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ELECTRONIC EXPERIMENTER'S HANDBOOK

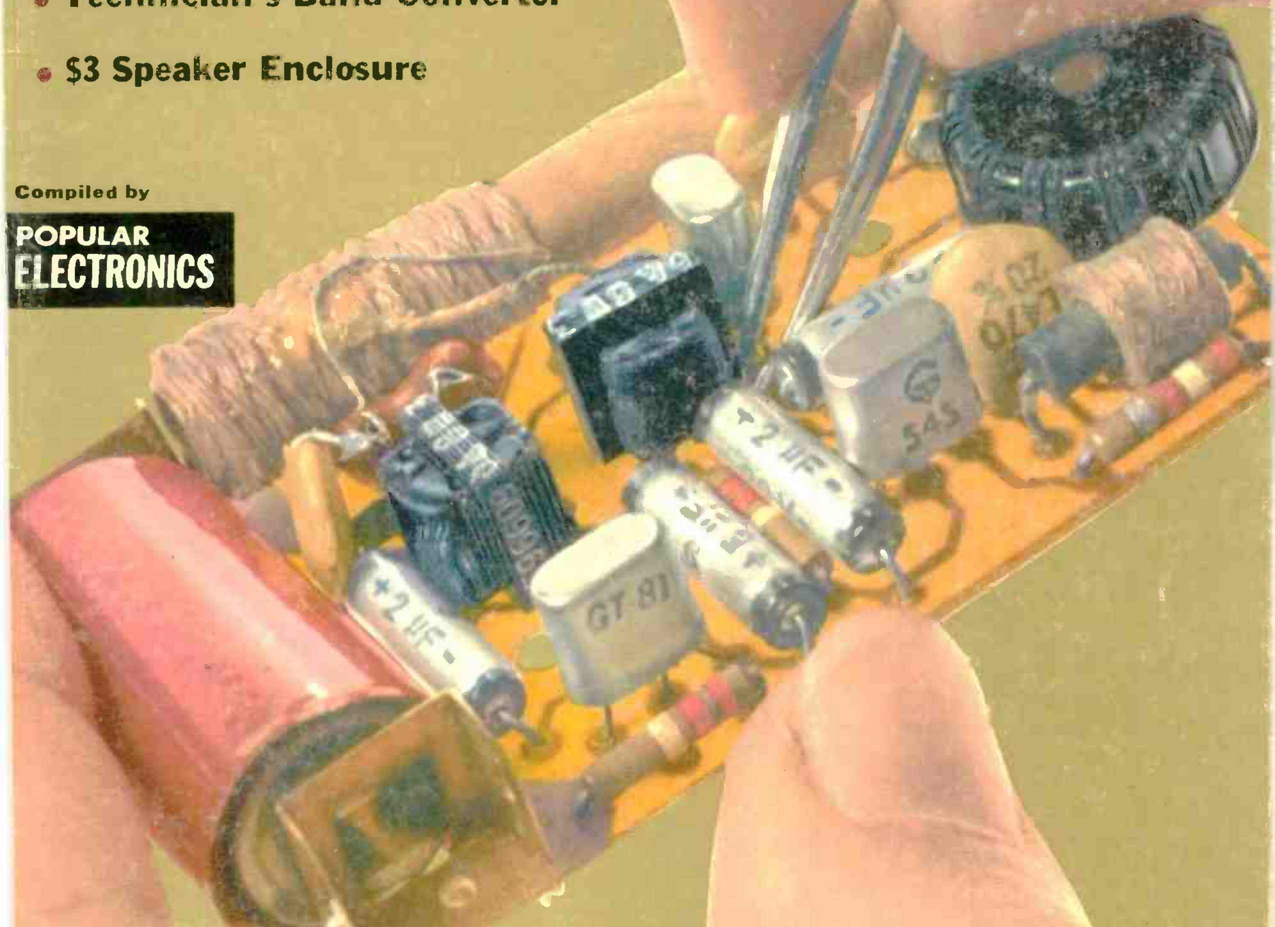
ANC

1957 EDITION

- Transistor Portables
- Television Commercial Silencer
- Technician's Band Converter
- $3 Speaker Enclosure

Compiled by

POPULAR ELECTRONICS



46 GADGETS for your home, hobby, & children

ON OUR COVER: Miniaturized transistor radio, photo by Harvey Shaman.

Contents

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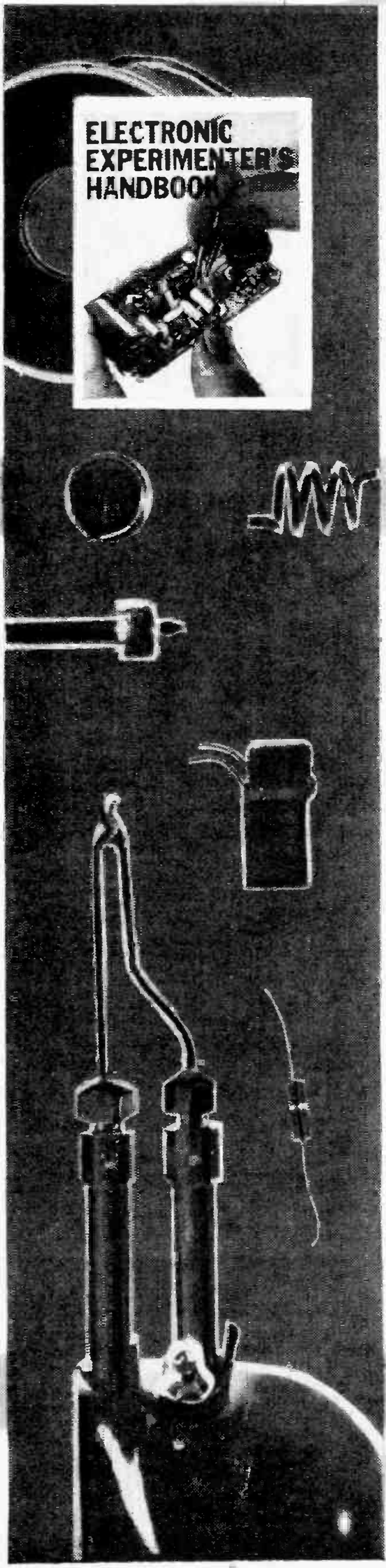


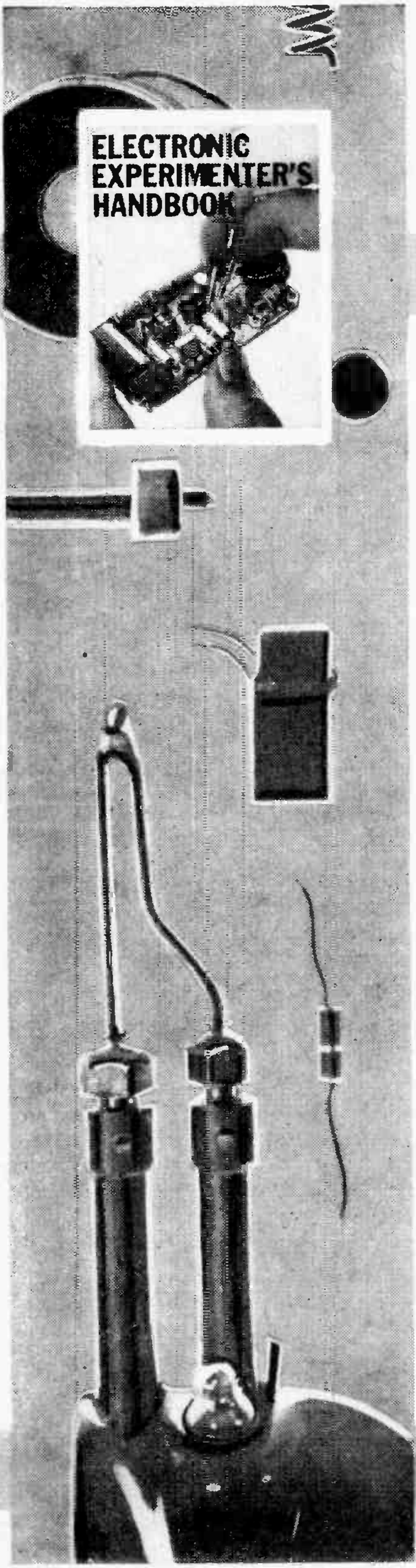
ELECTRONIC EXPERIMENTER'S HANDBOOK

Introduction

IF YOU like to build things that are useful and if you want to learn some electronics in the process, this book is for you. Most of the devices described here are easy to build and require little or no electronics knowhow. Some of the projects, however, are quite advanced, making this book of interest to the seasoned electronics experimenter as well as the neophyte.

More than 46 projects are described in the nine chapters of this book. A rain alarm, fire alarm, baby sitter, and similar devices for the home are described in the first chapter. The second chapter describes novel and educational toys for children. Outdoormen, hi-fi fans, radio amateurs, photographers, musical gadgeteers, and radio control fans will each find a chapter devoted to their interests. The last chapter contains some projects of general interest and unusual novelty.

The devices in this book are, in a way, pretested, having previously been described in POPULAR ELECTRONICS magazine. The widely popular and original pictorial diagrams used in that magazine are retained here, as is the direct, clear style. We're sure that you will get much enjoyment and use from these projects. *C.T.*



Chapter 1

For Your Home

Keep Dry with this "RAIN ALARM"

By EUGENE RICHARDSON

DOES the lady of the house have to keep an eye open for clouds whenever she hangs out the laundry? When there's a heavy storm, is it necessary to keep checking the basement for possible water leaks? Has anyone ever turned on the sprinkler to water the lawn, lain down for a short nap, then awakened to find that a storm had come up and water was being wasted on a lawn already soaking from a torrential downpour? Has anyone ever left the top down on a convertible in the evening, had showers during the night, and had to drive to work in a wet car?

If the answer to any of these questions is "yes," or if rain, moisture condensation or water leaks are likely to introduce problems in a personal or business life, then here's a handy little gadget that will help reduce future worries—a novel "rain alarm" so sensitive that the slight moisture condensing from one's breath on its *sensor plate* is enough to operate it.

Yet with all its amazing sensitivity, the rain alarm uses a very simple circuit requiring but a single vacuum tube. It is quite easy to assemble and a cinch to use. An experimenter or home builder of average skill should have no difficulty assembling and wiring his own unit in one or two evenings or on a weekend.

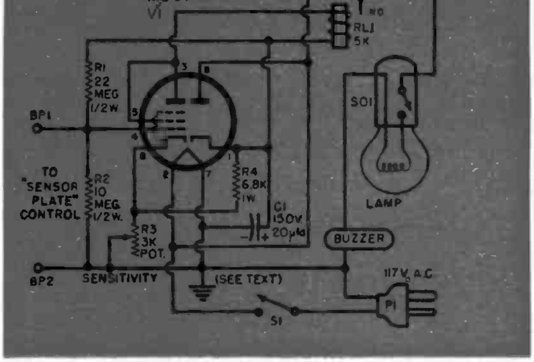
Assembling the Rain Alarm

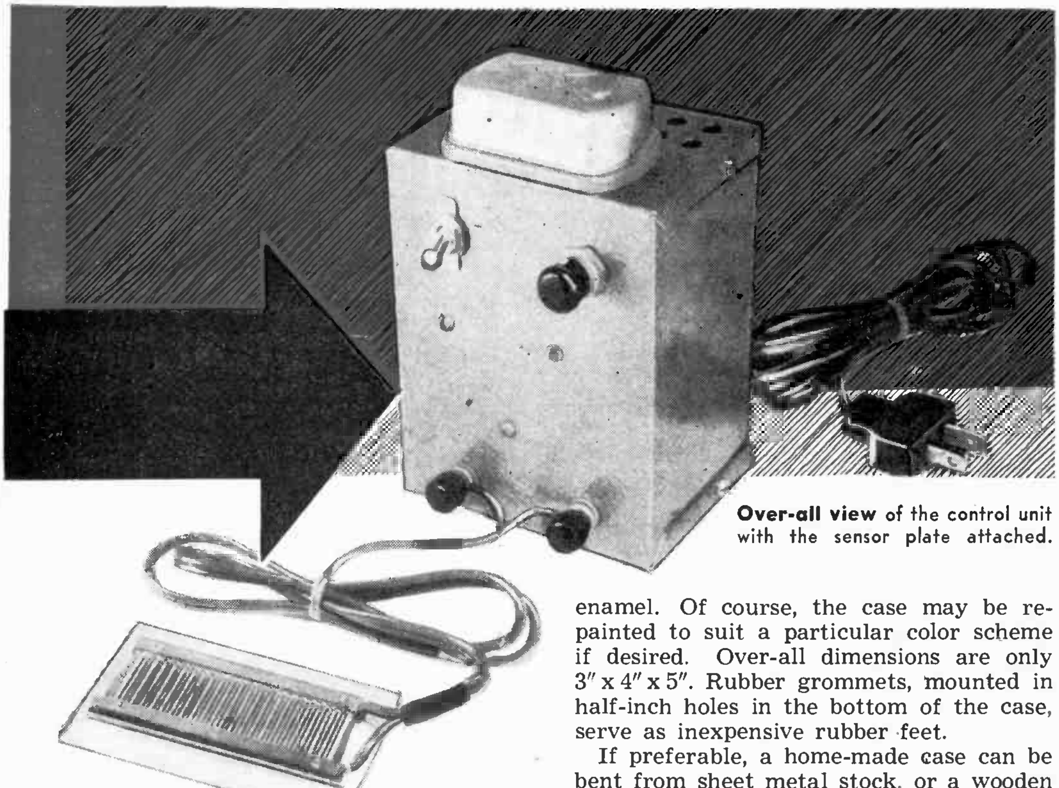
Because of the simple circuit employed, relatively few inexpensive, readily available components are required, and these are all specified in the parts list. Chances are all of the parts will not be found at a radio parts distributor, however. It may be necessary to pick up the buzzer, lamp socket and bulb, and one or two other items at a local hardware store.

The complete rain alarm consists of two independent units—the "Control Box," which includes the electronic circuits as well as the alarm signaling devices, and the "Sensor Plate" which detects the presence of moisture. A length of twin conductor lamp cord is used to connect the two units.

The Control Box: The complete electronic circuit shown in the schematic diagram is assembled in the control box. Wiring and layout are not critical and lead dress is not too important. However, a few construction hints should be of help in avoiding errors and in making sure that the unit works the first time it is turned on.

A single piece of sheet metal measuring approximately 3½" x 5¼" is bent to form





Over-all view of the control unit with the sensor plate attached.

the chassis. Either steel or aluminum may be used, but aluminum is easier to machine and to bend. If steel is used, it will be necessary to give it a protective coating of some sort to prevent rust. Enamel, plastic, or a plating (such as cadmium or copper plating) may be employed.

The model shown is housed in a commercially available aluminum box, finished with an attractive gray hammer-tone enamel. Of course, the case may be repainted to suit a particular color scheme if desired. Over-all dimensions are only 3" x 4" x 5". Rubber grommets, mounted in half-inch holes in the bottom of the case, serve as inexpensive rubber feet.

If preferable, a home-made case can be bent from sheet metal stock, or a wooden or plastic case may be used in place of a metal housing. However, regardless of the case employed, be sure to allow a reasonable amount of working space, make certain the vacuum tube is not too close to material likely to be damaged by heat, and provide adequate ventilation. In the model, ventilation is provided by a series of 3/8" holes drilled in the back cover, together with a pattern of 1/4" holes in the top. These two sets of vent holes act together to provide a sort of "chimney" effect which gives efficient cooling.

Fig. 1. Schematic diagram and parts list of control unit and sensor plate.

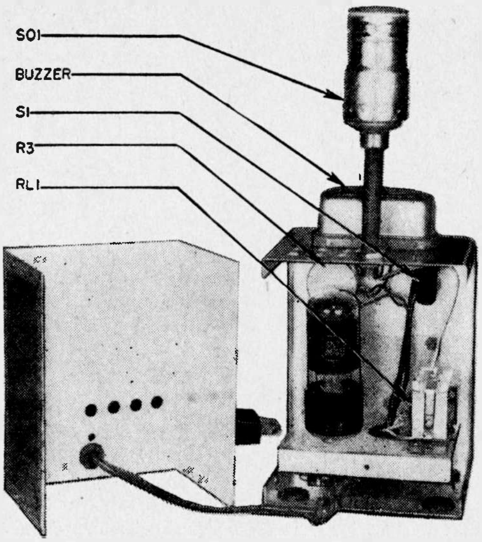
CONTROL UNIT

R1—22 megohms, 1/2 w. carbon res.
R2—10 megohms, 1/2 w. carbon res.
R3—3000 ohm wirewound pot.
R4—6800 ohm, 1 w. carbon res.
C1—20 μfd., 150 v. tubular elec. capacitor
BP1, BP2—Binding post terminals
RL1—S.p.d.t. plate relay, 5000 ohm coil (Potter and Brumfield Type LB5 or LM5)
PL1—Polarized line plug (see text)
S1—S.p.s.t. toggle switch
SO1—Standard lamp socket, with switch
V1—117L7/M7GT tube
BUZZER—6 v. a.c.-d.c. buzzer (Edwards No. 725 "Dixie" Buzzer)
LAMP—Standard 115 v., 100 w. lamp
1—Metal cabinet, 3" x 4" x 5" (Bud "Minibox" CU-2105)
1—Sheet of aluminum, approx. 3 1/2" x 5 1/4" x 1/16", for chassis
1—Octal socket
1—Line cord
1—2-lug terminal strip
6—1/2" rubber grommets
Misc.—Screws, nuts, wire, solder

SENSOR PLATE

2—Metal pet combs (Obtain from pet shop or hardware store—see text)
4—4-36 x 1/4" flat-head machine screws
1—piece of Bakelite, fiberboard, or plastic, 3 1/2" x 2 1/4" x 1/8"
Misc.—Short leuth of lamp cord, solder, electrical tape

Total cost of parts, approx. $17.50



Rear view of control unit with cover removed. Note the subchassis on which the tube and relay are mounted. Holes in back and top are for ventilation.

The lamp socket, *SO1,* and the buzzer are mounted on the top of the case. Be sure to obtain a lamp socket with a built-in switch so that the alarm can be turned "off" when desired.

Wire as much of the chassis as possible before mounting it in the case. The partially wired chassis is shown on page 13 and major components are identified.

NOTE ON GROUND CONNECTION: One side of the power line connects to circuit "ground." This ground connection may be to the chassis and case, *provided a polarized line plug is used, so that the chassis is always at ground potential.* As one side of the power line is connected to earth ground in all installations following standard UL code, all standard outlets are "polarized" to receive a special plug in only one way, but they will receive regular plugs in two ways. Where one side of the power line is connected to the chassis of a piece of equipment, and a regular plug is used, it is possible to make the chassis "hot" with full line voltage (with respect to earth ground) if the plug is inserted in a certain way in the wall receptacle. This might result in a severe shock. In a polarized plug, one of which is used in this model, one prong is wider than the other, with the widest prong connected to the "ground" side of the line. It can be inserted in a wall socket in only one way.

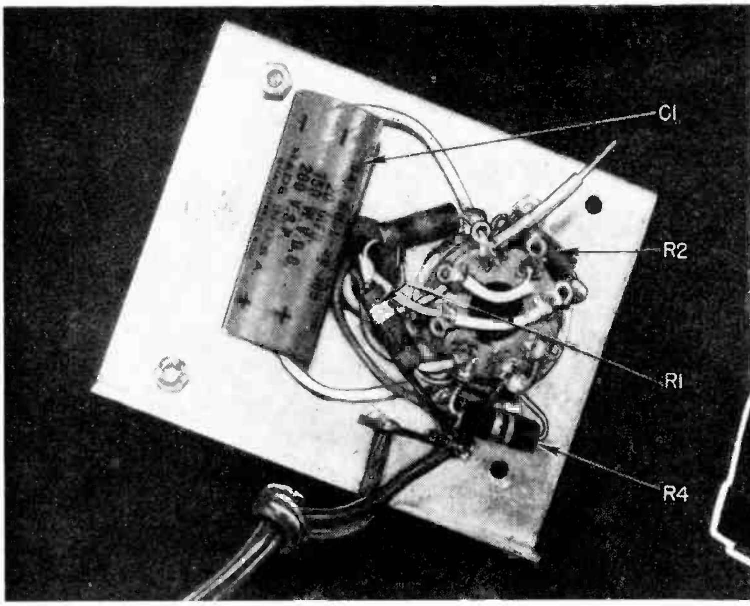
If a polarized plug is not available, and cannot be obtained, one can be made out of a standard plug by soldering a small piece of wire around the outer edge of one prong to increase its width. A paper clip will furnish a preformed wire for this purpose. *Remember that the widest prong is the ground connection. Under no circumstances make a power line connection directly to the chassis of the rain alarm* (or any other piece of electronic equipment) *unless a properly connected polarized line plug is employed.* To do otherwise is to invite disaster.

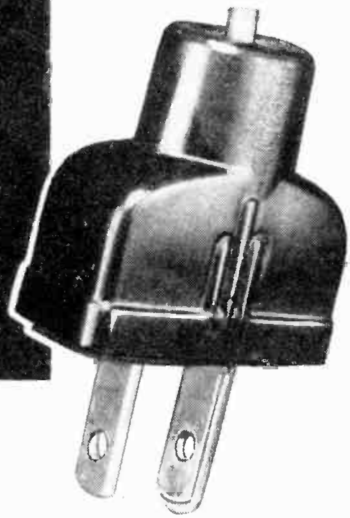
When the wiring is completed and double checked for errors, the tube and the 100 w. lamp bulb can be installed. Turn the lamp switch "off," the power switch "off," and the *sensitivity* control *R3* to its maximum resistance position. Plug the unit into a wall outlet, then throw the power switch "on" and allow a minute or two for warm-up. Listen for the relay to pull in (there'll be a distinct "click"). If the relay doesn't pull in after a reasonable warm-up period, gradually turn *R3* to a lower resistance position. The relay should pull in before the half-way point of control rotation. The point at which the relay pulls in is the "normal" setting for the sensitivity control. Greater or less sensitivity may be obtained by adjusting to either side of this point.

After setting the sensitivity control, check the operation of the control box by connecting a 1 megohm resistor (any wattage value) across its "control" terminals (binding posts *BP1* and *BP2,* Fig. 1). With the resistor in place, the relay should drop out; when the resistor is removed, the relay should pull in again. If the relay drops out, but doesn't pull in again when the resistor is removed, readjust *R3* to a lower resistance setting.

Finally, with the test resistor removed, and *R3* adjusted so that the relay has pulled in, close the switch on the lamp socket (*SO1*). The lamp should remain dark and the buzzer silent. If the lamp lights and the buzzer sounds, connection has been made to the "NO" terminals instead of the "NC" terminals (Fig. 1). Next, check over-all operation by reconnecting the test resistor across the control terminals . . . immediately, the lamp should light and the buzzer should sound.

The Sensor Plate: Two equally good methods may be used for making the sensor plate. The model shown in the photograph was assembled from two pet combs and a small piece of plastic material. In assembling a similar unit, obtain two all-metal pet combs and remove the handles and shafts. Drill and tap two small holes in the back of each comb, then mount the two combs on a piece of Bakelite, fiber, lucite, or similar plastic. The teeth of the two combs should be inter-





(Left) Subchassis viewed from underneath with the majority of components in place. (Below) Plug with wire soldered to one prong, forming a polarized plug.

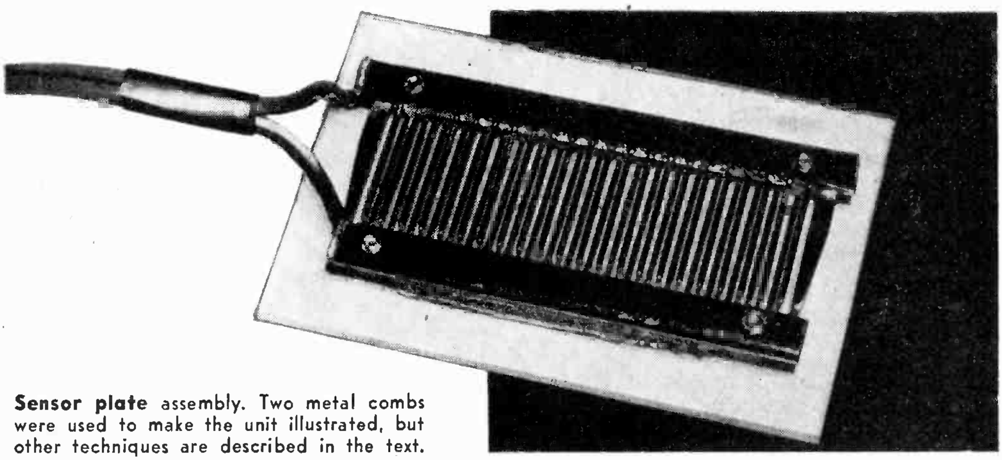
leaved, but not touching. Each comb serves as a separate electrode and is connected to one of the "control" binding posts on the control box. Ordinary twin conductor line cord is satisfactory for connecting the two units together.

A lower cost sensor plate may be made by cementing a piece of aluminum foil to a piece of plastic, then cutting a narrow strip out in such a way that the foil is divided into two electrodes, each of which has a maximum area exposed in close proximity to the other, but without actual contact made at any point.

OPERATION

The 117L7 tube used in the rain alarm is a multi-purpose tube and is equivalent to two separate vacuum tubes in a single envelope. One section is a beam power amplifier, the other section a half-wave rectifier. In the rain alarm, the beam power amplifier section is triode-connected (screen grid connected to plate) and is used as a control tube. The rectifier section supplies a d.c. operating voltage for the control section. *C1* serves as a filter capacitor; no filter choke or filter resistor is needed.

In operation, cathode resistor *R3* together with bleeder resistor *R4* develop a



Sensor plate assembly. Two metal combs were used to make the unit illustrated, but other techniques are described in the text.

high bias voltage that would normally prevent the control tube from drawing sufficient plate current to close the relay *RL1*. This high bias is just balanced out by a positive voltage applied to the grid of the tube by voltage divider network *R1-R2*, however, and sufficient plate current flows to close the relay.

But the voltage divider network is made up of very high resistances, and any external resistance connected across grid resistance *R2* will drop the positive grid voltage sufficiently to allow the cathode bias to reassert its effect, reducing plate current and allowing the relay to drop out. Since the sensor plate is connected directly across *R2*, any moisture on the plate which reduces the resistance between the two electrodes acts effectively like an external resistor shunted across *R2*.

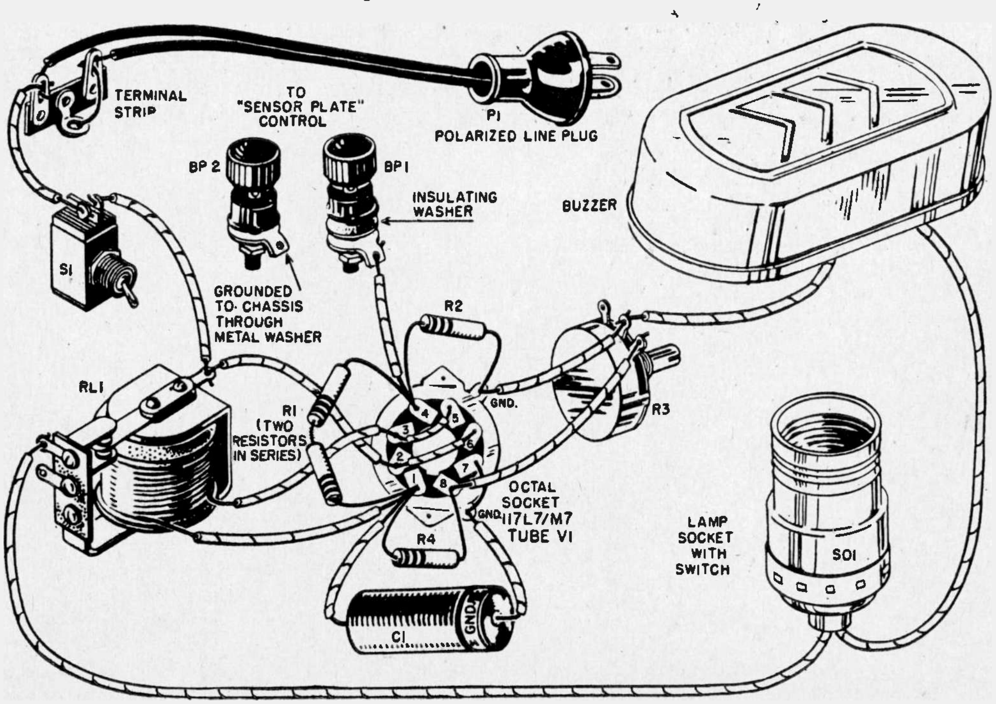
The setting of cathode resistor *R3* determines the initial bias and hence the relative sensitivity of the circuit. Sensitivity is such that a resistance of 10 megohms or less connected across its control terminals will initiate operation of the device.

When the relay drops out, voltage is applied to a series circuit consisting of a 100 w. lamp bulb and a six volt buzzer. Both the lamp and buzzer operate. The lamp actually takes the place of a large wattage resistor and acts to drop the line voltage to the proper value for buzzer operation while, at the same time, providing an "alarm" signal of its own.

Using the Rain Alarm: The control box is generally placed in the home at some location where its buzzer may be heard easily or where its light may be seen. The sensor plate is then placed outside where the first drop of rain is likely to strike it. Ordinary line cord is used for connecting the two units. The length to be used will be determined by the quality of the insulation on the line cord. Since this varies so much with different types of cord, it is best to determine maximum length experimentally.

Circuit Modifications: The basic circuit, as described and shown, is designed both to sound an audible alarm and to light a visual alarm whenever a drop of moisture accumulates on the sensor plate. Some experimenters may wish to make modifications in the basic circuit to meet their own specialized needs. One modification would be to use the relay contacts to supply power to a motor, closing windows instead of sounding an alarm. Another application might be to replace the sensor plate with a pair of prongs mounted in a tank, using the rain alarm as a "floatless" level control. There is virtually no limit to the possible applications of the basic circuit. —30—

Pictorial diagram of the control unit of the rain alarm.



By HARVEY POLLACK

SAFEGUARD YOUR HOME With a Thermistor Fire Alarm

Fire may strike your home next! Build and install this effective system to warn of fire in its earliest stages

A SENSITIVE, quick-acting fire alarm can effectively protect the home-owner against the dangers of unchecked fires that often start around central heating plants, in basements, and in attics. Such an alarm, which can also be used as a high-temperature safeguard in countless other applications, will be described in this article.

By making minor circuit modifications, the alarm may be changed to an aquarium or incubator thermostat, a freezer cutoff alarm, or a control for individual room heaters. Because of its circuit characteristics, it is ideal for remote control installations where the building to be protected against rampaging fire is situated at a relatively great distance from the main house at which the alarm bell is to be located.

Performance

The circuit utilizes a modern heat-sensing element, the *thermistor*. A thermistor is a resistor whose ohmic resistance drops sharply with rising temperature, i.e., it has a high negative temperature coefficient. These interesting units are readily available in many sizes and values ranging from

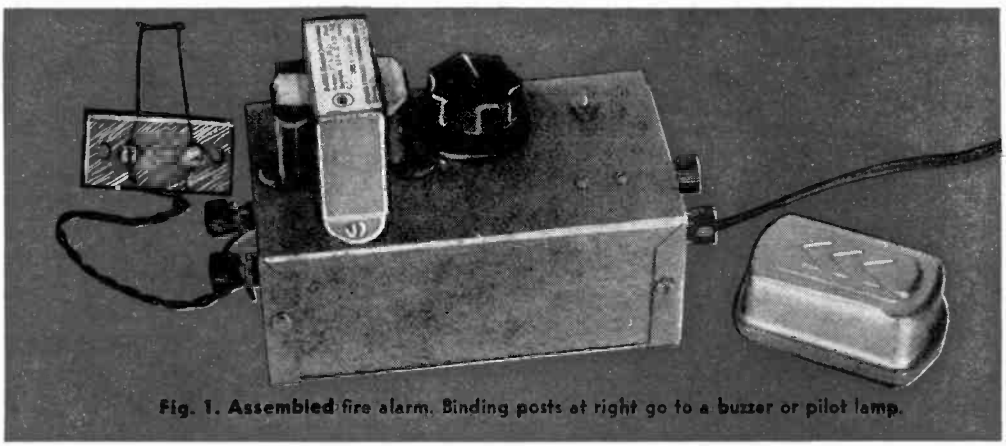


Fig. 1. Assembled fire alarm. Binding posts at right go to a buzzer or pilot lamp.

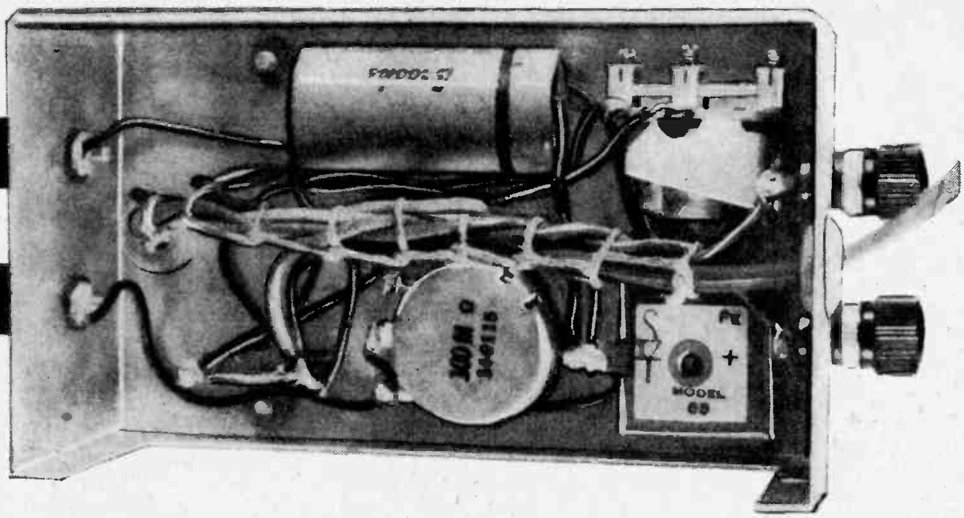


Fig. 2. Under-chassis view of unit shows location of the major components.

about one ohm to hundreds of thousands of ohms. Correctly used, they enable the builder to meet the following performance specifications:

(1) *Low initial cost*—the relative simplicity of the circuit brings the over-all initial cost down to about $11.50.

(2) *Low operating cost*—the choice of a high-resistance thermistor coupled with a low-current sensitive relay permits the circuit to idle continuously with a current drain of something under .002 ampere. At present power rates, this makes the yearly operating cost less than 24 cents.

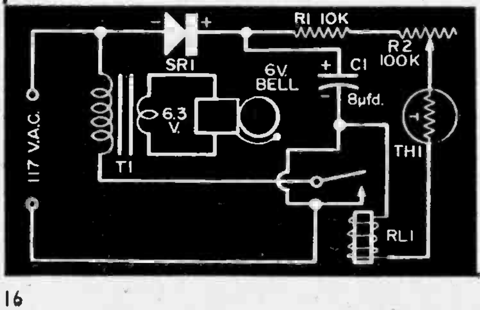
(3) *Reliability*—alarms of this type should be inspected and checked periodically to insure reliability of operation in time of need. Since all circuit components operate at less than half-maximum rating, and because the relay and rectifier are enclosed in a metal case which is as close to being dust-proof as one could desire, dependability is assured even though the test-checks are few and far between.

(4) *Remote control*—to make the device universally applicable, components and design factors were selected to permit the builder to use very long leads—literally thousands of feet, if desired—between the thermistor and the control box. Even the alarm bell may be placed hundreds of feet from the control section should this separation be desirable.

(5) *Adjustable sensitivity*—to satisfy individual requirements, the circuit is arranged so that it can be made to react swiftly to almost any above-normal temperature between 120 and 500° F or higher.

Fig. 3. Schematic diagram and parts list for the thermistor fire alarm.

C1—8-μfd., 450-volt electrolytic capacitor
R1—10,000-ohm, ½-watt resistor
R2—100,000-ohm potentiometer, linear taper (IRC Q-11-128 or equivalent)
RL1—Sensitive relay, 10,000-ohm coil, pull-in rating 1 to 2 ma. (Advance SO-1C-10,000D, Sigma 2F, or equivalent)
SR1—65-ma. selenium rectifier (see text)
T1—Filament transformer, 6.3 volt @ 1.2 amp. (Stancor P-6134 or equivalent)
TH1—Thermistor, VECO Type 51R2 (Victory Engineering Corporation, Springfield Rd., Union, N. J.—a kit of thermistors and varistors, available from the company for $10.00 by mail, contains this thermistor)
1—Line cord and plug
1—Standard doorbell or buzzer
1—Case, aluminum, gray hammertone finish, 5¼" x 3½" x 2⅛"
4—Insulated binding posts
1—2-lug tie point
1—Potentiometer knob, any type
Misc. grommets, machine screws, wire, solder, etc.



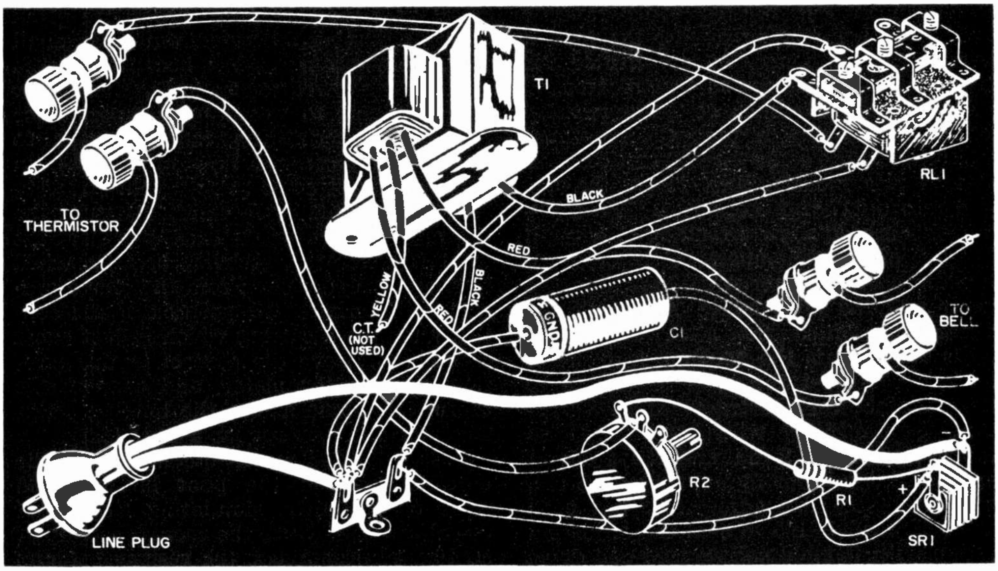


Fig. 4. Pictorial diagram of the alarm.

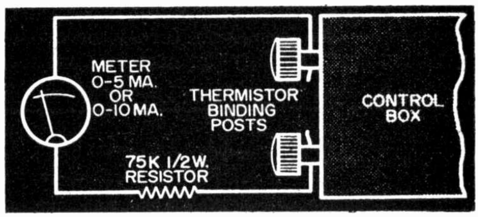


Fig. 5. Hookup for initial adjustments.

(6) *Latch-in feature*—once the fire alarm is triggered, the alarm bell continues to ring even though the heat around the thermistor sensing element temporarily subsides. This action is accomplished automatically by adjusting the relay properly, as will be described later.

(7) *No BX cable or conduit required*—low-voltage wires may be run between the bell and central control.

Construction

Whether the reader duplicates the alarm system exactly or makes modifications to suit his tastes, just a few preliminary constructional precautions are desirable. The rectifier (*SR1*, Fig. 3) should be rated at 35 ma. at the least, even though the total current drain is less than 2 ma.; this makes for cool operation over extended periods of time. Filter capacitor *C1*, an 8-μfd. unit, should have a working voltage rating of 450 volts although the total anticipated potential across it never exceeds 150 volts; long capacitor life may be expected under these conditions. The transformer *T1* may be mounted either inside or outside.

Terminals for the thermistor are isolated from the line by the 10,000-ohm resistance of the relay and by a protective 10,000-ohm resistor *R1*. An even better arrangement would be to use an isolating transformer, such as the Triad R54X. This unit has a 115-volt secondary for operating the thermistor and relay circuit, thus completely isolating it from the line. Also included is a 6.3-volt winding for operating the alarm bell. With such an arrangement, the relay contacts would be connected in series with the 6.3-volt winding and the alarm bell.

The binding posts are insulated from the case by means of shoulder or extruded fiber washers. Holes drilled to take these washers must be large enough to allow the extrusion to "sit" inside the rim of the opening, thus preventing the metal screw of the post from touching the case. Live rubber grommets are necessary for the feedthrough leads to protect the latter against fraying over the years.

Testing and Adjustment

All wiring should be completed before proceeding with adjustment and testing. A.c. power should not be applied until it is determined, by means of an ohmmeter, that no bare wires are in contact with the case and that there are no short circuits which might injure the selenium rectifier, the thermistor, or the relay. An ohmmeter is mentioned because it is usually a part of a multitest meter which is needed for current measurements.

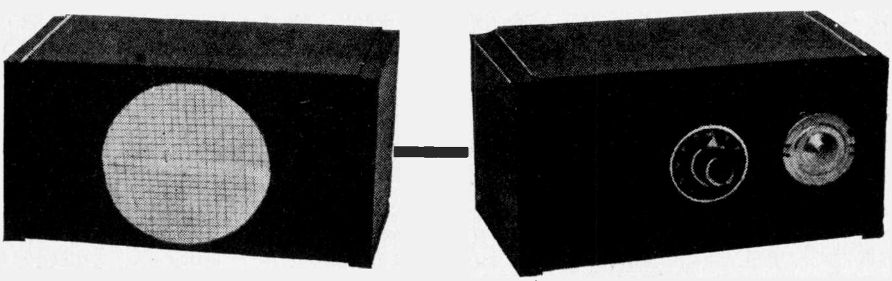
For the following test, do not connect the thermistor into the circuit at all. Instead, connect the multitester as a low-range milliammeter (0-10 ma. range is just about right) in series with a 75,000-ohm resistor across the thermistor binding posts as shown in Fig. 5. To avoid raucous buzzing or bell-ringing during the test, a 6-volt pilot lamp may be substituted for the alarm signal device as an indicator.

First rotate the knob of the *sensitivity* control *R2* so that it presents maximum resistance to the series circuit (fully clockwise in this model), then insert the a.c. plug into a 117-volt a.c. outlet. The milliammeter should show a reading of a small fraction of a milliampere. Gradually rotate the potentiometer while watching the meter and the pilot indicator, noting the current at which the pilot lamp first lights up. This is the "pull-in" current of the relay. Adjust the relay according to the manufacturer's instructions (these accompany the relay when purchased) so that it pulls in at 2 ma. and drops out at an appreciably lower figure, such as .8 ma. to 1 ma. Once this adjustment has been made, it is advisable to seal the adjusting screws with flexible polystyrene coil dope.

Again rotate *R2* to maximum resistance and replace the 75,000-ohm resistor with the thermistor, leaving the meter connected. Repeat the "creep-up" procedure given above, adjusting the potentiometer in small steps. This is necessary because, as the current is allowed to rise in the thermistor and it begins to warm up, its resistance diminishes, permitting more current to flow. The increased flow of current, in turn, warms it some more, again reducing resistance. This cycle continues until the thermistor radiates its heat away as fast as it is generated, stability being reached in about ten seconds. From the above procedure, determine the position of the control knob for a setting which is just short of pull-in. Leave the control in this position, remove the meter, and connect the thermistor alone across the binding posts. The alarm is now set for a heat test.

Pass a lighted match quickly under the thermistor body; the pilot lamp should come on instantly, simulating ringing of the alarm bell. Once the correct setting of *R2* has been obtained, the response should be instantaneous when the ambient temperature around the sensing element exceeds 120-150° F. —30—

Electronic Baby Sitter



By **BYRON G. WELLS**

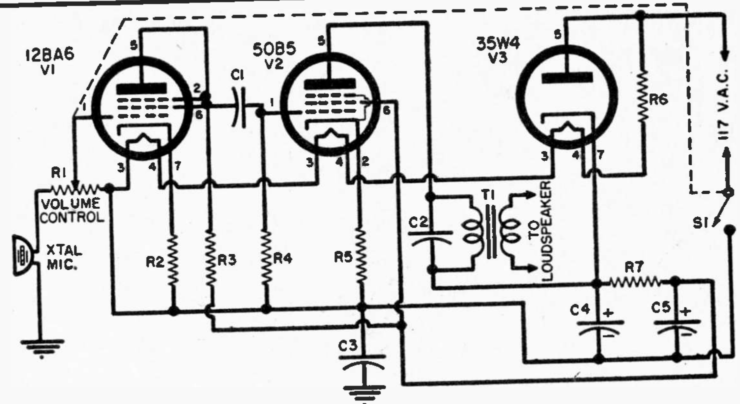
Listen to the baby from another room—or another house—with this sound amplifier

THIS versatile unit is easy to build and low in cost, and the results obtained from it are most gratifying. It is contained in two boxes, one housing a microphone and an amplifier, the other the loudspeaker. The two boxes are connected by means of television twin-lead, which can be of any length up to 150 feet. You can place the unit with the microphone in any convenient place in the baby's room and the loudspeaker box in another room of the house where the parents are likely to be—the bedroom, living room, etc. It has been used even between adjacent houses or apartments with good results, permitting neighbors to baby-sit for each other without having to leave their own homes or apartments.

The schematic shows that the circuit is equivalent to the final two stages and rectifier of a small a.c.-d.c. broadcast receiver, with a resistor in the filament circuit to produce a voltage drop equal to that of the filaments of the two additional tubes which normally appear in such a receiver.

The placement of parts is not at all critical. The microphone and volume con-

Schematic diagram of the Electronic Baby Sitter. Follow this and the pictorial wiring diagram below in wiring your unit. Notice that chassis ground is not connected to either side of the power line.

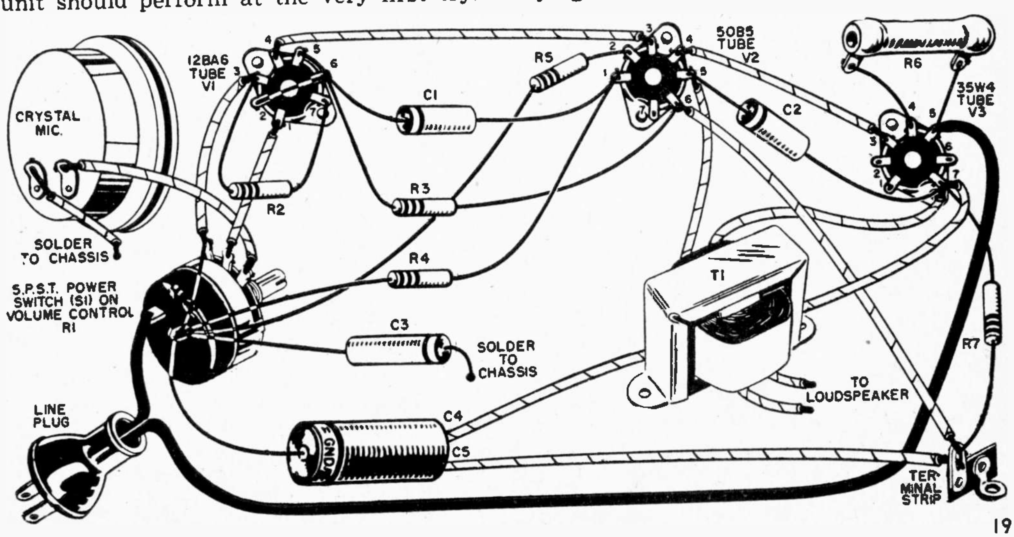


R1—1 megohm audio taper pot. with switch, S1 ("Volume Control")
R2—1000 ohm, ½ w. res.
R3—50,000 ohm, ½ w. res.
R4—250,000 ohm, ½ w. res.
R5—150 ohm, 1 w. res.
R6—150 ohm, 10 w. wirewound res.
R7—10,000 ohm, 1 w. res.
C1—.01 μfd., 400 v. capacitor
C2—.02 μfd., 400 v. capacitor
C3—.1 μfd., 400 v. capacitor
C4-C5—20/20 μfd., 150 v. two-section elec. capacitor
S1—S.p.s.t. "Power" switch (on R1)
T1—Audio output trans. to match 10,000 ohms to speaker voice coil (A universal output trans. such as the Stancor A-3856 may be used.)
V1—12BA6 tube
V2—50B5 tube
V3—35W4 tube
Xtal Mic.—High output or hearing-aid type crystal microphone
Loudspeaker—Small PM loudspeaker
Cabinet; chassis; terminal strip; line cord and plug; knob for volume control; screws, etc.

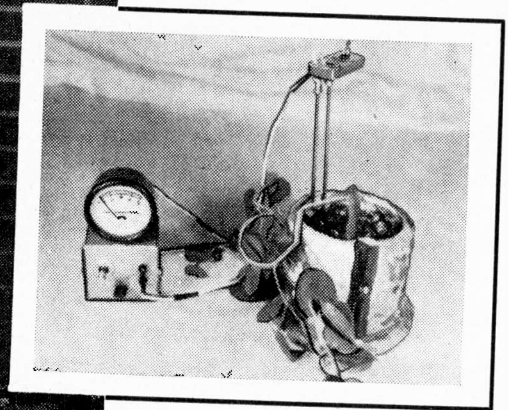
trol are mounted on the front of the cabinet and the other parts on a metal chassis. Before finally mounting the parts, position them tentatively on the chassis. Work out an arrangement in which as many as possible of the wires between parts are short and direct, but space the components far enough apart so that you will not be cramped when doing the actual wiring.

In doing the wiring, follow the schematic and pictorial wiring diagrams carefully, solder all wires properly, and make sure that no short circuits are caused by bare wire or excess solder. If this is done, the unit should perform at the very first try.

With the unit plugged-in in the baby's room and the loudspeaker box in another room, the volume can be regulated to a comfortable level. The sensitivity is so great that, with the microphone fifteen feet from the baby's crib, you can hear every breath the baby takes. While this is novel and makes a good demonstration of the unit, it also can be annoying, as background noise, such as window shades and venetian blinds rattling, also is amplified. It is best to adjust the volume so that no noise comes through until a higher level of sound is reached, such as the baby crying. —30—



Inserting one of the probes for the watering control into place on lawn.



The moisturemeter is shown here being used to check the condition of the soil in a potted plant. It can also be used to check moisture in a lawn or garden soil, after calibration.

Electronic Gadgets for the Gardener

Give electronics the task of controlling your sprinkler and indicating when your house plants need watering

DID YOU EVER DREAM that the science of electronics might be of help to you in your gardening activities? Probably not—it seems like a rather far-fetched, imaginative, futuristic dream even to consider such a possibility.

But it is not far-fetched—in fact, you can build electronic equipment right now which will aid you tremendously in both inside and outside gardening activities. The first device to be described will actually take over the problem of watering the lawn or garden and perform such watering automatically—keeping the moisture level of the soil at the desired point.

And the second device will permit you to determine, quickly and easily, whether watering is necessary—either outdoors or in your "window garden." This device uses an ordinary meter, a single transistor, and a small battery.

Before going into the actual construction details on these two devices, we should perhaps dwell a little on the basic principles by means of which both devices operate.

Dry earth is a very poor conductor of electricity. In fact, it might be called a fairly good insulator. However, when earth is moistened, the story is different. Its conductivity increases greatly until, with certain types of soil and extremely moist conditions, it can be called a good conductor. In between these extremes, the resistance varies over wide limits.

If we could contrive some method of measuring the soil resistance when we know moisture conditions are optimum, we would have a characteristic which we could use to control external equipment, such as a sprinkling system, or which would give an indication of moisture conditions on a meter. A method for doing each of these is covered in this article. Neither device is complicated, and a detailed knowledge of electronics is not necessary to understand the operation of either. And a lot of construction experience is not required.

So, head for your workbench, get out the soldering iron (a low-wattage one for transistor circuits, please), and build yourself either or both of these gadgets.

WATERING CONTROL

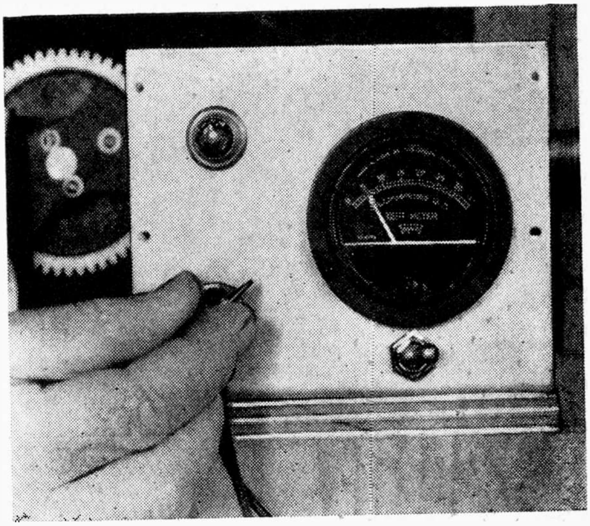
By Walter B. Ford

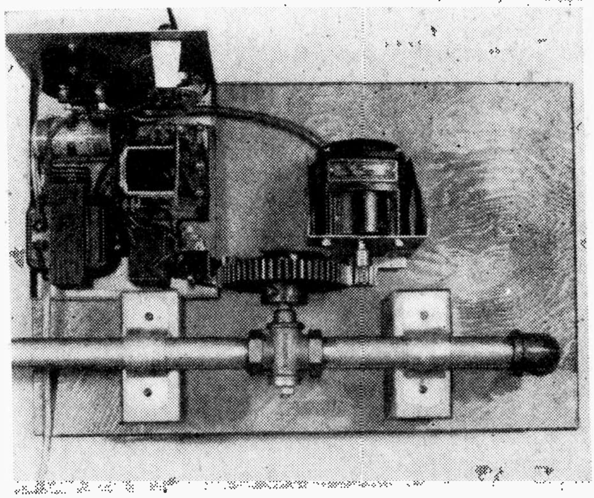
If you are tired of the drudgery of watering your lawn or garden, relax and let this gadget take over. It is highly reliable, constantly on the alert, and will keep the moisture content "just right."

As mentioned previously, this device operates on the principle that the resistivity of the soil changes with varying moisture conditions. We insert two electrodes in the ground at opposite ends of the garden and impress a small d.c. voltage across them, in series with a relay. When there is plenty of moisture present, enough current will flow to keep the relay closed and thus prevent the sprinkler system from operating. Once the ground has dried out, though, the current will drop, the relay will open, and the sprinkler system will start. When sufficient moisture has been soaked up by the ground, the sprinkler will shut itself off.

Basically the system consists of a 24-volt d.c. supply in series with the coil of a sensitive relay, a milliammeter and an adjusting potentiometer. The 24-volt supply is produced by a door-chime transformer and selenium rectifier. When sufficient current flows, the relay is closed and the switching circuit is such that a motor drives the water valve to the "off" position. When the current drops, due to the soil drying out, the relay falls open. This starts the motor, and it continues to run until the water valve is in the "on" position.

Construction of this device is fairly evident from the photographs and pictorial diagram. All components except the motor and valve are mounted inside a suitable box, either aluminum or steel. Exact size is not important—just be sure that it is big enough to hold all the components.



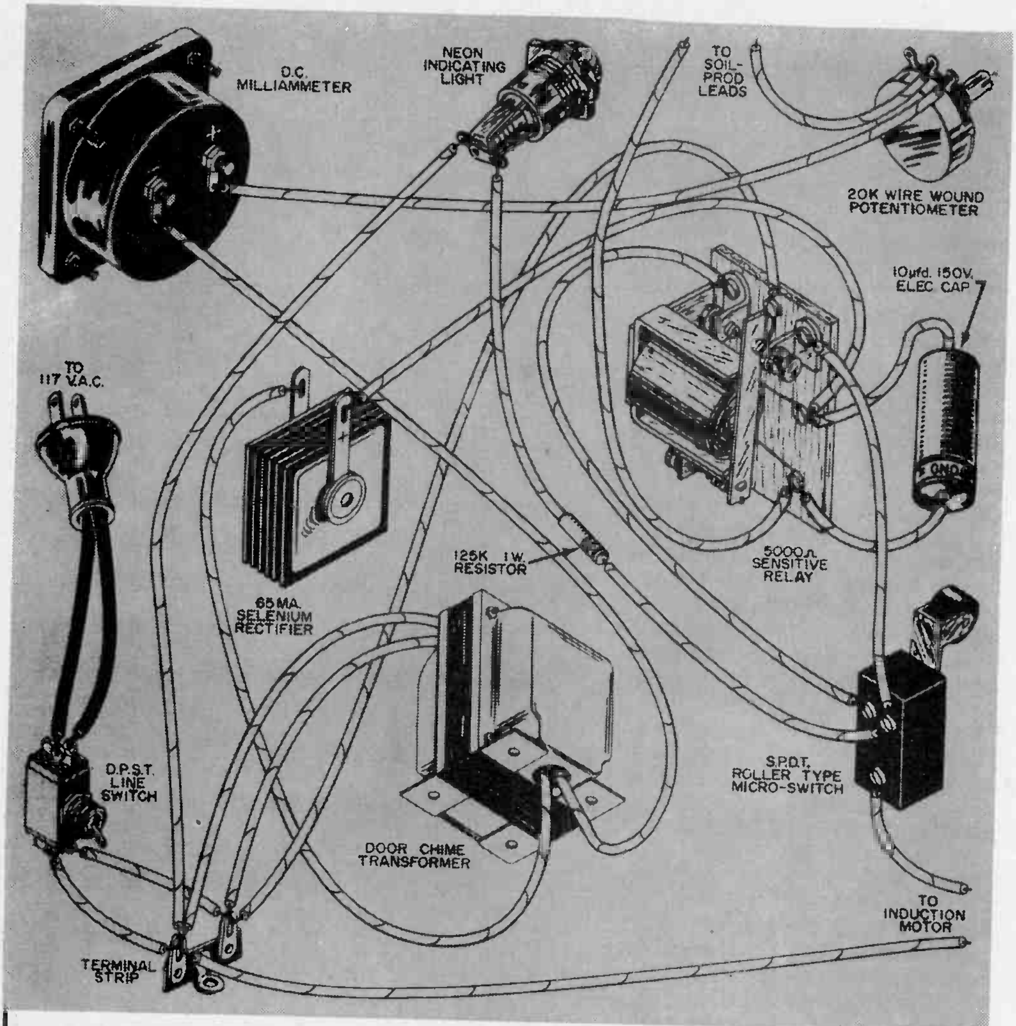


Top, front view of control unit showing the potentiometer being adjusted. Neon indicating lamp is at upper left, "on-off" switch is just below meter. At the extreme left can be seen the large gear with the fiber cam in place. Bottom, interior view shows placement of parts inside cabinet and indicates how motor, gears, and valve are mounted. The pipe and valve are supported on wood blocks of the proper thickness, and are securely held by pipe clamps. The edge of the fiber cam may be seen immediately above the large gear, and the Microswitch and roller just to the left. Mount the fiber cam securely to the large gear with screws, as shown.

The roller-type microswitch is actuated by a fiber cam mounted on the gear driving the water valve. This cam is shaped so that the switch alternates between two positions for each ¼-revolution, since ¼-revolution of the valve is required to turn from "off" to "on" and vice versa. The gear ratio between the motor and valve is not critical—use whatever you can obtain. But be sure that the motor and valve are secure.

Make each prod out of a piece of brass rod about 8" long and 3/16" dia., with a half-inch wood dowel on one end for a handle. Sharpen the other end so it will push into the ground easily and solder on a piece of flexible wire for a lead. Two of these prods are necessary.

Adjustment is made by means of the potentiometer once the unit has been assembled. Select a time when the area to be monitored needs watering, and insert the two prods in the soil at opposite ends of the



1—Small induction motor, such as Holtzer-Cabot, Model RWC-2505, 2 rpm synchronous, available from National Pneumatic Co., Holtzer-Cabot Div., 125 Amory St., Boston 19, Mass.
1—Sensitive s.p.d.t. relay, 5000-ohm coil (any value between 4000 and 10,000 ohms should work)
1—Door chime transformer, 24 v. sec.
1—Selenium rectifier, 65 ma.
1—Milliammeter, 0-35 ma. (see text)
1—20,000-ohm wire-wound potentiometer
1—10-µfd., 150 v. elec. capacitor
1—Microswitch, roller arm type, s.p.d.t., available at Herbach & Rademan or Allied Radio Corp.
1—¼ watt neon bulb, socket, and bezel
1—125,000-ohm, 1-watt resistor
1—Set of gears (see text)
1—"Service cock" water valve with head turned to fit large gear
1—Fiber cam mounted on lárge gear (see text)
1—Metal cabinet (see text)
Misc. wire, solder, etc.

Pictorial diagram and parts list for the automatic sprinkler control system.

garden. Insert them to the desired watering depth probably 3" to 5". With the water valve in the "off" position, rotate the gear wheel with the fiber cam attached so that the cam just releases the microswitch arm; then secure the gear wheel to the valve head and turn the control unit on. The motor should turn the valve to the "on" position where the motor will stop. When the area being monitored has received sufficient moisture, adjust the potentiometer so that the relay closes. No further adjustments should be necessary. You may omit the meter if you wish—it is merely a convenience in making adjustments.

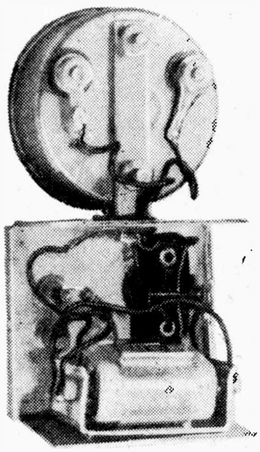
The author has operated this system successfully with the electrodes spaced as far as 100 feet apart. Pull-in current was 4 ma. and drop-out current 1½ ma. for the particular relay used. These values may be varied somewhat by adjusting the tension on the armature spring.

TRANSISTORIZED MOISTUREMETER

By Joseph Chernof

If you just want an indication of the amount of moisture present in the soil, and are not concerned with any control functions, this gadget will serve nicely. It will also give you experience in working with transistors in non-critical circuits.

Essentially, this device measures the current flowing between two electrodes—or probes—inserted in the soil, and thus



Rear view of moisturemeter with cover removed. Construction is extremely simple and should only take a short time. Be sure that you have the battery polarity correct and that the transistor is connected in circuit properly.

gives an indication of soil resistance. With a little experience, you can tell very closely the condition of any type of soil, whether in the garden or in a flower pot in the house. If the indication is that the soil is too dry, it's time to water!

A 15-volt battery impresses a voltage across the probes in series with a resistor and the base-emitter circuit of the transistor. This 15-volt potential causes a current to flow through the soil, the exact value of which depends on moisture conditions. The current, which in general will be rather small, is amplified in the transistor and is read on the meter in the collector circuit.

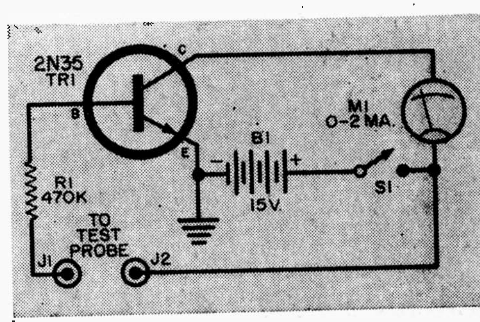
Construction of the probe can be determined from the photograph on page 20. Two 10″ lengths of ⅛″ brass welding rod are mounted 1″ apart on a piece of Plexiglas. This spacing is not at all critical, but is a convenient value to use. Mounting is accomplished by soldering each rod to a standard terminal lug, and then bolting to the Plexiglas. File the opposite end of each rod to a sharp point to facilitate penetration in the soil. The lead-in wires from the probe can be any convenient length, and terminate in standard phone tips which mate with the tip jacks on the front panel.

Mount all components except the meter and transistor socket inside the metal cabinet. Bend an L-shaped bracket, as shown in the photo, to mount the meter above the cabinet. This type of mounting is employed to permit changing transistors easily for experimental purposes, and to allow the meter to be used for other purposes.

The parts placement is not at all critical, and the author's layout does not need to be followed exactly. No heat is generated within the enclosure, so ventilation is no problem.

Resistor *R1* should be selected experimentally, but the value will probably be somewhere in the neighborhood of the value specified. Short-circuit the probes and note if a full-scale reading (2 ma.) is obtained. If not, adjust *R1* accordingly. *R1* will probably have to be changed if a different transistor is employed. Any high-gain transistor may be used, but if you try a *p-n-p* type, be sure to reverse battery connections before turning the switch on!

Exact calibration instructions are difficult, since basic soil resistivity varies widely with the type of soil. As a guide, however, the author found that in his locality a reading of 1 ma. indicated adequate soil



B1—15-volt miniature battery (Eveready #411 or equivalent)
J1, J2—Miniature nylon tip jacks
M1—0-2 ma. meter (Sterling #835 or equiv.)
R1—470,000 ohm, ½-w. resistor (see text)
S1—S.p.s.t. toggle switch
TR1—Type 2N35 n-p-n transistor (see text)
1—Battery holder (Austincraft #411 or equivalet, or homemade holder)
1—Transistor socket
1—Chassis, 2″x1¾″x1¾″ (LMB No. MOO or equivalent)
Misc. wire, solder, etc.

Schematic and parts list of moisturemeter.

moisture, while a lower value meant that liberal sprinkling or watering was in order. You will have to experiment with the soil in your locality and be guided by indications of moisture content such as feeling and appearance. Once you have played around with this gadget for a while, though, you can give an immediate answer—"to sprinkle or not to sprinkle." —30—

Shoot to Kill TV Commercials

By LOUIS E. GARNER, JR.

Add this transistorized photocell relay to your TV set to allow switching the sound on and off at will with the aid of a flashlight

IN THE EARLY DAYS of television, when it was still pretty much of a novelty, viewers would watch every bit of each program with avid interest. But today viewers are more discriminating—they pick and choose. One thing most viewers like to discriminate against is the numerous *sponsors' messages* or "commercials."

Some TV commercials are just as interesting as the program material. But, unfortunately, not all sponsors make a real effort to present a truly interesting sales pitch. It's easy enough to avoid *looking* at a boring commercial, but the sound is difficult to eliminate without leaving one's easy chair.

Add the simple gadget shown in the photographs to any TV receiver and, without leaving the easy chair, the viewer can "shoot" a beam of light at the set and effectively "kill" a pitchman's spiel before it starts. The "Commercial Killer" is also useful for silencing the receiver while talking on the telephone, answering the door, or doing any of a dozen other tasks that can be done better in silence. And once the commercial is over, sound can be restored by casually "shooting" another beam of light at the set. Operation is fully automatic, once triggered by the light beam—there's no need to hold the light beam on continuously either to kill or restore the sound.

The "Commercial Killer" is a self-contained instrument and, in most cases, may be installed by simply attaching two leads between it and the TV receiver. Since the unit has its own built-in power supply (a single long-life battery), it can be placed anywhere in the room; it need not be located near a wall outlet, and there's no extra line cord to add clutter to the room.

Operation

This unit consists of two self-generating selenium photocells, *SP1* and *SP2* (see Fig. 1), followed by a two-stage transistor d.c. amplifier which, in turn, operates a relay (*RL1*). Power is supplied by a single 6-volt battery. The simple design of the instrument is based on the similar—but opposite—characteristics of *p-n-p* and *n-p-n* junction transistors. Corresponding electrode currents flow in opposite directions in the two types of transistors, permitting direct coupling between stages.

In operation, a small base bias current flows through the 2N34 *p-n-p* transistor. This current is established by the adjustment of sensitivity control *R1* and fixed series resistor *R2*. The fixed resistor is included simply to limit the maximum bias current that can flow, and thus to protect the transistors from accidental overload. The collector current of the 2N34 transistor is several times larger than the base current, due to the amplification of the stage; and this current is also the base current for the 2N35 *n-p-n* transistor. Additional amplification is obtained in the second stage, with the result that the collector current of the 2N35 transistor may be 100 times greater than the initial base bias current. The highly amplified current flows through the relay and controls its operation.

Under normal operating conditions, and with *R1* properly adjusted, sufficient collector current flows through the relay to hold it closed, but not to close it (more current is required to close a relay than to hold it closed).

When light is applied to selenium photocell *SPI*, a small voltage is developed which, applied to the base-emitter circuit of the 2N34 transistor, increases the bias current slightly. This increase in bias current, amplified by two stages of direct-coupled amplification, is sufficient to close the relay. The maximum relay current is slightly over 1.0 milliampere. The relay, once closed by the small increase in current through its coil, stays closed due to the steady current established by the initial bias, even though the light is removed from photocell *SP1*.

If light is applied to photocell *SP2*, the resulting voltage is such as to *oppose* the steady bias current. Note that the *SP2* photocell is connected with opposite polarity to the 2N34 transistor. This causes a drop in the output collector current which is sufficient to allow the relay to drop out or open. Once opened, the relay stays open even though the light is removed from photocell *SP2*.

Thus, by using a fixed bias and by connecting two self-generating photocells with opposite polarity to the input of a direct-coupled transistor amplifier, it is possible to obtain a "self-latching" relay action. The relay will stay either open or closed, depending on which photocell is excited last. This action is dependent on the adjustment of sensitivity control *R1*. If too little resistance is used, the initial bias current may be sufficient to close the relay and to hold it closed at all times. If too great a resistance is used, the bias current may not be sufficient to hold the relay closed.

The complete schematic wiring diagram for the "Commercial Killer" is given in Fig. 1. The control box circuit should be mounted using the chassis layout shown in Fig. 2. The subchassis may be of aluminum, steel, brass, or plastic, as preferred by the individual builder.

Two 5-pin subminiature "in-line" tube sockets are mounted on the subchassis, but the use of these sockets is optional—the transistors may be permanently wired into position if preferred. If the tube sockets are used, however, mount them by cutting small rectangular holes in the subchassis which are slightly smaller than the tube socket bodies. The tube sockets are then forced into place with a few drops of general purpose cement (such as *Duco* or *General Cement* No. 45-2 cement) added for additional security.

Assembling Photocell Arm

In operation, a light beam striking one photocell turns the sound off; when the beam strikes the other photocell, the sound is turned back on. Since most inexpensive flashlights do not furnish a really sharp focused beam, the two photocells are mounted at opposite ends of a control arm. Thus, it is possible to aim the light beam at

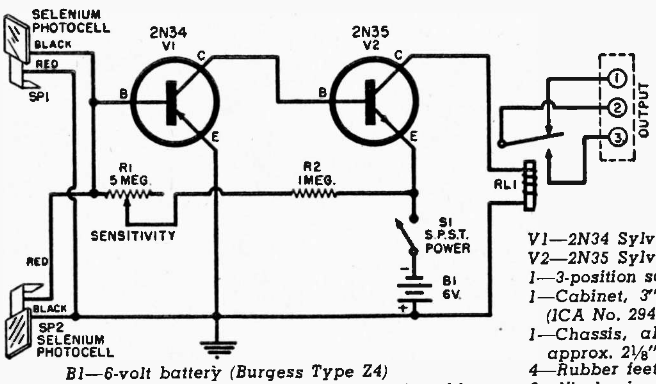


Fig. 1. Schematic diagram and parts list for control unit. Light shining on SP1 closes relay RL1; light shining on SP2 opens relay.

