Almost any standard 10" or 12" speaker may be used. Suitable types may be bought from parts distributors for perhaps as little as $3. If you prefer, you can salvage a large speaker from a junked receiver. If you use such a part, check the paper cone for tears or holes. Make sure the cone is not loose around the edges, re-cementing if necessary. Inspect the frame for dents or warps. And make sure the speaker voice coil is not off center and rubbing against the magnet's pole piece. You can do this by *gently* moving the cone back and forth, with your thumbs placed close to the voice coil. You'll be able to feel any rubbing if it's off center.

If you buy a new speaker, you may find that it is supplied without the familiar circular cardboard spacing ring. If this is so, check the phone book for a "Loudspeaker Reconing Service." Such firms can supply a suitable mounting ring at nominal cost. Otherwise, you can use thick felt weatherstripping as a substitute.

To apply the felt, first cut a length to size, temporarily fitting it around the speaker's outer rim. If the felt is too wide, touching the corrugations around the edge of the cone, slit it lengthwise to proper width. Using a general-purpose cement, such as Pliobond, apply a coat to one side of the felt. When it's dry, apply a second coat. At the same time, put a coat on the rim of the speaker frame where the felt is to be cemented. Allow the new coats to dry until tacky, then press the felt into place, shaping it carefully to the curve of the frame. Once it's in place, invert the speaker on a flat surface so that the weight of the assembly will serve as an adequate clamp.

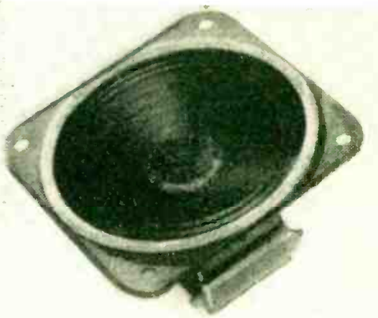
Ideally, the woofer cone should move back and forth as a single unit. Unfortunately,

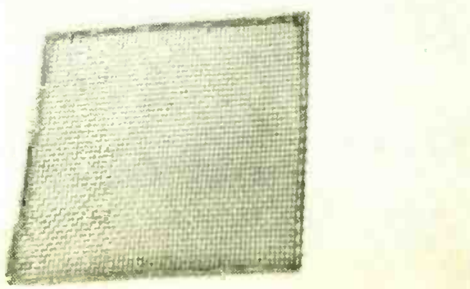
by
luis vicens

If the woofer doesn't have a cardboard spacer ring, you can cement felt weatherstripping around the rim (see the photograph above) as a substitute.

Apply plastic spray to stiffen woofer cone, as shown at left.

Window screening is used as high-frequency diffuser on tweeter (below).





big cones do not move rapidly enough to respond to high frequencies. Instead, a certain amount of "cone breakup" occurs (different parts of the cone move in different directions). Because of this, a large-diameter speaker does a much more efficient job of reproducing low frequencies, where cone movement is slower.

Since we are going to use a separate tweeter to reproduce the high frequencies, we can modify the large speaker's cone to improve its response to low frequencies. To do this, we stiffen the cone by spraying on two or three coats of clear Krylon acrylic plastic. Use a standard pressurized spray can for this job, taking care to spray only the cone's surface. Avoid coating the flexible corrugated edge of the cone. Allow the plastic to dry thoroughly between coats. When the last coat is dry, you're ready to add the tweeter.

the tweeter

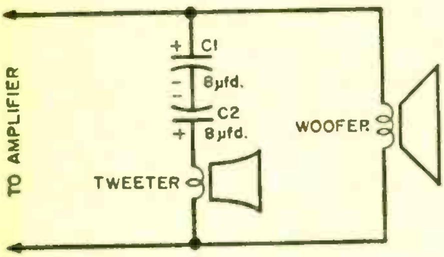
Any 3" to 5" speaker may be used, but be sure it has the same voice coil impedance. You won't have to make modifications in the unit itself, but you will want to add a small "diffusing screen." Higher frequency sounds tend to be highly directional. In order to break up this pattern and to permit "spreading" the sound over a wide area, you should mount a small piece of metal screening in front of the tweeter. Ordinary household window screen may be used. Copper or brass is preferred, but other materials such as aluminum or galvanized screen will work. After you've cut the screen to fit the front of the tweeter, run a small solder bead along each edge. This will reinforce and stiffen the screen and prevent raveling.

You'll need four mounting brackets for the tweeter. These can be bent from ¾" wide strips of ⅛" thick aluminum or steel. They are cut and drilled to fit the mounting holes around the rims of the tweeter and woofer. Bend a small offset in the mounting brackets to provide clearance for the forward movement of the woofer cone.

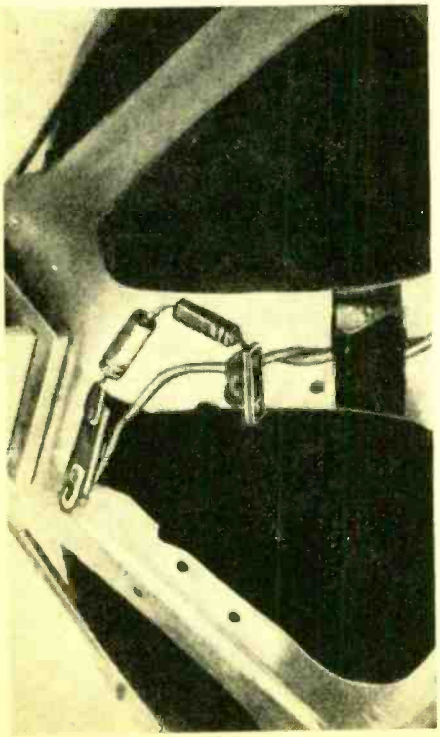
final assembly

Before mounting tweeter on woofer, connect a pair of 18"-long hookup wires to the tweeter terminals. These are twisted together and later taped to one of the mounting brackets. Use machine nuts and bolts to fasten the brackets to the tweeter. The bolts are also used to hold the screen in place. Tighten them "finger-tight" until after you've mounted the tweeter on the woofer's frame with additional bolts.

If you find that the tweeter projects beyond the front of the woofer due to the offset bends in the mounting brackets, build up the outer mounting rim of the woofer with additional strips of felt until the front of the tweeter (including the diffuser screen) and the forward mounting rim of the woofer are flush.



A simple crossover network . . .



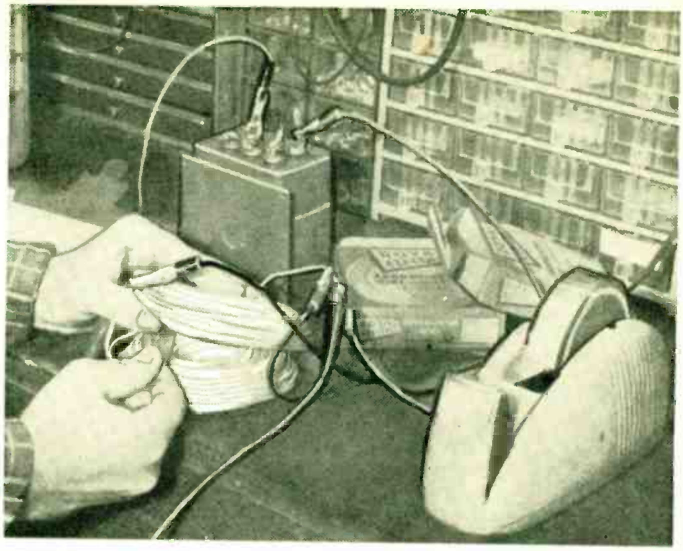
. . . using a series capacitor on woofer frame.

installation

For best results with your completed "$5 Coax" you'll need a *crossover network* to insure feeding the proper high- or low-frequency signals to the tweeter and woofer. The simplest network is nothing more than a large-value capacitor connected in series with the tweeter speaker. The capacity is generally between 4 and 16 µfd., depending on the speaker's voice coil impedance. A larger value is used for low-impedance (4-ohm voice coil) speakers, a smaller value for higher impedance (16-ohm) units. Paper capacitors are preferred, although you can connect two electrolytic capacitors "back-to-back." The two negative leads of the capacitors are connected, with the positive leads hooked to the speakers.

This type of crossover network, while inexpensive, will not give as good results as the more complex coil-capacitor type described in the next article. With the crossover connected, you should give your completed system a thorough bench test before installing it in a cabinet or enclosure. Connect it to your amplifier and try listening to several pieces of music through it. If you have a test record, so much the better.

Any loudspeaker, whether a low-cost unit such as you built here or a multi-unit one costing several hundred dollars, will give you better results if mounted in a properly designed enclosure. You can mount your finished coaxial speaker in a plain baffle, bass-reflex cabinet, horn-type enclosure, or high-efficiency Karlson-type.



Hardware Store Hi-Fi Crossover

by king murdock

Practically everyone knows the "why" of crossover networks in quality sound reproduction. A speaker cone that will sashay in and out along the distance necessary to pump a fat, low sound into the room just can't move fast enough for the highs; and the perky jobs that will trill out the highs just can't move far enough and push enough air to manufacture large low notes. And, even in "wide-range" speakers, there is danger of the high notes being squeezed out of shape by the cone's low-note excursions. Hence, it is desirable to have more than one speaker.

If you connect bass and treble speakers to your amplifier, each unit will try to do part of the other's job, resulting in loss and all-around confusion. The use of two speakers calls for a crossover network, which is simply an automatic tone-sifter to switch the various tones to the speaker that can handle them.

Unfortunately, the "how" is not so clear, since most designs require coils of special values which the hi-fi fan must wind himself. However, there is a way to build a crossover unit without any meticulous measuring or winding.

Figure 1 shows how the crossover works; Fig. 2 shows the circuit. At the crossover frequency, both speakers are fed equally. Below this point, the woofer receives more power and the tweeter less, and vice versa, at the rate of 6 decibels per octave.

The two speakers should have the same impedance rating. If the rated impedance of the two speakers does not happen to match, consider the combination to have an impedance half-way between the two values.

building the network

To build your network, first decide on the crossover frequency. This will depend upon the frequency range of each of the speakers, and how much of the load you want each to carry. The point chosen should be in a frequency region which both speakers are able to reproduce, although it may be close to their response limit. In Table 1, follow the proper speaker impedance column down to its intersection with the horizontal line

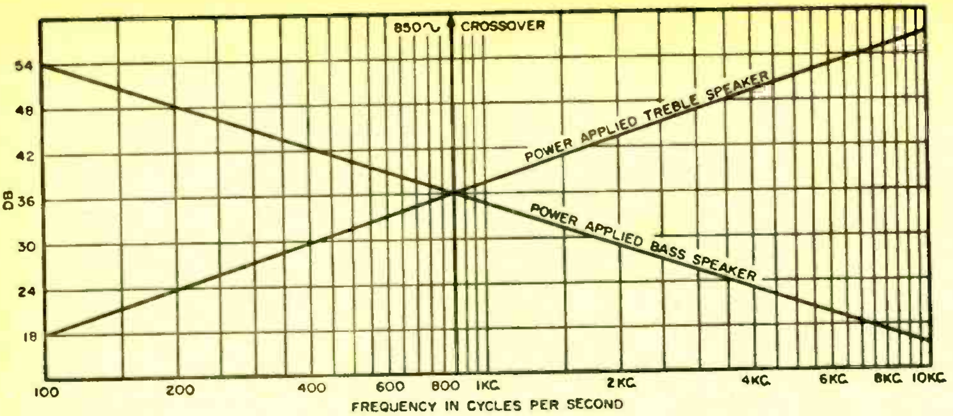


Fig. 1. Assuming 72 db of available sound energy, half of it (36 db) is applied to each speaker at the crossover point. At other frequencies the proportion varies, one speaker getting less while the other gets more, but the sum of 72 db is constant.

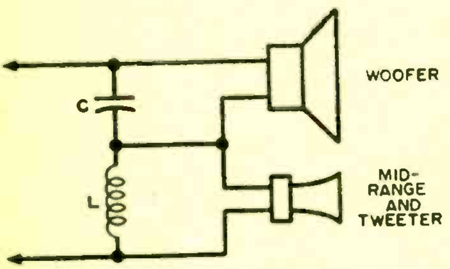


Fig. 2. Elementary crossover circuit for a system using a single woofer and a single tweeter. The inductive component, or coil, may be made at home (see text) from inexpensive materials that you will find at your local hardware store.

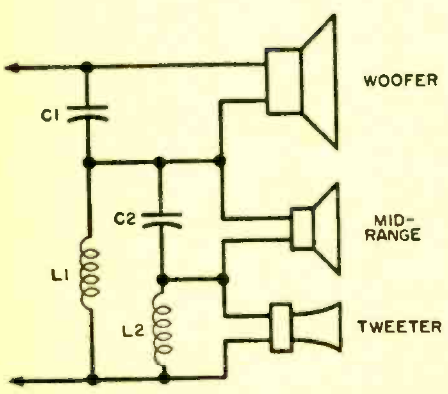


Fig. 3. Three-way system involves the use of a more complex crossover network. Twice the number of components required for a two-way network are necessary when designing three-way network.

corresponding to the desired crossover frequency. The figure at the intersection is the value of capacitance required for the crossover network. This may be made up by connecting different-value capacitors in parallel to give the desired sum. These capacitors may be low-voltage units. (Surplus bins are an excellent source of capacitors for this use.) Paper capacitors are preferred because they retain their rated value indefinitely, while electrolytic capacitors tend to drop off or leak with age.

However, if it is necessary to use electrolytics, they will be perfectly satisfactory, as long as periodic tests are made to insure that they have not gone bad. With electrolytics, it is necessary to connect two sections, back-to-back (positive-to-positive or negative-to-negative). Otherwise, they would pass current in one direction. Because of the series connection, the capacitance of each section used must be twice the total value desired.

Stock rolls of plastic-insulated #18 bell wire, available in hardware stores, can be used for the coil. These rolls commonly come packaged in 1-lb. and ¼-lb. rolls, constituting a ready-made air-core coil with tolerably low loss. The characteristics of several such packages have been measured, and found to be quite suitable for our purpose. The coils illustrated in this article had the following dimensions: 1-lb. roll—5" diameter, 1½" hole, 1" thickness; and ¼-lb. roll—3" diameter, 1½" hole, 1" thickness. Try to get wire made up in packages as close to these dimensions as possible.

Now go into Table 2, following the same speaker impedance column down to the line marked by the previously chosen crossover frequency. At the intersection, the amount of wire required in the coil is shown in pounds. For example, a 1¼-lb. coil is required for a 4-ohm speaker to cross over at 500 cycles. This coil should consist of one 1-lb. coil, and a ¼-lb. coil stacked on top, the two then being connected in series.

Stack the coils so that the direction of winding is the same for both coils, and make the series connection by joining the inside end of one coil with the outside end of the other. Connect the rest of the circuit to the remaining two free wires.

To obtain any of the odd values of weight which may be needed, stack 1-lb. and ¼-lb. coils to arrive at the nearest quarter-pound in excess of the desired weight. Values of ⅛ lb. can then be obtained closely enough by simply removing half of a ¼-lb. coil.

Then connect the capacitor and the coil in series across the amplifier output. The treble speaker is connected across the coil, and the bass across the capacitor. The amplifier output impedance tap should be set to the rated value of a single speaker because, in the series-parallel connection, this is the load the amplifier "sees."

checking it out

Judge the operation of the network by listening to any full-range music with which you are familiar. If the woofer seems to be loafing, peel a little more off the coil. On the other hand, response can be pushed the other way by adding several turns. Not much change will be evident after small alterations—it takes at least ⅛ lb. for the difference to show up to any noticeable degree.

Suppose you want to use three speakers, which ordinarily calls for a three-way network. You can get out of the woods very simply by using a network such as has just

Crossover Frequency (cycles)	Speaker Impedance			
	4 ohms	8 ohms	12 ohms	16 ohms
	Capacitance in Microfarads			
500	80	40	26	20
750	53	26	18	13
1000	40	20	13	10
1500	26	13	9	6.5
2000	20	10	7	5
2500	16	8	5	4
3000	13	6.5	4.4	3.3
4000	10	5	3.3	2.5

Table 1.

Crossover Frequency (cycles)	Speaker Impedance			
	4 ohms	8 ohms	12 ohms	16 ohms
	Pounds of Wire			
500	1¼	1⅜	1½	1¾
750	⅝	¾	1	1¼
1000	½	¾	⅞	1¼
1500	⅜	⅝	¾	1
2000	¼	½	⅝	¾
2500	¼	½	⅝	⅝
3000	¼	⅜	½	⅝
4000	¼	¼	⅜	½

Table 2.

been described, with the crossover at the frequency desired to separate bass and mid-range speakers. Then, connect another similar network in place of the mid-range speaker across the first network coil. The second network should have the crossover frequency to separate the mid-range from the treble. The exact value in each case depends upon the speakers used. Connections are shown in Fig. 3.

Since the attenuation attained with these networks is smooth and gradual, a few cycles one way or the other make little difference—so don't bother splitting hairs. The main thing is to get the desired proportion of highs and lows into the appropriate speakers without humps or hollows. Your "hardware store" crossover network will do the job as well as many costing a great deal more money.

Build Your Own Presence Control

by ***leonard feldman***

Most "presence controls" in hi-fi components are built right into the circuits of preamplifiers or amplifiers. Yet it is quite simple to add this type of control externally to almost any hi-fi system.

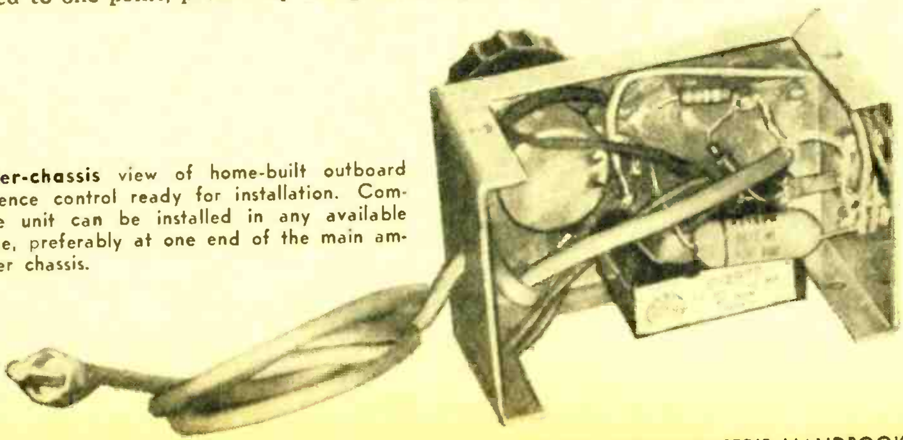
The only electrical requirement is that your total system have a "reserve" of gain of about 12 to 14 db. Since most preamp and amp combinations are never operated near to "full volume," it is safe to say that the extra gain is available.

The entire control and associated circuitry can be built on a tiny chassis which, fully enclosed, measures only 3¼" x 2⅛" x 1⅝". Since the completed unit is to be inserted between the preamplifier and power amplifier of your system, the input jack you should use is a standard phono jack which is mounted by means of 4-40 x ¼ machine screws and nuts at one end of the chassis. The output is brought out by means of a short length of single-conductor shielded cable, through a 3/16"-diameter hole at the opposite end of the chassis. The end of this cable is fitted with a standard phono-tip plug.

Mount the control itself, as well as the 1.5-henry choke, against the largest surface of the chassis by means of suitable hardware. A one-point insulated terminal strip is also mounted on this surface, to accommodate the junction of *R1* and *R2*.

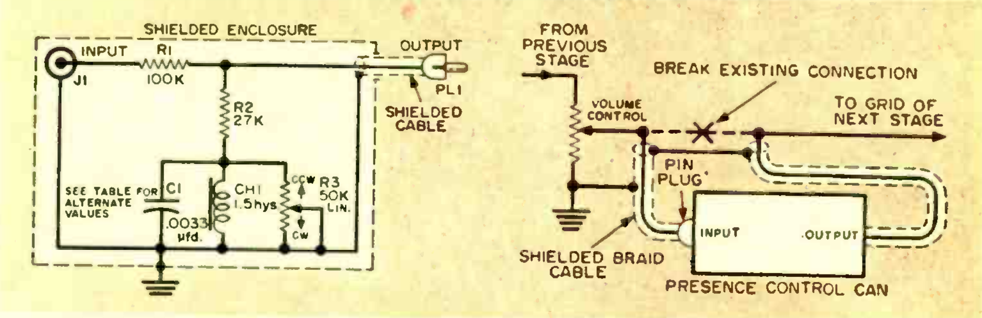
In wiring the connections of potentiometer *R3*, observe the "sense" of rotation. The presence effect should become greater as the control is rotated clockwise. Therefore, the arm, or center terminal of the control, should be wired to the right-hand terminal (as viewed from the rear of the control with the terminals facing upward); and this point, in turn, is wired to "ground."

Speaking of "ground" connections, all the ground-returns in the circuit should be returned to one point, preferably the ground side of the input jack.



Under-chassis view of home-built outboard presence control ready for installation. Complete unit can be installed in any available space, preferably at one end of the main amplifier chassis.

Schematic diagram and method of connecting presence control into circuit of complete amplifier. Table at lower right lists different presence frequencies that may be emphasized by use of different values of capacitance for C1.



parts list

C1—0.0033-µfd. tubular capacitor (see table)
CH1—1.5-henry, 10-ma. audio choke (Merit #C-2973 or equal)
R1—100,000-ohm, ½-watt composition resistor
R2—27,000-ohm, ½-watt composition resistor
R3—50,000-ohm, ¼-watt linear taper potentiometer (IRC #Q-11-123 or equal)
1—Terminal strip with mounting foot and one insulated tie point
1—3¼" x 2⅛" x 1⅝" aluminum box
Misc. shielded cable, phono plug and jack

C1 (µfd.)	Freq. (cps)
.01	1250
.0068	1800
.0047	2000
.0033	2500
.0022	3000
.0015	3500
.001	4000

installing the control

If your system includes a separate preamplifier-control-chassis and a basic power amplifier, or if you have an FM-AM tuner which includes tone controls and preamplifier, no additional wiring or soldering is required. Simply disconnect the cable now running between the output jack on your preamplifier and the input jack on your power amplifier at the power amplifier end. Connect the pin plug of this cable to the input jack of the presence control. Connect the pin plug of the presence control output cable to the input jack of the power amplifier.

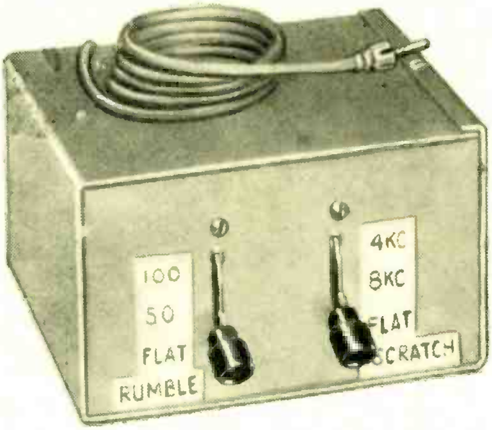
how to use it

With the control turned fully counterclockwise, your hi-fi system will have its normal "flat" response. You may prefer this setting for listening to symphonic music where emphasis of a particular portion of the audible spectrum may not contribute noticeably to the over-all results. Rotating the control clockwise causes a gradual insertion of mid-frequency emphasis. In the case of solo instrumentalists or vocalists, a setting of the control adds the feeling of "presence" without seeming unnatural.

If your equipment includes an all-in-one preamplifier-amplifier combination, it is a simple matter to "tap into" the circuit at a convenient point and take advantage of the presence effect. A suggested method of doing this is shown. Disconnect the lead now wired to the arm of your existing volume control. Run a length of shielded conductor cable from the arm of the volume control to the input of the presence control by installing a pin plug on the end of the shielded cable. The output cable of the presence control, less pin plug, should be spliced to the lead which was previously connected to the volume control. Solder both shielded braids to volume control ground side.

how it works—In this version of the "presence control," a maximum accentuation of 6 db was found to be ideal, and the frequency of the "presence bump" was designed to be at 2500 cycles. To obtain these results, *R3* was selected as 50,000 ohms and *C1* was chosen to have a value of 0.0033 µfd. Since opinion and tastes vary as to the amount and frequency of "presence" which is ideal, other values of *C1* may be used for different "presence" center frequencies (see table above). Increasing the value of *R3* will produce somewhat greater maximum accentuation values. For example, if *R3* is a 200,000-ohm potentiometer, the maximum presence effect will be about 8.5 decibels. Increasing the value of *R3* much beyond this value will not materially increase the presence effect at maximum because the reactance of the inductance *CH1* itself begins to limit the action.

Build Your Own Hi-Fi Filter



by ***leonard feldman***

Including a combination record-scratch and turntable-rumble filter in your hi-fi system provides you with a double guarantee. It means that you can enjoy your old records with a minimum of noise. It also means that you'll be able to enjoy your present records when *they* reach old age, or when your record player begins to rumble and you're not yet ready to replace it with a new one.

Many commercially available preamplifier-control units have these filters already built in. But older or less costly equipment may not. Actually, it is a lot easier to include an "outboard" type of filter, such as the one to be described, than to try to design one into an existing circuit.

how much filtering?

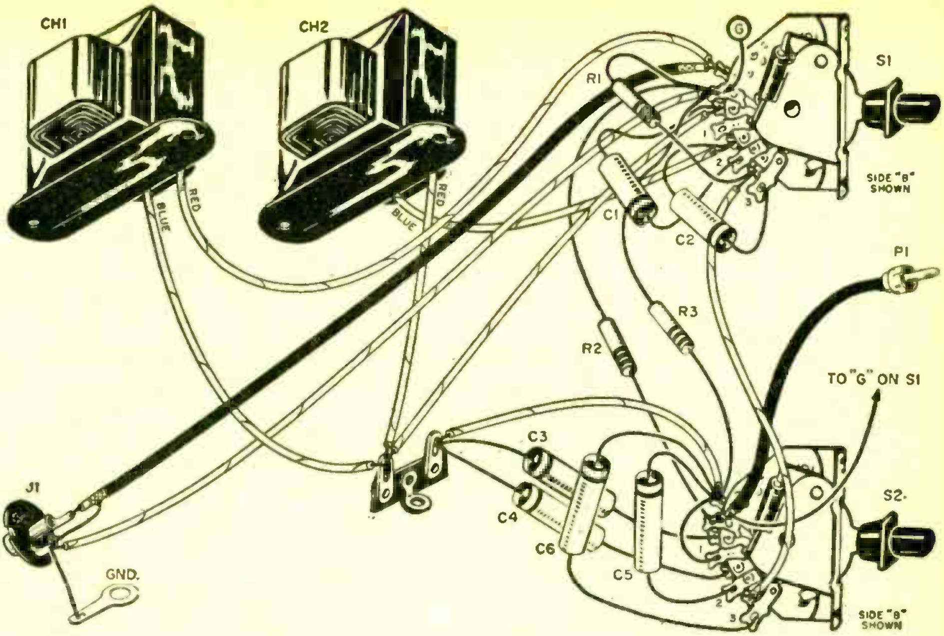
Quite a bit of experimenting with old and new records was required to decide on the cutoff frequencies for the scratch filter portion of this circuit. We finally decided that two settings of filtering other than the normally flat response setting would do the trick. The first cutoff was set at 8000 cycles, and is intended for use with somewhat older microgroove recordings that are beginning to develop a definite "hiss." The second setting starts "cutting out" frequencies at about 4000 cycles and is intended for old 78-rpm recordings which have quite a bit of scratch and noise.

The rate of cut was designed to be 12 decibels per octave. This means that at the 4000-cycle setting of the scratch filter response will be relatively flat up to 4000 cycles, whereas 8000-cycle noise will be reduced by a ratio of 4 to 1, with even higher frequencies reduced still further. This "rate of cut" is about twice that possible with regular tone controls whose action is much more gradual.

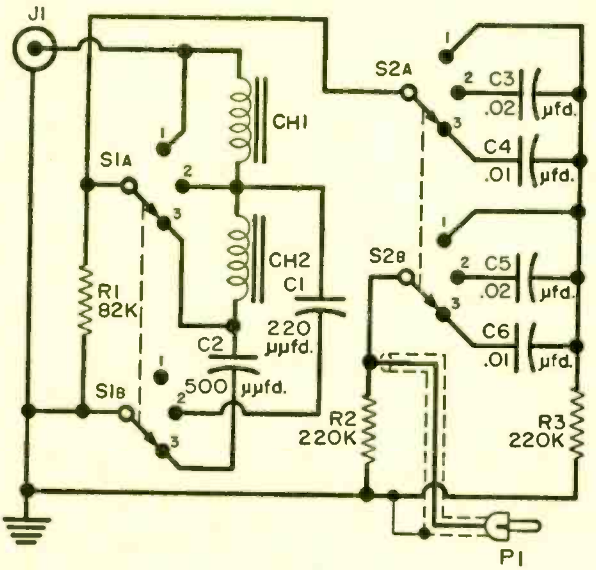
As for the rumble frequency filter, the two cutoff points selected are 50 cycles and 100 cycles, with the rate of cut about 10 db per octave. The first "cut" position is for very low frequency turntable rumble troubles, whereas the extreme 100-cycle setting will get rid of higher frequency rumble troubles *as well as* some 60-cycle power line hum which may possibly be present in your system.

building the filter

The entire unit is built into an aluminum two-piece case which, when completed, acts as a complete shield for the circuit, preventing any hum pickup from power supply transformers located on nearby equipment. Lever-type switches were selected because of their professional appearance and because the settings can be spotted easily from



Pictorial diagram above details relationship of parts used in the filter. Note that leads on chokes CH1 and CH2 are colored, and must be wired according to instructions. Below are the schematic diagram, table of frequency cutoff action for different switch settings, and parts list. Switches are shown at 100-cps and 4000-cps cutoff positions. All ground points, including shield of output cable, should be returned to connection at ground on J1.



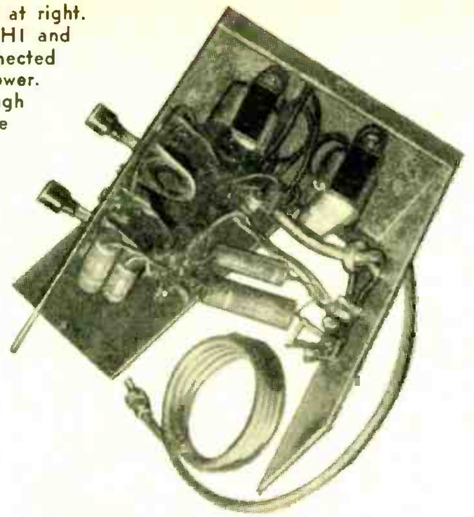
SWITCH POSITIONS		
	RUMBLE (S2)	SCRATCH (S1)
1	FLAT	FLAT
2	50~	8000~
3	100~	4000~

C1—220-μμfd. ceramic capacitor (Centralab BC220)
C2—500-μμfd. ceramic capacitor (Centralab BC501)
C3, C5—0.02-μfd. tubular capacitor (Cornell-Dubilier 2S2)
C4, C6—0.01-μfd. tubular capacitor (Cornell-Dubilier 4S1)
CH1, CH2—1.5-hy., 10-ma. choke (Merit C-2973)
J1—Phono jack (RETMA standard type, non-insulated)
P1—Phono tip plug (RETMA standard type)
R1—82,000-ohm, ½-watt resistor
R2, R3—220,000-ohm, ½-watt resistor
S1, S2—Double-pole, triple-throw lever switch (Centralab 1452)
1—3" x 4" x 5" aluminum chassis-case (Insuline 29215)

your armchair across the room. The orientation of these switches is such that flat response is achieved with both switch knobs all the way *down*. The rumble switch is mounted to the left of the scratch switch (since we normally think of low frequencies as being at the left of the audio scale and high frequencies at the right). Check the pictorial diagram for the exact position of the switch contacts, shown in the "flat" position, before mounting.

The only metal cutting necessary involves a few small round holes and narrow slots for the two lever switches. Each switch requires two round 3⁄16" holes spaced 11⁄16" apart with a 1⅛" x 3⁄16" slot centered vertically between the two mounting holes. As

Inside view of filter, with wiring completed, is shown at right. Lever switches are mounted on front panel. Chokes CH1 and CH2 are mounted on left inside panel. Unit is to be connected between preamp and power amp. It requires no power. With both switches in "flat" positions, signal is fed through directly. For instructions on using filter with complete or "single-chassis" amplifier, see drawing and text below.



the aluminum of the chassis recommended in the parts list is quite soft, the slot was made by drilling a 3/16" starting hole at each end of the intended slot area and carefully cutting the slot between the end holes, using an ordinary coping saw.

wiring tips

Capacitors *C1, C2, C5* and *C6* can all be pre-wired to their respective switches before assembly. One end of *C3, C4, R1, R2* and *R3* can also be wired to the switches before installation, reducing the number of wiring steps after all the parts are installed in the case.

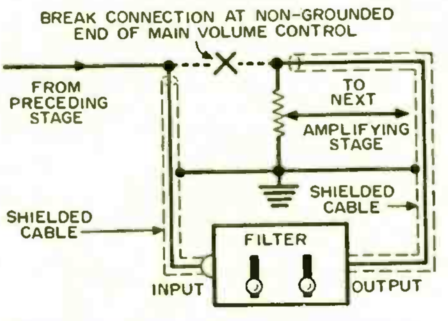
You will note from the schematic diagram that *CH1* and *CH2* are actually wired in series. The chokes are color-coded and this coding should be strictly observed in order to get the full 3 henrys from a series combination. Start with the red lead of *CH1* wired to point 1 of *S1a*. The *blue* lead of *CH1* and the *red* lead of *CH2* are then joined together and wired to point 2 of *S1a*. Finally, the *blue* lead of *CH2* is wired to point 3 of *S1a*. Keep all unshielded leads as short as possible, and be certain that only a single chassis ground is made—using the "ground" side of the input jack *J1* for this purpose.

installation and use

Connect the output cable from your preamp to the input jack of the filter. The output cable of the filter is then connected to the input jack of your power amplifier. If you have a combination preamp-amplifier, the best place to "tap into" the circuit is at the ungrounded end of the main volume control, as shown in the partial schematic on this page.

On quality FM broadcast programs, you will want to leave both switches in the flat position; on weak signals, however, setting the scratch filter to 8 kc. will often dispense with some of the FM hiss normally associated with weak reception. For AM broadcasting, we found that the 4-kc. setting gets rid of a lot of static, and since this type of transmission is limited to a maximum range of about 5000 cycles, practically no program content is lost.

The rumble filter setting will depend upon the quality of your turntable or record changer. Remember to set it back to "flat," however, when listening to radio, unless the radio station's turntable has some rumble, too—which has been known to happen!

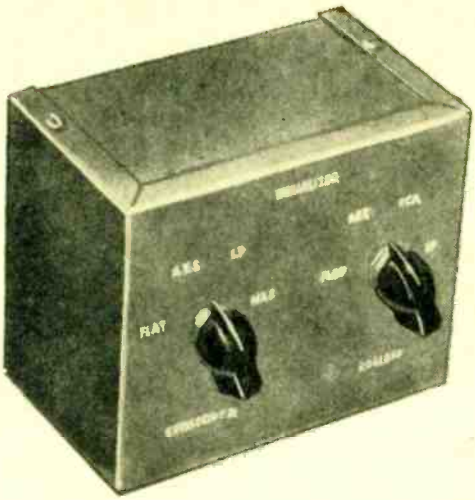


Filter may be used with "single-chassis" amplifier by tapping into amplifier's own circuit as shown in above schematic. Note use of shielded cable for carrying the audio signal.

how it works

Scratch Filtering. At low frequencies, the chokes offer very low impedance as compared to the 82-000-ohm load resistor *(R1)*. Conversely, the 500-$\mu\mu$fd. capacitor *(C2)* has very high impedance across the load, and consequently causes no shunting action. The result is that full input voltage is developed across the load resistor. At 10,000 cycles, the choke acts like a series impedance of about 200,000 ohms, and the combined parallel impedance of the 82,000-ohm resistor and the 500-$\mu\mu$fd. capacitor (whose impedance to high frequencies is low) is now reduced to about 20,000 ohms. By voltage divider action, then, only about 1/10th of the 10-kc. input signal is available at the output. This corresponds to a reduction of 20 db at this particular frequency.

Rumble Filtering. At high frequencies, the two 0.01-μfd. capacitors *(C4* and *C6)* act as a short circuit. The entire signal is developed across the 110,000-ohm effective load (two 220,000-ohm resistors in parallel). At 20 cycles, for example, each capacitor has a series impedance of about 800,000 ohms, and again—by voltage-divider action—the output voltage is about 1/25th of the total. It corresponds to a reduction of about 28 db at this particular frequency.



Building a Hi-Fi Equalizer

by *leonard feldman*

For the past several years all recordings have been standardized so that you need no longer vary equalization settings. Any good preamplifier with accurate RIAA (*Record Industry Association of America*) playback characteristics will reproduce records correctly—*provided that* they don't happen to be made before 1953, the year the record manufacturers got together and agreed on a standard equalization curve.

Before that time, virtually every important disc maker had his own way of "gimmicking up" his recording equipment during a session, so that your hi-fi equipment had to provide different record equalization settings. Since the end of 1953, however, life has become much simpler. Purchasers of new recordings merely set their equalization switches to RIAA (sometimes called Orthophonic, by *RCA)* and leave them there.

Some equipment manufacturers, taking their cue from this simplification, abandoned the extra levers, knobs and switches in favor of this single standard setting.

but what about older records?

However, with so many "fixed equalization" preamplifiers in use, what does the penurious hi-fi fan do about reproducing records made before 1953?

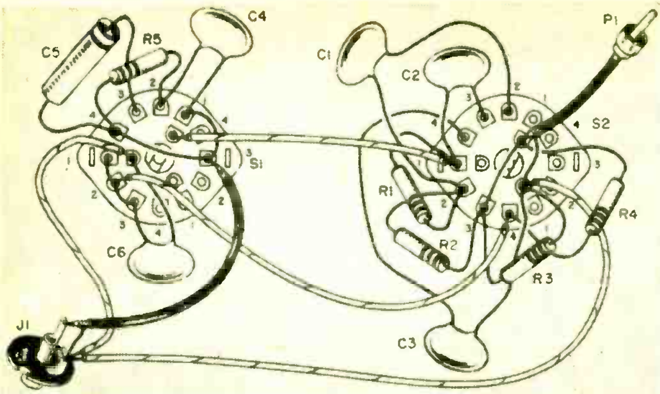
The equalizer shown here has two very important aspects. First, the parts required to build it cost less than $4.25 and are all available from standard jobbers. Second, the unit is an outboard affair which is plugged in between your preamp—any preamp—and your amplifier.

The latter feature makes this equalizer compatible with almost any setup for which it provides a choice of equalization settings. What's more, because it is "patched into the circuit" after preamplification, there's no danger of hum and noise because the signal has already been amplified at the point of insertion to a level where these problems no longer exist.

what the equalizer does

There are four selectable positions of low-frequency equalization (sometimes called "turnover") and four positions of high-frequency equalization (sometimes called de-emphasis or roll-off). Since the two selector switches operate independently, the unit can actually produce sixteen distinct equalization settings to accommodate virtually any record ever made.

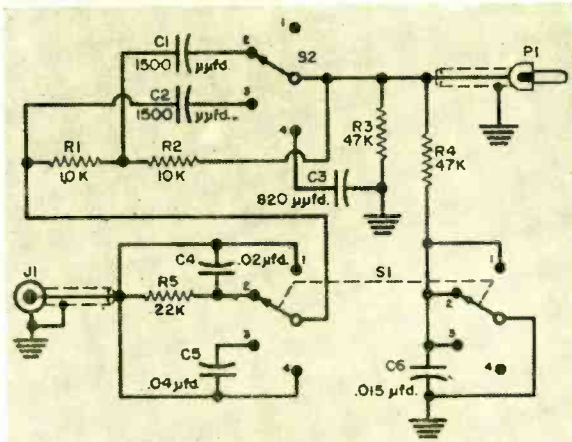
Since your preamp already has RIAA equalization built in, the equalizer discussed here merely adds or subtracts the *difference* between RIAA and the old playback curve to restore flat response. As the maximum deviation of any of the curves compared to



Wiring layout for the equalizer should closely follow the pictorial diagram at left. Switches S1 and S2 are viewed from rear. The schematic diagram below shows how S1 controls the bass turnover frequency while S2 regulates treble roll-off.

parts list

C1, C2—1500-$\mu\mu$fd. disc capacitor
C3—820-$\mu\mu$fd. disc capacitor
C4—0.02-μfd. disc capacitor
C5—0.04-μfd., 200-volt paper tubular capacitor
C6—0.015-μfd. disc or tubular capacitor
J1—Standard phono-tip jack
P1—Standard phono-tip plug
R1, R2—10,000-ohm, ½-watt carbon resistor
R3, R4—47,000-ohm, ½-watt carbon resistor
R5—22,000-ohm, ½-watt carbon resistor
S1, S2—3-pole, 4-position rotary switch (Mallory 3134J)
1—Cabinet (ICA No. 29440)
Misc. shielded cable, hookup wire, etc.



SWITCH POSITIONS

	1	2	3	4
S1	RIAA	AES	LP	NAB
S2	RIAA	AES	RCA	LP

RIAA is only about 5 db, it was possible to construct this unit without any tubes. The total volume loss introduced by the equalizer is just slightly less than 6 db, which simply means that your volume control on the amplifier will have to be set *slightly* higher.

building the unit

Wiring should follow exactly the layout shown in the schematic and pictorial diagrams. The two switches, *S1* and *S2*, form the heart of the system. For standardization, two 3-pole, 4-position switches were chosen even though not all the lugs of both switches are actually utilized. Some of the extra lugs are used as tie points.

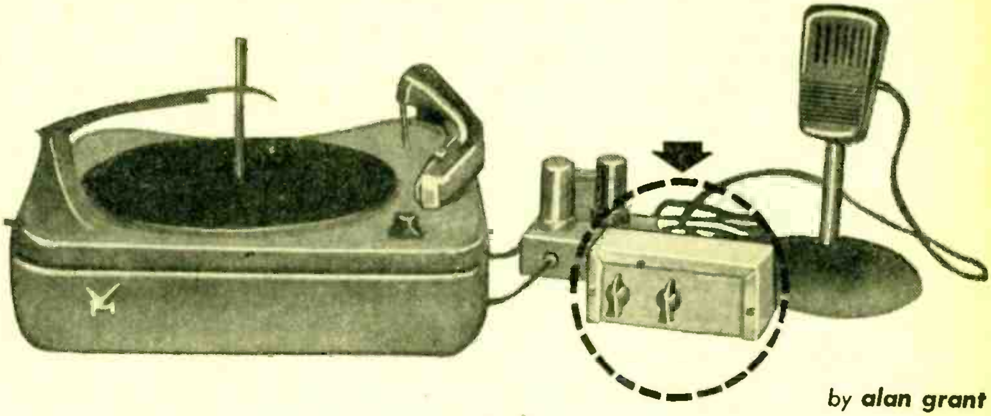
The front of the chassis requires two symmetrically spaced ⅜" holes for mounting the switches. At the rear of the chassis, there should be a ¼" hole for the output cable and a 11/32" hole centered between two clearance holes for #6 machine screws, 11/16" apart, in which the input phono jack *J1* is mounted.

wiring hints

Most of the switch wiring can be done before mounting the switches to the chassis. It is not necessary to use shielded wire, except where indicated in the diagram. The only physical return to chassis ground is made at the input jack, a practice highly recommended.

Connect the shielded cable now going from your preamplifier to your main amplifier to the input of the equalizer instead. The output cable from the equalizer (which should not be longer than 8 feet) is then connected to the input jack of your main amplifier. With the two equalizer switches set in the flat position, you will get RIAA equalization just as before and this setting is correct for all of the newer recordings.

Simple Hi-Fi Mixer-Equalizer



by **alan grant**

tubeless circuit permits mixing and equalizing signals from phono pickups and microphones

This mixer-equalizer adds signals from a mike and magnetic phono pickup to be fed into a tape recorder or public address system. It can also match two microphones of different sensitivity, or "gain down" the signal from a crystal pickup or tuner to the lower output level of the magnetic pickup.

Many experimenters and technicians have high-gain p.a. amplifiers which would be excellent for use with a magnetic pickup except for the fact that they do not provide for equalization of the incoming signal. This easily built device provides the desired equalization for the pickup.

Note, however, that this unit does not take the place of a preamplifier. It cannot be used unless the amplifier possesses sufficient gain to be driven by a crystal mike.

For those who already have preamplifier-equalizer circuits in their amplifiers, this circuit provides a means of adjusting the amount of bass boost and also provides variable high-frequency roll-off, a feature not found in many hi-fi amplifiers.

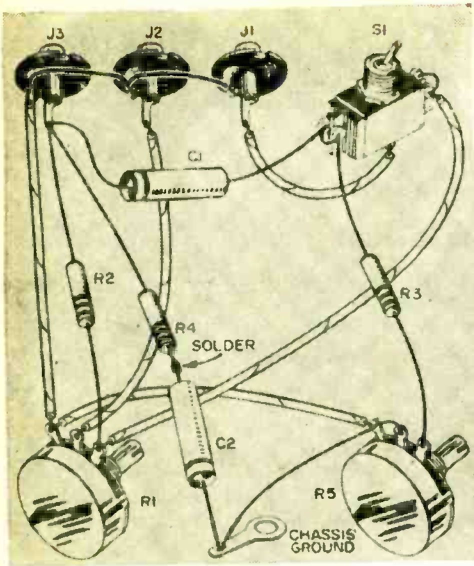
circuit features

Switch *S1* enables you to switch the equalizer network in or out of the circuit. With the equalizer out of the circuit, jack *J1* can be used for another microphone.

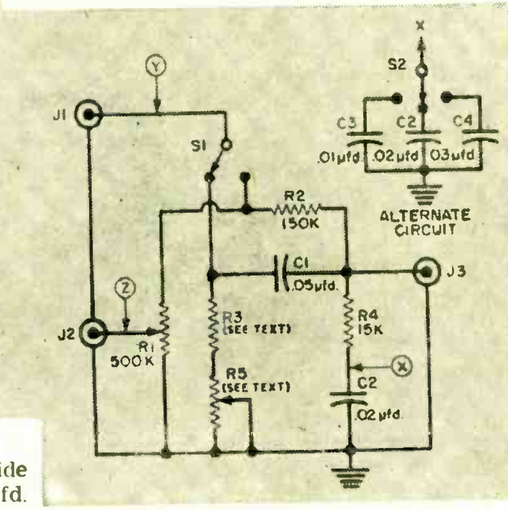
There are two potentiometers. *R5*, which controls the amount of high frequencies to be amplified, can be used to reduce surface noise on old records as well as the boosted highs found on some high-fidelity recordings. The other potentiometer, *R1*, serves as a gain control across the mike input. Relative loudness of the phono pickup can be controlled by the gain control located at the amplifier input.

Before this unit is used with an amplifier, it is wise to check the input circuit to make sure that there are no *RC* networks which will affect the tone quality of the material to be amplified. For instance, a mike input often has a small ceramic capacitor and resistor-to-ground network to peak voice frequencies. Naturally, this must be removed if any kind of high-quality response with records is to be obtained. Also, any phono equalization networks designed for magnetic pickups must be removed if the equalizer is to function properly; failure to do this may result in unnaturally boosted lows and exaggerated highs, caused by "double equalization."

If you want to be able to vary the amount of bass boost to compensate for various record characteristics, you may insert two additional capacitors and a three-position rotary switch at point ⓧ (see schematic). Capacitor *C2* provides a slight bass



Schematic and pictorial for building the mixer-equalizer. Parts list is given below. If bass is too prominent for good voice intelligibility on microphone input, a small capacitor (on the order of 0.001 μfd.) should be inserted at point Ⓩ.



boost. A 0.03-μfd. capacitor will provide essentially flat response, while an 0.01-μfd. unit will increase the bass. If you don't want to bother with the switch, simply experiment with different values until you find one that is pleasing to your ear.

construction hints

This mixer-equalizer will have very little insertion loss or hum if properly constructed in a small aluminum chassis box. Don't use a wooden box or an open chassis.

Because of the extremely low level of magnetic pickups (about 15 millivolts), it is imperative that all "hot" leads be kept as short as possible and close to the sides of the chassis box. One of the switch lugs on *S1* serves as the tie point for *C1* and *R3* (see pictorial diagram).

C1—0.05-μfd., 200-volt paper capacitor
C2—0.02-μfd., 200-volt paper capacitor
*C3—0.01-μfd., 200-volt paper capacitor
*C4—0.03-μfd., 200-volt paper capacitor
J1, J2, J3—Connector jack, either microphone type or RETMA standard type
R1—500,000-ohm potentiometer, audio taper
R2—150,000-ohm, 1/2-watt resistor
R3—About 7000 ohms (minimum resistance value allowable as a load resistor for specific magnetic pickup used—see manufacturer's recommendations)
R4—15,000-ohm, 1/2-watt resistor
R5—10,000-15,000-ohm potentiometer (depending on the recommended load resistor)
S1—S.p.d.t. switch
*S2—Three-position rotary switch
1—Miniature aluminum chassis box
*For variable bass boost (see text)

using the mixer-equalizer

Connect a microphone to *J2* and a magnetic pickup to *J1*. Adjust the amplifier gain control to a moderate level. Then, talking in a normal voice, adjust the microphone volume control, *R1*. If the phonograph volume level tends to override the mike (as may be the case with a dynamic type), insert a 150,000-ohm resistor at point Ⓨ to balance the two inputs.

Many amplifiers do not have equalization in their "tape-in/tape-out" sections. You can use the equalizer when transcribing discs to tape to insure flat response. Be sure that the signal does not go through equalization twice, however.

The *RC* values in this equalizer network were selected to match most G. E. cartridges. However, the G. E. people have recently placed on the market a cartridge for which they recommend a 220,000-ohm load resistor. Previously they recommended lower values. Using a 220,000-ohm unit would necessitate replacing *R5* with a 200,000-ohm potentiometer, with *R3* becoming 20,000 ohms.

From this example, you can see how the circuit could be modified to accommodate any type of magnetic pickup. Simply pick a resistor-potentiometer combination that equals the manufacturer's recommended load resistance for maximum high-frequency response. The impedance of the pickup is taken into consideration in computing this resistance.

Make Your Own Electrostatic Tweeter System

by *leonard feldman*

a do-it-yourself tweeter system featuring low cost and simple design

Hi-fi refinements seem to run in cycles, if you'll pardon the pun! The "first awakening" involved the quest for higher highs; supersonic amplifier response and tweeter capabilities were all the rage.

Next, attention was turned to bass and its attendant problems of baffling, enclosures, loading, placement and power. The results of this phase of sound improvement were so startling that they virtually revolutionized the whole concept of sound in the home.

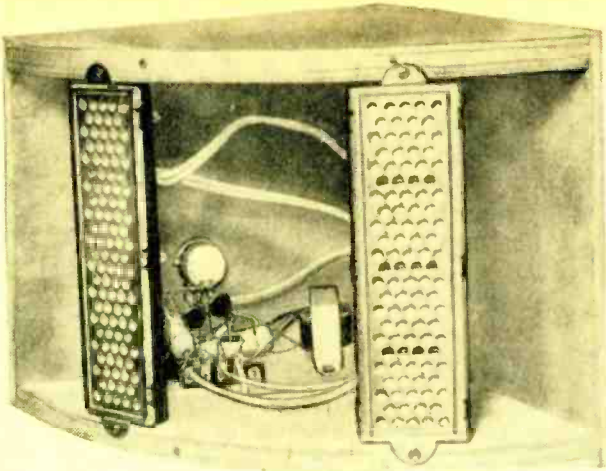
Now, perhaps it is time to go back a bit and re-evaluate what has happened to the highs, particularly in light of the development of the electrostatic tweeter. It is *theoretically possible* to design an electrostatic speaker capable of reproducing the entire audible range (and some have actually been constructed in the labs). However, problems of size and spacing of the plates, as well as the voltages necessary to produce sufficient movement of the diaphragm, make such a loudspeaker a thing of the future.

At the moment, though, many excellent units are available for use on high frequencies. A pair of these inexpensive units may be assembled to provide a very serviceable tweeter to supplement your existing speaker system.

why two tweeters?

The directional characteristics of the Isophon electrostatic tweeters used in this construction are such that if you sat directly in front of one you would hear an absolute level of sound of about 50 decibels. If you moved away from "dead center" to an angle of 60° from the perpendicular to the speaker, the level of sound would be only about 38 db. To an extent, this is true of all tweeters—electrostatic or magnetic type. To solve the problem, we used two tweeters mounted at an angle of 120° from each other to give a better distribution of sound.

Still another source of trouble lies in your room furnishings. A tweeter aimed at a heavily draped wall will seem to produce much less sound than another aimed at a hard, non-covered wall. Treble tones are substantially absorbed by soft materials. Therefore, in the design of our "tweeter box," provisions were made for adjusting the mounting angles of the two units to suit individual requirements.



Completed electrostatic tweeter system. Tweeter elements should be positioned for best high frequency dispersion.

electrostatic tweeter circuits

Electrostatic speakers require high audio voltages, generally taken from the primary or plate side of the output tubes, through suitable d.c. blocking networks and frequency-determining *RC* networks. It's not a good idea to pass *all* frequencies on to these tweeters because the large-amplitude low-tone voltages—while not producing any sound—will cause the movable plate to distend to a point where the audible highs may be distorted.

This type of hookup works fine *if your speakers are very close to your amplifier.* Since the opposite situation is true in many hi-fi setups, we decided to work out a method whereby it would not be necessary to drag around high-impedance, oscillation-susceptible plate leads.

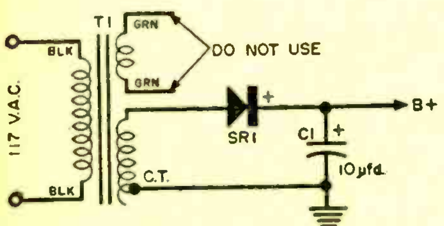
Speaker efficiencies vary tremendously. A high-efficiency speaker fed with one watt of audio power can easily be deafening, whereas the same amount of power fed to a low-efficiency speaker may cause barely a murmur. Simply to install a pair of electrostatic units in conjunction with an existing speaker system, with no provision for adjusting levels between the old and the new, would be inviting severe unbalance—the odds are just too great.

We decided, therefore, that our tweeter design would have to include a means of varying the amount of highs both to suit the companion speaker efficiencies and to allow for differences in taste, room furnishings and—in some cases—even program material.

A suitable circuit, arrived at after the above considerations, is shown in the schematic on the opposite page. Transformer *T1* is any inexpensive, single-ended audio output transformer. This unit is called upon simply to step up the voltage available at the voice-coil connections of your present amplifier to a usable value, and therefore handles practically no power.

What would normally be the voice-coil secondary is used as the primary of this circuit. Conversely, what would be the primary of the output transformer serves, in this case, as a secondary to drive the tweeter circuit. This connection enables you to feed audio into the "tweeter box" from the same pair of leads now feeding your main speaker system.

A crossover network is provided by *C1*, *C2*, and *R1*.



T1—TRANSFORMER, STANCOR #PS-8416
C1—ELEC. CAPACITOR, TUBULAR, 10µfd., 350V.
SR1—SELENIUM RECTIFIER, 130 R.M.S. VOLTS, 20 MA. D.C. OUTPUT

Power supply for feeding B-plus to tweeter when B-plus is NOT taken from amplifier.

installation

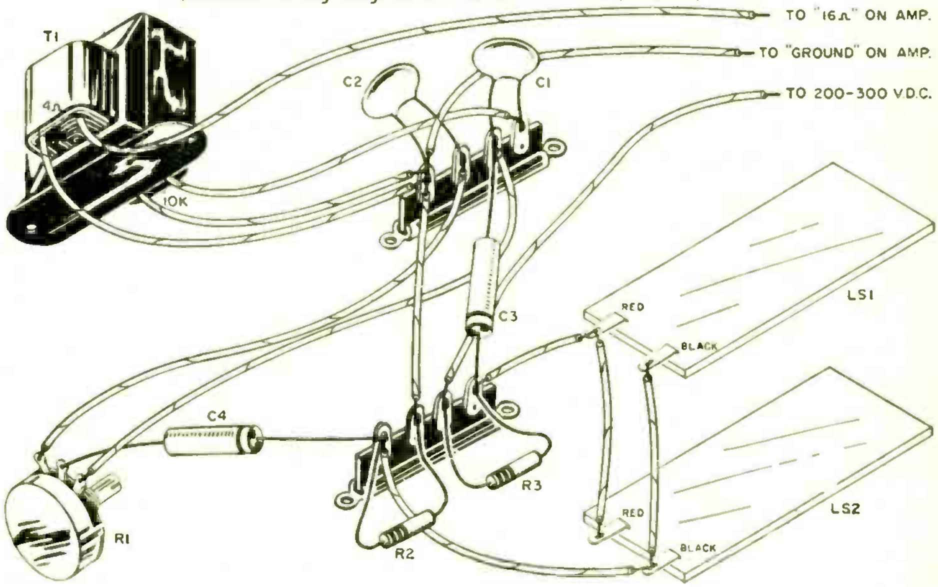
The tweeter cabinet is not a speaker enclosure in the traditional sense, but merely a convenient housing. Cautions usually applied to speaker enclosure construction need not apply here. All electronic parts for the circuit can be built right into the rear of the wooden box itself. The third wire, which comes from the hi-fi amplifier, is for the d.c. polarizing voltage—it may be any amount from about 200 to 300 volts and it need not be particularly well filtered (remember, you can't hear 60 or 120 cycles from an electrostatic tweeter). This B-plus wire can be run right along with your regular speaker leads back to the amplifier where a suitable voltage point can be found readily. For those who may be a bit hesitant about running such voltage around the house, we have also shown a small, separately built power supply which can be housed right inside the tweeter box.