B1—6-volt battery (Burgess Type Z4)
R1—5-megohm carbon potentiometer (sensitivity)
R2—1 megohm, ½-watt carbon resistor
RL1—Sensitive relay, s.p.d.t. contacts, 5500-ohm coil (Advance No. SV/1C)
S1—S.p.s.t. slide switch
SP1, SP2—Selenium photocell (International Rectifier No. B2M)
V1—2N34 Sylvania p-n-p junction transistor
V2—2N35 Sylvania n-p-n junction transistor
1—3-position screw-type terminal strip
1—Cabinet, 3" x 2⅛" x 5¼" aluminum box (ICA No. 29441)
1—Chassis, aluminum, brass or steel sheet, approx. 2⅛" x 2⅜"
4—Rubber feet
2—1" aluminum caps
2—5-pin subminiature tube sockets
1—10½" length, 1" O.D. Reynolds aluminum tubing
1—8¼" x ⅞" diameter wooden dowel
1—Small knob
1—Small, sharply focused flashlight (accessory)
Misc. machine screws, nuts, wire, solder, etc.

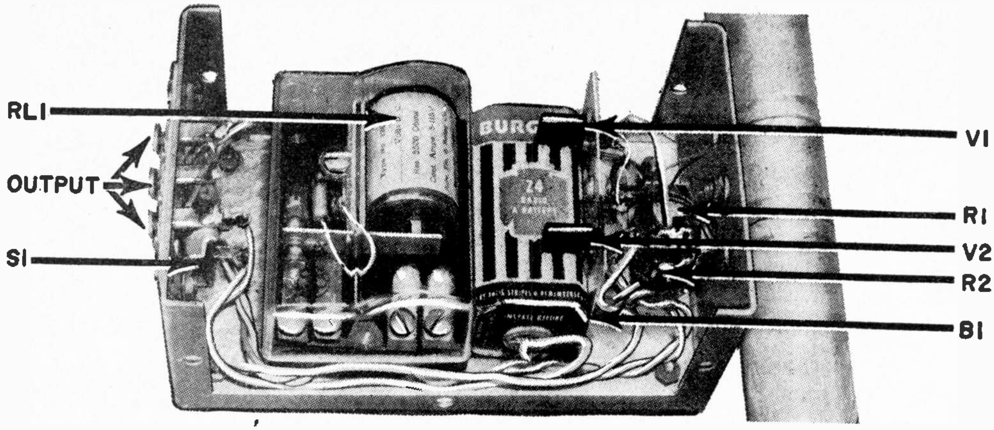


Fig. 2. Interior view of main chassis shows location of parts.

the desired photocell without affecting the opposite cell. Construction details for half of the control arm are given in Fig. 3—the other side of the arm is identical.

The selenium photocells (*SP1* and *SP2*) are mounted with small wood screws at opposite ends of an 8¼"-long wooden dowel. A plastic rod may be substituted for the wooden dowel if desired, but a metal support should not be used since the photocells are connected internally to their mounting brackets. Mounting both on a metal support will short them and prevent proper operation.

A groove is chiseled or whittled in the wooden dowel and the photocell lead wires run through it. "Scotch" electrical tape is used to hold the lead wires in position.

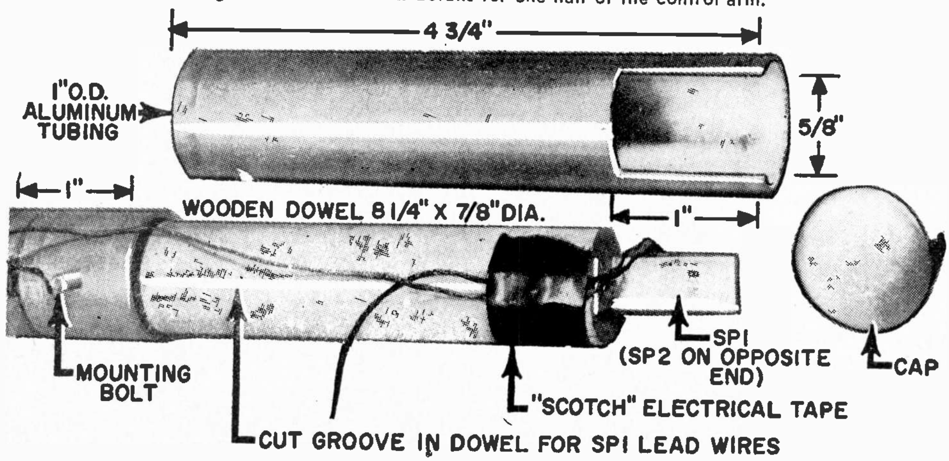
The completed assembly is covered by lengths of aluminum tubing, with holes cut out at each end to permit light to strike the photocells. Plastic, cardboard, or fiber tubing may be substituted for the aluminum if desired, for its only purpose is to protect the cells and to provide a "finished" appearance.

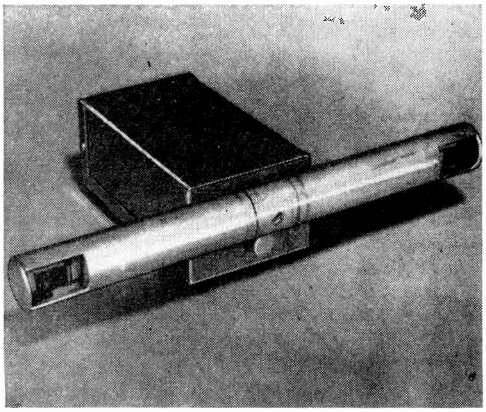
Use of a two-stage direct-coupled transistor amplifier provides considerable sensitivity and eliminates the need for a lens to focus light on the photocells. If a lens were used, the sensitivity could be increased still further, but only at the expense of a limited range of operation. With a lens, the light would have to come from almost directly in front of the unit to obtain proper operation. Without a lens, satisfactory operation can be obtained with light coming from a wide angle.

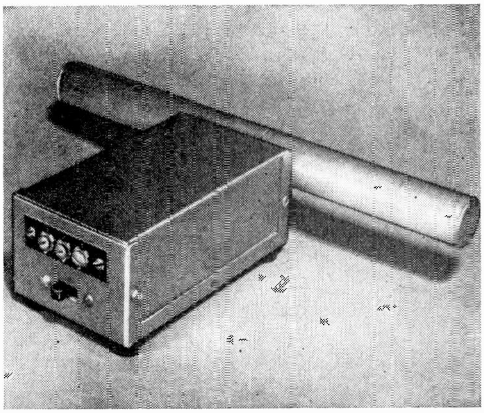
With the control box and control arm assembled, the two units may be mounted and connected together. A single long machine screw and nut may be used for mounting the control arm on the control box.

Lead dress is not at all critical, but a few general precautions should be followed

Fig. 3. Construction details for one-half of the control arm.



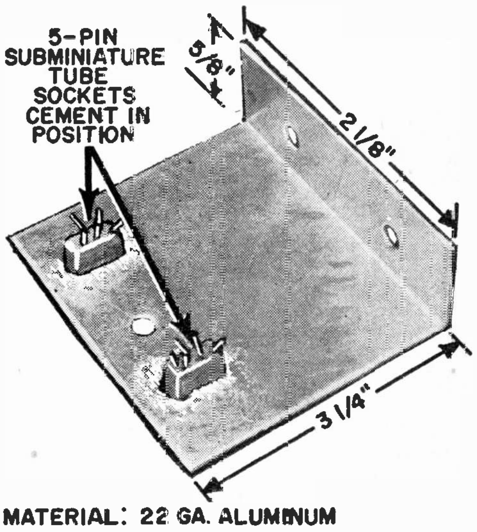




Front view (left) and rear view (right) of complete assembly.

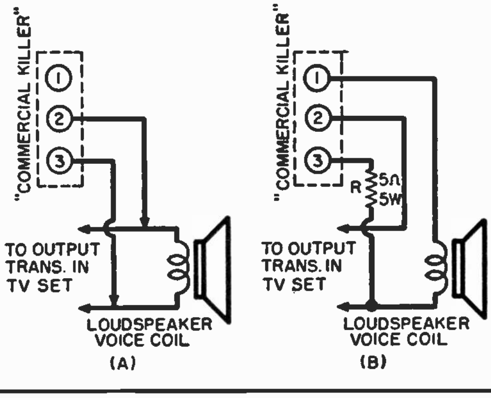
to avoid damaging the components. Pay particular attention to the transistor connections—note that two different types of transistors are used in the circuit. Interchanging the transistors or connections can lead to serious damage. Identify the transistor sockets in some way. Mark the 2N35 (*n-p-n* transistor) socket with a dab of red fingernail polish.

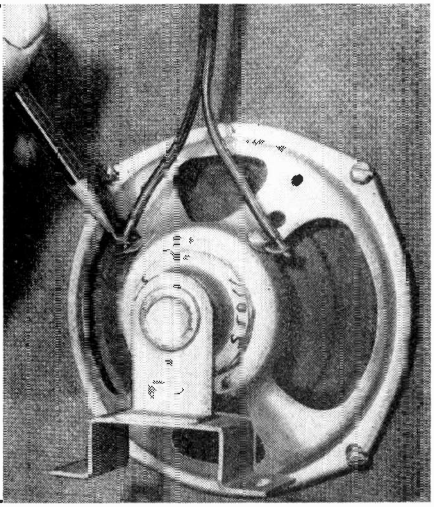
When the wiring is completed and double-checked for errors, install the transistors in their proper sockets and turn the power switch (*S1*) on. Adjust sensitivity control *R1*. With the control turned to maximum resistance, the relay should be open; with it turned to minimum resistance, the relay should be closed. The point of proper operation is where the relay is just ready to close. If it is impossible to open and close the relay by turning *R1* to its limits of rotation, a defective part or an error in wiring is indicated—turn off the power immediately and double-check for errors!

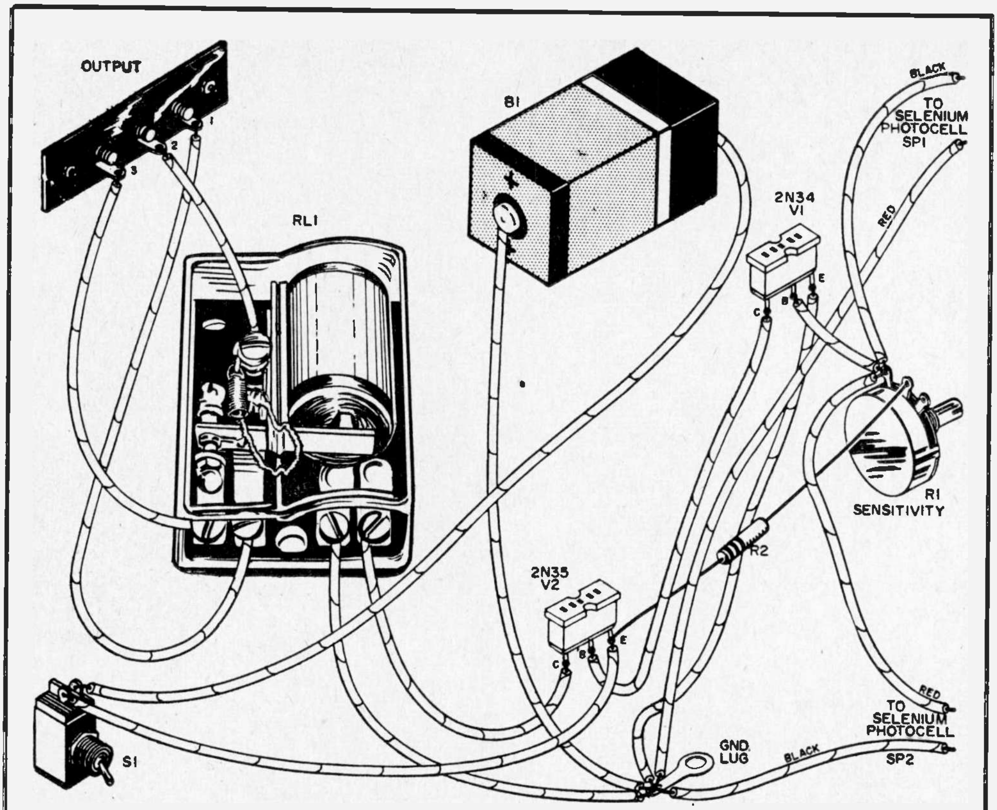


Details of subchassis construction.

Fig. 4. Two methods for connecting the speaker to the "Commercial Killer." Photo at right shows leads connected to speaker.







Pictorial diagram showing how the various components are interconnected.

Installation and Adjustment

With the wiring completed and the "Commercial Killer's" operation checked out, the top cover may be installed and the unit connected to the TV receiver. Connections are made to the loudspeaker's voice coil, using a short length of ordinary lamp cord. Two different connection methods may be used, and both are illustrated in Fig. 4.

The connection method shown in Fig. 4(A) is the simplest and is satisfactory for the majority of installations. Leads from the unit are merely connected in parallel with the voice coil terminals. When the relay closes, the voice coil is simply shorted out. This will usually "kill" the sound; but if the connection lead is long, its impedance may approach the low impedance of the loudspeaker voice coil, with the result that an imperfect "short" occurs and the sound is simply reduced in volume—without being "killed" completely.

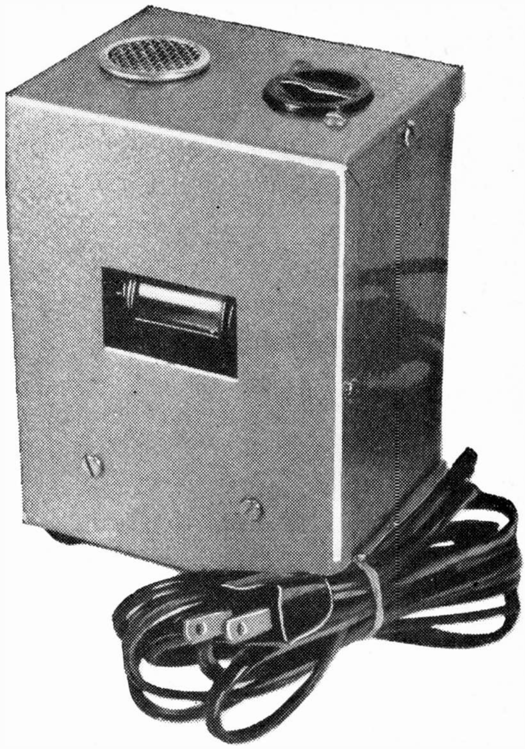
A somewhat better installation method is shown in Fig. 4(B), but it requires one additional component (a small wire-wound resistor), three leads, and a little more work. One of the leads from the loudspeaker's voice coil to the output transformer is opened, then connected to the relay terminals of the "Commercial Killer." With this connection method, the audio output signal is fed either to a resistive load or to the loudspeaker.

Once the speaker connections have been made, the unit may be adjusted for proper operation. Place the unit either on top of the television receiver or on the floor beneath it.

With both the TV receiver and the "Commercial Killer" turned on and a TV program tuned in, use a flashlight to strike each photocell, in turn, with a beam of light. Illuminating one photocell should "kill" the sound; illuminating the other should restore sound. If the relay does not hold either on or off when the light beam is removed, readjust the sensitivity control until the desired operation is obtained. Once set, the sensitivity control usually can be left fixed in position unless the light level changes considerably, or until the battery weakens.

The design of the "Commercial Killer" is such that, once adjusted, it is more or less "self-balancing" with changes in room lighting conditions. —30—

An Automatic Light Switch for the Home



It will switch lights on at night, and off in the morning—it can be used for other purposes also.

By LOUIS E. GARNER JR.

YOU won't have to worry about coming home to a dark house at night if you build an automatic light switch like the one described here. When a table or floor lamp is plugged into its receptacle, it will automatically turn the lamp on at night and off during the day.

The light switch is useful for discouraging prowlers and housebreakers, too. If you plan to be away from home on a vacation for a few days, you can plug a lamp into the light switch. Every night the light will go on and every day it will go off . . . just as if someone were in the house.

Compact, inexpensive, and easy to build, the light switch is an ideal "rainy day" project for the electronics hobbyist. Only two tubes are used, a type 921 phototube and a type 117L7 amplifier-rectifier.

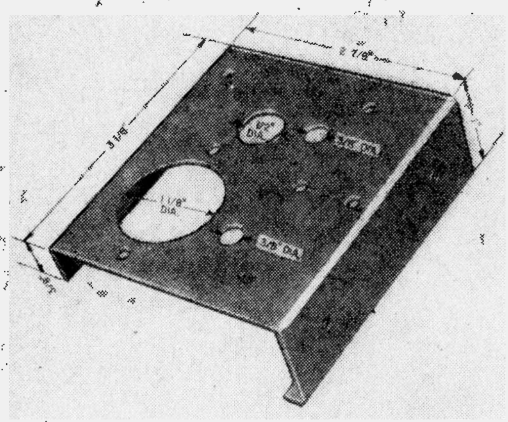
The components you'll need to build your own light switch are given in the parts list. All the parts are standard and should be available at your nearest radio parts distributor. However, if you are unable to locate the parts locally, you can order them from one of the large mail order supply houses, such as the *Allied Radio Corporation*, 100 N. Western Avenue, Chicago 80, Illinois, or the *Radio Shack Corporation*, 167 Washington Street, Boston 8, Massachusetts.

Construction

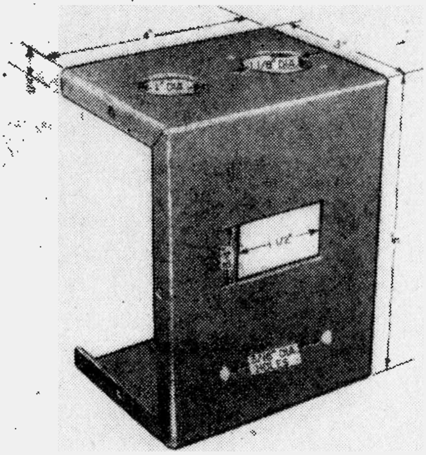
A small commercial aluminum chassis (*Bud* type CB-1617) measuring 4" x $3\frac{1}{8}$" x 1" may be cut down and drilled and punched as shown. If you prefer, you can make up a chassis "from scratch" using sheet stock. Except for the phototube, the parts layout and hole locations are not critical. Simply place the relay and tube sockets on the small chassis to locate the mounting holes, arranging the phototube socket so the phototube will be close to the front of the case.

If you want to duplicate the model exactly, you can use a standard *Bud* "Minibox" measuring 3" x 4" x 5" for housing your unit. Locate the $\frac{3}{4}$" x $1\frac{1}{2}$" rectangular hole directly in front of the phototube. Other hole locations are not critical.

Although finished in an attractive gray hammerloid enamel, the "Minibox" may be repainted to suit the color scheme in your



Subchassis for the Photoelectric Light Switch.



Case front. See text for "window" position.

home. Mount small rubber feet on the bottom of the case to prevent scratches on your tables.

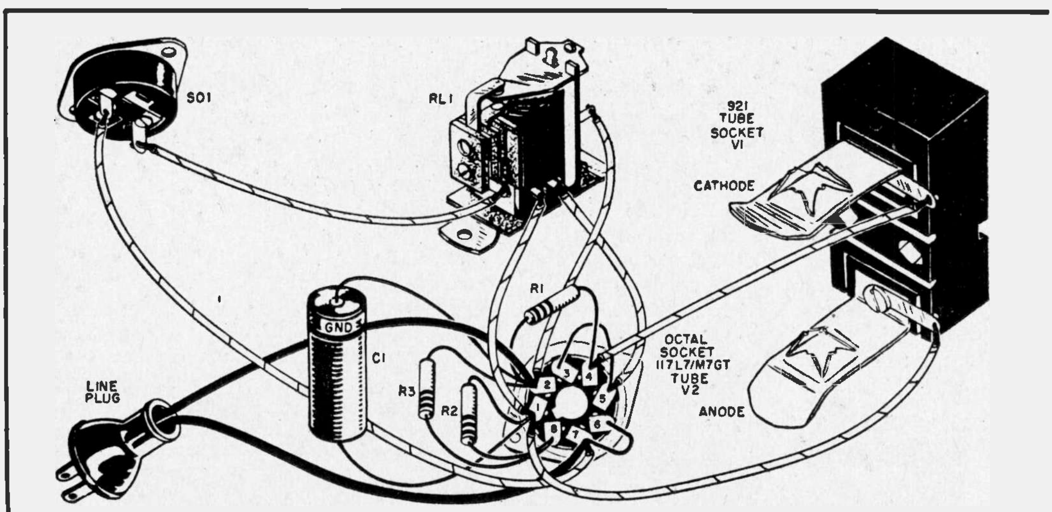
On the other hand, if you don't want a metal case, you can assemble your own light switch in some other type of housing. Either a wooden cabinet or a plastic case is satisfactory. An ingenious builder might combine a table lamp and the automatic light switch in a single attractive unit.

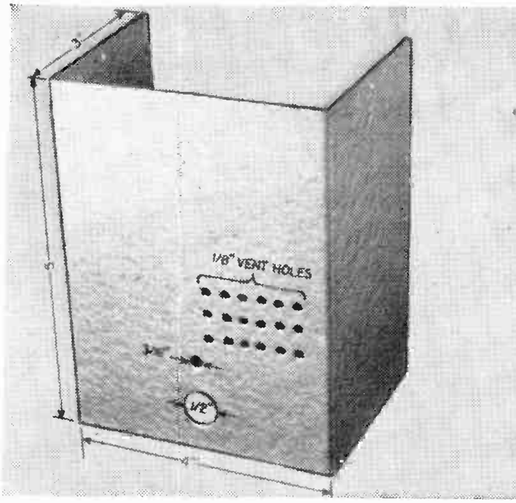
However, regardless of the type of housing you use, be sure to provide adequate ventilation for the 117L7 tube and make sure that outside light can strike the phototube. In the model, ventilation is provided by a rectangular "pattern" of eighteen ⅛" diameter holes drilled in the back and by a 1" "vent plug" in the top of the case.

Except for the connection to the line receptacle (mounted on the top of the case), all components and wiring are on the small chassis. Do all the chassis wiring first, following the schematic and pictorial wiring diagrams. Small machine screws and hex nuts are used for mounting the tube sockets and the relay. Use only *rosin core* solder when wiring the unit.

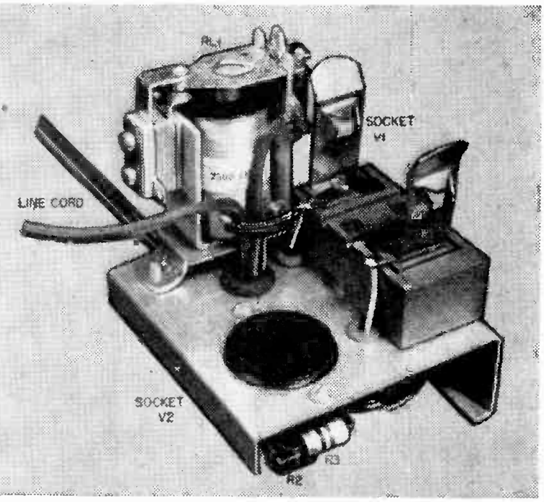
Lead "dress" is not critical. However, you should protect any bare leads with spaghetti tubing to avoid accidental shorts. Use rubber grommets for protection wherever leads pass through holes in the chassis or case.

Use temporary "lap" joints when installing *R3*. The final value of this resistor will have to be determined experimentally after the unit is wired.





Rear of case for Photoelectric Light Switch.



The subchassis, with parts mounted and wired.

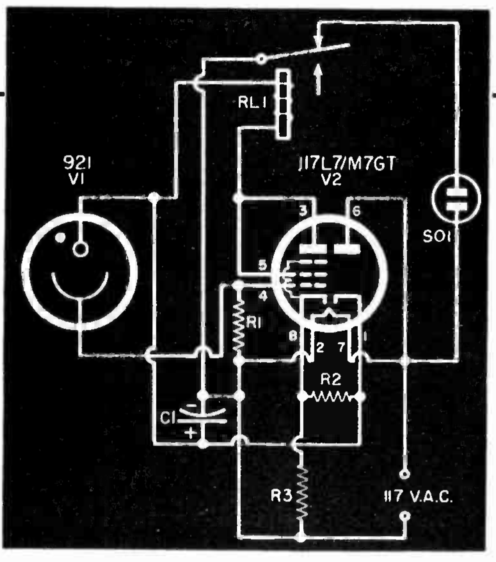
When you've completed the chassis wiring and double-checked for errors, tape the leads to the line receptacle (making sure they don't accidentally short together). Plug the unit into a wall socket and allow several minutes warm-up. *CAUTION: If a blue glow develops in the phototube when you plug the light switch in for the first time, pull the plug out immediately. The phototube has been installed backwards. Reverse the connections to the phototube.*

Check the operation of the light switch by placing it where normal daylight (not direct sunlight) falls on the phototube. The relay should close. Darken the phototube by placing a cardboard box over the unit; the relay should open.

If this action is not obtained, there is either an error in wiring, a defective component, or the value of *R3* needs to be changed. Assuming the wiring to be right and all parts to be in good condition, you can determine the proper value for *R3* very quickly.

Connect either a *resistance substitution box* or a 5000-ohm rheostat in place of *R3*. Checking the unit for operation by alternately lighting and darkening the phototube, adjust the resistance until proper operation is obtained. The correct value for *R3* will generally fall between 2700 and 4700 ohms. Once the proper value has been determined, install a fixed resistor.

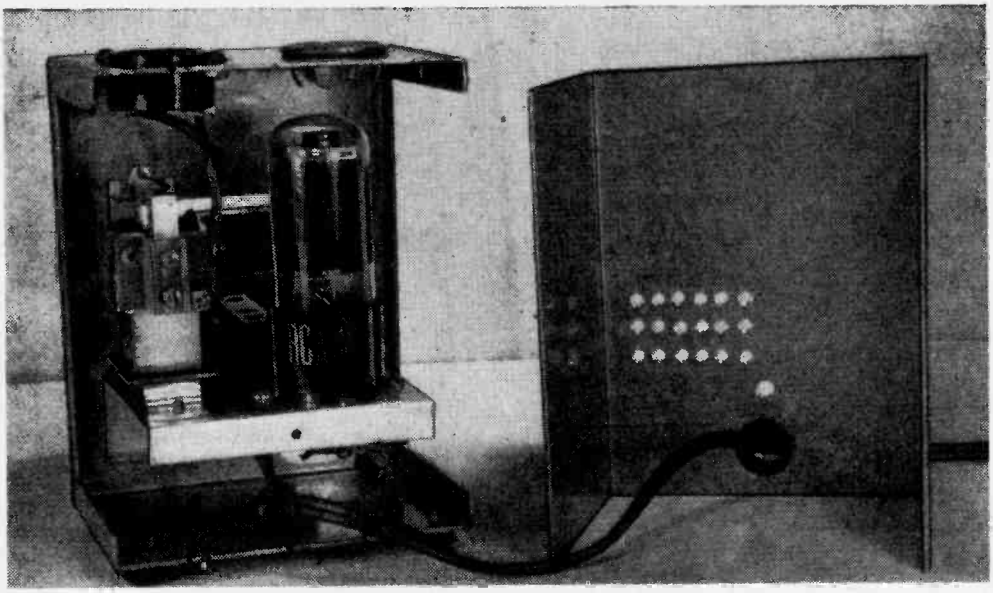
If you prefer a control on sensitivity, you



In wiring the switch, use the schematic with the pictorial wiring diagram. Note that none of the components are connected to chassis.

R_1—10 megohm, ½ w. carbon res.
R_2—10,000 ohm, 2 w. carbon res.
R_3—3900 ohm, 2 w. carbon res. (See text)
C_1—20 μfd., 150 v. tubular elec. capacitor
RL_1—2500 ohm coil plate relay, s.p.d.t. contacts (Potter & Brumfield type LB-5)
V_1—921—phototube
V_2—117L7/M7GT tube

Misc.—one octal socket; one phototube socket (Amphenol type 146-121); one a.c. line plug receptacle (Amphenol type 61-MIP-61F); line cord and plug; 1" vent plug; four rubber feet and mounting screws; small aluminum chassis (Bud #CB-1617); 3" x 4" x 5" metal box (Bud #CU-2105); one pkg. assorted rubber grommets; one pkg. assorted sheet metal screws; one pkg. assorted machine screws and nuts; wire, solder, spaghetti tubing, etc.



Automatic Light switch after wiring, but before front and rear sections of cabinet are assembled.

can install a 5000-ohm rheostat in place of *R3* as a permanent part of the circuit.

After the final value of *R3* has been determined and this resistor permanently installed, the light switch chassis may be mounted in its case. Use either self-tapping or sheet metal screws for mounting the chassis. Lockwashers are not generally necessary.

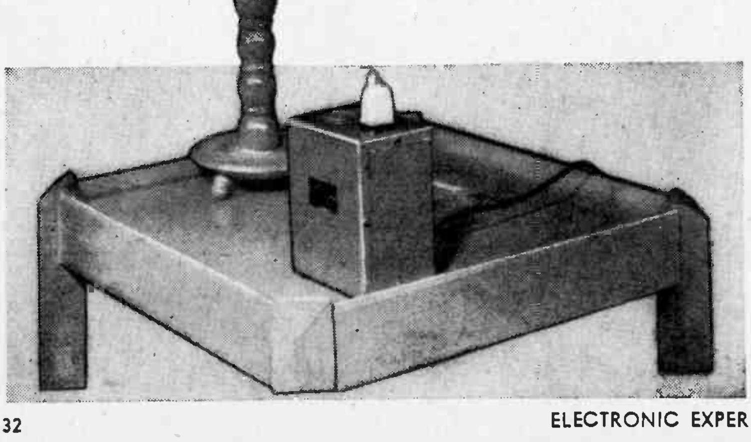
Applications

Once you've completed the assembly of your automatic light switch, you'll find many applications for it in addition to controlling a lamp in the home. Here are a few possibilities:

Photo Darkroom: Plug the safelight into the light switch. When the normal lights are turned out, the safelight comes on automatically.

Store Windows: Connected to control display lights, the unit will turn them on automatically at night or on cloudy days.

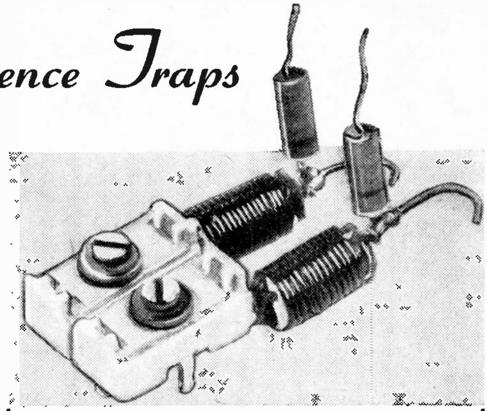
"Morning Alarm": Connected to a buzzer or bell and placed so the morning sun strikes the phototube, the light switch will wake you at "the crack of dawn." Of course, it may not sound the alarm till late on cloudy days, but most people like to sleep late on such days, anyhow. —30—

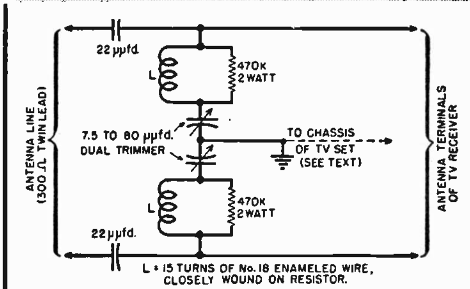


The Light Switch in use. The lamp is controlled by light passing through the window in the box.

Simple TV Interference Traps

By WALTER H. BUCHSBAUM





Band rejection filter is shown above.

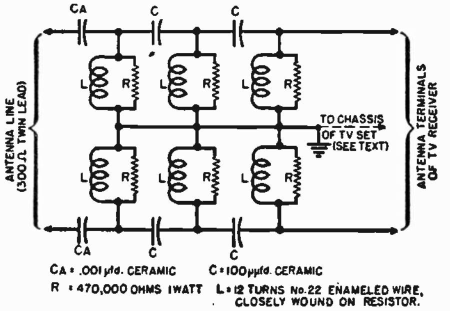
OF THE various types of signals that can interfere with TV reception, perhaps the most prevalent are from strong transmitters located nearby. Such installations as police radio, amateur transmitters, industrial r.f. heating and diathermy machines may radiate signals which are amplified by the TV set and interfere with the picture. When interference is present on all TV channels, or at least on channels 2 to 6, it is most likely from one of these sources. The best place to eliminate these interfering signals is right at the antenna terminals of the TV receiver, and to do this, use a filter.

The television frequencies extend from 54 mc., channel 2, all the way to 890 mc., channel 83, while the intermediate frequencies used in practically all modern TV receivers are either from 21 to 26 mc., or from 41 to 46 mc. Therefore, any signal below 54 mc. can, in some form or other, cause interference.

Two types of filters are described here. One type is called "high-pass" and passes only signals above the 54 mc. limit of channel 2. This filter is designed for the 300-ohm balanced twin-lead commonly used as TV transmission line. All the parts are standard items available from any radio distributor. The shield can of an old broadcast i.f. transformer can be used as a container with a terminal strip.

All coils are wound on 1-watt carbon resistors. The resistance value is not critical, as long as it is higher than at least 220,000 ohms, since the main purpose of the resistors is to serve as simple, inexpensive coil forms. Any style of capacitor can be used, except the paper tubular type. This type has some inductance at the higher TV channel frequencies.

This high-pass filter can be mounted on a terminal strip and inserted in an i.f. can.

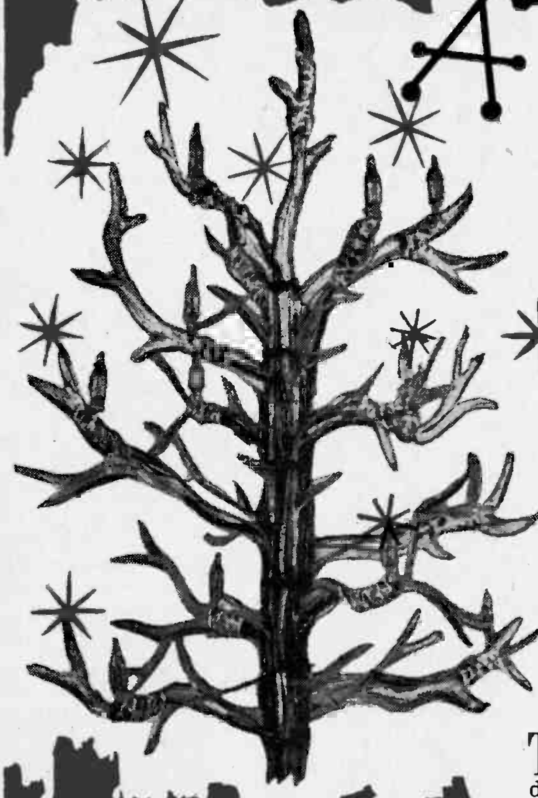


This type of filter is recommended where the interference is quite severe and its radio frequency is not known. Often in such cases the a.c. power line is also a source of interference and a commercially available power line interference filter may have to be used in addition to the filter used in the antenna line.

Shown above is a single frequency, balanced filter, often called a "band rejection" filter. Using two 2-watt carbon resistors as coil forms and a dual trimmer capacitor from an old i.f. transformer assembly, the filter comprises two series resonant circuits. At the frequency to which the filter is tuned, these series circuits present a short circuit bypassing it from the antenna terminals. Connect this filter between the transmission line and the TV receiver terminals. When the interference is present, tune each trimmer capacitor in turn for minimum interference on the screen. Be sure to use a non-metallic screwdriver to avoid hand capacity effects.

Both filter diagrams show a dotted line connection to the TV receiver chassis which in some instances will help in the interference elimination. —30—

A Twinkling



By
E. D. MORGAN

The completely wired tree. The base, not shown, can be decorated to suit.

THE Christmas season usually stirs an urge in most of us to attempt something different in the way of holiday decorations. Our favorite way of expressing this seems to be either in our Christmas trees or in exterior house lighting. In any case, most people must limit themselves to commercially available items which they simply purchase and install. A worker or hobbyist in any of the electrical fields is not so restricted. He is familiar with the materials and tools required and has the know-how to handle many unusual and novel lighting effects.

The Christmas tree described in this article certainly qualifies as novel. It is a clear, plastic tree about 12 inches high and is decorated with many tiny flickering lights. It makes a fine table centerpiece, mantle decoration, window display, or television lamp. It is portable and there is no need to worry about line cords or the location of the nearest power outlet.

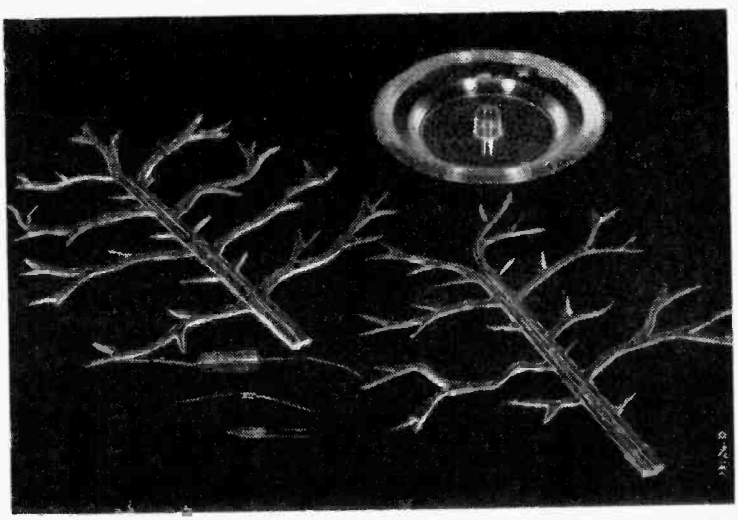
Christmas Tree

The NE-2 neon glow lamps used are the appropriate size to trim a tree this small and they have a soft red glow when lighted. Unlike an incandescent lamp, they have no filament and can be flashed very rapidly. Fifteen of these lights were used because that was the number of major branches on the tree. Fourteen of them blink on and off (about once or twice per second) while the top light remains steady. The power required for these lamps is quite low and a dry cell supply is entirely satisfactory.

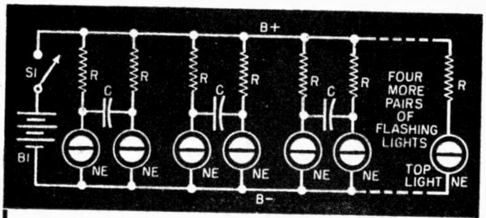
It is almost impossible to make the wiring inconspicuous and so an attempt was made to keep it attractive. The wire chosen was AWG No. 22, stranded, with red and green plastic insulation. There is a lot of wiring involved and the smallest wire you can get will be the most desirable. Dark green spaghetti tubing was used to cover bare wires, such as resistor leads. Soldered points were covered with electrical tape, for safety purposes, but the entire area was then covered with gaily colored gummed tape in a Christmas motif. The battery and capacitors, which are used to cause the lights to flash, were built into a square base. This was, in turn, covered with a bright cloth.

The plastic tree is sold as the "Party Tree" and widely distributed through variety and department stores as well as gift and novelty shops. The same type of tree is probably manufactured and distributed under different names. When purchased, the tree is in two pieces and comes equipped with a base as shown in the accompanying photograph. The two parts are each slotted halfway through the trunk so that they dovetail together and fit into the plastic base. By doing most of the wiring before assembling the two halves, a much neater effect can be obtained, as well as simplifying the construction.

The schematic wiring diagram and parts list is shown in Fig. 1. The neon lights



Some of the parts needed to build the tree. The base is used to supply the plastic material needed to secure lamps to branches. A NE-2 neon lamp is also shown along with resistor and capacitor.



R—2.2 megohm, ½ w. res. (15 required)
C—.1 µfd., 150 or 200 v. capacitor (7 required)
NE—NE-2 neon glow lamp (15 required)
S_1—S.p.s.t. toggle switch
B_1—90 volt battery
1—12" clear plastic Christmas tree
3—Three or more terminal strips to provide at least 16 tie points

Fig. 1. Schematic diagram and parts list covering the flashing circuit for the tree.

are connected in pairs using the "flashing" circuit indicated, which is an outgrowth of the relaxation oscillator. There are seven flashing pairs while the top light remains steady. Each pair flashes at a slightly different rate and the lights seem to dance from branch to branch.

The neon lamps have no sockets but must be soldered directly into the circuit. There is nothing critical about any of the parts, except that the capacitors and battery should be as small as possible, otherwise, the base size must be increased out of proportion to the size of the tree.

Mounting and Wiring the Lights

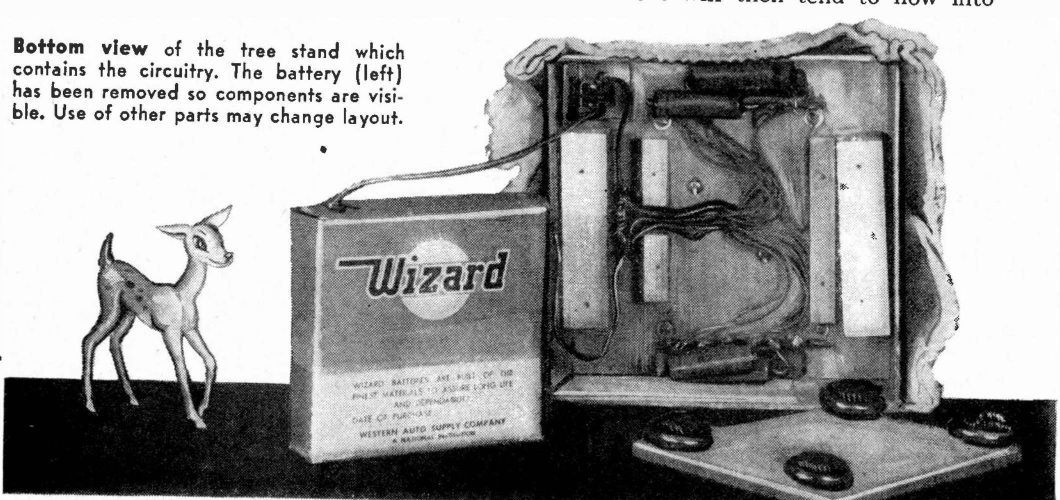
The first step in construction is the mounting of the neon lights on the individual branches. After trying several methods of doing this, the simplest way seems to be that shown in Fig. 2A. The tree and base are made of a thermoplastic material, which means that if heated it becomes pliable and when cooled returns to a solid state and the process can be repeated over and over.

As the base serves no purpose in the final mounting, it can be used to help in the securing of the lamps to the tree. Simply break off pieces of the base, place the lights in the desired position and, using a soldering iron to supply heat, literally "weld" the light in place. A small strip of the plastic can be used much as wire solder is manipulated. You can then feed in the plastic and form a smooth covering over the two wires on the lamp base. Be sure to keep the base wires separated so that the plastic, upon cooling, acts as an insulator between them. In this fashion you can proceed to mount all the lights on the two halves of the tree.

The next step is to make the connections to the lamps before assembling the two halves. One side of the lamp connects to both a resistor and capacitor, while the other side returns to the "B—" or common side of the battery. As both the battery and the capacitors are to be mounted in the base, the wiring for them must be carried down the trunk of the tree. Fig. 2B shows the method followed in making these connections. The wire fastened to the resistor side of the lamp must be left long enough to allow it to reach into the base, while the other wire must be long enough to reach the trunk of the tree and connect to a common bus wire there. The resistor leads can be cut so that they, too, reach the trunk of the tree and connect to a "B+" bus running toward the base.

As we have already mentioned that the material is easy to melt with the application of heat, you must take pains that the soldering operation does not undo what you have already accomplished in mounting the lights. The easiest way to insure this is to grasp the wires between the lamp and the soldering iron with pliers and the heat will then tend to flow into

Bottom view of the tree stand which contains the circuitry. The battery (left) has been removed so components are visible. Use of other parts may change layout.



the pliers, instead of up the wire to the plastic. Put spaghetti tubing over the resistor leads before soldering. The lamp on the tree top, which will not flash, does not need the extra lead to run down into the base. Connect a resistor to one lead of this lamp and a wire to the other to reach the "B—" bus wire.

Then fold the resistor and the common lead back along opposite sides of the tree branch and tape all exposed wiring as indicated in Fig. 2C. Fold the wires so that the resistors are all on one side of the tree and the common leads on the other.

The wiring is greatly simplified if this is done. The electrical tape should be cut into small widths before taping the exposed joints. In this way you can do a smoother and less bulky taping operation. The neater it is done, the better the finished product will appear. The electrical tape is then covered with Christmas wrapping tape to improve its appearance.

It would be wise to study the wiring diagram of Fig. 3 carefully before proceeding. It will be necessary to put the two halves of the tree together after they are wired and so care must be taken to insure that this is possible. The solid lines represent the "B+" bus and the dotted line the common, or "B—" bus. You can either scrape the insulation back at intervals on these bus wires, or use bare wire and put spaghetti tubing between connections. It is also wise to use different colors for the positive and negative bus wires so they can be easily identified after you later thread them into the base. Note carefully that the wiring is arranged so that the center section of the tree trunk is never crossed by any wire. This is absolutely necessary if the two halves are to fit together when you are finished. Again, tape all exposed wiring. Be careful to keep the wires and the iron away from the plastic to avoid melting or warping it.

Base Construction and Wiring

You must now build a base and wire the bottom section before you can proceed with the tree proper. Many of the construction details for the base can be seen in the photograph. The battery has been removed so the wiring and assembly will be apparent. Other types of bases could be designed and your choice depends upon the materials and tools you have to work with, and on the size of the components. Fig. 4 shows many of the construction details of the base used for this particular tree. It consists mainly of a 6″ square piece of ¾″ board with a ½″ hole in its center. Mounted on the upper side of this is a small 2″ square piece of the same material with a ⅝″ hole to hold the tree in place.

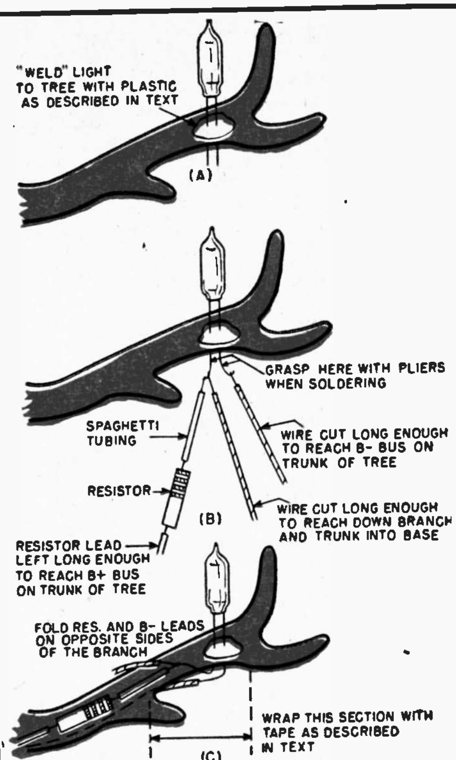
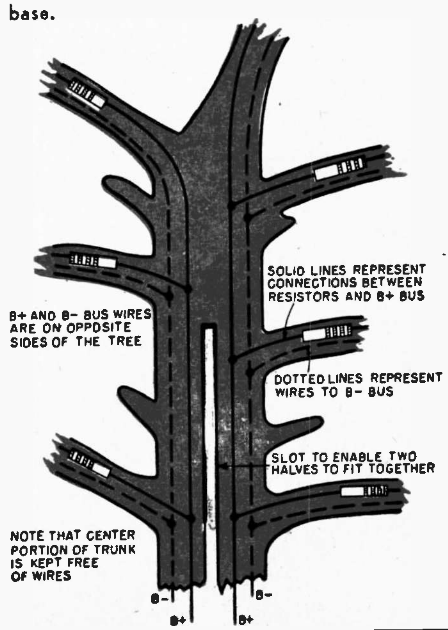


Fig. 2. Method of mounting and wiring neon lamps on individual branches. (A) Using plastic to "weld" light to branch. (B) Fastening resistors and leads to base of lamp. (C) Placement and taping of the wiring used in construction.

Fig. 3. Method of wiring trunk of the tree. Each half is wired in the same manner before they are put together. The assembled tree will have four "B+" and four "B—" leads into the base.



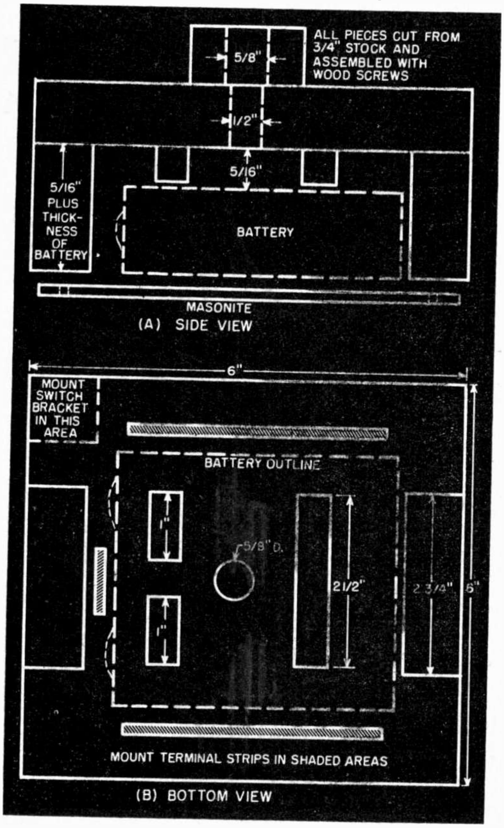
The wiring goes through these two holes into the base.

On the under side of this board are mounted the terminal strips to support the capacitors and provide tie points for the wires coming from each of the fourteen flashing lights. Another terminal strip acts as a tie point for the positive and negative bus leads. Small pieces of wood act as stand-offs for the battery so that the wires have room to run to the various terminals.

A switch is mounted in one corner of the unit on a small L-shaped bracket of thin metal. Two other side braces serve to support the entire unit as well as to secure the battery in place. These pieces are cut long enough to reach the level of the battery when it is inserted against the stand-off strips. A piece of Masonite across the tops of these blocks holds the battery firmly. Furniture glides serve as mounting legs and fasten this piece of Masonite to the blocks.

With this type of construction the sides do not support any weight and so they were cut from a piece of Bainbridge board.

Fig. 4. Suggested layout for building the base of tree. Dimensions must be altered if any of the parts chosen by builder is changed in size.



This is a high grade cardboard often used for sign painting. It merely closes in the base as the cloth completely covers this portion of the tree.

Final Assembly

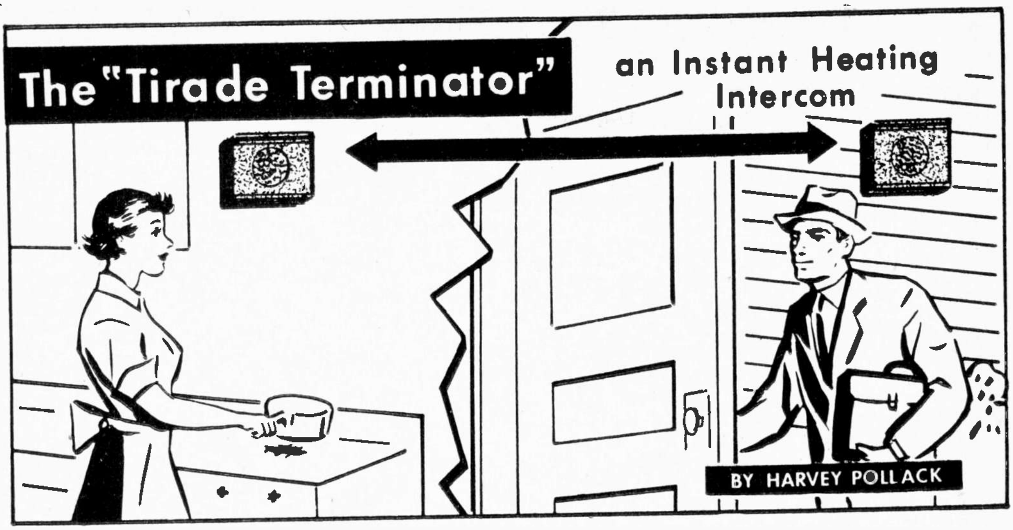
After building the base and mounting the capacitors and switch, the tree may be assembled and inserted in the ⅝" mounting hole. The fourteen leads from the lights should be carried straight back along each branch and fed along the trunk into the base. At intervals along the trunk of the tree, tie the wires in place so they will retain their position. Green darning thread is ideal for this purpose. Your neatness will again affect the final appearance.

The leads should be connected to the capacitors in a random fashion, one wire to each end of the seven capacitors. It is not necessary to pair the lights in any particular fashion and only if two lamps side by side appear obviously coupled together when you are through, will there be any reason for further change. The "B+" and "B—" leads should be fastened to their respective terminal strips. The battery can then be connected through a six- or eight-inch pair of wires to the "B—" terminal and through the switch to the "B+" terminal. The battery should have a long life with this small power drain and so you can solder the wires directly to its terminals unless you happen to have the proper connector. Check the entire unit for proper operation and then insert the battery in place, fasten the retaining pieces, and cover the base.

The covering operation is best delegated to the female branch of the family. Mothers, wives, and sisters have a much better knack for this sort of thing than the men of the household and they can cover it as they see fit. The author's unit was covered with a cloth sold at Christmas time for such purposes and often called "glitter cloth" because it is covered with highly reflective colored pieces to catch and reflect the light.

This particular phase of the construction is a good chance for the ladies to display their ingenuity. The family's name can be spelled out in sequins, a model village can nestle in the "snow," or greens can be draped artistically around the "box" to hide its construction.

With that the tree is completed and in a dimly lighted room will soon become the center of conversation. It is certainly unusual and you can be sure that you will be asked many times where you got it. Be prepared with a ready defense, however, or you will find yourself spending the entire holiday season building them for your friends and relatives. —30—



UNLESS YOU LIVE in a very unusual household, you must have had more than one exasperating session with an irate wife or mother on the subject of time wasted in the workshop building useless gadgets. Here's a warranted method of putting an end to those dispiriting gripe sessions. Build something for *her* exclusive use.

As a protective device and step-saver, an instant-heating (no warm-up time) intercom between the kitchen and the front door will permit her to find out who is ringing the bell without approaching the door itself; undesirable callers can be sent on their way through the medium of a two-way conversation right from the kitchen sink!

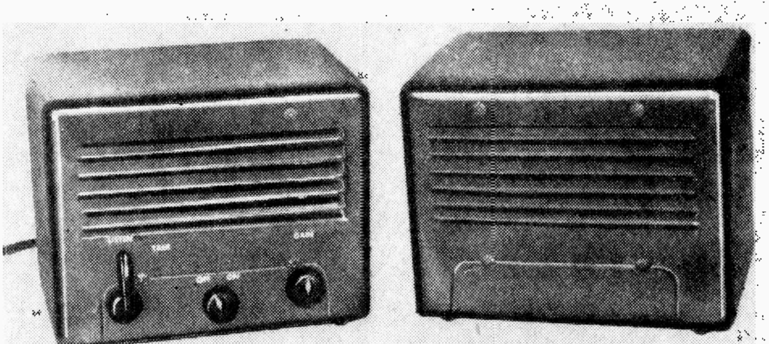
Ordinary office intercoms are not satisfactory for home use. Generally, they use tubes that have a 15 to 30 second warm-up time. To avoid this waiting period, such units are usually left running all day long —an unnecessary extravagance for the average apartment-dweller or home-owner. The intercom described in this article eliminates the need for warm-up interval by using battery-type tubes arranged for 117-volt a.c. operation.

Construction

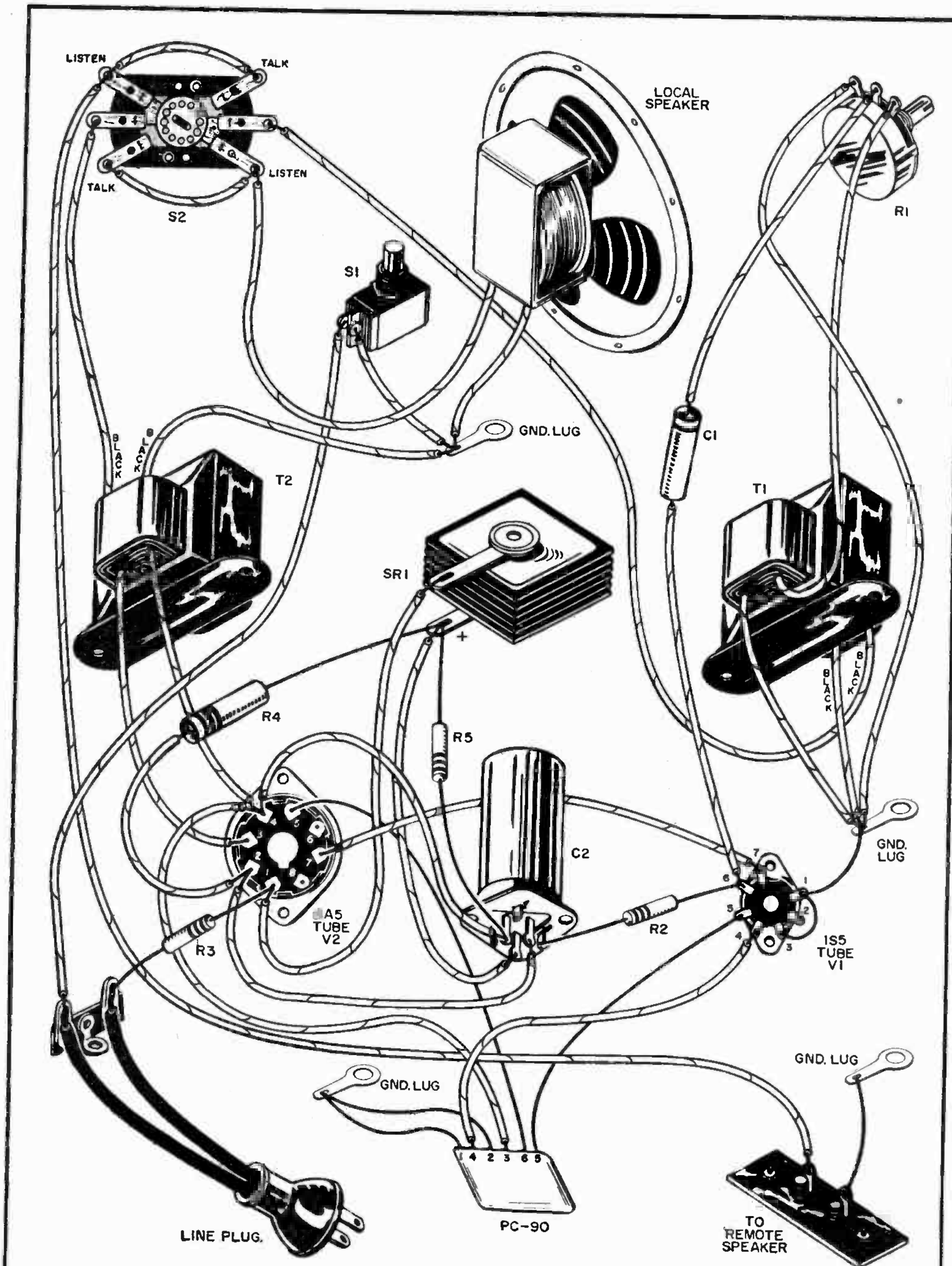
The plastic cabinet is supplied without holes for the controls in the front panel so that it may be used as either the master unit or the remote speaker housing. Three 3/8" holes should be drilled in the desired locations before doing anything else; they can be used as templates for locating the control openings in the front apron of the little chassis.

Mount the major parts on the top of the chassis (see the photo on page 41). Secure the gain control (*R1*), the canopy-type switch (*S1*), and the *TALK-LISTEN* selector switch (*S2*) to the front apron.

Plan your layout so that input transformer *T1* is physically close to *R1* and pantode amplifier *V1*. Since connections between these parts are high impedance paths, they are quite subject to hum pickup and feedback unless made as short and direct as possible. Except for this grid circuit, the remainder of the wiring is not



Plastic cabinet comes without holes for controls drilled in front panel; it can serve either as master unit or remote speaker housing. Trimming the cabinet with decals will make intercom look like expensive commercial unit. A waterproof housing may be used for the remote out-of-doors unit.



Hook up the components of the "Tirade Terminator" as shown in this pictorial diagram.

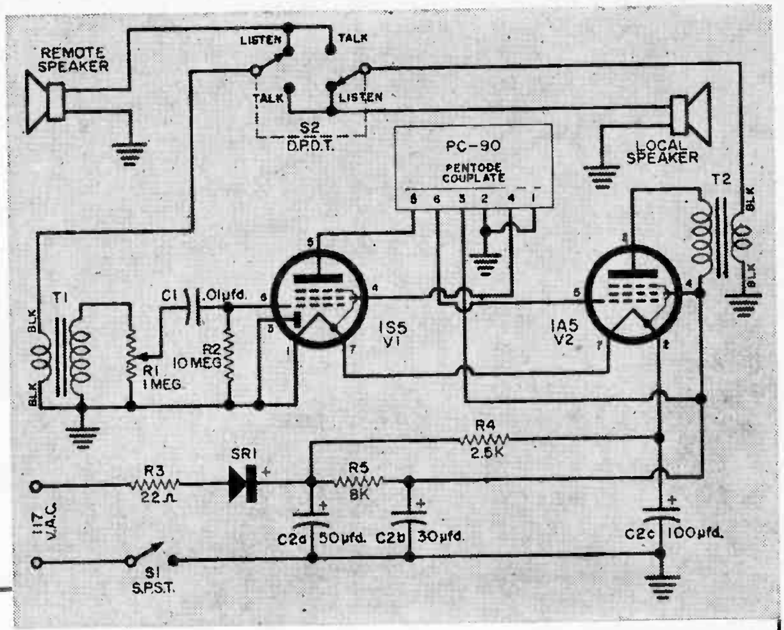
particularly critical. However, delicate filaments combined with high-gain amplifiers are subject to 60-cycle hum unless carefully handled. If the hum is excessive, it usually means one of three things: poor grounds, defective filament filtering capacitor (*C2c*), or extra long 1A5 grid leads.

All wiring should be completed before the pentode Couplate (PC-90) is installed. This is a printed electronic circuit which replaces three capacitors and resistors.

Testing and Installation

Preliminary tests are always performed with the a.c. plug disconnected from the power line. These tests do not guarantee that the circuit wiring is correct in all de-

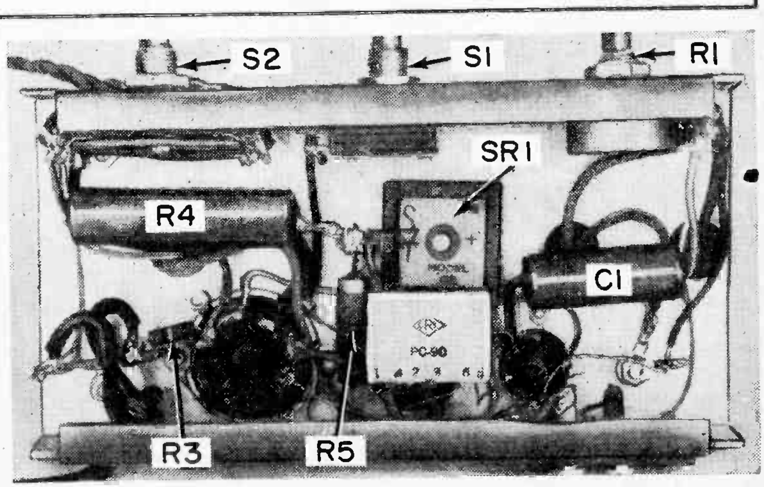
Wiring diagram for instant-heating intercom. The "Tirade Terminator" eliminates need for a warm-up interval by using battery-type tubes arranged for 117-volt a.c. operation — making it particularly suitable for home use. Only the wiring for the grid circuit is critical. The pentode Couplate (PC-90) should be installed after all other wiring is completed.



PARTS LIST

C1—0.01-µfd., 400-volt paper tubular capacitor
C2a/C2b/C2c—Filter block capacitor, 50-30-100 µfd., 150-150-25 volt, Twist-lok type in can (Sprague TVL-3427)
R1—1.0-meg. volume control potentiometer, audio taper (Mallory U-53, Midgetrol)
R2—10-megohm, ½-watt resistor
R3—22-ohm, ½-watt resistor
R4—2500-ohm, 10-watt resistor (Sprague Koolohm Type 10KT)
R5—8000-ohm, 1-watt resistor
S1—S.p.s.t. switch, rotary canopy type with long shaft
S2—D.p.d.t. TALK-LISTEN switch, spring return (Centralab Type 1464)
SR1—65-ma. selenium rectifier (Sarkes-Tarzian Model 65)
T1—Intercom input transformer, primary 4 ohms to secondary 25,000 ohms (Stancor Type A-4744)
T2—Output transformer, 25,000-ohm load to 4-ohm voice coil (Stancor Type A-3327)
V1—1S5 tube
V2—1A5 tube
PC-90—Pentode-type Couplate (Centralab)
SPEAKERS—4"-diameter, 4-ohm voice coil PM speakers (Lafayette SK-25)
1—Miniature 7-pin socket, top mounting with shield saddle
1—Octal socket, 1" mounting hole, bottom mounting
1—Shield for 1S5 tube
1—3" x 6⅛" x 1¼" chassis (ICA 29080)
1—Intercom cabinet, brown plastic (Available from Lafayette Radio, 100 Sixth Ave., New York, N. Y.)
1—Cabinet for remote speaker (outdoor use—ICA 3988; indoor use—Lafayette unit above)
1—Insulated terminal board, two terminals, for remote speaker leads
1—Line cord and plug for 117-volt a.c. line, Elmenco fuse plug, with two 1-amp. fuses
Misc. rubber grommets, solder lugs, hardware, hookup wire, line cord for remote speaker

Parts are mounted as shown in photo at right (under-chassis view). If you fit a small piece of plywood tightly into slots near bottom of cabinet, the chassis can rest on this base. A small plywood lip glued to the back of the wood will prevent chassis from sliding, thus holding it securely in place without use of metal screws anywhere.



HOW IT WORKS

A permanent magnet dynamic speaker may be used as either a microphone or an audio reproducer. On the *TALK* position of the switch, the local speaker is connected to the input transformer (*T1*) and serves as a microphone. Varying acoustic pressure applied to the speaker cone by sound waves induces a tiny audio voltage in the voice coil. This voltage is stepped up by the high secondary-to-primary turns ratio of *T1*, further amplified by pentode *V1*, and the signal fed to the grid of the output tube where it is converted to audio power. The remote speaker is activated by the output tube via the selector switch. In the *LISTEN* position, the speaker functions are reversed, the local speaker now doing the reproducing and the remote speaker acting as a microphone.

Use of battery-type tubes is made possible by rectifying the a.c. from the 117-volt power lines and then by filtering it in *C2a*, *C2b*, and *R5*. *R4* is the filament dropping resistor which insures that a maximum of only 0.05 ampere will flow through the series filaments. The remainder of the circuit is straightforward. To save considerable space, a printed circuit Couplate is used between *V1* and *V2*.

tails; they are intended merely as protective measures to avoid damaging tubes or other components when power is first applied.

To test the filament circuit connect an ohmmeter between the plus side of the selenium rectifier and the chassis. You should read 2500 ohms. The ohmmeter should read 3300 ohms when connected between pin 4 of *V2* and chassis; this tests the plate and screen circuits. With the TALK-LISTEN switch on LISTEN, the ohmmeter should read 10 ohms between an ungrounded remote speaker terminal screw on output terminal board and the ungrounded voice coil lug on local speaker. The ohmmeter should give the same reading with the switch on TALK. With *S1* off, the ohmmeter should read infinite between both prongs of the a.c. line cord plug.

When the requirements of the tests have been satisfied, power may be applied with both speakers connected. *It must be remembered that the chassis is at the potential of one of the legs of the a.c. line.* The following precautions *must* be observed to avoid possible electrical shock and blown fuses.

Connect a 117-volt incandescent lamp (any wattage will do) from the chassis to a ground pipe or other ground point. Turn the intercom on and then insert its line cord plug into the wall receptacle.

If the lamp lights, the a.c. plug is in the wrong way and must be reversed; reversal should cause the lamp to go out, indicating that the chassis is now at house-ground potential. If the lamp does not light, reverse the plug to make sure it does light when the plug is in the wrong way. This is the only means of establishing that the ground point you are using is *really* at house-ground potential.

—30—

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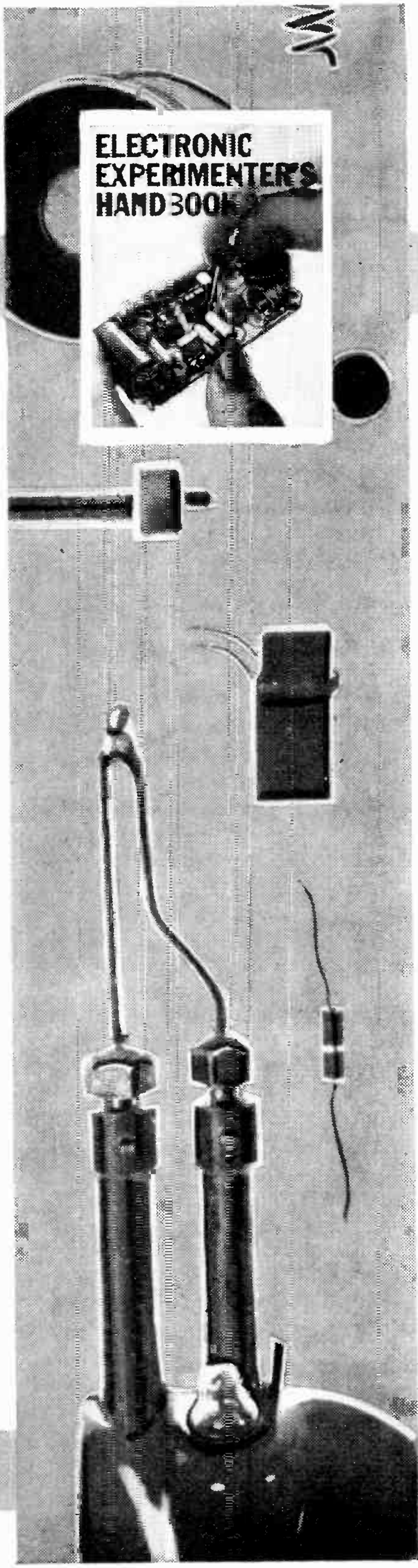


Chapter 2

For Your Children

INTRODUCTION TO PUZZLE-TRONICS

By HARVEY POLLACK

Entertain your friends with these intriguing puzzles, which can be assembled in one evening from a few inexpensive parts

ONCE UPON A TIME a farmer approached a stream on his way to market. With him were a hen, a bushel of corn, and a pet wildcat. On the shore was a boat which could carry the farmer—the only one who could row, of course—and one of his possessions at a time. The hen's consuming desire was to eat the corn while—at the same time—the wildcat had exactly the same ideas about the hen. On the other hand, the wildcat, being strictly carnivorous, looked with disdain upon the corn. Only the presence of the farmer prevented the massacre of his possessions, so he had to be careful which of them he left alone with the others. After some meditation, he discovered a way to transport all of them across the river without having any of them consumed. How did he do it?