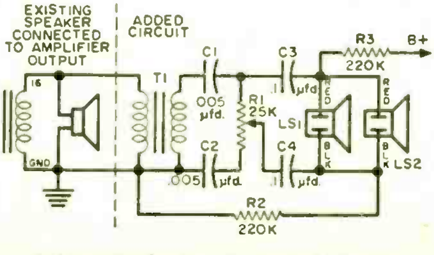
angling in

After the entire unit is assembled and the circuitry wired, mount the two tweeter units vertically, at an angle of about 120° from each other. The tweeter level control should be mounted on one of the side panels. Connect the two transformer leads to the 16-ohm tap of your amplifier. Connect the d.c. lead to the appropriate source of voltage, turn on your rig, and gradually increase the tweeter level control setting until you hear the highs as you like them.

Position the box in its final location and move about your listening room, noting the pattern of sound distribution. It may help to disconnect your woofer and mid-range speakers at this point so that you can more easily discern the distribution of highs alone in the room. If you find that the distribution is deficient in certain areas, simply change the "mounting angle" of your tweeters (either one or both) to favor the deficient sectors of the room.

Pictorial wiring diagram for the electrostatic speaker system.





Schematic for the electrostatic tweeter.

parts list

C1, C2—0.005-µfd., 500-volt disc ceramic capacitor
C3, C4—0.1-µfd., 200-volt paper capacitor
LS1, LS2—Rectangular electrostatic speaker, Model ST-H-5/16 (Arnhold Ceramics, Tweeter Div., 1 E. 57 St., New York, N. Y.)
R1—25,000-ohm linear taper potentiometer (IRC Type RQ-11-120 or equivalent)
R2, R3—220,000-ohm, 1/2-watt resistor
T1—Audio output transformer (Stancor A-3879 or equivalent)

Two-Tube Economy Amplifier

double performance with this two-tuber which does the work of four single tubes

by ***allan m. grant***

This is a simple, low-cost amplifier that can be used with a crystal pickup or FM tuner. Although the circuit contains only two tubes, there is ample output for both of these applications. Utilizing dual-purpose tubes, a 6SL7 for two amplifying stages and a 117N7 as a rectifier and beam output tube, its performance is equal to that of a three- or four-tube unit.

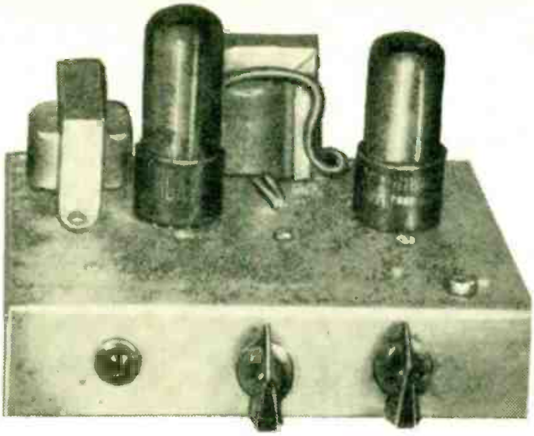
A tapped tone control boosts either the bass or the treble ranges, and can be used to equalize older records. Fidelity-wise, there are three applications of inverse feedback to make it nearly distortion-free. But naturally, the 117N7 tube with its 1-watt output cannot be expected to rival a 40-watt "monster."

circuit details

In place of a "hot" chassis, found in most small amplifiers of the a.c./d.c. variety, all circuit grounds terminate at a single lug which is chassis-grounded through capacitor *C2*.

Voltage for the two tube filaments is obtained from two different sources. The 117N7 tube (*V2*) works right across the 117-volt a.c. line without a dropping resistor. To obtain the necessary voltage for the 6SL7 (*V1*), the author settled on a 290-ohm resistor line cord. Any resistance up to 350 ohms can be used with equal results.

The pilot light (*PL1*) is connected in series with the 6SL7 heater. Although a choke (*CH1*) is shown in the wiring diagram, the constructor may substitute a 450-ohm resistor (5 watts) if he wishes.



On the front of the amplifier are located the pilot light, the tone control, and the volume control. As shown on the preceding page, amplifier is used in hi-fi system that has been chosen to provide good performance at low cost.

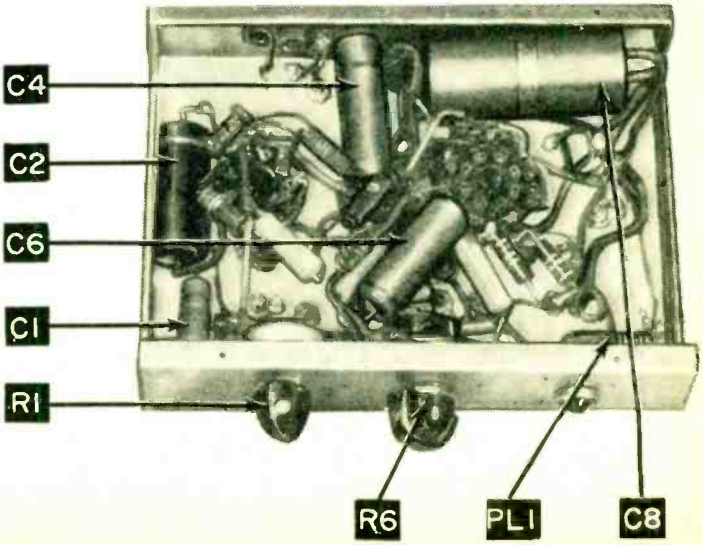
construction pointers

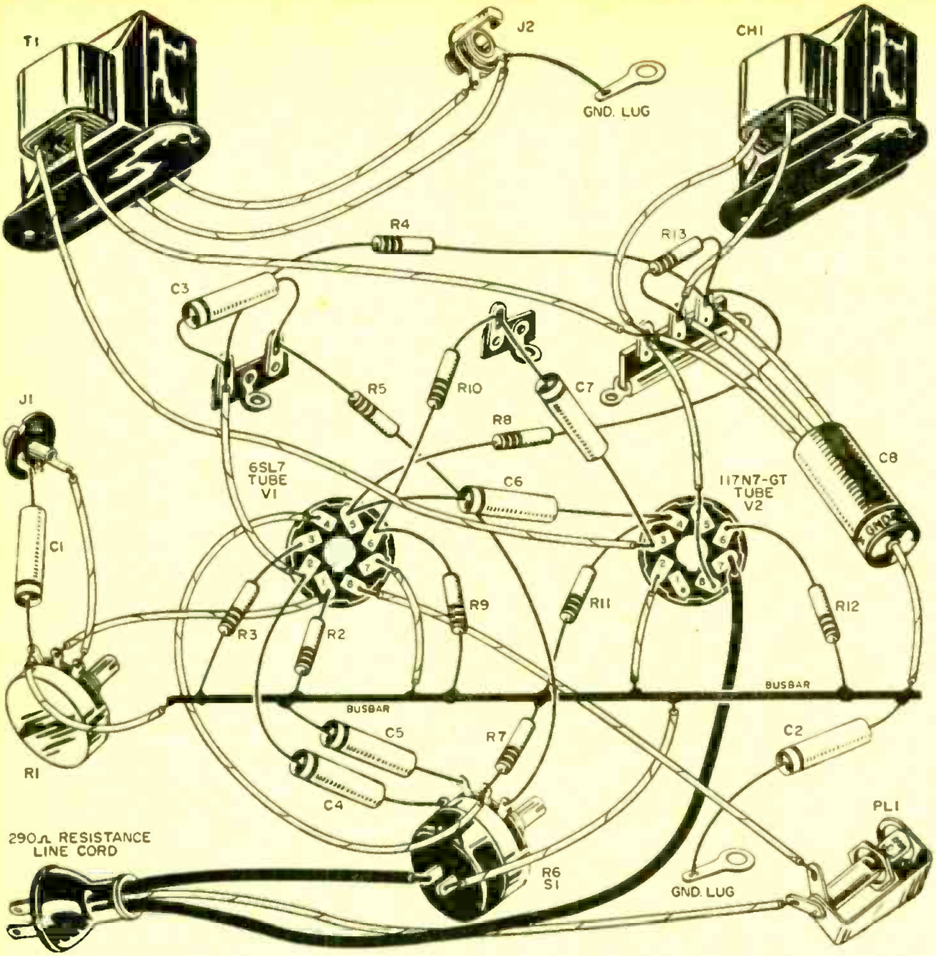
The author ran all leads as close to the chassis as possible. All high-level a.c. voltage leads were kept short. Because of the nature of the resistor line cord, the "on-off" switch (*S1*) is connected in the ground lead. The cord dissipates quite a bit of heat when working normally. Don't be alarmed if it becomes quite hot to the touch.

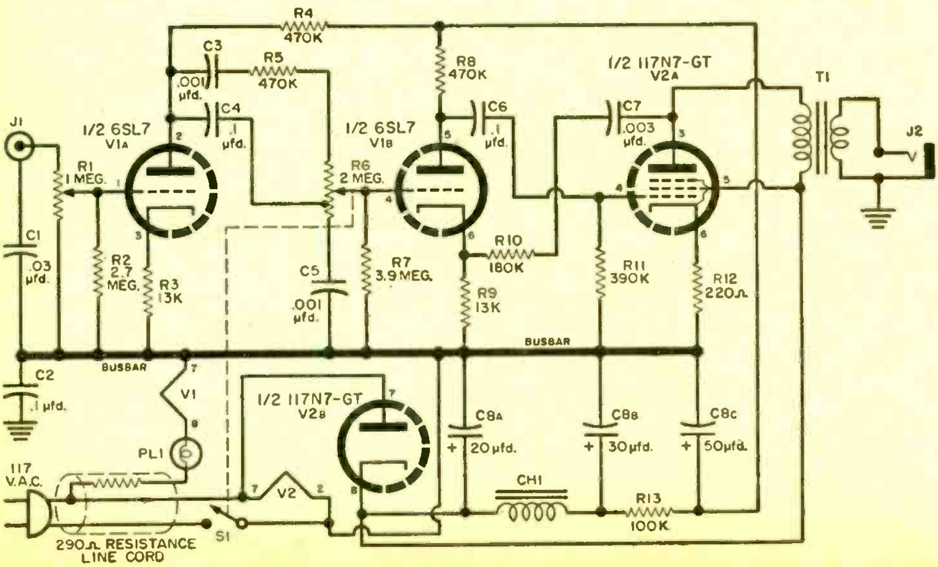
Wire carefully and avoid large blobs of solder. In the case of the ground lug, use a two- or three-lug terminal strip and connect the lugs together with a heavy piece of bare copper wire. Avoid letting solder run down to touch the chassis—this could result in a direct short. And remember that when the line plug is inserted and the switch is "off," the ground side of the circuit will be safe to touch but anything connected to the other side of the line definitely will not!

The output transformer is a high-quality universal type transformer such as the *Stancor* A-3856. Follow the manufacturer's instruction sheet in matching your speaker impedance to the 3000-ohm load resistance of the 117N7. For increased high-frequency response, you might try the A-3850, a unit of slightly larger size.

Underside of amplifier chassis, showing terminal board and point-to-point wiring. You will note that the major components are crowded to the back of the chassis. While this keeps hum away from the tone and volume controls, the top of the chassis looks somewhat unbalanced. You may want to experiment with alternate layouts to obtain a more balanced appearance while retaining minimum hum.




T1
J2
GND. LUG
CH1
R4
R13
C3
R5
R10
C7
J1
R8
C8
6SL7
TUBE
V1
C6
117N7-GT
TUBE
V2
C1
R9
R11
R12
R3
R2
BUSBAR
BUSBAR
C5
R7
C2
R1
C4
PL1
290Ω RESISTANCE
LINE CORD
R6
S1
GND. LUG


R4
470K
C3
R5
470K
.001
μfd.
R8
470K
1/2 117N7-GT
V2A
T1
C4
.1
μfd.
C6
.1
μfd.
C7
.003
μfd.
J1
1/2 6SL7
V1A
1/2 6SL7
V1B
J2
R1
1 MEG.
R6
2 MEG.
C1
.03
μfd.
R2
2.7
MEG.
R3
13K
R10
180K
R7
3.9 MEG.
R11
390K
R12
220Ω
C5
.001
μfd.
R9
13K
BUSBAR
BUSBAR
C2
.1 μfd.
V1
1/2 117N7-GT
V2B
C8A
20 μfd.
C8B
30 μfd.
C8C
50 μfd.
PL1
117
V.A.C.
V2
CH1
R13
100K
S1
290Ω RESISTANCE
LINE CORD

operation

When you first turn the amplifier on, a bright flash of light will be seen in the 117N7 tube, which will then heat up rapidly. The pilot light (if connected in series) should be operating near its maximum rating. With nothing connected to the input and the volume control in its loudest position, hum should be inaudible. (There will be a slight hum if you substitute a resistor for the filter choke.) If any hum is heard, reverse the line plug.

Connecting a record changer or tuner may produce some hum. If it does, reverse both plugs several times until an ideal match is indicated by an absence of hum.

For best operation, the constructor should adhere closely to all specified circuit values—with several exceptions. One is *R13*, in the power supply circuit. If for some reason you would like more gain, this resistor can be brought down to 50,000 ohms to supply more plate voltage to the 6SL7.

Other components open to change are *R10* and *C7*, which form the feedback loop. The over-all gain of the amplifier may be adjusted at this point. Decreasing the value of *R10* decreases the gain, and vice versa. *C7* controls the amount of feedback at lower frequencies. The larger the value, the more bass is fed back to the cathode, resulting in decreased bass response. If you have a highly efficient speaker enclosure, you may want to use a larger capacitor and decrease the amount of bass, *C7* can be varied up to 0.01 μfd.

Pictorial and schematic diagrams for the two-tuber are at left, with parts list below. Circuit values were chosen with care for maximum performance. See description of how the unit operates at right.

C1—0.03-μfd., 300-volt paper tubular capacitor
C2, C4, C6—0.1-μfd., 300-volt capacitor
C3, C5—0.001-μfd., 200-volt paper tubular capacitor
C7—0.003-μfd., 220-volt paper tubular capacitor
C8a/C8b/C8c—20-30-50-μfd., 150-volt d.c. electrolytic capacitor
CH1—450-ohm, 50-ma. filter choke (see text)
PL1—6.8-volt pilot light (screw base) and socket
J1—Phono jack with insulating washer
J2—Microphone type jack
R1—1-megohm audio taper potentiometer (Mallory Midgetrol 1-meg. Taper 1)
R2—2.7-megohm, ½-watt resistor
R3, R9—13,000-ohm, 1-watt resistor
R4, R5, R8—470,000-ohm, 1-watt resistor
R6—2-megohm potentiometer, tapped at 500,000 ohms, with switch (IRC 2-meg. 13-139X)
R7—3.9-megohm, ½-watt resistor
R10—180,000-ohm, 1-watt resistor
R11—390,000-ohm, ½-watt resistor
R12—220-ohm, ½-watt resistor
R13—100,000-ohm, ½-watt resistor
S1—S.p.s.t. switch (on R6)
T1—Universal output transformer (Stancor A-3856 or equivalent)
V1—6SL7-GT tube
V2—117N7-GT tube
1—5" x 7" chassis (minimum)
1—290-ohm resistor line cord
Misc. tube sockets, wire, hardware, knobs

how it works

Signal from the pickup or tuner enters by way of phono jack J1. C1 isolates the shielded phono cable from the "hot" a.c. line, and C2 is connected from the chassis to the common ground lug. R1 serves as a volume control and grid resistor R2 prevents overloading of the grid of V1a. R2 also serves as a high resistance path to ground for the potentiometer and prevents noise from developing in the control.

The bypass capacitor usually found across R3 is omitted, introducing some degeneration (negative feedback) into the stage. A tone control, consisting of C3, C4, C5, R5 and R6, emphasizes either high or low frequencies. With the arm of potentiometer R6 toward R5, high frequencies predominate. The 1.5-megohm section of the control is in series with R5, blocking out the low frequencies. Response is "flat" when the arm is at the tap position; moving it to the low end of the control "cuts" the highs and boosts the lows slightly. R7 eliminates noise problems which often develop in tapped controls, and serves as a grid resistor for the second half of the 6SL7 (V1b) which is used to make up for the insertion loss of the tone control.

R9, the cathode resistor for V1b, is also left unbypassed, because it serves as the connection for the inverse feedback loop consisting of R10 and C7. Plate voltage is supplied through R8. Blocking capacitor C6 keeps the d.c. component from the grid of the output tube.

The feedback loop returns a portion of the plate voltage to the cathode out-of-phase with the signal in V1b, canceling even-order harmonics and hum. C7 controls the amount of bass frequencies held back, and also blocks the plate voltage from the cathode. R10 controls the amount of feedback.

Junior Fi for the Small Fry

by donald smith

build this inexpensive phono unit for the kids

If your hi-fi has developed a split personality from double duty as a source of both "long-haired" sound for the grown-ups *and* "pop" for the youngsters, this two-evening project can be just what the doctor ordered.

Based upon the readily available *RCA* 45-rpm phono attachment, the completed player will prove the salvation of the hi-fi owner who has big problems with small fry. It's designed to decoy the "rock-and-rollers" away from your sensitive stylus and tender tone arm. You might even want to build extra models for your summerhouse, playroom or den.

Construction time can be cut down by using one of the small preassembled a.c./d.c. amplifiers (such as *Philmore's*) or, if you have more ambition, you can start from scratch and "roll your own." The schematic and pictorial are here, the construction and operation have been de-bugged—let's go!

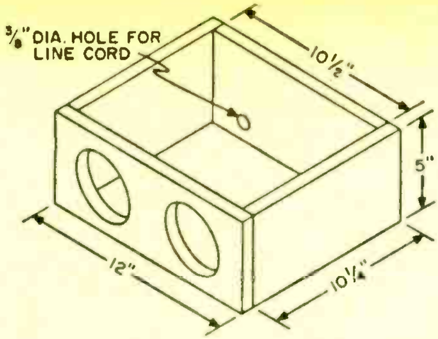
the base

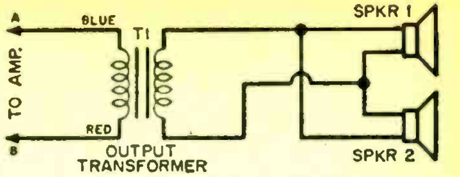
The best way to start is with an 11" x 12" plywood panel, ¼" or ⅜" thick. This is your motor board. Draw the area to be cut out as shown. Drill a large hole near the edge of the cutout, and then, using a coping saw, follow the outline shown. Next, drill the holes which will hold the changer and amplifier to the motor board.

After the motor board is complete, the front, rear and two sides of the base must be made. These are of plywood and ¾" thick.

Now for the front panel—use the illustration on the next page as a guide in drilling the speaker mounting holes, and cutouts for the grille. If you like, simple round holes of the correct diameter for the 4" or 5" speakers may be drilled. They can be dressed up with small squares of plastic speaker material stapled to the back of the front panel.

When all the wood parts of the base have been made, check them for fit. Next, sand all parts till smooth. Lay out all of the pieces and glue the cabinet together using a good wood glue. Use two 6-penny finishing nails at each joint. These should hold well





Hookup of 4" or 5" PM speakers may be made either in parallel as shown or in series (see text). Check for proper phasing by reversing the voice coil connections to one of the speakers; then note effect upon bass reproduction and connect for best results. T1 is a 50L6 output transformer. Complete phono amplifier circuit is on page 148.

and allow the glue to set. Do not glue the motor board, as it is held in place by wood screws, one in each corner. Now paint or varnish the wooden parts as desired.

mounting components

As soon as the base is finished and the glue dried, the electronic part of the assembly can be started. Install the speakers first. The output transformer can be held in place by one of the speaker mounting bolts.

The amplifier mounting is next. Simply remove the nuts which hold the two controls, volume and tone, to the amplifier chassis and insert them through the motor board; then put the nuts and washers back on the controls.

After the amplifier is mounted, remove the changer from its *RCA* plastic base, and install it on the new motor board. Use two of the original machine screws to attach the changer to the motor board.

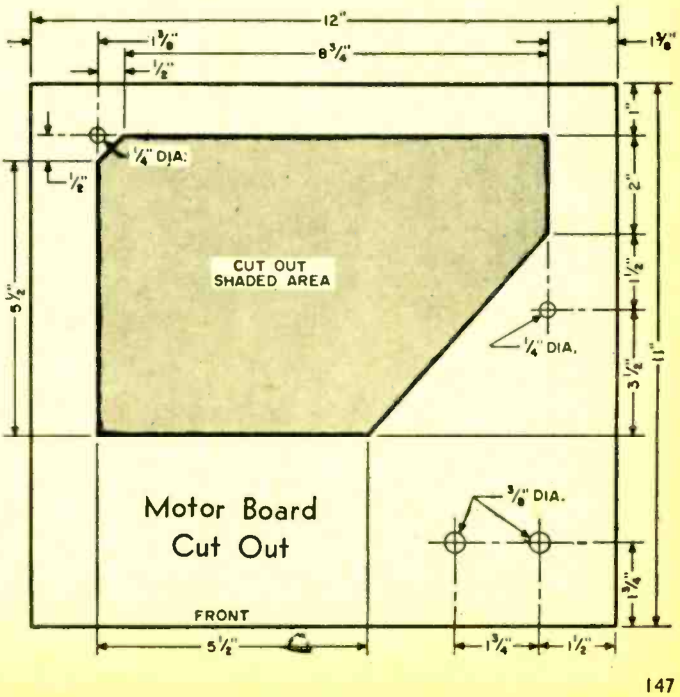
wiring

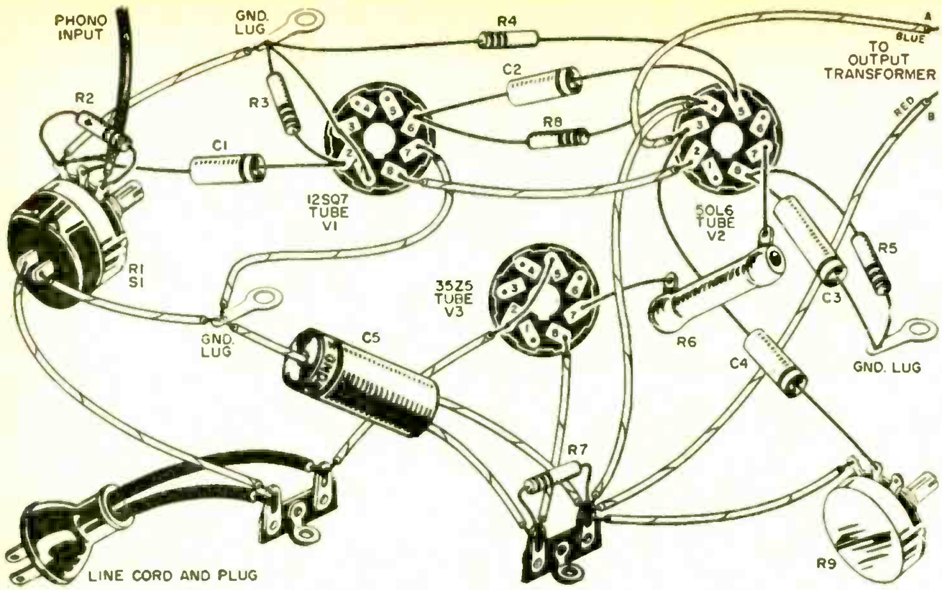
If you use a ready-built amplifier, little wiring is needed. Connect the voice coils of the speakers together in parallel or series (whichever sounds better) with two pieces of hookup wire. Connect the leads from the output transformer to the voice coil connection of the speaker nearest to the transformer.

Next, cut the a.c. plug from the changer line cord and shorten the cord to a convenient length for connection to the amplifier. Solder one of the line cord wires to the chassis of the amplifier at a nearby ground lug and the other to pin #5 of the 35Z5.

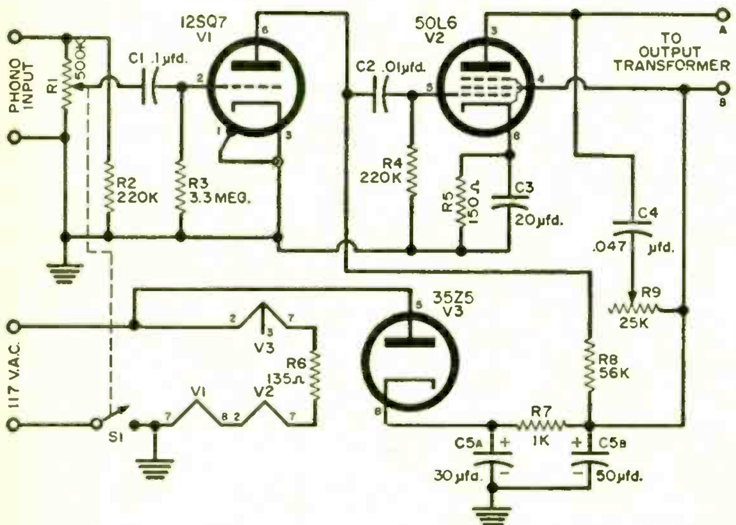
The shielded lead from the changer should be about 8" long to reach the volume control of the amplifier. Connect center wire to high side of the volume control and the shield to the ground side. Now place the motor board right over—and a little above—the base, and solder the blue lead from the output transformer to pin #3 on the 50L6 tube socket and the red lead to pin #8 of the 35Z5.

Place the motor board on the base and secure it with wood screws. Check to see that no wires are shorting to each other, and make sure that both the shielded wire running from the pickup to the





C1—0.1-μfd., 200-volt tubular capacitor
C2—0.01-μfd., 400-volt tubular capacitor
C3—20-μfd., 25-volt electrolytic capacitor
C4—0.047-μfd., 400-volt tubular capacitor
C5a/C5b—30-50-μfd., 150-volt electrolytic capacitor
R1—500,000-ohm volume control potentiometer
R2, R4—220,000-ohm, 1/2-watt resistor
R3—3.3-megohm, 1/2-watt resistor
R5—150-ohm, 1-watt resistor
R6—135-ohm, 10-watt resistor
R7—1000-ohm, 2-watt resistor
R8—56,000-ohm, 1-watt resistor
R9—25,000-ohm tone control potentiometer
S1—S.p.s.t. switch (on R1)
V1—12SQ7 tube
V2—50L6 tube
V3—35Z5 tube
Misc. tie points, ground lugs, line cord, nuts, bolts, etc.



Phono amplifier circuit, above and at left, may be modified to suit constructor. R2 can be varied from 68,000 ohms up to the figure shown here. Changing the value may improve the tone of some cartridges.

amplifier and the line cord are not in the way of the changer mechanism and are well separated from each other.

As a final touch, a sheet of heavy cardboard may be cut out and glued on the bottom of the case or fitted inside of it. The fidelity of the little unit will surprise you. It's not hi-fi by any means, but its sound quality is better than a number of commercial, low-priced record players and it should prove a useful little brother to that 10- or 20-watter upstairs.

Oval-Flex Speaker Enclosure

by **b. van sutphin**

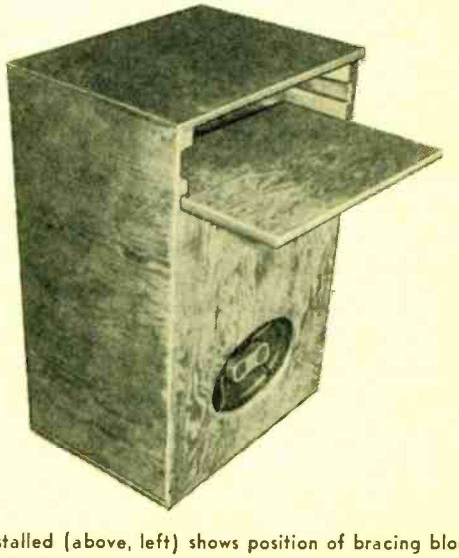
surprisingly good sound at an amazingly low price

You say an oval speaker can't be used for high-fidelity sound? Well, that's what it says in the books. But after you've built one, you'll be in for the shock of your life. An oval speaker never sounded like this before. There's a secret to it, though. You'll have to use a *coaxial* oval speaker. A very satisfactory 6x9 unit that sells for $7.95 is available from *Lafayette Radio Corp.*

The problem of the enclosure is easily solved. I chose the bass reflex because it can return reasonable fidelity yet is simple to build. Actually, the cost of materials was only about $4. I decided to use a ducted port for ease of construction. A tuned port would have required two front panels—one for the tuning experiments, the second for the final model.

The enclosure must be tuned to the speaker, i.e., the parallel resonant circuit of the enclosure must cancel the resonance of the speaker itself. When exact balance is obtained, the relatively sharp increase in speaker response at the resonant frequency is cut down and bass response is extended below the normal resonant frequency. This gives broad over-all response.

Three-quarter-inch plywood was used throughout. There is just one gimmick in the building—you have to go according to the diagram. The ducted port length must be varied until the proper tuning point is reached. Then the excess is cut off and dis-



Rear view of enclosure before speaker is installed (above, left) shows position of bracing blocks. Note how ducted port is installed. The back should be put on with screws for tightest fit. Photo above, right, shows how to tune ducted port—it's best to turn the enclosure upside down.

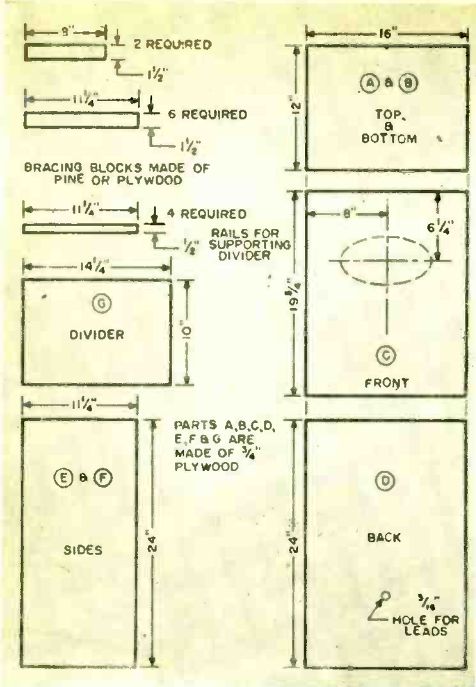


Diagram above gives dimensions of all the pieces of the Oval-Flex enclosure. Material used throughout by the author was ¾" plywood stock.

carded. Note inside view of enclosure before back was added. There are blocks in the four corners for mechanical strength and braces along the sides of the front panel. Extra blocks are provided at the rear so that the back can be put on with wood screws. This permits a tight seal, yet allows the back to be removed when necessary. The rest of the enclosure can be put together with nails, but screws are recommended.

Although not shown, 12" squares of sound-absorbing material (Fiberglas) are glued to the sides, centered in the area between the sliding panel and the top. A 10" square is centered on the back two inches down from the top. The amount of Fiberglas used will determine somewhat the brightness of the sound.

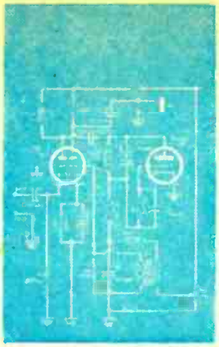
tuning

Turn the enclosure over when it's ready to be tuned. It's easier to work with, and there will be no obstruction in front of the port. Only a 1.5-volt flashlight battery is needed for tuning.

After installing the speaker, solder a 3' length of lamp cord or 300-ohm flat line to the voice coil terminals and insert it through the 3/16" hole in the back panel. Then close the back. Slide the panel all the way in, and touch the leads to the battery. You will hear a "thump." Slide the panel out slowly, touching leads at each new position until you hear more of a "click" than a "thump." You are approaching the proper point. Continue until you hear a sharp "click," then pass by until you get the "thump" again. Go back to the point which gave the sharp "click," and mark the sliding panel. Cut it off, replace it, and drive small nails in on each side, front and back, in order to hold it solidly in place.

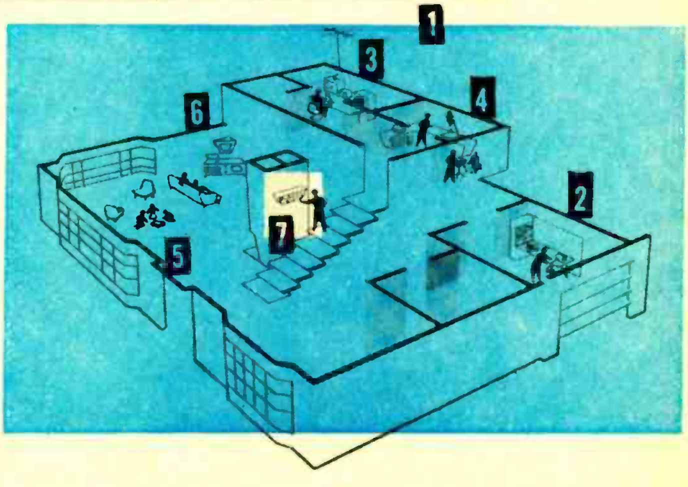
Basically, that's the Oval-Flex. You can finish it in any way you desire. You may have heard better, but for the price, it will amaze you.

Note that this oval speaker is rated at 5 watts, and its total voice coil impedance is only 3.2 ohms. If it is placed in parallel with the average 16-ohm speaker running at high volume, its tweeter assembly may be damaged through overload. If it is used as a remote bedroom speaker, shunting the main speaker, it might be advisable to try a 5 to 10 ohm, 5-watt resistor in series with the speaker line. This resistor would serve the dual function of limiting the amount of power taken by the Oval-Flex and, in addition, giving it a slight boost at the bass end. If the Oval-Flex is used directly at the output of your amplifier with no other speakers in parallel, then no series resistor is necessary.



Section 7

receivers



Transistorized

Pocket Receiver

by ***louis garner, jr.***

Both experimenters and builders will agree that a pocket radio receiver would win almost any construction popularity poll. Here is a transistorized pocket super-het with a circuit that uses only three transistors. It features a reflex arrangement and direct coupling.

A small, clear plastic box makes an excellent cabinet for the receiver. You can color the cabinet by spraying the box on the inside with Acrylic plastic of whatever color you prefer.

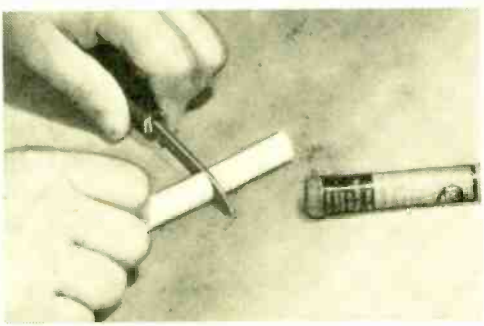
assembly

Cut a piece of thin Bakelite board to fit the plastic box and use this as a chassis, following the general layout shown in the photographs, and wiring according to the schematic and pictorial diagrams. Neither layout nor lead dress is especially critical.

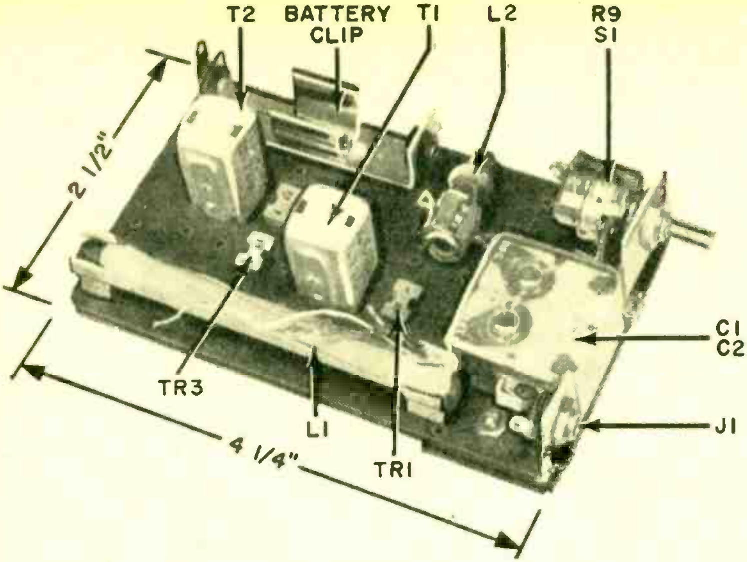
The volume control (*R9*) and output jack (*J1*) are mounted on small brackets. Coils (*L1* and *L2*), i.f. transformers (*T1, T2*), the battery holder, diode (*CR1*), transistors, the tuning capacitor (*C1a/C2b, C2a/C2b*), and ceramic and electrolytic capacitors are mounted above the Bakelite chassis. Resistors are below the chassis.

Use two small fuse clips to mount coil *L1*, placing one clip at each end of the ferrite core. Coil *L2* is simply cemented in position with one terminal inserted through the chassis. Transformer (*T1, T2*) and coil (*L2*) connections are identified on page 55; the coil leads to *L1* are color-coded.

Although the self-contained antenna coil, *L1*, should have adequate pickup for strong local stations, you'll find that the receiver's sensitivity can be increased if you add a short (2′ to 3′) antenna lead to the "white" terminal of *L1*.



Operating power for the simple receiver is supplied by an 11.2-volt battery, made up by cutting an eight-cell section from an RCA Type VSO87 "separable cell" battery. You can easily cut out the desired section with an ordinary pocket knife.



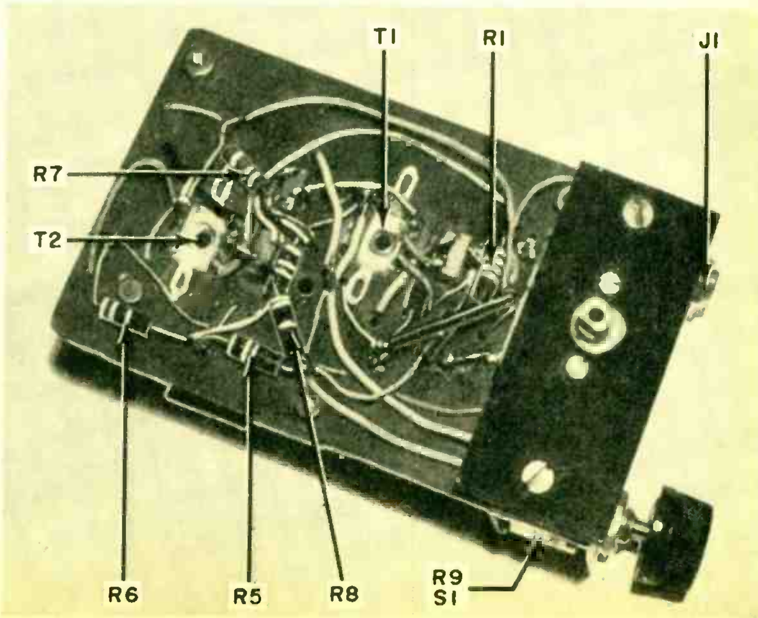
Top view of the receiver chassis shows location of all major components. The transistors are not in their respective sockets. Screw adjustments of C1b and C2b are visible on the top of C1/C2. Antenna coil L1 is held in place with a pair of fuse clips.

alignment

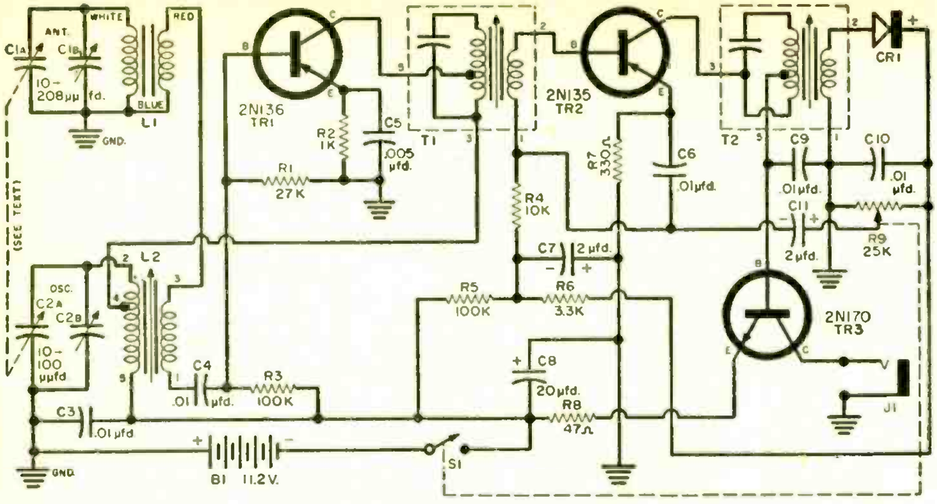
Like all superhet receivers, this set must be aligned before use. It is a fairly simple operation and consists of adjusting all fixed tuned circuits for maximum performance. You'll need a standard r.f. signal generator and an insulated alignment tool.

Connect the signal generator's "ground" lead to circuit "ground" (positive side of *B1*). Connect the "hot" lead through a small (10 to 25 $\mu\mu$fd.) capacitor to the "white" terminal of *L1*. Make sure the tuning capacitor plates are fully meshed. Then adjust the signal generator to deliver a *modulated* r.f. signal at 455 kc.

Advance the volume control to maximum output, listening to the earphone for an audio tone. Adjust the "output" control of the signal generator until the tone can just be heard. Using the insulated alignment tool, adjust the iron core slugs of



Below-chassis view. Printed wiring could be used to simplify the appearance of the unit still further, but the author thought that direct wiring would enable the job to be done in the shortest time. The i.f. transformers are held in place by small tabs that are bent into place.



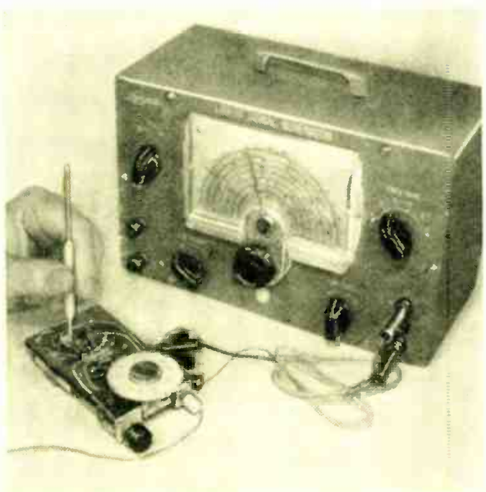
Schematic diagram and parts list for the reflex receiver.

B1—11.2-volt battery (from RCA No. VSO87 separable cell unit)
C1a/C1b (10-208 $\mu\mu$fd.), C2a/C2b (10-100 $\mu\mu$fd.) subminiature superhet tuning capacitor, two sections (Argonne No. AR-93)
C3, C4, C6, C9, C10—0.01-μfd. disc ceramic capacitor
C5—0.005-μfd. disc ceramic capacitor
C7, C11—2-μfd., 15-volt electrolytic capacitor
C8—20-μfd., 15-volt electrolytic capacitor
CR1—1N64 diode
J1—Open-circuit jack
L1—Transistor antenna coil (Lafayete MS-272)
L2—Transistor oscillator coil (Lafayette MS-265)
R1—27-000-ohm, 1/2-watt carbon resistor
R2—1000-ohm, 1/2-watt carbon resistor
R3, R5—100,000-ohm, 1/2-watt carbon resistor
R4—10,000-ohm, 1/2-watt carbon resistor
R6—3300-ohm, 1/2-watt carbon resistor
R7—330-ohm, 1/2-watt carbon resistor
R8—47-ohm, 1/2-watt carbon resistor
R9—25,000-ohm miniature potentiometer
S1—S.p.s.t. switch, on R9
T1, T2—Transistor i.f. transformer (Argonne No. AR-60)
TR1—2N136 transistor (General Electric)
TR2—2N135 transistor (General Electric)
TR3—2N170 transistor (General Electric)
1—Small plastic case
1—Bakelite mounting board
3—Transistor sockets
2—Small fuse clips
1—Miniature plug
Misc. battery clip, control knobs, machine screws, nuts, wire and solder, etc.
Accessory—High-impedance magnetic earphone

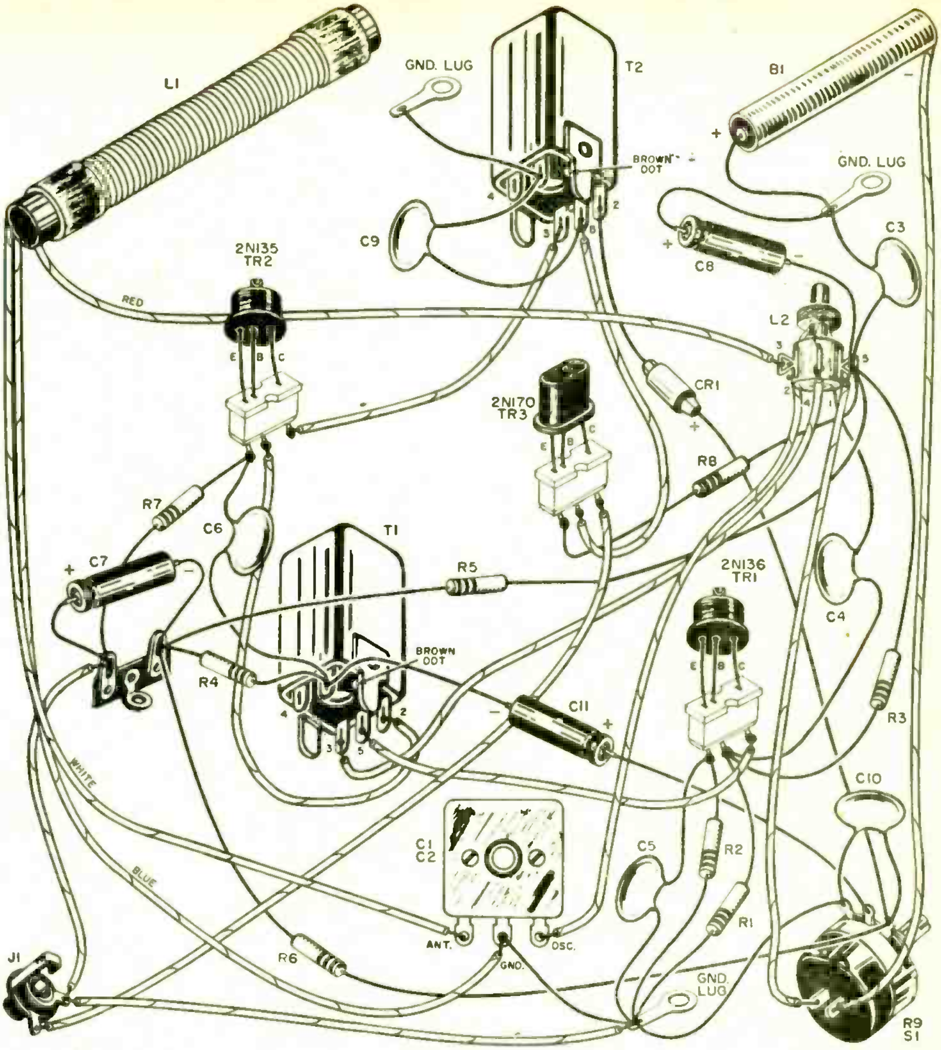
the i.f. transformers for maximum output, as heard in the earphone. These cores are reached through holes in the bottom of the transformers. Always use the *minimum* signal that will give you an easily heard tone.

After peaking the i.f. transformers, remove the coupling capacitor (attached to the "white" terminal), replacing it with a much smaller unit (about 5 $\mu\mu$fd.). Shift the signal generator to 1600 kc. and open the tuning capacitor's plates. Adjust the trimmer, *C2b*, on the back of the oscillator capacitor for a peak in output. Then turn the receiver's tuning dial to 1500 kc. (plates partially meshed), and shift the signal generator to this frequency. Adjust the r.f. trimmer, *C1b*, for a peak in output.

Finally, shift the signal generator to 600 kc. and turn the receiver's dial to the low-frequency end of the band—the tuning capacitor's plates should be almost fully



To align the superhet, you'll need a signal generator and an insulated alignment tool.



This is the way to hook up the transistorized superhet's various components.

meshed. Now, "rocking" the tuning capacitor back and forth slightly, adjust the slug of *L2* for a peak in output. Recheck all three adjustments (*C2b, C1b,* and *L2*).

With the alignment completed, remove the signal generator lead and the small input coupling capacitor. Complete the assembly by installing the receiver in its plastic case.

how it works

In operation, r.f. signals are picked up and selected by tuned circuit *C1a/C1b-L1*. The first transistor, *TR1*, is connected as *oscillator-converter*, with *L2* serving as the oscillator coil. The incoming r.f. signal and the locally generated signal are combined in this stage to produce the 455-kc. i.f. signal which, in turn, is selected by a tuned circuit (*T1*) serving as the collector load for the stage.

The second transistor stage, *TR2*, serves as *both* the i.f. amplifier and the first audio amplifier stage. Capacitors *C6* and *C9* serve as r.f. bypass units. A fixed bias is applied through *R5*, bypassed by *C7*, and isolation resistor *R4*, acting in conjunction with emitter resistor *R7*. In addition to the fixed bias, a variable bias is supplied from the detector's load resistor *R9* through isolation resistor *R6*.

After amplification, the i.f. signal is coupled through transistor *T2* to the second detector, a type 1N64 crystal diode. Detection (demodulation) occurs in this stage, and appears across diode load resistor *R9*, the volume control. The a.f. portion of the detected signal is coupled through *C11* to the base of *TR2*. This signal is then amplified with the base-emitter circuit of *TR3* serving as the collector load for *TR2 as far as the a.f. signal is concerned*. *TR3* serves as the second a.f. stage and the earphone serves as the collector load for *TR3*.

This general type of circuit arrangement used here is known as a *reflex* circuit.

Build a Superregen Pocket Receiver

by *george sebestyen*

take this receiver with you to listen in on the ball game

Many enthusiastic electronic experimenters undertake the task of building a pocket radio only to find that they have to resort to dangling wire antennas to get enough r.f. energy into the set. The end result is not quite what everyone considers to be a true pocket radio. However, this article describes a one-tube pocket-size radio which delivers comfortable volume without an external antenna.

It is a superregenerative receiver with an added feature which makes tuning easier. One usually annoying fact about superregenerative receivers is the critical handling required by the regeneration control; unless the signal is very strong, the regeneration control requires careful adjustment. The circuit used by the author takes the audio output from directly across the regeneration control, with the result that the audio volume is increased at low regeneration—when needed, and decreased at high regeneration—when it is not needed. In listening to strong local stations, the same potentiometer can be used as a volume control.

The single tube is a *Raytheon* Type CK533AX used as a triode with the screen grid externally connected to the plate. The tuning coil and the "tickler" are the main and the antenna windings of a Feri-Loopstick antenna. (If a loopstick having L2 is not available, any broadcast band loopstick can be used. To form L2, wind 16 turns of wire in single layer ¼" away from present winding.) Tuning is achieved by means of a modified trimmer capacitor (*C1*). A hearing-aid volume control serves as the regeneration control (*R1*), but this can be replaced by any 50,000-ohm miniature composition potentiometer.

In a one-tube receiver, it is essential to get all the available audio power into the earphone. In this case, a hearing-aid crystal earplug is used to give a good impedance match to the regeneration control. The earphone can be either an Archer E-1X crystal earphone (*Radio Shack Corporation*) or an MS-111 (*Lafayette Radio*).

putting it together

The receiver is housed in a 2" x 3" x ¾" plastic box that originally contained small screws and nuts. A penlite cell and a 22½-volt hearing-aid battery are both just under two inches and will fit snugly into the box. In this way, the battery mounting problem is eliminated.

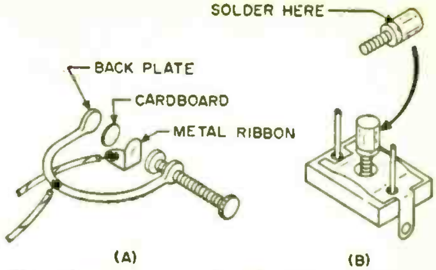
Connections to the ground side of the batteries are made by cutting out a thin copper strip about 1½" long, bending its ends at right angles, and pressing it into the inside wall of the plastic box with the gentle persuasion of a hot soldering iron. After the softened plastic sets, in a few seconds, the copper strip is firmly embedded in the wall of the box. The other two battery connections for the A+ and B+ are pressed into the other side of the box in a similar manner. Bending the ends of these two battery connections to act as springs will assure good electrical contact to the batteries.

As the current drain is very small, the batteries may be soldered directly into the circuit. Several months of operation can be obtained from one set of batteries. No switch is necessary for the 22½-volt supply, as no plate current is drawn when the filament is turned off.

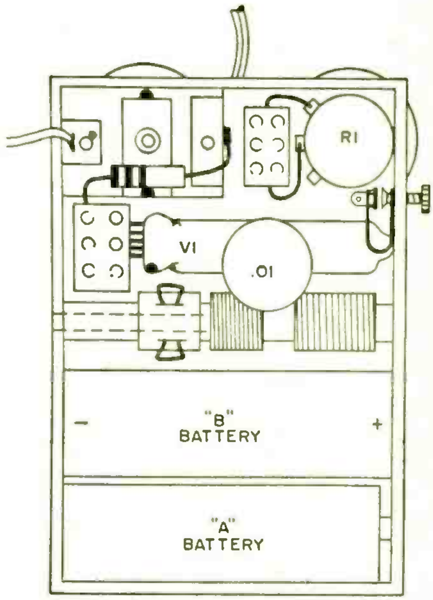
Solder the CK533AX directly into the circuit without a tube socket. When soldering the tube leads into the circuit, it is wise to grip the leads with a pair of long-nose pliers near the tube to conduct the heat away and reduce the danger of cracking the envelope.

Make the tuning capacitor mount by soldering two ½" No. 12 busbars into the two mounting holes. After these busbars are heated, they can be pressed into the plastic box to make a very rigid unit. Before doing so, however, the shaft of *C1* must be modified. Cut a 3/16"-diameter copper rod (a machine screw may be used) to a suitable length (about ⅜") and hold it in a vise with the flat end up. Take out the flathead machine screw from the trimmer and place it on top of the copper rod. Then solder the two together. Now screw the whole unit back in the trimmer and drill a hole in the plastic box to clear the rod.

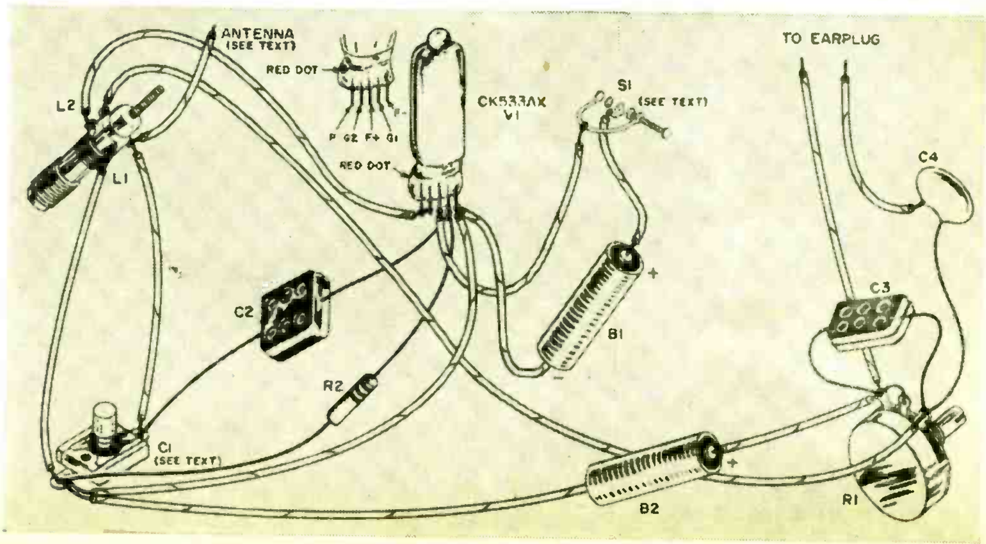
The antenna is a coiled-up three-foot length of insulated wire. Cut down the cardboard coil form of the Feri-Loopstick and clip off a piece of the screw to make it fit into the box. When the coil tuning slug is flush with the end of the main winding of the coil form, almost the entire broadcast band can be covered. Pushing the slug back and forth before cementing it in place



Two special components assure complete miniaturization: on-off switch (A) made from an earring, and (B) extension to capacitor C1.



Parts layout above shows how components can fit into very small case. Compare this diagram with the pictorial at bottom of page.



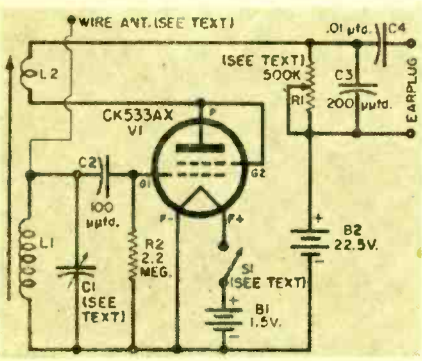
will best determine the coverage.

The most serious mechanical problem is presented by the extremely small size of switch *S1*. In this receiver, the switch is improvised from a cheap screw-type earring. Unsolder the base of the earring with the screw in it from the metal earring. Then cement a piece of cardboard to the backplate facing the screw. A thin metal ribbon cemented to the cardboard serves as the other switch contact. Electrical connection between the two switch contacts is established by turning the screw until contact is made between the screw and the ribbon.

trying it out

Put the earplug in your ear and turn on the receiver by turning the earring screw until a crackle is heard. Set the regeneration control (*R1*), and tune the trimmer capacitor until a strong whistle is heard. The station is tuned in best when the pitch of the whistle is lowest. Now decrease the regeneration (increase *R1*) until the whistle disappears and the station's program is clearly heard.

To minimize the effect of body capacitance on detuning the receiver, the set should be held at the bottom near the batteries. Tuning the receiver rapidly requires a little practice; but once the experience is acquired, this pocket receiver will give you many hours of enjoyment.



Schematic diagram and receiver parts list.

B1—1½-volt penlite cell
B2—22½-volt hearing-aid battery (Eveready No. 505E)
C1—Homemade adjustable capacitor with approximate capacity of 50-380μμf. (see text)
C2—100-μμfd. mica capacitor
C3—200-μμfd. mica capacitor
C4—0.01-μfd. disc capacitor
L1, L2—Feri-Loopstick antenna coil (see text)
R1—0.5-megohm potentiometer (see text)
R2—2.2-megohm, ½-watt resistor
S1—Homemade switch (see text)
V1—Subminiature hearing-aid tube (Raytheon CK533AX)

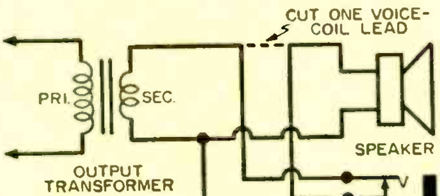
Dynamic Pillow Speaker

This easily assembled pillow speaker will allow you to listen to your bedside radio as late as you please without disturbing the sleep of others. It consists of a 2½" speaker in a tough plastic case.