Solving puzzles like this is fun in itself, but planning and constructing electrical puzzle circuits (or "pircuits" as they are sometimes called) is even more exciting. Then, after they are built, they can provide many evenings of entertainment for friends and visitors.

Essentially, a puzzle circuit is an electrical arrangement of switches, battery, and buzzer which maintains complete silence as long as the human player executes each move without error, but which buzzes raucously when the wrong move is made. The player gets the sensation of being inexorably monitored by a machine of deadly accuracy, and he quickly learns that every action must be thought out carefully if he is to avoid being caught by the electronic "brain."

"Farmer" Circuit

For those who would like to try their hands at this amusing electrical work, it is suggested that they start with a relatively simple setup like that of the farmer and his stock, building up the circuit (Fig. 1) on a cigar box or similar enclosure.

When the farmer problem is considered for a while, it becomes apparent that only the wildcat and the bushel of corn can be left unguarded. Thus, the farmer first carries the hen across the stream, leaves her there alone, and returns to pick up the bushel of corn. He takes the corn to the other side but brings the hen back with him on the return trip. Depositing the hen on the shore, he then rows the wildcat across and leaves the wildcat with the bushel of corn while he goes back once more for the hen. When the switches are moved in this sequence, the circuit to the buzzer is never completed, so it remains silent; but should the switches that simulate the hen and the corn, or the hen and the wildcat ever make contact while the farmer switch is in the opposite position, the machine instantly sounds off.

The prospective builder should trace out the schematic diagram of this circuit for each possibility so that he may see the logic behind the switching arrangement. Readers should note that this puzzle can be constructed using three single-pole, double-throw switches and one double-pole, double-throw switch instead of the arrangement shown. A schematic diagram of this simpler version is shown in Fig. 2.

"Three Jealous Husbands"

The more adult puzzle illustrated in Figs. 3, 4 and 5 goes something like this. Three insanely jealous husbands—the proverbial threesome: Tom, Dick, and Harry—and their beautiful brides must cross a stream on their way to a honeymoon resort. All six people are accomplished rowers. The only available boat can carry a maximum of two people. None of the husbands will permit his bride to be on the same side of the stream with another man unless he, the rightful husband, is also there. For example, if Tom has crossed to the north shore leaving Tina on the south shore with either Dick or Harry or both, the situation is intolerable even though Dora or Helen may still be with their own husbands. One, two, or all three wives may be on the side opposite their husbands only if no other men are there.

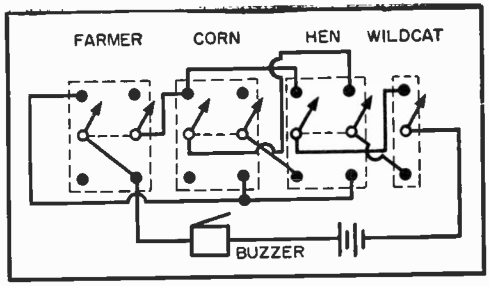


Fig. 1. Original "farmer" puzzle schematic.

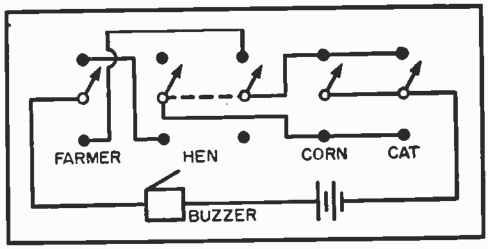


Fig. 2. Revised circuit for "farmer" puzzle.

Starting from either of the two shores, switches may be moved singly or in pairs to conform with these conditions until the crossing is accomplished peacefully. If the buzzer sounds—indicating an illegal com-

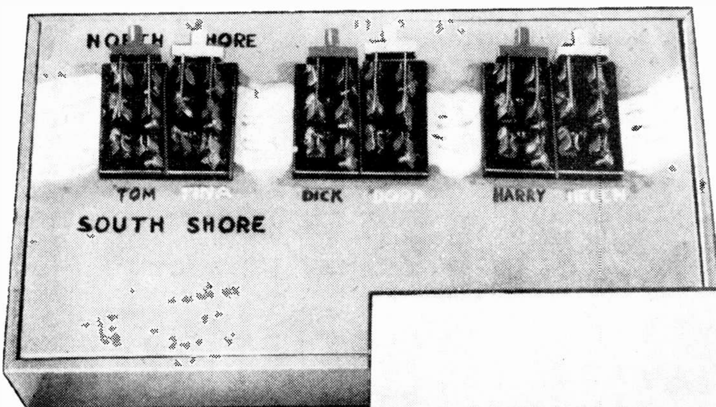


Fig. 3. Top view of the author's version of the "jealous husbands" puzzle. A specially made wooden box was employed, but any suitable enclosure of metal or wood may be used.

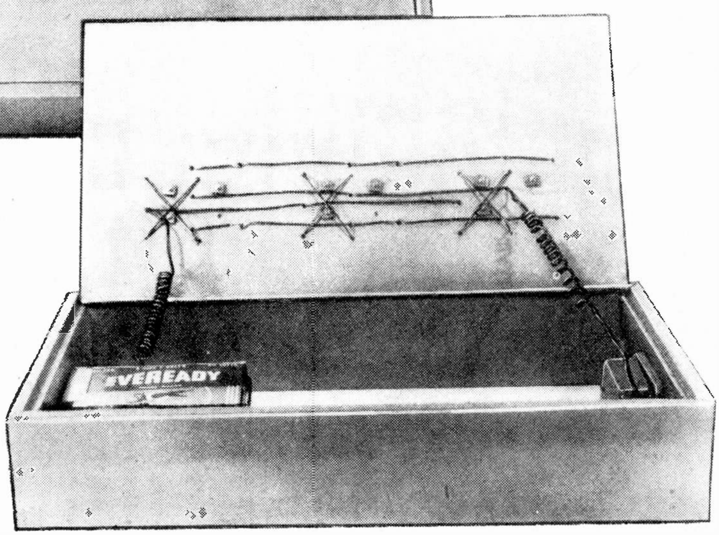
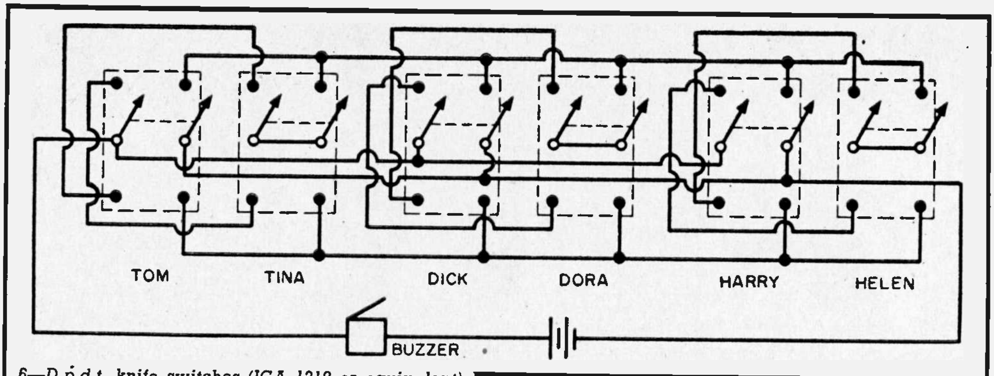


Fig. 4. Interior view of "jealous husbands" puzzle, showing a portion of the wiring. Some of the wiring is hidden underneath the switches (see text).



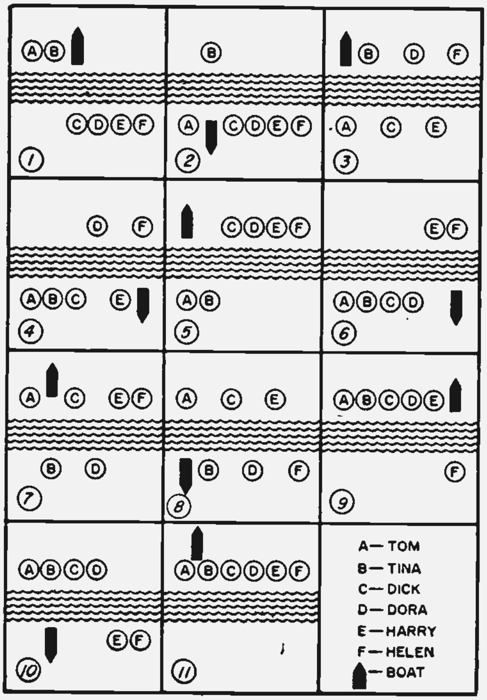
6—D.p.d.t. knife switches (ICA 1219 or equivalent)
1—Doorbell buzzer
1—4½-volt battery (Eveready No. 736, Burgess No. F3, RCA Type VS 067)
1—Enclosure, metal or wood (Figs. 3 and 4)
Misc. wire, solder, etc.
Catalog price of parts, approx. $7.50

Fig. 5. Schematic diagram and parts list for the "jealous husbands" puzzle.

bination on either shore—the player must start from the beginning again. It is helpful to emphasize that the boat must go back and forth with passengers at all times since it has no volition of its own.

Switches representing the husbands are painted red (jealousy is the red-eyed monster) and those which simulate the brides are bright yellow (the color of sun-kissed blonde hair). The wiring is quite symmetrical and requires no more than a few hours of work after the parts are mounted on the panel. In this model, the jumpers which join the movable knives on each of the "wife" switches were wired in under the respective switches before mounting them on the panel, so that they are not visible in the underside view. The battery, which provides 4½ volts for the buzzer, is held to the side of the case by means of two aluminum "U" brackets bent from thin sheet stock. Wires leading from the panel to the battery and buzzer are wound around a pencil and then slipped off, to provide a bit of spring action that prevents flopping leads yet permits the panel to be lifted without stretching the wires taut.

Fig. 6. Solution to the puzzle of Fig. 5.

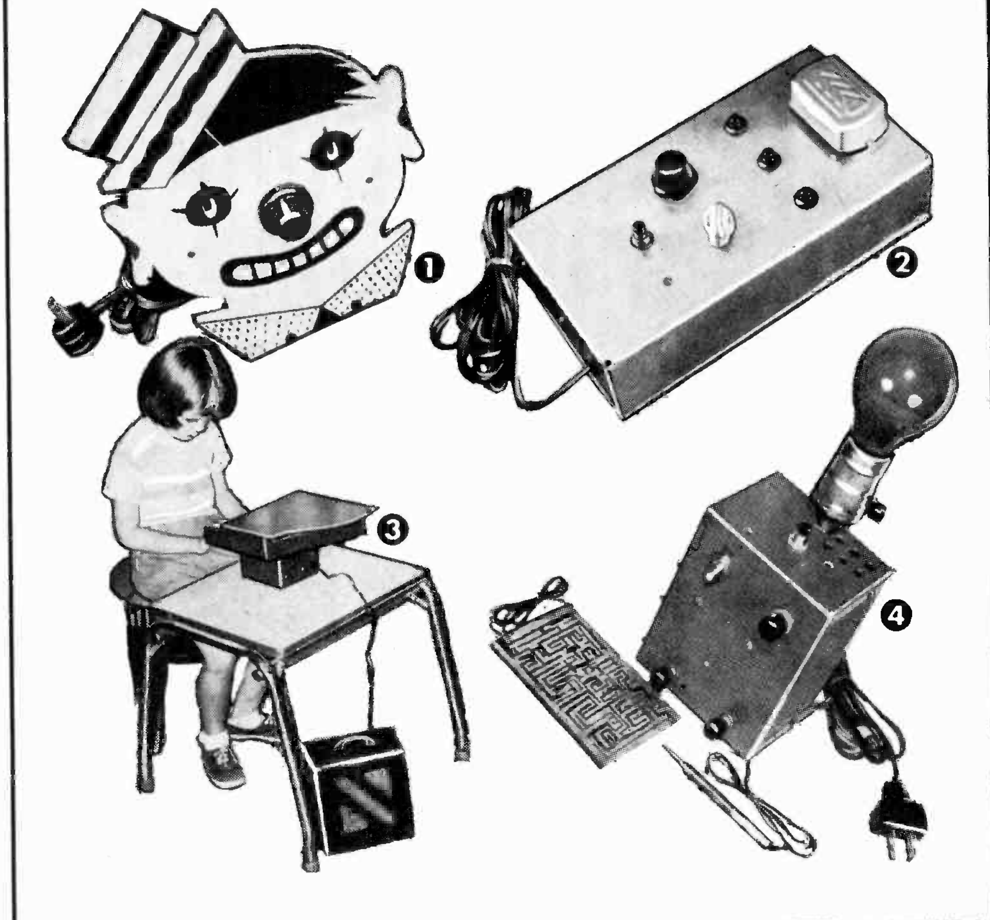


The solution to the husband-and-wife problem can be shown mathematically to require a minimum of 11 moves. To get some idea of the difficulty of the problem, use six squares of paper correctly labeled and simulate the river crossings with these, being careful not to permit forbidden combinations to occur. If it works out—fine! It not, follow the 11 boat trips shown in Fig. 6, noting each time how the required conditions are met.

It's worlds of fun designing new "circuits" around problems involving sequential moves based upon a set of rigid rules. Also, many refinements and trimmings can be added to make the puzzles more interesting. Relays may be used to show the position of the boat after each crossing, "location" lights being employed for the purpose. A thermal time-delay relay of perhaps three or four seconds may be included to keep the player in suspense after each move. To provide light as well as aural signals of errors, a trouble lamp can be used in conjunction with the buzzer. An electronic time-delay circuit of 15 to 25 seconds may also be utilized to force the plays to be made quickly.

In any case, whether simple or complicated, puzzle circuits can be exciting and amusing. Try one and see! —30—

Electronic Toys



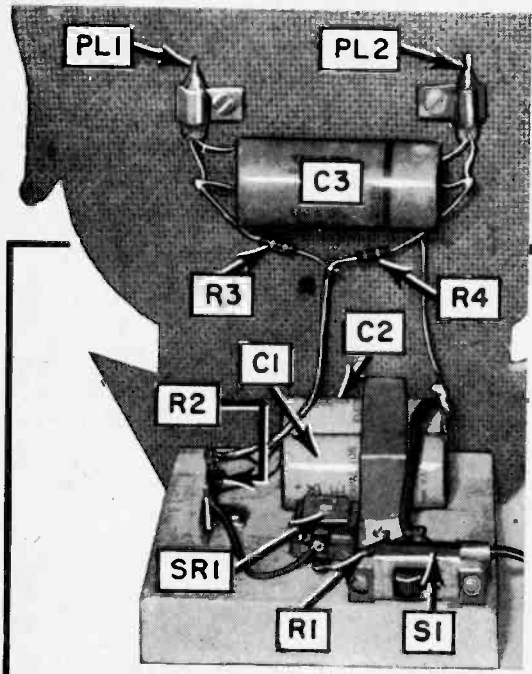
These four projects are ideal for long winter evenings—these are toys your children (and you) will not tire of too quickly.

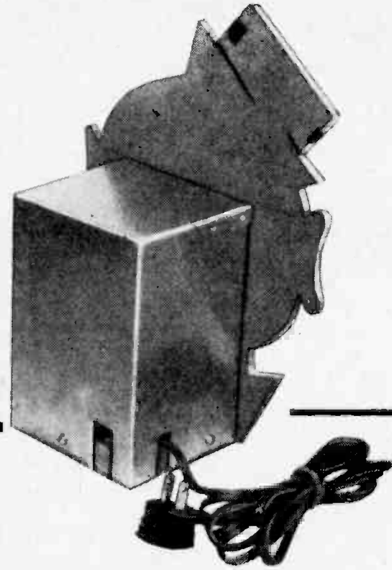
By E. G. LOUIS

ELECTRONIC toys have tremendous appeal for youngsters of all ages; they combine the newness and "mystery" of science with real play value. Most electronic toys fall into a few simple categories . . . code practice oscillators and blinkers for the novice ham, simple receivers, record players, and electronic oscillator "musical" instruments. But here are four electronic toys which are off the beaten track. They are both fun to assemble and fun to use, and will bring many hours of pleasure to the user . . . even if he doesn't know an electron from a resistor!

Each toy is described as a separate project, with each designed to have maximum appeal for a particular age group . . . ranging from the very young to mature adults. All four toys are inexpensive and share the common characteristics of simple design, reliability, and ease of construction.

The "Winking Clown" (Proj. 1) appeals to the very young—those from one to five years of age—but also has some appeal for older children. For the budding young rocket engineer or nuclear scientist, the





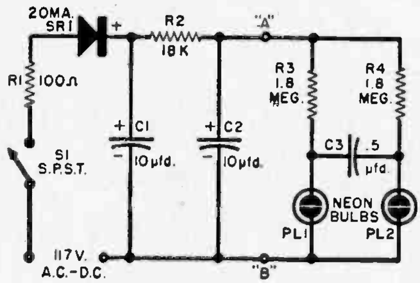


Fig. 1 (above). Rear view of "Winking Clown" with protective cover removed and the various components identified.

Fig. 2 (top, rt.). Rear view of clown with the protective metal cover in place.

Fig. 3 (ctr., rt.). Schematic diagram and parts list for the complete project.

C1, C2—10-μfd., 150-volt electrolytic capacitor
C3—0.5-μfd., 200-volt paper capacitor
PL1, PL2—Type NE-2 neon bulb
R1—100-ohm, ½-watt resistor
R2—18,000-ohm, ½-watt resistor
R3, R4—1.8 megohm, ½-watt resistor
S1—S.p.s.t. slide switch
SR1—20-ma. selenium rectifier
1—Line cord and plug
1—Small metal box for back cover (see text)
2—Cable clamps for ¼" cable
1—2-terminal tie point
1—10" x 10" piece of ⅛" Masonite or ¼" plywood
Misc. solder, wire, screws, brackets, scrap wood, paint, etc.

Catalog price of parts, approx. $4.50

"Gadget Box" (Proj. 2) will attract much interest; fun for children in the four to eight age group, it is a good project if a well-stocked junk box is available. With the appeal of an electronic instrument, but the simplicity of an inexpensive toy, the "Electronic Piano" (Proj. 3) is designed to be of maximum interest to the seven to twelve year group, and is also attractive to both younger and older children. Finally, the "Electronic Maze" (Proj. 4) should appeal to everyone from eight to eighty; depending on the individual maze board used, the game may be made simple enough for a young child or difficult enough to serve as a test of skill for the personnel department of an industrial concern.

Project 1—"Winking Clown"

In operation, the "Winking Clown" (Proj. 1) alternately winks his orange glowing eyes as long as power is supplied. Since power consumption is negligible, the soft glow of his eyes may well serve as a good night light for the children's room. The Clown makes a good *double-purpose* project; although the completed toy has maximum appeal for the very young, assembling the project could furnish considerable entertainment to an eleven or twelve-year-old, who could build the project for a younger brother or sister.

Construction Hints: The circuit for the Clown is given in Fig. 3. Only inexpensive, readily available parts are used. Wiring is straightforward and non-critical. The Clown's face is cut from plywood or hardboard (*Masonite*) using a jig saw, scroll saw, or similar tool. An original design may be preferred to the one shown for a timely toy, a Santa Claus "face" may be used for Christmas, a rabbit's head for Easter, a cut-out of Uncle Sam for the fourth of July, or a witch's head, pumpkin, or skull for Halloween. Two narrow slots, approximately 3/16" x 1/2", are cut out for the neon bulbs, *PL1* and *PL2*, which are held in place by small cable clamps and screws. Slots may be either horizontal or vertical . . . or round holes may be used if preferred. The face is painted with ordinary paint or enamel . . . the model was painted with fingernail polish!

After the parts are installed according to the diagram (observe proper polarity when wiring the selenium rectifier, *SR1*, and the electrolytic capacitors, *C1* and *C2*), a protective back cover should be added to keep curious fingers out of the wiring. If a battery-operated version is preferred, the line cord, selenium rectifier (*SR1*), power supply resistors and capacitors, *R1*, *R2*, *C1* and *C2*, may be left out. Simply install a 90-volt B battery, with switch, connecting the positive lead at point "A" and the negative lead at point "B" in the circuit (Fig. 3). A *Burgess* type N60 is a suitable battery.

How the Clown Works: Referring to Fig. 3, resistors *R1* and *R2*, capacitors *C1* and *C2*, and the selenium rectifier *SR1* all form a simple d.c. power supply. *R1* protects the selenium rectifier from burning out during the initial charging of *C1*. Rectifier *SR1* converts the applied a.c. power to pulsating d.c. by half-wave rectification, and resistor *R2*, together with capacitors *C1* and *C2*, form a simple filter to smooth the pulsating d.c., removing all ripple. All of these components may be replaced by a battery, if desired. The "heart" of the circuit is an interlocked *relaxation oscillator* consisting of *R3*, *R4*, *C3*, and the two neon bulbs.

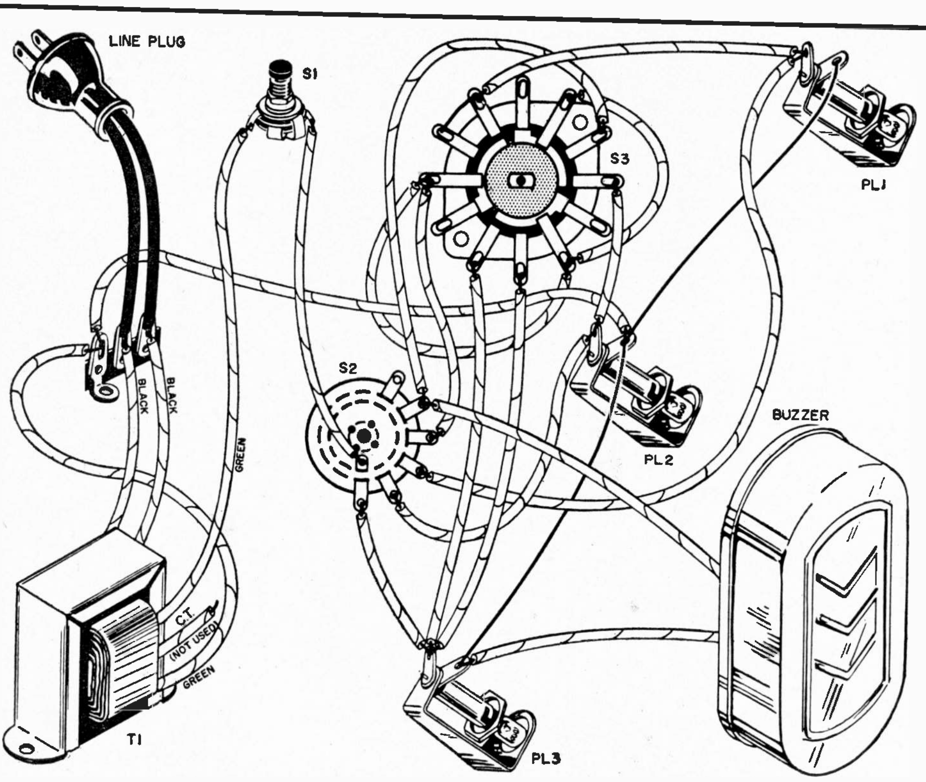
In operation, when power is applied to the relaxation oscillator circuit, one of the two neon bulbs will "fire" first. Let's say it's the right-hand bulb. Once the bulb fires, it acts almost like a short circuit, and *C3* is charged through *R3* and the bulb. While *C3* is charging, there is insufficient voltage available across the left-hand bulb to fire it. Once *C3* is charged, however, the left-hand bulb will fire, virtually shorting the right-hand bulb and extinguishing it, then discharging *C3* and charging it through *R4* with a charge of opposite polarity. Once *C3* is charged again (but with opposite polarity), the right-hand bulb will fire, extinguishing the left-hand bulb. This action continues as long as sufficient voltage is applied to fire the bulbs.

The rate of charge and discharge, and hence the rapidity of "winking," depends on the applied voltage and on the values of *R3*, *R4*, and *C3*. As these components are made larger, the Clown "winks" more slowly. As they are made smaller, the Clown "winks" more rapidly. As long as *R3* equals *R4*, each "eye" stays "open" about the same length of time; but if these two resistors are made unequal, one "eye" will remain "open" longer.

Project 2—"Gadget Box"

With a "Gadget Box" similar to the one shown in Fig. 4 in his hands, plus his innate imagination, a child can pilot a submarine in the dark depths of the sea, can control a powerful nuclear power plant, or can fly a rocket ship through the far reaches of outer space. As he manipulates

Fig. 4. Using "Gadget Box"—a trip to the moon, perhaps? There's no limit to the imagination of youngsters playing with Project 2.



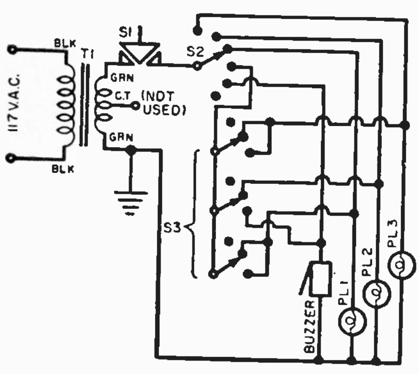


Fig. 5 (top). Pictorial diagram of the author's version of the "Gadget Box."

Fig. 6 (left). Suggested schematic and parts list. Many versions can be built, depending on the components available.

Buzzer—6-8 volt buzzer (Edwards No. 725 or equivalent)
PL1, PL2, PL3—6-8 volt pilot lamp (No. 40 or equivalent)
S1—S.p.s.t. push-button switch, normally open
S2—S.p. 6-pos. wafer switch (Mallory 32112J or equivalent, only 6 positions used)
S3—4-p. 3-pos. single-gang switch (Mallory 3243J or equivalent)
T1—Filament transformer, 6.3 volts @ 1 amp.
3—Miniature screw base pilot light sockets
1—5" x 9½" x 2½" aluminum chassis and bottom plate
1—Line cord and plug
2—Knobs
1—3-point terminal strip
Misc. wire, solder, hardware, etc.
Catalog price of parts, approx. $4.50

the switches and controls, vari-colored lights flash on and off, buzzers sound, and all sorts of interesting and mystifying actions can take place.

Construction Hints: The circuit used in the author's model is given in Fig. 6, but it should be used only as a general guide. Ransack the junk box for rotary switches, push-button and toggle switches, buzzers, bells and pilot lamp bulbs. Mount the components on an old chassis or in an empty cigar box, and connect the switches, buzzers and pilot lamps together so that varying units are switched on and off as the controls are manipulated. A small filament or bell-ringing transformer serves as the power source. The completed model should be sealed against unauthorized tampering. Use a bottom plate on a chassis . . . or, if a cigar box is employed as a "cabinet," use the bottom as the front panel, then seal the cover closed after the wiring is completed and checked for operation.

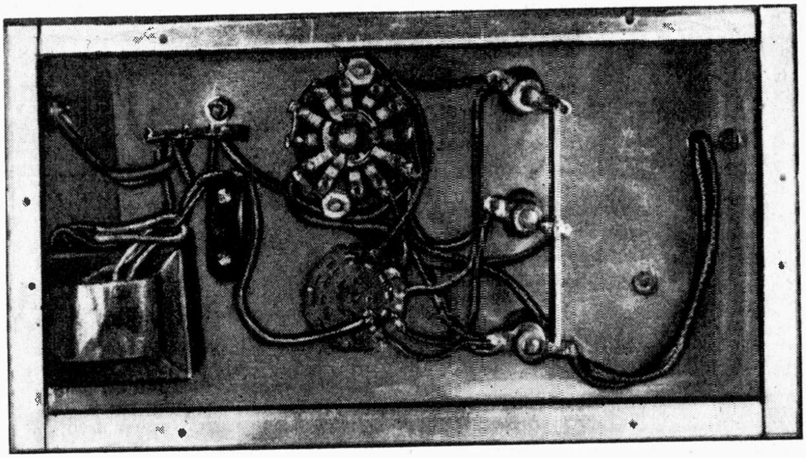


Fig. 7. Below-chassis view of the author's "Gadget Box" after the wiring has been completed. It is essential that a durable protective cover be installed on the bottom to prevent wandering fingers from coming in contact with parts connected directly to power line.

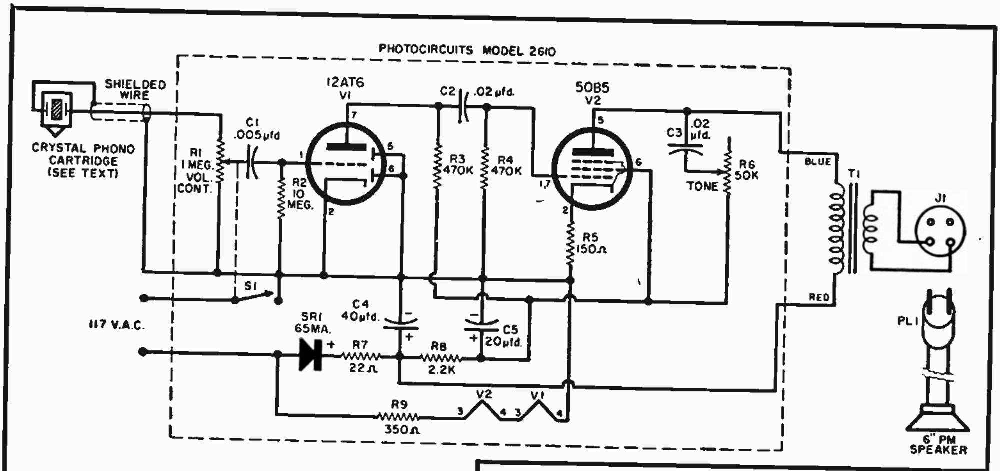
For maximum effect, the pilot lamp bulbs (*PL1, PL2,* etc.) should be in several colors . . . use fingernail polish or a commercial dial light coloring kit. The bulbs are mounted in rubber grommets on the front panel . . . save pilot light jewels and brackets for other projects! If sockets are available, use them, but connections to the pilot lamp bulbs can also be made by soldering leads directly to the metal shell and center terminal.

Project 3—"Electronic Piano"

Electronic "musical instruments" are always popular, not only with children, but with adults as well. The majority of electronic musical toys consist of a variable-frequency audio oscillator coupled to an audio amplifier and loudspeaker. Often only a single note can be sounded at a time. But the "Electronic Piano" shown in Fig. 8 uses a somewhat different approach. An efficient *vibration pickup* serves to couple the output of a toy piano to the input of a compact audio amplifier which, in turn, drives a remote loudspeaker. Thus, the desirable features of both "standard" and "electronic" musical instruments are combined in one unit. The operator has full control over volume and tone, as in an all-electronic instrument, but—at the same time—the versatility and simplicity of a mechanical instrument are achieved.

Construction Hints: A toy piano serves as the "heart" of the instrument. This may be either a new unit, picked up at a local toy store, or a discarded and broken toy which, nonetheless, can be rehabilitated with a coat or two of paint and a nail or two installed at appropriate places. In order to keep the assembly and wiring simple, a commercially available *printed-circuit* audio amplifier is used. To this are attached the line cord, output transformer (*T1*) and speaker, and the special vibration pickup.

Fig. 8. Interior view of the toy piano, with an enlarged view of the phonograph pickup used to pick up the vibrations of the sounding pins. The pickup can be located approximately in the position indicated by the arrow, but exact position should be determined experimentally so that optimum volume and tonal quality are obtained from the instrument.



C1—0.005-µfd. disc ceramic capacitor*
C2, C3—0.02-µfd. disc ceramic capacitor*
C4, C5—Dual electrolytic capacitor, 40/20 µfd., 150/150 volts*
J1—4-prong jack
PL1—Matching plug for J1
R1—1-megohm potentiometer (volume control), audio taper, with switch S1*
R2—10-megohm, ½-watt resistor*
R3, R4—470,000-ohm, ½-watt resistor*
R5—150-ohm, ½-watt resistor*
R6—50,000-ohm carbon potentiometer, tone control*
R7—22-ohm, ½-watt resistor*
R8—2200-ohm, ½-watt resistor*
R9—350-ohm, 10-watt wire-wound resistor*
S1—S.p.s.t. switch (on volume control R1)*
SR1—65-ma. selenium rectifier*
T1—Output transformer, 2000 ohms to voice coil
V1—Type 12AT6 tube*
V2—Type 50B5 tube*
1—Line cord and plug
1—6" PM loudspeaker and wall baffle
1—Toy piano (see text)
1—Crystal phonograph cartridge
1—Kitchen cabinet handle
1—Small wooden box (approx. 4¾" x 4¾" x 3½")
2—7-pin miniature tube sockets*
Misc. solder, wire, hardware, etc.

Catalog price of parts, approx. $18.50

**Components marked with asterisk are included in Photocircuits Model 2610 printed circuit audio amplifier. If kit is not available locally, contact Photocircuits Corp., Glen Cove, N. Y.*

Fig. 9. Schematic diagram and parts list for the "Electronic Piano." The dotted box encloses the printed circuit amplifier.

The complete wiring diagram is given in Fig. 9 (including the schematic of the amplifier).

If a second-hand toy piano is to be used, make sure the "tone bars" are not bent or broken before progressing too far with the assembly job. Also inspect the hinges of the small "hammers" attached to each playing key. If any of these hinges are broken, repair with cloth tape.

The amplifier board, output transformer (*T1*) and output jack (*J1*) are mounted in a small wooden box. Essential dimensions for the box are given in Fig. 10, while the completed assembly, after attachment to the piano body, is shown on page 49. Mounting holes for the amplifier board, as well as holes for the *volume* and *tone* control shafts, may be located by holding the amplifier board against the box. Vent holes are provided near the top of the box, rubber feet on the bottom. The small box may be made from scrap wood if desired . . . the one shown in the model was cut down from an *El Producto* "Queens" wooden cigar box, then given a coat of dark stain.

Mount the amplifier board on small spacers, as shown in Fig. 11. Take care that no "hot" terminals may be touched anywhere outside the box. Cover the bottom of the box with protective screening or perforated hardboard when all wiring (including connections to the vibration pickup) is completed and checked. Ventilation is necessary, but the wiring should be protected from inquisitive fingers to avoid possible shock. The large series heater resistor (*R9*) should be bent away from the electrolytic capacitor *C4-C5* before the amplifier is used as electrolytics are sensitive to excessive heat and may dry out rapidly.

The vibration pickup consists of a small crystal phonograph cartridge mounted inside the body of the piano. Experiment with the location of this pickup. Sometimes best results are obtained when the pickup is mounted on the top board (where the "tone bars" are located), sometimes when mounted on the bottom board of the piano. The efficiency of the vibration pickup is increased appreciably by adding a small weight. To make the weight, select a small common nail with a diameter small enough to fit in the needle chuck of the phonograph cartridge. Wrap No. 14 gauge

Fig. 10 (right). Layout for the wooden box which is used to house the audio amplifier.

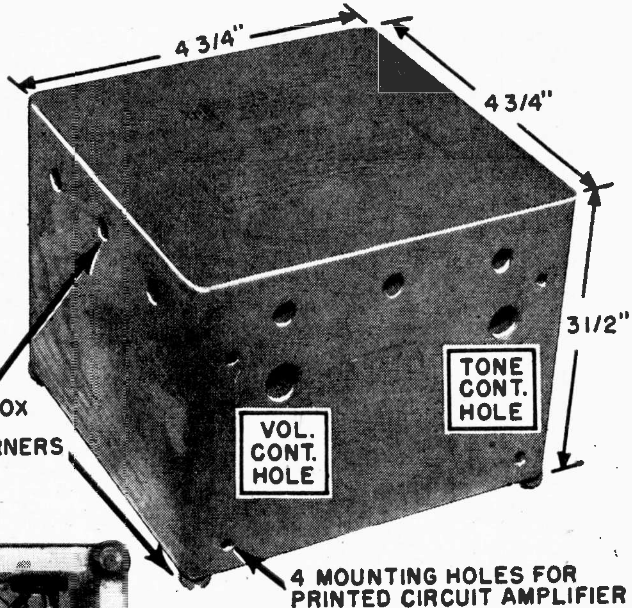
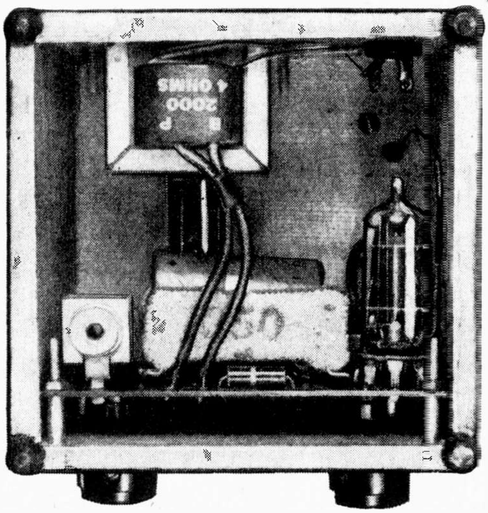


Fig. 11 (below). Bottom view of amplifier box showing amplifier board and output transformer in place. If commercial printed circuit amplifier is not used, the layout may vary considerably from this one.



copper busbar along about half an inch of the nail, then flow solder over the wire and nail to form a solid piece. Bend the free end of the nail so that the weighted portion lies parallel to the phono cartridge when the nail is inserted in the needle chuck. A shielded single conductor lead connects the phono cartridge to the input of the amplifier. The cartridge itself is held in place with two small screws through its regular mounting holes.

A separate loudspeaker is used. This is mounted in a small cabinet or box and connected to the amplifier proper by means of a piece of ordinary lamp cord and a small plug. A wall speaker baffle makes an admirable cabinet when equipped with a kitchen cabinet handle (for carrying) and rubber feet. However, any small box may be used for a speaker baffle.

How the Piano Works: The only thing really unusual about the Electronic Piano is the operation of the vibration pickup. But before discussing this, let's review, briefly, the operation of the audio amplifier circuit.

A portion of the audio signal appearing across volume control *R1* is coupled through capacitor *C1* to the grid of the first amplifier stage *V1*. Resistor *R2* serves as the grid resistor for this stage and the large value (10-megohm) used here sets up *contact bias* for the tube. An amplified audio signal appears across plate load resistor *R3* and is coupled through capacitor *C2* to the grid of the power output stage. *R4* serves as the grid return resistor for this stage, with unbypassed cathode resistor *R5* furnishing operating bias. The power output stage, *V2*, is matched to the low-impedance loudspeaker voice coil by means of output transformer *T1*. Capacitor *C3*, together with tone control resistor *R6*, forms a losser type of tone control. As the value of *R6* is reduced, *C3* becomes more and more effective in bypassing high-frequency signals.

D.C. operating voltages are furnished by a conventional half-wave rectifier power supply circuit using a selenium rectifier (*SR1*, Fig. 9) and an RC filter consisting of electrolytic capacitors *C4* and *C5* and resistor *R8*. Resistor *R7* is not essential to the filtering action but is provided to protect the selenium rectifier against a heavy current surge as *C4* is charged when the unit is first turned on. A series heater connection is used, with *R9* serving to limit heater current.

Referring back to the vibration pickup, the vibrations of the piano (as a note is struck) are transferred to the outer case of the crystal cartridge. The cartridge case tends to vibrate *around* the interior crystal cell, which resists this vibration by means of its own inertia, *plus the inertia of the added weight.* A twisting or bending action is thus set up, which results in the generation of a small audio voltage, much in the same way that an audio voltage is generated when the crystal cell is vibrated by a needle riding in the groove of a phonograph record. It is this audio voltage that is applied to the amplifier, permitting electronic amplification of the sounds produced by the toy piano.

Project 4—"Electronic Maze"

More of a game than a toy, the "Electronic Maze" (see page 49) offers a challenge to adult and child alike. By simply changing the playing board, the game may be made simple enough for an eight-year-old or so difficult that even a highly skilled technician would have difficulty completing a play with a "perfect" score. In more conventional "maze" games, the player has but a single task . . . to find his way through the maze successfully. To make things a little more exciting, a time limit may be imposed. But with the Electronic Maze, the player's path is beset with "danger," for not only must he find his way through the maze, but he must stick to the straight and narrow. *If he touches either "wall" of the maze in trying to find his path, he's immediately caught by an electronic sentry.*

Construction Hints: The complete game is made up of three independent pieces: (1) the electronic sentry box, with its telltale red warning light, (2) the maze board on which the game is played, and (3) the scribe which the player uses for tracing his path. The complete circuit diagram, showing how the three pieces are connected, is given in Fig. 12.

Assembling the Sentry Box: The sentry box is an adaptation of a sensitive electronic relay circuit described in a previous article in this book (see "Keep Dry With This Rain Alarm," on pages 10 to 14). The original circuit has been modified to provide a "self-latching" action to prevent cheating.

Only standard, readily available parts are used. Construction is simple and straightforward, and the wiring and layout are both non-critical. The average worker should have no difficulty assembling a duplicate unit in one or two evenings or on a weekend. The tube socket, relay, and terminal strips are mounted on a small alu-

C1—20-µfd., 150-volt electrolytic capacitor
PL1—25-watt, 117-volt red bulb
R1—10-megohm, ½-watt resistor
R2—1500-ohm, 1-watt resistor
R3—3000-ohm wire-wound potentiometer (sensitivity)
R4, R5—10-megohm, ½-watt resistor (a single 22-megohm, ½-watt resistor may be used if it is available)
R6—6800-ohm, 1-watt resistor
RL1—S.p.d.t. 5000-ohm plate circuit relay (Potter and Brumfield Type LB5 or LM5 or equivalent)
SO1—Standard lamp socket (switch optional)
S1—S.p.s.t. push-button switch, normally open (reset)
S2—S.p.s.t. toggle switch (power)
V1—117L7/M7 tube
1—Pair of insulated binding posts
1—Scribe (sharpened nail cemented in short piece of tubing with flexible lead attached)
1—Maze board (see text); in the model, a KEPCO printed-circuit kit was used (Keil Engineering Products, 4356 Duncan Ave., St. Louis 10, Mo.)
1—Line cord and polarized plug
1—Metal utility cabinet, 3" x 4" x 5"
1—Aluminum subchassis, 3½" x 5¼"
1—Octal socket
1—Small knob (sensitivity)
2—2-lug terminal strips
6—Rubber grommets
Misc. solder, flexible wire, screws, etc.
Catalog price of parts, approx. $12.50

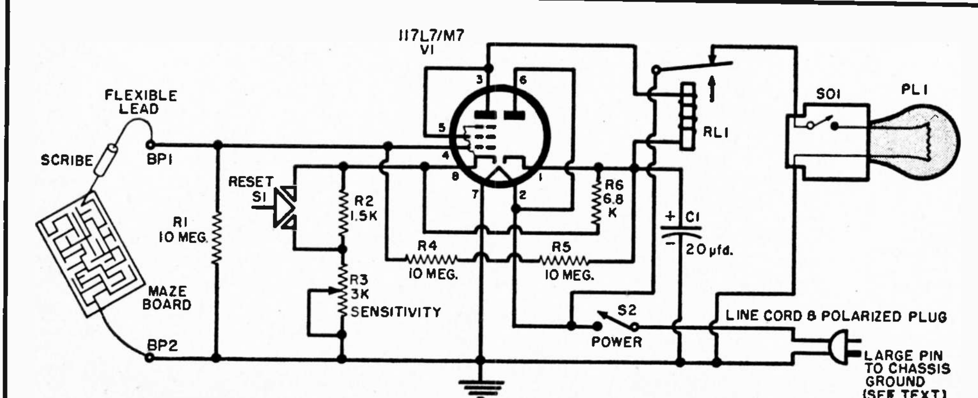


Fig. 12. Schematic diagram and parts list for Project 4—the "Electronic Maze."

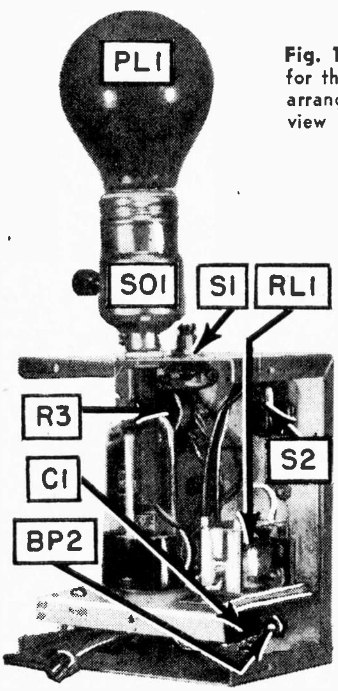
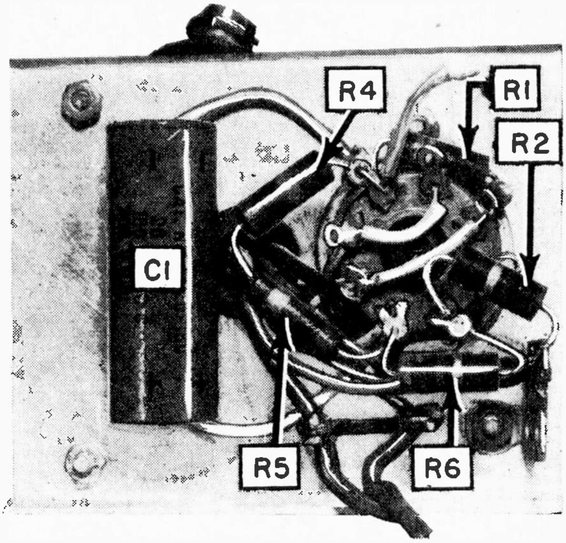


Fig. 13 (left) is a rear view of the completed sentry box for the "Electronic Maze" with the cover removed, showing arrangement of parts. Fig. 14 (below) is a below-chassis view of the wired subchassis assembly for the sentry box.



minum subchassis, with most of the circuit wiring completed before the subchassis is mounted in the cabinet. Above- and below-chassis views of the wired subchassis are given in Figs. 13 and 14 respectively.

A commercially available metal cabinet was used to house the model, but a cabinet of metal or wood can easily be made. In either case, be sure to provide good ventilation for the 117L7/M7 vacuum tube, which gets quite hot in operation. In the model, adequate ventilation is provided by holes in the back and top of the cabinet which, together, give a sort of "chimney" cooling effect. Since the completed game will probably be played on a table, be sure to install soft rubber feet on the sentry box. Thick rubber grommets, mounted in appropriate-sized holes, are good substitutes if conventional rubber feet are not available.

In order to keep the circuit simple and inexpensive, a "transformerless" power supply has been used. With such an arrangement, one side of the power line is connected to circuit ground. Many commercial a.c.-d.c. radio receivers and inexpensive record players use a similar circuit arrangement. Unfortunately, where a conventional line plug is used, it is possible to insert the plug in a wall socket in such a way that the chassis becomes "hot" with respect to earth ground. Therefore, a *polarized plug* should be used on the line cord, with the thicker pin connected to circuit ground. If a polarized plug is not available, one can be made by soldering a small piece of wire around the *edge* of one of the pins of a standard plug. On the other hand, a preferable arrangement is to use a 1:1 "isolation" transformer which can be installed between the line connection and the power input to the sentry box to prevent possible shock. A 25-watt isolation transformer should be satisfactory.

With the subchassis wiring completed and double-checked for errors, the subchassis and controls may be installed in the cabinet. The lamp socket (*SO1*) and *reset* push-button switch (*S1*) are mounted on the top of the cabinet. The two binding posts, the sensitivity control (*R3*), and the power switch (*S2*) are mounted on the front panel.

The Maze Board: The "maze" itself is a non-conducting (insulated) path through a solid sheet of conducting material. It may be made up in any one of several ways and using an almost infinite variety of designs. The maze board used with the model is shown in Fig. 16 and was etched from a copper-clad phenolic sheet using "printed circuit" techniques. A *Kepro* printed circuit kit furnished the component materials. Two other techniques might be used. One method is to cement a sheet of aluminum or copper foil to a sheet of plastic, then to cut out the desired path using a razor blade or sharp knife. Still another technique is to "paint" the desired pattern on a phenolic or plastic board using a silver conducting paint (such as *General Cement* No. 21-1 Silver Print).

Regardless of the method used to make up the maze board, several general "rules" should be followed. First, the basic design must be chosen for the players' abilities. For children, leave a fairly broad path and keep the maze simple; for adults, a relatively narrow path may be used, together with a fairly complicated maze. The game may be made even more interesting if the width of the path varies over different parts of the board. Secondly, remember that all parts of the conducting *wall* must be connected together electrically. As a maze is designed, sections of the conducting surface may be isolated. These may be connected together later by means of jumpers across the back of the board, passing through holes to the different conductors. With care, it is possible to design a maze with only two isolated conducting surfaces, which may be tied together with a single jumper. The design shown in Fig. 16 represents such a maze.

The Scribe: The scribe used with the model was made up by cementing a sharpened nail in a short piece of plastic tubing. A flexible lead was soldered to the nail before it was cemented in place. As in the case of the maze board, any one of several methods may be used for making up the scribe. Basically, the scribe is a sharpened conductor with an insulating plastic shell, and with a flexible lead to connect it to the sentry box. An old ball-point pen, if it has a plastic outer shell, could be made into a satisfactory scribe.

How the Electronic Maze Works: It's not necessary to know how the circuit operates in order to enjoy playing with the Electronic Maze. However, for those of our readers who are as much interested in "How It Works" as they are in "How to Build It," here goes. . . .

In playing the game, the player uses a metallic scribe to trace a path through a maze with conducting "walls." He is not allowed to touch a wall. If he does so, he closes an electrical circuit, causing a relay

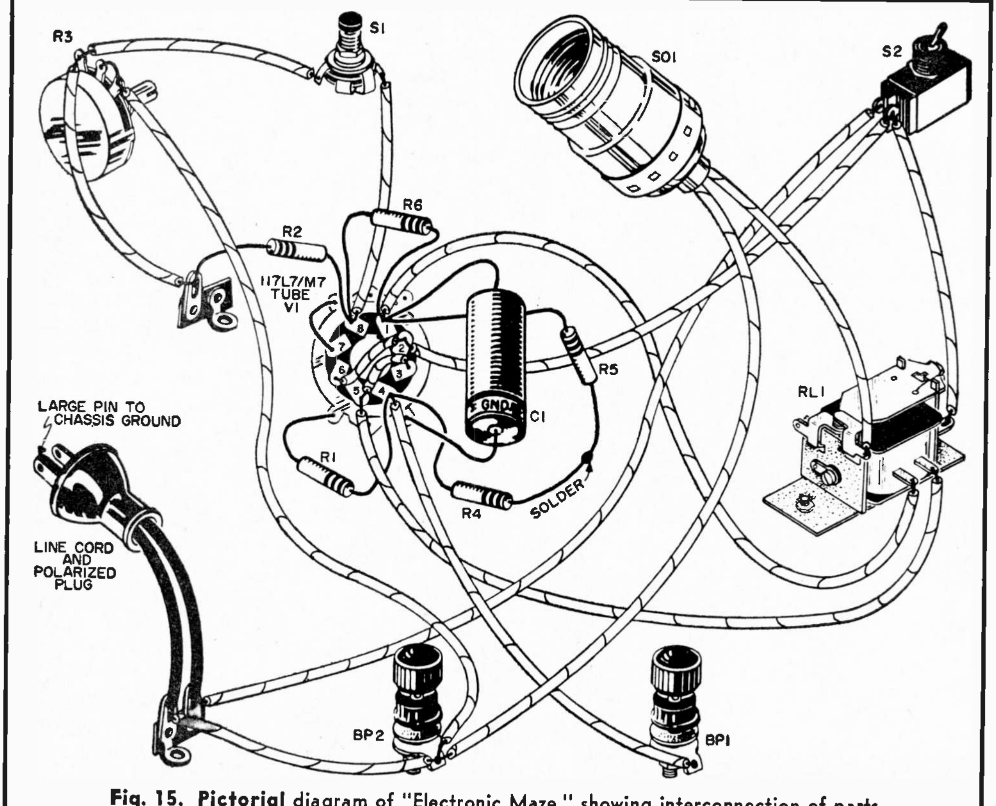


Fig. 15. Pictorial diagram of "Electronic Maze," showing interconnection of parts.

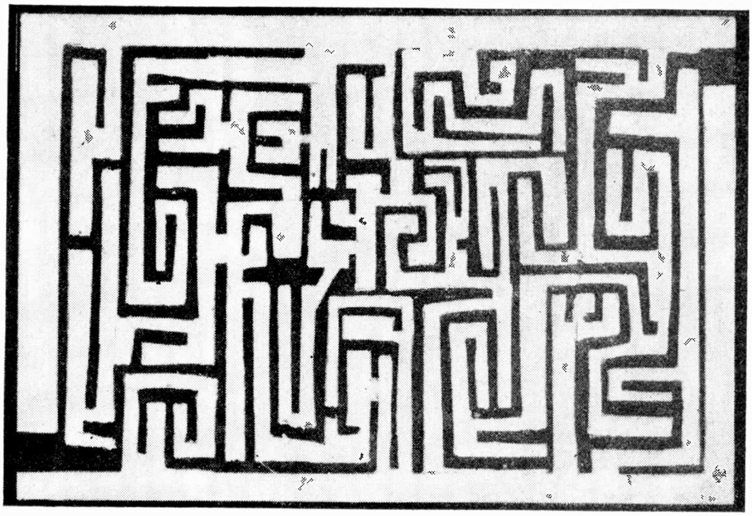


Fig. 16. Maze board used with the author's model. Over-all dimensions are approximately 3" x 4½". This is intended merely as a guide—a large variety of other designs may be easily worked out.

to operate and lighting a "tell-tale lamp." To prevent cheating, the relay locks on until reset by a push-button switch. In order to obtain the locking action and to insure positive operation even if the walls are touched quite lightly, a sensitive electronic relay is used as a sentry.

Referring to Fig. 12, the 117L7/M7 tube is a multi-purpose vacuum tube, containing a beam power amplifier and a diode rectifier within a single envelope. The screen grid and plate of the amplifier section are tied together to provide triode operation. The diode section is used as a half-wave rectifier to supply a d.c. operating voltage for the amplifier, with electrolytic capacitor *C1* serving as a filter.

In operation, cathode resistors *R2* and *R3*, together with bleeder resistor *R6*, develop sufficient bias to limit plate current below the value needed to operate the relay (*RL1*). The bias is balanced by a positive voltage applied to the grid of the tube through a high-resistance voltage divider consisting of *R1*, *R4*, and *R5*. This positive bias permits sufficient plate current to flow to hold the relay closed, but not enough to close it.

Since more current is required to close a relay than to hold it closed, the relay will stay either "locked" open or "locked" closed until the bias is upset. To close the relay initially, push-button switch *S1* (reset) is pressed, shorting cathode resistor *R2*, and dropping the cathode bias enough to permit the relay to close. The relay then remains closed as long as the binding posts connected to grid and to ground, respectively, remain open. A momentary short here, as occurs when the scribe touches a "wall" of the maze, reduces the positive bias on the grid of the tube, and allows the cathode bias to take over, reducing plate current and opening the relay. On opening, the relay applies voltage to the red bulb ("tell-tale lamp") installed in socket *SO1*. The relay remains open even after the short between the binding posts is removed, until the reset switch *S1* is depressed.

Playing the Game: With the wiring completed and double-checked for errors, install the 117L7/M7 tube in its socket, a 25-watt red lamp bulb in its socket, and close the case. Connect the maze board to *BP2*, using a flexible wire. The scribe is connected to *BP1*. With the unit plugged in to a wall receptacle and the power turned "on," allow a few minutes warm-up. Adjust the sensitivity control (*R3*) until the bulb lights (making sure that the socket switch is closed). Now, depressing the reset switch (*S1*), turn the sensitivity control back until the relay pulls in and the light goes out. Proper adjustment is reached when the relay holds in on release of the reset button. The game is now ready to be played.

The task confronting the player is to trace through the maze board, using the scribe, without touching any walls. To heighten interest, a time limit may be imposed. To provide a competitive game for several players, points may be scored for each second under the allotted time which the player does not require, and deducted for each second past the allotted time needed to complete the maze. Additional points are deducted each time the red light flashes . . . or, to make the game really "tough," the player is required to start over whenever he's "caught" by the electronic sentry.

Familiarity with the Electronic Maze will make it easy to devise many variations of the basic game. —30—

The simple "Voice-trol" for operating a model train. The device can be operated by a child and is 100 per-cent safe.

Voice Operated Model Train Control

By
KARL GREIF

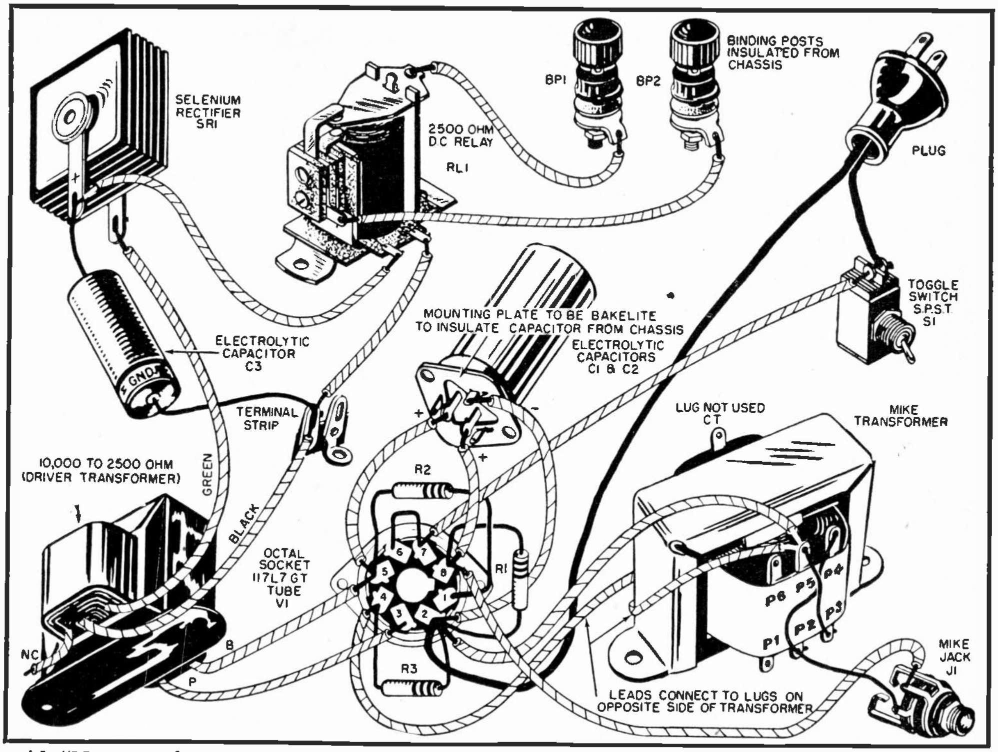
Talk your model train into performing an interesting series of switching tricks.

IF JUNIOR is starting to lose interest in that terrific electric train layout that Santa brought him, here's just the thing to revive his enthusiasm. Dad and Junior will battle for turns at the mike and will have no end of fun mystifying the neighbor kids with this electronic ear!

Designed to operate with either *American Flyer* or *Lionel* standard remote-control trains, the terminals of the "Voice-trol" are simply connected in series with one of the track feeders. That is, one of the leads from the train transformer connects to one of the binding posts on the "Voice-trol" unit. A lead from the other binding post then runs to the track. Plug the unit into any 117 volt a.c. line (house current), speak into the mike, and the regular stepping relay in the locomotive does the rest.

The entire unit is built into a 5" x 6" x 4" utility cabinet which comes with an attached chassis. Either a surplus T-17 carbon mike, or a chest set as shown, can be used. The chest set is preferable if you want both hands free. If you do use a T-17 microphone, remove the push-button coil spring and lubricate the side of the button, otherwise the noise of pressing the button will trip the relay.

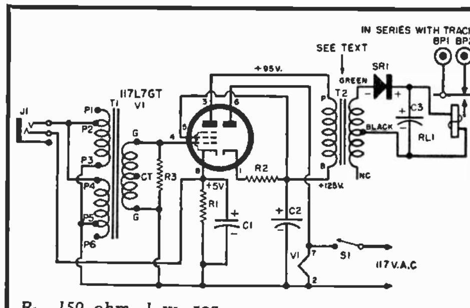
Operation is quite simple, although a little careful practice will make for better results and a much more impressive display for your friends. Speak close to the mike. Speak in a sharp, clear commanding tone, making each word distinct, otherwise the signals may run together and give an incorrect message to the locomotive. If the train is moving forward, you know it would require one press of the remote-control button to stop it. Likewise, if you say "Stop!", the "Voice-trol" sees this as a signal sound and stops the train. Another single interruption would cause the train to move backward, so you can say "Back!" If you had wanted the train to move forward, you could have



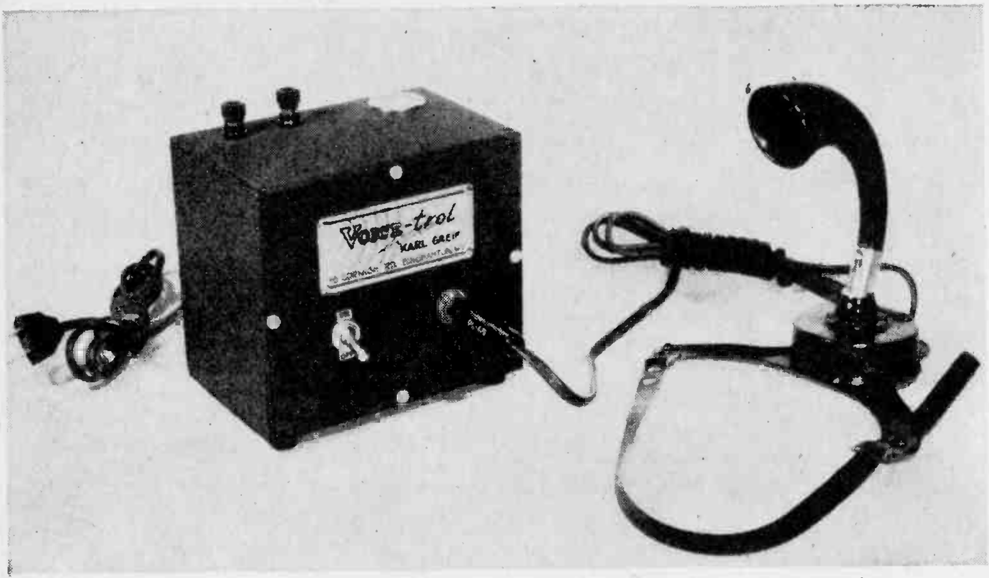
said "Now go forward!," the three words making the three interruptions required for this operation. When moving forward, say "Back up!" and the train will reverse immediately. The word "Stop!" will halt it.

When moving backward, the command "Now forward!" will send it forward again. It is only necessary to realize the normal sequence of operations of the locomotive stepping relay: forward, stop, reverse, stop, forward, stop, etc. With this in mind, you visualize how many words or syllables are necessary for the desired action. After the train has been stopped for a period of time and the next direction in which it will move is forgotten, just stay "Start!" and begin controlling after the train is in motion.

Now to building the unit! The circuit is built around a 117L7GT tube. Power for the carbon microphone is obtained from the cathode circuit of the tetrode half of this tube. (Power is automatically applied to the mike when the mike plug is inserted in the mike jack, *J1*. Note that a three-circuit jack is specified. The shank, which is grounded to the cabinet, is not used. It is necessary, therefore, to use a three-circuit plug with this jack. This method is specified to eliminate the necessity for connecting the shank of the jack to the 117 volt power line which eliminates the possibility of getting a shock from the cabinet or from the phone plug.) A standard single-button mike transformer is used to drive the grid of the tube. The amplified signal is fed to the output of transformer *T2* where it is rectified and filtered. The value of filter capacitor, *C3*, has been chosen so that it smooths out only the individual cycles of a



R_1—150 ohm, 1 w. res.
R_2—15 ohm, ½ w. res.
R_3—470,000 ohm ½ w. res.
C_1, C_2—100/40 µfd., 25/150 v. elec. capacitor (both units housed in same container)
C_3—4 µfd., 250 v. elec. capacitor
RL_1—S.p.d.t. 2500 ohm d.c. relay (Potter & Brumfield LM5 used by author. Since second contact was not used, a s.p.s.t. relay could be used instead)
SR_1—75 ma., 117 v. selenium rectifier (Federal Model 1003)
S_1—S.p.s.t. toggle switch (power "on-off")
BP_1, BP_2—Binding post (Eby)
J_1—Three-circuit microphone jack (see text)
T_1—Mike-to-grid trans. 500/333/200/125/50 ohms (Stancor A-4352 was used. Connections P_1 and P_6 on the primary and the center tap on the secondary were not used)
T_2—Output trans. 10,000 ohms to 2500 ohms (Stancor A-4713 or equiv.) The bottom half of the split secondary was not used)
V_1—117L7GT tube



Close-up view of the complete "Voice-trol" system, including chest-model microphone.

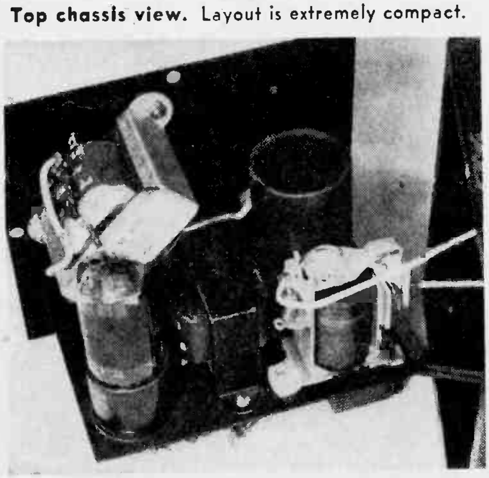
sound and does not tend to "hold up" the d.c. level between syllables or words.

The plate voltage is provided from the diode half of the tube. The relay should have an armature with as little mass as possible so as to be capable of very snappy operation. The relay mechanism should be adjusted to pick up with from 8 to 10 milliamperes of current. The rectifier, *SR1* in the circuit diagram, is mounted under the relay and held in place by the relay mounting screw.

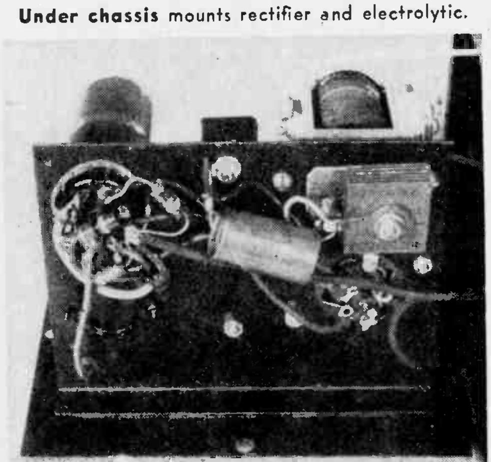
Only half of the split secondary of *T2* is utilized, the green lead located at the primary end labeled "B" being the correct one to use along with the black center-tap. If you have any doubts about this connection you can find the correct lead as follows. Whistle loudly and steadily into the mike and try each green lead. The one causing the highest voltage across the relay is correct. The circuit functions only during the period when the tube conducts heavily, or on the negative-going swings at the plate. Because of this the transformer and rectifier polarities are important.

Since the click of the relay in the "Voice-trol" is audible, it is best to just plug in the unit alone, without the train connected and practice the basic commands until you have the technique well in hand, with the relay tripping nicely for each word or syllable. Then, with the train connected, you will be ready to sit back and control your locomotive easily and surely—much to the amazement of your friends! —30—

Top chassis view. Layout is extremely compact.



Under chassis mounts rectifier and electrolytic.



By Louis E. Garner, Jr.

Music as you ride—with this simple "portable."

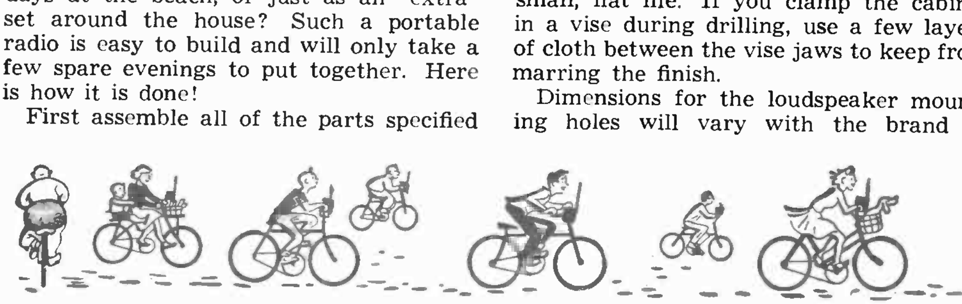
BUILD THIS SIMPLE

Bike Radio

HOW about a little music while you ride? Or perhaps you have given up bicycle riding but would like to build a bike radio for your son or daughter or other small friend. Such a radio could be put between the handlebars of the bike and is no hazard to safe riding. Or have you often thought it would be nice to have a good-looking portable receiver for those camping trips, days at the beach, or just as an "extra" set around the house? Such a portable radio is easy to build and will only take a few spare evenings to put together. Here is how it is done!

First assemble all of the parts specified in the parts list. You will note that a commercially-available cabinet and chassis are used which eliminates the problem of bending and finishing. These are drilled and punched as shown in Fig. 10. The large opening for the loudspeaker is made by punching a 1" round hole in each corner and sawing between them with a keyhole hacksaw. Final smoothing is done with a small, flat file. If you clamp the cabinet in a vise during drilling, use a few layers of cloth between the vise jaws to keep from marring the finish.