A lightweight 2-conductor plastic-covered cord, with a plug on each end, per-

mits the speaker to be plugged into a closed-circuit jack installed on the radio. (Mount the jack on the radio cabinet or back panel, making sure that it is insulated from the radio's chassis.) The jack is wired into the voice-coil circuit in a manner that mutes the radio's speaker when you plug in the pillow speaker.

The writer used a "Sound Box" maroon-colored speaker case (*Lafayette Radio* MS-315) which has a removable back and a factory-installed socket on one side. A 2½" speaker is simply placed in the case and wired to the socket. When the back is screw-fastened to the case, the speaker is held firmly without rattling.



How the pillow speaker jack is wired into the voice-coil circuit of the bedside radio.

NOTE: This hookup is not recommended in cases where one side of the output transformer secondary goes to one side of the speaker voice coil via the metal chassis, unless you re-wire the voice-coil circuit to isolate the coil from a possible hot chassis. —*Art Trauffer*

The V.H.F. "T-Ear"

by ***william i. orr***

miniature v.h.f. receiver doubles your fun while traveling via airlines

Have you ever gotten something for nothing? It isn't easy these days. But here is something for *almost* nothing—a transistorized v.h.f. receiver that tunes from 90 mc. to 145 mc. and operates from one or two penlite cells.

If you are around an airport, you can use it to listen to the control tower talk to the aircraft. If you take a flight, you can listen to the aircraft talk to the ground control station. If you participate in a ham radio hidden-transmitter hunt, you can "track down" the quarry with bloodhound-like accuracy. And you can do all this with the receiver operating in your pocket!

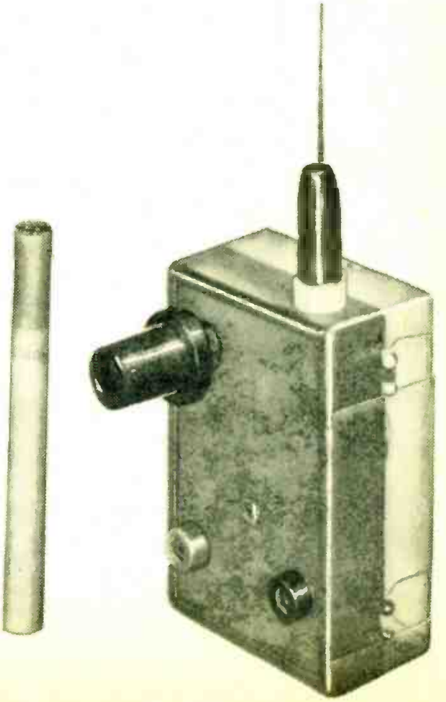
The unit that performs all these stunts is shown in the photographs. It employs a 1N82 v.h.f. silicon crystal diode detector, and an inexpensive CK722 transistor as an audio amplifier. The transistor is powered by one or two 1½-volt penlite batteries.

assembly

You can build the v.h.f. "T-Ear" in a plastic box measuring approximately 2" x 2⅞" x 1" (obtainable from a local five-and-ten-cent store). A banana jack atop the box holds a 16" length of wire used as an antenna. On the front of the box is a tuning capacitor, *C1*; this is an ordinary 9-μμfd. midget capacitor.

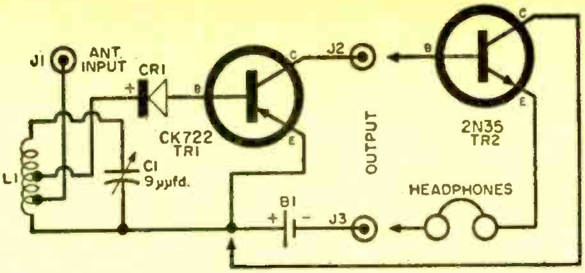
At the bottom of the plastic box, the penlite cell(s) is held in place by two short pieces of solid wire, soldered to the ends of the battery. Your negative (battery shell) lead goes directly to the earphone jack above the battery, while your positive lead goes to the transistor's emitter terminal. The collector of the transistor is distinguished by a red dot on the case. This terminal of the tie-point strip is connected to the other earphone pin-tip jack.

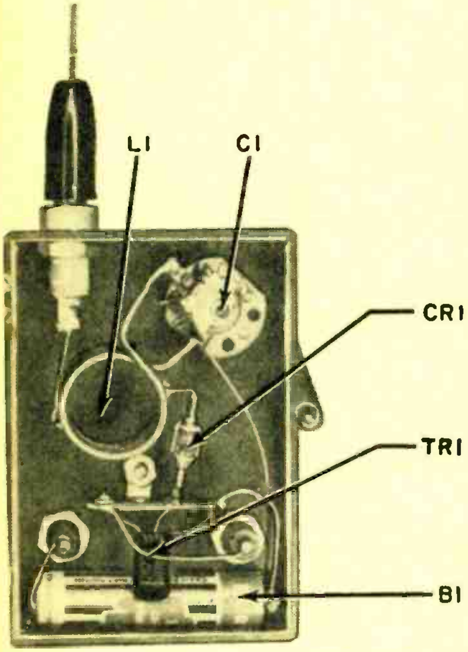
Wind a simple four-turn coil of #16



Miniature size of the transistorized "T-Ear" is apparent when compared with size of cigarette.

Simplicity of construction is shown in photo and schematic diagram of receiver. Headphones can be plugged directly into output of single transistor, but greater volume results if transistor TR2 is added and J2/J3 repositioned in circuit.





parts list

B1—Penlite cell
C1—9-µµfd. variable capacitor (Johnson 9M11)
CR1—1N82 v.h.f. diode
J1—Tip plug and jack
J2, J3—Tip jack
L1—4 turns of #16 tinned wire, 3/4" diameter, spaced to 1/2" long
TR1—CK722 transistor (Raytheon)
TR2—2N35 transistor (optional—see text)
1—2" x 2 7/8" x 1" plastic case
1—Phenolic tie point (Cinch-Jones 53E)
1—Knob, 3/16" shaft
1—16" length of stiff copper wire for antenna

tinned wire and mount it across the terminals of *C1*. The coil is tapped one-half turn up from the end attached to the rotor of *C1*. Connect this tap to the antenna jack by a short length of wire. The rotor of *C1* is connected to the emitter of *TR1* by another length of short wire.

The last item to be placed in the circuit is the 1N82 v.h.f. diode. This connects between the base of the transistor and a tap on the tuning coil. Place the tap two turns up from the end of the coil attached to the rotor of *C1*.

As in the case of the transistor, the 1N82 crystal may be damaged by excessive heat. As you solder each into the circuit, hold the wire between the crystal and the solder junction with long-nose pliers. Immediately after the 1N82 is soldered in, moisten your fingers and touch the joint to draw as much heat out of it as possible. The crystal should be so oriented in the circuit that the terminal with the arrowhead is attached to the tie point.

As indicated in the caption above, the "T-Ear" can be made in two versions. Addition of the second transistor (the *n-p-n* 2N35, *TR2*) will increase the volume. This is particularly important if you want to use the "T-Ear" in a noisy area or with a very high impedance earphone. If your earphone has a d.c. resistance of between 1000 and 1500 ohms, the simple circuit with the single transistor will probably work very well. A 2000-ohm headset requires the additional transistor and an increased battery voltage (3 volts).

testing

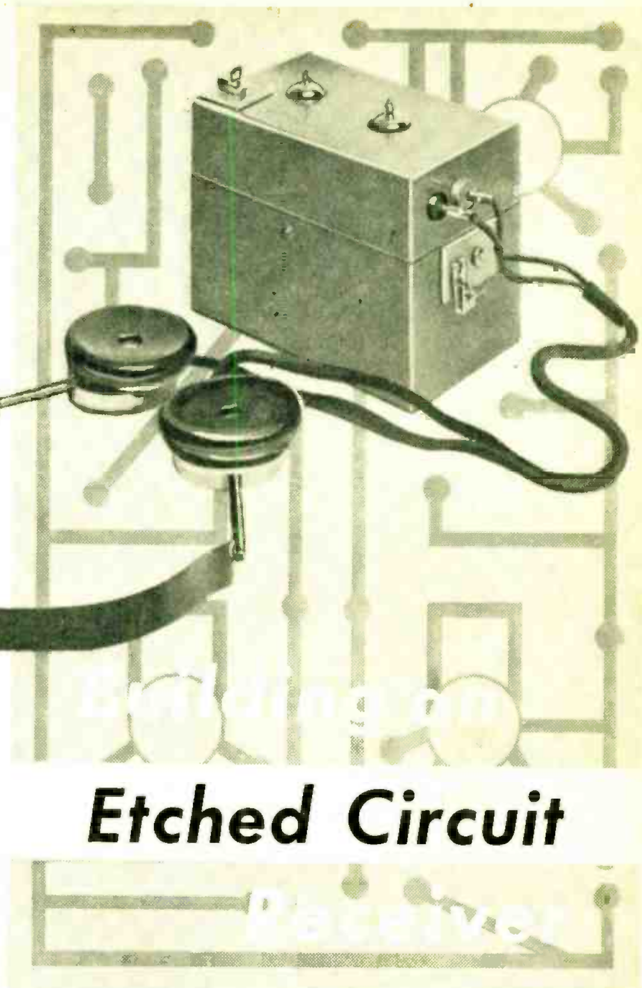
After the v.h.f. "T-Ear" is completed, it may be tested by bringing coil *L1* near a grid-dip oscillator tuned to the vicinity of 100 mc. If an antenna is attached to the GDO, and the GDO is modulated with a tone, it should be possible to receive the signal 10 or 15 feet away.

Don't expect the signals to blast your ears. The sensitivity of the "T-Ear" is very low. A good check for the sensitivity, and operation of your "T-Ear," is to listen in near a running automobile. If the sensitivity is up there where it belongs, you should hear the popping and snapping of the car's ignition.

Using the model at the local airport, the control transmitter could be heard several hundred feet from the tower, and the approaching planes could be heard as they were coming in for a landing.

Low-cost two-tuber, mounted in a file box, can be assembled in a few hours

by
donald a. smith



Building an Etched Circuit Receiver

There are two reasons why electronics experimenters should seriously consider building this two-tube receiver. First, it provides a good example of elementary printed circuit techniques, and second, it is a useful Civilian Defense project.

Even the most inexperienced builder should have no trouble with this project. In spite of the fact that the receiver is preset to a fixed frequency in the AM broadcast band, there is no reason why it cannot be taken on picnics or beach parties. A variable tuning capacitor was not built in, although one of the midget transistor variety could be added without upsetting the circuit. There is no volume control since signal pickup will depend largely upon the length of the antenna you use. The cost has been kept as low as possible, and should be about $5.50 plus the batteries.

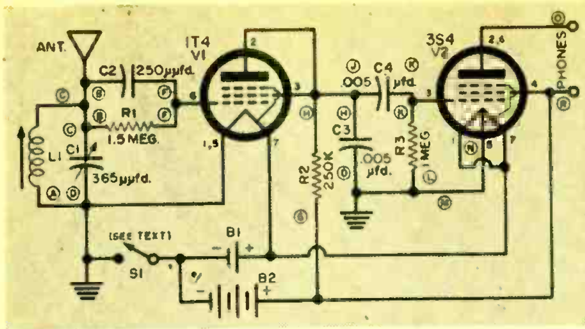
construction

First obtain the material for the printed circuit board. This will consist of one piece of single-faced copper board, a roll of pressure-sensitive tape resist, and a small quantity of etchant.

Put the tape resist on all the shaded areas drawn full scale on page 162. The tape resist goes on the copper side of the board. Make sure that it adheres to the board. Then mix the etchant solution, following the manufacturer's instructions.

Place the board into the solution and rock the tray back and forth until all of the visible copper is removed. This will usually take 15 to 20 minutes. Remove the board and wash it with water until all of the etchant has disappeared.

After the board has dried, the tape covering the remaining copper can be removed.



parts list

B1—1.5-volt "D" cell
B2—67.5-volt battery
C1—365-μμfd. variable capacitor
C2—250-μμfd., 300-volt capacitor
C3, C4—0.005-μfd., 300-volt capacitor
L1—Feri-Loopstick
R1—1.5-megohm resistor
R2—250,000-ohm resistor
R3—1-megohm resistor
S1—"On-off" switch (see text)
V1—1T4 tube
V2—3S4 tube

Clean this copper lightly with fine steel wool, so that good electrical connections can be made.

Now the necessary holes should be drilled through from the copper side of the board. Drill all holes with a small drill first and then enlarge them as needed.

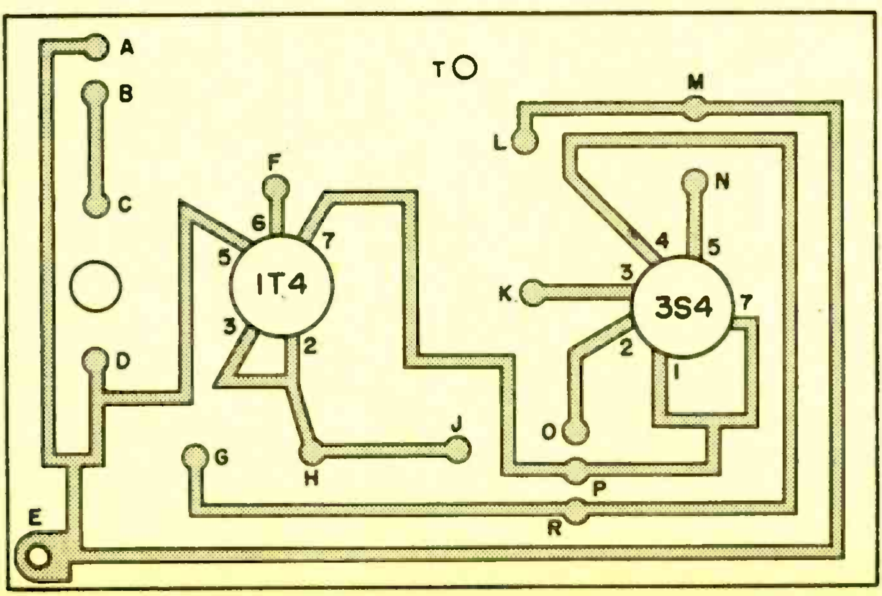
After all holes are drilled, the various radio parts can be mounted. Force the tube sockets through the openings you have drilled for them, from the bare side of the board through to the copper side. Align and bend the pins of the sockets down against the board so that each socket pin touches the correct corresponding copper strip. Then solder each of the socket pins to the copper strip under it.

Force the leads of *C2* through holes *B* and *F*, then squeeze the leads of *R1* through the same holes. Cut off the leads close to the board and solder. Be sure to insert the leads on the bare side of the board so that they come through on the copper side.

The leads of *C3* go through holes of the board, *H* and *D*. Do *not* solder. Leads of *R2* go through *H* and *G*. Now solder hole *H*. Place the leads of *C4* through holes *J* and *K*. Do *not* solder *K*. Then place *R3* through *K* and *L*, and solder both. Take a small piece of wire and connect holes *M* and *N*; this is a jumper wire to connect pin 5 of the 3S4 to the ground line.

Take capacitor *C1* and bend the ends so that one end will touch hole *C* and the other end will touch hole *D*. This is mounted on the copper side of the board. When you have adjusted the capacitor in the above manner, solder it in place.

Now look at the Feri-Loopstick, find the connection marked "Gnd" and solder it directly to hole *A*. Then take a scrap piece of wire and connect the terminal marked "Ant" on the coil to hole *C*. Connect a 6" length of wire to hole *P* and solder. The board is finished!



Full-scale layout of the printed circuit board. Tape resist goes on all shaded areas.

installation

The cabinet used in this model is a metal index file card box. Holes are drilled in the cabinet to ventilate the tubes and provide earphone, antenna, and ground connections. The photos show the approximate positions of the holes. The "on-off" switch is a homemade plastic job using two nuts and a bolt separated by a clip.

Before placing the batteries in the bottom of the cabinet, first solder the lead coming from hole *P* of the board to the positive terminal of *B1*. Solder a 6" length of wire to the case of *B2* and take a turn or two of tape around the battery so that there will be no chance of either terminal shorting out to the cabinet. Connect the wire coming from the negative terminal of *B2* to the wire coming from the negative terminal of *B1*.

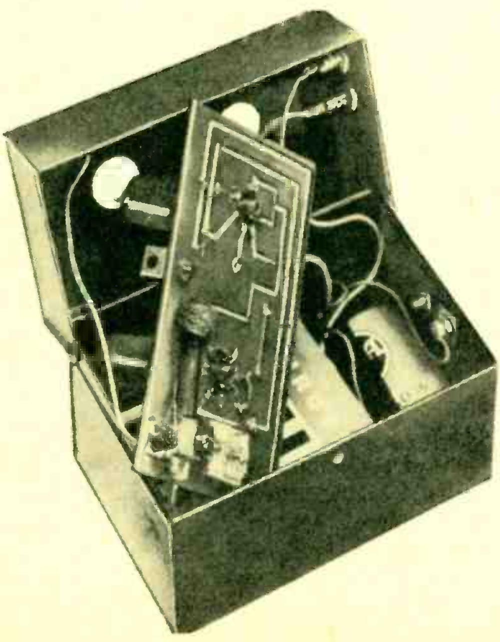
With short *6-32* screws, attach two L-brackets to the printed circuit board (holes *E* and *T*). Now mount the board in the cabinet and secure it to the cabinet walls with two *6-32* screws through the L-brackets.

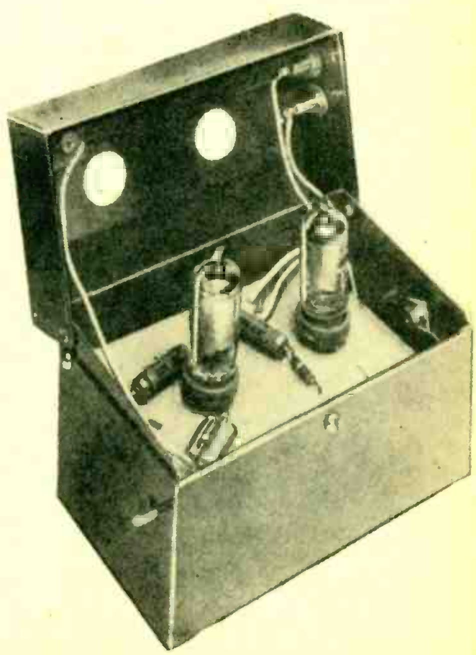
Mount two insulated phone jacks in their holes as shown in the photo below. When they are installed, connect the wire from the plus terminal of *B2* to one of them, and run another wire from this jack to hole *R* in the circuit board. Connect the other jack to hole *O* in the board with a short length of wire.

operation

You should have no difficulty in getting the set tuned and ready for use. Plug earphones into the two jacks, connect an antenna and turn on the "switch." You will hear a local station which is quite strong in your location.

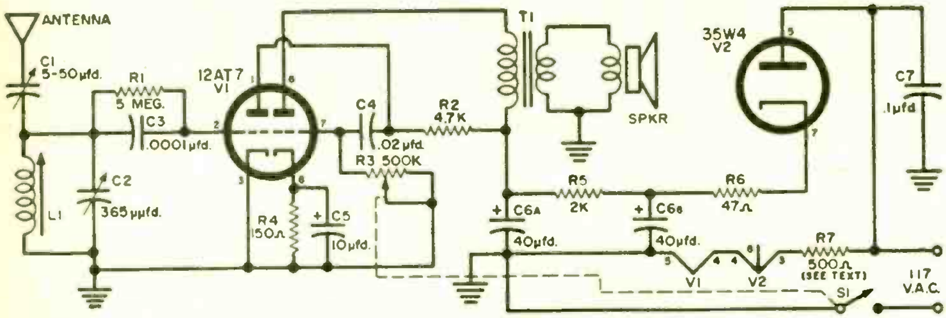
There are two methods for tuning the receiver to Conelrad. If a signal generator is available, it should be adjusted for 640 or 1240 kc. Work first with the slug adjustment of the coil and then *C1*. Peak up the signal with the *L1* coil adjustment and tune to the generator frequency with *C1*. The other method is to follow the same procedure as above, except that instead of employing a signal generator to locate the proper frequency, a local station close to the Conelrad frequencies can be used.



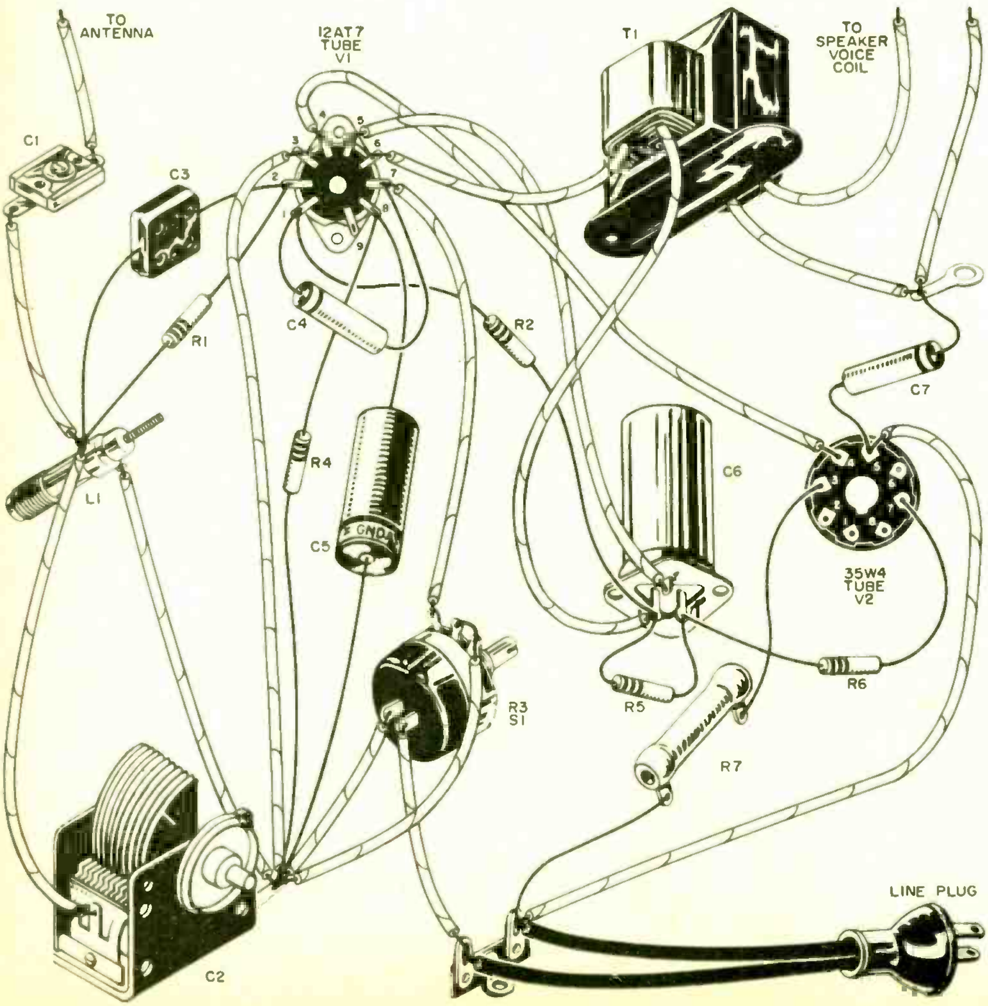


The photos above show completed receiver with cabinet open. At left is view of printed circuit board being put into place. Photo at right shows completed assembly. Note location of phone jacks, batteries, etc.

Junk Box Broadcast Special



Schematic and pictorial diagrams for junk box receiver. A 12AU7 can be used in place of the 12AT7 if it is more easily obtained.



by ***w. c. wilson***

When you look at the wide variety of existing transistorized receivers and miniature components, it seems as if some of us are forgetting that broadcast-band receivers can be easily built from surplus components. All of the parts for this simple, two-tube receiver are probably available in the junk box of an average radio experimenter.

Coil *L1* is the rather common Feri-Loopstick, and tuning capacitor *C2* can be any high-capacity variable salvaged from a junked AM receiver. Filament-dropping resistor *R7* may be a single 500-ohm, 20-watt resistor or a pair of 10-watt, 1000-ohm resistors in parallel.

The circuit uses a 12AT7 (*V1*) as a detector and audio amplifier, and a 35W4 serves as a half-wave rectifier. Although the grid leak detection method may add some distortion in very strong signal areas, the sensitivity is much greater than that obtained with crystal diode detectors.

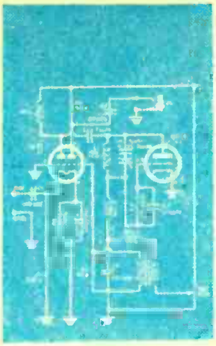
Keep in mind that this is an a.c./d.c. receiver and that care must be exercised in grounding the chassis. Unless you have had considerable previous experience, it is better to keep the chassis away from water pipes and outside electrical grounds.

The antenna can be any length of wire. Using only six feet of antenna, stations at night up to 500 miles away were pulled in. The local stations were quite strong during the day.

Once the antenna is connected, tune in a very weak station near the minimum capacity of tuning capacitor *C2*. Then adjust the core in the Feri-Loopstick for maximum volume.

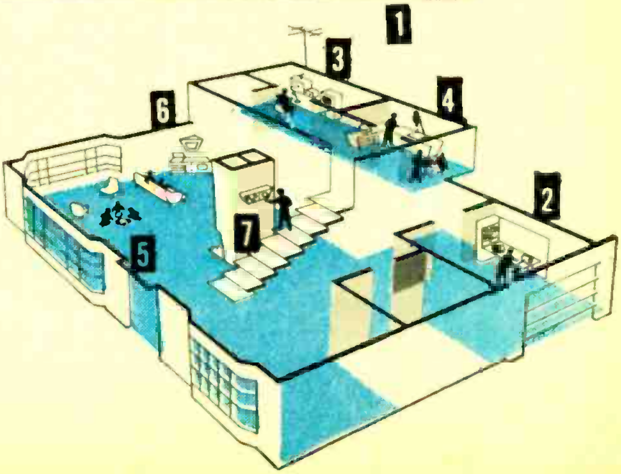
parts list

C1—5-50 μfd. variable capacitor
C2—365-μμfd. variable capacitor
C3—0.0001-μfd. mica capacitor
C4—0.02-μfd., 400-volt paper capacitor
C5—10-μfd., 25-volt electrolytic capacitor
C6a/C6b—40-40 μfd., 150-volt electrolytic capacitor
C7—0.1-μfd., 400-volt paper capacitor
L1—Feri-Loopstick
R1—5-megohm, ¼-watt carbon resistor
R2—4700-ohm, ½-watt carbon resistor
R3—500,000-ohm volume control potentiometer
R4—150-ohm, ½-watt carbon resistor
R5—2000-ohm, 1-watt carbon resistor
R6—47-ohm, 1-watt carbon resistor
R7—500-ohm, 15-20 watt wire-wound resistor
S1—S.p.s.t. switch (on R3)
SPKR—PM speaker
T1—Output transformer, 4000-ohm primary, 3.5-ohm secondary
V1—12AT7 tube
V2—35W4 tube



Section 8

try these for fun



by *e. g. louis*

Solar Battery Experiments

the difference between silicon and selenium cells, and how they are used in three simple circuits

Power from the sun! In recent years these exciting words, along with the equally magical phrase, "power from the atom," have fired man's imagination. Oddly enough, these two expressions mean much the same thing, for the sun is simply a gigantic atomic engine, generating heat and light by atomic *fusion,* a process similar to that used in the H-bomb.

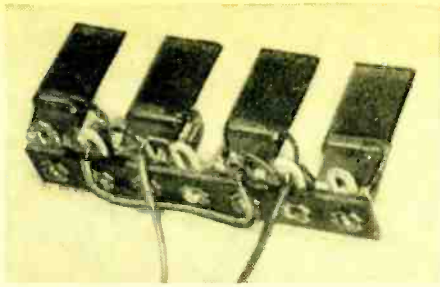
The day of inefficient, indirect and extremely lengthy methods of employing sun power is rapidly drawing to a close. With semiconductors—materials similar to those used in the fabulous transistor—science has at last unlocked the secret of changing sunlight directly into electrical power. Today, the light falling on a few square inches of sensitive material will operate a radio receiver, an audio oscillator—or even a practical radio transmitter.

solar cells and sun batteries

The word *Sol* is the name of the ancient Roman god of the sun. Hence, *solar,* derived from *Sol* and meaning "of the sun," is often used interchangeably with *sun.* Devices for changing sunlight into electrical power may be called either *solar cells* or *sun cells,* while a bank of such devices may be termed a *sun battery,* or, if preferred, a *solar battery.*

Modern solar cells are made from either of two elements—*selenium* or *silicon. Selenium* units have been available longer, having been used in photographer's exposure meters, simple light controls, etc. Selenium, one of the family of semiconductor elements which includes germanium—the principal ingredient of most commercially available transistors, is also used in power rectifiers. Selenium sun batteries for the experimenter are available from *International Rectifier Corporation,* 1521 East Grand Ave., El Segundo, Calif.

Silicon, the principal ingredient of common sand, has been used in practical solar cells for a comparatively short period of time. Developed by *Bell Telephone Laboratories,* the silicon cell is much more efficient than the older selenium cell. Silicon, like selenium, is widely used in high-power rectifiers and, like germanium, is also



Multi-cell battery, as shown above, will provide greater voltages than a single cell, and can be easily assembled. Fig. 1, at right, shows the schematic diagram for this hookup arrangement.

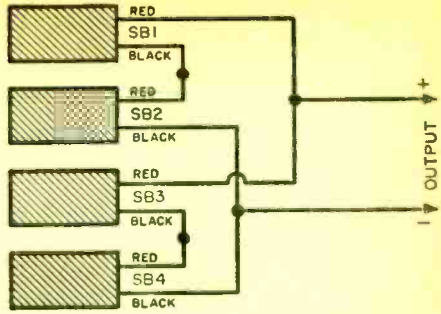


Fig. 1. Four-cell battery with series-parallel connection. The upper pair and lower pair are each connected in series and then in parallel. Color coding shown applies to B2M selenium cells.

employed in the production of transistors. A manufacturer of silicon solar cells is *National Fabricated Products, Inc.,* 2650 West Belden Ave., Chicago 47, Ill.

The voltage developed by a single solar battery or cell depends both on the materials used in its construction and on the amount of light striking its sensitive surface. The current it can deliver depends on the amount of light striking its surface, on its internal resistance, on the resistance of the load, and *on its area*—the larger the cell, the greater the current it can deliver, and hence the greater its power output.

In full noon sunlight, a selenium cell will develop about 0.5 volt under typical "no-load" conditions. Under ideal conditions, it may develop close to 0.6 volt. A silicon cell develops between 0.3 and 0.5 volt under similar conditions.

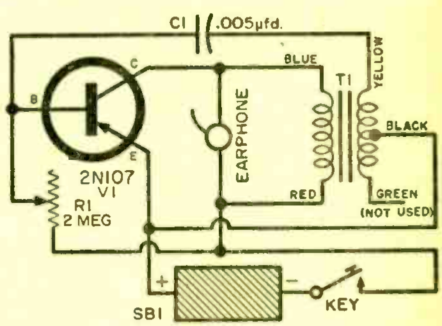
Where a greater voltage or current is needed than can be obtained from a single cell, whether silicon or selenium, a "bank" or battery of many cells may be used. To obtain greater voltages, the individual cells are collected in series. To obtain greater currents, a larger cell may be used, or many cells may be connected in parallel.

For experimental applications, a series-parallel connection of the cells is preferred. A typical four-cell battery, employing a series-parallel connection, is shown schematically in Fig. 1.

experimental applications

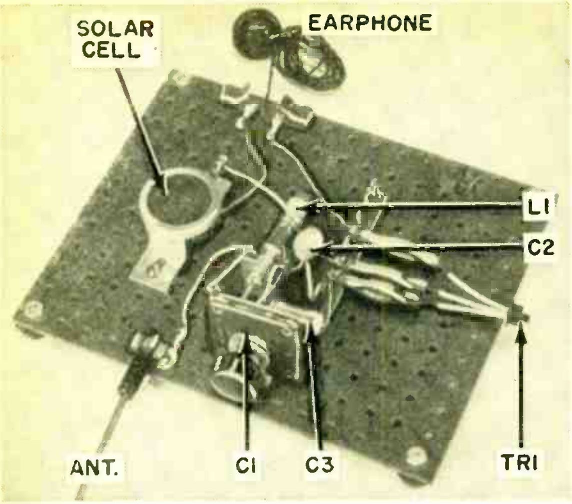
With solar cells and sun batteries now available on an "across-the-counter" basis from leading electronic parts distributors, any interested experimenter can investigate and work in this exciting field. Here are three easy-to-build projects you can start with—a code practice oscillator, a simple broadcast band receiver, and a c.w. radio transmitter. All three of these projects use transistors, whose minute power requirements make them ideally suited for operation in sunlight-powered circuits.

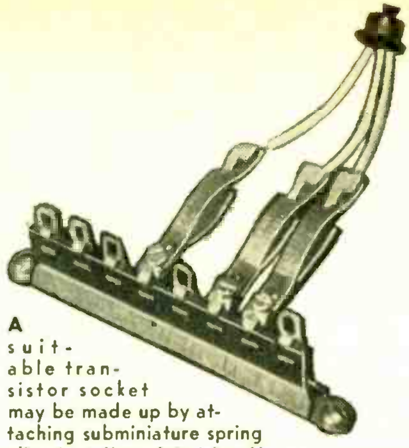
For your experiments, use either a *NAT-FAB* S-1 Solar Cell (silicon cell) or an *International Rectifier* B2M Sun Battery (selenium cell). For optimum results, you'll do best with a multi-cell "battery" similar to the arrangement shown in Fig. 1. Either silicon or selenium cells may be used for making up the battery. If you choose the silicon cell, the outer case is the *positive* terminal, while the center terminal, on the rear of the unit, is the *negative* terminal. Color-coded leads are attached to the B2M selenium cell—red for positive, black for negative.



C1—0.005-μfd. disc ceramic capacitor
R1—2-megohm carbon potentiometer
SB1—Solar battery (see text)
T1—Transistor transformer (Argonne No. AR-109)
V1—2N107 p-n-p transistor (General Electric)
Earphone—High-impedance magnetic earphone (crystal will work also)
Key—Standard hand key
1—Breadboard chassis (perforated Masonite, about 6" x 8")
1—Transistor socket
Misc. rubber feet, volume control bracket, knob, solder lugs, Fahnestock clips, machine screws, nuts, wire, solder, etc.

Fig. 2. Schematic diagram and parts list for sun-powered code practice oscillator.

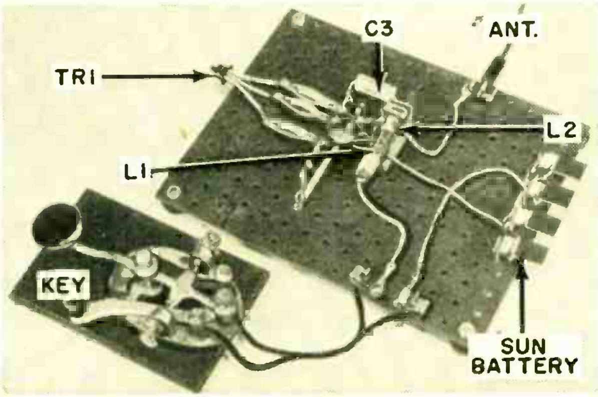




A suitable transistor socket may be made up by attaching subminiature spring clips to a tie-point strip. Use a 7- or 8-terminal strip; you'll find the extra terminals handy for other components.

The broadcast receiver is shown above, made up in breadboard fashion to simplify construction and experimental changes in parts value or circuit arrangement. Perforated Masonite makes an excellent breadboard chassis, and you don't have to worry about layout and machine work as you would on metal.

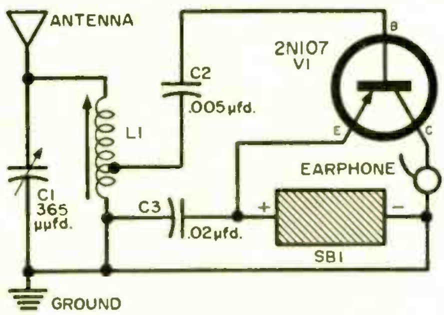
The radio transmitter and its key are at right. See page 172 for schematic diagram and parts list. If the transistor socket is also constructed on perforated board, it will simplify trying different transistors and eliminate need for cutting transistor leads short.



code practice oscillator

Wire this project following the circuit in Fig. 2. The earphone may be either a high-impedance magnetic or a crystal unit. Close the *key* and adjust *R1* for proper operation, with the battery (*SB1*) exposed to full sunlight. If you can't get oscillation, try reversing either the primary *or* secondary leads of *T1*—but not both. Tone quality can be changed by varying size of capacitor *C1*.

The transistor is used in a "tickler feedback" audio oscillator arrangement, with transformer *T1* furnishing the feedback necessary to start and sustain oscillation. Capacitor *C1* serves to couple the feedback signal to the base electrode of the transistor, with base bias current supplied through *R1*. The "load" is connected in parallel with the primary winding of *T1*; because of its relatively high impedance, the earphone has a negligible effect on circuit operation. The common-emitter circuit configuration is used.



C1—365-μμfd. variable capacitor (Lafayette No. MS-215)
C2—0.005-μfd. disc ceramic capacitor
C3—0.02-μfd. tubular capacitor
L1—Tapped Loopstick
SB1—Solar battery (see text)
V1—2N107 p-n-p transistor (General Electric)
Earphone—High-Impedance magnetic earphone
1—Breadboard chassis (perforated Masonite, about 6" x 8")
1—Transistor socket
Misc. rubber feet, tuning capacitor bracket, coil bracket, solder lugs, Fahnestock clips, machine screws, nuts, wire, solder, etc.

Fig. 3. Schematic diagram and parts list for the simple AM broadcast band receiver.

broadcast band receiver

A receiver wired according to the circuit diagram given in Fig. 3 will have considerably more gain than the average crystal receiver, but will still require a good antenna and ground for best results. No special precautions need be followed in wiring the circuit, but a magnetic earphone must be employed. In some cases, depending on local conditions, better results are obtained if a crystal diode (such as a 1N34A) is substituted for coupling capacitor *C2*. Connect the anode terminal to the base of the transistor. Individual stations are tuned in by adjusting variable capacitor *C1*. You will obtain best operation in full noon sunlight.

Radio signals picked up by the antenna-ground system are selected by tuned circuit *C1-L1*. A tap on *L1* permits matching the low input impedance of the transistor, avoiding excessive loading on the tuned circuit, and thus insuring good selectivity and gain. The selected r.f. signal is coupled through capacity *C2* to the base-emitter circuit of the transistor, connected as an unbiased common-emitter detector-amplifier. Demodulation (detection) occurs in the base-emitter circuit of the transistor, with the resulting audio-signal amplified by the transistor and used to drive the earphone. Capacitor *C3* serves as a simple r.f. bypass across the power source.

c.w. radio transmitter

With a good antenna and earth ground connected, and with battery *SB1* exposed to full sunlight, you should be able to send c.w. (code) signals to a standard communications receiver from distances up to 40 or 50 feet using a radio transmitter wired according to the circuit in Fig. 4. To get this range, you'll need a multicell battery, however.

There are no special "tricks" in wiring and layout is non-critical. Feedback coil *L2* consists of around 10-15 turns of enameled wire, tightly wound on top of *L1*—you may have to reverse the connections of this winding to get oscillation. You will need an r.f. type transistor for best results—a *G.E.* Type 2N170 *n-p-n* unit is specified, but you can substitute a *Raytheon* Type CK768 *p-n-p* unit if you reverse the battery leads.

With the wiring completed and double-checked for errors, install the transistor, attach a good antenna and ground, and place the unit within eight or ten feet of a communications receiver. The receiver should be tuned to a "dead" spot near the middle of the broadcast band (about 900 to 1200 kc.) and its BFO should be "on"—since this is a c.w. transmitter, a BFO must be used with the receiver to hear the code signals. Close the *key* and expose the battery to full sunlight. With an insulated alignment tool, gradually adjust *L1*'s iron "slug," listening for a signal from the receiver. If you can't pick up a signal after adjusting the "slug" over its entire range, try reversing the connections to *L2*.

Once you are sure the transmitter is operating, you can move it away from the receiver, experimenting to determine the maximum range possible with your particular circuit.

In operation, the transistor is connected as a "tickler feedback" r.f. oscillator, with *L2* serving as the feedback winding. Frequency of operation is determined by tuned circuit *L1-C1*, plus various distributed wiring capacities. A tap on *L1* prevents excessive loading on the tuned circuit and insures reasonably stable operation. R.f. energy from *L2* is coupled through capacitor *C2* to the base of the transistor, with bias current supplied through resistor *R1*. The common-emitter circuit configuration is employed. Capacitor *C3* serves as a simple r.f. bypass across the *key*.

parts list

C1—50-300 µµfd. tubular ceramic capacitor
C2—0.005-µfd. disc ceramic capacitor
C3—0.02-µfd. tubular capacitor
L1—Tapped Loopstick
L2—Feedback winding (see text)
R1—100,000-ohm, ½-watt carbon resistor
SB1—Solar battery (see text)
V1—2N170 n-p-n r.f. transistor (General Electric)
Key—Standard hand key
1—Breadboard chassis (perforated Masonite, about 6" x 8")
1—Transistor socket
Misc. rubber feet, coil bracket, Fahnestock clips, solder lugs, machine screws, nuts, wire, solder, etc.

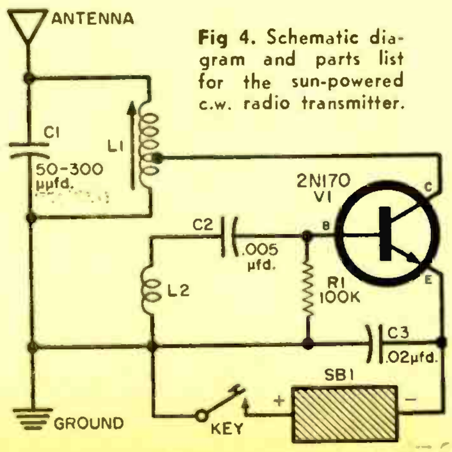
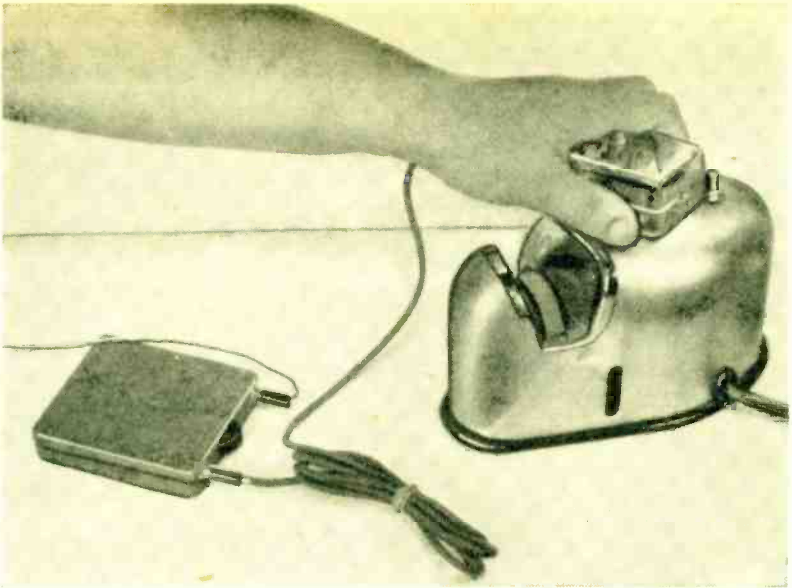


Fig 4. Schematic diagram and parts list for the sun-powered c.w. radio transmitter.



Track Down Trouble with an

Electronic "Detectoscope"

by *louis e. garner*

use of printed circuit audio amplifier simplifies building of unusual listening device

If you're the typical electronics hobbyist, chances are you get just as much enjoyment out of assembling an instrument or gadget as you do out of using it. But one of your greatest thrills is the admiration of friends, relatives and neighbors, and their compliments on your handiwork.

Here's an instrument which is sure to impress even the most sophisticated of your friends . . . an electronic "detectoscope." With it, you can make a ticking watch sound like heavy industrial machinery . . . you can open tumbler-type combination locks as easily *as if you knew the combination* . . . and, under the proper conditions, you can listen to conversations in closed rooms—right through walls, doors and windows!

The electronic "detectoscope" is a modern "sound microscope" designed primarily for non-medical applications. Almost everyone who works with machinery or mechanical devices will find it helpful in his work . . . and the experimenter will have lots of fun using it and demonstrating it. Locksmiths and watchmakers can employ it in their delicate work . . . refrigerator, washing machine and appliance repairmen can identify obscure troubles with it . . . auto mechanics can track down rattles and unusual noises with it . . . and even detectives and policemen will find it useful.

Three separate units make up the complete "detectoscope" assembly—an earphone, an amplifier, and a vibration pickup or transducer. If the word "transducer" is an unfamiliar one, simply remember that it is a device for changing energy from one form to another. Everyday examples of transducers are microphones and loudspeakers; these change sounds into electrical signals and vice versa. The transducer used here changes mechanical vibrations into electrical signals.

construction hints

Only standard, readily available components are used in the design of the "detectoscope." The schematic wiring diagram of the complete amplifier assembly is shown in Fig. 1. Heart of this assembly is a *Centralab* "Ampec" printed-circuit audio amplifier. This unit was chosen to simplify the construction and thus to make the project suitable for the advanced worker and the beginner alike.

Although the "Ampec" unit is smaller than a pack of book matches, it includes all the essentials of a complete three-stage audio amplifier, excluding only the input and output circuits, the gain control and the power supply. Input, output, gain control and power connections are made through nine wire leads.

Cement the "Ampec" amplifier plate to a small piece of perforated Bakelite measuring approximately 2⅛" x 1¾", which previously has been cut out and drilled to accept the gain control and power switch (*R10* and *S1*) and a small bracket or "frame" which supports the input and output jacks (*J1* and *J2*). The small "frame" may be cut out and bent from a scrap piece of aluminum or brass. Install eyelets in the Bakelite mounting board for the output load resistor (*R8*) and for the A and B battery connections.

If desired, the case may be a small plastic box; but there will be less chance of noise and hum pickup if a metal box is employed. You can use either a commercial aluminum case or an empty metal cigarette box, cough lozenge or tobacco container. The model was assembled in an empty container which originally held English-made cigarettes. If you use an empty box of this nature, you can give the final instrument a professional appearance by covering the box with a coat of glossy enamel.

transducer assembly

The transducer consists of an inexpensive crystal or ceramic phonograph cartridge.

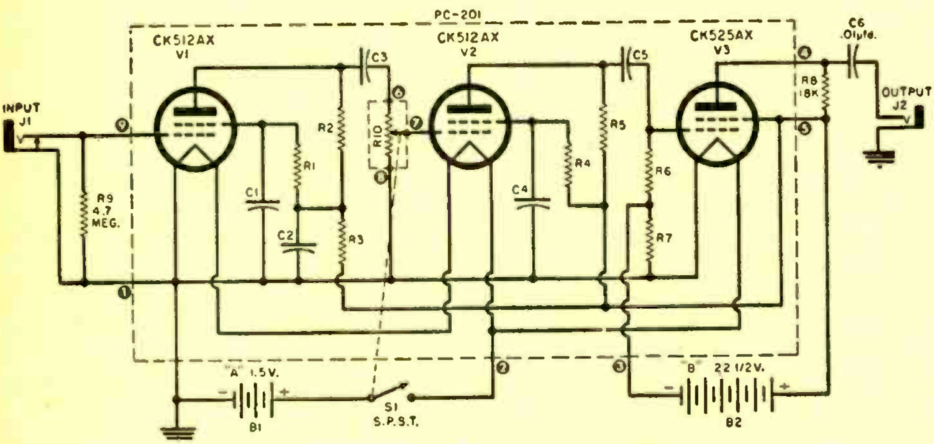
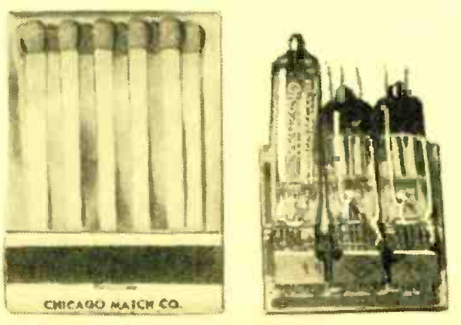
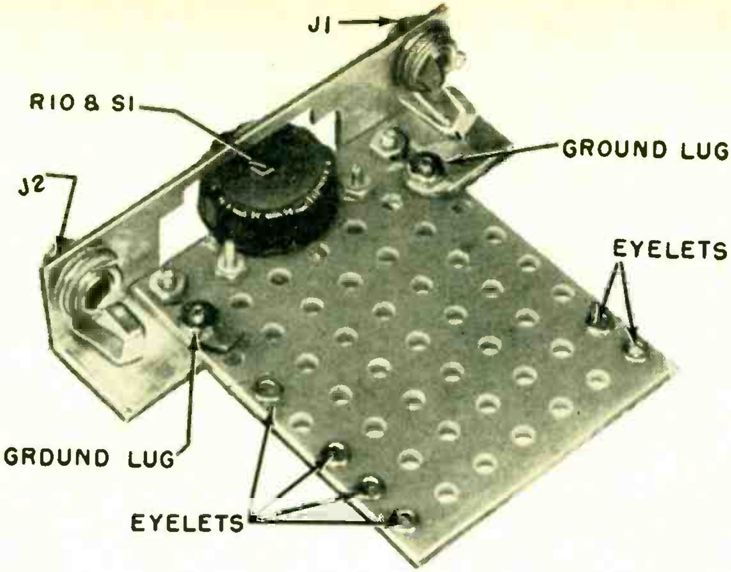


Fig. 1. Schematic diagram of complete amplifier assembly. Portion of circuit within dashed line (except R10) is part of printed circuit plate PC-201. See parts list.

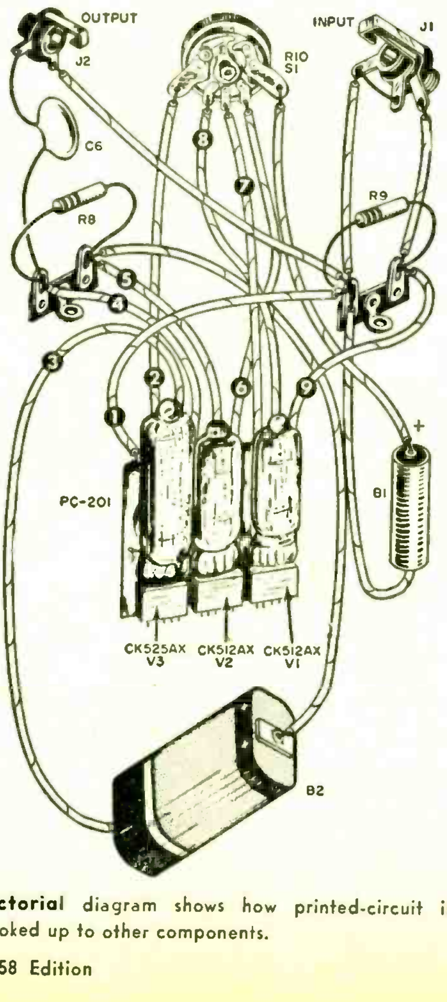
PC-201—Printed-circuit amplifier plate, with tubes (Centralab "Ampec" Model PC-201)
B1—1.5-volt penlite cell (Burgess Type Z)
B2—22½-volt hearing-aid battery (Burgess Type U15)
C6—0.01-µfd. ceramic disc capacitor
J1—Miniature closed-circuit jack (Telex No. 8570)
J2—Miniature open-circuit jack (Telex No. 9240)
R8—18,000-ohm, ½-watt carbon resistor
R9—47-megohm, ½-watt carbon resistor
R10—Miniature potentiometer, with knob and s.p.s.t. switch, 5 megohms, audio taper (Centralab No. B16-228)
S1—S.p.s.t. switch (on R10)
1—Small metal case
1—Bakelite mounting board
1—Standard crystal phonograph cartridge, high-output type (Shure No. W78, Astatic No. L-72A, Lafayette Type PK-11, etc.)
1—Small plastic box
1—30" flexible single-conductor shielded cable, and small plug (Telex No. 9231)
1—Sensitive earphone, and small plug (Telex No. 9231)—accessory



Printed-circuit plate with three sub-miniature tubes installed is smaller in size than book of matches. Unit is a complete three-stage audio amplifier excluding only power supply and volume control.



Preliminary assembly of the Bakelite mounting board, "frame" for input (J1) and output (J2) jacks, gain control (R10) and the power switch (S1). Small eyelets are installed in board as terminal connections. Use either or both ground lugs shown for grounding the circuit in accordance with Fig. 1. The ground tie point in the pictorial diagram below should be connected to one of these points.



Pictorial diagram shows how printed-circuit is hooked up to other components.

Mount it in a plastic or metal case and connect it to the amplifier proper with a short length of shielded single conductor cable, terminated with one of the subminiature Telex plugs.

In most cases, you can obtain good results with the phono cartridge alone. Occasionally, however, somewhat greater sensitivity may be had by mounting a small weight in the needle chuck. The weight serves to increase the effective inertia of the crystal system and to make it more sensitive to vibrational forces. The amount of weight needed will vary with the exact type of phono cartridge used and with the type and size of case. For best results, you'll have to determine this value experimentally. The simplest weight is a short length of heavy wire which just fits the needle chuck.

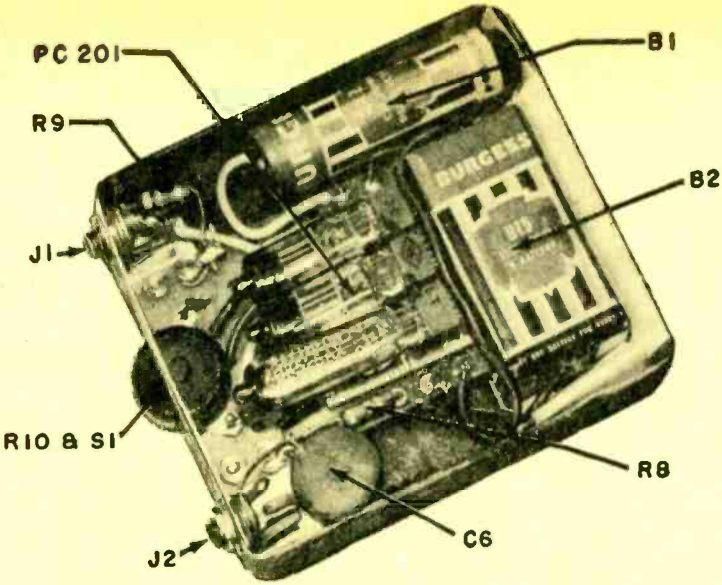
Another possible modification in the transducer design is the addition of a probe. This may be desirable where you need to reach into tight corners or through gratings. You can make a suitable probe from a 4" to 8" length of steel rod. Attach the rod to the case using any mounting method you prefer, but make sure that the back of the rod rests against the phono cartridge to insure the best transfer of vibrational energy.

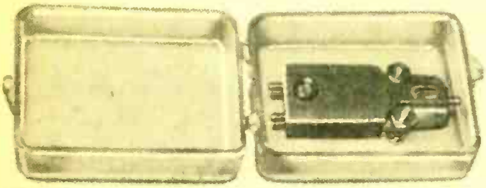
using the "detectoscope"

Insert transducer plug into jack *J1* and the earphone plug into jack *J2*. With the 'phone to your ear, hold the transducer on the equipment to be checked, making sure that either the crystal mounting screws or the metal probe (if one is provided) makes good contact with the equipment.

Turn the amplifier on and continue to

Complete amplifier with A and B batteries in place and components identified. Connections to the PC-201 are made through nine wire leads which are identified by number on an instruction sheet furnished with the printed circuit. Best results will be obtained if a metal case is used to house the amplifier. Because of compactness of unit, batteries will stay put without clamps.





Vibration pickup or "transducer" assembly consists of phono cartridge mounted in plastic case.

rotate the gain control, gradually increasing volume until a comfortable listening level is obtained. *Do not use excessive volume*—you may overload the amplifier, with resulting distortion and poor quality, giving difficult-to-interpret signals.

Get a lot of experience. Try the instrument out on different types of equipment. Listen to the vibration sounds produced by washing machines, refrigerators, mixers, and other household appliances; listen to the vibrations produced by your auto when it's idling; listen to watches and clocks. If you plan to use the "detectoscope" as an aid in servicing mechanical equipment, you'll have to practice with it quite a bit. Only experience will teach you how to correlate various sounds with defects or misadjustments in the equipment you are repairing.

Since the amplifier assembly proper is essentially a high-gain audio amplifier, you can use it for many other applications. By replacing the transducer with a crystal microphone cartridge, you can make an effective hearing aid out of the instrument. A telephone pickup coil connected to the input provides you with a useful telephone amplifier. A simple tuned circuit connected to the input changes the instrument into a radio receiver that will fit in your pocket.

As you gain experience with the electronic "detectoscope," you'll be able to dream up dozens of other practical applications on your own.

how it works

Audio signals obtained from the transducer and appearing across input resistor *R9* are fed directly to the grid of the first amplifier tube, *V1*. An amplified signal appears across the plate load resistor, *R2*, and is coupled through capacitor *C3* to gain control *R10*. The setting of this control determines what portion of the available signal is passed on to the second stage, *V2*.

The first stage, *V1*, is decoupled from the rest of the amplifier through an "L" type filter network consisting of *R3* and *C2*. Screen voltage for this stage is provided by *R1*, bypassed by *C1*.