Dimensions for the loudspeaker mounting holes will vary with the brand of



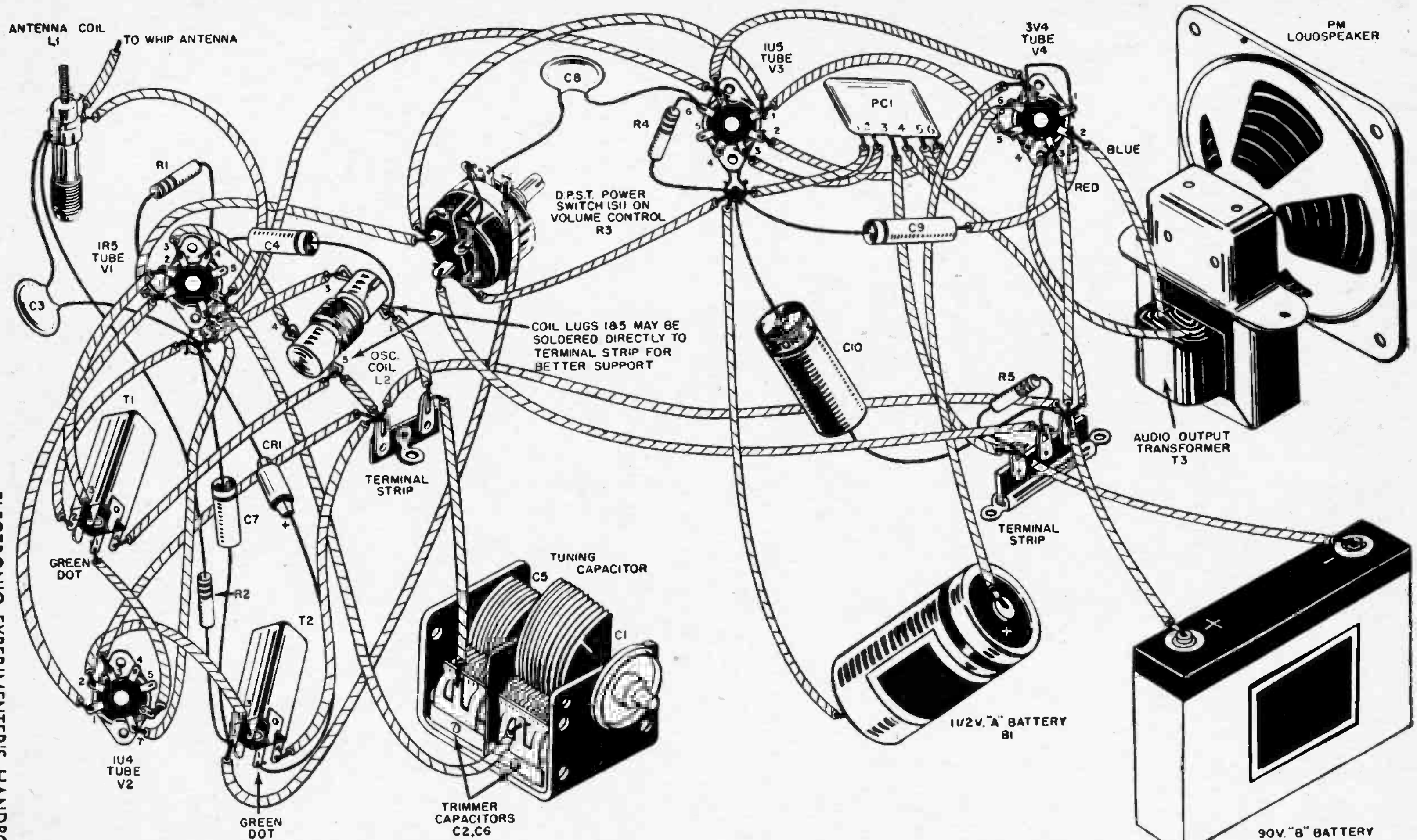
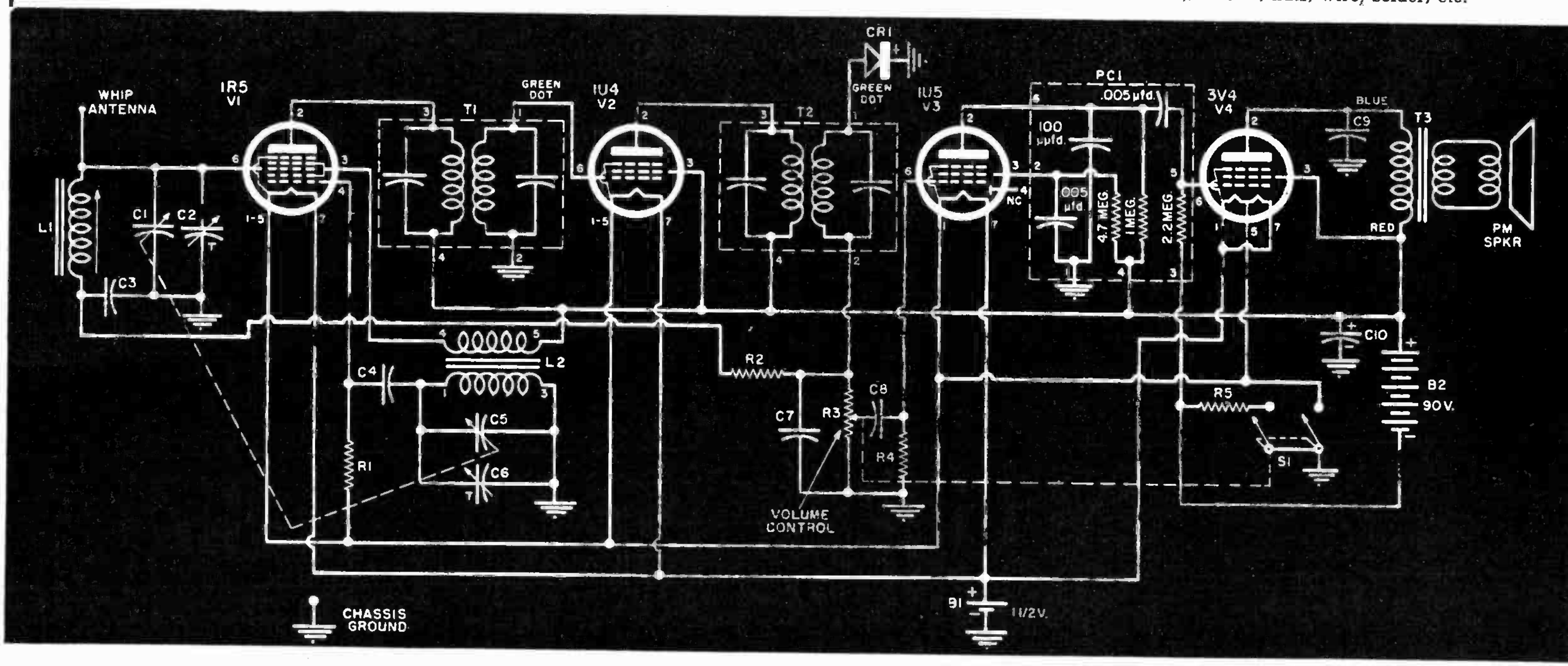


Fig. 1. Pictorial Diagram.

TRIMMERS C2,C6 MAY BE MOUNTED ON OPPOSITE SIDE OF VARIABLE CAPACITOR

Fig. 2. Complete schematic and parts list for the four-tube "bike" radio receiver.

R1—100,000 ohm, ½ w. res.
R2—4.7 megohm, ½ w. res.
R3—1 megohm potentiometer with switch (S1), audio taper ("Volume Control")
R4—10 megohm, ½ w. res.
R5—470 ohm, 2 w. res.
C1, C5—Two-gang broadcast-type tuning capacitor (Philmore No. 904S) with trimmers (C2, C6)
C3—.01 μfd. disc ceramic capacitor
C4—50 μμfd. ceramic capacitor
C7—100 μμfd. ceramic capacitor
C8—.002 μfd. disc ceramic capacitor
C9—.005 μfd., 200 v. capacitor
C10—8 μfd., 150 v. elec. capacitor
L1—Antenna coil (Superex "Vari-Loopstick")
L2—Miniature broadcast osc. coil (Miller No. 70-Osc.)
S1—D.p.s.t. "Power" switch (on R3)
T1—455 kc. input i.f. trans. (Miller No. 10-C1)
T2—455 kc. output i.f. trans. (Miller No. 10-C2)
T3—Audio output trans. to match 10,000 ohms to speaker voice coil (A "universal" output trans. such as the Stancor A-3856, may be used if desired)
PC1—Printed circuit pentode plate coupler (Erie No. 1407-03)
CR1—1N34 germanium crystal diode
B1—1½ volt "A" battery (RCA VS-236, size G)
B2—90 volt "B" battery (Burgess No. N60)
V1—1R5 tube
V2—1U4 tube
V3—1U5 tube
V4—3V4 tube
1—3½ inch PM loudspeaker
1—Whip antenna (salvage from TV "rabbit ears" or use an auto antenna)
1—Tuning dial (National Type AM was used)
1—Cabinet (Bud No. CU-2110 "Minibox")
1—Chassis (Insuline No. 29060)
4—7-pin miniature tube sockets
Misc. 1 knob for volume control; 1 standoff insulator; 1 feedthrough insulator; 1 kitchen cabinet handle; 5" x 5" flocked screen material; 2 ground lugs; 1 two-terminal strip; 1 three-terminal strip; 90-volt battery harness; 2 "U" bolts to fit bike handle bars; rubber tubing to cover "U" bolts; 8' strip of ½" wide, .050 aluminum or 20 ga. steel (for battery brackets); screws; nuts; wire; solder; etc.



speaker you use. Determine the correct location by holding your speaker against the back of the front panel, then mark the correct spots.

After you have finished all drilling and filing operations on the front panel you can apply decals to identify the "Tuning" and "Volume" controls. Follow the manufacturer's instructions for applying these. When the decals are dry, spray the front panel with about three coats of transparent plastic spray for protection.

The square mounting holes for the i.f. transformers can best be made by first cutting or punching a ½" x ½" square hole, as shown in Fig. 9 (top), then filing until the transformer just slips into place. Use a square *Greenlee* or *Pioneer* punch or a cold chisel for making the initial hole.

The tube sockets and other parts are mounted on the chassis as shown in Fig. 6. Use ¼" 4-40 machine screws and small hex nuts for the tube sockets and terminal strip and ¼" 6-32 screws for the tuning capacitor. Mount the i.f. transformers by bending the mounting lugs flat against the chassis.

The tuning dial, volume control, and loudspeaker are mounted on the front panel. Use flocked screening to protect the speaker. You may wish to reinforce the screening with cardboard over the speaker opening but if you do, cut a 1" x 3" hole in it as an air passage (see Fig. 7) otherwise the sound will be muffled when the radio is mounted in its cabinet.

Details for mounting the antenna are shown in Fig. 3. A feedthrough insulator is used for the bottom mounting and a simple standoff insulator used for the top mounting. The upper mounting ring was made by soldering a flat washer to a machine screw. The antenna itself was salvaged from a discarded TV "rabbit ears" antenna. A small auto antenna may be used instead, if desired.

The batteries are mounted to the back of the case by a single bracket and a ⅜" 8-32 screw and nut, as shown in Fig. 5. Simply bend a strip of ½" wide sheet metal to fit over the two batteries, as shown.

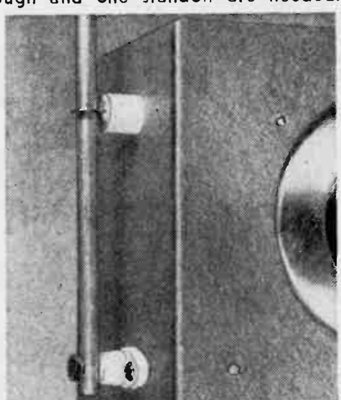
A kitchen-cabinet door handle is mounted on the top of the case with two machine screws to make the receiver "portable."

The pictorial wiring diagram and the complete schematic are given in Figs. 1 and 2 respectively. The author found it easier to wire the chassis as a separate unit before attaching it to the front panel. Final connections to the antenna, volume control, loudspeaker, and batteries may be made after mounting.

A commercially-available printed circuit is used for coupling the 1U5 and 3V4 stages. If you prefer, however, you may use individual parts in place of the printed circuit. Parts values for these components are given on the diagram of Fig. 2.

The oscillator coil, *L2*, is mounted simply by soldering it to the two-terminal "tie-

Fig. 3. Details of antenna mounting. One feedthrough and one standoff are needed.



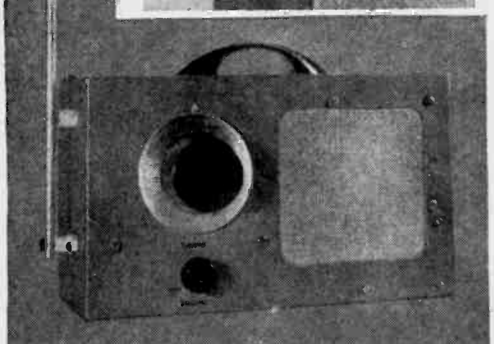


Fig. 4. The completed receiver is a handsome and compact portable anyone will be proud to claim.

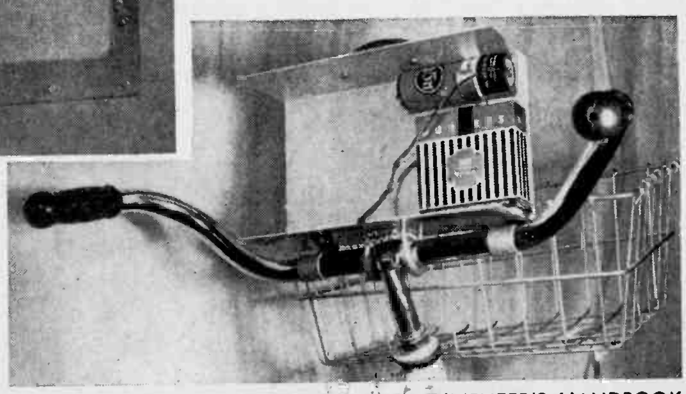


Fig. 5. Mounting the completed receiver on a bike. Case is affixed to handle bars with "U" bolts, then chassis is mounted in case.

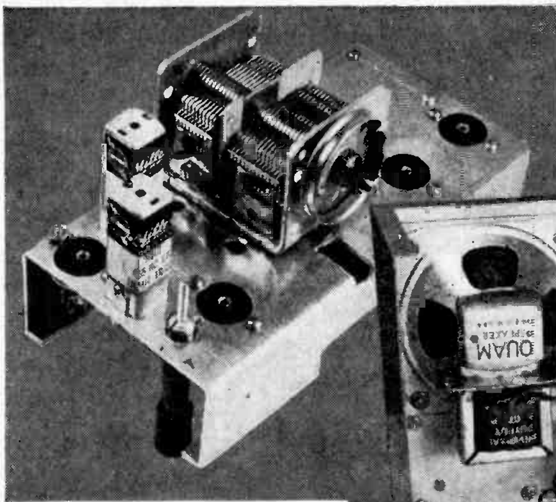


Fig. 6. **Above-chassis view** of the receiver showing the major parts mounted. Section of tuning capacitor with small rotor plates is the "oscillator" unit.

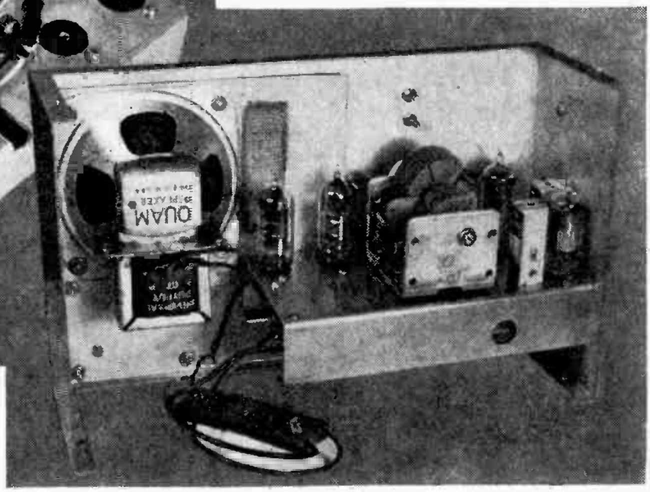


Fig. 7. Interior view of the completed receiver. Because of the roomy layout, the builder should experience no construction difficulty. Mount all parts rigidly.

point" strip, as shown in Fig. 1. Flow sufficient solder over the connections to insure a strong joint.

Once the wiring is completed and double checked for errors, the receiver may be aligned. You'll need an r.f. signal generator and a small alignment tool for this operation. Place all tubes in their proper sockets and connect the batteries.

Turn on the signal generator and allow it to warm up for a few minutes. It isn't necessary to let the receiver warm up. Couple the signal generator loosely to the antenna by wrapping two turns of insulated wire around the antenna and connecting the "hot" lead of the signal generator to them. The "ground" lead should be connected to the receiver chassis.

With the signal generator set to deliver a 455 kc. modulated signal, turn on the receiver and turn up the volume control to full volume. Connect a wire between the stator plates of the oscillator section of the tuning capacitor and ground. Close the tuning capacitor plates.

Adjust the i.f. transformers for maximum output as determined by the tone heard in the loudspeaker. Use the minimum signal from the signal generator needed to permit a tone to be heard with the maximum setting of the "Volume" control.

If oscillation occurs during this part of the alignment procedure, use the best i.f. peaking you can obtain before oscillation takes place—you can touch up the i.f. transformers later.

Once the i.f. transformers are peaked, remove the wire from the tuning capacitor's oscillator section and set the tuning capacitor to minimum capacity. Set the signal generator to 1600 kc. and adjust the local oscillator and antenna trimmer capacitors for maximum output (*C2* and *C6*, Fig. 2, mounted on the tuning capacitor).

Set the signal generator to 1400 kc. and adjust the tuning dial until the signal is heard in the loudspeaker. Then adjust the antenna coil, *L1*, for maximum output.

Next set the signal generator to 550 kc. and adjust the tuning dial until the capacitor plates are fully closed. "Rock" the

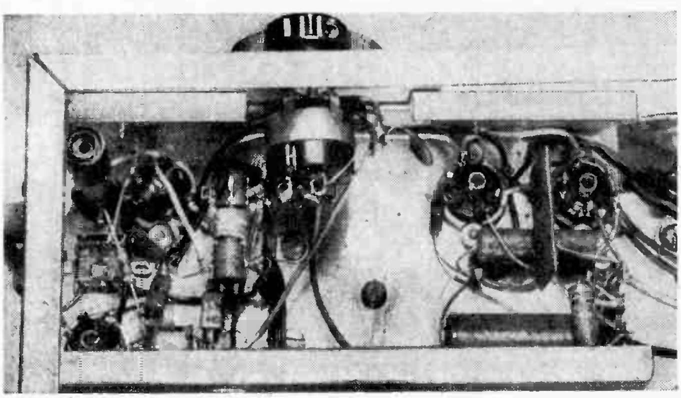
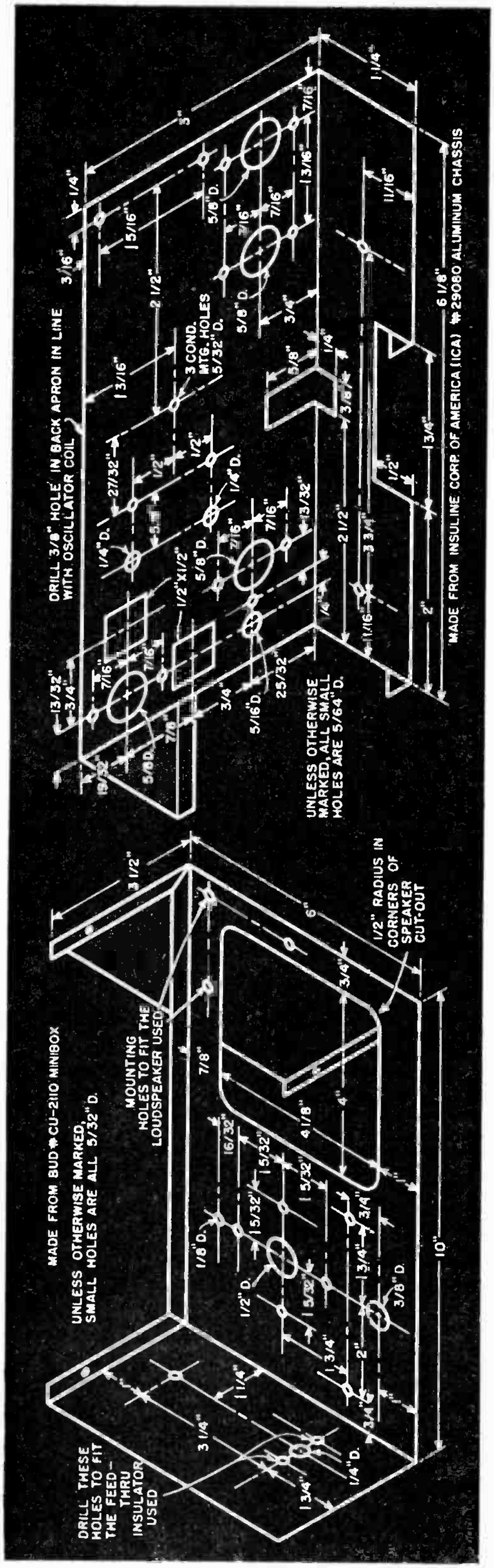


Fig. 8. Under chassis view of the completely wired radio.



capacitor plates slowly back and forth and adjust the oscillator coil, *L2*, for maximum output.

Repeat the adjustments at 1600, 1400, and 550 kc. at least three times, as one adjustment will affect the others. Try to obtain the best possible compromise during the operation.

If the thought of trying to align your receiver gives you a weak-in-the-knees feeling or you can't locate a signal generator with which to perform this operation, your local radio technician or a friendly radio amateur with a small lab will probably be glad to do the job for you—so don't hesitate to build this handy portable on that account.

You may mount the completed receiver on the bicycle handle bars by using small "U" bolts, as shown in Fig. 5. Use cardboard or small wood blocks between the receiver case and the handle bars to protect the finish on both the case and the bicycle. For the same reason, slip short pieces of rubber tubing over the "U" bolts.

Just a word of caution when using this portable receiver as a bike radio. Don't become so engrossed in the radio programs while riding that you fail to watch the traffic. It only takes a moment's inattention to cause an accident!

If the idea hasn't already occurred to you, I would like to suggest that the cabinet can be dressed up and "personalized" by the addition of some snappy decals in color or the cabinet itself may be sprayed with enamel to match or contrast with the bike's paint job. Since the receiver isn't hard to build, clubs could construct a number of these portables on an "assembly line" basis so that members could have matching portables when the group goes on bike jaunts together. We are willing to bet that once you start the fad, other groups will be following suit in short order.

If you don't want to mount the bike radio permanently, you can carry it in your bicycle basket. You will find that the completed receiver makes a compact and handsome portable you will be proud to use anywhere!

For trouble-free performance the author suggests that the novice builder duplicate the instructions and dimensions given in the mechanical diagrams exactly. Those with a little more experience in building electronic gear can take some liberties wth chassis layout and cabinet size and shape. —30—

← **Fig. 9.** (Top) Mechanical details of the chassis layout. A standard chassis base is used. (Bottom) Front panel layout. Take care not to mar the finish while drilling.

Build A Child's Record Player

Simple one- or three-speed record player for children.

A SMALL, lightweight phonograph, like the one shown in the photo, can give a good deal of pleasure to your children. You shouldn't have much difficulty in building a similar unit in a few evenings' time.

Use a child's or doll's "overnight" bag for the basic case. Be sure to choose one large enough. The one shown measures approximately 10" x 12" x 5" inside. In each corner of the case glue a small triangular wooden block. The height should be chosen so the plywood board will fit flush when the case is open.

Cut a piece of ¼" or ⅜" plywood to fit the case. The cut-outs needed in the board will depend on the phono motor, loudspeaker, and carrying case you use. Locate the mounting hole for the crystal pickup by using the template furnished by the manufacturer.

The output transformer is mounted on the loudspeaker and the entire assembly is then mounted on the board. Use flocked screening over the speaker opening for protection. Mount the motor on the board.

The chassis is made up from a piece of .050 aluminum or 20 ga. steel. A single right-angle bend is required, as shown.

Fasten the chassis to the board with the nut that holds the crystal pickup in place. The 6-position terminal strip is held in place with ¼" #8 sheet metal screws. These go right through the chassis and bite into the board, also helping to secure the chassis.

The tube socket is mounted with ¼" 4-40 machine screws and small hex nuts. A long bolt is used to mount the selenium rectifier.

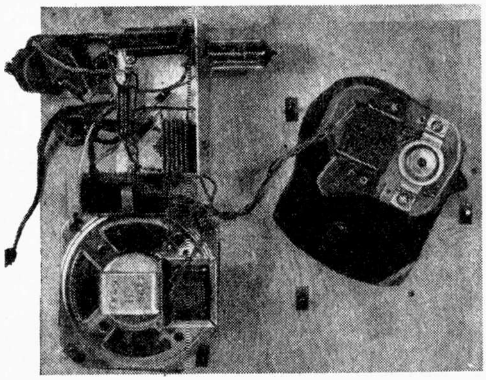
Separate power switch and volume control are used and mounted, respectively, on the board next to the chassis and the side of the carrying case. You may prefer to combine these two parts and mount them where the power switch is shown.

This circuit features "instant-heating" operation—no warm-up time is required. Because of this, it is practical to have a single power switch for both the motor and the electronic circuit.

C1 and *C2* are not critical. Values from 40 to 80 µfd. at 150 v. (or higher) may be used here. Any value from 20 to 40 µfd. may be used for *C3*. Values from .01 µfd. to .05 µfd. are satisfactory for *C4* and *C5*.

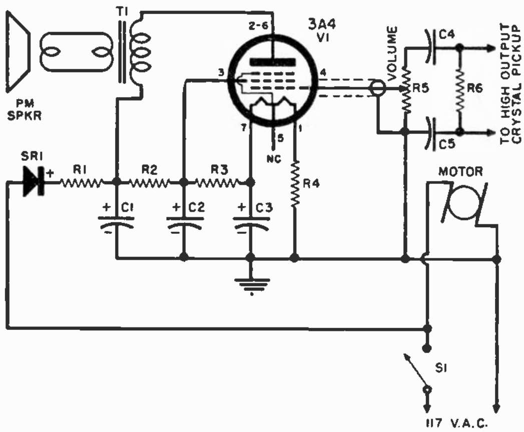
Once you've completed all wiring, double check for possible errors. Place the tube in its socket and plug the unit in. Turn the power switch on and the volume control to full output. Touch your finger to the phono needle—you should hear a scratching sound in the loudspeaker.

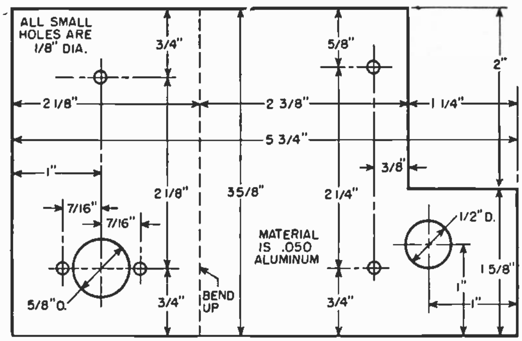
After testing, mount the wired board in its carrying case and the phonograph is ready for use. —30—



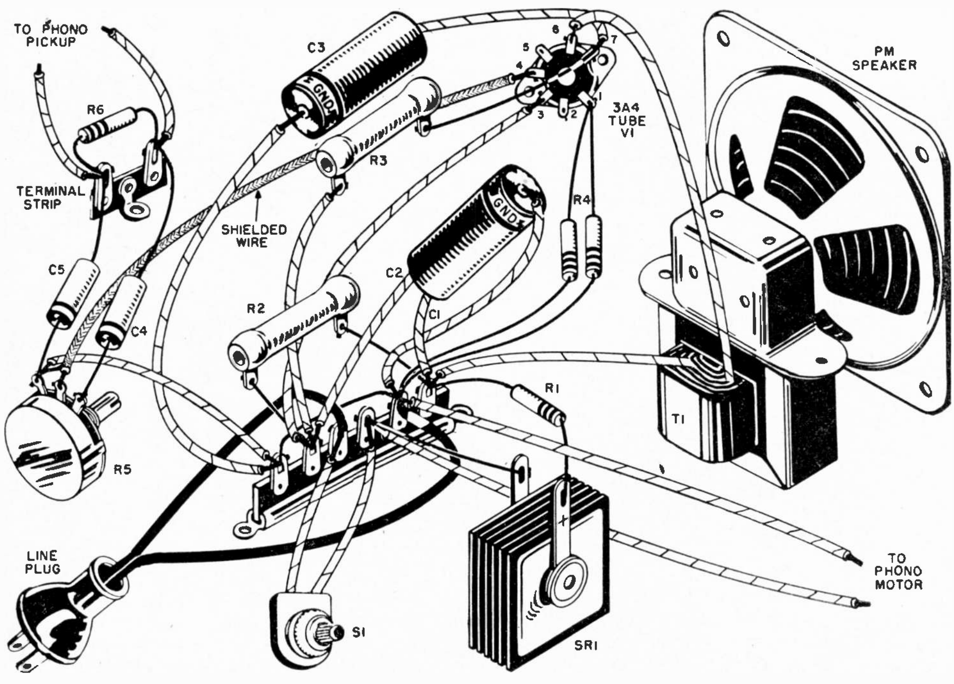
Bottom view of record player motor and amplifier shows wiring and mounting.

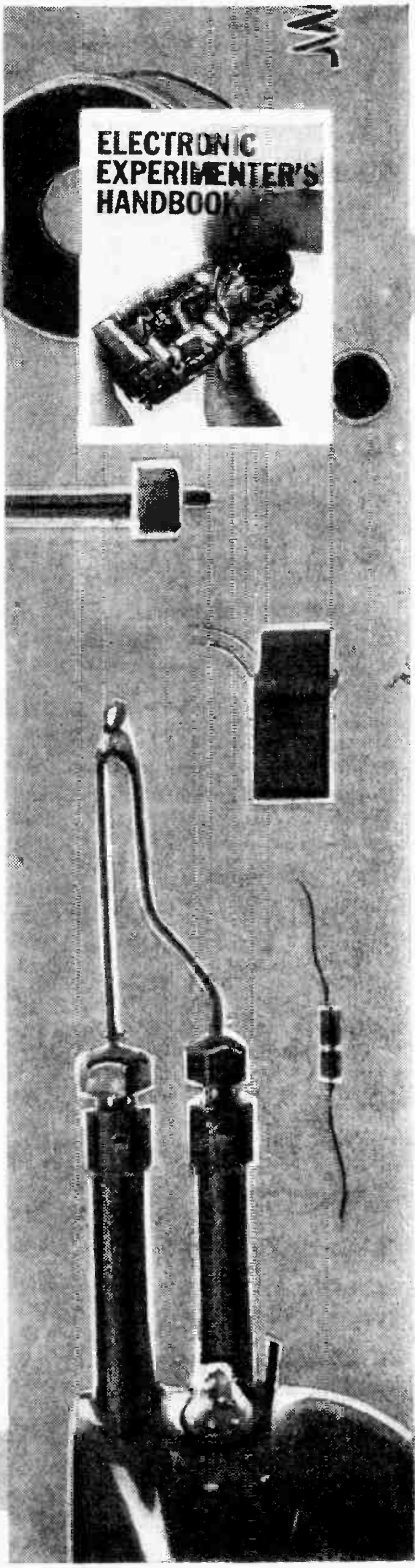
R_1—27 ohm, 2 w. res.
R_2—250 ohm, 10 w. wirewound res.
R_3—800 ohm, 20 w. wirewound res.
R_4—75 ohm, 1 w. res. (two 150 ohm, ½ w. res. in parallel)
R_5—2 megohm audio taper pot
R_6—1 megohm, ½ w. res.
C_1, C_2—50/50 μfd., 150 v. dual elec. capacitor
C_3—20 μfd., 150 v. elec. capacitor
C_4, C_5—.02 μfd., 200 v. capacitor
T_1—Small output trans. to match 8000 ohms to speaker voice coil
S_1—S.p.s.t. rotary switch
SR_1—150 ma. selenium rectifier
V_1—3A4 tube
PM Spkr.—4" to 6" PM loudspeaker
Motor—Phono turntable and motor, General Industries Models LC or LX, Alliance Model MP8 (for single-speed 78 rpm) or General Industries Models DSS, SS, or TR or Alliance Model JPT8 (for three-speed)
1—High-output phono pickup, Astatic P-12, Shure 96A, or American J1 (for 78 rpm), or Astatic P-29 or Shure 92-U (for three-speed)
Misc.—7-pin miniature tube socket, 6-terminal strip, line cord and plug, knob (volume control), small suitcase (see text), 4" x 6" pc. aluminum, ¼" or ⅜" plywood to fit case, 6" sq. pc. flocked screening, wire, solder, screws, etc.





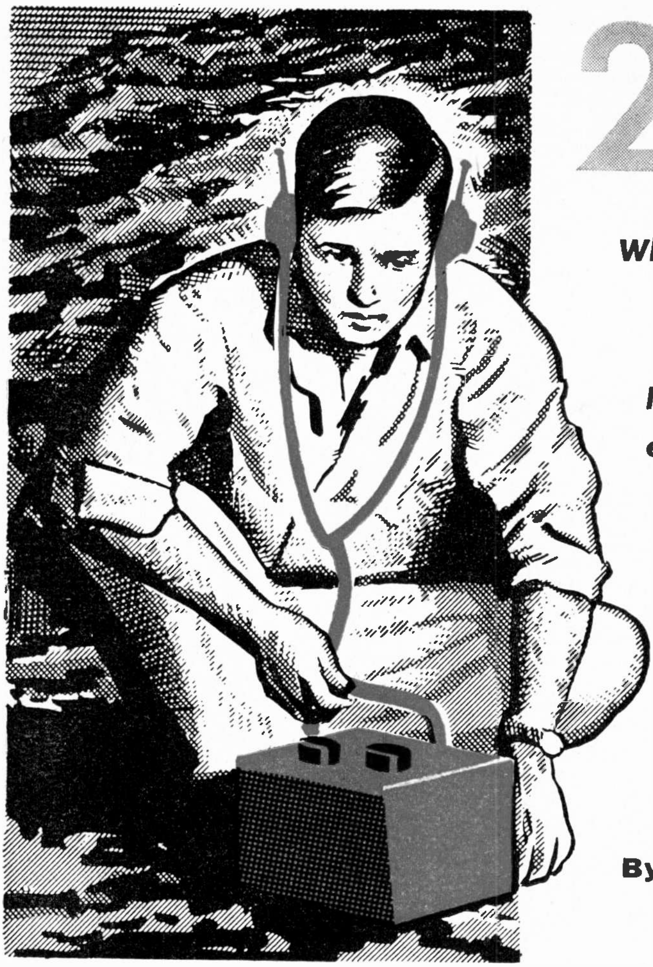
Shown here are the schematic diagram and parts list (above), the chassis drawing (right), and the pictorial wiring diagram (below). These, together with the text and the photographs on page 69, give you all the information you need to build this compact record player.





Chapter 3

For the Outdoorman



2 SIMPLE

What are you looking for in a Geiger counter? These two units feature light weight, small size, economy and simplicity —take your choice!

UNIT ONE

By James E. Pugh Jr.

YOU CAN ENJOY prospecting for uranium if your equipment isn't so heavy that it bogs you down, and if you don't have to carry a set of spare batteries around with you because of the high current drawn by the equipment. Also, you'll probably be able to have more fun with your equipment if you haven't spent a fortune to build it. And if it is simple to construct and maintain, so much the better.

The first instrument to be described here was designed for your enjoyment—it takes full advantage of the small size, light weight and low operating cost of a transistor amplifier combined with a relatively cheap Geiger counter tube.

An ideal enclosure for this instrument is a 3″ x 4″ x 5″ utility box. Total weight, including batteries, is less than 2½ lbs. The physical layout, shown in the photos, lends itself to easy assembly and is such that batteries can be easily replaced.

Exact layout is not critical, but the 300-volt battery takes up a large portion of the available space; so it is well to plan carefully in advance to make sure that everything fits.

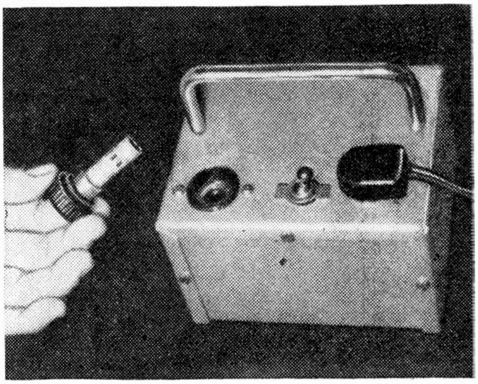
Proper mechanical balance is obtained by locating the handle off center. This technique also allows more room for the controls on top of the case. The battery strap is mounted on one side of the bottom section of the case, and consists of a single strip of metal clamped to the battery by two long screws.

A simple mount for the counter tube can be fashioned from a sheet of ⅛″ polystyrene 1½″ x 4″ and a 3″ piece of ½″ i.d. polystyrene tubing. Cement the tubing lengthwise on top of the sheet about 3/16″ from one end. Drill a hole at the other end of the sheet and mount a 2-terminal tie point at this same location, with a flat-head screw recessed flush on the bottom. Wrap a 3″ x ⅛″ rubber band around the 1B86 as in Fig. 2 (page 76), slip the assembly inside the plastic tube, and carefully solder the 1B86 leads to the tie point. Center the

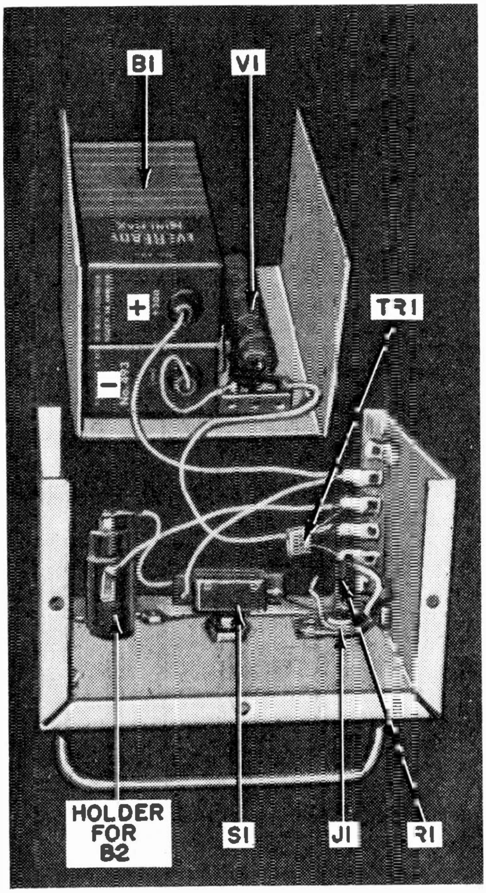
Transistorized Geiger Counters

Geiger tube assembly in the bottom of the case after the 300-volt battery has been installed, and cement in place with Polyweld "912" or a similar cement.

For the 1½-volt battery holder, modify a type HPC fuse holder as shown in Fig. 3. First, clamp the lug in a vise, pull the fuse holder outward to compress the internal spring, and cut off the shaft as close as possible. Disassemble the holder, and drill and tap the shaft as shown. Replace the original spring with a two-turn volute—or spiral—spring clipped from a medium-sized spring in a General Cement assort-



Weighing less than 2½ pounds, the first unit is housed in a 3" x 4" x 5" utility box. Fuse holder is modified to take the 1½-volt penlite cell as shown in Fig. 3 on page 76. Placing the handle off-center makes for proper mechanical balance.



Interior view (at left) shows location of important components and wiring details. As the 300-volt battery fills up much of the available space, care must be taken to make sure that everything fits — although the exact layout is not critical.

HOW IT WORKS

Two basic circuits for the first unit are shown in Fig. 1, one for an *n-p-n* transistor and the other for a *p-n-p* transistor. Aside from polarities, the circuits are identical and should provide equal performance, assuming that the transistors are equivalent. At the present, most *p-n-p* transistors are a little cheaper.

When a beta or gamma ray passes through *V1*, the gas in the tube ionizes and a small pulse of current flows through *R1*. This pulse is amplified by the transistor and appears as a click in the headphones.

A potential of 300 volts is required for operation of the Geiger tube. This is provided by a special 300-volt battery. Although fairly expensive, the current drain is very low, and battery life approximates shelf life. The transistor itself operates on 1½ volts and gives a gain of about 20 db. Here again, the current drain is very low—about 50 microamperes—which gives very long battery life.

High-impedance headphones will give good performance, but they must be of the magnetic type to provide a d.c. path for the collector circuit of *TR1*. The standard 2000-ohm units are satisfactory, but the Trimm 24,000-ohm style will give somewhat better volume.

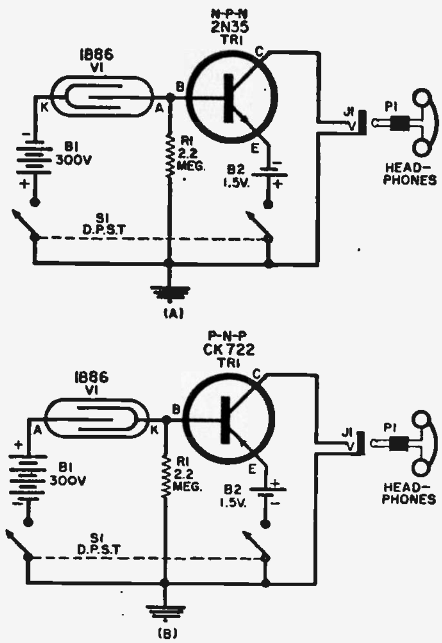
ment. Check Fig. 3 carefully for assembly details. When completed, a Burgess No. 7 penlite cell will fit nicely inside.

Mount a 4-lug tie point on one end of the case, as shown in the photograph above. Complete the wiring, including the 300-volt battery plugs, and solder all joints carefully. Excessive heat can permanently damage the transistor—grip the leads with long-nose pliers between the transistor and the point being heated, and don't remove the pliers until the joint has cooled.

Insert the battery in the fuse holder. Polarity will depend on the transistor used: for an *n-p-n* unit, insert the positive end first; reverse for a *p-n-p* unit. Plug in the

Fig. 1. Basic circuit for (A) n-p-n transistor and (B) p-n-p transistor. Parts list applies to both.

B1—300-volt battery (Eveready 493 or equivalent)
B2—1½-volt penlite cell (Burgess No. 7 or equivalent)
J1—Open-circuit phone jack (miniature)
P1—Phone plug to fit jack
R1—2.2-megohm resistor
S1—D.p.s.t. toggle switch
TR1—Type 2N35 or CK722 transistor (see text)
V1—Type 1B86 Geiger tube (Victoreen)
1—Pair of headphones (Trimm 24,000-ohm Featherweight)—see "How It Works"
1—Panel-mounted fuse holder (Buss HPC)
1—3" x 4" x 5" aluminum case (ICA Fleximount)
1—Handle (U. S. Eng. Co. No. 1010 or equiv.)
1—2-terminal tie point
1—5-terminal tie point
1—Set of battery plugs (Amphenol 71-1L and 71-1M)
1—Sheet of ⅛" polystyrene, 4" x 1½"
1—½" i.d. polystyrene tubing, 3" long
1—Coil spring (see text)
1—On-off switch plate
1—3" x ⅛" rubber band
Misc. wire, solder, machine screws, etc.



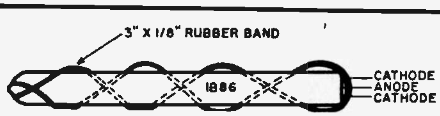


Fig. 2. How rubber band is wound around tube.

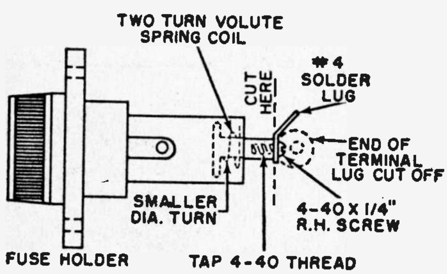


Fig. 3. The modification of the fuse holder.

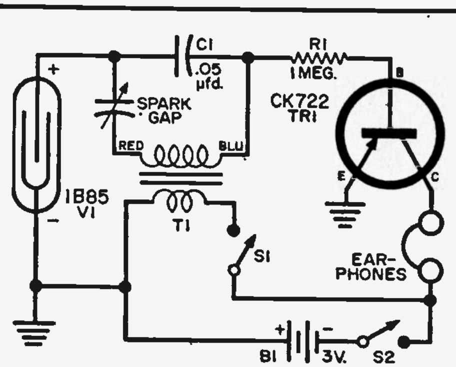
high-voltage battery connectors, turn on the switch, and listen for clicks. With no uranium in the vicinity, you should get a background count of about 30 clicks per minute.

UNIT TWO

By Wayne Milburn

For extreme simplicity and economy of initial cost and maintenance, this Geiger counter is hard to beat. The two 1½-volt flashlight cells give excellent life as the current drain is about 100 microamperes and few parts are needed.

A novel technique is employed to produce the high voltage (800-900 volts) for the Geiger tube. D.c. from the battery is passed



Schematic diagram and parts for second Geiger counter. A p-n-p junction transistor is used here.

B1—Two 1½-volt flashlight cells
C1—0.5-μfd., 1000-volt plastic sealed capacitor (author used 600-volt rating, but higher rating is desirable)
R1—1-megohm, ½-watt resistor
S1—S.p.s.t. Microswitch or any snap-action spring-return switch
S2—S.p.s.t. toggle switch
T1—Small audio output transformer, such as 4000 ohms to 4-ohm voice coil (not critical—almost any output transformer should operate satisfactorily)
Gap—Altered 3-30 μμfd. trimmer capacitor (see text)
TR1—CK722 p-n-p junction transistor
V1—Geiger counter tube (Victoreen 1B85 or Raytheon CK1026)
1—3" x 4" x 5" aluminum cabinet
1—Kitchen cabinet handle
Misc. wire, solder, terminal strips, phone jack, etc.

through the voice-coil winding of an output transformer, and then quickly interrupted by the switch *S1*—inducing a high-voltage surge in the high-impedance winding. This surge will have two polarities—one when the primary current starts flowing, and one when it ceases. The larger of the surges will break down the special spark gap, and will charge up capacitor *C1*. This high voltage is then used to operate the Geiger tube.

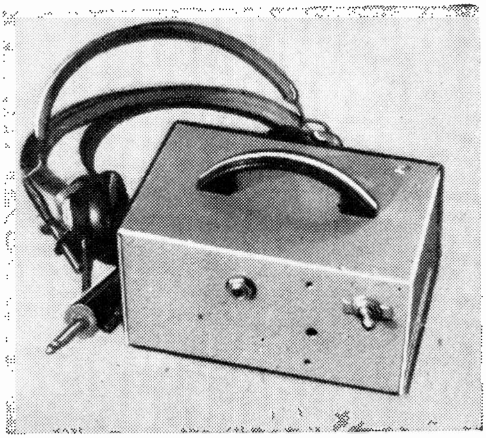
Heart of the device is the special spark gap, made from a small 3-30 μμfd. trimmer capacitor. Unscrew the adjusting screw, remove the mica insulation, and replace the screw. Adjust the screw to the point where it rectifies the transformed voltage but will not arc back.

It is essential that *C1* be charged to the proper polarity, as indicated in the schematic. Use a high-impedance voltmeter to determine polarity. If it is incorrect, reverse the voice coil leads in the transformer.

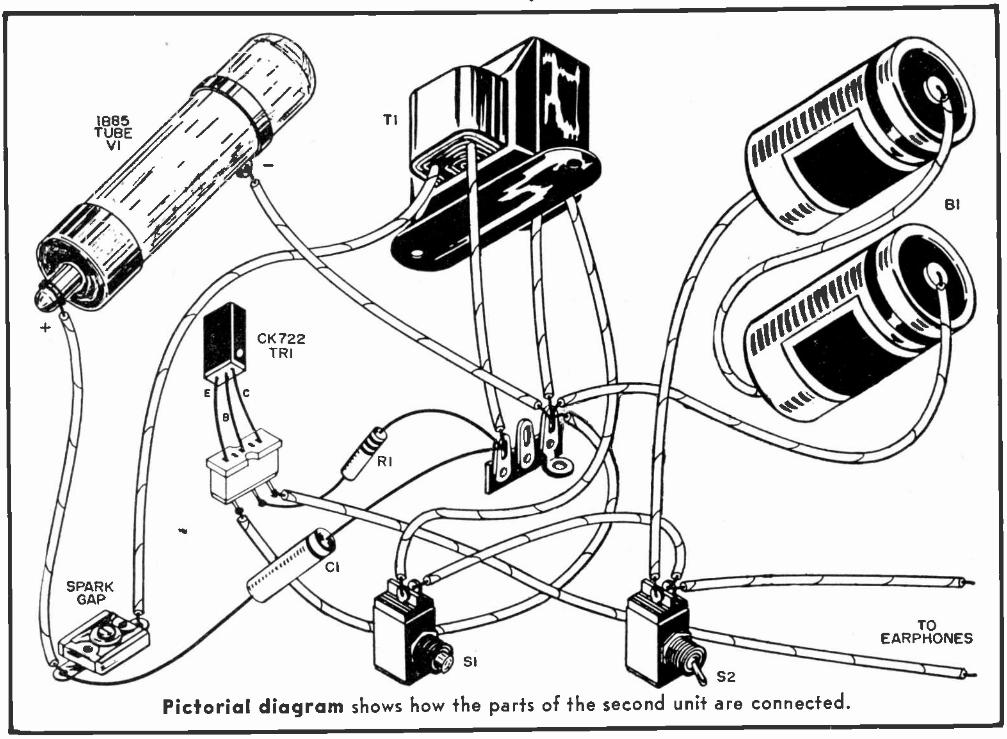
This arrangement should give 800-900 volts after 20 or 30 pulsings of *S1*, depending on the turns ratio of the transformer. Use a high-quality capacitor for *C1*, and make certain that it is well insulated from ground. A single charging should operate the Geiger tube for several minutes. An occasional push on the switch will then keep the counter in operation.

To provide comfortable headphone volume for the clicks, a transistor amplifier is included in the unit. It is direct-coupled to the counter tube, that is, the pulses of current from the counter tube also pass through the base-emitter circuit of *TR1*. *R1* serves to protect the transistor in case of an avalanche discharge through *V1*. Magnetic headphones must be employed to provide a d.c. path for the collector circuit of *TR1*.

Although inexpensive and simple to build, this counter will give reliable indications of the presence of radioactive material. Try it out on your luminous dial watch to check its operation. —30—



This unit, also housed in a 3" x 4" x 5" box, employs spark gap made from a trimmer capacitor.



Pictorial diagram shows how the parts of the second unit are connected.

Single Transistor Megaphone

By
LOUIS E. GARNER, JR.

Save your voice . . . let the electronic megaphone do all your shouting for you

ATHLETIC COACHES, lifeguards, policemen, firemen, plant guards, construction foremen, CD workers, and carnival spielers are but a few of the people who need to use their voices to issue commands, make requests, outline directions or to instruct and influence the public. If you or any of your friends have ever handled one of these jobs, you'll know how easy it is to strain your lungs and vocal chords in the attempt to outshout background din or to project your voice over a moderate distance. And you'll know how valuable a simple megaphone can be in directing your voice.

The conventional megaphone is a conical tube used to concentrate and to direct one's voice. It is named from the two Greek words meaning "great or mighty" (*mega*) and "sound or voice" (*-phone*). While such an instrument does concentrate and direct the voice, the user still has to shout to obtain any real volume. Even if the only time you have to raise your voice is to call the children home from play, you won't have to strain your lungs to give your voice the authority of power when you use the electronic megaphone described here. Lightweight, compact, portable and comparatively inexpensive, this instrument can be assembled and wired in one or two evenings, even by a hobbyist who is still fairly new to the electronics "game."

Construction Hints

In the author's model, the amplifier circuit is housed in a standard ICA "Channel-lock" aluminum utility box. The University speaker trumpet, battery boxes, terminal strip, and transistor were attached to this housing. The microphone is mounted by cutting a slightly undersized hole in the "back" cover of the amplifier housing, then using a force fit to mount the microphone cartridge and its rubber mounting ring in place. If you wish, you can apply a thin

Most transistor projects feature the use of low-power transistors. "High-power" units (1 to 5 watt ratings) have, in the past, been relatively expensive and difficult to obtain. The device described in this article uses a commercially available power transistor. Although the transistor used is more costly than lower power units, the total cost of the components needed is comparable with other transistor projects—for only a single transistor is used and other expensive components, such as matching and interstage transformers, have been eliminated. Thus, this project is suitable both for the more advanced worker desiring to gain experience with power transistor circuits and the experimenter looking for a simple—yet useful—project.

THE EDITORS

coating of rubber-to-metal cement around the rubber mounting ring prior to installation.

In the interior view of the completed model, the parts arrangement used by the author is clearly shown. However, since neither circuit layout nor lead dress are critical, you can either follow the model or design your own amplifier "cabinet" and layout, as you choose. Resistor *R1* is made up of three (3) 10-ohm, 1-watt carbon resistors, installed so that all three may be connected in parallel, two may be used in parallel, or one may be used alone. The final arrangement is determined after all wiring is completed and the unit is ready for test. Connect the microphone's return lead temporarily to the center of the power pack, so that only three (rather than six) volts are applied to this circuit.

The 2N68 power transistor may be supplied with either of two types of lead connections. These are shown at (A) and (B) in Fig. 1. If your unit is provided with the lead arrangement shown at (B), you can use a subminiature "in-line" tube socket for the transistor. If your unit has the lead arrangement shown at (A), you'll have to make soldered connections to the transistor terminals. Leave the transistor leads at least one inch long and protect with insulating spaghetti tubing. While soldering each connection, hold the lead with a pair of long-nosed pliers at a point between the body of the transistor and the place where the soldering iron is applied. The pliers act as a "heat sink" to absorb excess heat and to prevent accidental damage to the transistor.

Note that no "ground" connection is shown in the schematic diagram. The collector electrode of the transistor is connected—internally—to its outer shell, and this is automatically "grounded" to the amplifier housing when the transistor is installed. *Do not connect any other component of this circuit to "chassis ground."*

Quite a number of parts substitutions are possible if needed to meet the requirements of the individual builder. The transistor specified in the parts list and used in the model is a Sylvania Type 2N68 *p-n-p* junction power transistor. A Sylvania Type 2N101 may be substituted directly for the

HOW IT WORKS

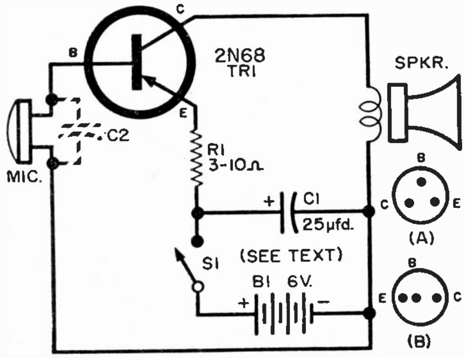
The megaphone is basically a single-stage *common-emitter* transistor amplifier. It differs from conventional audio amplifiers in several respects. First, the use of a transistor permits a single low-voltage (6-volt) power source to be employed. Secondly, the low input impedance of the transistor permits direct coupling between the carbon microphone and the base-emitter circuit, eliminating the need for the usual input matching transformer. In a similar fashion, the low output impedance of the power transistor permits direct coupling to the small paging "trumpet" used as a loudspeaker, eliminating the need for an output transformer. Finally, since the instrument is designed for "close-talking," its output level may be varied simply by varying the level of the voice. Hence, no volume control is needed or provided.

In operation, sound waves vary the mike resistance which, in turn, results in a similar variation of the transistor's base bias current. Since the base bias current determines collector current, the audio signal appears in the collector-emitter circuit, but it is of much greater amplitude due to the gain of the transistor. Small variations in base current result in much larger variations in collector current.

Emitter resistor *R1* provides a degree of d.c. stabilization by setting up a bias voltage which tends to oppose major changes in the transistor's d.c. operating currents. If the collector current tries to increase appreciably, the bias across *R1* tends to reduce base current, restoring collector current to normal. This resistor, by providing some degeneration, helps keep distortion to acceptable figures and, at the same time, increases the input impedance of the transistor to insure a more efficient transfer of the signal from the microphone to the transistor.

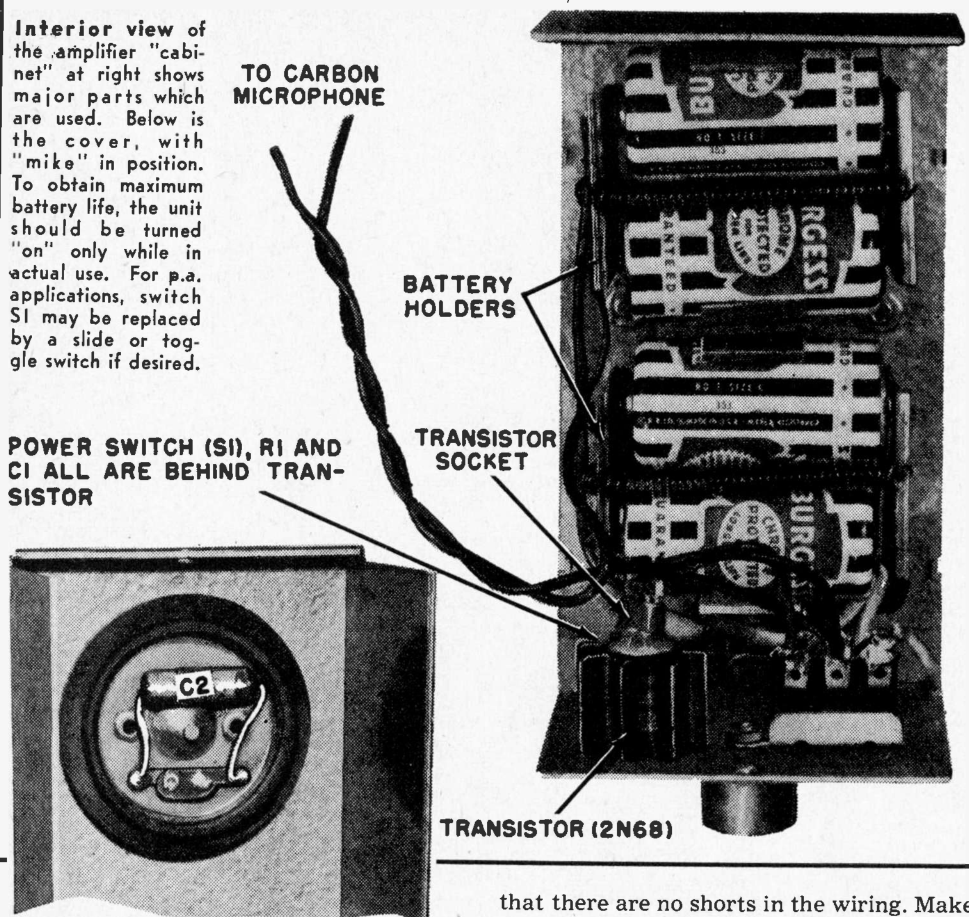
The remaining electrical components in the circuit are capacitors *C1* and *C2*, switch *S1*, and the *power* source. Capacitor *C1* is used simply to absorb transient peaks as the circuit is turned "on" and "off" and thus to prevent current surges from shortening the life of the transistor. Capacitor *C2* is a simple bypass unit to reduce microphone "hiss" and is furnished by the manufacturer of the microphone as a part of the "mike" assembly.

Fig. 1. Schematic wiring diagram of transistorized electronic megaphone. See parts list at right.



B1—Four 6-volt Size "C" flashlight batteries in series (Burgess No. 1)
C1—25-µfd., 6-volt capacitor (Barco P6-25)
C2—Paper bypass capacitor (part of MIC.)
R1—Three 10-ohm resistors (see text)
S1—S.p.s.t. push-button switch
TR1—P-n-p power transistor (Sylvania 2N68)
MIC.—Carbon microphone cartridge (Shure R-10)
SPKR—45-ohm low-power "paging" speaker (University No. MIL-45)
1—Cabinet, 5½" x 3" x 2⅛" "Channel-lock" box (ICA No. 29410)
2—"Battery-boxes" holding two Size "C" cells each (Austincraft)
1—Microphone adapter (Atlas AD-11)—optional
1—Terminal strip, with 3 insulated terminals
1—Transistor socket (if needed—optional)
1—⅜" rubber grommet
Misc. machine screws, nuts, lock washers, wire and solder

Interior view of the amplifier "cabinet" at right shows major parts which are used. Below is the cover, with "mike" in position. To obtain maximum battery life, the unit should be turned "on" only while in actual use. For p.a. applications, switch S1 may be replaced by a slide or toggle switch if desired.



2N68. If desired, *n-p-n* junction type 2N102 may be used in place of the 2N68, *provided the battery polarity is reversed* as well as the leads to capacitor *C1*.

Although Burgess No. 1 (size "C") flashlight cells are employed in the model, other size cells may be used instead. A size "D" cell will provide slightly longer battery life. And if the individual builder's layout and housing permit, four large mercury cells (such as Mallory Type RM12R) will provide the maximum in battery life.

Capacitor *C1* is non-critical, and either a larger or smaller unit may be employed here. It is best to use at least 10 μfd., if possible, but values as large as 200 μfd. may be used if desired. Regardless of the capacity, make sure that the working voltage at least *equals* 6 volts.

Adjustment and Test

With the wiring completed, double-check all connections *before* installing the batteries. Make sure that *C1* is installed with the proper polarity, that *S1* is "open," and that there are no shorts in the wiring. Make sure, too, that the "return" lead of the microphone connects to the "3-volt" position on the power supply (two cells on either side).

When you are sure there are no errors in wiring, push the switch "on" and speak in a normal or slightly loud voice into the mike. Have a friend listen to note volume and quality of the amplified voice. Now, connect two of the 10-ohm resistors in parallel to change *R1* from 10 to 5 ohms. Try the unit again. You'll probably notice an increase in volume. Finally, connect all three resistors in parallel, dropping the total resistance to a little over 3 ohms. Again try the unit. For a final connection, use the *maximum resistance you can which gives the best compromise between volume and distortion*. The larger *R1*, the better.

Once you've selected the best value for *R1*, try transferring the "return" microphone lead to the 1.5-volt (one-cell), 4.5-volt (three-cell) and 6-volt (four-cell) positions, trying the unit after each change. Make the final connection to the terminal which gives the best over-all results. The 3-volt (two-cell) tap was used here. —30—

Portable METAL LOCATOR

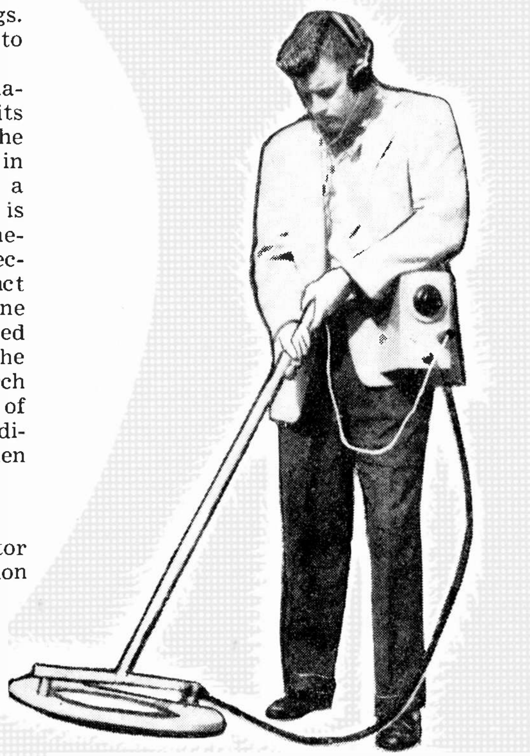
By Harvey Pollack

COMBINING fun and profit is something one hears about, but seldom enjoys. The metal locator described in this article, carried in the trunk of the car, can be assembled in minutes and will provide endless hours of fun and excitement with the constant possibility of a rich find. It responds with equal facility to non-ferrous and ferrous metals or ores. It will find underground wires and pipes, metals buried in sand, and electrical conduit lines in brick, plaster, or mortar walls and ceilings. Best of all, it is inexpensive and easy to construct.

The complete outfit consists of two major components: the search coil and its fittings, and the electronic detector. The former is a four-turn coil, 18 inches in diameter, wound in and protected by a plywood "sandwich" 20 inches across. It is carried at the end of a 5-foot length of one-inch round stock when in use. The electronic equipment comprises two distinct battery-operated oscillators. Except for one component, both oscillators are contained within the metal cabinet shown in the illustrations. The exception is the search coil; this forms the tank circuit of one of the oscillators and alters electrical conditions to provide an audible indication when metal is approached.

Construction of the Search Coil

Any sensitive electronic metal locator demands absolute rigidity of construction to avoid wobble and spurious response; in addition, the shielding must be well-nigh perfect if one is to avoid masking of the desired signal by ground capacitance changes. The construction of the search coil should be started first because the work on the electronic portion may be begun while the glued coil frame is drying.



The metal locator in operation. Any kind of wooden handle may be employed to support the search coil.

Construct the plywood frame as shown in the drawings, then glue entire assembly together (*no nails or screws are used anywhere in the construction of the search coil*) using a good resin or casein cement such as *Weldwood* or *Pliobond*; for obvious reasons, water soluble glues should not be used.

When the coil frame has set, the search coil may be wound in the groove of the "sandwich." Double cotton covered wire, #22 or larger, should be used. Starting near one of the one-inch round projections, wind two full turns and bring out a twisted center-tap. Then wind the remaining two turns, terminating near the same projec-

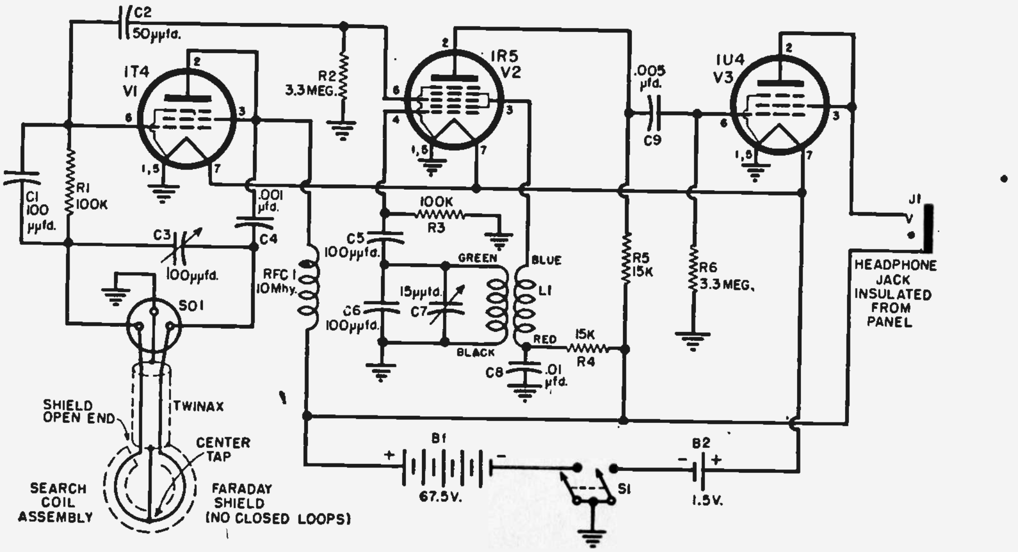
Schematic diagram, parts list, and pictorial (see opposite page).

DETECTOR UNIT

R1, R3—100,000 ohms, ½ w. res.
R2, R6—3.3 megohms, ½ w. res.
R4, R5—15,000 ohms, ½ w. res.
C1, C5—100 μμfd. mica capacitors
C2—50 μμfd. mica capacitor
C3—100 μμfd. variable capacitor, screwdriver adjustment, capable of being insulated from chassis (National Type W-100 or equivalent)
C4—.001 μfd. paper capacitor
C6—100 μμfd. ceramicon capacitor
C7—15 μμfd. variable capacitor, ½" shaft, chassis mounting, double-bearing (Bud Type MC-1850 or equivalent)
C8—.01 μfd. paper capacitor
C9—.005 μfd. paper capacitor
B1—67½-volt "B" battery, Burgess Type XX45
B2—1½-volt "A" battery, Eveready Type 720 or RCA Type VSO-69
J1—Open circuit headphone jack
L1—Shielded oscillator coil, Meissner Type 14-4243
RFC1—Radio frequency choke, ceramic cone standoff, 10 mhy., (National Type R-100U or equivalent)
S1—D.p.s.t. toggle switch
V1—1T4 tube
V2—1R5 tube
V3—1U4 tube
1—Aluminum utility case, Premier Metal Products Type PAC 596
1—Aluminum chassis base, 4" x 4⅛" x 1", ICA Type 29083
3—7-pin miniature shielded sockets
1—4 ft. strap (An adjustable surplus Army webbing strap was used in this model. The finishing ends were bent from thin sheet tin and pressed flat in a vise. One 8/32 machine screw and nut holds each end of strap to detector case. Do not use sheet metal screws for this purpose.)
1—Pair magnetic headphones, high impedance
1—4" dial, Bud D-1734 or equivalent
1—4-lug terminal strip
2—2-lug terminal strips
1—Connector strip with leads, for "B" battery
1—2-prong plug to fit "A" battery
SO1—Three-contact chassis receptacle, shielded microphone type, Amphenol Type 91-PC3F or equivalent
Machine screws and nuts as required (Screws for mounting tube sockets are 4/40, ⅜"; others are 6/32, ⅜".)
Hookup wire and solder

SEARCH COIL AND CABLE ASSEMBLY

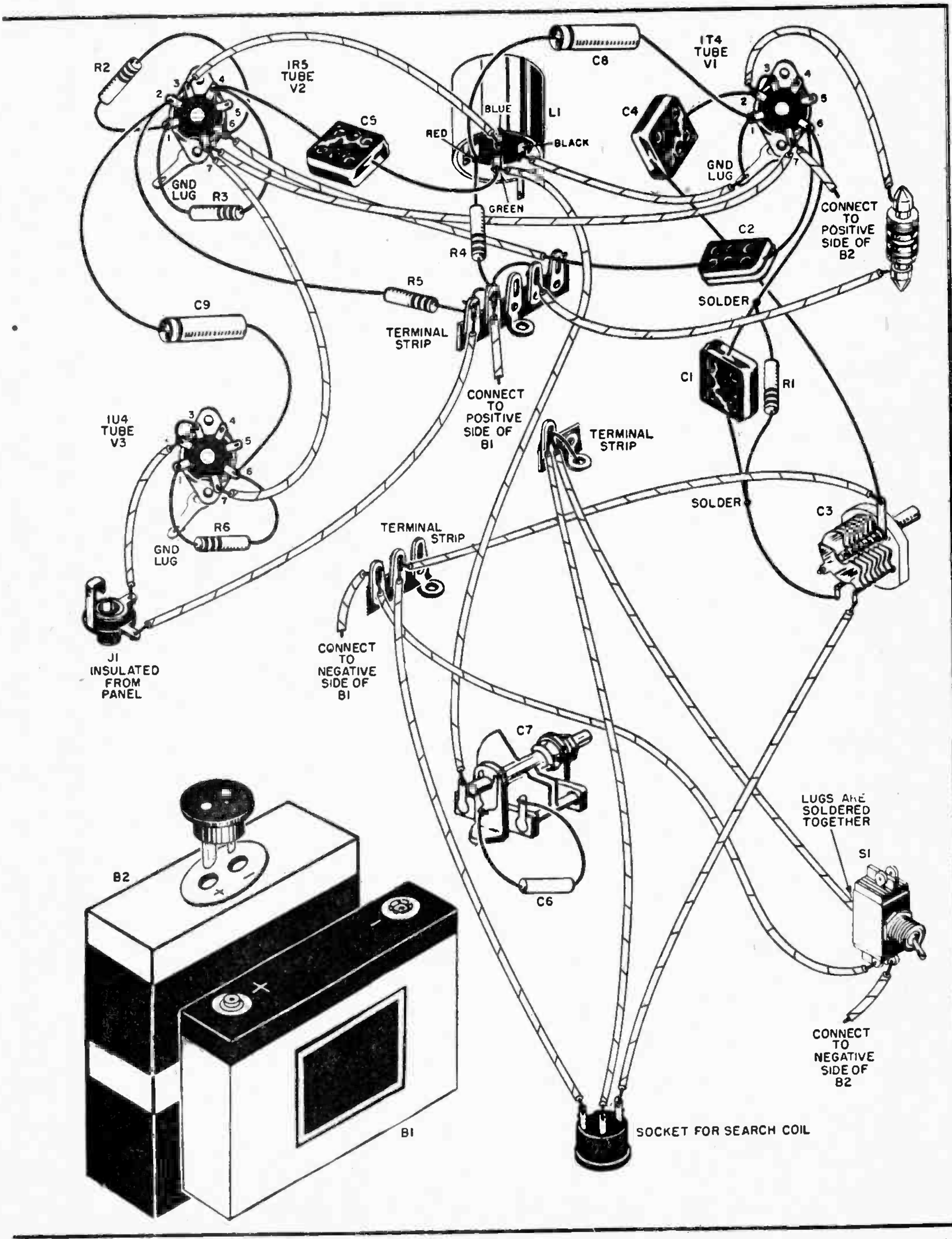
1—¼" plywood panel, 3-ply, approximately 20" x 40", to be cut in half
1—6 ft. length of 1" round stock, light-weight wood
1—1 ft. length, ⅜" dowel
1—3 ft. length of ¾" x 2" lumber for cross-bar on search coil assembly
19 ft. of #22 or larger double cotton-covered copper wire for search coil
150 ft. of #22 bare (not enameled) copper wire
75 ft. of 1" wide paper masking tape (If 2" cloth or plastic tape is used, reduce by half.)
1 pt. of good quality white shellac (Varnish may be used, but drying time is greater.)
5 ft. of Twinax (double conductor shielded cable) RG-22/U or equivalent having no more than 17 μμfd. per foot. Federal Type K-111 shielded twinlead can be used as second choice.
1—Small can of Weldwood, Pliobond, or similar water-resistant glue
1—Jones strip, three terminals
1—Three-prong plug, shielded microphone type, Amphenol Type 91-MC3M or equivalent
Total cost of parts, approximately $25.00



tion. Bring the two ends of the coil and the center-tap out through three fine holes near the inner circumference of the upper ring. Draw fine radial lines on the rim of the frame to aid in layout of the Faraday shield to be wound later. Now give the whole assembly one or two coats of clear shellac or varnish and let it dry thoroughly.

Construction of the Faraday Shield

The search coil responds to metal by inducing eddy currents in the metal masses by virtue of its magnetic field. Unless protected by adequate and proper shielding, it will also react capacitively to both magnetic and non-magnetic metals. Since this



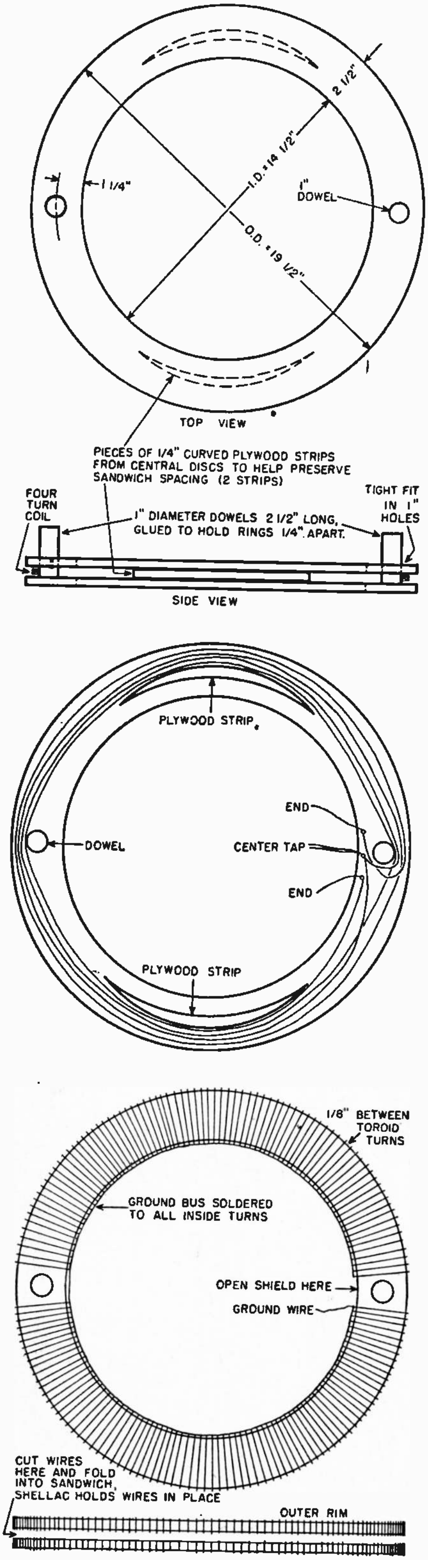
is highly undesirable, a shield must be built which permits the movement of magnetic lines of force without permitting capacitive coupling. Such a shield is called a Faraday shield; it must have no closed loops or current paths in which eddy currents can flow. Neither metal foil nor copper screening is satisfactory because these are full of closed loops which cause serious magnetic field losses, reducing the penetration of the field so that the device becomes insensitive.

To construct the Faraday shield, #22 bare copper wire (not enameled) is wound around and around the rim of the sandwich in toroid fashion, with about ⅛-inch spacing between turns. The radial lines mentioned earlier assist the builder in keeping the winding neat and uniform. The toroid winding starts from one side of the one-inch round stock projection where the search coil wires emerge and continues around, finishing on the other side of the same projection. This leaves a one-inch gap in the large circumference of the toroid, avoiding a closed loop.

A piece of #22 bare wire is now soldered all around the *inside* rim to each turn of the shield; good contact must be established between the shorting bus and *each turn*. Again, the bus leaves a one-inch gap near the same projection. A four- or five-inch length of the same bus wire should be brought up through the center small hole which already carries the center-tap of the search coil.

The entire assembly should now be given at least three coats of shellac or varnish. This coating must prevent water absorption and also hold the turns of the Faraday shield in place when the individual turns are cut open in the next step. Allow the coating to dry thoroughly.

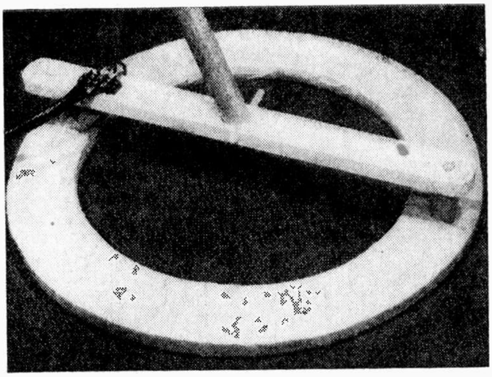
Since there are still closed loops formed by individual toroid turns, a sharp pair of shears or cutters is now used to open each individual turn around the outer rim. As each turn is cut, its ends are pressed inside the sandwich groove to prevent contact between them after the frame is taped. Taping may be accomplished with paper masking tape, which requires a coat of shellac after finishing, or with waterproof cloth or plastic tape, which do not require shellac protection.



Construction details of the loop. Top drawings show top and side views of wooden frame. Center drawing indicates how windings are placed on the frame, and bottom sketches give detailed information on the construction of the Faraday shield.

Completing the Search Coil Frame

The frame is given added rigidity and a socket for the holding pole by means of the ¾" x 2" x 20" crossbar. The crossbar is pegged in place by wood doweling, ⅜" in diameter, by drilling ⅜" holes downward in the vertical projections to a depth of about one inch and gluing the crossbar in place. A one-inch hole is cut in the center of the crossbar to receive the end of the holding pole. The latter is also pegged in place by means of a ⅜" wood key, which is removable to permit disassembly of the unit for transportation. A three-terminal *Jones* strip is then screwed to the crossbar; the coil terminals and center-tap are then secured to the *Jones* strip. The Faraday shield connection goes to the same *Jones* screw as the center-tap of the search coil.



Completely assembled loop, ready for operation. Note terminal strip for connecting the shielded "Twinax" cable, the other end of which connects to a 3-prong plug.

Construction of the Electronic Detector

The two oscillators are built as shown in the photos, the schematic diagram, and the pictorial wiring diagram. Although the layout illustrated is good, the builder may make any alterations he pleases, as long as he observes these precautions:

(1) The shielding between oscillators must be excellent. Note that all tubes and the fixed oscillator coil are completely shielded and that the tuning capacitor and oscillator coil of the 1R5 oscillator are above the chassis while the tuning capacitor for the search oscillator is below the chassis. The oscillator coil for the search section is completely outside the box, of course!

(2) All parts must be mounted super-rigidly with short leads used throughout to prevent vibration while the cabinet is being carried. Even the r.f. choke is supported instead of being secured only by its pigtails. Resistors and capacitors belonging to one oscillator should be kept as far as possible from components of the other oscillator, with their major axes at right angles. The battery leads are not critical but the batteries must be held firmly in place to prevent their motion during transportation. In the author's model, a simple aluminum bracket, bent to fit, is pressed against the batteries on one side and the side-wall of the cabinet on the other. This is shown in the photo with the back cover removed.

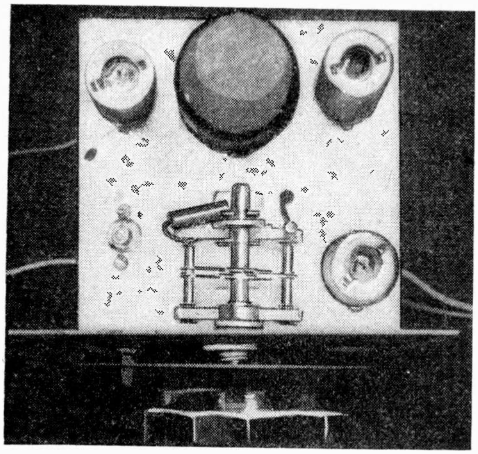
(3) Connection between the search coil and the detector cabinet must be made with low-capacity *shielded* twin-lead or *shielded Twinax.* Unless well-grounded shielded twin-conductor cable is used, body capacitance and stray capacitance acting on the connecting cable will produce instability. Connection between the cable and the detector cabinet is made through a shielded, three-terminal microphone connector.

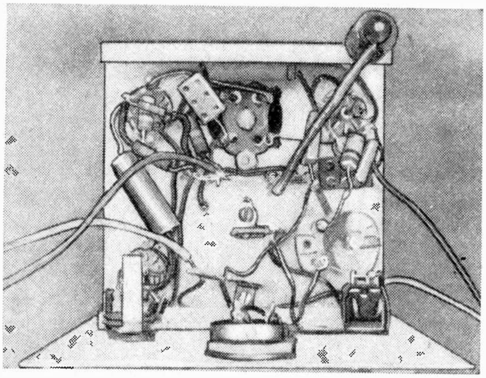
A U. S. Army surplus web strap was cut to size and end-finished by means of thin sheet metal bent around the cut end and peened in place. The strap frees both hands for handling the carrying pole, yet keeps the tuning dial within convenient reach of the operator for the occasional readjustments that may be required.

Testing the Complete Metal Locator

Before connecting the batteries, check the connecting wires for short circuits with an ohmmeter; even a short circuit of brief duration is enough to ruin the batteries—so be careful!

Connect the batteries; set the main tuning capacitor at a little less than full capacitance; turn the switch on and slowly rotate the screwdriver-tuned variable capacitor from full capacitance outward until a loud whistle is heard. While doing this, many whistles of varying intensity will be heard due to various combinations of harmonics of the two oscillators. These are to be disregarded; the beat note between the fundamental frequencies of the two oscillators is three or four times as loud as the others. Leave the semi-variable capacitor at that setting and readjust the main tuning dial for a loud whistle of *low* frequency. As this adjustment brings the heterodyne closer to zero-beat, the oscillators will lock in with each other and the whistle will disappear. Now bring a relatively large mass of any kind of metal into the vicinity of the search coil; the beat note should immediately reappear, becoming shriller as the metal approaches closer. When the locator follows this pattern, it is ready to be installed permanently in its cabinet.





Top (left) and bottom (above) views of chassis, showing location of components.

If beat notes are not heard, the trouble must first be localized to one of the two oscillators or to the audio amplifier. Common trouble spots are weak batteries, incorrect connections, poorly soldered joints, defective components, or components of wrong value. These possibilities should be investigated first.

Oscillators in good working order generate a bias voltage that is easily measurable. Using a vacuum-tube voltmeter or a regular voltmeter having a sensitivity of at least 20,000 ohms per volt, measure the voltage on the grid pins of the 1T4 and the 1R5 with respect to chassis. (Pin #6 on the 1T4, pin #4 on the 1R5.) A negative potential of 3 volts or more indicates proper operation. If the measurement does disclose an inoperative oscillator, check each part and its connection until the trouble is located.

With both oscillators performing as they should, the only other source of possible malfunction is the audio amplifier stage and its associated components. Touching the tip of a screwdriver to the control grid pin of the 1U4 (pin #6) should produce a click or thump in the headphones. If it does not, look for trouble between the plate of the 1R5 and the remainder of the audio circuit up to and including the headphones, using voltage and resistance measurements. *Remember that the headphone jack must be insulated from the panel,* otherwise the "B" battery will be short-circuited. The B+ to B– check suggested in the first paragraph under "Testing the Complete Metal Locator" would have revealed such a short circuit—if it exists—provided that the circuit has been connected as shown in the pictorial diagram and schematic. The author assured good insulation here by drilling a ¾" hole for the headphone jack sleeve and using large shoulder washers on each side of the hole.

Adjusting and Using Metal Locator

There are two alternative methods of using the locator; one is more sensitive than the other, but is less convenient and requires more careful adjustment.

1. *High Sensitivity Method*—Strap the locator cabinet to your shoulder and connect the headphones and search assembly. The main tuning dial should be within easy reach of your left hand. Hold the search coil a few inches from the ground and adjust the tuning until you hear a low-pitched *fundamental* (loud) beat note, about 30 cycles per second or so. Move forward slowly as you sweep the search coil from side to side parallel to the ground. An approach to metal will be indicated by a sharp rise in pitch of the tone. The disadvantage is that the sound is audible at all times and may become annoying.

2. *Medium Sensitivity Method*—Adjust the tuning very carefully, starting with maximum capacitance of the main variable capacitor, until the oscillators *just barely lock in*. This will be shown by a complete cessation of the beat note. The note will reappear abruptly when metal is approached, so that one may operate in complete silence until the metal mass announces itself.

Sensitivity is somewhat lower for this method than for method 1, because there must be a larger change in inductance of the search coil to produce an audible indication. This is because the two oscillators are "locked" together, and tend to remain locked until an appreciable change in inductance takes place. In method 1, the oscillators are not locked, and any minute change in inductance of the search coil will result in a change in pitch of the audible beat note. The ear is quite sensitive to small changes in pitch, so method 1 results in a detector of high sensitivity.

Penetration

The depth to which the locator penetrates depends upon three factors: (1) the mass of the metal, (2) the kind of metal—purity, conductivity, etc., and (3) the condition of the soil. To provide the reader with some idea of what might be expected of the instrument, the author performed the following experiments:

(a) Dry soil, galvanized iron trash can cover, buried approximately 3½ feet underground, was easily detected.

(b) Dry soil, same location, an aluminum snow shovel measuring about 15" x 18" was detected at a depth of about 3 feet.

(c) An 8" roll of copper wire, weight about 1½ lb., was located without difficulty at a depth of 3 feet.

(d) Wet soil reduces penetration by about 10% for objects above.

(e) Steel reinforcing rods were easily located in a 12" concrete retaining wall and exact spacing accurately determined.

(f) BX cables in plaster and plaster board walls were located precisely.

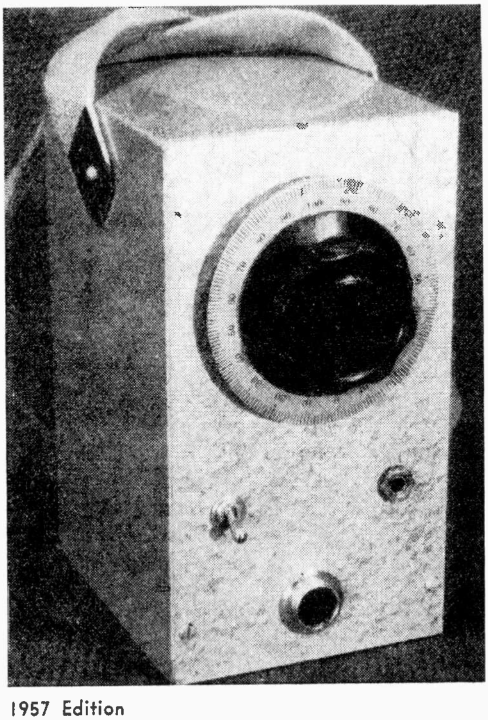
(g) A 275-gallon steel oil tank was "located" at a distance of 6 feet through the foundation wall of a building.

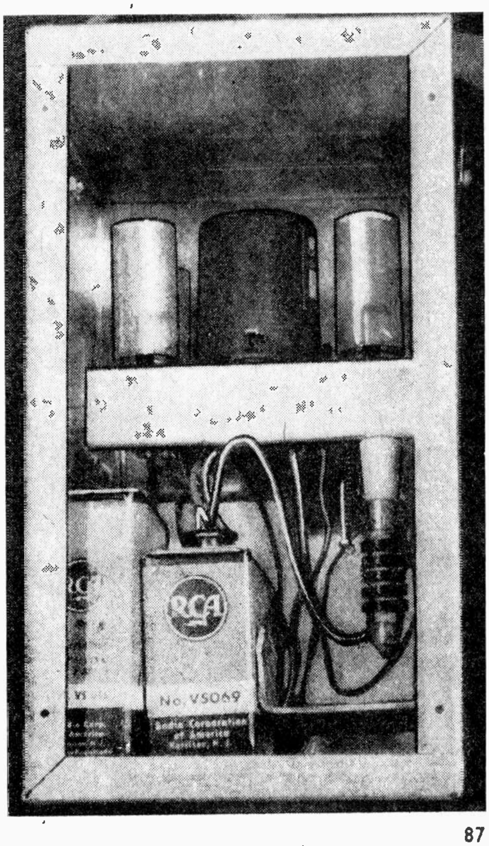
(h) A buried sewer "cleanout" cover was found at once although it was covered by a thick layer of concrete topped by about 5 inches of wet soil.

Operating Principles

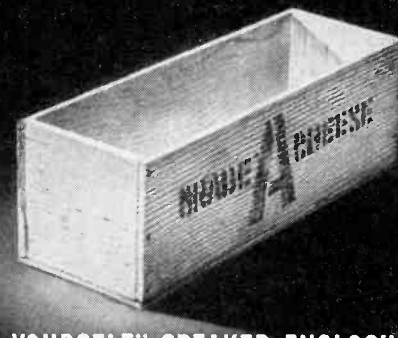
The two oscillators operate at frequencies around 2 mc. When their frequencies are within 10,000 cycles of each other, a high pitched beat note is heard as a result of the mixing in the 1R5 converter tube; the 1U4 audio amplifier intensifies the beat note so that it is sufficiently loud to be heard even in noisy locations. Assuming that the oscillators are adjusted to produce a beat frequency of 300 to 500 cycles per second, an approach to metal with the search coil causes the induction of eddy currents in the metal mass. According to a well-known electrical law (Lenz's Law), the magnetic field generated by these eddy currents in the metal opposes the field of the search coil. This is reflected back to the search coil as an effect which reduces its inductance. Since the search coil is the tank inductance of one of the oscillators, any change in its inductance causes a proportional change in the frequency of oscillation; this, in turn, changes the pitch of the beat note sharply. —30—

Over-all view of the complete unit with shoulder carrying strap (below) and rear view with cover removed (right), indicating how batteries are held in place.





DON'T BUY A CHEESE BOX



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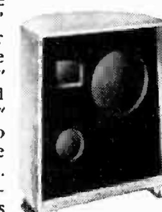
KEN-15—$49.75 Net.



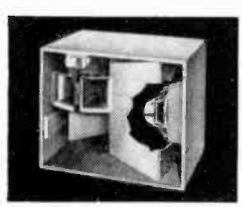
KEN-15

Model KEN-12 — Similar to Model KEN-15 except that mounting board is pre-cut for all 12" speakers. Adapters also supplied for most of the popular 2 or 3 way P.S.E. combinations. Dimensions: 30" E x 21½" W x 15¾" D.

KEN-12—$39.75 Net.

KEN-12

Model EN-CB Unfinished-Utility Enclosure



A true folded self-contained exponential horn, operates with highest quality wherever placed independently of walls or floors. Complete in itself with all acoustically correct elements always in place. EN-CB is identical in design to the enclosure used in the famous "Classic" *"Decor-Coustic"* system. Ideal for the do-it-yourself home decorator finishing is limited only by the imagination. Can be used horizontally or vertically. Fully assembled, constructed throughout of ¾" Birch plywood with locked and mitre joints and braced with heavy glue blocks. Supplied unfinished, less base and frame, but with necessary hardware for mounting speaker. Recommended components are: Model C15W Dual Impedance Woofer, Model HF-206 Super-Tweeter, Model Cobreflex—2 Mid-range Horn with T-30 Driver, Model N-3 Network. 40" x 30" x 24". Shpg. Wt. 150 lbs. **$120.00 Net.**

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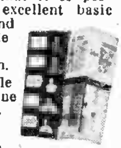

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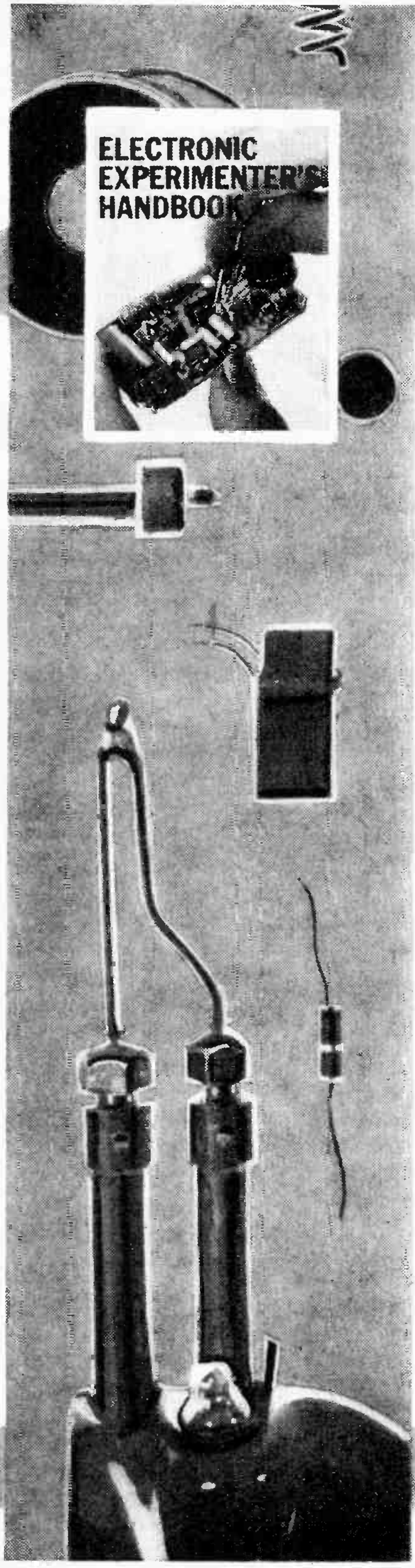


Chapter 4

For the Hi-Fi'er

TO THOSE accustomed to the type of music obtainable with low-cost table-model radio receivers, listening to a high-quality audio system connected to a high-fidelity tuner will reveal a tonal quality never thought possible. Take a good-quality phonograph amplifier with matched speaker system, add the simple hi-fi tuner shown in the photographs, connect an antenna and ground . . . and prepare for real listening enjoyment.

Hi-fi fans (frequently called "audiophiles") will be familiar with the expression "tuner." For the uninitiated, a tuner is a basic radio receiver, but without an audio power amplifier or loudspeaker. It is designed to be used with a separate audio system to form a complete receiver. Tuners may be used with both commercial and home-built audio amplifiers, including public address systems, but they give best results when used with a high-fidelity installation.

Although this simple hi-fi tuner will meet the requirements of a discriminating audiophile, the circuit used is not at all complicated. Even a beginner should have little or no trouble assembling the tuner in two or three evenings or on a week-end.

Build an AM HI-FI TUNER

Assembling the Tuner

Either one of two versions of the tuner may be assembled, depending on the requirements of the individual builder. The schematic wiring diagram for a *powered* version is given in Fig. 1, while the circuit changes necessary for a *non-powered* version are shown in Fig. 2. The photographs show the powered version.

Operation of both versions is similar, except that the powered version requires a source of line voltage (117 volts, a.c.) and has somewhat greater sensitivity, permitting its use with most audio amplifiers without a preamplifier. On the other hand, if an audio system has a good preamplifier, the non-powered version may be preferred—the circuit is simpler, requires fewer parts, wiring is easier, and no power source is necessary.

Components needed for both versions of the tuner are specified in the parts list. Those parts used only in the powered version are identified. All parts are standard and should be available at local radio parts distributors. If there is no distributor near at hand, the items needed can be purchased through one of the large mail order supply houses.

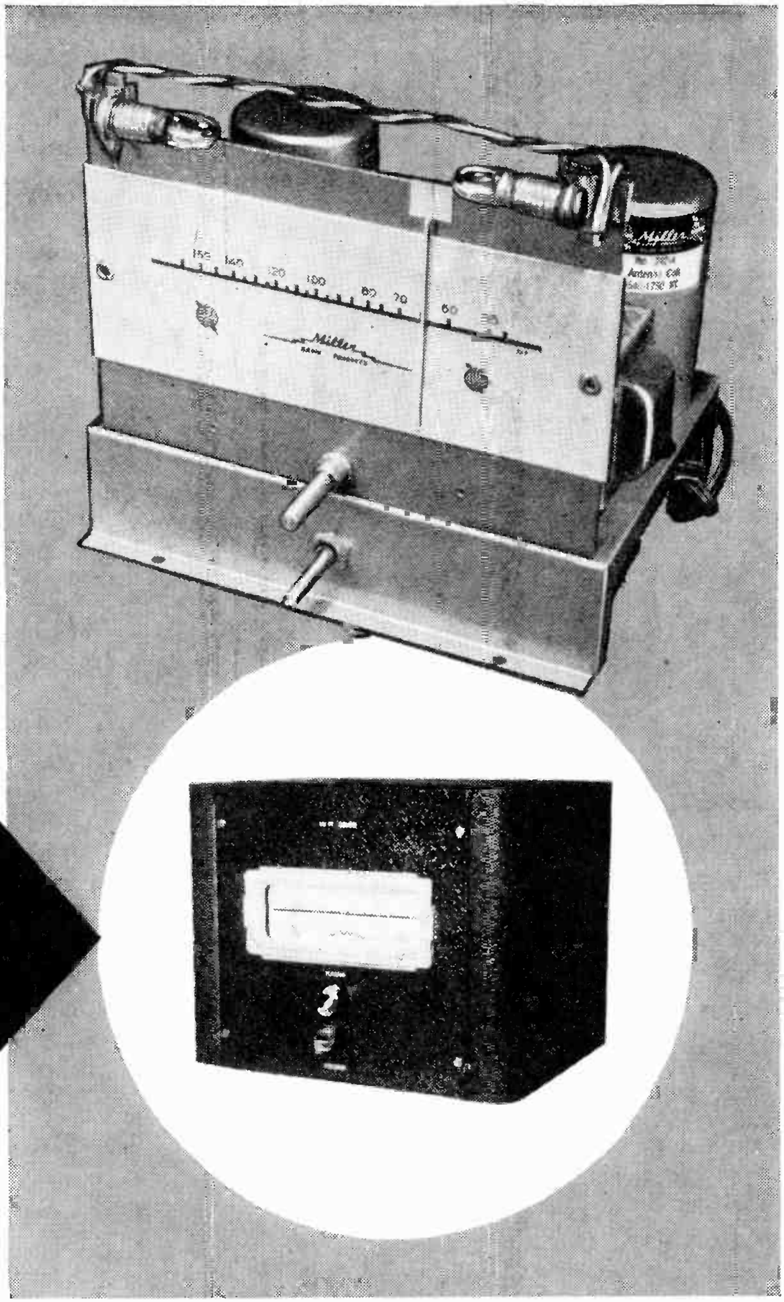
Construction Hints: A commercially available prepunched metal chassis base was used in the model. With this chassis, no chassis machine work will be required to assemble the non-powered version. To assemble the powered version of the tuner, it will be necessary to drill and punch a few additional holes.

To bend the chassis base from sheet metal, use the layout shown in the photographs as a general guide. Except for the mounting holes, exact dimensions are not critical. Locate mounting holes exactly by holding the part to be mounted on the chassis and marking hole locations with a scribe.

With the chassis machine work completed, mount the major components, using small machine screws, nuts and lock washers. The photographs of the model will serve as a guide in determining parts location. Above chassis parts are identified in Fig. 4, below chassis parts in Fig. 3.

Wiring is comparatively easy and straightforward. There is plenty of room below the chassis, so don't worry about working in tight corners. Coil lug connections are identified in Fig. 1. Only a few general precautions should be observed in wiring the unit.

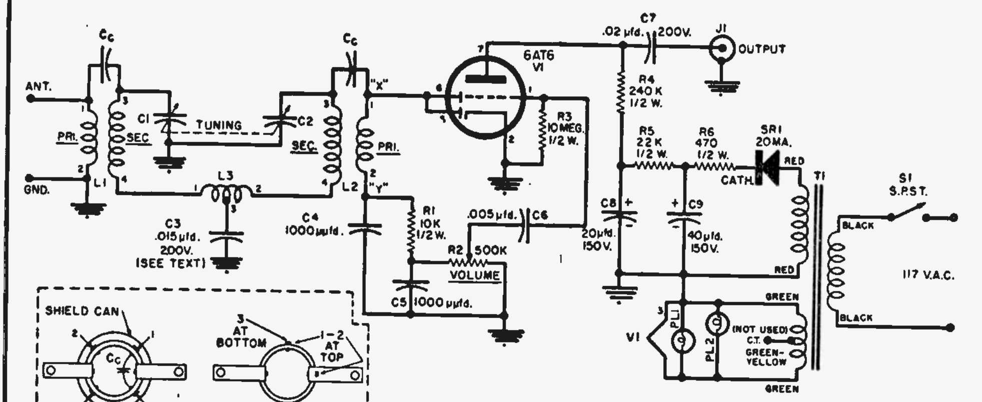
In assembling the powered version, take care when soldering leads to the selenium rectifier, *SR1*. Complete this soldering as quickly as practicable to avoid overheating the terminals. Be sure to observe cor-



Over-all view of powered tuner without cabinet, showing pilot lights and dial (top), and the unit installed in a metal cabinet (bottom).

By LOUIS E. GARNER, Jr.

Here is an AM tuner which will reproduce the full range of audio frequencies transmitted by local broadcast stations



C1*, C2*—2-gang tuning capacitor, approx. 365 µµfd. per gang
C3*—0.015 µfd., 200 v. tubular capacitor
C4**, C5**—1000 µµfd. disc. ceramic capacitor
C6**—0.005 µµfd. disc ceramic capacitor
C7**—0.02 µfd., 200 v. tubular capacitor
C8**, C9**—20/40 µfd., 150 v. dual elec. capacitor
C10—0.00025 µfd., 200 v. tubular capacitor (see text and Fig. 2)
C11—0.05 µfd., 200 v. tubular capacitor (see text and Fig. 2)
J1*—Phono jack
L1*, L2*—T.r.f. antenna coils (Miller No. 242-A, including Cc)
L3*—Mutual coupling coil (Miller No. EL-55)
PL1**, PL2**—6.3 v. pilot lamp bulb and socket
R1**—10,000 ohm, 1/2 w. resistor
R2—500,000 ohm carbon potentiometer, audio taper
R3**—10 megohm, 1/2 w. resistor
R4**—240,000 ohm, 1/2 w. resistor
R5**—22,000 ohm, 1/2 w. resistor
R6**—47 ohm, 1/2 w. resistor
R7—100,000 ohm, 1/2 w. resistor (see text and Fig. 2)
S1**—S.p.s.t. switch (on R2)
SR1**—20 ma. selenium rectifier
T1**—Power transformer, 150 v. @ 25 ma., 6.3 v. @ .5 amp.
1—7-pin miniature tube socket**
1—Line cord and plug**
1—1N34 crystal diode (see text and Fig. 2)
1—Chassis,* approx. 7" x 5" x 1½" (Miller No. 585-1)
1—Slide rule dial* (Miller No. 152-H)
1—Cabinet (optional, Bud C-1789)
1—2-position screw-type terminal strip*
1—2-lug terminal strip
1—3-lug terminal strip
Misc. wire, solder, etc.

* These items are included in the basic Miller kit, No. 585. If unavailable elsewhere, contact J. W. Miller Company, 5917 S. Main St., Los Angeles 3, Calif.
** These components are not required for the non-powered version (Fig. 2).

Total cost of parts, approx. $21.50

Fig. 1. Schematic diagram and parts list for the powered version of the AM tuner.

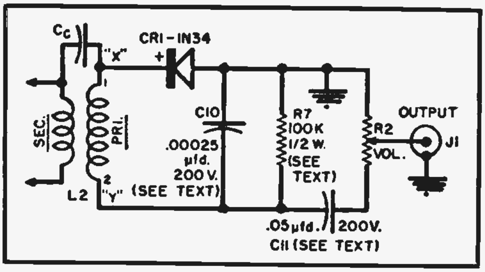


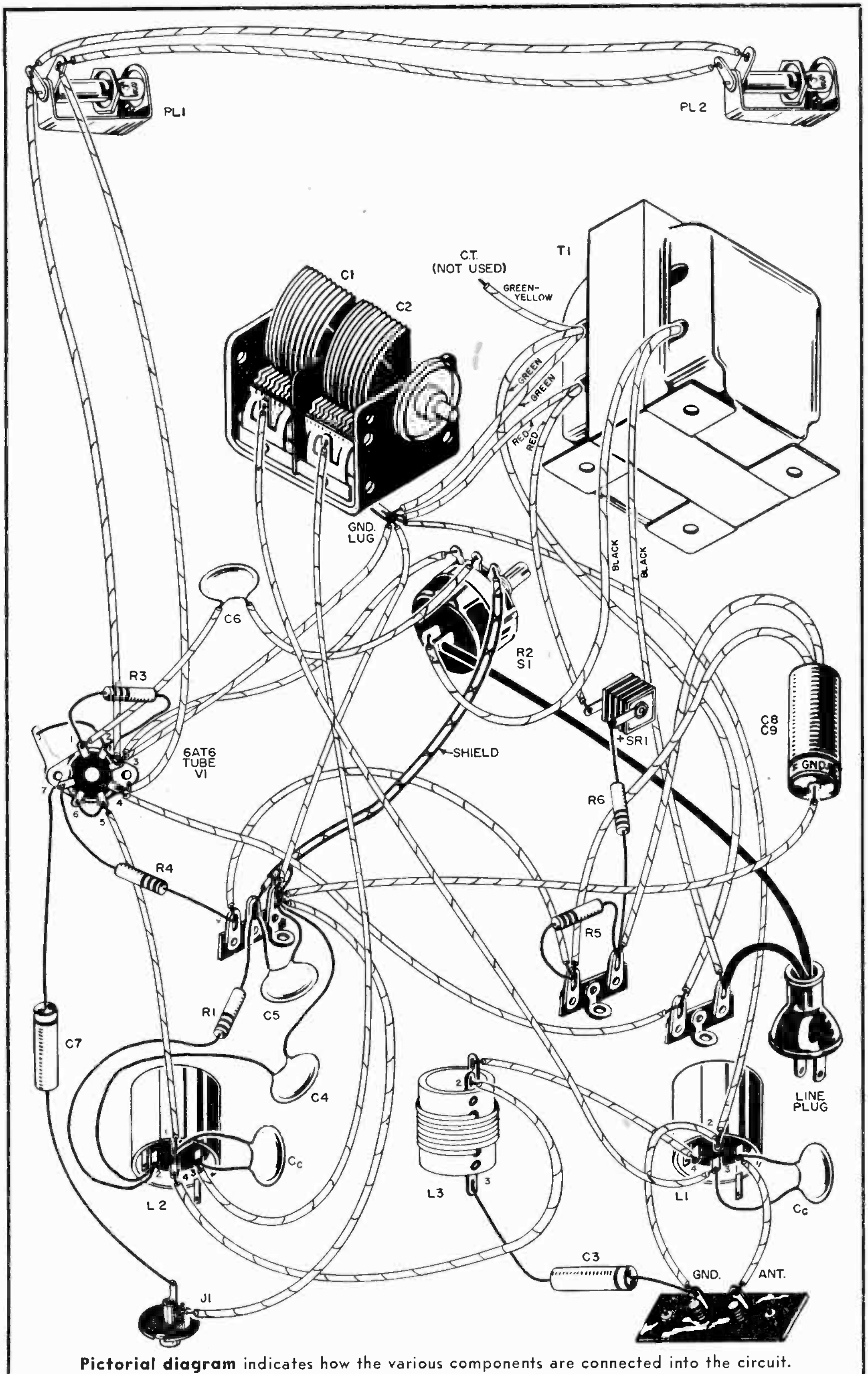
Fig. 2. Partial schematic of non-powered unit.

rect lead polarity when connecting the electrolytic filter capacitor (*C8, C9*). Shield any long leads carrying audio signals to avoid hum pickup.

Parts *C10, C11, R7* and the 1N34 crystal diode are used only in the non-powered version of the tuner. In building this version, wire the r.f. circuit as shown in Fig. 1 up to points "X" and "Y." From these two points, follow the circuit in Fig. 2. When installing the 1N34 diode, take special pains to avoid heat damage. Use reasonably long leads and hold each lead with a pair of long-nosed pliers while soldering the diode in place. The pliers tend to absorb heat, keeping it away from the sensitive part of the diode.

When the wiring is completed, double check for possible errors. Install the 6AT6 vacuum tube (if the powered version has been assembled) and mount the control knobs. Prepare a length of shielded single-conductor cable for connecting the tuner to an audio amplifier. At one end, use a connector to fit the output jack, *J1*, of the tuner. At the other end, use a connector to match input jack of audio amplifier.

Alignment: Alignment of the completed tuner is quite simple and requires no expensive test equipment. All that is necessary is a standard insulated alignment tool for adjusting the small mica trimmer capacitors. One is mounted on each section of the main tuning capacitor and is connected in parallel with it.



Pictorial diagram indicates how the various components are connected into the circuit.

Connect a *good* antenna and ground to the proper terminals of the tuner. Using the shielded connecting cable, connect the tuner to the audio amplifier and turn both units on. Turn up the gain or volume controls on both the tuner and the audio amplifier.

Adjust the tuning dial so that the pointer is at the extreme low frequency end of the dial when the tuning capacitor (*C1, C2*) plates are fully meshed. Next, tune in a strong local broadcast station whose operating frequency is near the higher frequency end of the dial (from 1200 to 1600 kc.). Check to see if the dial reading corresponds to the station's operating frequency. If it does, no further adjustment is necessary.

If the dial reading does not correspond to station frequency, use the insulated alignment tool to adjust the small trimmer capacitors mounted on the sides of *C1* and *C2*, shifting the point at which the station is picked up in the proper direction . . . i.e., towards the correct station frequency. Continue to adjust the trimmers, retuning the dial each time, until the dial reading corresponds exactly to station frequency when best reception is obtained. Be sure to *adjust both trimmers each time.* When dial and station frequency correspond, the alignment is complete.

Operation

In operation, r.f. signals picked up by the antenna-ground system are coupled into the primary of r.f. transformer *L1* in the powered version (Fig. 1). *L1, L2, L3,* and *C3,* together with tuning capacitors *C1* and *C2* and coupling capacitors *Cc* form a band-pass tuner circuit which selects the desired station frequency as the values of *C1* and *C2* are changed. This double-tuned circuit has a bandwidth of 25 kc. at the 2-db points, yet—because of the high *Q* of the coils used—is able to separate local stations without difficulty.

The selected r.f. signal, appearing at points "X" and "Y," is applied to the diode section of the 6AT6 dual-purpose tube, where detection occurs. *R1,* together with volume control *R2,* acts as the diode load resistor, and the detected audio signal appears across these components. Since the resistance of *R2* is large compared to that of *R1,* most of the audio signal appears across the volume control. However, *R1,* acting with capacitors *C4* and *C5,* serves as an r.f. filter network to remove any r.f. signal that might remain.

Fig. 3. Under-chassis view of powered version of the AM tuner, showing location of selenium rectifier, electrolytic capacitor, and socket for audio amplifier tube V1.

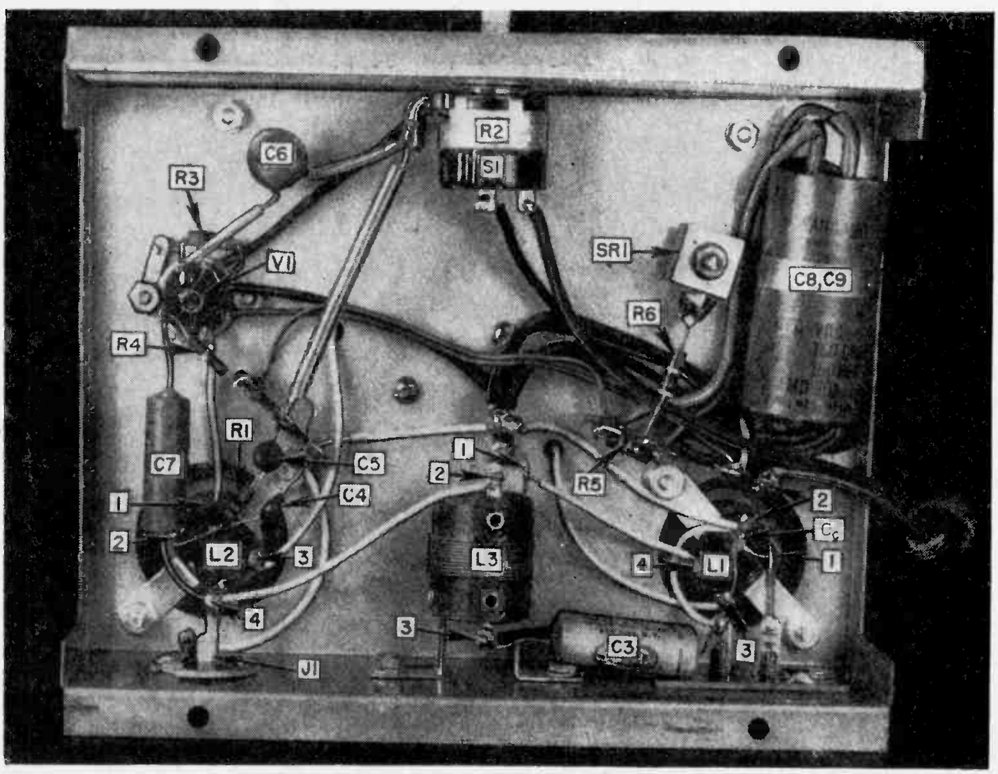
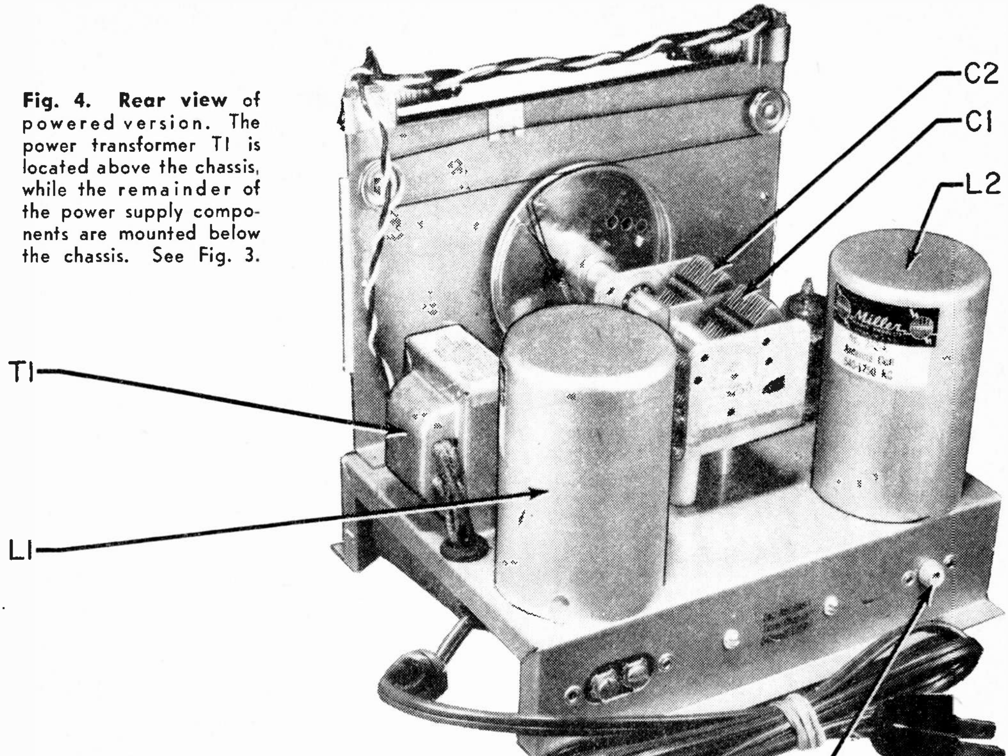


Fig. 4. Rear view of powered version. The power transformer T1 is located above the chassis, while the remainder of the power supply components are mounted below the chassis. See Fig. 3.



A portion of the available audio signal is fed through coupling capacitor *C6* to the grid of the triode section of the 6AT6 tube. The amount of signal applied to the grid of the tube depends on the setting of *R2*. Grid return resistor *R3* has a high value and serves to establish contact bias for the triode tube. An amplified audio signal appears across the tube's plate load resistor *R4*, and is coupled through d.c. blocking capacitor *C7* to the output jack *J1*, where it can be picked up and fed to an audio amplifier.

D.c. operating voltages for the amplifier are obtained from a conventional half-wave rectifier circuit employing the selenium rectifier *SR1*. *R5*, together with electrolytic filter capacitors *C8* and *C9*, forms a standard *RC* "brute force" filter circuit to remove ripple. A small resistor, *R6*, prevents the current surge into *C9* (when the unit is first turned on) from damaging the rectifier.

A.c. voltages for the rectifier circuit, as well as filament voltages for the vacuum tube and pilot lamps, are obtained from transformer *T1*. A s.p.s.t. switch, *S1*, serves as a power switch and is mounted on the rear of the volume control, *R2*, as shown in the pictorial diagram.

In the non-powered version of the tuner, the pickup and selection of the r.f. signal is the same as in the powered version. However, the diode tube section is replaced by a crystal diode detector (1N34 diode), and no amplification of the audio signal is obtained. Thus, when the non-powered version is assembled, it should be used with an amplifier having a good pre-amplifier section.

Installation and Use

The completed hi-fi tuner may either be used "as is" or it may be mounted in a cabinet. It fits well into a commercial metal cabinet (specified in the parts list and shown in the lead photograph), but may also be mounted in a home-built or wooden cabinet.

In order to keep the circuit simple, a straight t.r.f. (tuned radio frequency) circuit has been used, with no r.f. amplification. Therefore, the tuner requires a *good antenna and ground* for proper operation and is designed to be used primarily with local AM broadcast stations. In rural areas having only a few local stations, the sensitivity of the tuner may be greatly increased at a slight loss in selectivity (ability to separate stations) by adding two 15-μμfd. fixed ceramic capacitors across terminals 1 and 3 of coils *L1* and *L2*. These capacitors are in addition to capacitors *Cc* already mounted in the coils. —30—

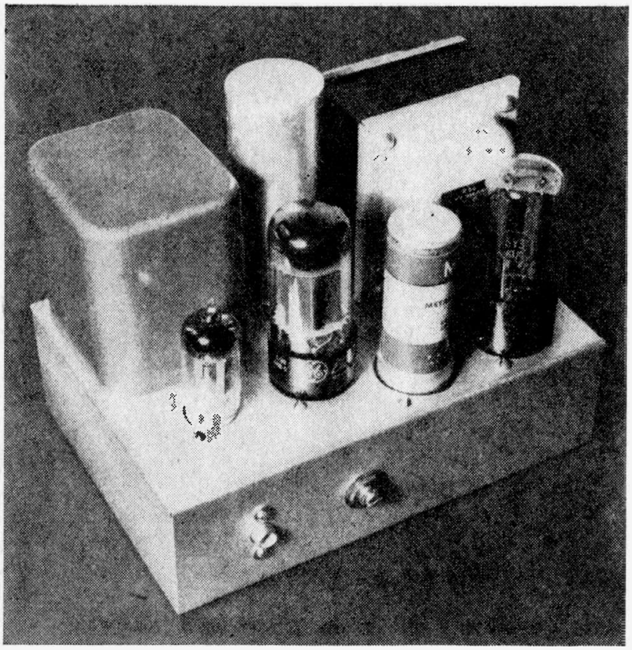


Fig. 1. Home-built amplifier measuring 5" x 7" x 2".

Small fi

By

Paul Popenoe, Jr.
W6IWM

An economical approach to good quality

THE amplifier shown in Fig. 1 should provide an answer to those who require a high-quality power amplifier of small physical dimensions. This unit is constructed on a 5" x 7" x 2" steel chassis base and has an over-all height of 6 inches. It may be operated from most tuners and preamplifiers to give adequate output for ordinary home requirements. The total cost of parts is under $35.

To many people, this unit, with its 4-watt rated output, may seem underpowered. There is no need to recount the usual arguments as to desirable power levels. Many of our ideas about power requirements are handed down from the days of high-distortion amplifiers, and low-efficiency speakers. With modern speakers, an average listening level of 250 milliwatts is a very loud level indeed—louder than most people can comfortably enjoy in the average living-room. Those who wish to verify this statement may do so by actually measuring the output of an amplifier while listening to it. Many will be surprised at the small amount of audio required to provide comfortable listening.

If 250 milliwatts is considered as maximum average listening level, allowing 10 db for peaks, the peak power requirements for comfortable living is 2.5 watts.

The amplifier has low transient distortion due to a good damping factor. The damping factor is 8, which is equivalent to a 2-ohm generator across the 16-ohm speaker tape. This allows the speaker to deliver good, clean bass, an important requirement for hi-fi amplifiers.

A listening test was made operating the amplifier into a *Jim Lansing* rear-horn-loaded speaker system, model D-34001. The unit described compared favorably with much larger and more expensive amplifiers.

Other characteristics of this amplifier are frequency response flat within 1 db from 20 to 100,000 cycles measured at 1-watt output, response flat 20 to 30,000 cycles measured at 4-watts output, and an input requirement of 1.5 volts r.m.s. for 4-watts output. Approximately 8.5 db of feedback is provided around a loop which includes the output transformer and the input stage. The hum and noise are so low as to be inaudible with the ear placed next to the speaker.

Examination of the circuit diagram, Fig. 3, will show that the circuit is very simple, requiring only two tubes plus a rectifier tube. The first tube, *V1*, is a 12AX7 which operates as a voltage amplifier and phase splitter. Feedback is applied to the unbypassed cathode of the voltage amplifier. The output of this stage is resistance-capacitance coupled to the other half of the 12AX7, the phase splitter. There is nothing critical in this circuit, and ordinary tolerance components may be used.

The phase splitter provides a push-pull signal to the grids of the output tube by means of equal 47,000 ohm load resistors in the cathode and plate. These two resistors, *R4* and *R7*, should be matched in value as closely as possible. Matching within one per-cent is desirable. It should be possible to accomplish this with an ordinary ohmmeter. It is also desirable to match the grid resistors, *R8* and *R9*, of the output stage, but these are not as critical as the plate resistors.

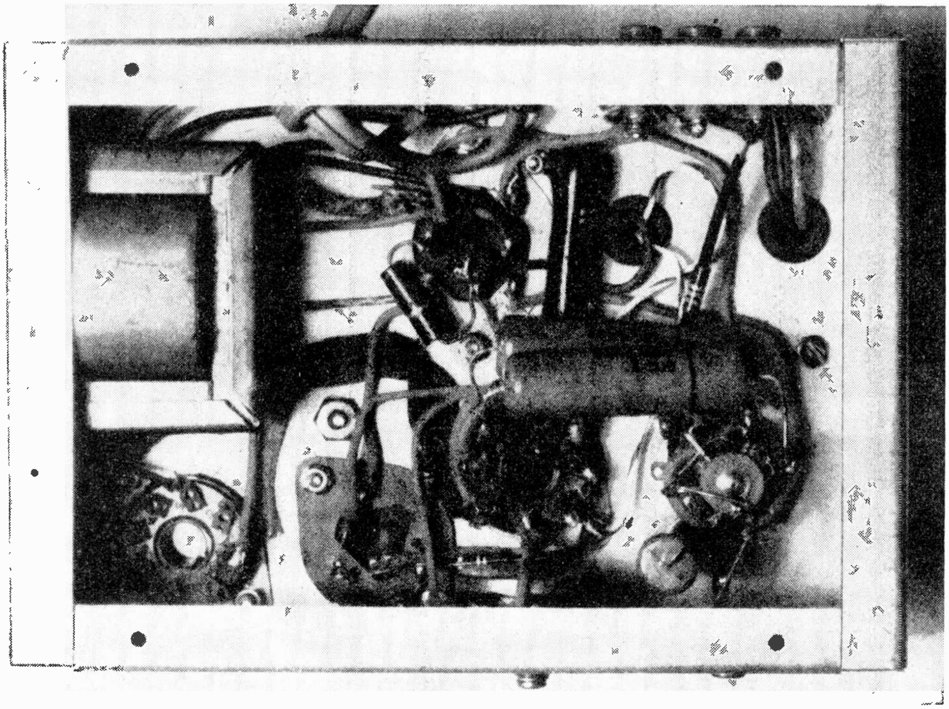
The output stage makes use of a 6BX7GT dual triode, *V2*, as a push-pull power amplifier. Although this tube was developed for use in television receivers, it makes an ideal audio tube. It has high transconductance, indirectly heated cathodes, and a 12-watt combined plate dissipation. A 100-ohm potentiometer, *R11*, is provided in the cathode circuit to balance the plate currents. The tube requires an 8000 ohm plate-to-plate load which is provided by a *Peerless* type S-510-F output transformer coupling into an 8- or 16-ohm voice coil. The output taps are brought out to tip jacks at the rear of the amplifier chassis.

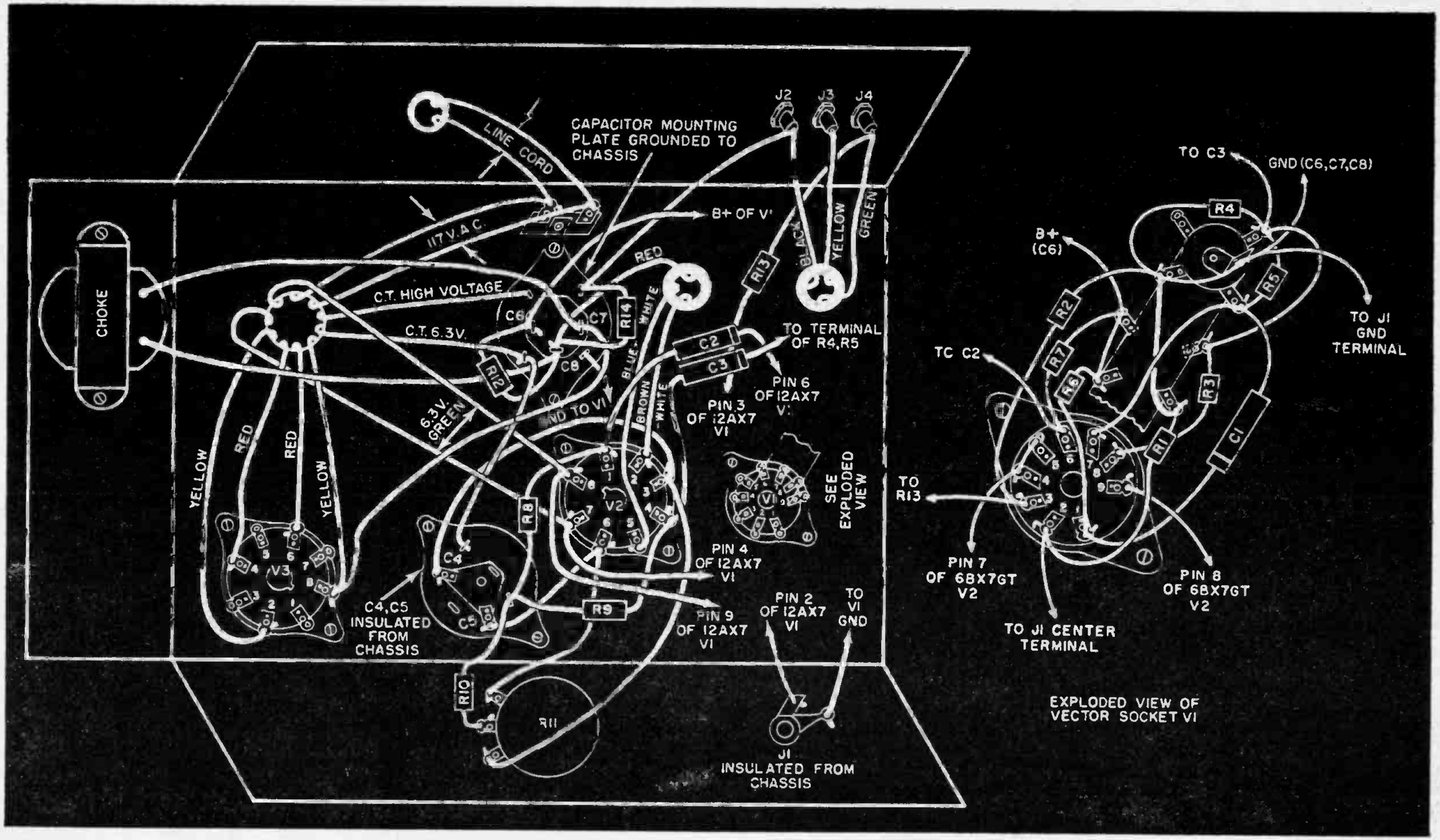
Feedback is taken off the 16-ohm tap of the output transformer and applied to the cathode of the first stage through the 27,000 ohm resistor, *R13*. This provides 8.5 db of feedback which is adequate to give excellent characteristics to the amplifier without requiring too high an input voltage. Those who wish to experiment with greater amounts of feedback may do so by decreasing the size of *R13*.

The power supply is conventional. It uses a 500 volt center-tapped transformer to supply about 270 volts to the 6BX7GT. A filter consisting of two 40 μfd. capacitors and a 12 henry check gives hum-free operation. An additional 10 μfd. of filter is used on the 12AX7. A higher voltage power transformer is not desirable since it may cause the 6BX7GT to exceed its plate dissipation rating. No switch is used in the primary circuit since it is asumed that all a.c. switching will be done in the preamplifier.

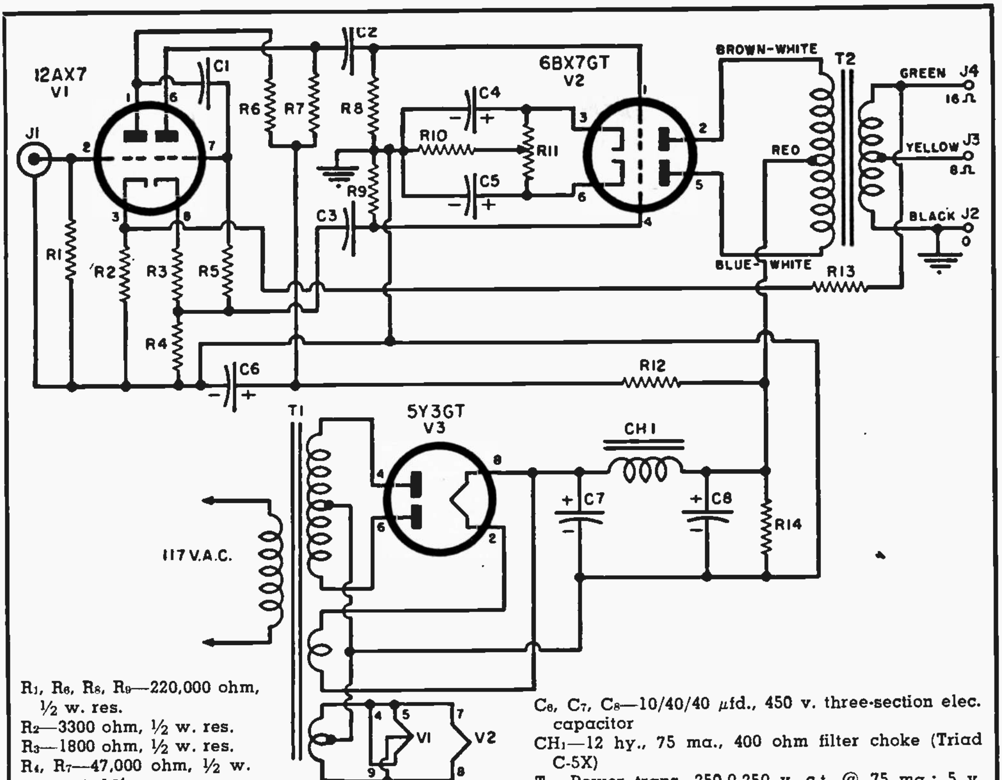
Construction details may be seen from the photographs, Figs. 1 and 2. The power transformer, output transformer, electrolytic capacitors, and the tubes are all mounted above the chassis. The input jack and balancing potentiometer are on the front of the chassis. The filter choke is

Fig. 2. Under chassis view of the amplifier showing how components are mounted.





Pictorial wiring diagram of the amplifier. See Fig. 3 for schematic and parts values.



R_1, R_6, R_8, R_9—220,000 ohm, ½ w. res.
R_2—3300 ohm, ½ w. res.
R_3—1800 ohm, ½ w. res.
R_4, R_7—47,000 ohm, ½ w. res. ± 1%
R_5—470,000 ohm, ½ w. res.
R_{10}—500 ohm, 10 w. wirewound res.
R_{11}—100 ohm wirewound pot (slotted stub-shaft type)
R_{12}—2200 ohm, ½ w. res.
R_{13}—27,000 ohm, ½ w. res.
R_{14}—50,000 ohm, 10 w. wirewound res.
C_1—.05 μfd., 600 v. capacitor
C_2, C_3—.1 μfd., 600 v. capacitor
C_4, C_5—50/50 μfd., 150 v. two-section elec. capacitor (use insulated mounting plate)
C_6, C_7, C_8—10/40/40 μfd., 450 v. three-section elec. capacitor
CH_1—12 hy., 75 ma., 400 ohm filter choke (Triad C-5X)
T_1—Power trans. 250-0-250 v. c.t. @ 75 ma.; 5 v. @ 2 amps; 6.3 v. c.t. @ 2.5 amps. (Triad R-8A)
T_2—Output trans. 8000 ohms c.t. to 8 or 16 ohm 10 watts (Peerless S-510-F)
J_1—Shielded phono pin jack (insulated from chassis)
J_2, J_3, J_4—Insulated tip jack
V_1—12AX7 tube
V_2—6BX7GT tube
V_3—5Y3GT tube
2—Octal sockets
1—Noval socket (Vector)

Fig. 3. Complete schematic of the 4-watt amplifier. It may be operated from most tuners and preamplifiers and provides adequate output for ordinary home listening.

mounted on the end of the chassis directly under the power transformer. Note that a Vector-type turret is used for *V1*.

The output transformer has two sets of primary taps. Only the 8000 ohm leads and the center tap should be brought out to the bottom of the chassis. The 10,000 ohm leads may be taped to the underside of the transformer.

All grounds should be made to one point on the chassis. The lugs of the filter capacitor make a convenient ground point. The dual cathode capacitor (*C4, C5*) of *V2*, the 6BX7GT, should be mounted on a plastic plate to prevent grounding at that point.

For ease of construction, wire all capacitors and resistors related to the 12AX7 to the socket before mounting it on the chassis.

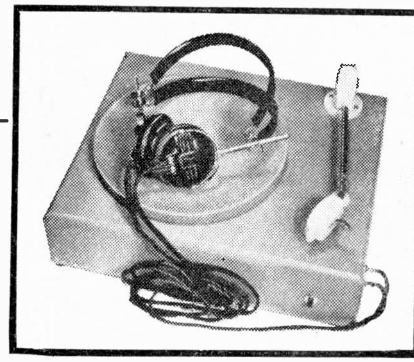
Before operation, the wiring should be double-checked to see that it is correct. Particular attention should be paid to the output transformer leads to see that they correspond to the color code shown on the diagram of Fig. 3. If the plate leads are reversed, positive feedback will cause oscillation.

After applying power, the output stage should be balanced. This may be done by measuring the voltage drop across the two sides of the output transformer primary and adjusting the balancing potentiometer, *R11*. When the voltage drops are equal, equal plate currents will be indicated. Each section of the 6BX7GT draws about 20 milliamperes.

The set is now ready for the "listening" test. We are sure the builder will find the results pleasing. —30—

Amplifierless Record Player

By ART TRAUFFER



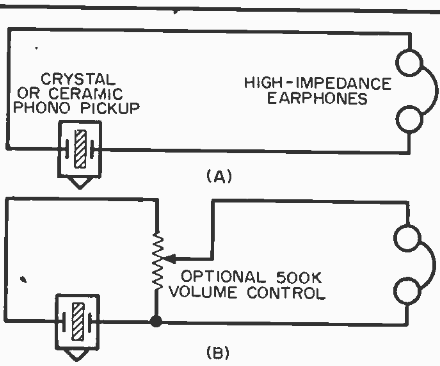
WHILE EXPERIMENTING with an old crystal phono cartridge, the author connected a pair of high-impedance magnetic earphones across the terminal lugs on the cartridge and was pleased to find that the recorded material could be heard with surprising volume and clarity.

There are a number of instances where it might be desirable to dispense with an audio amplifier and speaker. Many public libraries, for instance, are equipped with record players using amplifiers for record-auditioning in their record-loaning departments. Every librarian would welcome a simple record player having improved fidelity, no hum, no tubes to wear out, and consisting of only a turntable with pickup, and a pair of phones. In record shops, the usual row of poorly ventilated booths could be replaced with a row of turntables with pickups, and earphones.

Measuring 10" x 12" x 3", the author's record-player cabinet was constructed of wood and covered over with Contact adhesive plastic-coated material. You can build a cabinet, buy a ready-made one, or use any suitable record-player cabinet you have on hand. The model utilizes a 33⅓-rpm phono motor, but you may want to use a modern 3-speed motor.

The crystal phono pickup is a Ronette FF2 low-resonance 12" arm containing a Ronette 284-P high-fidelity crystal cartridge. Although the voltage output of the 284-P is relatively low (between .15 and .38 volt) as compared with many crystal cartridges, the earphone volume seems to be entirely satisfactory. Those with below normal hearing, however, will need to use a crystal or ceramic cartridge having a high voltage output. Other high-fidelity crystal or ceramic phono cartridges which may be used are the Sonotone "3" series, the Electro-Voice "80" series, the Shure "Music Lovers Cartridge," etc. Magnetic and dynamic phono cartridges are not suitable for amplifierless earphone listening, due to their very low outputs.

Use high-impedance earphones to match the high impedance of the crystal or ceramic cartridge. A crystal headset is the logical choice. Those who do not wish to invest in a pair of top-quality crystal earphones will find that the little crystal earpiece available from Lafayette Radio, 100 Sixth Ave., New York, N. Y. (Catalog No. MS-111, $1.49 net), is as sensitive as a pair of phones. The frequency response is not nearly as smooth, though, and you'll have to push the earpiece firmly into your ear to get good bass response. Nevertheless, this little earpiece does a fine job for the money. —30—



Simple hookup (A) for the amplifierless record player. If greater output voltage is used, volume control in (B) may be desirable.

Printed circuit techniques as utilized in this unit result in a preamp which is light in weight and very easy to build

MAKING AN ETCHED PREAMP

Etching is done in a small glass or plastic dish which should be placed in a sink. Flush all excess etching solution down the drain with plenty of water when the etching process has been completed.

By H. J. CARTER

ADDING a preamplifier to a hi-fi or radio amplifier is often complicated by lack of mounting space for the preamp. A neat way out of this difficulty is to use an etched circuit board mounted under the amplifier chassis.

An etched preamp can be made for the same cost as a standard chassis type and mounted practically anywhere. The circuit shown here is that of the well-known *G-E* preamp, which may be modified for any pickup or microphone by changing the value of the input shunt resistor *R1*.

Of course, a handmade board will not look as "pretty" as a commercial product since no photographic process is used, but it is just as functional. Once the steps to be described here have been completed, any other circuit can be laid out and etched with ease.

The circuit is etched onto a piece of phenolic laminated with .0028" copper foil on one side. There are a number of brands of laminate available, such as those manufactured by the *Synthane Corporation* and the *Continental-Diamond Fibre Company*. Consult the "plastics" section of the classified telephone directory for local distributors.

Order the laminate cut to the required size, 4¾" x 2½" x 1/16", and . . . if possible . . . have the supplier cut the ¾" socket hole shown on the guide line diagram. If preferable, the socket hole can be cut by clamping the board to a smooth piece of wood for backing and using a hole saw or flycutter; a hole punch would crack the phenolic. Be sure to start cutting from the copper foil side. All other holes are drilled after etching the board.

Etching

The first step in making the etched board is to wash the copper surface to eliminate grease films. Use a kitchen cleanser and rinse in warm water. After the board is dry, cover the entire copper surface with strips of "Scotch" brand flat-back tape No. 225. Overlap the strips about ⅛", and rub with a spoon bowl to insure good adhesion and removal of air bubbles.

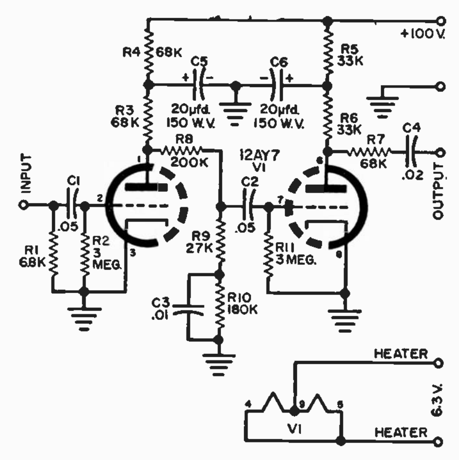
Next, trace the guide line diagram onto translucent paper. Cut a piece of carbon paper the same size as the board, and lay the tracing over the carbon paper with the carbon surface next to the tape. Use some cellophane tape to hold the tracing and carbon paper in place.

Now go over the tracing with a sharp pencil to transfer the guide lines onto the tape. Remove the tracing and carbon paper and ink in the lines with India ink, using a "Speedball" pen No. B-3. The pen will make heavy lines of correct width but the lines should be widened at each of the small circles, as shown in Fig. 2.

Next, cut the tape on the sides of the inked lines with a sharp knife such as an "X-acto" No. 16. Bear down to be sure of cutting through the tape. Remove the tape between ink lines, leaving the tape on those portions where the copper is to remain after etching. Trim and press down the edges of the tape remaining on the card. Before etching, check the card against Fig. 2 to be sure the pattern is correct.