An amplified audio signal appears across load resistor *R5* of the second stage, *V2*, and is coupled through d.c. blocking capacitor *C5* to the grid of the output amplifier, *V3*, appearing across grid resistor *R6*. Screen grid voltage for *V2* is provided through screen resistor *R4*, bypassed by capacitor *C4*. Bias voltage for the output stage is provided by resistor *R7* in series with the B- lead. All the current used by the amplifier passes through this resistor, developing the necessary bias voltage for the output stage, *V3*.

The final output signal appears across the third stage's plate load resistor *R8*, where it is coupled through d.c. blocking capacitor *C6* to the earphone. Power to operate the amplifier is supplied by a single penlite cell serving as an A battery, and a 22½-volt hearing-aid battery serving as the B supply. The A battery is controlled by s.p.s.t. switch *S1*, mounted on the gain control.

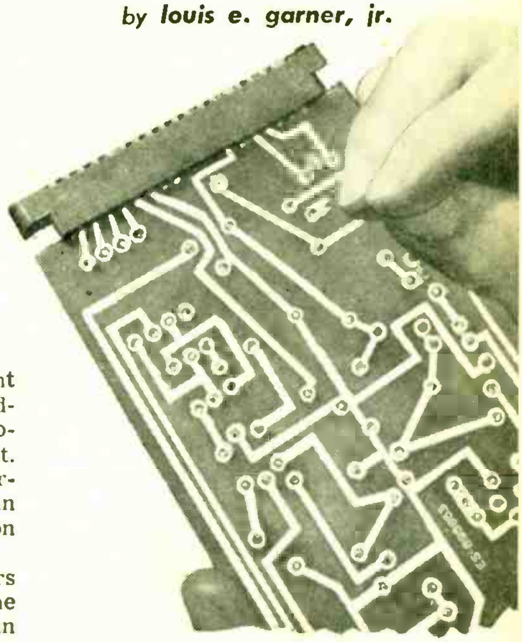
Operation of the transducer involves a signal voltage developed by the piezoelectric crystal as the case vibrates around the crystal element, which resists this vibration by virtue of its own inertia. It is for this reason that adding weight to the crystal system through the needle chuck increases the sensitivity and output of the device . . . it simply increases the effective inertia of the crystal system.

Unfortunately, the weight that can be added is critical. If too much weight is used, the "damping" of the needle chuck will be insufficient, with the result that self-resonant vibrations will be set up in the crystal system every time it is excited externally—producing new sounds not present in the original signal. If too little weight is used, there will be little or no increase in sensitivity.

Simplified Etched Circuits

by ***louis e. garner, jr.***

New products and old ideas combine to ease preparation of printed circuits



More and more electronic equipment manufacturers are turning to printed-circuit wiring boards as a means of producing quality equipment at a lower cost. Along with this increase in the use of wiring boards by manufacturers has come an increased interest in such techniques on the part of experimenters.

There is no doubt that many readers are interested in printed circuits, but the demand has been for *simpler* rather than for more *advanced* techniques. Here is more information on simplified methods of making up etched circuits.

review of basic steps

The basic steps followed in preparing a printed wiring or etched circuit board are outlined in the block diagram on page 178.

First, make a wiring layout of your circuit. Redraw the circuit full-size and show actual lead connections and placement of parts on a circuit board. Take care to minimize wiring crossovers and to insure that there is ample space for all parts needed. Graph paper is handy to use in making up this layout.

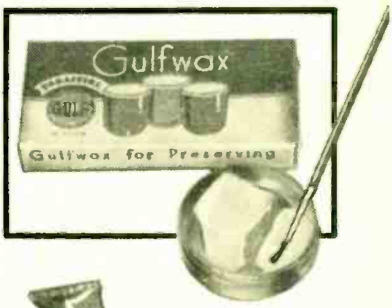
With the layout completed, cut a piece of copper-clad phenolic board to required size. The surface of the board is prepared for etching by cleaning with steel wool or with "gritty" household cleanser and a dampened cloth.

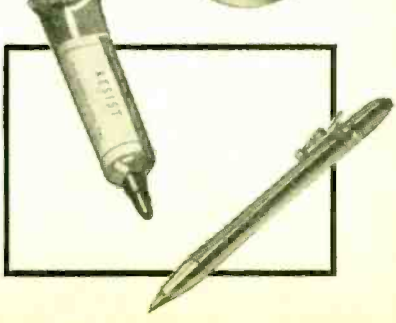
The layout is transferred to the board as a pattern of *acid resist*. As you may recall, recommended *resists* included asphalt-based ink and Scotch electrical tape.

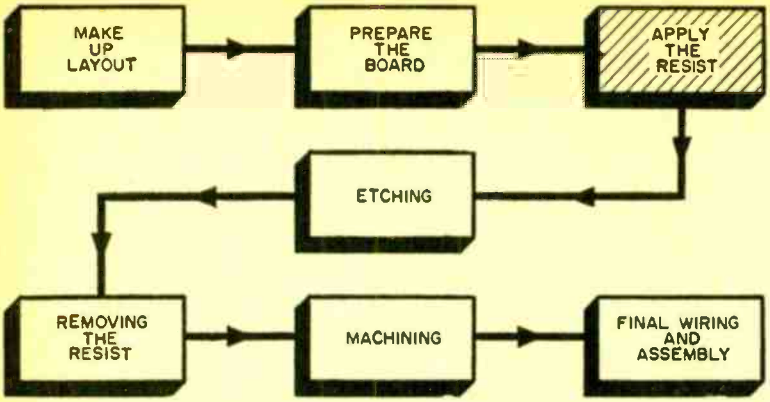
With the *resist* applied, the board is etched in a special ferric chloride solution or in *etchant* obtained from a commercial printed-circuit kit. Inspect the board frequently during etching to insure that all bare copper is removed.

The etching step may require from as

Special resists with tools for applying them are shown below: paraffin wax and small brush, Techniques ball-point ink tube, Mark-Tex pen.







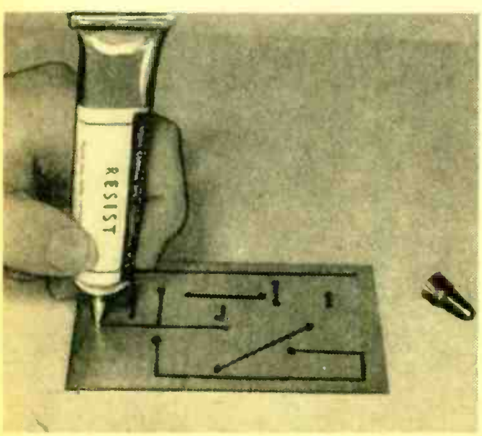
Basic steps in the preparation of an etched circuit. It is in the step labeled "APPLY THE RESIST" that simplified techniques can be used and time saved.

little as three to as many as fifteen minutes, depending on the amount of copper to be removed, the condition of your *etchant* solution, and whether you use a cold or hot etching process. Cold etching may be done in a plastic, glass or enamel tray at room temperature. Hot etching requires the use of a *resist* that is unaffected by heat, and you must use a Pyrex glass or enameled metal tray. Of the two methods, hot etching is by far the fastest. It is carried out while the *etchant* is heated over an electric hot plate or similar source of heat.

Next, the etched board is removed from the *etchant,* washed and dried. Remove the *resist* either by buffing with steel wool, wiping with a soft cloth dampened in general-purpose solvent or, in the case of tape, by simple "peeling."

Machining is the next operation. Holes are drilled for mounting parts, any necessary cutouts are made, and the board is readied for final wiring.

The last step is final wiring. All components are mounted in position, leads and connections are soldered, and all hardware—such as mounting brackets and tube sockets—is installed.



Using a ball-point ink tube to draw the circuit.

simplified techniques

The most time-consuming steps in the preparation of an etched circuit are laying out the circuit and applying the *resist.* It is here that you can use simplified techniques to accomplish your objective.

You can acquire skill in designing circuit layouts by making up practice designs based on the schematic diagrams of construction projects. You needn't carry your circuit through to final etching and assembly to make this practice of value. Rather, you should learn to visualize a circuit in terms of two-dimensional wiring.

Once you have acquired skill in layout, you'll find that you can eliminate the initial step entirely and design your layout as you apply the *resist* to the copper-clad board. Then you can simplify the latter step by using a type of *resist* that is easy to apply. However, be sure to clean the board before applying the *resist.*

The conventional *resist,* asphalt-based ink, is rather messy to use; it dries rapidly and becomes thick, making it difficult to apply. Tape *resist,* while cleaner to use, is tedious to apply; the tape must be burnished against the copper-clad board to insure good adhesion—if care isn't taken here, the *etchant* will eat under the tape and ruin your circuit board.

Fortunately, there are other *resists* suitable for etched circuit work that do not have such disadvantages. Paraffin wax is a *resist* used for centuries in the acid etching of metals and glass. And, more recently, several manufacturers have introduced free-flowing acid resistant inks with suitable ball-point pens for application. Using such a pen, you can actually draw your

Placing prepared circuit board in the etchant.

circuit outline directly on the circuit board itself.

using a wax resist

There is a definite technique to applying a paraffin wax *resist* to a circuit board.

First, melt the wax in a small metal container. Make sure that all the wax is thoroughly melted (good quality wax will look like water when liquid), but don't allow it to overheat or to smoke.

It is very important to preheat the copper-clad board. If the board is too cold, the applied wax will freeze on its surface and not adhere properly. If the board is too warm, the wax will spread and flow over the surface.

The wax is applied to the board using a fine brush. Simply "paint" the pattern you wish directly on the board.

A paraffin wax *resist* is suitable for all types of etched circuit boards. However, you must use a cold etching process when you use a wax *resist*—a hot *etchant* will melt the wax and ruin your circuit board.*

using a ball-point pen

This is perhaps the easiest technique of all, but there are a few precautions to observe: (1) keep a scrap of board handy for "starting" the pen; (2) hold the pen vertical; (3) keep the point clean of excess ink, hair or dust; (4) don't use too much

* An interesting variation of the wax *resist* technique is the use of an ordinary wax crayon. Sharpen the crayon to a moderately fine point, and simply draw your circuit on the preheated copper-clad board. If you wish, you can use different colored crayons for color-coding the wiring.

pressure—simply allow the ink to flow into place; and (5) don't touch the inked surface until dry.

The inks supplied by the *Mark-Tex Corp.* for use with its pens are resistant to heat as well as to acid. The red ink can stand quite high temperatures. If you use this type of ink *resist,* the circuit can be drawn directly on the copper-clad board.

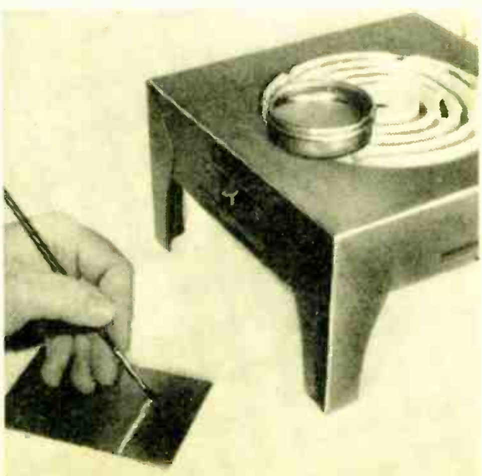
Especially designed ball-point pens with acid-resistant inks are manufactured by: (1) *Mark-Tex Corp.,* 453 W. 17th St., New York 11, N. Y., and (2) *Techniques, Inc.,* 178-84 Central Ave., Hackensack, N. J. Both of these manufacturers can also supply acid-resistant inks in a variety of colors. By obtaining several colors, you can color-code your etched circuit board, drawing r.f. circuits in one color, power supply wiring in another, and so on. Later, after etching, you remove the ink only where you plan to make soldered connections. The result is an attractive color-coded wiring board that is easy to work with and also easy to service.

If you make a mistake in drawing your circuit, don't worry. Simply allow the ink to dry, then scrape off and redraw the circuit on the clean board.

completing the job

Once the *resist* is applied in the desired circuit pattern, you can proceed with the other steps shown in the block diagram.

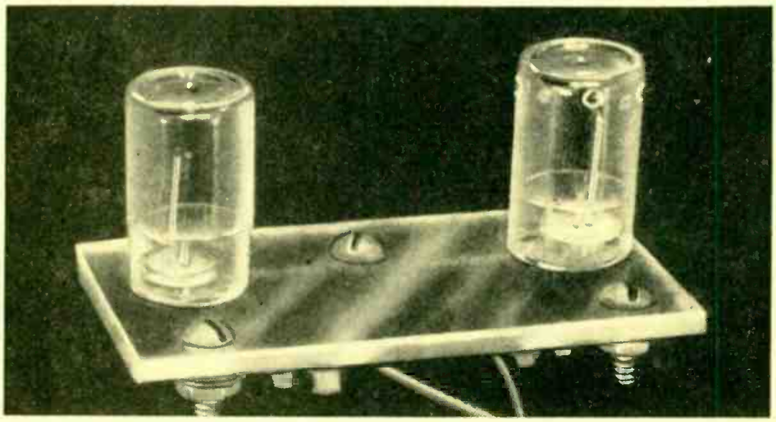
Wax *resist* may be removed by scraping or by wiping with a warmed cloth. Ink *resist* can be removed by scraping or by wiping with a cloth dampened with a suitable solvent, such as acetone. Or you can scrub off either of these special resists with steel wool.



Applying paraffin wax resist with a fine brush.

by *harvey pollack*

An Electronic Anemometer



Want to know how strong the wind is? Build this wind speed meter

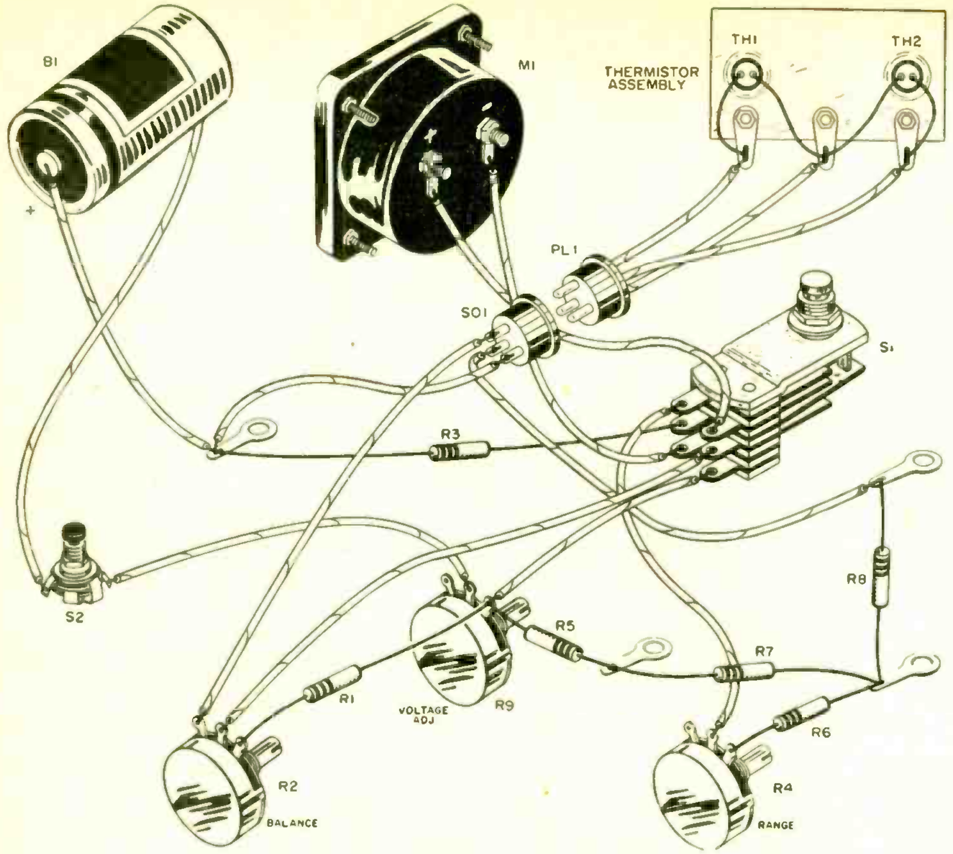
The word "anemometer"—meaning a device which measures velocity of the wind—calls to mind a cross-rod affair with end-mounted cups whirling around in the fashion of a horizontal windmill. Although such anemometers are far from obsolete, the thermistorized anemometer discussed in this article, together with the electronic thermometer* and the all-electronic hygrometer**, makes up a very modern home weather station.

The thermistorized anemometer is an electronic bridge containing two thermistors of identical characteristics. One of these is completely enclosed in a polystyrene capsule while the other is exposed to air movement through small holes in a second capsule. Wind velocity is read from a meter by referring to a calibration chart. You will be able to obtain the matched pair of thermistors from parts distributors or directly from *Victory Engineering Corp.*, Springfield Road, Union, N. J.

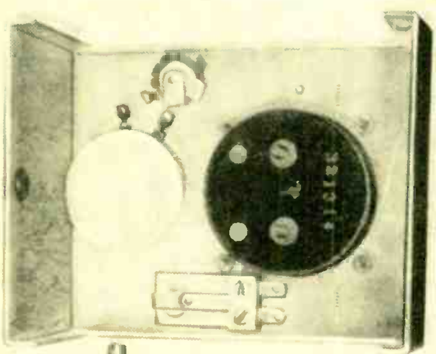
construction

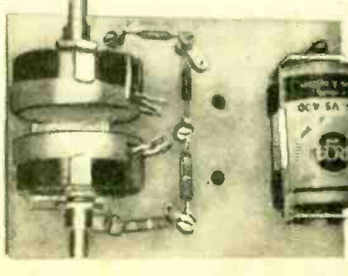
Use an aluminum box with hammertone finish as the case, and mount the main controls on the front panel. No chassis is necessary; the battery holder, most of the small fixed resistors, and two of the three potentiometers (*R2* and *R4*) are mounted on a

* "Make Your Own Electronic Thermometer," Popular Electronics, April, 1956, p. 62.
** "Build an All-Electronic Hygrometer," Popular Electronics, October, 1956, p. 65.



Pictorial wiring diagram of the anemometer.





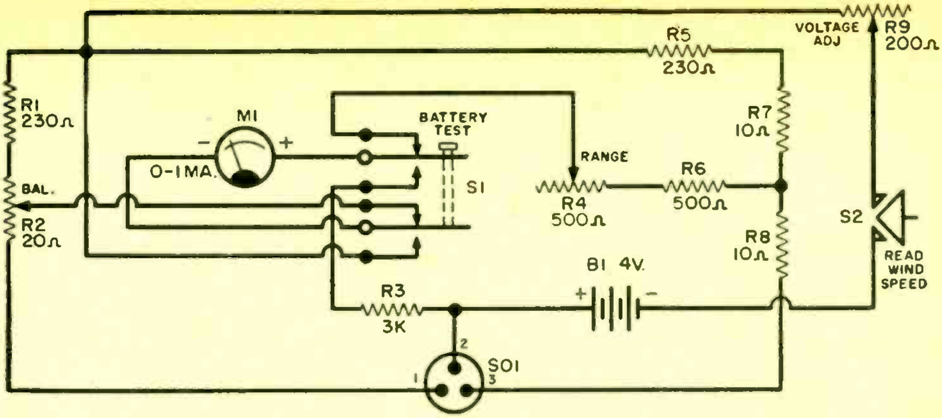
Chassis and subchassis of the control box are at left. The polystyrene subchassis sheet is mounted to rear of meter by the meter terminal screws.

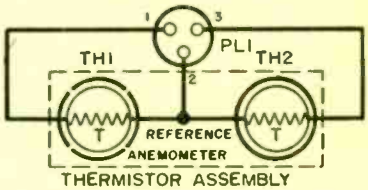
how it works

When the *Read Wind Speed* button *(S2)* is pressed, the battery is connected to the bridge circuit. If the *Battery Test* button *(S1)* is operated at the same time, the current from the battery follows the path through *R3*, the meter, and back to the battery through *R9*. *R3* and *R9* act as voltmeter multipliers and, if *R9* is set at about half range, the voltage applied to the main circuit is:

$$E = IR = .001 \times 3100 = 3.1 \text{ volts}$$

The anemometer circuit is a modified Wheatstone bridge. Two thermistors form a part of the bridge and are closely matched in nominal resistance so that the bridge may be balanced. When current flows through the thermistors, it causes them to heat. As the wind blows through the holes in the shield of one thermistor, this unit is cooled and its resistance rises sharply, upsetting the bridge balance, and causing the meter to show a reading. The size of the meter deflection is determined by the magnitude of the resistance change, which, in turn, is a function of the wind velocity.

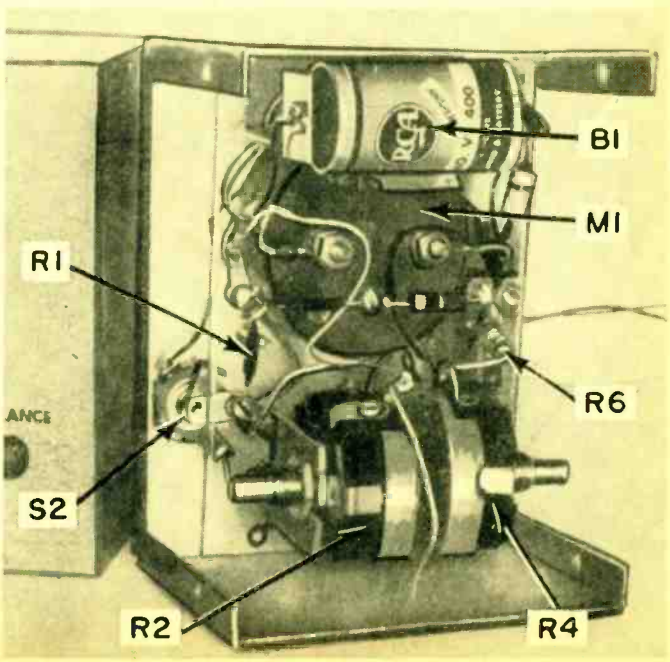




Diagrams and parts list for the electronic anemometer. The circuit above is contained in the control box; the thermistors diagrammed on the right are placed on a separate base and located out in the open. A three-wire cable connects the thermistor assembly to the control box containing the meter. Pictorial diagram showing method of connecting parts is at the left.

B1—4-volt mercury cell battery (RCA VS-400)
M1—0-1 milliammeter in 2" square case (Triplett Model 227-T)
PL1—Three-prong plug (optional)
R1, R5—230-ohm, ½-watt resistor
R2—20-ohm potentiometer
R3—3000-ohm, ½-watt resistor, 5% tolerance
R4—500-ohm potentiometer
R6—500-ohm, ½-watt resistor
R7, R8—10-ohm, ½-watt resistor
R9—200-ohm potentiometer
S1—Spring-operated, d.p.d.t. push-button switch
S2—Spring-operated, s.p.s.t. push-button switch (Switchcraft Type 201)
SO1—Three-prong socket (optional)
TH1, TH2—Thermistor assembly; a matched pair of 2000-ohm nominal (25°C) thermistors (Victory Engineering Corp. Type A-33)
1—5" x 4" x 3" aluminum case, hammertone finish (Premier PMC-1005)
1—Battery holder for 4-volt cylindrical mercury cell
Misc. polystyrene sheeting, hardware, three-wire cable, solder, wire, etc.

Inside view at right shows the location of the major parts on the chassis and the subchassis.



1/16"-thick sheet of polystyrene about ¾" smaller than the inside dimensions of the case. Secure the polystyrene sheet to the box with the meter terminal screws.

Potentiometers *R2* and *R4*, which do not require frequent adjustments, have slotted shafts and are available through grommetted holes in the sides of the case. Bend a strip of scrap aluminum about ¾" wide into a U-bracket and slot it to take the shaft bushings of these potentiometers. Mount *R2* and *R4* back-to-back so that their shafts protrude outward toward the sides of the case; the shafts are cut and slotted with a hacksaw.

A 3-wire cable emerges from the bottom of the case. This is the transmission line from the remotely located thermistors on the rooftop.

The matched pair of thermistors are packaged in two small polystyrene vials which make perfect casings for the thermistors in the final assembly. Punch four very tiny holes symmetrically around the top of one of the vials by means of a fine sewing needle heated to dull red. A 3½"x1⅜" polystyrene base plate is used to hold the assembly; drill very small holes in it to pass the thermistor leads.

Cement the vials to the base plate with polystyrene cement. The wires are soldered to lugs screwed to the base plate. One common connection between the two thermistors and the two remaining leads comprise the terminals for the three-wire transmission cable that goes to the control box.

Front view of anemometer control box with meter which may either be calibrated directly to read wind velocity or may be used with a graph.

testing

Set both the *Voltage Adj* control (*R9*) and the *Range* control (*R4*) to maximum resistance. Set the *Balance* control (*R2*) at the center of its range.

Depress *both* push buttons (*S1* and *S2*) simultaneously and hold them down for about 5 seconds. The meter should read somewhat above half scale. Now advance the *Voltage Adj* control slowly until the meter reads exactly full scale. This adjusts the voltage to approximately 3.1 volts—a value which represents the standard operation of the instrument.

Release the *Battery Test* button (*S1*), maintaining pressure on the *Read Wind Speed* button (*S2*). Make sure that the thermistor assembly is in still air. Now adjust the *Balance* control for a zero reading on the meter.

Release the *Read Wind Speed* button and advance the *Range* control. Again press the *Read Wind Speed* button and, if necessary, readjust the *Balance* control to its maximum resistance position. The anemometer is now ready for calibration.

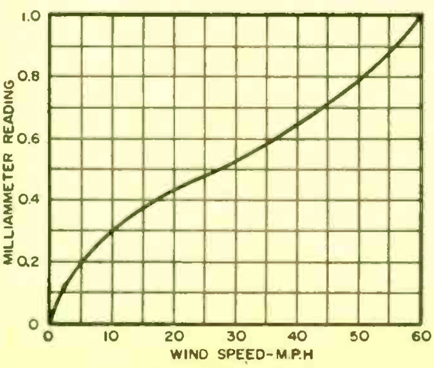
calibration

Enlist the services of a competent automobile driver for this task because you are going to "generate" a readable wind speed by holding the thermistor assembly out of a car window while in motion at various speeds. Choose a highway which permits maximum state speed limits.

Have your driver accelerate to and maintain a speed of 60 m.p.h. Hold the thermistor assembly as far out the window as possible and depress the *Read Wind Speed* button. The meter reading should be substantially less than full scale. Advance the *Range* control until you arrive at a full-scale reading on the meter. At this point, a reading of 1.0 ma. is equivalent to a wind speed of 60 m.p.h.*

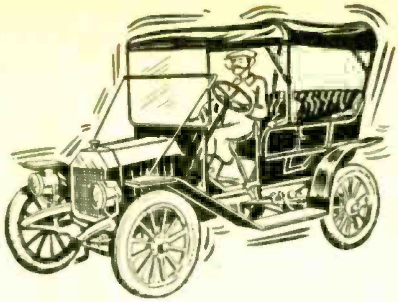
Repeat this procedure for speeds of 55, 50, 45, 40, etc., m.p.h., but do not alter the setting of the *Range* control. Keep records of the meter readings for each of these speeds for your calibration curve.

* If full scale is not reached at 60 m.p.h. with any setting of the *Range* control, the needle-baffle holes should be *slightly* enlarged.



Typical calibration graph used with meter.

Electronics Will Locate Those Car Rattles



by **r. wayne crawford**

find that rattle and shake the kinks out of the family car with this novel gadget

Most of us have noticed annoying rattles in our automobiles. At the first opportunity we drive into a garage, get out the screwdriver, pair of pliers and wrench, and start tightening every screw and bolt in the general vicinity of the rattle. Then, all too often, we find the rattle still present the next time we are out driving.

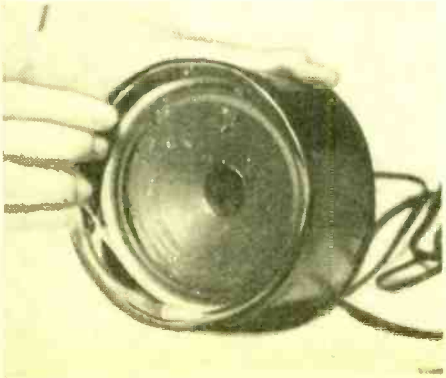
A rattle is caused by the vibration of a loose screw or bolt that has a "natural frequency" at which it will vibrate or oscillate. This vibration will also occur at any integral multiple of the "natural frequency"—which is the reason that some of the rattles in your automobile are noticeable only at particular speeds. As you drive at different speeds, you may hear entirely different rattles.

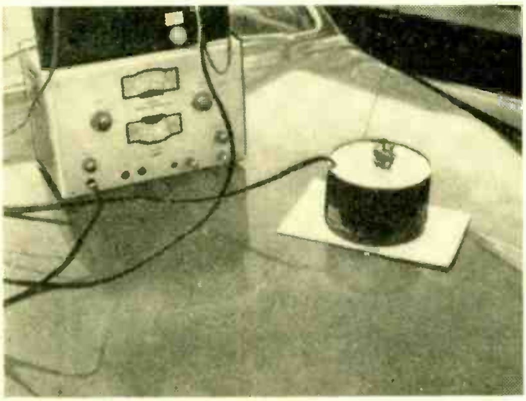
It's easy to locate rattles! By utilizing the "natural frequency" phenomena and introducing a vibration, the loose object can be made to rattle when the car is not in use. Once the object has started rattling, you can locate the rattle and eliminate it. An audio oscillator and a speaker may be used to introduce the vibration.