The etching is done with ferric chloride, obtainable at any drug store. Three ounces dissolved in six ounces of water will be sufficient if a small glass or plastic dish deep enough to cover the board is used. *Caution:* do the etching in a sink. Handle the solution with the same precautions that would be taken with photographic chemicals or household ammonia.

Immerse the board tape-side-up in the etching solution. Wait a few minutes after bubbles cease to appear, and then slowly flood the dish with tap water to wash the solution away. When the wash water is clear, pick up the board and remove the tape resist. Rinse under running water and dry.



C1, C2—0.05 μfd., 200 v. tubular capacitor
C3—0.01 μfd., 200 v. tubular capacitor
C4—0.02 μfd., 200 v. tubular capacitor
C5, C6—20 μfd., 150 v. elec. capacitor
R1—6800 ohm, ½ w. resistor (see text)
R2, R11—3 megohm, ½ w. resistor
R3, R4, R7—68,000 ohm, ½ w. resistor
R5, R6—33,000 ohm, ½ w. resistor
R8—200,000 ohm, ½ w. resistor
R9—27,000 ohm, ½ w. resistor
R10—180,000 ohm, ½ w. resistor
V1—12AY7 tube
1—4¾" x 2½" x 1/16" piece of copper-clad laminate
3 oz.—Ferric chloride crystals or powder
1—9-pin socket (Cinch-Jones, 9EB)
1—Roll Sotch tape (No. 255) 1" wide

Catalog price of parts, approx. $8.00

Fig. 1. Schematic diagram and parts list.

Construction

Place the board on a hard surface and put a *small* center punch mark at each wide section of conductor, following the pattern in the guide line diagram. Drill a No. 54 drill hole at each punch mark, and drill the four corner mounting holes with a No. 25 drill. Compare with Fig. 2 before mounting the parts.

Prepare the parts for mounting by grasping them next to the body with small-nose pliers and bending their leads at right angles, keeping them in the same plane. Remove the mounting flange from the socket, insert the socket into the ¾" hole and bend the lugs until they are close to the conductors, as shown in the pictorial

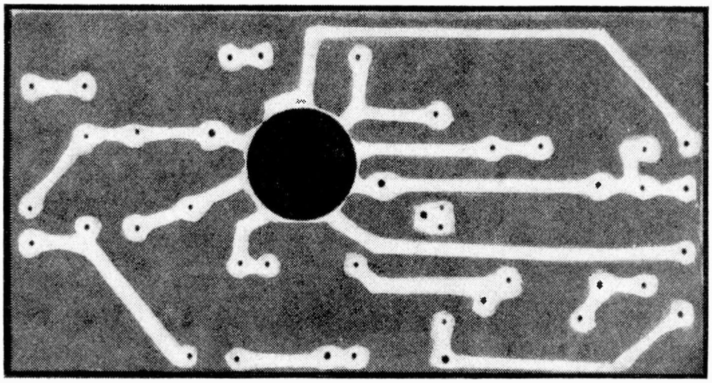


Fig. 2. The etched board, drilled and cleaned, and ready for mounting socket and component parts. Mounting holes for the electrolytic capacitors may have to be enlarged somewhat.

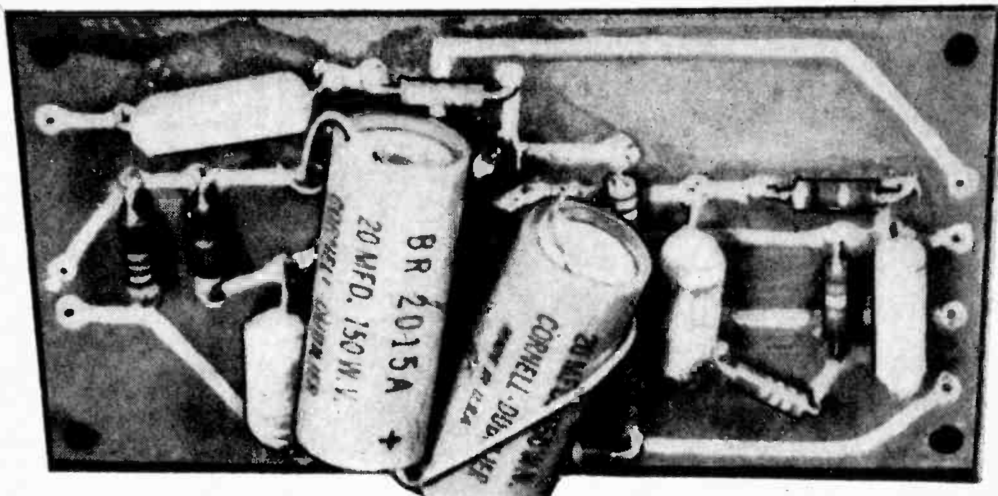


Fig. 3. View of complete amplifier with all component parts mounted.

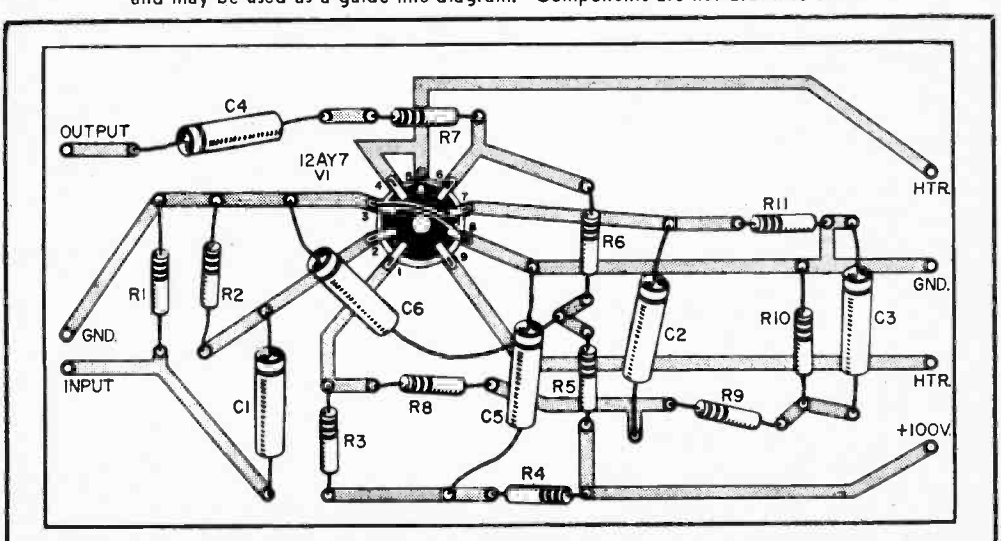
drawing. Rotate the socket to the correct position and solder into place. Solder a small bare wire strap across the socket to connect pins 3 and 8 if both external ground terminals are not grounded at the same place on the chassis.

Install all the resistors and capacitors except *C5* and *C6*, bending their leads behind the board to hold them in place. After soldering the leads to the conductors with rosin-core solder and a small pencil iron, clip the protruding leads flush with the card back. Finish the assembly by soldering *C5* and *C6* into place.

Resistor *R1* is shown as 6800 ohms, the correct value for the *G-E* pickup. This resistor can be easily changed to the value recommended for any other pickup. Power requirements for the preamp are very modest. The B+ voltage should be in the neighborhood of 100 volts, and the current drain is less than 1 ma. For the 12AY7 heater, 6.3 volts at 0.3 amp. or 12.6 volts at 0.15 amp. is necessary. Socket is shown wired for a 6.3-volt supply. Power can usually be obtained from the main amplifier without danger of overload.

Mount the board on insulating standoffs with *6-32* screws, and connect the power terminals to the amplifier power supply. The pickup shield should be grounded at the input ground conductor terminal. —30—

Fig. 4. This pictorial diagram shows the exact size of the mounting board, and may be used as a guide line diagram. Components are not drawn to scale.



RECORDER and AMPLIFIER MIXER

By
LOUIS E. GARNER, JR.

This handy gadget can be built in a few hours and should be of special interest to the tape recording enthusiast.

MOST home amplifiers and recorders utilize single "mike" input jacks. Two "mike" inputs, however, are often desirable . . . . either for use of an "off-stage voice" in amateur theatricals, for providing sound effects, for balanced recording of a solo voice and instrument,or simply to permit a large group of voices and/or instruments to use the equipment at one time.

The "Audio Mixer" shown in Fig. 1 can double the number of mike inputs of any piece of audio equipment which now has a single high-impedance mike jack. What's more, it allows *individual* control over each mike input, permitting "fading." It is ideal for sound effects and for announcing musical selections.

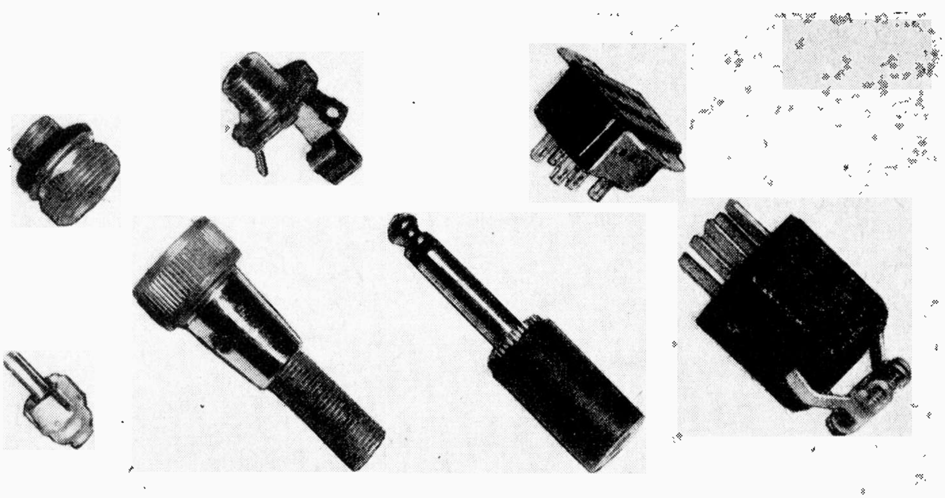
The mixer requires no circuit changes in present equipment, so don't worry about voiding a factory guarantee by opening the "works" of a new recorder. The unit simply plugs into the mike jack of the recorder or amplifier, and may be removed just as easily.

Parts cost is low and the unit is easy to assemble and wire. At current prices, all new parts should cost well under $5.00. Assembly time, for the average experimenter, should not run over two or three hours.

Material needed for assembling the mixer is specified in the parts list. *However, before purchasing the plug or jacks, check on the connectors used on the audio equipment and microphones.* The model shown uses a phone plug and jacks to match the equipment with which it is used. Other audio equipment may be equipped with a different type of connector—a *Jones* plug, a coaxial microphone connector, or some other type of connector.

Although a standard aluminum *Bud* "Minibox" houses the model, any small case is suitable. A plastic, or even a wooden, case may be used if the interior wiring is well shielded.

The underchassis view on page 106 should serve only as a guide, for exact dimensions are not critical, and considerable latitude in choosing parts location may be exercised by the individual builder. Either a larger or a smaller case size may be employed, provided there is room for mounting and wiring the components.



Examples of the many plugs and jacks used with tape recorders. The constructor must alter his mechanical arrangement to employ the proper jack with the mixer.

For a "professional" appearance, label the controls and inputs of the mixer. Use either metal name plates and dials or commercially available decals for this job. Decals were used to label the model. If decals are used, don't apply them until after machine work has been completed. After application, protect them with two or three coats of clear plastic spray or lacquer.

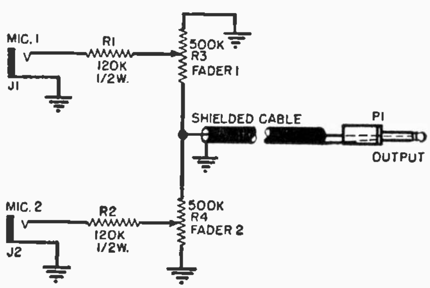
Some type of protection should be provided on the bottom of the case to prevent scratches to tables or cabinets on which the mixer may be placed. Rubber feet might be used, if available. Or, for an inexpensive substitute, use rubber grommets.

Wiring is straightforward and simple, requiring no special precautions. In the model, a piece of #12 tinned bus bar was run the length of the case, and all ground connections were made to it.

Operation

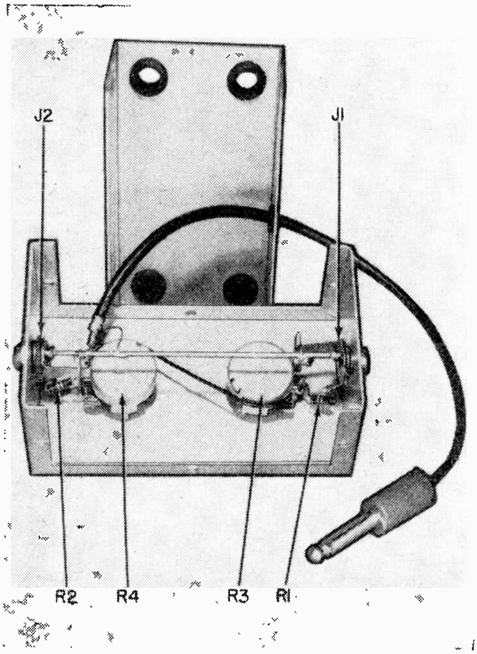
Referring to the schematic wiring diagram, mikes may be plugged into jacks *J1* and *J2*. Audio signals from the microphones are fed through resistors *R1* and *R2* to the center arms of "fader" controls *R3* and *R4*. Audio level obtained from each microphone now depends upon the settings of *R3* and *R4*. Either of the two inputs may be emphasized, both may be turned "off," or both may be turned to full volume, depending on how the controls are set. The combined signals are led into the "mike input" jack of the recorder or amplifier.

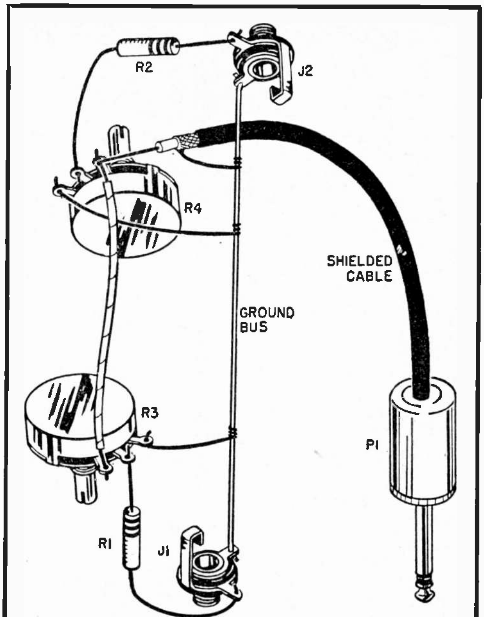
In operation, resistors *R1* and *R2* serve two functions. First, they act in conjunction with their respective controls, *R3* and *R4*, to vary the output signal level. These series resistors also act as voltage dividers. As the center arm is moved up to increase volume, the resistance between the center arm and ground increases, and a greater portion of the available signal appears across the control. As the center arm is turned down to reduce volume, the resistance between the center arm and ground decreases, and less signal appears at the output. With the control arm turned all the way back, the signal from the mike is essentially grounded and the series resistors act as a load on the respective microphones. The second function of series resistors *R1* and *R2* is to serve as *isolation* resistors between the mikes, preventing



R1, R2—120K, ½ w. carbon resistors
R3, R4—500K carbon potentiometers, audio taper
J1, J2—Open circuit phone jacks (see text)
P1—Phone plug (see text)
4—½" rubber grommets
1—⅜" rubber grommet
2—Pointer knobs
1—Single-conductor shielded cable (12")
Misc.—Case—5¼" x 3" x 2⅛" (Bud Minibox #CU-2106; decals; wire; solder; screws, nuts, etc.

Fig. 1. Wiring schematic and parts list of the mixer. The author indicates that the total cost should be less than $5.00.





Pictorial wiring diagram of the mixer.

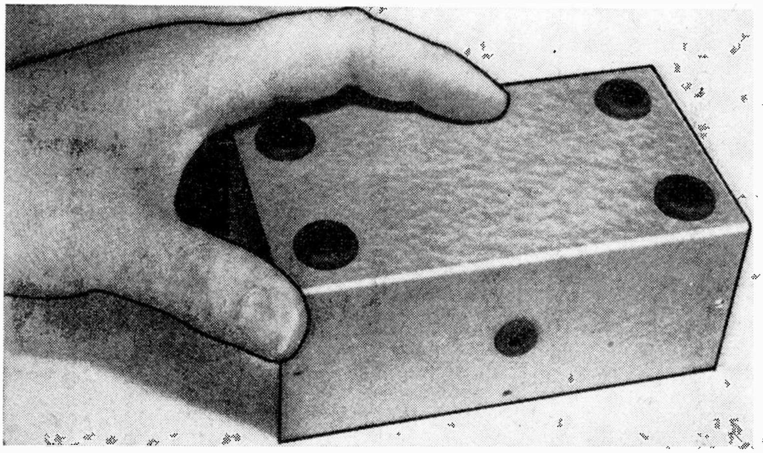
Underchassis view of mixer (above, left). Exact position of the two potentiometers is not critical. The author's potentiometers are equally spaced along one side with the input jacks at the ends. The cable to the recorder passes through a grommet in the side of the box. Use the proper plug for the tape recorder or amplifier at the end of this cable.

crosstalk even when both controls are turned up full.

Using the Audio Mixer

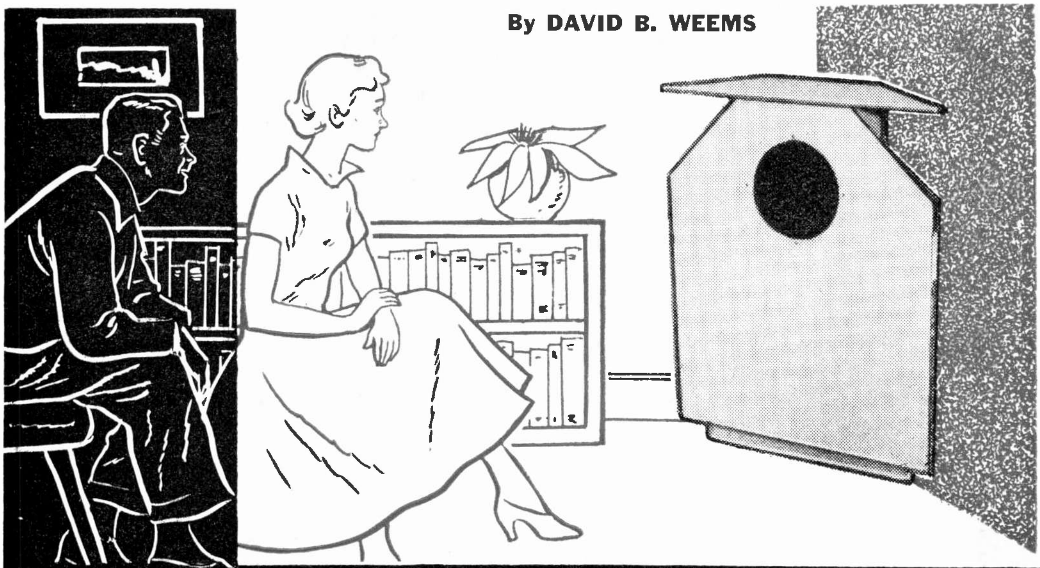
To use the mixer, connect the microphones to the input jacks and connect the output plug to the "microphone input" of the audio amplifier. Use the mixer's fader controls to vary the level of each mike, and the gain control on the amplifier as a master fader.

Instead of using the mixer to couple two microphones to an amplifier, it may be used to couple a mike and a record player —or mike and radio tuner. Thus, the user can announce musical selections or "break in" on radio programs. Obviously, there are many other possible applications for the mixer, and the constructor should have no trouble finding new ones for this unusual gadget. Such applications might include mixing two microphones for a public address system. Experimenters could also use this idea for mixing two inputs to an intercom where provision has only been made for one microphone. —30—



Drill four holes in the bottom of the metal box and insert rubber grommets to prevent scarring or scratching of furniture.

By DAVID B. WEEMS



The Mark II - A $3 Speaker Baffle

HEREWITH is a sweet-sounding and low-priced hi-fi enclosure for 12-inch speakers. It's designed for corner placement and is ideal as a temporary or extra installation.

Assembling this sonic wonder is simple, the six functional parts can be cut and fitted together in about an hour. There is no cabinet finishing involved, the design is not critical, and the material allows for tolerances in measurement. The completed enclosure (or more properly speaking, baffle) costs only $3.00.

This baffle has been based upon the design principle of the acoustic labyrinth type enclosure. Other enclosure designs were rejected as requiring too much space, being too critical to construct, or necessitating the use of expensive lumber. Celotex was chosen because it is non-resonant, inexpensive, and furnishes the required rigidity.

Making the Mark II

To build the Mark II, you'll need the greater part of a 4′ x 8′ sheet of Celotex. This will cost about $2.50. Refer to Fig. 1 as you go over the following instructions. First, nail the back piece ("E") to the sides ("C" and "D"). Next, nail the front ("A") to the sides. Remember to place the rough surfaces of the Celotex on the inside, toward the speaker.

Now, nail the bottom into place. The top panel must wait until last, because the speaker is inserted from the top. If glue is to be used in the joints (which is a good idea), don't use it for the top panel—this would make it practically impossible to change speakers, since you can reach them only by removing the top panel.

To prevent unwanted peaks in the mid- and high-frequency audio ranges, line the walls of the labyrinth baffle with a sound-absorbent material. The Celotex itself does some good in this respect, but the open tube in the rear of the baffle adds to the number of hard surfaces that serve as the walls of the labyrinth. Ozite rug padding, fiberglass insulation, or anything similar may be used. Cut the material to size and tape it to the walls of the room.

Mark II Sounds Off

The new baffle does a fine job on bass notes. Good results are possible with many types of 12″ speakers. A coaxial speaker will, of course, provide more highs—and some listeners may find this necessary for better balance of sound. Others will want to start with a general-purpose, single-cone speaker, and add a separate tweeter later. The Mark II's design allows for such addition without any further changes.

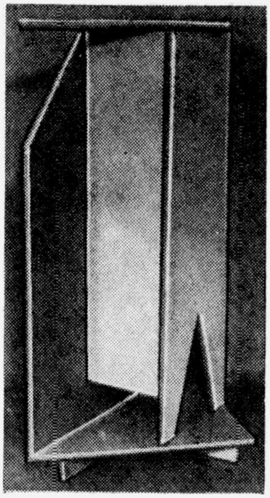
An inexpensive cone-type tweeter may be attached to the back panel so that the highs are squirted up into the corner and then reflected back over the room. Spreading highs in this way avoids the harshness of "focused" treble. Care should be taken to see that the tweeter does not feed the highs into the padding, which would absorb them.

The only trouble you may encounter in using an inexpensive tweeter is that its lack of efficiency can leave an unbalance in favor of the woofer. For best results, the tweeter and woofer should be perfectly matched with regard to efficiency. This isn't always feasible, however, and often a combination must be used whether it is a well-matched one or not.

In such a situation, you can balance the woofer and tweeter by using an "L" pad in the circuit of the woofer (assuming it is the more efficient of the two). Use of an "L" pad is demonstrated in Fig. 2. Typical values for the resistors would be 4 ohms for $R1$ and 8 ohms for $R2$. As $R1$ is raised in value and $R2$ is made smaller, the greater the action of the pad will be in order to reduce the output from the woofer. In the case of an overpowering tweeter, a simple tweeter control may be added as in Fig. 3.

Small Speaker as Tweeter

If a tweeter is not available, any small speaker may be used. Even if its high range is no greater than that of the large speaker, there may be an improvement in over-all sound because of the better distribution of highs. With an ordinary small speaker, a simple high-pass filter will serve as a crossover. Such a filter would require a larger value of capacitance than the 2 μfd. shown in Figs. 2 and 3. As paper capacitors of high values are expensive, a



Back view of the $3 baffle, the Mark II. The opening for the speaker cannot be seen in this view because it is on the front panel, which faces away to the left. Access to the speaker mounted in the baffle is obtained by removing the top panel. For this reason, the top panel should not be glued in place, but simply screwed on.

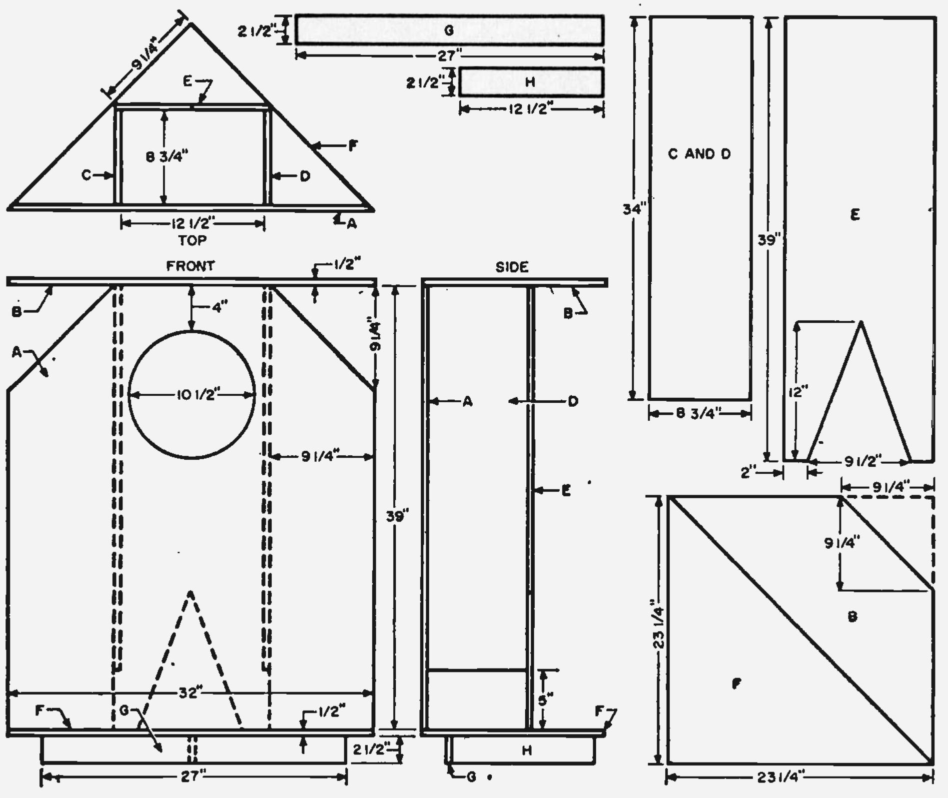


Fig 1. Complete layout and construction plans for building the Mark II out of a single piece of 4' x 8' Celotex. The only other materials needed are nails and glue.

cheap and effective substitute can be made by using two electrolytics of equal value. Simply tie their negative leads together and use the positive leads for the circuit connection shown in Fig. 4.

A can-type electrolytic may be used, too —its various elements usually have a common negative in the can itself, and connections "A" and "B" can be made directly to two positive terminals of equal capacitance. Typical values for each section may vary from 8 to 20 µfd. If the filter value that is chosen is of the higher figures, the phasing of the small speaker will become more important. Listen carefully as the leads are switched, and you should be able to choose the correct arrangement.

When this enclosure is fitted with a good coaxial speaker, or a balanced woofer, and tweeter, it can offer some exciting listening. It has enough presence to please anyone who possesses a critical ear as well as a desire to get the most for his money. —30—

2-WAY SPEAKER SYSTEMS
Using the Mark II

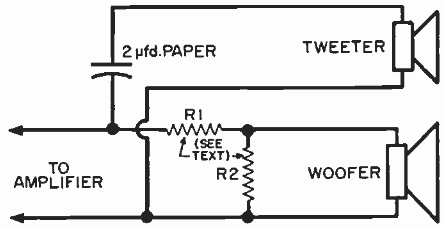


Fig. 2. A typical two-way system for use in the Mark II. Capacitor serves as crossover network. L-pad matches woofer with less efficient tweeter.

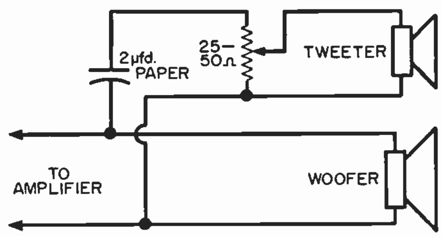


Fig. 3. If tweeter tends to overpower woofer, use potentiometer of values shown to serve as a simple control to regulate output of highs.

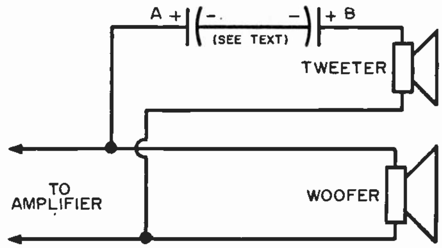
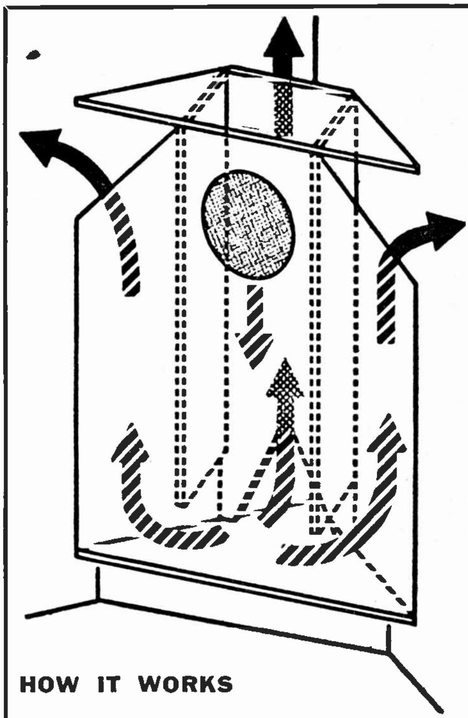


Fig. 4. When a paper capacitor is not available, use two electrolytics, with terminals connected as shown. See text for full details.



HOW IT WORKS

The Mark II is a labyrinth type of enclosure. Air passages created by the maze help load and damp the speaker cone. Loading enables an efficient transfer of acoustic energy (sound) from vibrations in the speaker cone to air mass in the listening room. Damping reduces bass boom by restricting excessive cone excursions at resonant frequency.

A speaker whose resonant frequency is 70 cycles requires an optimum labyrinth length of 4 feet. The labyrinth's cross-sectional area must be at least as great as the radiating area of the speaker cone.

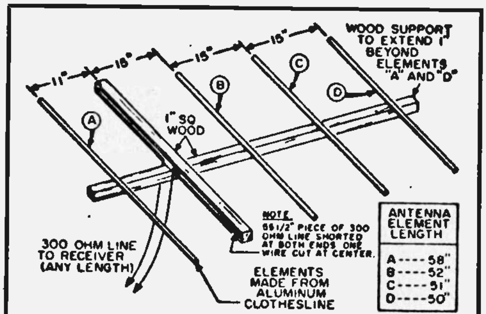
Made for an 8" speaker, the original enclosure used only two open-ended tubes. A third tube was added to the rear of this baffle to utilize space more efficiently. Path length of the added tube is longer than that of the other tubes, tending to broaden the frequency range over which damping is effective. With a wider damping range, the enclosure can accommodate a greater variety of speakers. The triangular openings at the front and the inverted V passage from the main tube to the rear also help in this respect.

In fact, the range of damping in the Mark II is effective from below 50 cycles to about 75 cycles, which means that any worthy 12" speaker may be used. If a speaker's resonance is below 50 cycles, it will probably not be very noticeable, and damping is not so important. On the other hand, a 12" speaker with a cone resonance much higher than 75 cycles would be of little value in an ordinary enclosure. Some enclosures resonate at about 60 cycles and add to the annoyance of 60-cycle hum from other components. This situation is happily avoided in the Mark II.

a simple

FM Yagi Antenna

IF YOU are situated 30 to 40 miles from a large city and want to take advantage of high-quality FM broadcasts, you will probably find that a directive antenna must be attached to your FM tuner or receiver. The antenna described in this article can be constructed on a Saturday morning from a few short lengths of solid aluminum clothesline, some scrap lumber and enough 300-ohm twin lead for the lead-in and radiator. If all parts are purchased new, total cost should not exceed $1.50.



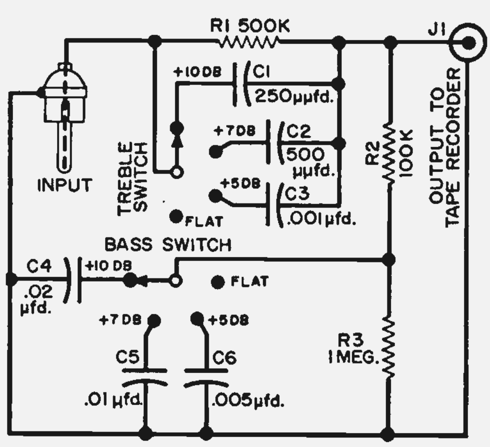
Construction details of the antenna. Note that antenna elements are stapled to 1"x1" frame.

Dimensions of the antenna are shown in the drawing. Its frame is constructed with scrap 1" x 1" lumber and extends one inch beyond the end of the elements. Just staple or tack the 300-ohm line and the aluminum wire rods to the crossbar. Tape the connection between the lead-in and antenna to prevent weather damage to the connection. When completed, the antenna should be elevated as high as possible and the lead-in connected to the receiver.

A directive Yagi antenna (named after the designer) acts to receive stations best when "aimed" by pointing it at the FM transmitter. Aluminum length "A" is a reflector, while lengths "B," "C," and "D" are directors. Properly erected, the antenna has the effect of providing the tuner with a signal that appears to be five or six times as strong as that obtained with a simple dipole. —*Donald L. Stoner*

Tone Compensator for Your Tape Recorder

ALTHOUGH most tape recorders are properly compensated, many of us would like to have some control over the amount of bass or treble that goes on the tape. When recording, the frequency response is fixed, and varying the tone controls has no effect. In dubbing records that are a little scratchy, it is handy to be able to cut the highs off. When dubbing records that are not scratchy but lack the highs, the tone compensator will bring out the highs. For those who like lots of bass, this unit will boost the bass notes about 10 db—a level greater than this might possibly overload the tape recorder amplifier.



The compensator has separate bass and treble switches, as shown in the schematic diagram. All components and the two s.p. 4-t. switches can be mounted in an aluminum box of convenient size. It could be incorporated on the amplifier chassis if desired—the circuit is in no way critical. The source of audio is connected to the input connector and the compensated audio is connected to the tape recorder through a length of shielded cable. It is advisable to keep this cable short to eliminate loss of the highs. After the unit is connected, adjust the switches until the most pleasing sound is obtained. As a check, a recording should be made and then played back and compared to the original sound. —*Donald L. Stoner*

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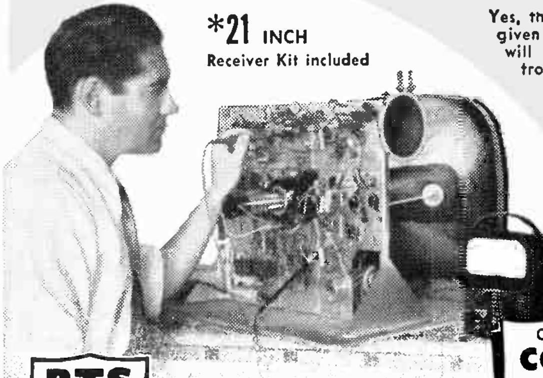

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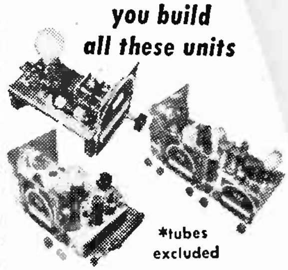

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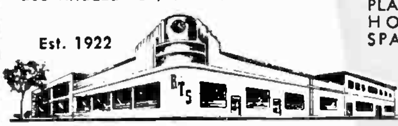

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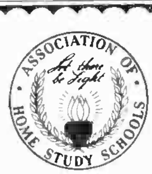

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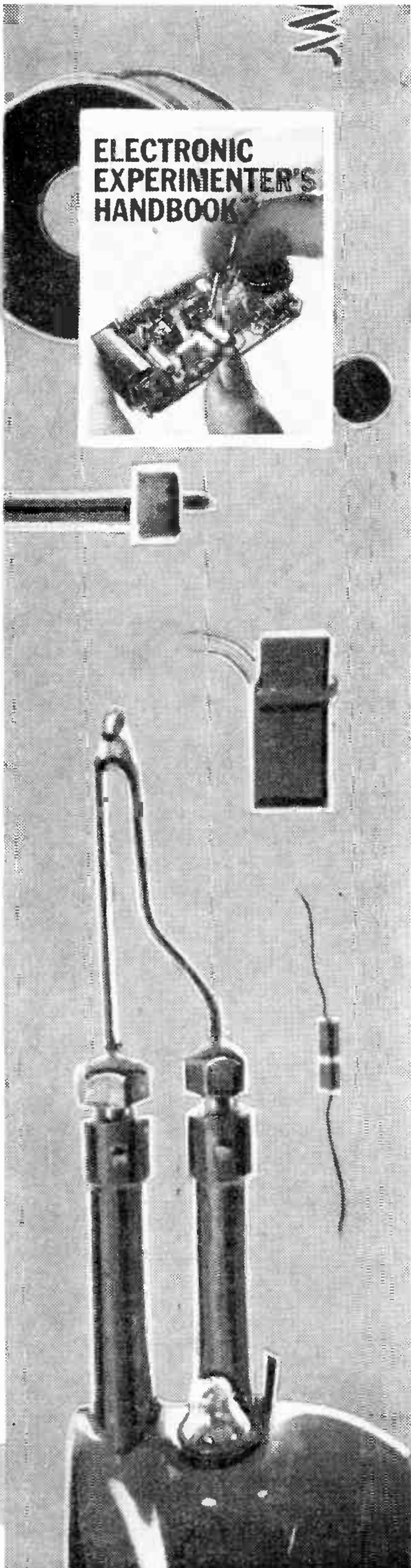


Chapter 5

For the Ham

Tech-Band Converter

Two-tube converter for the 50-mc. band requires few parts for sensitive and efficient operation

WITH the new FCC regulations allowing Technician class licensees to operate on the 6-meter band, a comparatively unused amateur band has come to life. This band offers many of the good features of the 2-meter band as well as an opportunity to work some DX.

Anyone with a limited amount of technical ability and a receiver that will tune to 4000 kc. is only eight hours away from receiving signals on six meters. While the tuner to be described is simple, it is by no means a toy. The approximate cost of parts is $15.00, less the amount of any parts found in the junk box.

The 6-meter band does not present some of the construction problems of the higher frequencies. Chassis layout and lead length are important but not critical. Most of the miniature tubes still operate satisfactorily on this band. Obtaining gain is not difficult. It's a band where the average technician can build his own equipment, expect good results, and conduct vital experiments. No short cuts were taken to reduce the cost of this tuner at the expense of quality. It's simplicity dictated low parts cost. The tuner consists of six resistors, twelve capacitors, six coils and two tubes. All parts are commercially available. The coils require modification which is not difficult.

Operation

Operation of the tuner is as follows. *L1* is the antenna coil. The only capacity across this coil is the input capacity of the tube. Cathode resistor *R1* is shunted by capacitor *C1*. *C2 is* the screen bypass capacitor which serves as the B+ capacitor for *L2* as well. Decoupling resistor *R2* is also used to reduced the plate voltage to 100 volts.

Capacitor *C3* couples the plate of *V1* to the grid of *V2A*. *R3* is a grid resistor, and *C10* is the plate capacitor for *L3*. *C9* is a B+ bypass capacitor, while *R6* serves as a decoupling resistor as well as the plate voltage dropping resistor to reduce the voltage to 100 volts. *C8* is a bypass capacitor for the screen and the plate of the oscillator. *R5* is a decoupling resistor, *L3* the i.f. output transformer, *C7* the oscillator grid capacitor, and *R4* the grid leak. *L4* is a tapped oscillator coil. Negative coefficient trimmer capacitor *C6* compensates for drift. *C5* is the main tuning capacitor. Coupling capacitor *C4* feeds injection voltage from the oscillator into the grid of the mixer.

Chokes *RFC1* and *RFC2* are heater chokes and *C11* and *C12* are heater bypass capacitors. Standard-type coil *L3* requires no modification. *L1, L2* and *L4* were made by modifying *J. W. Miller* Type 1474 coils. It is not necessary to use these coils, but they do have high-frequency cores and lugs on the coil forms which make winding coils a simple process. The only actual requirement is to wind coils that will tune to the proper frequency without too much reduction in *Q*.

The modification of these coils is as follows. Remove wire from a *Miller* Type 1474 coil form. Wind 14 turns of No. 24 enameled wire, close-wound on the top end of the coil form. Attach wires to the top and bottom lugs on the coil form. Then, place a layer of Scotch tape over the winding. Wind three more turns over the ground end of the coil. Attach the ends of the coil to the coil form lugs, and paint the windings with polystyrene cement.

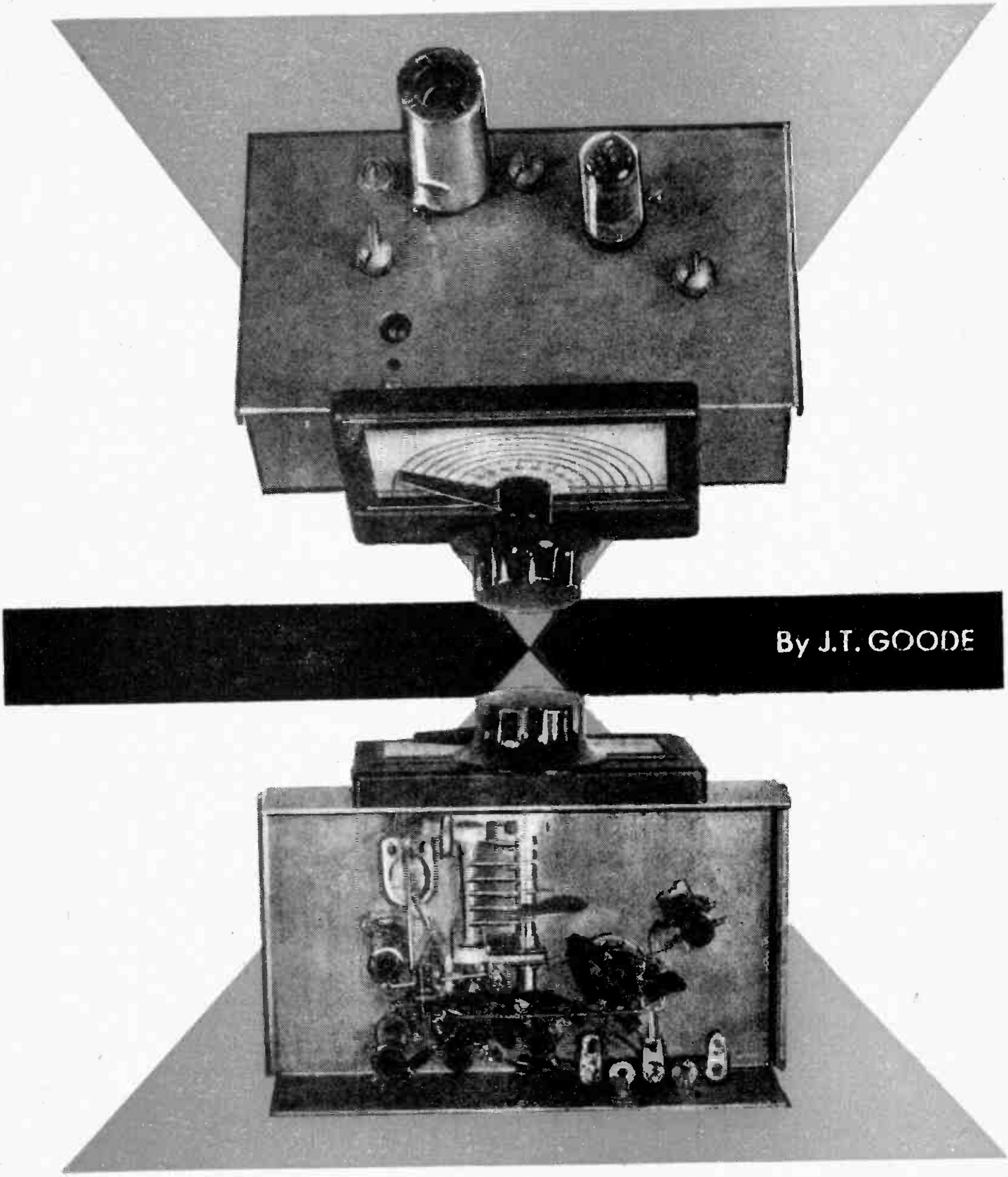
Wind coil *L2* the same way as *L1,* using nine turns, but omit Scotch tape and second winding. Apply cement to winding.

Coil *L4* is slightly different since a tap is used. Start winding the coil from the bottom of the coil form. At three turns, attach the wire to one of the lugs; bring the wire back up the coil form and complete the next five turns. Apply cement to the winding.

Chokes *RFC1* and *RFC2* are made by close-winding 20 turns of No. 24 enameled wire around a 1/8" rod. After removing winding from the rod, dip coils in polystyrene cement and let dry. These coils are light and are wired point to point.

Construction Notes

First wire *V1* socket. Attach a ground lug close to this socket. Use No. 22 solid tinned wire and connect pin 3, pin 7, center



post of tube socket, and the ground end of *L1* to the ground lead. Keep these leads as short as possible. Connect *R1* and *C1* from pin 2 to ground lug. *C2* is wired from pin 6 to ground lug. Keep this lead short. *R2* goes from pin 6 to insulated tie point mounted at rear of chassis. Pin 5 connects to the top lug of *L2* and the bottom lug connects to pin 6. Pin 1 is wired to the top lug of *L1*. *RFC1* connects from pin 4 to the tie point, and *C11* goes from pin 4 to pin 3. This completes the wiring of the r.f. stage.

Wire the mixer stage circuit next. Locate a ground lug between the mixer socket and variable capacitor. With No. 22 solid tinned wire, connect pin 5, pin 7 and center post of socket to ground lug. *C12* connects to pin 4 and pin 5. *RFC2* is wired from pin 4 to heater tie point.

C8 connects from ground lug to pins 1 and 3. *R5* extends from pin 1 to B+ tie point. *C3* connects from top lug of *L2* to pin number 2, and *R3* goes from pin 2 to ground lug. *C4* connects from pin 2 to top lug of *L4*.

C10 is wired from pin 6 to ground lug. Pin 6 also connects to *L3*. Note that this connection should be to the end of the coil winding which is away from the pickup winding. The end of the coil nearest the pickup coil is always connected to B+, thus reducing capacity coupling in this coil.

Capacitor *C9* connects from the B+ end of *L3* to the ground lug. *R6* goes from this same point to the insulated tie point located on the variable capacitor. From this tie point, a piece of heavy busbar No. 16 is used to make connection to the tie point at the rear of the chassis. This additional tie point was added, since the lead length of *R6* was not sufficiently long to reach from the top of *L3* to the B+ tie point.

Wiring of the oscillator section comes next. Ground the ground lug on the end of the variable capacitor to the common ground lug with busbar. The bottom end of *L4* and the ground side of *C6* connect to the ground lug. *C6* is a ceramic trimmer and the ground contact is the lug connected to the movable part of the capacitor. The stators of both *C5* and *C6* extend to the top of *L4*. *C7* connects from the top of *L4* to pin 9, and pin 8 is wired to the tap on *L4*. *C4* goes from the top of *L4* to pin 2.

Connecting the Antenna

The antenna lead should be coaxial cable. A proper match is made when the coil is tuned by adjusting the iron core of *L1* to the desired frequency. The cable should be wired directly to lugs on the coil form.

Output connections should be made with coaxial cable connecting directly to the lugs on the coil form of *L3*. This will reduce stray pickup in the output leads.

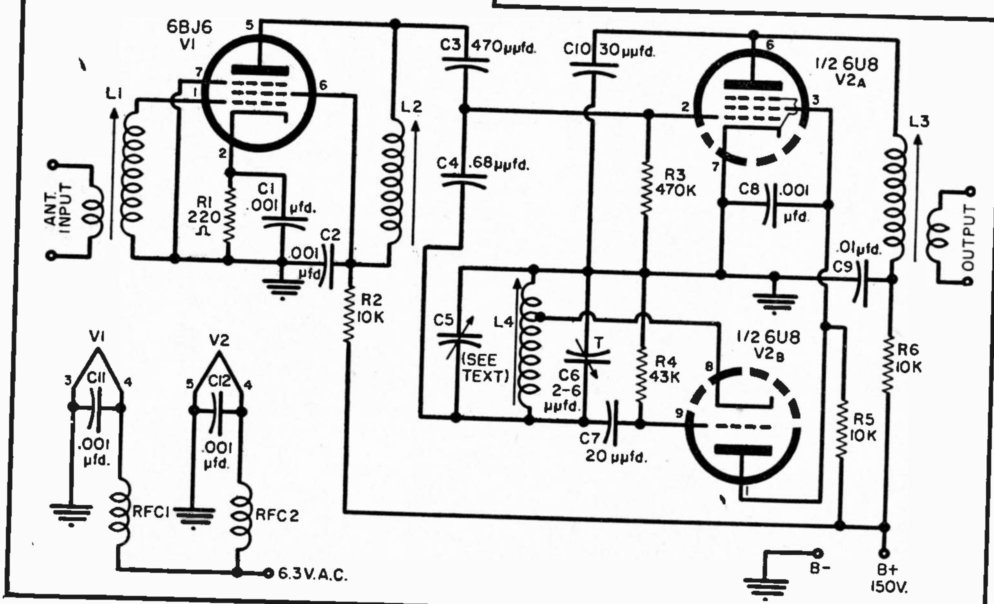
Power connections are made at the tie point located at the rear of the chassis. Power requirements: 6.3 volts, a.c. or d.c., 0.5 ampere. B+ voltage is 150 volts at 20 ma.

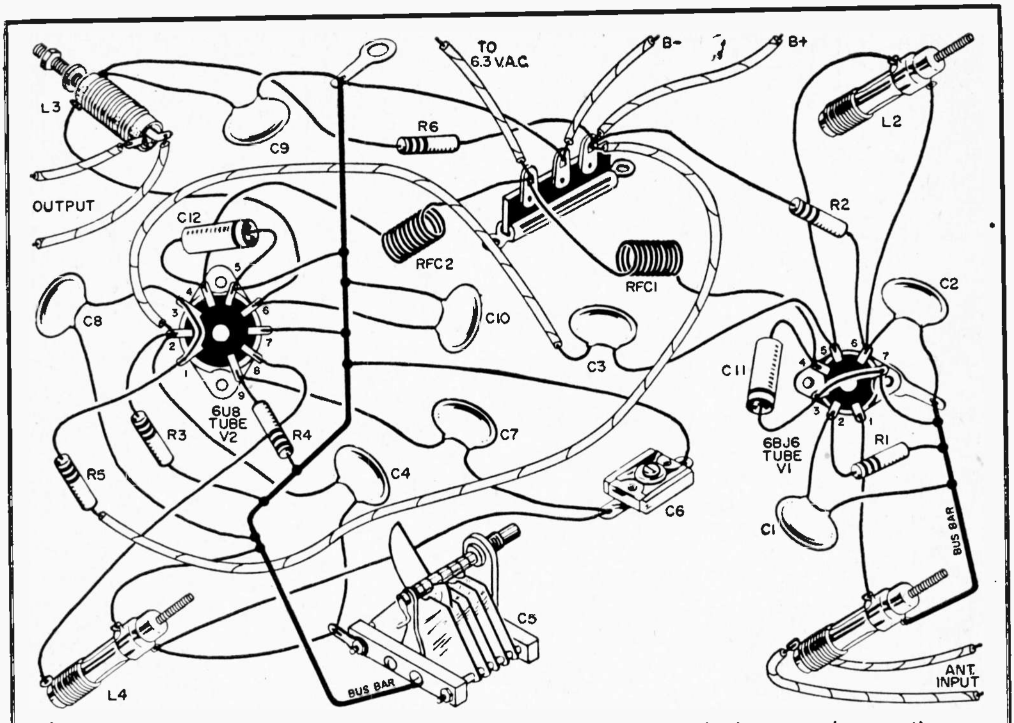
A grid dip oscillator is required to make the initial adjustments. The adjustments will only take about five minutes. Those builders who do not own such a piece of equipment should be able to borrow one for the short time required.

Rotate the main tuning capacitor *C5* for maximum capacity. Rotate trimmer *C6* for minimum capacity. Tune *L1* to 52 megacycles. Tune *L2* to 50 mc., *L4* to 45 mc.,

C1, C2, C8, C11, C12—.001-μfd. ceramic capacitor
C3—470-μμfd. ceramic capacitor
C4—0.68-μμfd. ceramic capacitor
C5—Three-plate variable capacitor made from a BUD Type MC-900 by removing all but one of the rotor plates
C6—2-6-μμfd. trimmer similar to Centralab 820-A
C7—20-μμfd. zero coefficient ceramic capacitor
C9—.01-μfd. capacitor
C10—30-μμfd. capacitor
L1—9/32 outside-diameter coil form with 14 turns of No. 24 enamel wire on secondary and 3 turns No. 24 enamel on primary
L2—9/32 outside-diameter coil form with 9 turns of No. 24 enamel wire on primary
L3—Similar to J. W. Miller B-5495-A
L4—9/32 outside-diameter coil form with 8 turns of No. 24 enamel tapped at 3 turns (both L1, L2 and L4 were made from Miller 1474 coils)
R1—220-ohm, ½-watt resistor
R2, R5, R6—10,000-ohm, 1-watt resistor
R3—470,000-ohm, ½-watt resistor
R4—43,000-ohm, ½-watt resistor
RFC1, RFC2—20 turns close-wound of No. 24 enamel wire on ⅛" inside-diameter form
V1—6BJ6 tube
V2—6U8 tube
Chassis—2" x 3½" x 6"

Wiring schematic and parts list.





The pictorial diagram shown above emphasizes the use of a busbar ground connection.

and *L3* to 4000 kc. Apply voltage to the tuner and check with the grid dip oscillator to see that the oscillator circuit is oscillating at 45 mc. Final tuning can be completed on received signals.

Connect the output winding of *L3* by means of coaxial cable to the antenna and ground terminals of a receiver that will tune to 4000 kc. Filament and B+ voltage can be supplied from the receiver. The current drain of the tuner is low, so that the power supply should not be overloaded in the receiver.

Minimum Frequency Drift

Reducing frequency drift to a satisfactory amount is an adjustment that requires no test equipment. If the drift is noticeable, increase the capacity of trimmer *C6* slightly and adjust the iron core of *L4* to return the dial calibration to normal. A majority of the drift will take place in the first 20 minutes. It may be necessary to make this adjustment several times. Final calibration should not be made until the drift adjustment is finalized. The center of the dial calibration should be 52 mc. To set the calibration, adjust the iron core of oscillator coil *L4*.

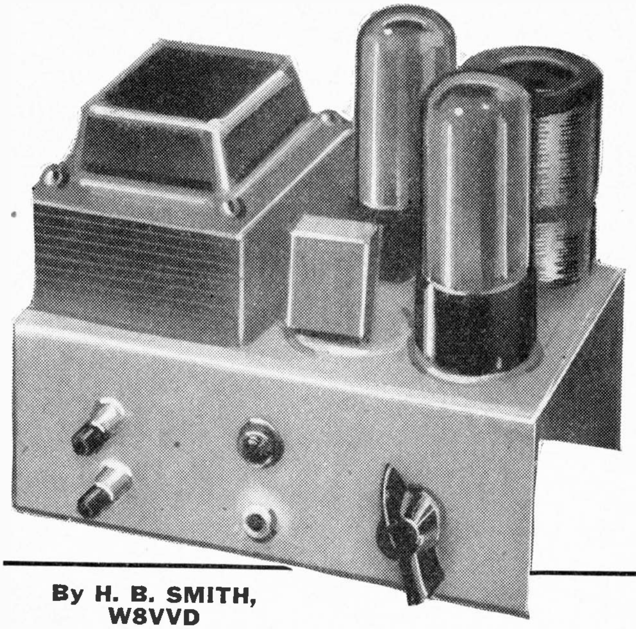
With a received signal, adjust iron core of *L1* for maximum gain. This adjustment should take place when the received signal is near the center of the band. the adjustment of *L2* is the same but there will be calibration change when *L2* is adjusted. It will be necessary to retune the dial for maximum signal while adjusting *L2*. When maximum gain is obtained, readjust *L4* for correct dial calibration.

This pulling effect between the oscillator circuit and the mixer circuit tends to cause tracking over the band. The tuner is essentially a fixed-tuned, broadband 4-mc. bandpass converter.

With the iron core adjustment, the *Miller* B-5495-A coil used for *L3* will tune from 4 to 6 mc. If it is desirable to use 6000 kc. as an intermediate frequency, simply adjust the iron core of *L3* to this frequency. The oscillator should then tune from 48 to 44 mc. *L4's* iron core will allow this much adjustment.

The tuner can be operated from batteries. In this case, reduce the value of *R2*, *R5* and *R6* to 1000 ohms, ½ watt, and use a 90-volt battery. If small B batteries are used, it is not necessary to make any connections other than an antenna connection to a car receiver. The filament voltage can be supplied by the car battery. —30—

Editor's Note: As specified in the parts list, the tuning capacitor, C5, is constructed from a BUD Type MC-900 variable capacitor. The number of rotor plates is reduced until only one is left in place anywhere on the rotor.



the hart-25

By H. B. SMITH, W8VVD

Amateur transmitters can be inexpensive and simple enough for a novice to build. Here is an example.

OPERATING a novice ham station is not only interesting, but one of the few hobbies where the participants can enjoy every minute of it with an outlay of only a few dollars. Catalogue prices of radio transmitters are disheartening when the pocketbook is thin, but putting a transmitter together for the novice ham bands is not an expensive proposition. This article describes a complete, easily-constructed transmitter that costs about $20.00—if all the parts are purchased new. Or the novice may purchase it in kit-form to save himself the trouble of punching holes in a suitable chassis. The photographs show the appearance of the completed transmitter.

Assembling the Parts

The first step to be taken after deciding to build this transmitter is to make a list of the parts required and to take it to the nearest ham radio jobber or distributor. Ask for someone interested in ham radio —they generally have at least one ham on the staff—and get the salesclerk to take the parts out of stock, or to make suitable recommendations, if substitutions are required. Don't worry about substituting other manufacturers' parts for the ones shown in our list. Radio parts of the specifications can be used regardless of the manufacturer. In the case of the power transformer *T1* we strongly recommend the one specified, because of the physical size and shape. A larger transformer will require a larger chassis and a smaller one might not do the necessary work without overheating.

Wiring and Construction

This transmitter has been made very compact and the wiring procedure must be followed step-by-step. If it is not, the builder may find himself with the problem of squeezing one part into the space already occupied by another component previously soldered in place.

Punch out the chassis holes for the four tube sockets with a *Greenlee Punch*, or comparable tool. Mount all of the sockets as shown in Fig. 1 with their keyways exactly in the positions in this drawing (this is *very* important). Now mount the two rotary switches, *S1* and *S2*. The power transformer, *T1*, is put in place with the color coded leads facing the directions shown in Fig. 1. Put a small soldering lug under the mounting nut in the lower left hand corner. Then bolt down the "terminal strip" with another soldering lug—this time under the right hand nut.

Begin the wiring by twisting the two yellow leads together and then cutting and soldering them, one to pin 2, and the other to pin 8 of the 5Y3GT tube socket. Take

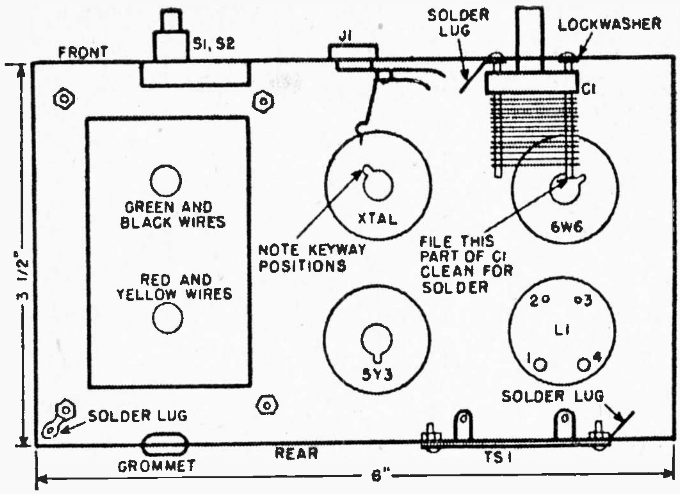


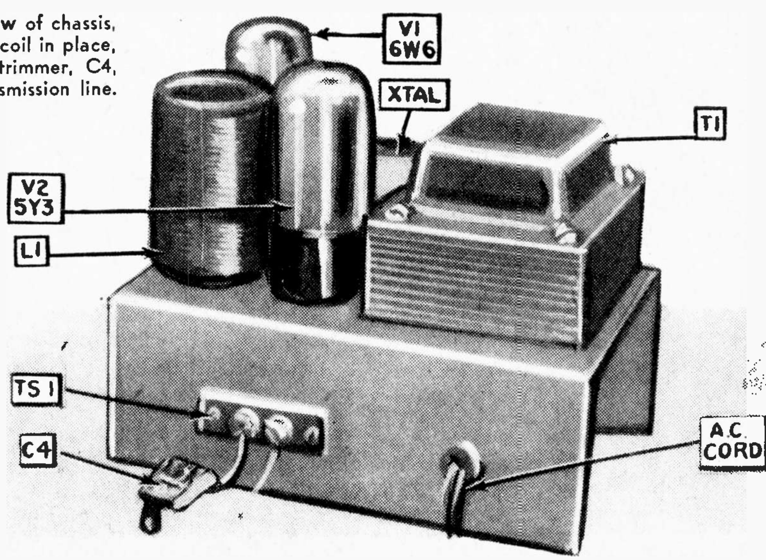
Fig. 1. This bottom view of the chassis shows the placement and orientation of the most important parts of the transmitter.

the red/yellow lead and the green/yellow lead of *T1* and solder them to the soldering lug in the corner. Now run one red lead from *T1* to pin 4 of the 5Y3GT socket and the other red lead to pin 6. Twist the two green wires together and cut and solder them, respectively, to pins 2 and 7 of the 6W6GT socket. The last step in the transformer wiring is to cut one of the black wires so that it will connect to pin 1 of the 5Y3GT socket and the other black wire to connect to pin 3. These pins are unused by this tube so it is safe to use them in place of soldering lugs.

Cut and solder one of the leads from *S1* to pin 3 of the 5Y3GT socket. The other *S1* lead is connected to pin 5 of the 5Y3GT socket. The line cord runs through a grommet at the rear of chassis and is soldered to pins 1 and 5 of the 5Y3GT socket.

To put the filter capacitor *C5* into the circuit, solder the red positive lead to pin 8 of the 5Y3GT. The black, or negative lead is soldered to the lug near *T1*. Leave about 1½ inches of wire on the positive lead before cutting and soldering. Now take the two resistors, *R4* and *R5*, and twist their leads together so that they are parallel to one another. Then solder one of these twisted leads to pin 8 of the 5Y3GT and the other to the soldering lug under

Fig. 2. Rear view of chassis, with 3.7 mc. band coil in place, showing antenna trimmer, C4, in series with transmission line.



one mounting screw for the terminal strip.

With some hookup wire run a lead from pin 8 of the 5Y3GT to pin 2 of the *L1* coil socket. Another lead should run from pin 2 of *L1* to pin 4 of the 6W6GT socket. Now cut one lead of *C3* so that it is ½ inch long and also solder it to pin 4 of the 6W6GT. Leave the other lead temporarily disconnected. Run a lead from pin 5 of the 6W6GT to pin 4 of the crystal socket. Connect together pins 1, 4, 5, and 8 of the crystal socket with a single piece of bare wire. Do the same to pins 2, 3, 6, and 7. Then solder a wire about 1½ inch long to pin 3 of the crystal socket. Leave the other end temporarily disconnected.

Shorten one lead of *R2* (33,000 ohms) until it is ½ inch long and solder to pin 7 of the crystal socket. Fasten one lead of *RFC1* to pin 5 of the same socket. Shorten, twist and solder the leads from *R2* and *RFC1* together.

Put a rubber grommet in the upper center hole on the front of the chassis. Press *PL1* into it until approximately ¼ inch of the glass bulb protrudes beyond the grommet (see photograph). Carefully solder to the tip of *PL1* one of the leads from switch *S2* and a short lead running to the terminal strip. The other lead of *S2* is soldered to the threaded portion of *PL1*. Also run a wire from the threaded base of *PL1* to pin 4 of the *L1* socket. Then solder a wire between pin 1 of the *L1* socket and the last free tab on the terminal strip.

Mount *C1* with a long soldering lug under the left hand screw as shown in Fig. 1. To make sure that the rotor plates of *C1* are grounded, solder a short lead from the wiping contact to the soldering lug. Then solder in the free wire running from pin 3 of the crystal socket to this lug. One end of *C3* is still hanging free and this should also be soldered to the lug under *C1*.

Trim the leads of *C2* until it will just fit between pin 8 of the 6W6GT socket and the grounding lug under *C1*. Short pieces of spaghetti tubing should be fitted over these bare leads before they are soldered into place. Resistor *R3* now has its leads trimmed until it will fit between pin 3 of the 6W6GT socket and pin 3 of the coil *L1* socket. A short wire is then soldered between the fixed plates (stator) of *C1* and pin 3 of the coil socket. The connection to *C1* is made at the ends of one of the support arms.

The last few wiring steps include mounting *J1* and soldering a lead from unused pin 7 of the 5Y3GT socket and the springy contact of *J1*. Then trim the leads of *R1* and put on short lengths of spaghetti tubing. Solder *R1* between pins 8 of the 6W6GT socket and 7 of the 5Y3GT.

Tuning Up the Transmitter

We have now completed wiring the transmitter and it may be tested (provided of

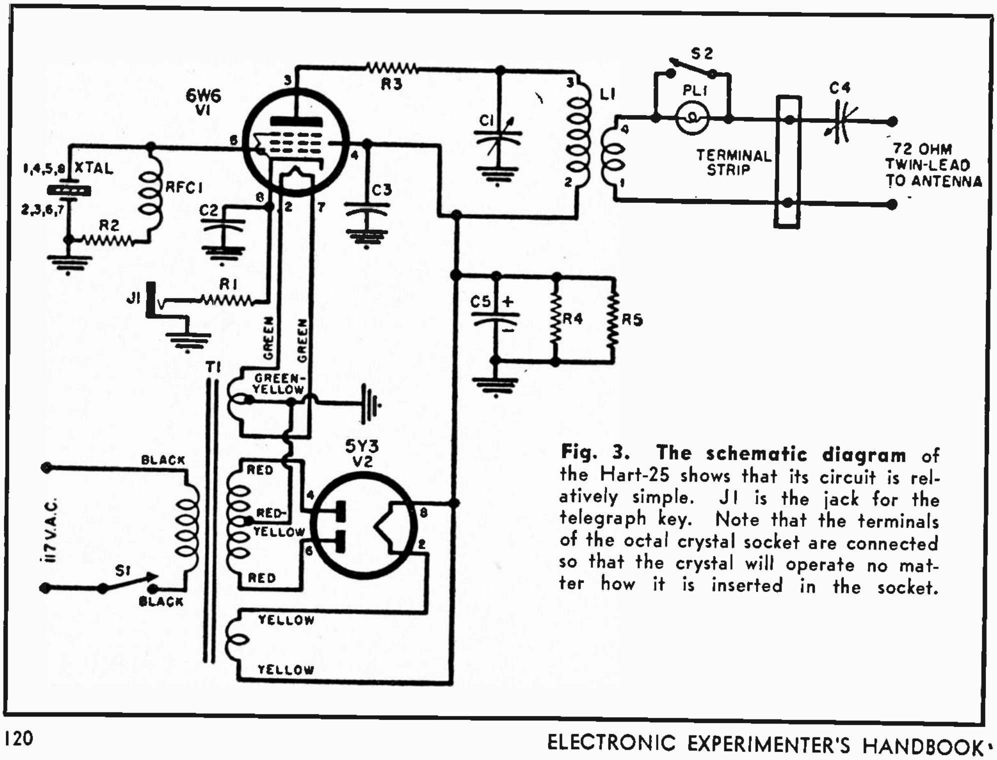


Fig. 3. The schematic diagram of the Hart-25 shows that its circuit is relatively simple. J1 is the jack for the telegraph key. Note that the terminals of the octal crystal socket are connected so that the crystal will operate no matter how it is inserted in the socket.

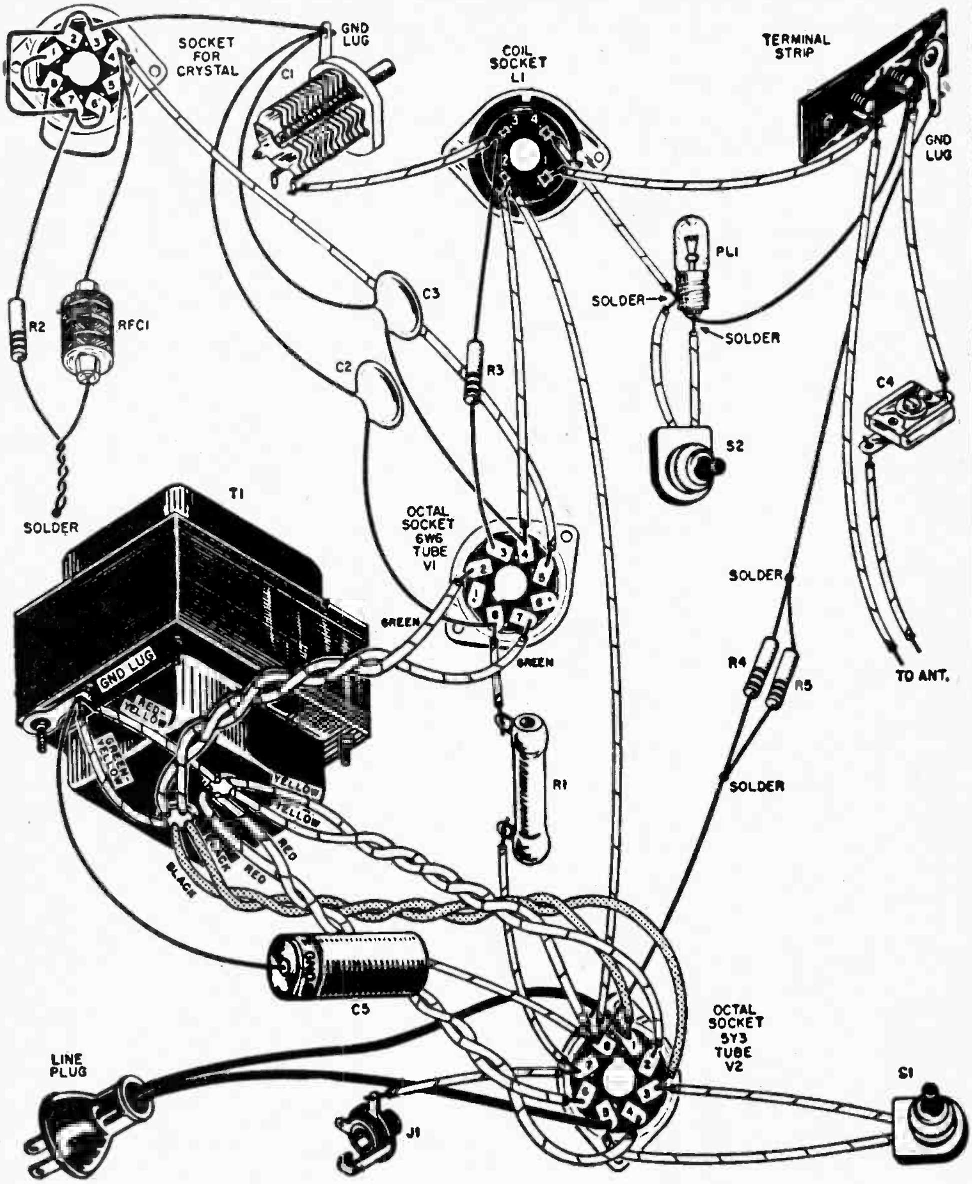


Fig. 4. The pictorial wiring diagram of the transmitter shows how the parts are connected; relative positions of the parts are not the same as on the actual chassis.

R1—250 ohm, 5 w. wirewound res.
R2—33,000 ohm, ½ w. res.
R3—27 ohm. 1 w. res.
R4, R5—330,000 ohm, 1 w. res.
C1—140 μμfd. variable capacitor (Hammarlund APC140 with short length of ¼" shaft added)
C2, C3—.01 μfd. disc ceramic capacitor
C4—25-280 μμfd. mica padder capacitor
C5—20 μfd., 500 v., electrolytic capacitor
J1—Open circuit phone jack
L1—3.7 mc. band: Plate coil 31 turns, #20 enamel closewound; Antenna coil 18 turns, #20 enamel closewound; ICA type 2158 coil form
L1—7 mc. band; Plate coil 16 turns, #20 enamel spaced diameter of wire; Antenna coil 13 turns, #20 enamel closewound; ICA type 2158 form
RFC1—2.5 mhy. r.f. choke
S1, S2—S.p.s.t rotary switches (H and H type 41047)
T1—Power transformer, sec 650 v.c.t. @ 40 ma., 5 v. @ 2 a., 6.3 v. @ 2.0 a. (Stancor type PM-8406)
TERMINAL STRIP—2 screw terminal strip
V1—6W6GT tube
V2—5Y3GT tube
PL1—#46 pilot bulb
XTAL—3.7 mc. or 7 mc. transmitting crystal
Misc.—Screws, nuts, wire, solder

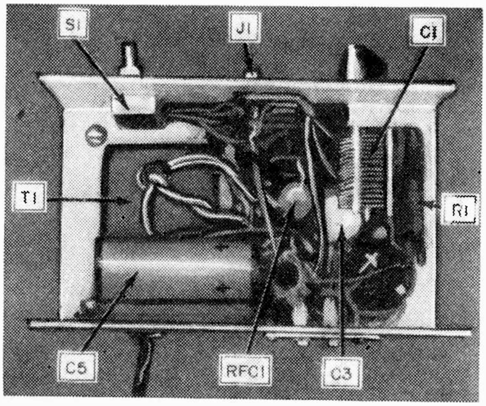


Fig. 5. Bottom view of the Hart-25 chassis. Most of the major components are visible, except the socket for V1, the 6W6GT, which is hidden by the variable tuning capacitor, C1.

course, that the builder has a novice or ham ticket). Best results will always be obtained if a resonant antenna is used with this type of transmitter. Many antennas have been described in the various handbooks for amateurs. Make sure that the length of the antenna fits the operating frequency. Connect the lead from the antenna to the "terminal strip" with capacitor *C4* in series with one lead.

Plug in the tubes, coil, crystal, and telegraph key. Turn on *S1* after the a.c. line cord is connected. Hold the key down and rotate *C1* until *PL1* glows. If the bulb does not glow it may be that *S2* is shorting it out. Throw *S2* and then attempt to make *PL1* glow. After it has started to glow, rotate *C4* and *C1* to get maximum brilliance. When it is glowing the brightest, the transmitter is drawing between 22 and 26 watts and is putting out around 9 watts of c.w.

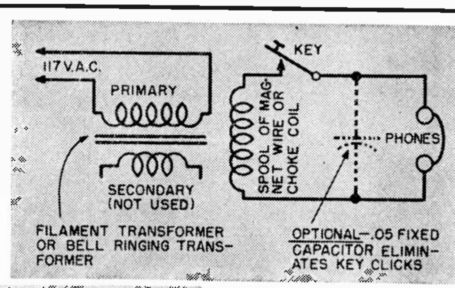
When the transmitter is tuned, throw *S2* to short out *PL1* again. It may be used occasionally to check the tuning, but when left continuously in the circuit it will burn up valuable antenna power.

Warning: The transmitter is safe according to modern electrical standards. However, do not work on it while the a.c. line cord is connected. Electric shocks can be fatal.

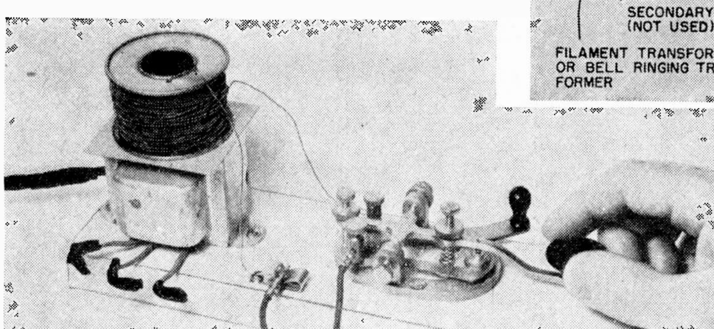
A kit containing all of the parts and components used in the construction of this transmitter is available from *Hart Industries,* 467 Park Ave., Birmingham, Mich. Additional information may be obtained by writing to the above address. —30—

A Code Practice Set

By ARTHUR TRAUFFER



The simple code practice oscillator which can be built from surplus or junk box parts.



The spool of wire set on a transformer picks up a.c. hum by induction. When the key is pressed, tone is heard.

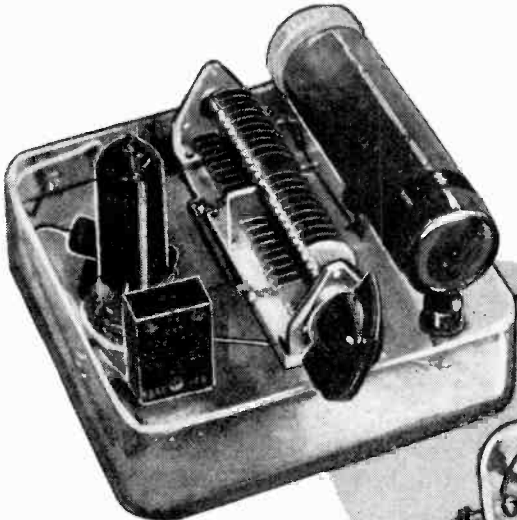
A NEIGHBOR lad wanted a code practice outfit and since his funds were limited, I made the following for him.

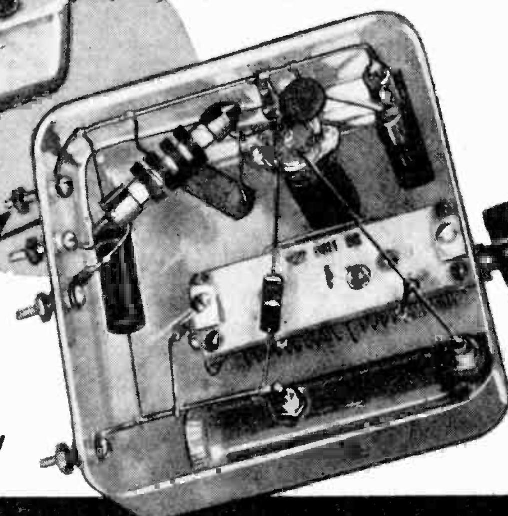
I plugged an old 2.5 volt filament transformer into the 117-volt line and taped the three secondary leads to prevent shorting. I connected an old half-pound spool of #24 silk-covered magnet wire, a key, and a pair of 2000-ohm phones in series and set the spool of wire on top of the transformer.

The spool of wire picks up a.c. hum from the transformer by induction and when the key is pressed, a pleasant low-frequency hum is heard in the phones. The volume of the hum depends on the location of the spool of wire in relation to the transformer. If the hum is too loud for comfort with the spool placed on top of the transformer, place the spool somewhere else but close to the transformer.

If the key clicks are bothersome, connect a .5 or .1 μfd. fixed capacitor across the phone terminals. —30—

Beginners and old-timers alike will want to build this handy little crystal-controlled rig that uses a single 6AQ5 tube





Chassis consists of a small plastic sandwich box, found in most five-and-ten-cent or hardware stores. The coil is wound on a plastic pill carton.

By ELTON V. STOLBERG, W7OUV

Sandwich Box Transmitter

THIS inexpensive little transmitter consists of a one-tube crystal oscillator using a 6AQ5. It is a very active oscillator having plenty of output even with the most stubborn crystals. Incidentally, this circuit can be made to double and even quadruple the crystal frequency with good output.

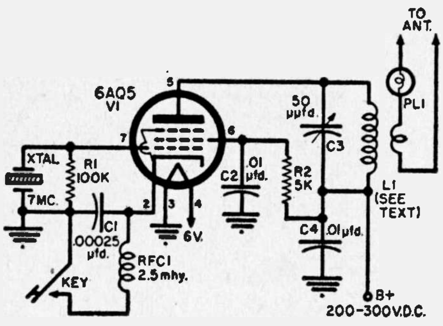
The transmitter was built on a plastic sandwich box turned upside down. Such boxes can be purchased in most five-and-ten-cent stores or hardware stores. Extreme care must be exercised when drilling the slightly fragile plastic.

In this particular rig, a piece of No. 14 wire, scraped clean of insulating enamel, was run from the crystal socket to the ground terminal on the back edge of the chassis to serve as a grounding bar. Bypass capacitors and the grid resistor are then grounded to this common bus. Using an insulated chassis has its advantages too, as you can mount the tuning capacitor (*C3*) and coil (*L1*) directly on the chassis.

The coil socket consists of two pin-type jacks mounted on the chassis alongside the tuning capacitor. The coil was made from a plastic pill box obtained from the corner drugstore. One inch in diameter and having a plastic cap, it was wound with 17 turns of No. 26 enamel wire, close-wound, and doped with coil cement. If desired, the coil form could be shortened and the cap replaced.

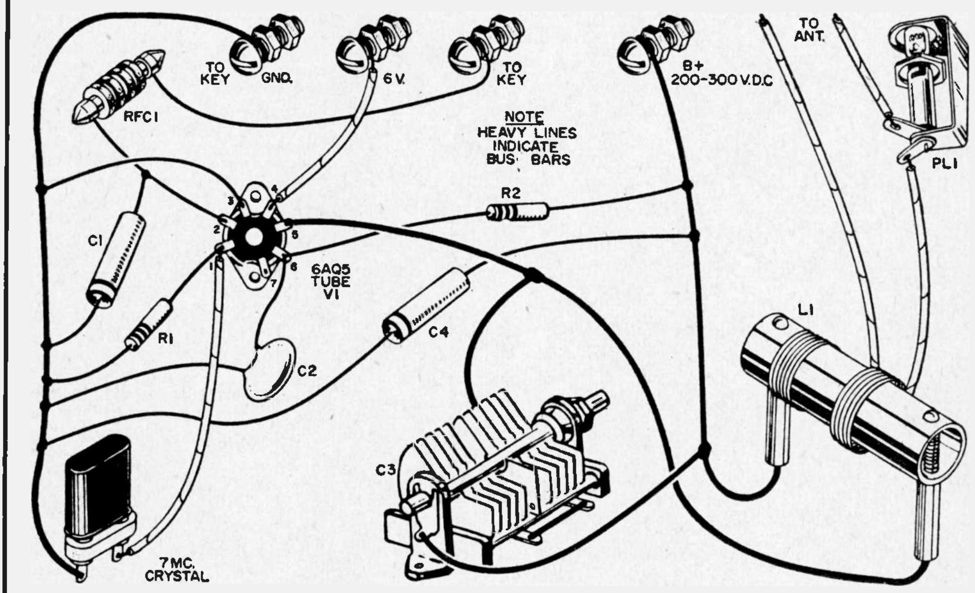
The coil prongs are two finishing nails, cut approximately in half, which fit snugly in the pin-type jacks. They are soldered to the heads of two *6-32* bolts which are then bolted to the coil form in the proper places. Coil wires are fastened to these bolts before they are tightened. The lower or pointed half of each nail was used, the upper half discarded.

Coil pins were deliberately spaced farther apart than necessary in order to give plenty of room for an 80-meter coil and also to allow room for the antenna link to



Wiring diagram of the transmitter, parts list, and pictorial diagram.

C1—250-µµfd. ceramic capacitor
C2—.01-µfd. ceramic capacitor
C3—50-µµfd. variable capacitor
C4—.01-µfd., 400-volt tubular capacitor
L1—Primary, 17 turns of No. 26 enamel wire close-wound on 1"-diameter form; secondary, 2 or 3 turns of hookup wire (see text)
PL1—Pilot light, 6.3 volt, with mounting assembly (for indicating r.f. current—not shown in photos)
R1—100,000-ohm, ½-watt resistor
R2—5000-ohm, 2-watt resistor
RFC1—2.5-mhy. r.f. choke
V1—6AQ5 tube
Xtal—7-mc. crystal
1—Plastic sandwich box
1—Plastic pill box
1—7-pin miniature tube socket
Misc. machine screws, wire, solder, etc.



be placed around the coil form. In the photographs, the coil is shown without the antenna link in place.

A simplified method of mounting the crystal socket was used in that it is completely suspended underneath the chassis with a small bolt. Holes were drilled in the chassis where the crystal holder pins pass through.

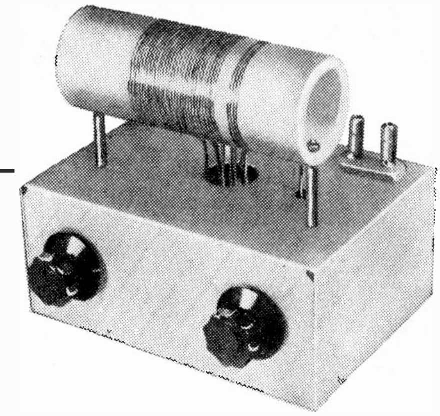
As can be seen in the photographs, the power and key terminals are simply four *6-32* bolts along the back edge of the chassis. Use three nuts on each bolt, two to secure it to the chassis and the third for securing the power supply wires. Do not attempt to solder any wires to the bolts, as the heat will melt the plastic chassis. The leads are twisted around the bolts before being tightened.

A separate power supply which gives 6.3 volts a.c. for the heater and about 200 to 300 volts d.c. for the plate supply should be built if one is not readily available. The antenna pickup loop is merely two or three turns of hookup wire wound around the coil form and slid along for best output.

Check operation of the oscillator without the crystal but with the key closed and B+ applied. There should be no oscillations regardless of the tuning capacitor (*C3*) setting. Also, have a friend of yours check for harmonic and spurious radiation after you get the rig on the air. With such low power, TVI will probably not be a problem even though the rig is not shielded.

Using this little transmitter and a surplus receiver operating from a 6-volt battery and vibrapack, I made 53 contacts in seven states and the Hawaiian Islands during a recent national field day test sponsored by the ARRL. Transmitter input was 11 watts and the antenna a simple 40-meter dipole. —30—

The SWL's Friend-An Antenna "Peaker"



By FRANK H. TOOKER

THE MAJORITY of radio amateurs wouldn't think of putting a transmitter into operation without first tuning the antenna and "matching" it to the power amplifier. Yet few amateurs and even fewer SWL's ever think of taking similar care with their receivers.

Now, the author has no particular quarrel with a random length of receiving antenna. Properly installed and properly used, it works surprisingly well. First of all, though, we must realize that such an antenna nearly always presents a poor match to the receiver. The result is a loss in signal at the very spot in the receiving setup where it hurts the most.

You can prevent this loss by tuning your receiving antenna just as they do in the biggest transmitting stations—in a much smaller fashion, of course. Using the "Peaker," you can probably produce a free signal gain of one to three S-units—which is equal to the transmitting station increasing its power 15 to 20 times!

The sketches shown in Fig. 1 are the two antenna terminations possible with the "Peaker." Figure 1(A) shows the antenna connected to terminal 2, no connection to terminal 1, and the ground to terminal 3. This is termed a series connection, because the coil, the variable capacitor, and the antenna-to-ground capacity are in series in the circuit. A series circuit is most useful when the antenna impedance is low.

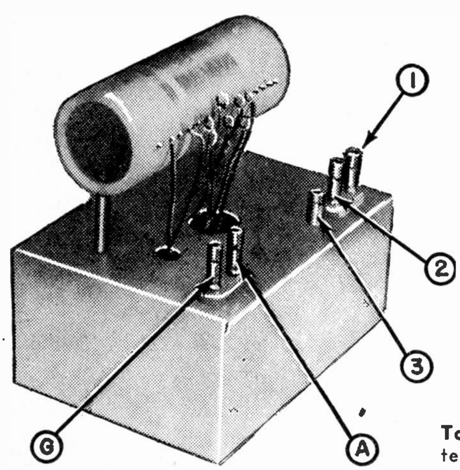
Figure 1(B) shows the parallel connection. The antenna is connected to terminal 1, and a jumper wire is connected from ter-

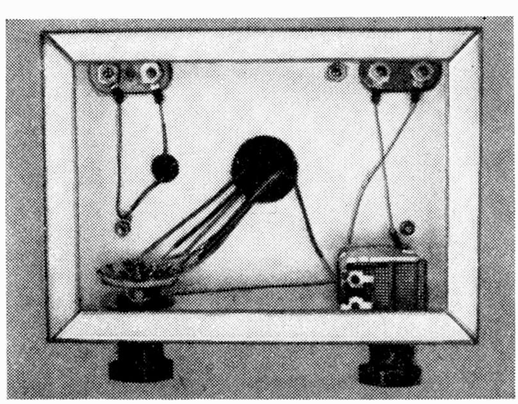
HOW IT WORKS

Under average conditions, the impedance of a random length antenna is either too low or too high to match the receiver input. The extent of the mismatch depends on the length of the antenna and lead-in, the frequency to which the receiver is being tuned, and the actual input impedance of the receiver at that frequency. For instance, if the length of the antenna plus its lead-in is equal to or near a quarter-wavelength or any odd multiple of a quarter-wavelength at the frequency being received, its impedance will be quite low.

The average commercially made receiver has a nominal input impedance of about 400 ohms. In practice, and with different makes of receivers, actual impedance will vary widely from this nominal value. The input impedance of home-built receivers is nearly always unknown. It can vary from a few hundred ohms for receivers using an antenna coupling coil to many thousands of ohms for receivers using a small capacitor from antenna terminal to the grid circuit of the first tube in the receiver. The latter type of input circuit cannot be used with this particular antenna tuner.

This simple device is a resonant circuit with switching facilities to permit its use in a series or in a parallel arrangement. By adjusting the coil tap and varying the capacitor, it can be made to cancel the reactance presented to it by a random length of antenna.





Top and bottom views of the "Peaker" show locations of antenna terminals. See wiring diagram on page 126 for details.

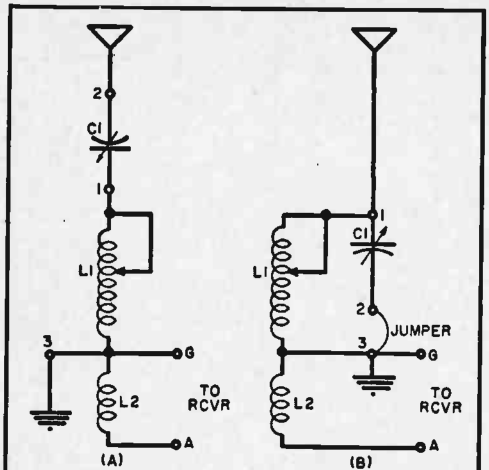


Fig. 1. Two possible antenna terminations: (A) series and (B) the parallel connection.

minal 2 to terminal 3. The coil, variable capacitor, and antenna-to-ground capacity are now in parallel. This connection is most frequently used when antenna impedance is high. Antennas that are very short will probably require such a parallel connection.

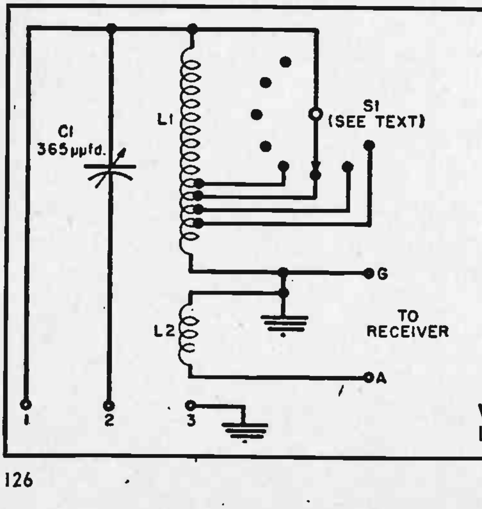
Try both the series and the parallel connection, and choose the one which performs best. It is reasonable to expect that a series connection will give the best performance at some frequencies and a parallel connection at others, even when the same antenna and receiver are used. In fact, the series connection and the parallel connection normally tend to follow each other alternately as one tunes continuously from one end of the short-wave spectrum to the other.

The antenna tuner and matcher has been designed for use with an average length antenna and an average receiver. It covers a frequency range of approximately 1.5 to 20 mc. Construction is simple, and the layout of parts and length of the leads are not especially critical.

The coil is 2" in diameter and consists of 32 turns of No. 20 solid tinned copper wire spaced to occupy two inches, i.e., 16 turns per inch. Spacing need not be exact. The link coil, *L2,* has 4 turns similarly spaced. It is located about ¼" away from the grounded end of the tapped coil. Any coil form of similar dimensions may be used instead of the one pictured. The tap switch should have ceramic insulation. The coil is tapped at 4, 8, 12, 16, 20, 24, 28 and 32 turns from the grounded end. To make the diagram easier to read, only a few of the taps are shown in the wiring schematic.

If your receiver has an r.f. amplifier stage preceding the mixer, connect the "Peaker" output terminals to the antenna and ground terminals of the receiver. Connect your antenna to the "Peaker" in either the series or parallel connection as shown in Figs. 1(A) and 1(B). Vary the tap switch, *S1,* and the variable capacitor, *C1,* until maximum output is obtained from the receiver. The "Peaker" will work best around the 20-mc. end of its range with all but four turns shorted out, and *C1* set with its plates almost full out. At the lower frequencies, say around 1.5 to 3.0 mc., none or few of the turns will be shorted out.

If your receiver doesn't have an r.f. stage, the "Peaker" should be connected and used as described in the preceding paragraph—with one exception. Coupling is more critical in a receiver having no r.f. stage. When the tuner has an undesirable effect on the receiver's oscillator, this effect is called "pulling." Pulling is indicated when you can receive no stations with the "Peaker" connected. Sometimes the receiver may break into instability and howl. If you use fewer turns on the link coil, *L2,* or move *L2* further away from *L1,* you can reduce the coupling and the pulling effect. —30—



C1—365-μμfd. broadcast-type variable capacitor
L1—32 turns No. 20 solid tinned copper wire spaced to occupy 2" on 2"-diameter form, tapped at 4, 8, 12, 16, 20, 24, 28 and 32 turns from ground end.
L2—4 turns, average, No. 20 solid tinned copper wire spaced to occupy ¼" and separated ¼" from L1 (see text)
S1—1-pole, 8-pos. rotary switch with ceramic insulation (Centralab Type PA-2001 or equal)
1—Chassis, 5" x 7" x 3"
2—2-terminal binding post terminal strips
1—Ground binding post
1—Coil form
2—Knobs
Misc. hardware, wire, solder, terminal lugs, etc.

Wiring diagram and the parts list for the "Peaker." Layout of parts and length of leads are not critical.

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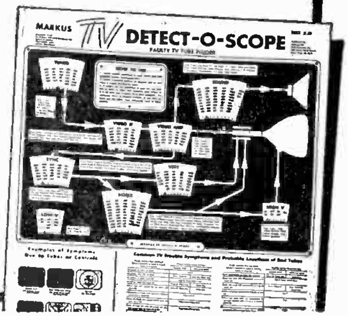

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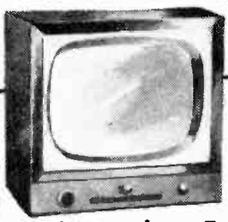

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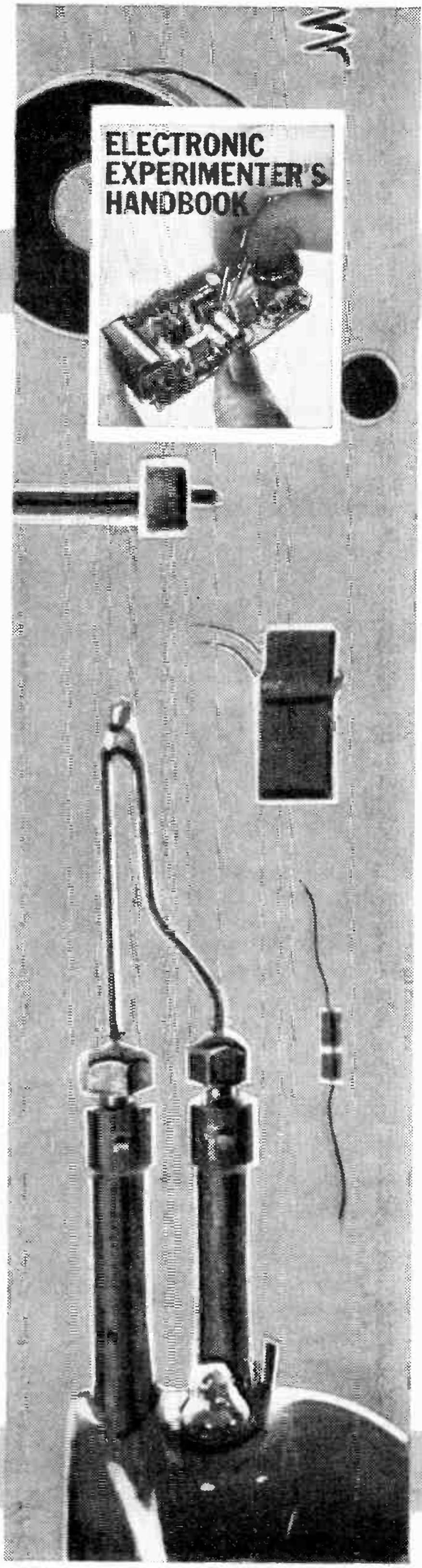


Chapter 6

For the Photographer

Home Built De Luxe Photographic Timer

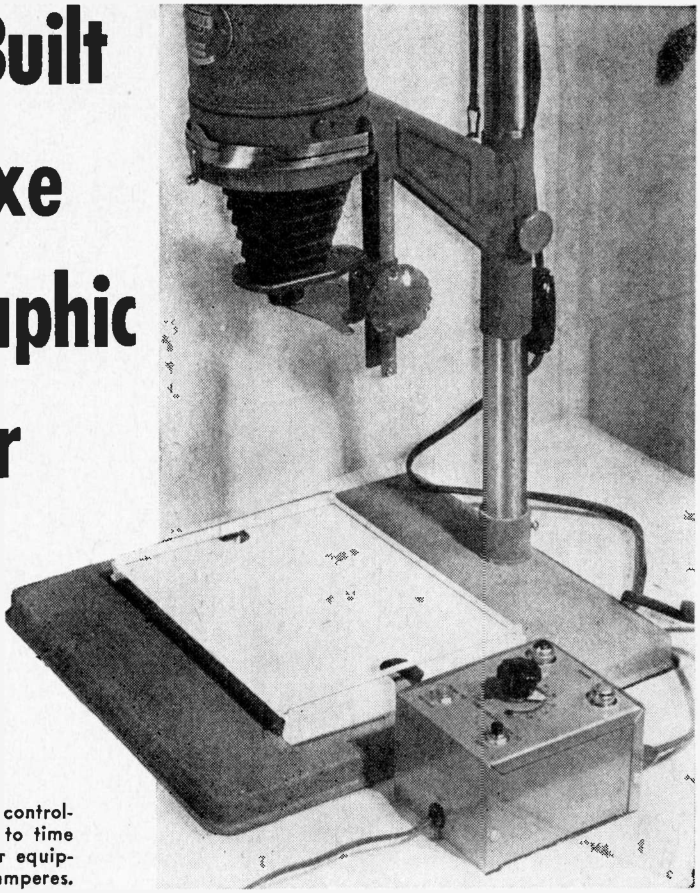


Fig. 1. The timer, shown here controlling an enlarger, can be used to time "on" or "off" intervals of other equipment drawing as much as five amperes.

YOU don't need a darkroom to find uses for the electronic timer shown in Fig. 1. Although originally designed for use with an enlarger, it may be used wherever it is desired to turn electrical equipment either "on" or "off" for predetermined intervals.

Although the unit measures only 3" x 4" x 5", it is completely self-contained and provides two separate outlets, one for "on" timing and one for "off" timing. Pilot lights indicate which outlet is energized. In addition, a special "Release" button is provided, permitting the timing interval to be cut short at any time.

You should be able to assemble your own timer in two or three evenings or on a weekend. The basic parts needed are given in the parts list. Standard, commercially available parts are used throughout.

Construction Hints: The 3" x 4" x 5" metal box used for a cabinet is available either with a gray hammerloid or an etched aluminum finish. Either style may be used.

The general layout used for drilling and punching the front panel is shown in Figs. 2 and 7. Dimensions are not given because the hole locations are not critical; the individual builder may easily modify the layout to suit his own requirements.

Black decals may be used to label the controls and switches on the unit. However, these should not be applied until after all shop work on the panel is completed. After application, the decals should be protected with two or three coats of clear plastic.

The chassis may be bent from a small piece of sheet aluminum or steel. Or, if you prefer, you can cut a standard chassis down to fit within the box (an *ICA* #29082 chassis base was used in the model, as shown in Fig. 3).

Drill or punch a number of small holes in the back and in one side of the outer case to provide ventilation when the completed unit is assembled. The ventilation holes should be located near the 117L7 tube. See Fig. 6.

Mounting the Parts: The two receptacles, the two pilot light assemblies, and the "Time Delay" control and "Power" switch are mounted on the front panel. The

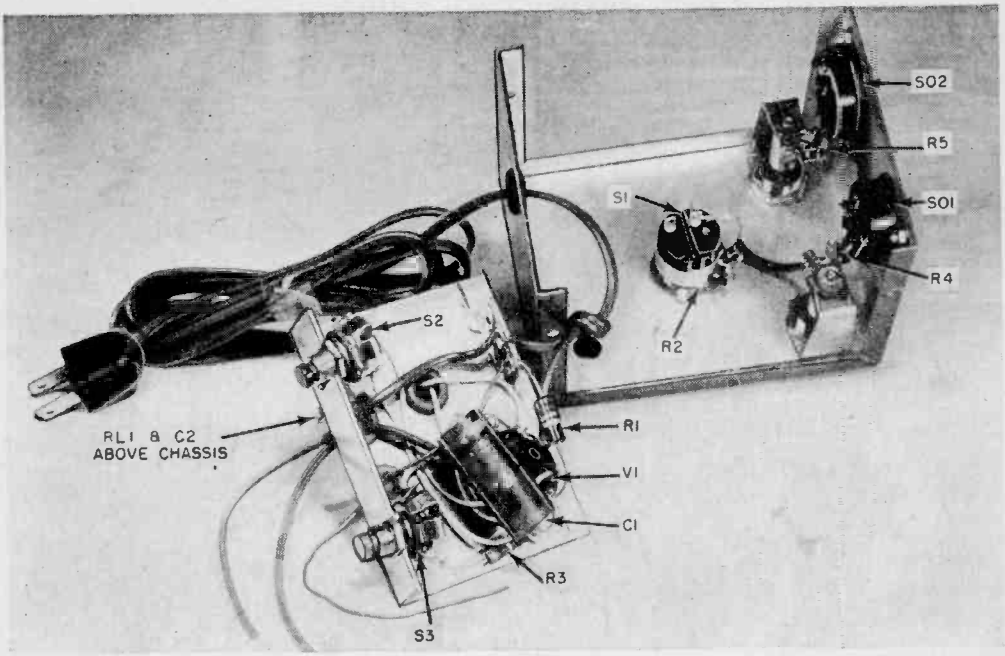


Fig. 2. All possible wiring is done before the subchassis and cabinet are assembled.

relay, octal tube socket, and other parts are mounted on the chassis.

The two push-button switches (the "Reset" and "Release" controls) are used to mount the chassis to the front panel.

Wiring Suggestions: Refer to the schematic diagram, given in Fig. 4, and to the pictorial wiring diagram, shown in Fig. 5, when wiring your unit. Parts location is not critical, and minor changes may be made without difficulty as long as the proper wiring is followed.

Mount an insulated "tie-point" or terminal strip below the chassis and make all common "ground" connections to it. *For safety's sake, do not "ground" any part of the electrical circuit to the chassis or case at any point.* A "floating" ground of this type keeps the chassis from being "hot" even though a transformerless circuit is used.

If you use the timer in a damp location, you can connect an earth ground to the outer case for added protection.

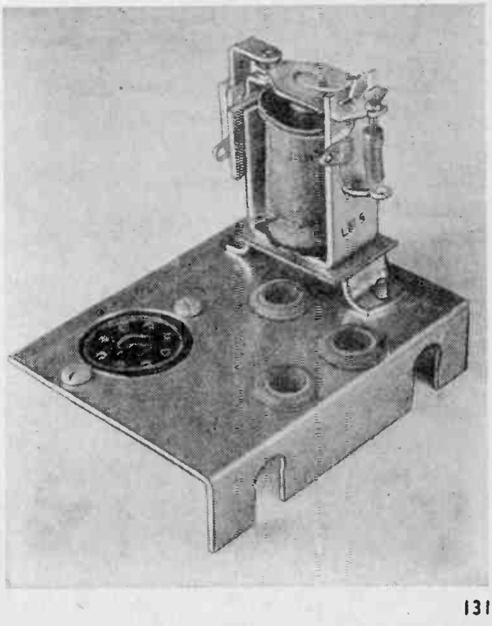
Do as much of the chassis and front panel wiring as you can before final assembly, allowing the leads from the chassis to the front panel to hang "free." Fig. 2 shows the partially wired timer before the final front panel connections were made.

After you've completed the wiring, recheck each soldered joint and every lead for possible wiring errors. Make sure, too, that there are no accidental shorts between terminals or leads. And check the operation of the relay by moving the armature with your fingers; make sure that no lead gets in the way of relay operation.

The completely wired model, with the back case removed, is shown in Fig. 6, while the assembled unit is shown in Fig. 7. The completed unit presents a real "commercial" appearance, even though built in a home workshop.

Circuit Modifications: If you use the

Fig. 3. Subchassis after the control relay, tube socket, and grommets have been mounted.



R1—27,000 ohm, 1 w. carbon res.
R2—10 megohm carbon pot with switch ("Time Delay")
R3—100 ohm, ½ w. carbon res.
R4, R5—220,000 ohm, ½ w. carbon res.
C1—2 µfd., 200 v. metallized paper capacitor
C2—10 µfd., 250 v. tubular elec. capacitor
S1—S.p.s.t. volume control switch, on R2 ("Power Switch")
S2, S3—S.p.s.t. push button switch, normally open ("Reset" and "Release" switches)
SO1, SO2—Line receptacles (Amphenol Type 61-M1P-61F)
RL1—S.p.d.t. plate relay, 5000-ohm coil (Potter & Brumfield Type LM5)
V1—117L7/M7 tube
NE1, NE2—NE-51 neon bulbs
Other parts: octal tube socket; line cord and plug; Bud #CU-2105 3" x 4" x 5" Minibox; ICA No. 29082 4" x 3⅛" x 1" chassis; rubber grommets; knob; two pilot light jewels and brackets; one two-terminal soldering lug strip; wire, solder, machine screws, and other small hardware

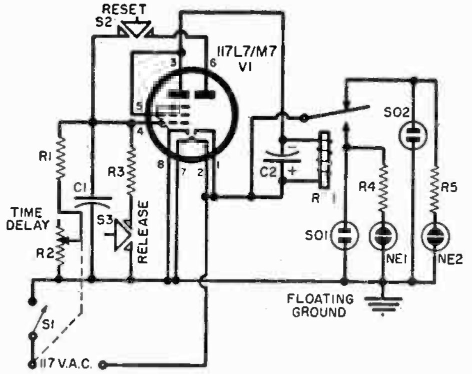


Fig. 4. Here are the schematic diagram and parts list for the home-built timer.

parts values given, the timing range will be from a minimum of slightly less than one second to about 25 seconds. The exact range covered will depend on the tolerances of the parts used, and as much as 25% variation from these values may be expected.

This range is more than ample for many types of enlarging work, especially where a "fast" enlarging paper such as *Kodabromide* is used.

Should you need a different timing range, you need only change the value of *C1*. Using a larger capacitor here will increase

Fig. 5. This pictorial wiring diagram will help you in connecting the parts.

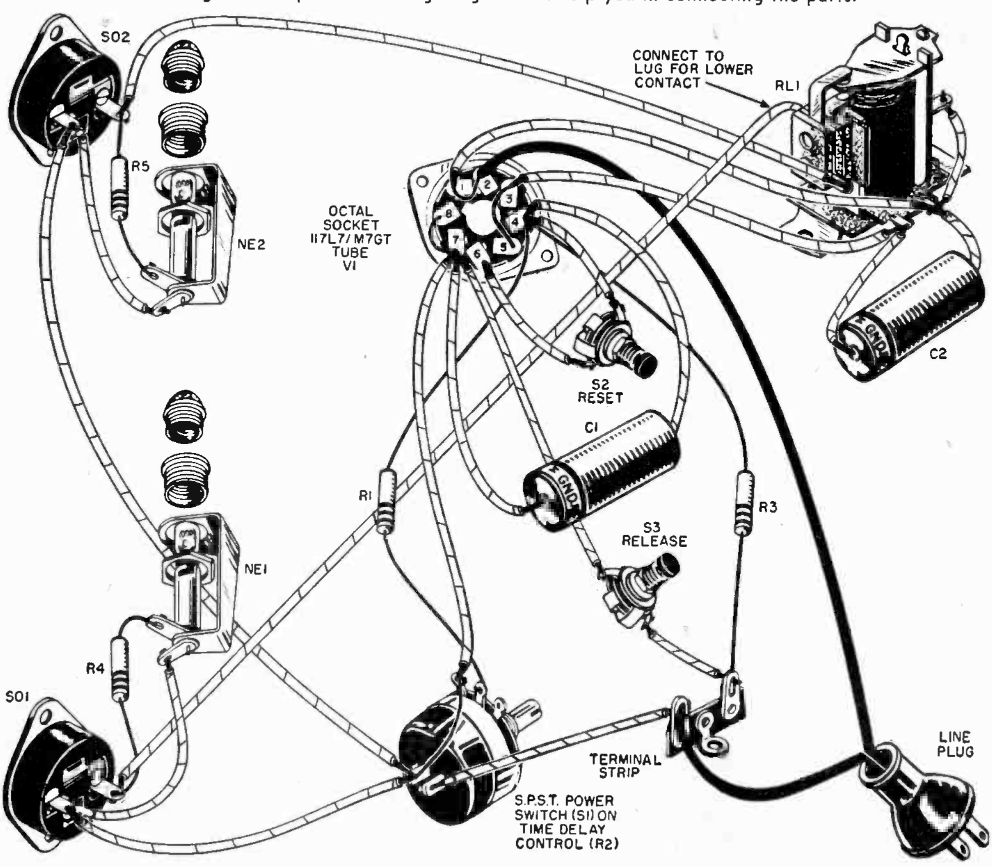
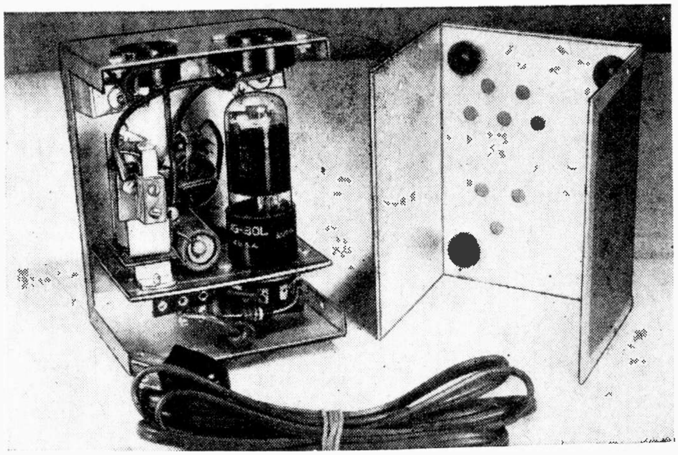


Fig. 6. **The timer** is shown here with the wiring and assembly completed, but before the two parts of the cabinet are assembled. Note the position of the sub-chassis and parts layout. The layout is not critical but it is best to keep it neat and compact.



the time delay; a smaller capacitor will reduce the timing interval.

A narrower range may be covered by replacing *R2* with a 5 megohm or a 2 megohm potentiometer.

Neon bulbs *NE1* and *NE2* indicate which of the sockets, *SO1* and *SO2,* has power applied. They can be distinguished by fitting them with different colored jewels.

Calibration and Use: With the 117L7 tube in place, plug the timer into a standard power line outlet and turn it "on." When the unit has warmed up properly, the relay will pull in with a distinct "click."

Set the "Time Delay" control about half way towards maximum. Press the "Reset" button and release it. The relay will drop out immediately and after an appropriate time interval, will pull in again.

If you wish to stop the timing interval at any time, simply press the "Release" button. The relay will pull in immediately.

You may calibrate the completed timer by checking the delay intervals with a stopwatch or standard "clock type" timer. You can then either make up a calibration chart for the timer or, if you prefer, prepare a hand-drawn scale for the front panel.

If you don't care what makes the timer work, as long as it does, you can skip the remaining paragraphs. The following explanation is for readers who do like to know what goes on in equipment they build.

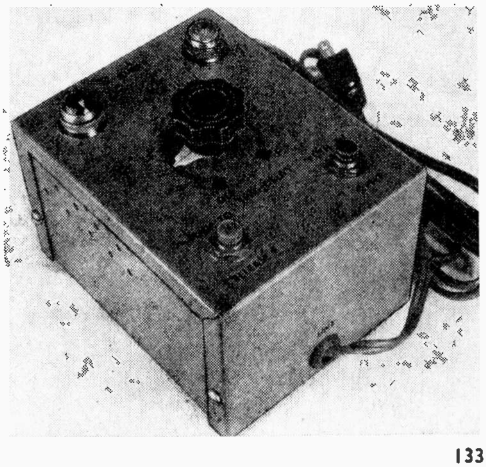
When *S1* is closed, the a.c. line voltage is applied through the contacts of *RL1* either to socket *SO1* or socket *SO2,* depending on whether relay *RL1* is energized or not. The line voltage is applied also to the heater of *V1* and to the plate-cathode circuit of the amplifier section of the tube and the coil of relay *RL1,* in series. Although a.c. voltage is applied, plate current flows only one way through the tube, and thus current flows only one way through the relay coil. The relay coil is energized and power is transferred from *SO2* to *SO1.*

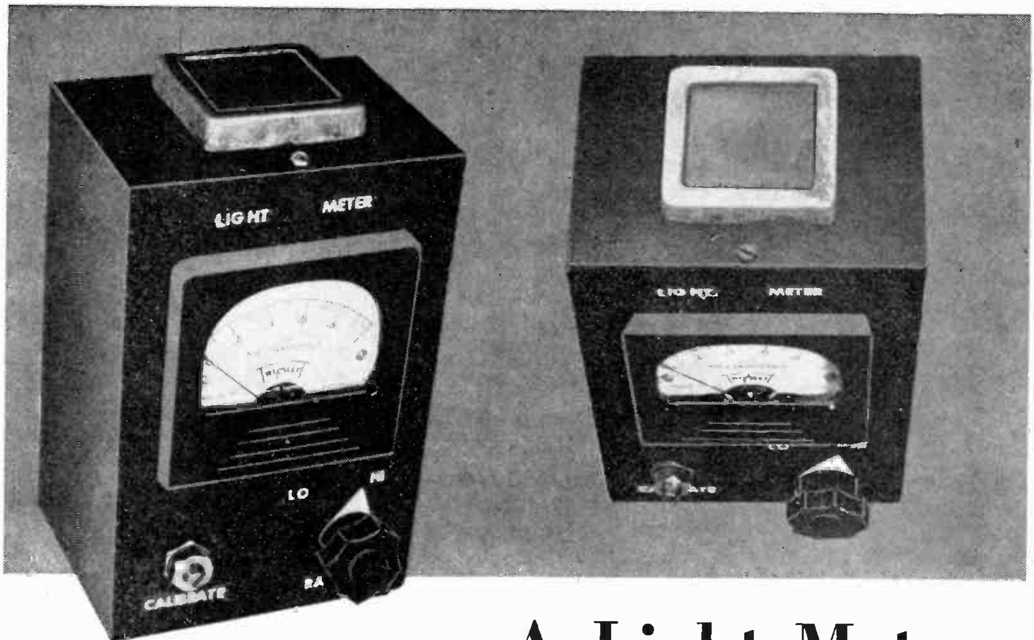
S2 and *S3* are momentary contact switches, normally open. When "Reset" switch *S2* is depressed, the rectified output of the diode section of *V1* charges *C1* and applies a large negative bias to the grid of the amplifier section of the tube, cutting off plate current flow. The relay is deenergized and power is transferred from *SO1* to *SO2.*

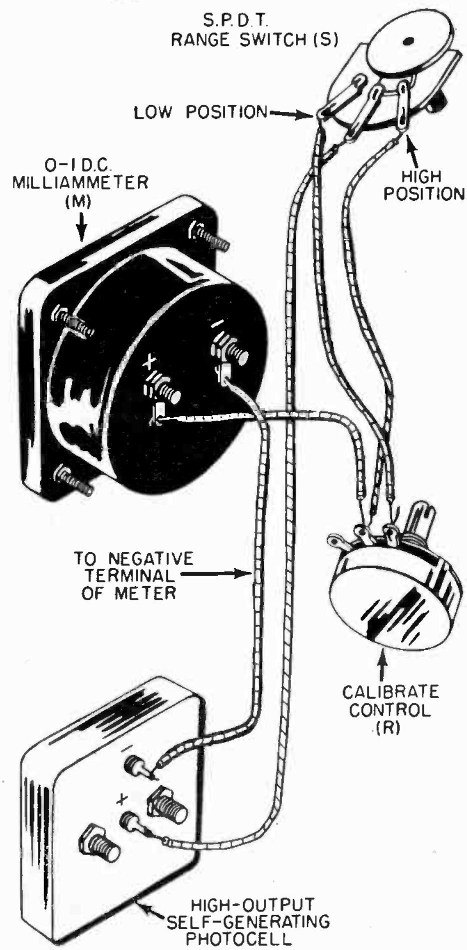
As soon as the "Reset" switch is released, *C1* begins to discharge through *R1* and *R2,* decreasing the bias on the amplifier section of the tube. When the bias drops to a low enough value, plate current flows again, the relay is energized, and power is transferred from *SO2* to *SO1.* The length of time *RL1* remains deenergized after the "Reset" button is released can be varied by means of *R2,* the "Time Delay" control.

If it is necessary to end the interval before the preset time is up, depressing "Release" switch *S3* will allow capacitor *C1* to discharge rapidly through *R3.* —30—

Fig. 7. **Finished timer** in its 3" x 4" x 5" case.







A Light Meter

A LIGHT meter is invaluable for measuring illumination levels in the home, office, or factory—and outdoors as well as indoors. It can be used, with proper calibration, as a photographic exposure meter and also in conjunction with enlargers and printing boxes in the darkroom.

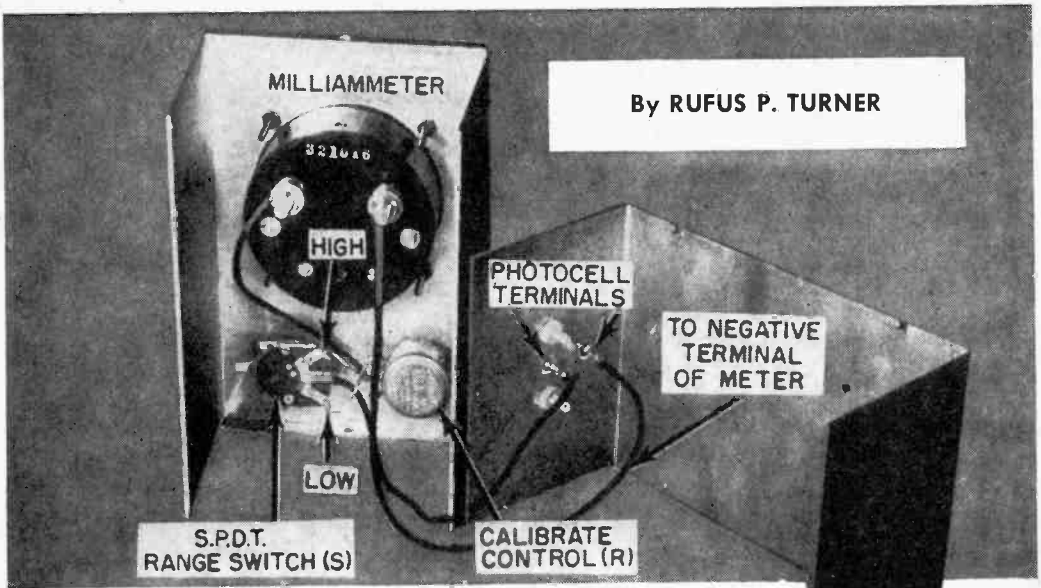
The basic light meter circuit consists of a self-generating photocell connected in series with a d.c. microammeter. When the photocell is exposed to light, it generates a small direct current which deflects the meter in proportion to the amount of light received. No batteries or tubes are needed.

Most professional light meters are both delicate and expensive because of the sensitive microammeters employed. The instrument shown here is able to use an inexpensive 0-1 d.c. milliammeter by employing a high-output photocell. The cell is an *International Rectifier Corp.* Type DP-5, which is designed to supply relatively high d.c. output to a low-resistance load such as a 1-ma. meter. With this photocell, about 150 footcandles will deflect a 55-ohm, 1-ma. meter to full scale. The cell is 2 inches square.

The light meter is light in weight and can easily be held in the hand when necessary. A smaller-sized instrument can be made by using a 1- or 2-inch meter.

The unit is built in an aluminum radio chassis box, 6″ long, 4″ wide, and 3″ deep.

A s.p.d.t. wafer-type switch (*S*) is provided for two sensitivity ranges. In the



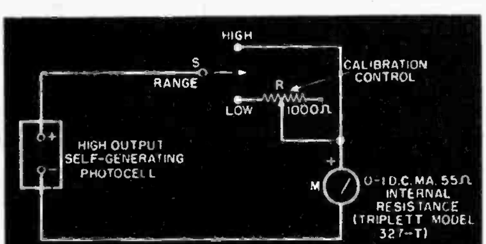
By RUFUS P. TURNER

You Can Build...

high position of this switch, the photocell is connected directly to the milliammeter (M). Very little light then is required for full-scale deflection. In its low position, the 1000-ohm radio volume-control-type rheostat (R) is switched in series with the cell and meter, so that higher illumination levels can be accommodated by the same meter.

The rheostat shaft is slotted for screw-driver adjustment and provided with a shaft-locking nut to prevent accidental movement, once it has been adjusted.

After the light meter has been wired, set switch S to its high position and point the cell toward a source of light. This can be a lamp or a window opening toward daylight. Adjust the amount of light reaching the cell by moving the instrument toward or away from the source of illumination until the meter reads exactly 1 ma. Now, without disturbing the position of either the instrument or the light source, throw switch S to its low position and adjust rheostat R for half-scale (0.5 ma.) deflection of the meter. Tighten the rheostat shaft lock. This completes the adjustment.



The meter scale may be calibrated directly in footcandles for each range of the switch, by comparison with another light meter or photographic exposure meter (such as *General Electric* Mod. 8DW58Y4) having a similar calibration. The two instruments must be placed close together and pointed toward the same light source.

As shown in the diagrams and photographs, this device is simple, compact, and easy-to-build. If the constructor lays out his cabinet carefully and proceeds slowly, there is no reason why "professional" looking equipment which gives "professional" performance shouldn't result.

The diagram on the opposite page clearly indicates how the various components are to be hooked up. Note that the *polarity* (+ and —) is marked on some of the terminals. These indications must be observed in order for the device to operate properly. There is the added danger that the meter might be burned out if the circuit is hooked up "backwards."

The time and effort involved in building a light meter are returned a hundredfold. You can have many hours of enjoyment from this simple device and the added satisfaction of knowing you have built a valuable instrument. —30—

A Simple B-C Flash Gun

By CLINTON E. CLARK

THIS SIMPLE B-C flash gun is designed for flexibility beyond the limits of most commercially available models. Because of the method of connecting it to the camera, several different picture-taking techniques may be used. The reflector may be held in the hand, attached by a clamp to furniture, or affixed to the camera itself. Many other ideas will undoubtedly come to mind after the unit has been constructed.

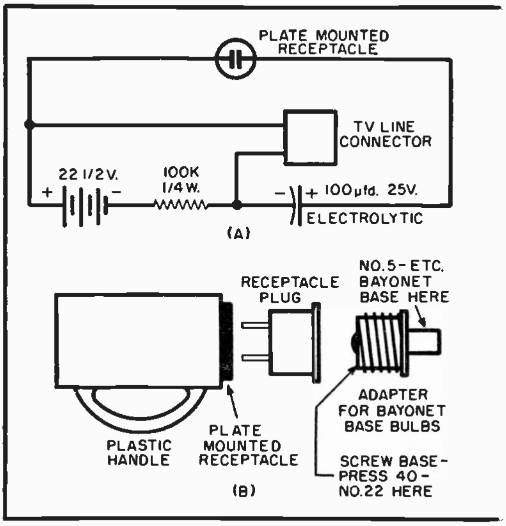
The B-C flash principle is quite simple. Instead of directly "firing" the flash bulb from the battery, a circuit is devised which permits the battery to charge a capacitor, and the surge from this capacitor ignites the bulb. This system is sure to work, and after its use has been mastered, the hobbyist will produce fewer weak or overexposed flash pictures.

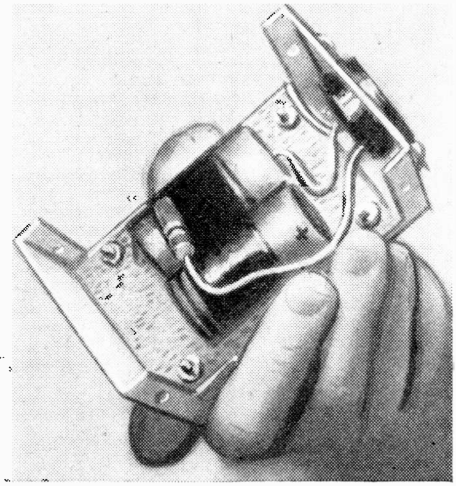
Build the B-C flash unit in an aluminum box similar to the *ICA* "Flexi-Mount" Type 29439. Mount the components on a piece of Masonite cut to fit into the aluminum box. Holes are drilled through the Masonite and the side of the box for bolts to secure the mounting board in place. A 3/8" hole is drilled through the side of the box under the Masonite to permit wires to be connected to the TV lead-in connecting socket (similar to *Mosley* Type 311). This socket is mounted on the aluminum box with a small strip of scrap metal.

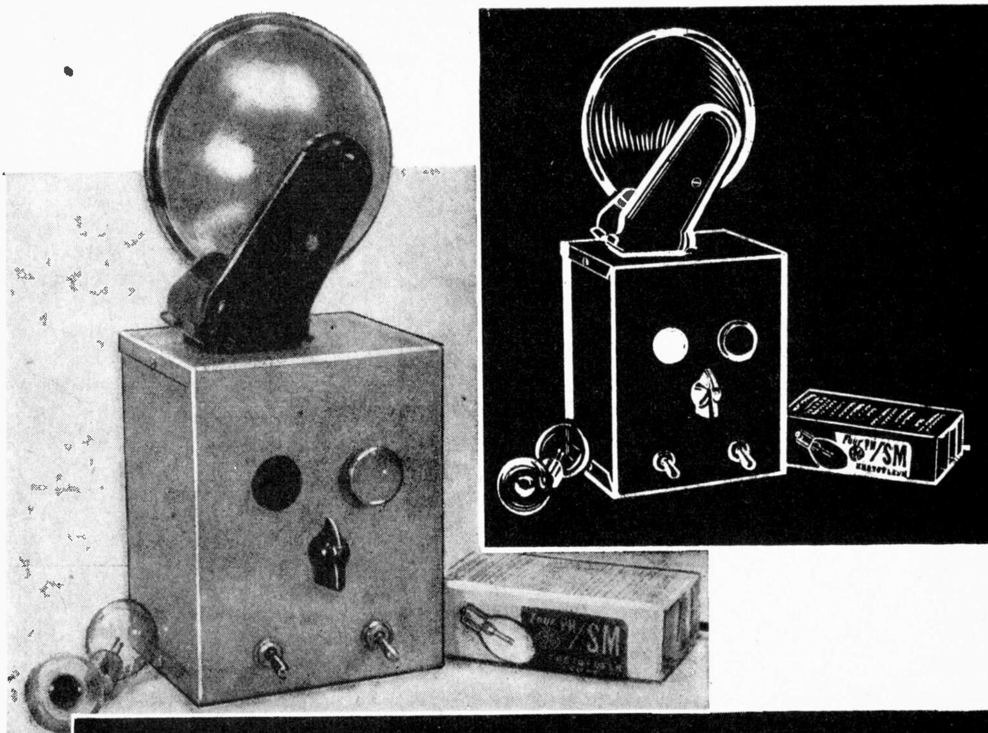
The simple circuit for this B-C unit is shown in (A) at the bottom of this page. The 100-μfd. capacitor (*Sprague* TVA-1207) is charged by the 22½-volt hearing-aid battery through the resistor and flash bulb. The circuit is arranged to fire the bulb by shorting the capacitor across the line between the battery, resistor, and flash lamp. This quick surge of power is far in excess of the amount given by common flashlight batteries. Concern over battery deterioration can be eliminated since the life of the battery will be equal to its shelf-life with normal usage.

Connecting the camera will depend upon the type of camera used by the constructor. Connection to the B-C unit is through a *Mosley* Type 301 plug. The reflector used by the author consisted of a 6" satin-finish metal mixing bowl. A hole was cut in the bottom for a snug fit to the screw base of one of the large-size flash bulbs. This then provided a seat for the adapter plug shown in (B) in the diagram, below left. A bracket for attaching the B-C unit to the camera was salvaged from a short length of aluminum bar stock. If desired, an accessory clip may be used for convenience. —30—

Very simple circuit at left may be mounted on a piece of Masonite as shown at right.







Slave Photoflash Trigger

By HARVEY POLLACK

Many photographers will welcome this valuable aid when taking flash pictures

DESIGNED to avoid entangling camera extensions and flash failures due to overloaded flash-gun batteries, the "slave" photoflash trigger unit described here will fire up to four other lamps distributed around a room from the light energy of the camera gun. No connection is needed between the camera and the "slave" unit; through the use of a high-speed electronic circuit, reliable triggering of the auxiliary flash lamps is realized even when pictures are taken by synchronized flash at rapid shutter speeds.

When photographs of large groups of people are to be taken, or when the room size requires additional coverage, the photographer usually places flash-lamp reflectors in strategic positions to improve the uniformity of illumination. Since practically all such pictures are taken by synchronized flash at relatively high shutter speeds, it is essential that all the lamps reach their peak at almost the same instant in time. Without a slave unit, a long and unmanageable extension cord from the primary flash gun is required; furthermore, unless the flash batteries are really in top shape, the overload of too many flash lamps demanding high current at the same time may prevent any of them from firing! A small SM or SF type requires a peak surge current of 3 amperes for dependable operation.

In the circuit described in this article, an 868 gas-filled phototube catches the light from the primary flash even before it reaches peak, instantly igniting a 2050 thyratron. It is the surge current through the thyratron which fires the slave lamps, the action being so fast that the peaks are reached within less than 1/500 of a second of each other!

The photographs and illustrations provide most of the information needed to proceed with the construction of the unit. With regard to the metal work, the following steps are strongly recommended because of the small—but important—differences which exist between listed parts and the equivalent components that the reader may procure.

1. Drill the holes for the two switches on the front apron first. These should be placed as far apart as possible to minimize the danger of accidental operation of the wrong switch. Mount the switches so that the *S1* toggle is *up* for the "on" condition and the *S2* toggle is *down* for "on."

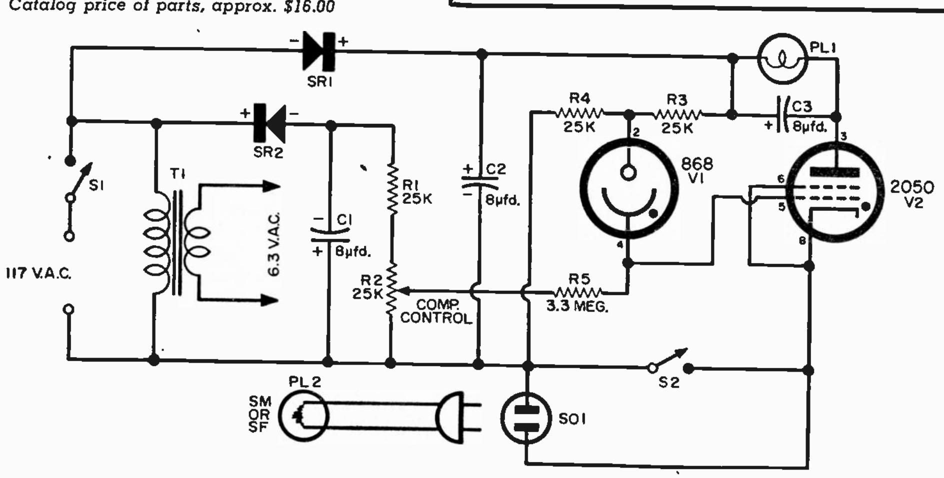
2. Punch the tube holes next, placing the 868 phototube as far forward as it will go without interfering with or touching the solder lugs of *S2*. If a somewhat larger chassis and cabinet are used, this presents no problem; but in the case of the compact unit shown, great care in planning and layout were necessary. The sockets recommended in the parts list require a 1¼" hole for the four-prong socket (868) and a 1" hole for the octal socket (2050). These holes are punched one behind the other, allowing ample room between them for the bulge in the thyratron envelope.

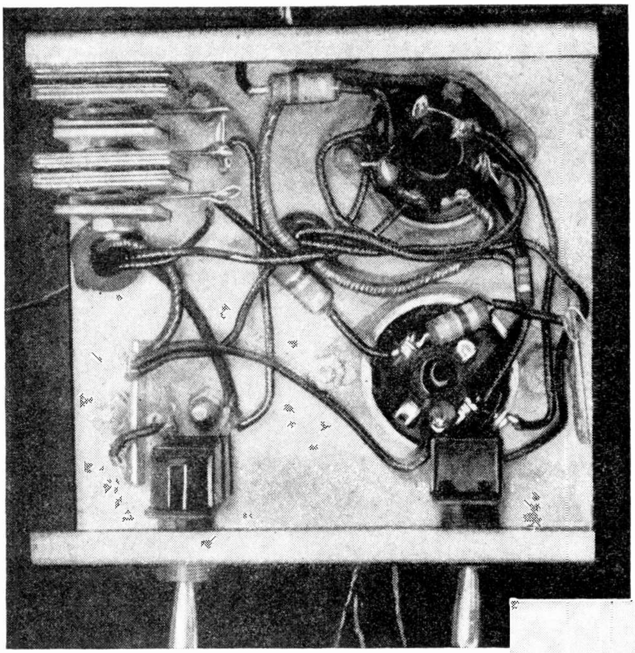
3. Place the filament transformer atop the chassis roughly in the position shown in the photographs, mark its mounting centers, and drill No. 27 holes (for 6-32 mounting screws). Next, drill the lead-down holes (⅜" in diameter) below the point where the leads emerge from the filament transformer; ⅜" rubber grommets are inserted in the lead-down holes. Also, drill a ⅜" hole in the center of the rear apron for a third grommet through which the 117-volt line cord goes, a No. 27 drill hole for the long machine screw which supports the stacked selenium rectifiers off to one side of the rear apron, and another hole of the same size near *S1* to secure one of the two-lug terminal strips. The other terminal strip is secured by the screw that holds the far end of the 868 socket in place.

4. Once all the foregoing components are in place, the wiring should be started. One two-lug strip anchors the line cord, and the other provides a pair of ground points. The chassis is *not* grounded, so bare wires must not be permitted to touch it. It is suggested that all subchassis wiring be completed at this point, bringing up the leads which go to the bull's eye indicator lamp, the output socket, and the "compensation" control through the grommets, tagging them for proper identification. Make the wires longer than necessary, so that they may subsequently be trimmed to size.

Circuit diagram and parts list.

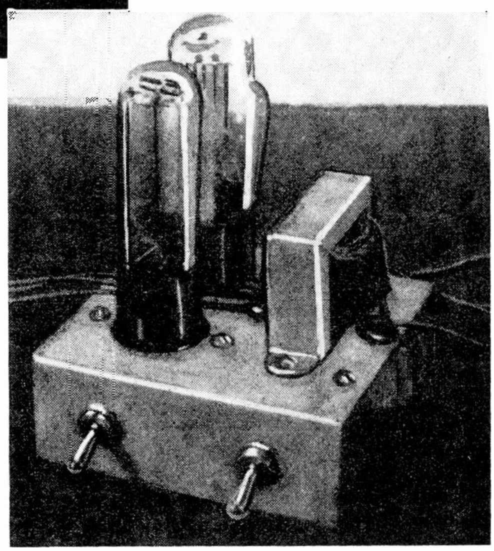
C1, C2, C3—8-µfd., 450-w.v. electrolytic capacitor
PL1—6- or 7-watt, 117-volt pilot lamp and candelabra base assembly
PL2—SM or SF flash lamp (see text)
R1, R3, R4—25,000-ohm, ½-watt resistor
R2—25,000-ohm carbon potentiometer, linear taper
R5—3.3-megohm, ½-watt resistor
SO1—117-volt a.c. receptacle, or other socket to fit flash-lamp assembly (see text)
S1, S2—S.p.s.t. toggle switch
SR1, SR2—65-ma. selenium rectifier, 130-volt r.m.s.
T1—Filament transformer, 6.3-volt @ 0.6-amp. secondary
V1—Type 868 phototube
V2—Type 2050 thyratron
1—Line cord and plug
1—4-prong socket
1—Octal socket
4—⅜"-diameter rubber grommets
2—2-lug terminal strips
1—Pointer knob
1—Aluminum open-end chassis, 3¾" x 4⅛" x 1"
1—Aluminum utility cabinet, 6" x 5" x 4"
Misc. wire, solder, screws, etc.
Catalog price of parts, approx. $16.00





Under-chassis view. The two selenium rectifiers are at the upper left, and the two toggle switches at the bottom.

Above-chassis view. The 868 phototube is in front with the 2050 thyratron behind. Filament transformer is at right.



5. As the chassis is secured to the cabinet by means of the switches alone, these cabinet holes must be drilled precisely to match those on the chassis. The phototube window must be located directly in front of the sensitive element. Other holes may be located to suit convenience and esthetic sense. Since the writer uses flash reflectors having standard line cords and plugs, the output socket at the top of the cabinet is a receptacle of this type. Any type of connector, single or multiple, may be installed with equal facility.

6. If capacitors *C2* and *C3* are made 40 μfd. rather than 8 μfd., up to 16 or more flash lamps may be fired simultaneously.

Adjustment and Use

Set the trigger cabinet on floor, chair, or table where there is an unobstructed "light line" between the phototube window and the primary flash gun. Both switches should be *down* and the compensation control fully counterclockwise. With both toggles down, *S1* cuts off a.c. power from the unit and *S2* short-circuits the output socket so that the auxiliary flash cannot be fired inadvertently. This is the reason for mounting *S2* in the inverted position. To most users, a down-toggle means "off" or "safety"; in this case, although the down-toggle closes the contacts of *S2*, it keeps the flash lamps safe by short-circuiting them.

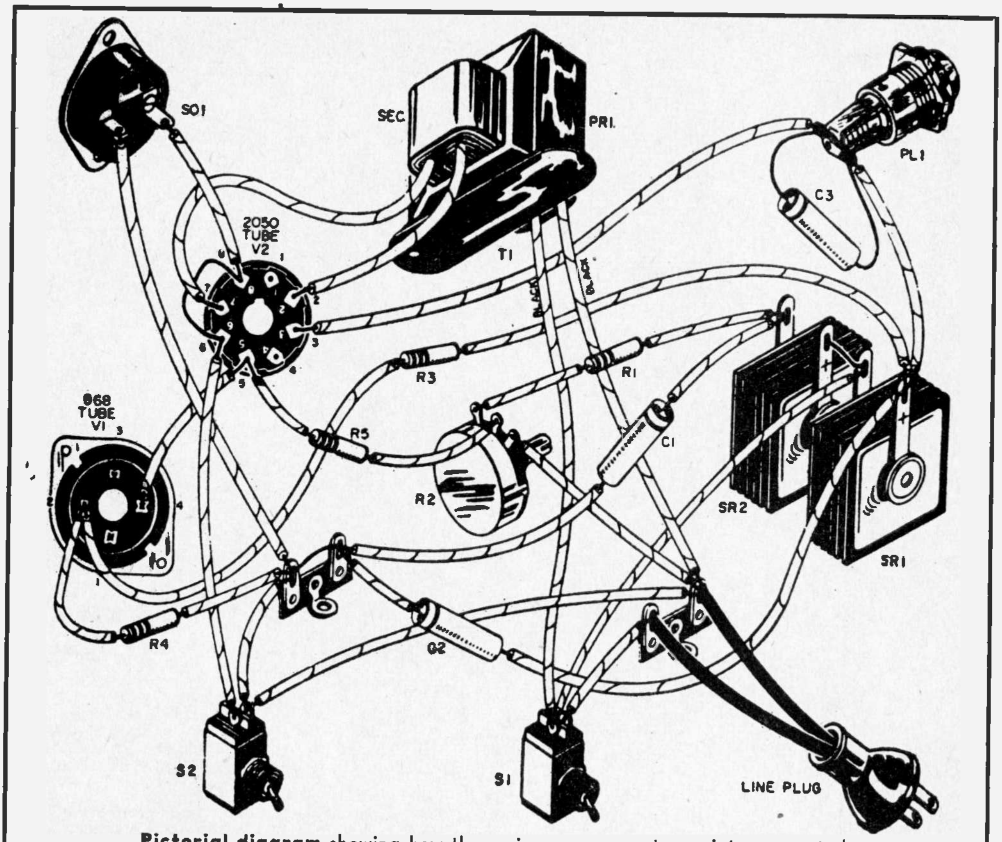
1. Insert one or more flash lamps in the output socket or sockets. SM, SF, No. 5, or No. 11 types may be used, although the first two are recommended because of their long peaks.