The frequency of an audio oscillator can be adjusted to the "natural frequency" of the object that is causing the offending rattle. The speaker serves as a transducer or means of transmitting the vibrations to the body of the automobile. These vibrations are of much lower magnitude than the vibrations of a moving automobile, but they are great enough to cause a loose object to rattle.

The audio oscillator should have sufficient power to drive the speaker. If it does not, a simple stage of amplification may be added. (The writer found that the audio stage of a discarded a.c./d.c. receiver worked very well.) Another consideration is the amount of noise you can create without upsetting your neighbors. If you have neighbors that object to the howling of a larger speaker, use a directional speaker to transfer the vi-

Mounting your speaker inside a 1-lb. coffee can (below) makes it directional enough to set up vibrations in the body of the automobile without using excessive volume, which might otherwise prove annoying to your neighbors.





To locate a rattle on the outside of your car, place the speaker in the general vicinity of the rattle. A sheet of paper under the can (above) prevents speaker itself from rattling and protects the finish.

bration to the automobile body at a moderate volume level.

A standard 1-lb. coffee can may be used to make a 4" speaker directional. Mount the speaker inside the can by drilling a hole in the bottom of the can and slipping a small clamp through the bracket that holds the magnet. Be sure to crimp the sealing rim around the lip of the can to prevent it from rattling. The cable to the speaker may be brought out through a hole in the bottom of the can. This cable should be about 12' long to enable you to move the speaker to different sections of the automobile.

locating rattles

The greatest number of rattles in an automobile occur in the area around the dashboard. The simplest way to locate a rattle in this region is to open the glove compartment door and set the speaker, open end down, on the door. Place a piece of paper under the speaker to prevent a rattle due to the vibration of the speaker against the glove compartment door. Start the audio oscillator at the low-frequency end and slowly increase the frequency. (It must be increased *slowly*, for the "natural frequency" of some of the loose objects may be quite critical.) At some point in the frequency spectrum, the loose screw or bolt will start to rattle. When a rattle occurs, adjust the frequency of the audio oscillator until the rattle is loudest. It will be simple then to locate the source of the rattle.

In the event the design of your automobile is such that the speaker cannot be mounted on the glove compartment door, attach an "L" bracket to the side of the speaker can and clamp the can under the dashboard with a "C" clamp.

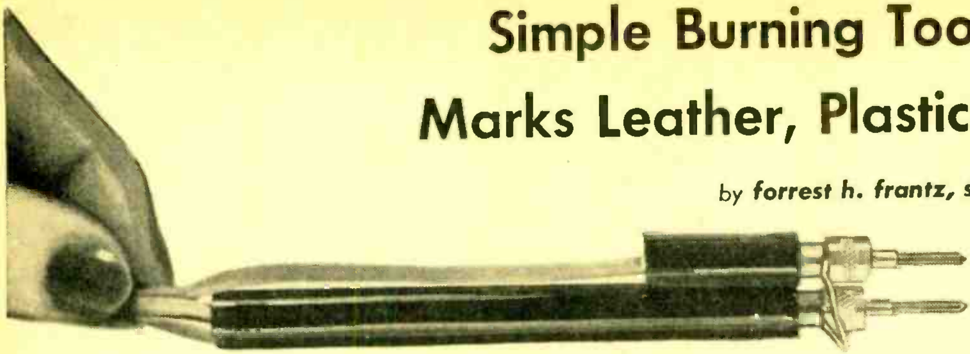
To find a rattle in a door, use a clamp that will clip over your window; when the window is rolled up, the speaker is firmly mounted. If a piece of the chrome trim on the hood is loose, you may isolate the rattle by placing the speaker face down on the hood. Rattles in the trunk of your automobile can be located by placing the speaker on the floor of the trunk. Avoid holding the speaker with your hand, so that your body will not absorb much of the vibration and lessen the effectiveness of the system.

check your appliances

This method of locating rattles is not confined to automobiles but works equally well in the home. It is especially valuable for locating rattles in appliances where it is dangerous or impossible to check for loose objects when the appliances are in operation.

Simple Burning Tool Marks Leather, Plastics

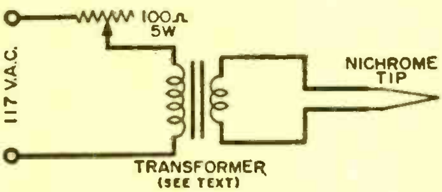
by *forrest h. frantz, sr.*



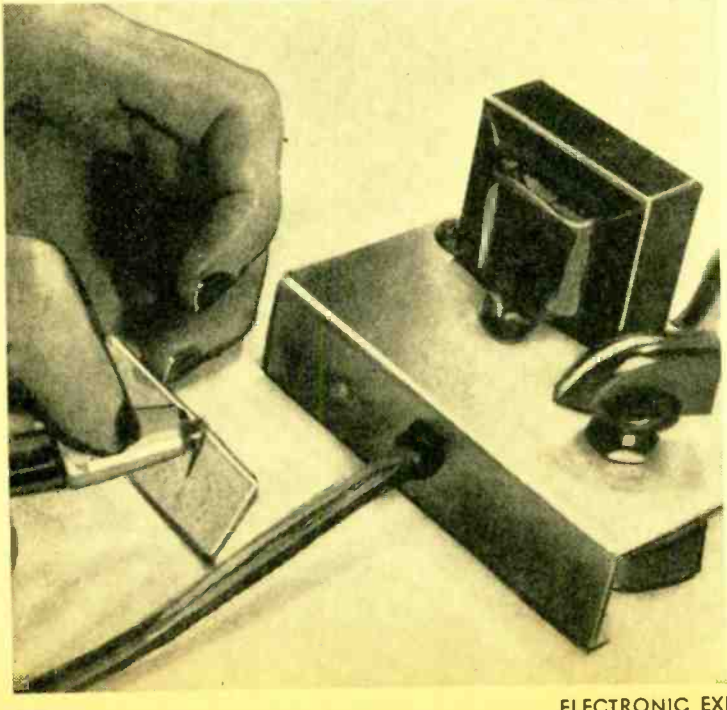
Here's a burning tool you can make in half an hour. You can probably find all the materials in your junk box, or at most, they would cost you $3 to $4 at any parts store. The transformer is a 6.3-volt filament transformer capable of delivering 3 or more amps. The 100-ohm, 5-watt rheostat is the temperature control. A short length of Nichrome wire makes up the burning tip, which you can attach to the ends of an ordinary pair of test prods.

You can find a million uses for the tool, particularly with leather and plastic. You can mark your possessions, such as suitcases or leather bags. Or you can burn designs into plastic objects which can then be filled with India ink to make them stand out.

The workings of the power supply can be fitted into a small aluminum chassis. It would be best to use a rubber grommet to protect your power cord, although you could put tape around the edge of the hole you drill in the chassis. The test prods should be glued together by Duco cement or the like.



Schematic above shows how easy it is to build the burning tool. In the photo at top of page, you will note how the Nichrome tip is attached to the ends of the test prods. If you wish, you can remove the prod points, since they may tend to obstruct your work. Cement holds the prods in place.



Note the construction of the power supply in the aluminum chassis. A rubber grommet is used to protect the power cord. Tool is being used to burn name into piece of plastic. The test leads themselves should not be plastic—the heat might melt them.

by **harvey pollack**

The "Varistrobe"

high speed stroboscope freezes motion

Would you like to examine the contortions of your high-speed circular saw, drill or bandsaw under conditions that seem to slow it down to a crawl? Any repetitive movement, whether rotary or reciprocating, can be viewed as though the moving body were at rest or in very lazy motion—under the flashing illumination of this wide-range "Varistrobe" (variable flash-rate stroboscope).

The "Varistrobe" consists essentially of a power supply, a time-base circuit or variable multivibrator, and a strobotron neon tube (631-P1, also called 1D21/SN4) which is triggered by the impulses from the multivibrator. On the *LOW* setting of the *RANGE* switch, the flash-rate may be varied from about 15 cps to a little above 60 cps; when set in the *HIGH* position, frequencies between 60 cps and 240 cps are easily covered. The intentional overlap of the two ranges permits the user to obtain any flash-rate from 15 cps (900 flashes per minute) to 240 cps (14,400 flashes per minute). The latter is the upper limit of the rating of the strobotron.

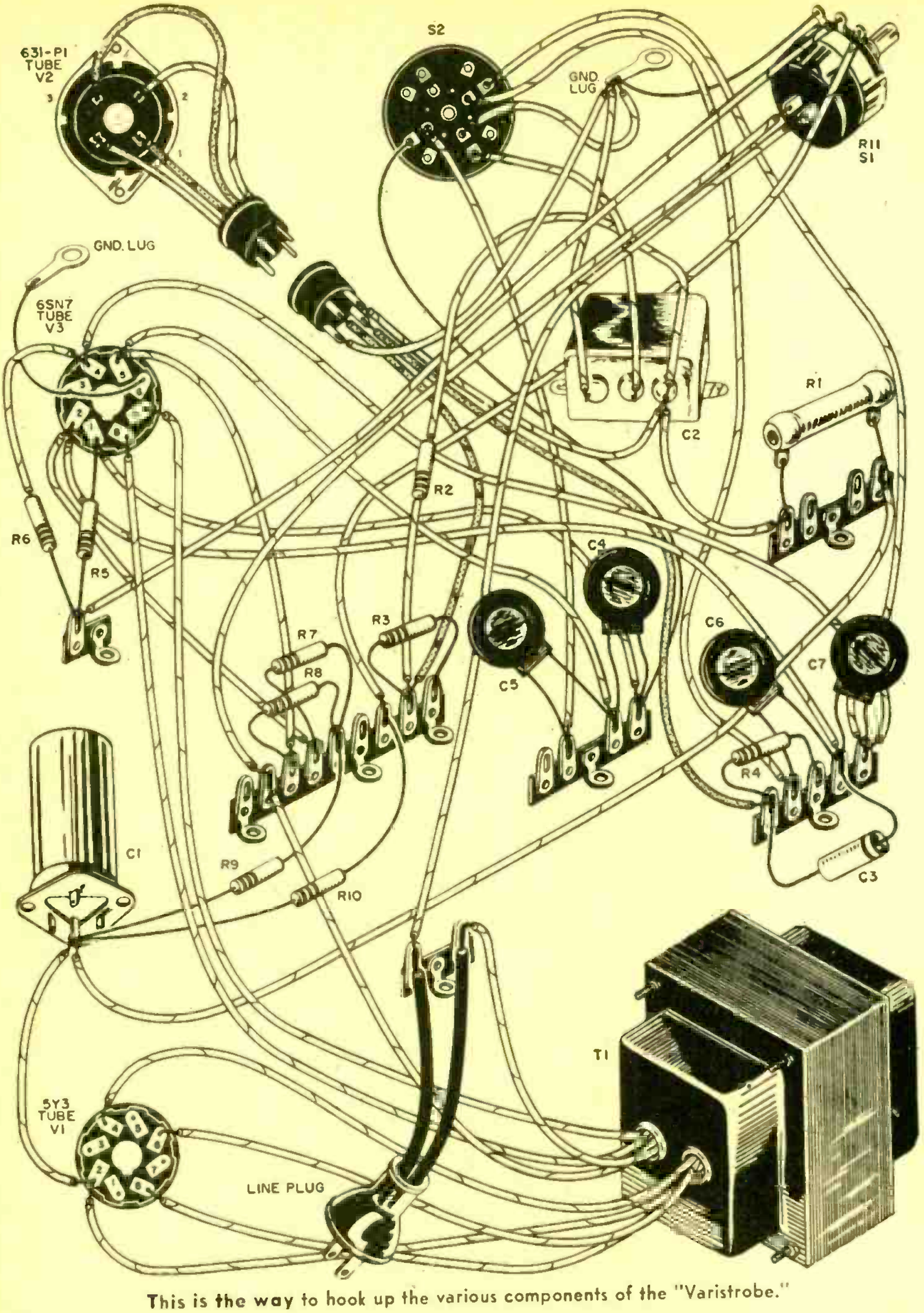
Each flash lasts between 1/2500 second and 1/5000 second. When the flash-rate is synchronized with the moving object, most of the motion occurs in darkness. The object is thus illuminated briefly in approximately the same spot each time it comes around, so that it appears stationary. If the flash-rate is a bit slower or faster than the number of rps, a lazy, crawling motion will be seen.

construction

Many of the chief structural details are shown in the photographs and illustrations. The power transformer, filter capacitor, discharge capacitor, and frequency control potentiometer all appear above the chassis; the smaller components and the *RANGE* switch are mounted below the chassis.

The *RANGE* switch is a four-circuit, double-throw type. It was chosen for its availability in standard catalogs and for its small size. Only three of the contacts are employed in a single-throw arrangement. When you are wiring this switch into the circuit, be careful to arrange the contacts so that all three of the *LOW* setting capacitors (*C2a*, *C5*, and *C6*) are connected across their mates (*C2b*, *C4*, and *C7*) when switch is in *LOW* position.

You'll take real pride in the unit if you add panel decals, a high-quality knob and vernier indicator, and a carrying handle. Effectiveness of the strobotron illumination



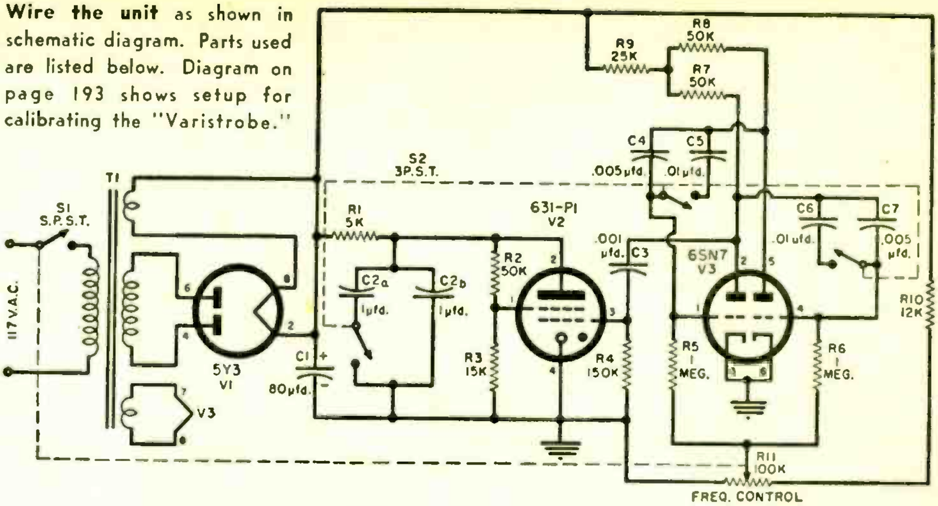
This is the way to hook up the various components of the "Varistrobe."

is heavily dependent upon the quality of the reflector used behind it. The one shown in the pictures comes from an inexpensive Bower pocket flash.

testing

Set the *RANGE* switch on *LOW* and rotate the potentiometer knob (*R11*) clockwise until the switch just clicks on. In about 30 seconds or less, the strobotron should start to flash at its slowest rate. *At this point, it is very important to remove the 6SN7GT from its socket while the strobotron is flashing.* This should extinguish

Wire the unit as shown in schematic diagram. Parts used are listed below. Diagram on page 193 shows setup for calibrating the "Varistrobe."



parts list

C1—80-µfd., 450-volt capacitor (Sprague TVL-1735, twistlok type, can ground)
C2—2 x 1.0 µfd., 600-volt capacitor (Cornell-Dubilier DYR 6110, can type, one lug common, can not part of capacitor)
C3—0.001-µfd., 450-volt tubular paper capacitor (Sprague 68P1)
C4, C7—0.005-µfd., 1-kv. capacitor (Centralab button type, Hi-cap 502)
C5, C6—0.01-µfd., 600-volt capacitor (Centralab button type, Hi-cap 103)
R1—5000-ohm, 10-watt wire-wound resistor (Sprague Type 10 KT or Type 10 NIT)
R2—50,000-ohm, 1-watt, 10% resistor
R3—15,000-ohm, 1-watt, 10% resistor
R4—150,000-ohm, 1-watt, 10% resistor
R5, R6—1-megohm, ½-watt, 10% resistor
R7, R8—50,000-ohm, ½-watt, 10% resistor
R9—25-000-ohm, 1-watt, 10% resistor
R10—12,000-ohm, 1-watt, 10% resistor
R11—100,000-ohm, linear taper potentiometer—frequency control (Mallory U-41)
S1—S.p.s.t. On-off switch mounted on R11 (Mallory U-41 control to take US-46 switch)
S2—3p.s.t. or 4p.2t. rotary type, non-shorting range switch (Mallory 3242J)—see text
T1—Power transformer, 235-0-235 sec. volts at 40 ma., 5 volts at 2 amp., 6.3 volts at 2 amp. (Stancor PM-8401)
V1—5Y3 rectifier tube
V2—631-P1 strobotron (Sylvania)
V3—6SN7GT multivibrator tube
1—6" x 6" x 6" cabinet, black wrinkle steel with built-in chassis (ICA Type 3823)
1—Case handle, 4½" over-all length, chrome (ICA 3500)
1—5"-diameter parabolic reflector for strobotron
1—4"-round dial, 325° rotation, chrome silver finish (ICA 2168)
1—Vernier dial marker for 4" dial (ICA 2191)

the glow in the strobotron completely. If the flashing continues with the multivibrator tube removed, it indicates that the anode grid voltages on the strobotron are incorrect—which may be caused by one or more of the following faults:

(a) *R2* and *R3* may have been interchanged.

(b) *C3* may be leaky or shorted.

(c) *R1* or *R2* or both may be shorted by some incorrect connection.

(d) The voltage output of the transformer may be too high if any other but the specified type is used. The voltage measured across the filter capacitor (*C1*) should be just about 300 volts.

If everything is working correctly, replace the 6SN7GT in its socket, and allow it to warm up once again. Slowly rotate the *FREQUENCY CONTROL* knob clockwise. The flash-rate should rise smoothly and evenly. As the frequency increases, the "song" of the strobotron rises in pitch and becomes a note of roughly 60 cps at the extreme clockwise position of the knob.

Return the control to its original counterclockwise position with the *ON-OFF* switch still *ON*, and turn the *RANGE* switch to its *HIGH* position. The flash-rate should advance appreciably and, as the knob is rotated clockwise again, should become much higher in pitch.

calibration

The procedure is straightforward. First obtain some finely divided graph paper. Mark off the horizontal axis (see sample calibration chart) in terms of dial readings.

Model is attractively housed in black wrinkle steel cabinet with panel decals, a high-quality knob and vernier indicator, and a carrying handle.

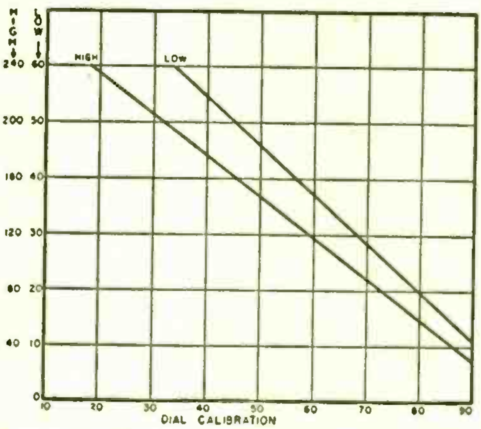
The vertical axis carries two columns of figures: one for the *LOW* setting of the *RANGE* switch and one for the *HIGH* position. For *LOW,* the numbers run from 0 to 70 cps, and for *HIGH* they range from 0 to 280 cps.

Set the "Varistrobe" in operation and let it run at its lowest frequency for a minimum of ten minutes to allow it to stabilize fully. While waiting, set up an old loudspeaker and output transformer and plug it into the 117-volt receptacle; the cone should hum loudly at 60 cps.

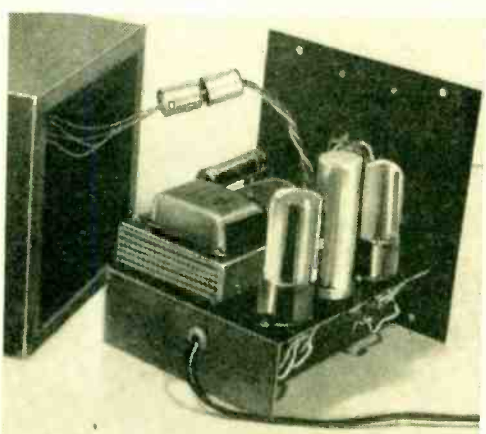
Keeping the *RANGE* switch on *LOW,* rotate the *FREQUENCY CONTROL* knob completely clockwise (frequency now being a bit higher than 60 cps), turn out the room lights, and illuminate the speaker cone with the strobe light. Slowly reduce the "Varistrobe" frequency until the cone appears to be absolutely stationary. Do it carefully so that you don't miss the first point where this occurs. The "Varistrobe" frequency is now exactly 60 cps, and a point may be placed on the graph with a hard, sharp-pointed pencil.

Again reduce the frequency slowly until the cone appears to "freeze" at the next setting; this is 30 cps, the cone being illuminated on every *alternate* vibration. Mark a point opposite the 30-cps scale level and above the new dial reading for this frequency. Repeat the procedure for 20 cps (cone illuminated every third vibration) and for 15 cps (cone illuminated every fourth vibration). This gives four coordinate points which may now be joined together by a straight line.

Using the same process on the *HIGH* setting of the *RANGE* switch yields the calibration line from 60 cps to 240 cps. This may be drawn on the same sheet of paper as shown in the sample. In this case, start from 60 cps and work your way up in frequency. Cessation of motion



Sample calibration chart. See text for details.



Components are mounted as shown here. Miniature cable connectors which join the four leads that go to strobotron socket on top of case make it simple to remove chassis for inspection or repairs.

can be observed for 60 cps, 120 cps, 180 cps, and 240 cps, giving four points for the second calibration line. Now your tachometer graph is ready for use. To find the speed of any rotating or reciprocating body, scratch or chalk it in one spot that will be clearly visible while it is in motion. Next, determine the *highest frequency* which freezes the reference mark so that it is visible in only one place. The dial may now be read and translated into cps.

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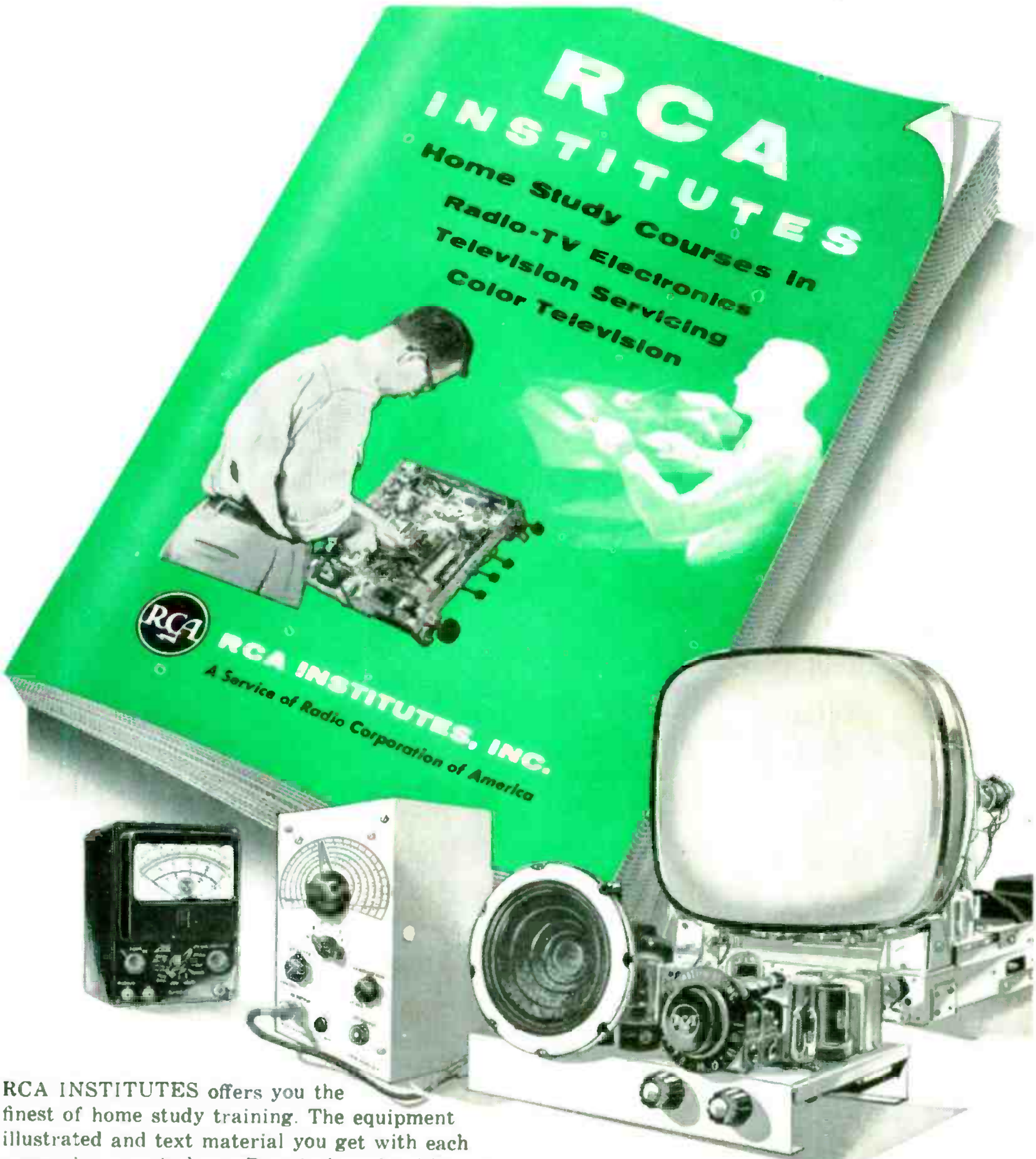
Anyone who has had occasion to use a VOM or VTVM knows the inconvenience of craning and twisting to get a head-on look at the meter. It always seems to be too high or too low, or it's not facing the experimenter squarely. Under such conditions, an accurate reading is often impossible.

After years of such nonsense, the writer finally took the logical step, long postponed, of building a mounting for his VTVM which makes it a simple matter to adjust the tilt of the meter to face him squarely. This mount or support can be simply constructed in less than an hour from some scraps of wood around the workshop.

Dimensions aren't given in this article. They'll vary with the size and shape of your test instrument. Just be sure that the mounting you build provides adjustment for tilt and swing, has a large and heavy base for stability, and is designed to permit easy removal of the instrument for use away from the shop.

Mine has a heavy oak base for weight and stability. The frame around the meter is a neat sliding fit. A narrow strip across the top-back of the handle holds the meter in place and still permits it to be removed with ease. —*R. L. Winklepleck*



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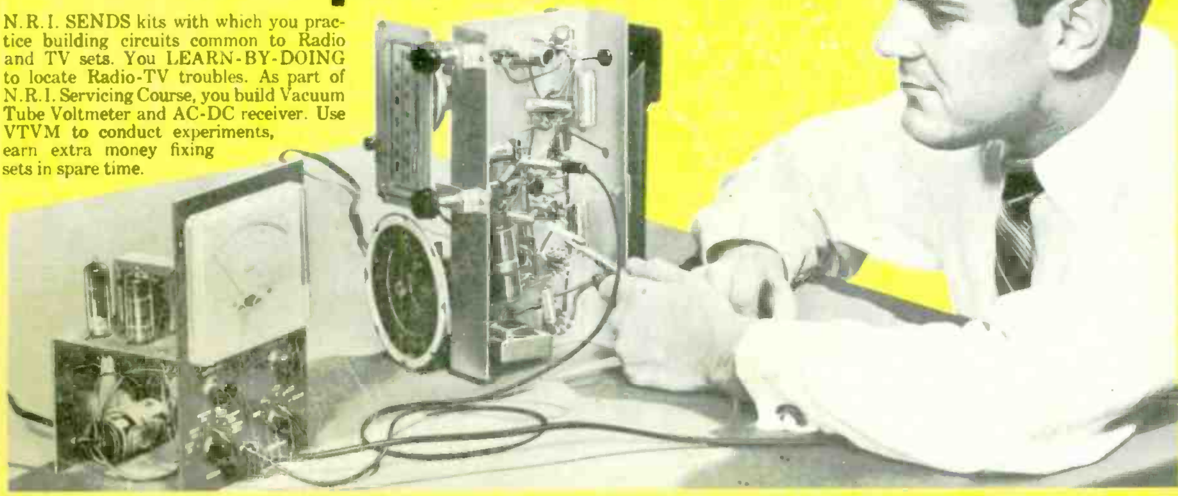

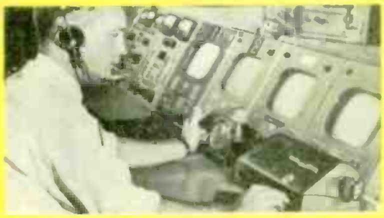

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