2. Close *S1* and allow about 30 seconds for warm-up time.

3. Rotate the compensation control knob (*R2*) clockwise until the bull's-eye indicator lamp flashes on. This indicates that normal room light is triggering the thyratron.

4. Back off the compensation control until the indicator lamp just goes out and remains extinguished. The room lights have now been compensated for, any additional illumination will again trigger the thyratron. This may be tested by lighting a match a few inches from the window; the indicator should fire briefly, then go out.

5. When ready to take pictures, flip *S2* up. This removes the short circuit from



Pictorial diagram showing how the various components are interconnected.

the output socket; the primary flash will now fire the slave lamps instantaneously. Once a photo is taken, flip *S2* to the down position at once before inserting flash bulbs for the next round.

Circuit Operation

Selenium rectifier *SR2* provides negative bias which prevents the 2050 from ionizing, the tube behaving like a switch in its "off" position. The compensation control governs just how much bias is applied to keep the thyratron from firing with normal room lights, yet remain quiescent in a highly sensitive condition. When light from the primary flash lamp reaches the phototube, a small current flows through *R5*—causing a voltage drop which cancels some of the "holding" bias and allows the thyratron to fire instantaneously. (The firing time lag is a little more than one microsecond!) Capacitor *C1* filters the bias voltage, while resistor *R1* forms a voltage divider with the compensation control to limit the range of bias adjustment and provide a more sensitive control.

SR1 applies d.c. plate potential to the thyratron and the phototube. A fraction of a second after power is applied, *C2* charges to about 135 volts and hold its charge until firing time. At the instant the thyratron ionizes, *C2* releases its charge through the flash lamp circuit, sending a very heavy surge of current through the lamp, the thyratron, and *C3*. The fuse element of the flash lamp burns out as the lamp produces its brilliant flash of light. *C3* has two functions. First, it is a surge bypass capacitor; without it the surge path through the lamp filament has too high a resistance. In addition, it serves to extinguish the thyratron when negative bias is restored. *R3* and *R4* forms a voltage divider which reduces the potential applied to the anode of the gas phototube to a safe value. This tube has a peak plate voltage rating of 100 volts.

A few words of caution might be in order regarding the last sentence in step 5 under "Adjustment and Use," i.e., returning *S2* to the down position after firing one or more lamps. This is important! With both switches up, jiggling a new flash lamp in its socket in attempting to insert it sets up transient voltages which may trip the thyratron even though its bias voltage is below cutoff. Always flip *S2* downward after each flash, insert the new lamps, then flip it up again. —30—

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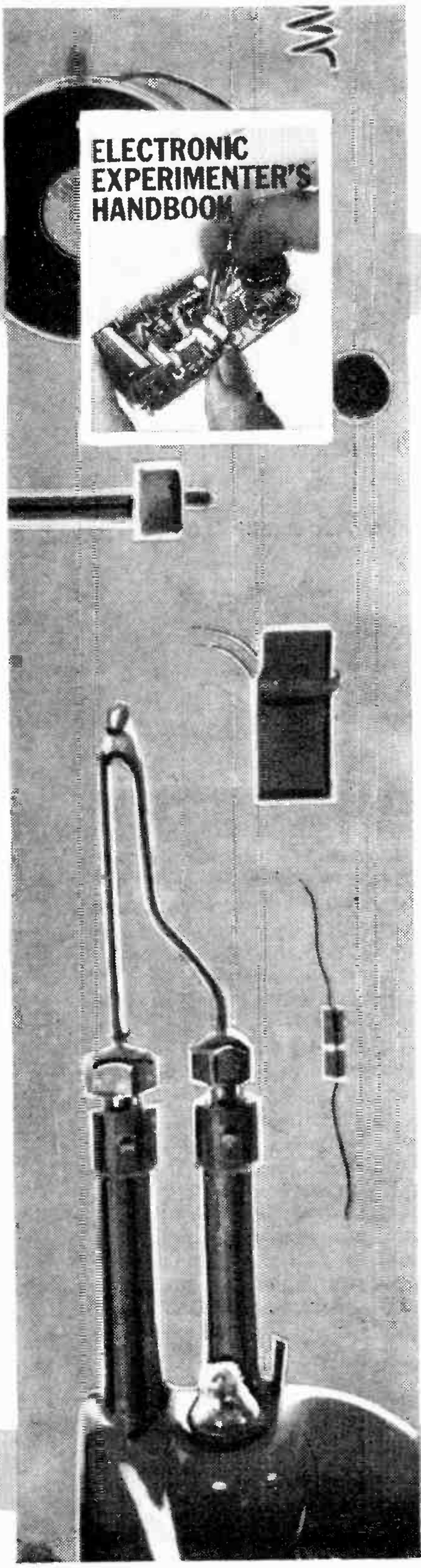


Chapter 7

For the Musical Gadgeteer

Simple

Simplicity of circuit design and all standard components make this handy three-tube amplifier unit easy to build

By LUIS VICENS

WHETHER you're an experienced experimenter or a beginner, you'll enjoy building this guitar amplifier. If you're an "old hand," you'll appreciate the straightforward simplicity of the circuit design and the lack of frills that make a circuit difficult to wire and to trouble-shoot. If you're a beginner who has "cut his eyeteeth" on a crystal receiver or a simple one-tube project, you'll find this three-tube amplifier advanced enough to challenge your interest, yet, at the same time, simple enough to insure success.

Although originally designed for use as a simple guitar amplifier, the unit can be used as a low-cost phonograph amplifier, with a microphone as an inexpensive p.a. system, or as a general-purpose test amplifier in the lab.

Components required are specified in the parts list. All parts are standard and should be readily available at a radio parts distributor or from one of the large mail order supply houses advertising in this book.

The chassis layout (Figs. 2 and 3) serves as a guide. Over-all dimensions and exact layout are not critical and modifications can be made to suit individual requirements. Don't crowd the rectifier and power output tubes too close to the electrolytic filter capacitor; excessive heat may damage this component. Locate the input jack *J1*, gain control *R1* and amplifier tubes in such a way that short, direct leads are used in all circuits. And, finally, make sure that the over-all dimensions are not too large for the cabinet.

Construction Details

The chassis used in the model was bent from a flat sheet of aluminum, but a standard commercial chassis will serve as well. When the chassis is completed, mount all chassis parts except the filter capacitor, using small machine screws and hex nuts.

Guitar Amplifier

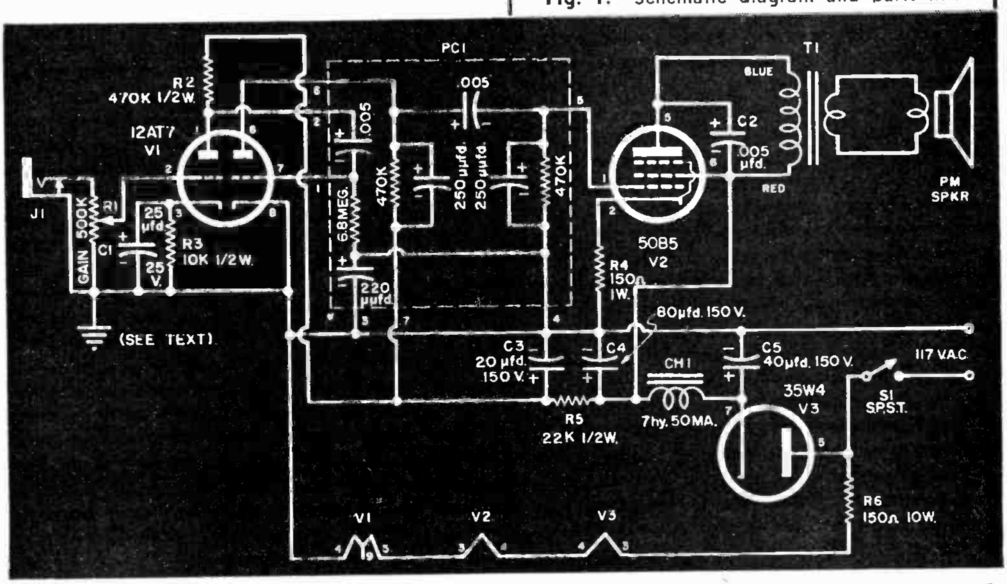
To mount the filter capacitor, first mount either the metal or the fiber mounting plate on the chassis, using machine screws, lock washers and nuts. Both types of mounting plates are furnished with the capacitor. Choose the metal plate if the chassis is to serve as "ground," the fiber plate if a "floating ground" is to be used. With the mounting plate in place, hold the capacitor against the plate so that the small mounting lugs project through the proper holes; give each lug a 45° twist, using a pair of pliers. The mounting lugs also serve as the B– connection to the capacitor.

A wall speaker baffle serves as a cabinet. It is modified by adding four rubber feet to its broader base and mounting a kitchen cabinet drawer pull on top to serve as a handle. Drawer pulls may be obtained at a hardware store. The loudspeaker and output transformer are mounted in this cabinet. Use ornamental head machine screws when mounting the speaker.

A piece of perforated *Reynolds* "do-it-yourself" aluminum serves as a ventilated back cover. This aluminum alloy is available at most hardware stores and the sheet stock, from which the back cover of the model was made, is soft enough to be cut with ordinary household shears. Special sheet metal shears are not needed. Several perforated designs are available.

C1—25-µfd., 25-volt tubular electrolytic capacitor
C2—.005-µfd. disc ceramic capacitor
C3, C4, C5—Triple-unit elec. capacitor; 20, 80, 40 µfd. @ 150 volts (Sangamo PLT-7385)
CH1—Filter choke, 7 hy. @ 50 ma. (Stancor C-1707)
J1—Closed circuit phone jack
PC1—Printed circuit plate (Erie 1408-02)
R1—500,000-ohm carbon potentiometer, audio taper volume control
R2—470,000-ohm, ½-watt carbon resistor
R3—10,000-ohm, ½-watt carbon resistor
R4—150-ohm, 1-watt carbon resistor
R5—22,000-ohm, ½-watt carbon resistor
R6—150-ohm, 10-watt wire-wound resistor
S1—S.p.s.t toggle switch (power)
T1—Audio output transformer, 2000 ohms to 4-4-ohm voice coil (Stancor A-3876)
1—6" to 10" PM loudspeaker, 3.2-ohm voice coil
V1—12AT7 tube
V2—50B5 tube
V3—35W4 tube
1—Small aluminum chassis (about 6"x4"x1½")
1—Polarized plug for line cord
1—Wall speaker baffle
1—Knob
2—7-pin miniature tube sockets
1—9-pin miniature tube socket
1—Line cord
4—Rubber grommets
4—Rubber feet with screws
1—Kitchen cabinet handle
1—Sheet of perforated metal (about 8" sq.)
1—Contact microphone with cable and plug
Misc. wire, solder, machine screws, nuts, hardware, terminal strips, etc.

Fig. 1. Schematic diagram and parts list.



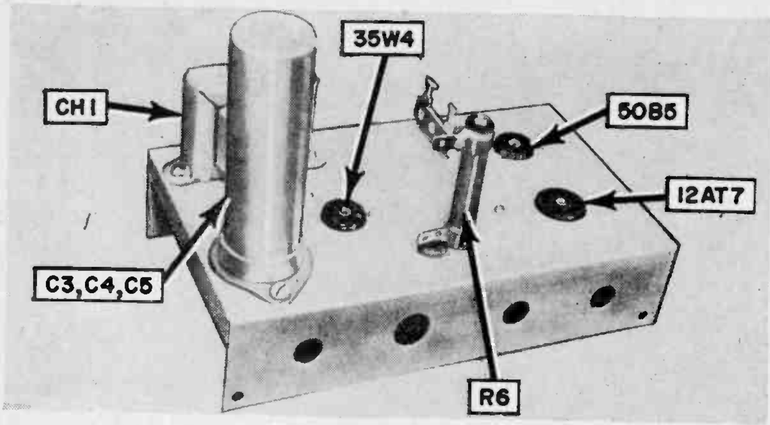
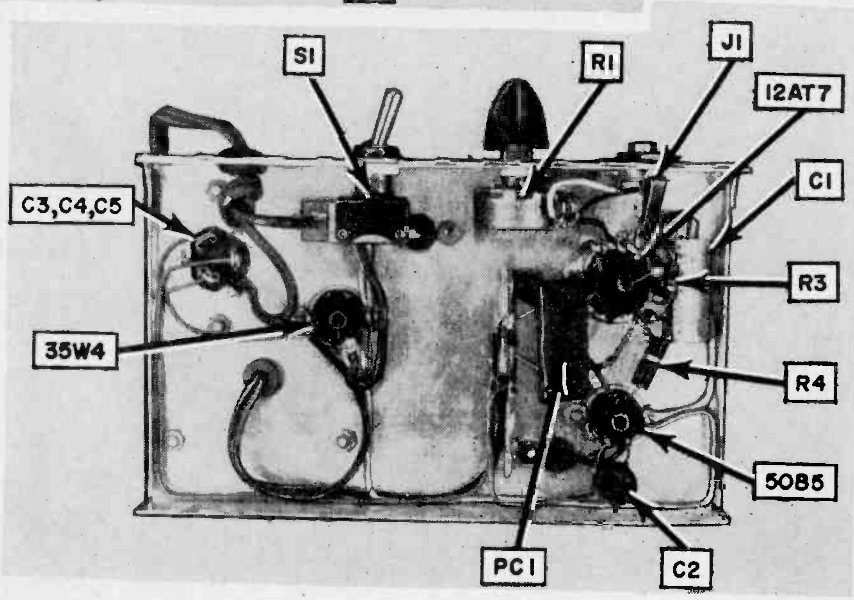


Fig. 2. Above-chassis view of amplifier (at left). Some parts are mounted but not wired.

Fig. 3. Below-chassis view of the wired unit. Parts are identified.



Only a few general precautions need be observed when wiring the amplifier. Carefully follow both the schematic and pictorial wiring diagrams, checking one diagram against the other as the wiring proceeds. Keep all signal leads as short and direct as possible. Insulate bare leads with spaghetti tubing. Don't bend the leads of the printed circuit plate too sharply as they may break off close to the plate.

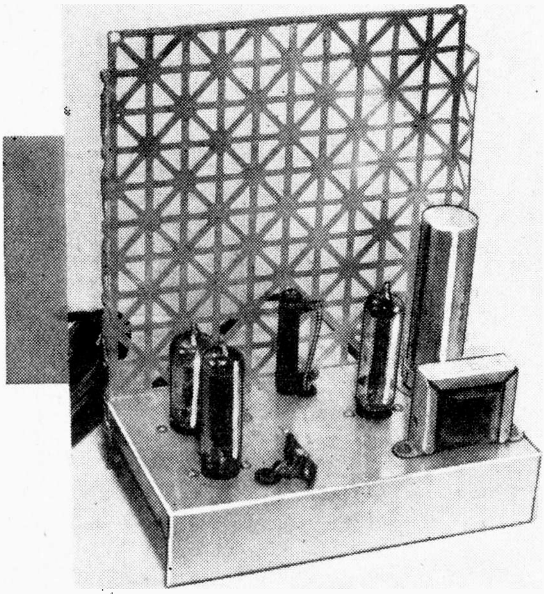
Referring to the schematic diagram, note that one side of the power line serves as the B— lead and connects to circuit "ground." This ground connection may be made to the chassis, *provided a polarized line plug is used, and the grounded side of the line connects to the wider prong.*

If it is impossible to obtain a commercial polarized line plug, make one by soldering a small piece of wire around the edge of one prong of a standard plug. A small paper clip will furnish a preformed wire for this purpose. See Fig. 4.

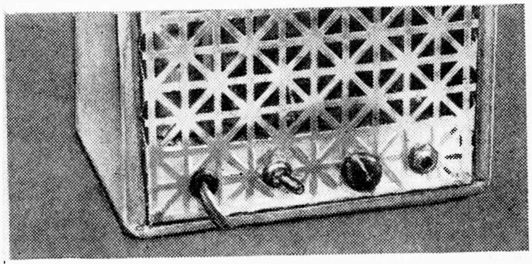
To use a standard line plug without modification, wire the circuit for a "floating ground" and avoid accidental shocks. To install a "floating ground," use the fiber plate when mounting the electrolytic filter capacitor (to insulate its shell from the chassis), and insulating washers when mounting the input jack *J1*, making all "ground" connections to an insulated terminal. Connect this terminal to the chassis proper through a 1-megohm carbon resistor, bypassed by a .01-μfd., 400-volt paper capacitor.

It should be noted that the microphone cable shield will be connected directly to one side of the line in this arrangement, which can present a severe shock hazard. Therefore, use of a standard line plug is not recommended.

Several modifications in the basic circuit are possible to meet the needs of the individual builder. For example, the printed circuit plate may be replaced by individual



Shown at left is the amplifier before it is mounted in its case. Perforated "do-it-yourself" aluminum serves as a ventilated back cover. Below is a rear view of the completed amplifier.



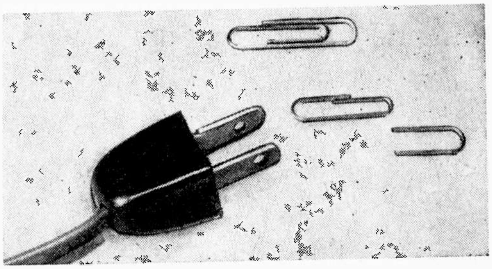


Fig. 4. How to make a polarized plug out of a conventional plug. See text.

components. The heater dropping resistor may be replaced by a line cord resistor or a ballast tube having the proper resistance.

The toggle switch used as a power switch may be replaced by a volume control type switch mounted on the gain control if care is taken to keep the a.c. leads away from the signal circuits. And the gain control itself may be replaced by a different unit. Although a 500,000-ohm control was used in the model, any value from 100,000 ohms to as high as 2 megohms may be used.

If desired, the PM loudspeaker may be replaced by an electromagnetic speaker, with the field coil connected as a filter choke in place of *CH1*. Coil resistance should be in the neighborhood of 500 ohms.

How It Works

The guitar amplifier consists of a two-stage triode voltage amplifier (12AT7) driving a beam power audio output stage (50B5), with d.c. operating power supplied from a conventional half-wave rectifier (35W4).

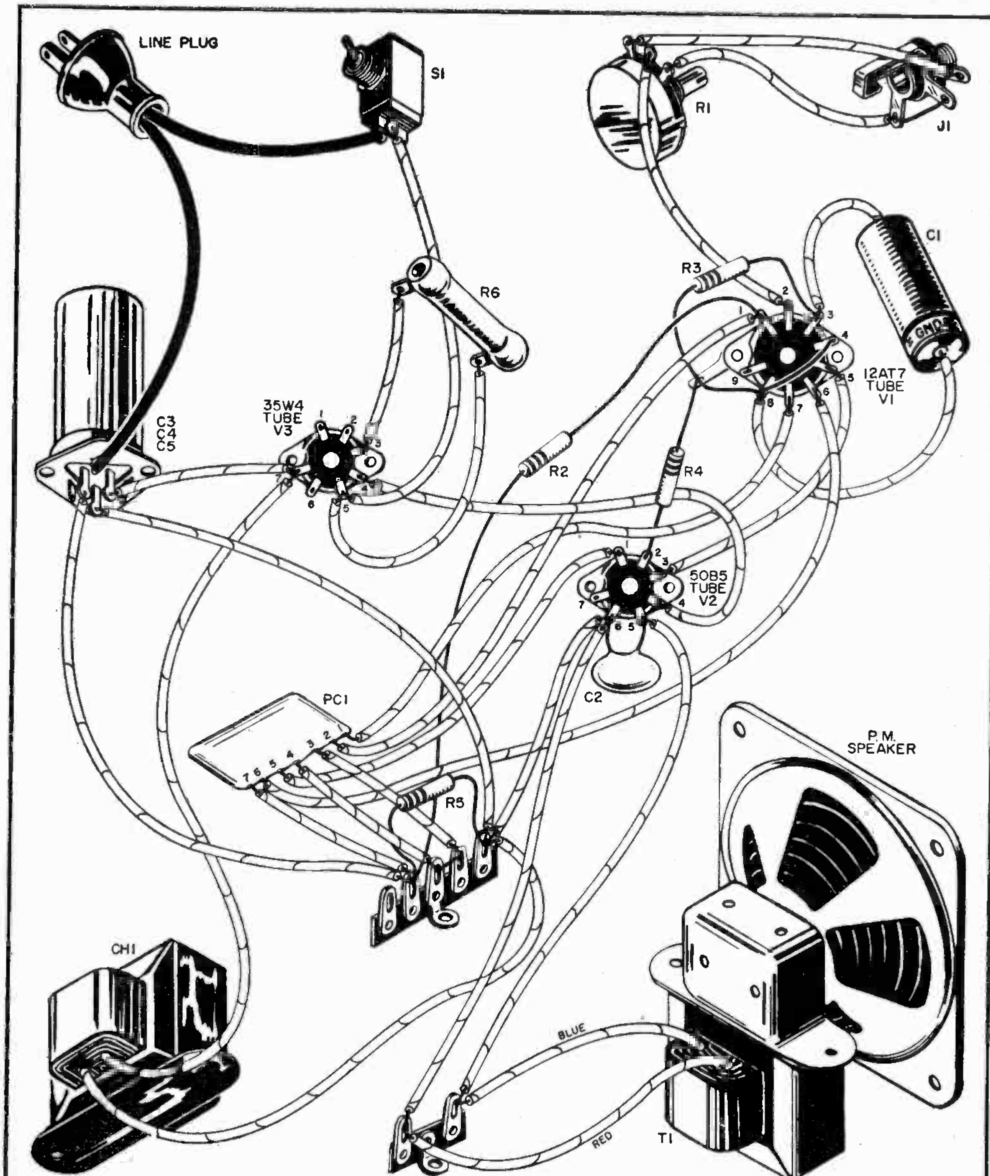
In operation, signals supplied by a microphone through input jack *J1* are applied across gain control *R1*, with the setting of this control determining what portion of the total available signal is applied to the grid of the first amplifier stage, half of a 12AT7 dual-triode tube. Bias for the first stage is supplied by cathode resistor *R3*, bypassed by capacitor *C1*.

The amplified audio signal appearing across plate load resistor *R2* is coupled through a .005-μfd. capacitor to the grid of the second amplifier stage, the last half of the 12AT7 tube. The small capacitor is part of a printed circuit plate *(PC1)* which also includes the grid resistor for the second stage (6.8 meg.), the plate resistor for the second stage (470,000 ohms), the coupling capacitor to the output stage (.005 μfd.), and the grid resistor of the output stage (470,000 ohms). Three additional capacitors are included on the commercial printed circuit plate and are shown in the schematic diagram, but are not essential to the operation of the circuit. Contact bias, supplied by the large (6.8-meg.) grid resistor, is used on the second stage.

The amplified audio signal appearing across the plate load resistor of the second stage is coupled through a .005-μfd. capacitor to grid of power output stage *V2*.

Capacitor *C2* acts to bypass high-frequency signals and thus to reduce the effects of whatever harmonic distortion may be present in the power amplifier. Transformer *T1* serves to match the high plate impedance to the low voice coil impedance of the PM loudspeaker.

Power to operate the amplifier is supplied by a half-wave rectifier (35W4) and a conventional "brute-force" pi-type filter network consisting of filter choke *CH1* and electrolytic filter capacitors *C4* and *C5*. Additional filtering for the voltage amplifier stages is provided by an *RC* filter consist-



Pictorial diagram of the guitar amplifier shows how components are connected together.

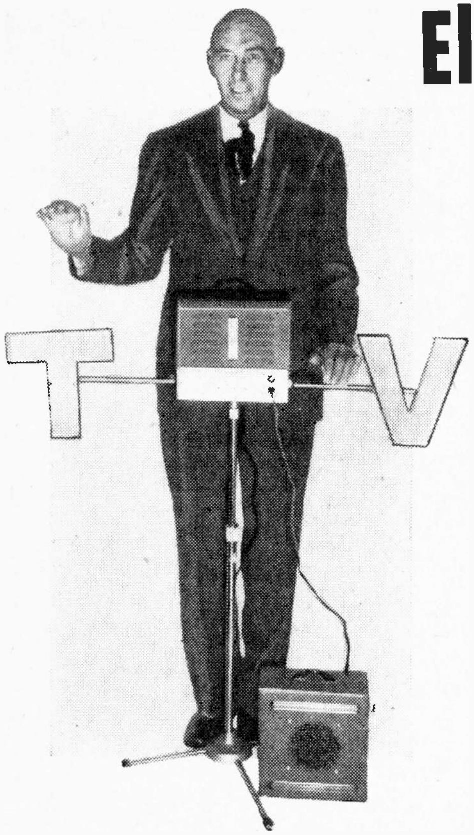
ing of *R5* and *C3*, another electrolytic capacitor.

The heaters are connected in series, with resistor *R6* added to permit operation on full line voltage. Switch *S1* serves as the power switch, with a polarized plug insuring that proper power line connection is always made.

Using the Amplifier

The amplifier is complete in itself. Just plug it into a wall receptacle, turn it on, and allow a few minutes warm-up. Only one accessory is required . . . a standard "contact" microphone. This is mounted on the guitar (or other musical instrument) and plugged into jack *J1* of the amplifier. Gain control *R1* may be set at the desired level by adjusting the control while playing a few bars on the instrument.

Don't try to set the gain control at too high a level or there may be a squealing or whistling sound after each note. In most cases, the amplifier should be set slightly in front of and to one side of the musician, but the exact location for best results will depend on individual room or auditorium acoustics. —30—



Electronic Music with the Theremin

By LOUIS E. GARNER, JR.

The musical instrument which is played without being touched—an advanced hobbyist can build it.

FRAMED by a spotlight, the musician stepped to the center of the stage and stood before his instrument. The expectant audience was hushed. Smiling, he lifted his arms. Eerie sounds came forth . . . wailings and howls, the call of a banshee, the rise and fall of a siren, moans and screechings. He dropped his arms and there was silence. Then he raised his arms again, and sound flooded the room. But no eerie howls or weird moans this time: instead, music, a lilting popular tune, with each note distinct and pure. . . .

Mystifying? Yes.

Fascinating? Definitely.

Unusual? Perhaps.

Impossible? No!!

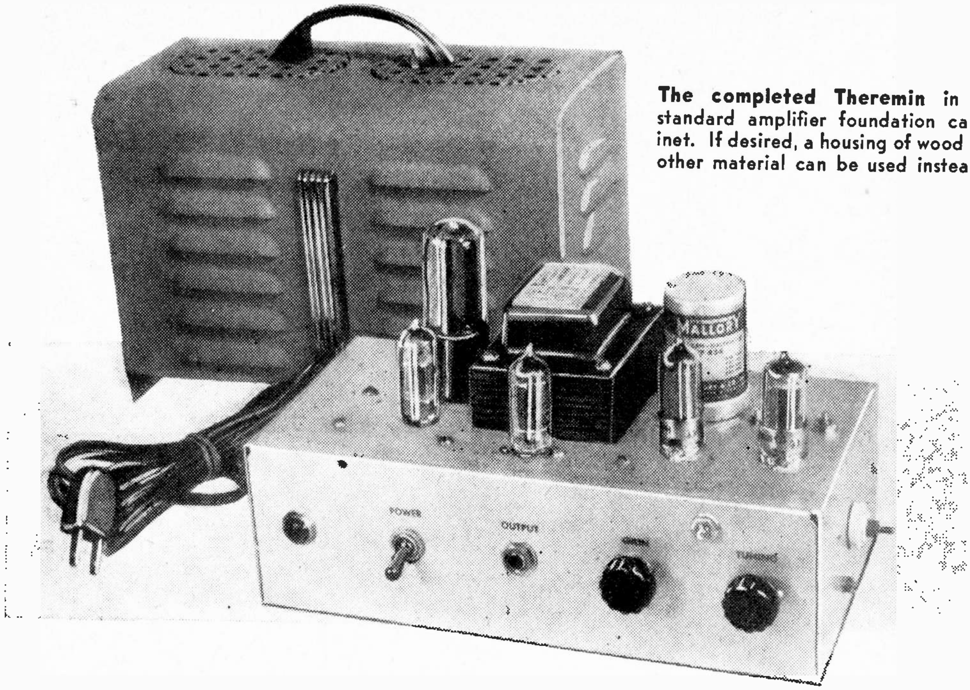
Almost any one with practice can duplicate the feats described if he uses a Theremin, one of the most interesting of electronic musical instruments. For with it, it is possible to bring forth the eerie howls and moans used in suspense movies and television shows or play the pure notes of a popular tune. And all by only waving one's arms!

The Theremin shown in the photographs is a "natural" for the home builder and electronics hobbyist. Although it provides many of the features found in complicated units and expensive commercial instruments, it is inexpensive and fairly easy to assemble. It's not a project for the beginner; for those who've "cut their teeth" on a few simple projects, this is their meat.

And, once the unit has been completely assembled, there will be lots of uses for it. Friends will applaud and enemies will admire the handiwork, for the Theremin is so mysterious to the average layman that it has an almost supernatural aura about it. And it can be used not only to play tunes, but to provide background sound effects for amateur theatricals. A complete show can be produced by combining its abilities to emit both music and sound effects.

After seeing it demonstrated, one of the first questions people ask is, "How does it work?" Let's dispose of that question right off, before discussing the construction of the instrument.

Refer to the block diagram. The operation of the Theremin depends on three basic things: (1) that the frequency of an oscillator may be changed by varying its stray capacities to ground; (2) that the output of an oscillator may be varied by changing its capacities to ground; and (3) that two signals, when combined in an electronic mixer, produce an output signal whose frequency is the *difference* frequency of the two original signals. Thus, if we combine signals of 200 kc. and 203 kc., we can obtain an output signal of 3 kc. (203—

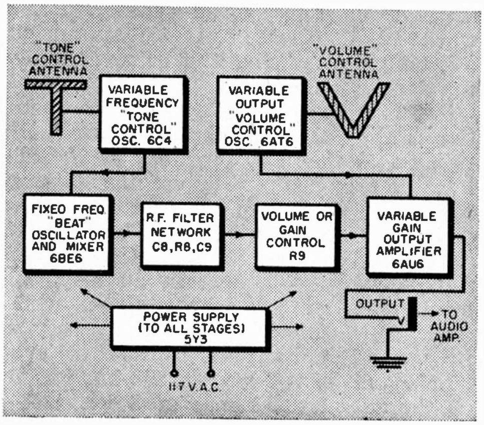


The completed Theremin in a standard amplifier foundation cabinet. If desired, a housing of wood or other material can be used instead.

200 = 3). The sum frequency (403 kc. in the example) is also produced by mixing action, but the sum frequencies are not used in the Theremin.

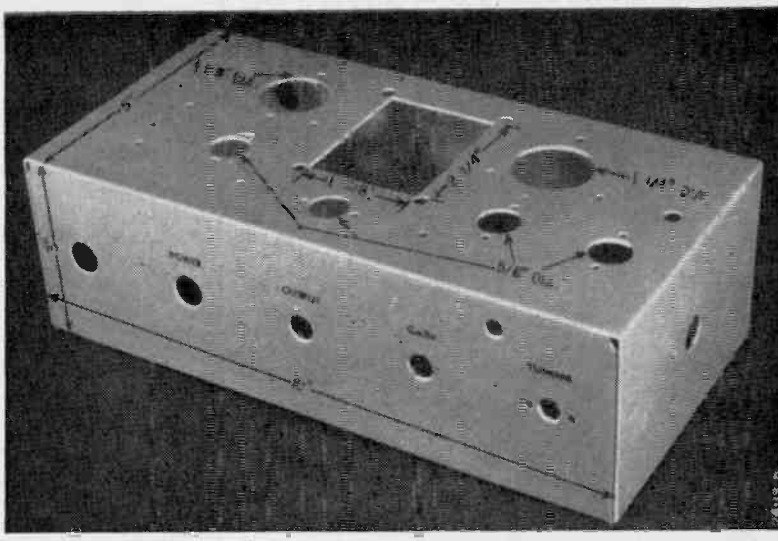
In operation, the signals from a variable frequency r.f. oscillator (the 6C4 stage) are combined with the signals from a fixed frequency r.f. oscillator in a mixer stage (6BE6). The difference frequency output, an audio frequency, is fed through a filter circuit to remove any r.f. signals that might remain and then to a variable gain amplifier (6AU6). The amount of amplification given by the 6AU6 stage depends on its grid bias and this, in turn, depends on the output of a third high frequency oscillator (6AT6). One antenna permits the operator to vary the frequency of the 6C4 oscillator ("T" or tone control antenna), and hence the pitch of the note produced. Another antenna permits the operator to vary the output of the 6AT6 oscillator ("V" or volume control antenna), and hence the loudness of the note. By moving his hands closer to and away from the two antennas, the musician, changes capacities to ground in the two oscillators and can play any note desired in a continuously variable scale.

Functional block diagram of Theremin. This diagram, with a block for each vacuum tube stage and other important circuits, shows main steps in sound production and control.

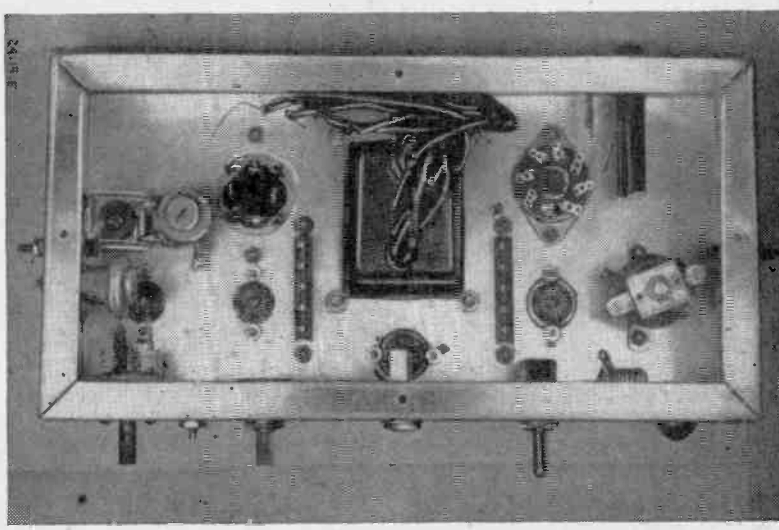


But enough of theory—here's how to build the Theremin:

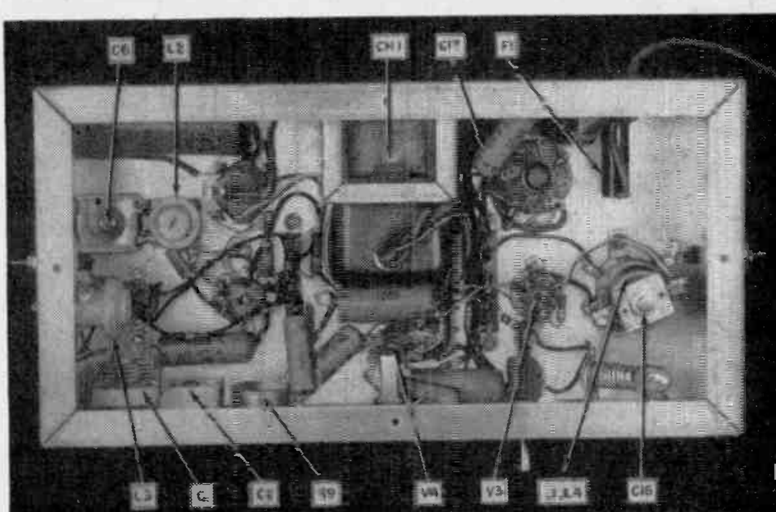
Construction Hints: The Theremin shown in the photographs was assembled on a commercially available "amplifier foundation" to give the completed instrument a professional, factory-built appearance. Those who are handy with tools might prefer to design and build their own cabinets. Holes are drilled and punched in the chassis for mounting tube sockets, controls, terminal strips and other components. Layout is not too critical, but the photographs and drawings should be followed fairly closely. The locations of the power transformer *(T1)* and filter choke *(CH1)* are es-



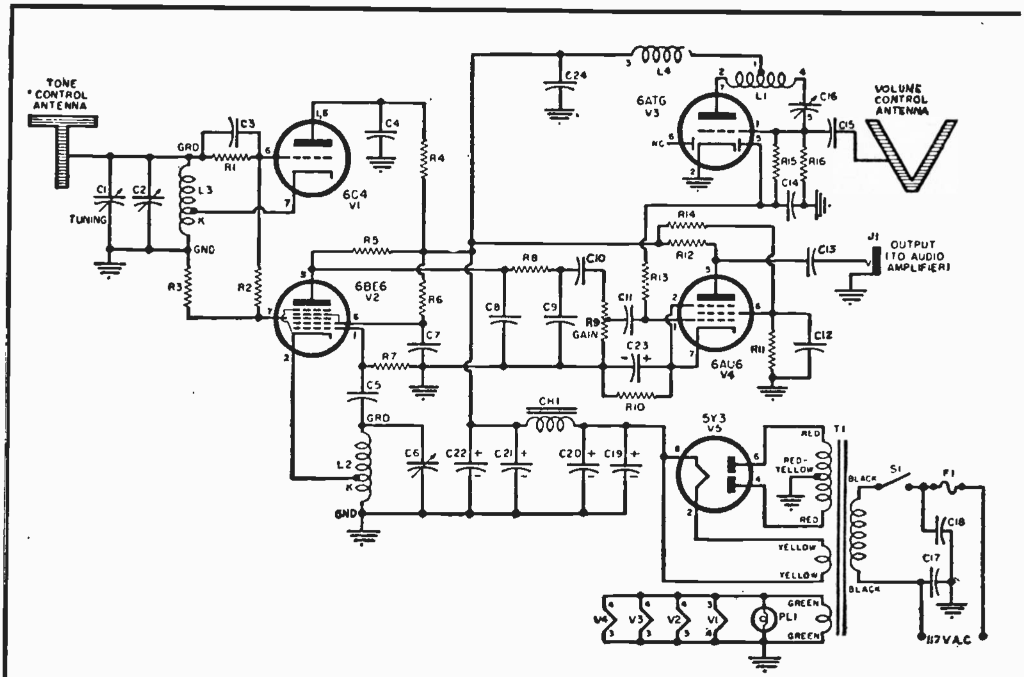
The Theremin chassis base, showing holes which must be cut or drilled, except holes for "V" insulator at left and parts at rear of chassis.

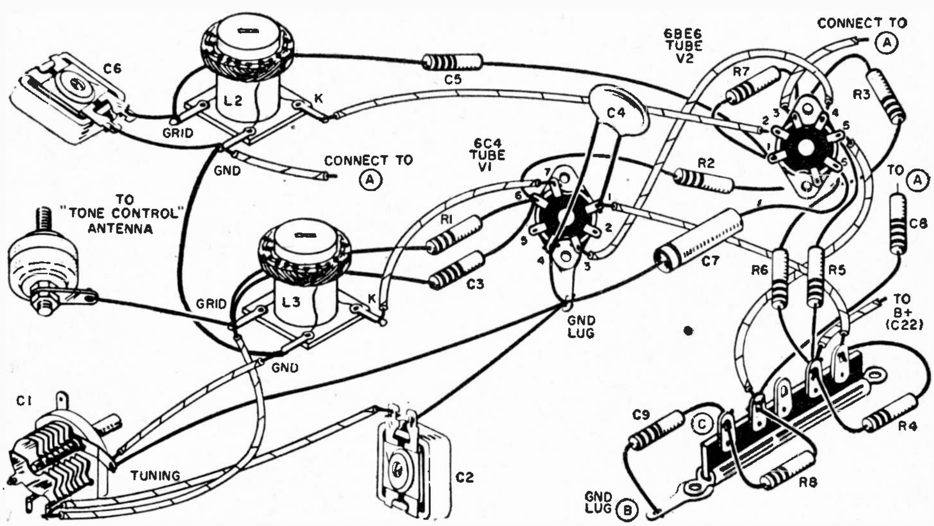


Bottom view of the chassis after all of the components except the filter choke have been mounted, but before any of the wiring is complete.

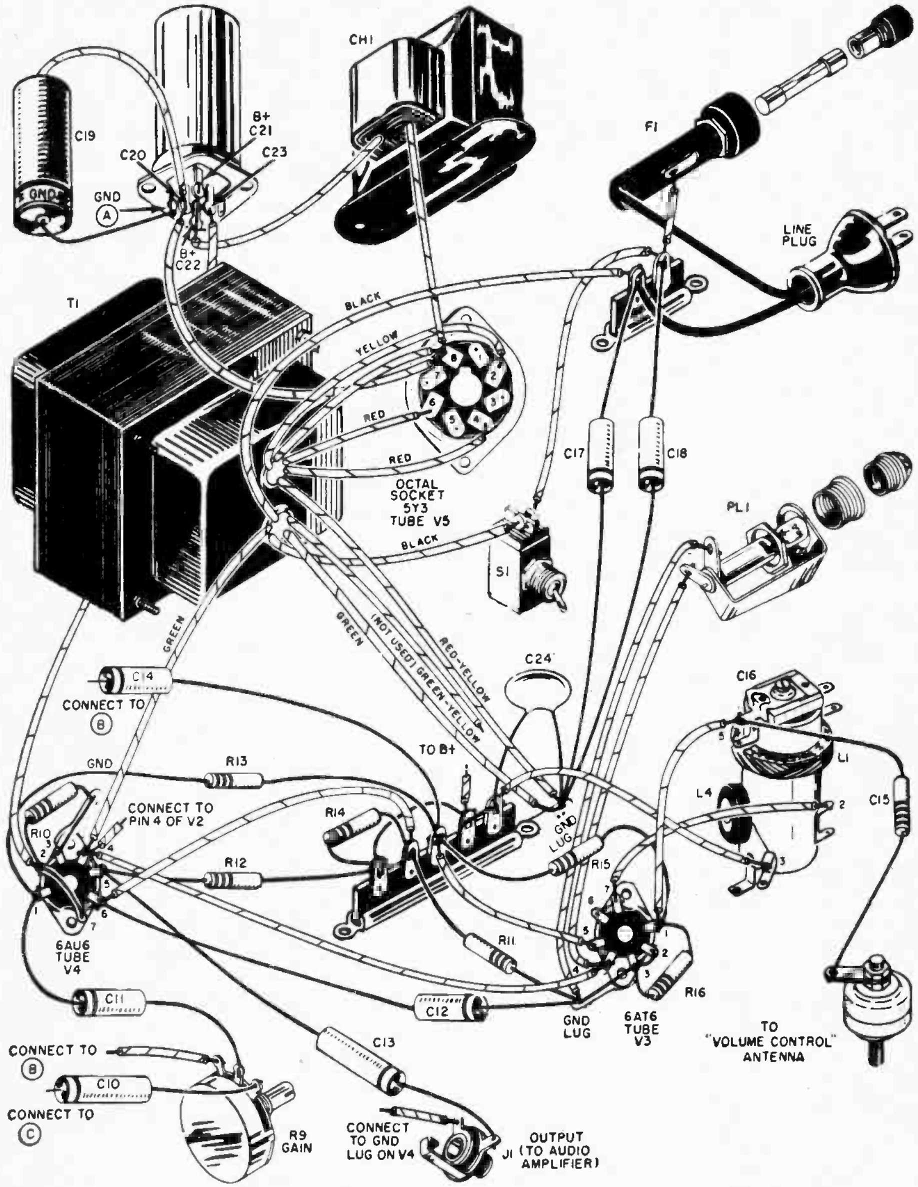


Bottom view of the chassis completely wired. See the following pages for detail photographs and schematic and pictorial diagrams.



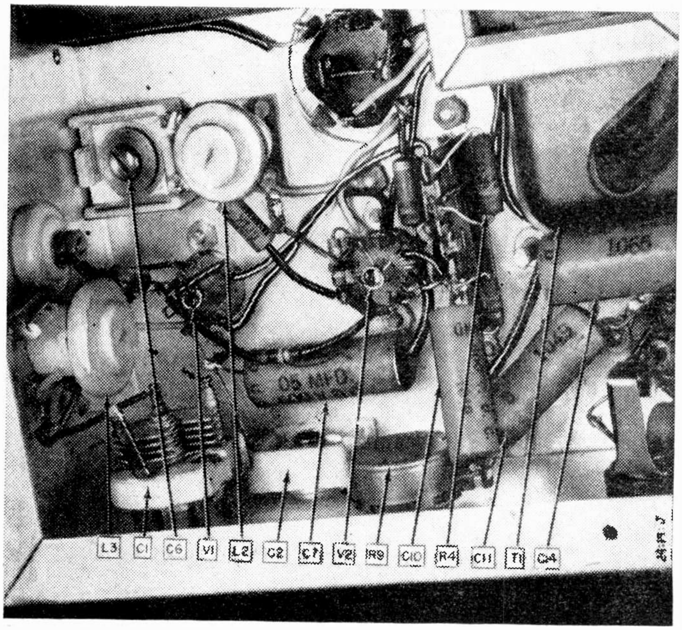


R1, R6, R7—47,000 ohm, ½ w. carbon res.
R2, R3, R5, R12, R16—100,000 ohm, ½ w. carbon res.
R4—1500 ohm, 1 w. carbon res.
R8—18,000 ohm, ½ w. carbon res.
R9—500,000 ohm, carbon pot., audio taper
R10—1500 ohm, ½ w. carbon res.
R11, R14—220,000 ohm, ½ w. carbon res.
R13—1 megohm, ½ w. carbon res.
R15—150,000 ohm, ½ w. carbon res.
C1—15-30 μμfd. (max.) tuning capacitor (Bud LC-2077, National PSE-25, Cardwell PL-6002, etc.)
C2, C6—340 μμfd. padder capacitors (Arco 303)
C3, C5—100 μμfd. tubular ceramic capacitors
C4, C24—0.01 μfd. disc ceramic capacitor
C7—0.05 μfd., 600 v. paper tubular capacitor
C8, C9—270 μμfd. tubular ceramic capacitors
C10, C11, C13, C17, C18—0.01 μfd., 600 v. paper tubular capacitors.
C12, C14—0.1 μfd., 400 v. paper tubular capacitors
C15—500 μμfd., tubular ceramic capacitor
C16—Trimmer (part of L1 and L4 coil assembly)
C19—40 μfd., 450 v. tubular electrolytic capacitor
C20, C21, C22, C23—10/10/10/10 μfd., 450 v. quadruple section upright electrolytic capacitor (Mallory FP 434)
CH1—8.5 hy., 50 ma., 400 ohm filter choke (Merit C-2981)
J1—Open circuit phone jack
L1, L4, C16—R. f. choke, oscillator coil, and trimmer assembly (Miller 695)
L2, L3—Oscillator coils (Miller 5481-K)
S1—S.p.s.t. toggle switch (Power)



T1—Power transformer (240-0-240 v. @ 50 ma., 5 v. @ 2 a., 6.3 v. @ 2.6 a. Merit P-2958)
V1—6C4 tube
V2—6BE6 tube
V3—6AT6 tube
V4—6AU6 tube
V5—5Y3GT tube
Misc.—Small amplifier foundation (Bud CA-1750 or ICA 3980)
Bottom plate to fit amplifier foundation
Extractor fuse post and 2 ampere fuse to fit
Pilot lamp jewel, bracket, and 6.3 volt pilot lamp bulb
Two small feed-through insulators
Four 7-pin miniature tube sockets
One octal socket
Two 5-terminal tie-point strips
One 2-terminal tie point strip
Two small knobs
Two kitchen cabinet handles (unless handles are supplied with the amplifier foundation)
One Sheet Reynolds "do-it-yourself" aluminum
One length Reynolds "do-it-yourself" U-channel aluminum
Line cord and plug
Rubber grommet, rivets, screws, nuts, wire, solder, ground lugs, decals, other hardware
Microphone stand and adapter (Atlas CS-33 and AD-11)
Shielded cable with connectors to fit phone jack and amplifier

Total cost, less amplifier and speaker: under $40.



Close-up view showing wiring of "tone control" and fixed oscillators and mixer stage.

pecially important. The completed instrument is designed to mount on a standard microphone stand and, for maximum stability, it is essential that the heaviest weight be more or less centered on the chassis.

The sizes of some of the mounting holes will depend on the particular components obtained. This is especially true of the tuning capacitors *(C1, C2, C6)*, the pilot light bracket, and the feed-through insulators. So don't complete the machine work until all critical parts are on hand. Once the machine work on the chassis is completed, however, the controls can be labeled with standard decals. These should be protected with at least two coats of clear plastic, sprayed on after application and after the decals have had a chance to dry thoroughly.

Mount the carrying handle on the top of the cover. Some commercial amplifier foundations are supplied with handles, but these generally mount on the ends of the chassis where they would interfere with the control antennas. If no handle is supplied, use a kitchen cabinet handle. These can be obtained at the nearest hardware store.

Parts are mounted with small machine screws and hex nuts. If the finished instrument is to be carried around quite a bit, use lockwashers. The filter choke *(CH1)* mounts on the back apron of the chassis, but for ease in wiring, this part should not be installed until the wiring is nearly completed. Do not draw up the nuts on the feed-through insulators too tightly; it is possible to crack the insulation and damage these components. Use the *metal* mounting plate furnished with the electrolytic capacitor *(C20, C21, C22, C23)* for mounting this part.

Wiring Suggestions: Follow the diagrams and photographs closely when wiring the unit. Use rosin core solder only. Lead dress is not too critical, but reasonably short and direct connections should be employed. Commercially available coils are used throughout, so don't worry about winding your own. The r.f. choke *(L4)*, "volume control" oscillator coil *(L1)*, and adjustment capacitor *(C16)* are all part of one commercially available assembly.

It is easiest to wire the Theremin by stages, whether all the work is done at one sitting, or spread over several evenings. Complete the filament, power switch and fuse, and power supply wiring first. Then wire the rest of the unit a stage at a time.

Final Steps: With the wiring completed and double-checked for accuracy, the control knobs, tubes, pilot lamp bulb, and fuse can be installed. Then set the unit aside temporarily—there are a few jobs remaining before final tests and adjustments are made.

Mount the *Atlas* AD-11 adapter in the center of the bottom plate, using short 6-32 machine screws and hex nuts. Drill or punch a ½" hole in the plate, located so that it falls just below *C16* when the bottom plate is installed. This hole may be covered with a standard "snap hole plug." The control antennas are made up by cutting large letters ("T" and "V") out of thin sheet aluminum and mounting these letters on brackets made from small U-channel aluminum. Either rivets or sheet metal screws may be used for attaching the letters to their brackets. Exact dimensions are not critical, but in the model, the brackets are about 12" long and the letters measure approximately 10" high by 10" wide overall.

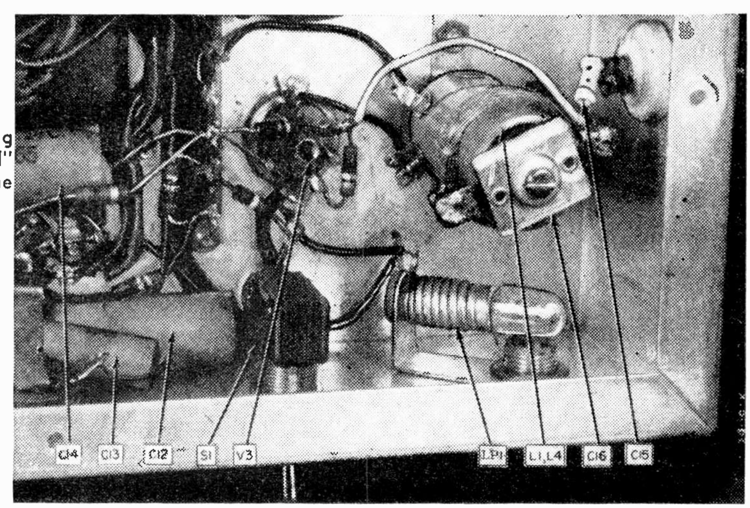
In order to keep the circuit simple and the cost low, no audio amplifier has been incorporated into the instrument, and it is necessary that a small audio amplifier be provided as an accessory. For small get-togethers, use the amplifier described in "Small fi" on pages 96 to 99. For home use, you may use the audio amplifier in a home radio; connect the output of the Theremin to the radio's phono jack. For large auditoriums, you'll want a more powerful unit. But regardless of the audio amplifier used, a shielded cable will be needed to connect the Theremin and amplifier together. Use standard microphone cable and keep the length reasonably short (under 10 feet if possible). Terminate one end in a standard 'phone plug to fit the Theremin *(J1)* and the other end in a connector to fit the mike input to the amplifier or the phono jack of the radio.

Adjusting the Theremin: With the bottom plate in place, install the Theremin on its mike stand. Install the control antennas, using standard wing nuts (these permit the antennas to be removed easily whenever desired). Remove the top cover. Adjust the TUNING control, *C1,* to about half capacity. Adjust the other variable capacitors, *C2, C6,* and *C16,* to full capacity by tightening the screws. Don't exert too much pressure; snugly tight is good enough. Use an insulated alignment tool when adjusting these capacitors. Connect the Theremin and the audio amplifier together with the shielded cable. Turn the GAIN controls of both units all the way up. Turn both on and allow several minutes warm-up. Later, as the preliminary adjustments are completed, the GAIN controls can be readjusted for a comfortable listening level.

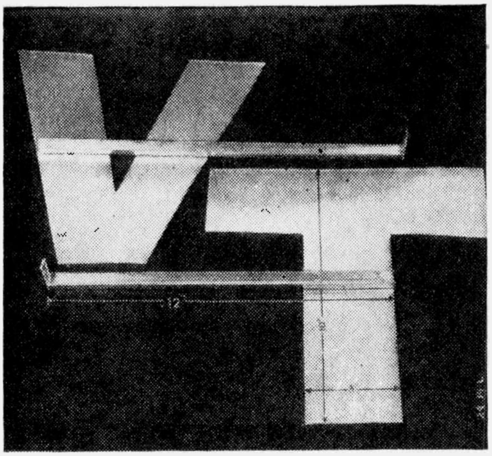
Using an insulated alignment tool, back off the screw of the "fixed" oscillator tuning capacitor, *C6,* about ½ to 2 full turns. This reduces the capacity somewhat. The exact setting is not too critical, but don't use more than 2 turns.

Next, with one hand on the "V" for volume control) antenna, and *keeping back from the "T" antenna,* gradually adjust *C2* with the alignment tool. As this capacitor is adjusted, listen for the following condition: a high pitched signal, gradually dropping in pitch to a low frequency, with the sound finally dropping out entirely (zero beat); and as further adjustment is made, the low frequency signal being heard again, gradually increasing in pitch to a very high frequency and finally dropping out entirely. *This may occur at several points.* However, proper adjustment of *C2* is where maximum volume is obtained on either side of zero beat. Final adjustment to zero beat is made with the top cover in place, using the TUNING control, *C1.*

To adjust *C16,* set the TUNING control slightly off its "zero" beat position so that a steady tone is heard when the "V" antenna is touched. Next, adjust *C16,* again using an insulated alignment tool, for the desired operation of the volume control antenna. The volume control circuit has been designed to have less sensitivity than



Close-up view showing wiring of "volume control" oscillator and part of the power supply.



The "volume control" and "tone control" antennas: they can be fastened to the U-channels by either sheet metal screws or rivets.

the tone control circuit, permitting a beginner to master the instrument with a minimum of practice. When *C16* is properly adjusted, maximum volume should be obtained just as the antenna is firmly touched with the hand. With the hand removed, and away from the antenna, the sound level should be very low, almost inaudible, if not gone entirely.

Using the Theremin

Skill in using the Theremin is acquired only through practice and familiarity with the instrument, but there are a few fundamentals which should be mastered first in order to produce a successful playing technique:

1. Always make sure the instrument is properly set to "zero beat" before starting a show or playing a piece. Generally, this is done by adjusting the TUNING control, *C1*, but if the instrument has been jostled a bit or hasn't been used for some time, readjustment of *C2* and *C6* may be necessary.

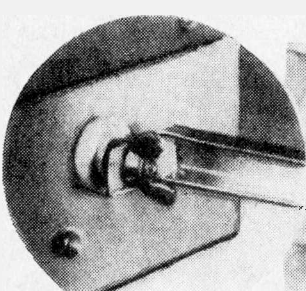
2. To change volume, bring the hand up to the "V" (volume control) antenna, touching it if necessary. A wavering sound can be obtained by moving the hand back and forth over the top or in front of the "V" antenna.

3. To change pitch, move the hand closer to or further away from the "T" (tone control) antenna. It will be noted that it is more sensitive than the "V" antenna. The other hand must be near the "V" antenna, of course, whenever a sound is to be produced.

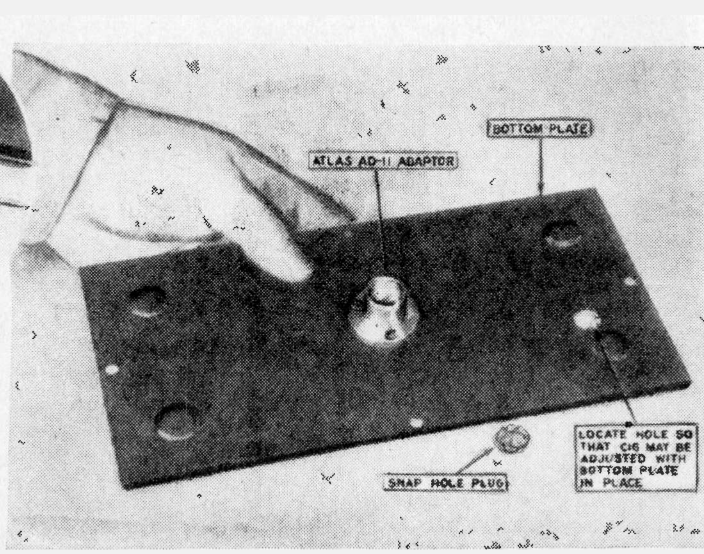
4. To sound individual notes, keep the hand away from the "V" antenna until the other hand is in position at the proper distance from the "T" antenna to sound the note desired; proper position is learned by experiment. Then bring the hand up to the "V" antenna, without moving the other hand (near the "T" antenna) long enough to sound the note desired. Finally, move the "V" control hand away quickly *before shifting the position of the "T" control hand.*

5. Practice! Practice! Practice! And more practice!

A lot of fun can be had experimenting with the Theremin, even if you never take the time to become an accomplished musician with the instrument! —30—



A detail view of mounting of one control antenna to its feed-through insulator.

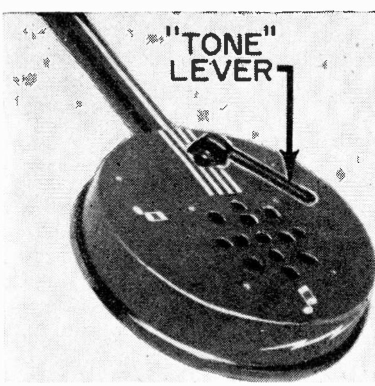


Chassis bottom plate with adapter for mike stand and hole to reach the volume control adjustment, C16.

Electronic banjo

Build and play this novel instrument resembling a banjo in shape but having a distinctive tone quality.

Right, electronic banjo being played. Below, close-up view shows tone lever.



By **LOUIS E. GARNER, JR.**

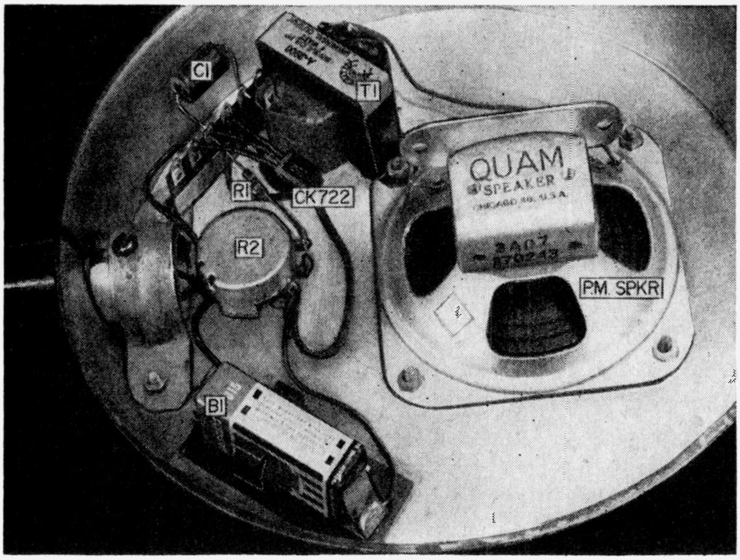
ELECTRONIC musical instruments that are easy to build and simple to play delight the experimenter. The instrument described here meets both qualifications, and in addition is inexpensive. Although it is shaped somewhat like a banjo, its tone quality is distinctive, resembling neither a banjo nor any other conventional musical instrument.

There were several reasons for choosing the "banjo" shape. The mechanical construction is fairly easy, costs are kept down, loudspeaker mounting is simplified, and all component parts can be mounted within the enclosure—leading to a completely self-contained instrument.

Tones are generated by a transistorized blocking oscillator using but a single transistor powered by a 22½-volt battery. Adequate power output is obtained to produce medium volume in a normal room from a 4" loudspeaker. Pitch is controlled by a carbon potentiometer manipulated by the player by means of a special lever-type knob. A push-button switch in the instrument's handle serves as the on-off switch, a tone being produced when the switch is depressed.

Basic Construction

Reference to the photographs and diagrams will show the basic construction of the electronic "banjo." The body is an aluminum cake pan, the arm an 18" length of 1"-diameter aluminum tubing. These two parts must be solidly mounted together. This can be accomplished by punching a 1" hole in the side of the cake pan close to



Interior view of banjo with various components identified and their relative positions indicated. The chassis is an aluminum cake pan, which contains the on-off switch S1.

its base, inserting the aluminum tubing and holding it in place with a standard pipe clamp, mounted with two *6-32* machine screws and nuts. In the model shown, for additional security, a sheet metal screw was run through the pipe clamp into the aluminum tubing.

The push-button control switch (*S1*) is mounted about 2½" to 3½" from the end of the arm, with its leads run inside the tubing to the body of the instrument. The open end of the arm should be closed, either with a standard metal cap or with a shaped wooden plug.

Drill holes for mounting the "pitch" control (*R1*), the transformer (*T1*), the terminal strip, the battery clip, and the loudspeaker. With a little ingenuity, one mounting hole may be made to serve for two or more parts. If a satisfactory battery clip cannot be obtained locally, mount the battery in place with a simple "Z" clamp and make connections by soldering directly to its terminals. Parts location is not at all critical—follow the photographs as a guide or make up an original layout, as desired.

The loudspeaker opening may be made in one of two ways. In the model, a series of ½"- and ⅝"-diameter holes was punched to form a regular pattern. If preferred, one large opening may be cut for the speaker. However, if this is done, some provision should be made to protect the speaker cone . . . either by means of a piece of screening or a grill of perforated sheet metal over the opening.

For a really "de luxe" appearance, the instrument may be painted and decorated. This part of the job should be done after all machine work is completed but before parts are mounted and wiring is started. The model shown was covered with two coats of enamel, applied with a "spray" can then decorated with commercially available decals (*Tekni-Labels* Set No. 116). But individual designs can be easily made up and applied.

Mounting and Wiring

In the model, the back is closed with a piece of Masonite hardboard, mounted on the rear of the loudspeaker. If a speaker different from the one specified in the parts list is used, it may be necessary to design a special mounting for the back cover . . . either brackets or clips of some sort. In any case, be sure that the back does not completely cover the top of the cake pan. Either cut the back cover slightly smaller than the pan opening, leaving a gap around the outer edge, or drill a few "vent" holes in it. Otherwise, the speaker may be muffled by the closed space.

The "tone" or pitch control lever arm in the model was assembled from a standard bar knob, a long machine screw, and a piece of plastic tubing, colored with fingernail polish. Lever knobs are commercially available, however.

Remember that the CK722 transistor is a relatively expensive part and is easily damaged by excessive heat. Therefore, don't cut its leads too short . . . leave them at least 1½" long, protected with insulated tubing. Use a hot, clean, well-tinned soldering iron, and complete the installation of this part as quickly as possible. For maximum protection, use a heat "sink," i.e., hold the lead being soldered with a pair of long-nosed pliers between the point where the soldering iron is applied and the body of the transistor. The pliers tend to absorb heat from the lead and prevent it from reaching the transistor proper.

In vacuum-tube circuits, an improperly installed battery generally results in little more than failure of the circuit to operate. But incorrect battery connections may ruin a transistor. Therefore, don't make final battery connections until lead polarity is assured.

Proper connections from the speaker voice coil terminals to the transformer's tapped secondary winding may be determined experimentally after the circuit is wired. Use the pair of terminals that gives the best results.

Once the wiring has been completed and operation checked, circuit modifications may be made to "tailor" the performance of the banjo to meet individual requirements. With the parts values listed, coverage is between two and three octaves, although exact range will depend on parts tolerance.

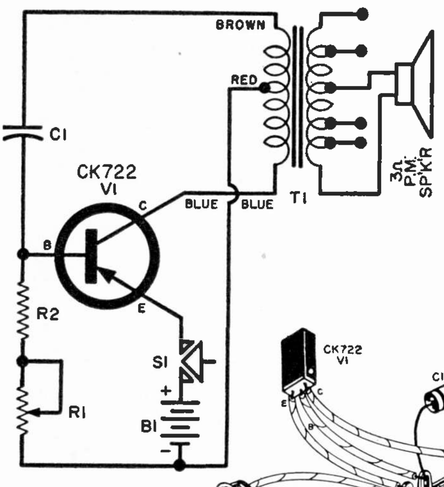
To reduce the range, replace the potentiometer (*R1*) with a unit having a lower value of resistance. To increase the range, use a higher value of resistance here. Do not reduce the value of *R2*, however. The upper limit of the tone range may be changed by varying the size of *C1*.

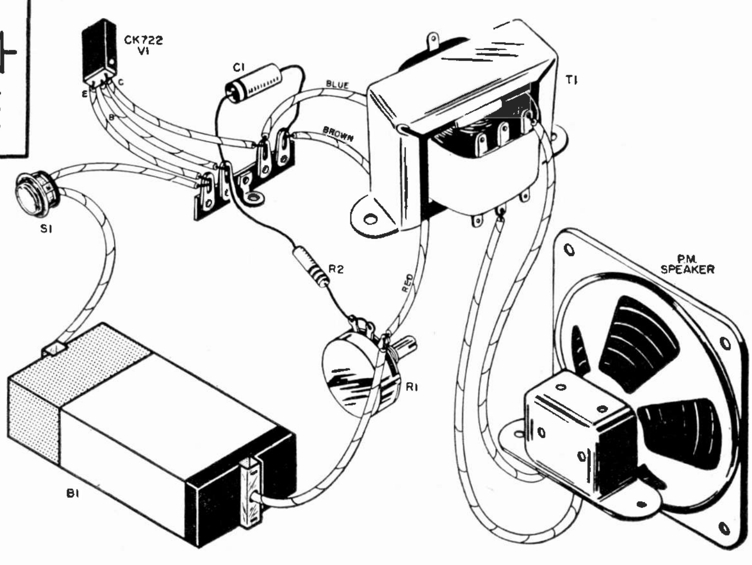
How It Works

The single transistor in a blocking oscillator circuit results in efficient operation and long battery life. Transformer *T1* acts both as an output transformer to match the high collector impedance to the low impedance of the loudspeaker voice coil and as an oscillator transformer, with the push-pull primary winding supplying the necessary feedback between collector and

B1—22½-volt hearing-aid battery (Burgess U-15, Eveready 412 or equivalent)
C1—0.25-µfd., 200-volt paper capacitor
R1—50,000-ohm carbon potentiometer, linear taper
R2—6800-ohm, ½-watt resistor
S1—S.p.s.t., normally open push-button switch
T1—Universal output transformer, 4 watts (Merit A-2900 or equivalent)
V1—CK722 transistor
1—Battery clip
1—8" x 1½" aluminum cake pan
1—18" length of 1" Reynolds "Do-It-Yourself" aluminum tubing
1—1" pipe clamp
1—1" tubing end cap
1—8"-diameter, ¼"-thick piece of Masonite
1—Set of decals (Tekni-Labels Set No. 116)
1—4-terminal tie strip
1—4" loudspeaker, 3.2-ohm voice coil
1—Bar knob or lever knob
Misc. wire, solder, machine screws, etc.

Catalog price of parts, approximately $10.00





Schematic diagram and parts list (top) and pictorial diagram (right) of the complete instrument.

base circuits to start and sustain oscillation. The "common emitter" circuit is employed and is roughly analogous to a vacuum-tube circuit in which the emitter (E) acts as cathode, the base (B) as grid and the collector (C) as plate.

Frequency of operation is determined by the time constant of the *C1-R2-R1* combination. Thus, varying either of these components will change the frequency (tone). In practice, *R1* is made variable and serves as the tone or pitch control.

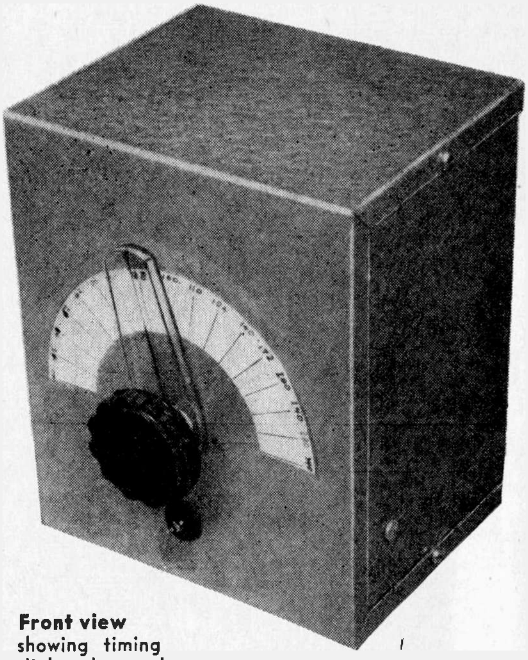
Since the transistor is operated in short pulses (as individual notes are played) rather than continuously, it is safe to operate it close to or slightly exceeding its maximum ratings, permitting moderate loudspeaker volume even though the transistor utilized here is a low-power device.

The push-button switch *S1* is in series with the battery (*B1*) used as a power supply. Hence, the circuit operates only when the switch is depressed, and no "standby" current is required.

The electronic banjo is held just like a conventional instrument. One hand is placed on the arm, with one finger just above the push-button switch. The other hand holds the tone lever lightly. To play an individual note, move the lever to the proper position and depress the push button. Hold the button down long enough to sound the length note desired . . . 1/8, 1/4 or a full note. Release the button and move the lever to position for the next note. —30—

Neon Tube Metronome and Seconds Timer

By HARVEY POLLACK



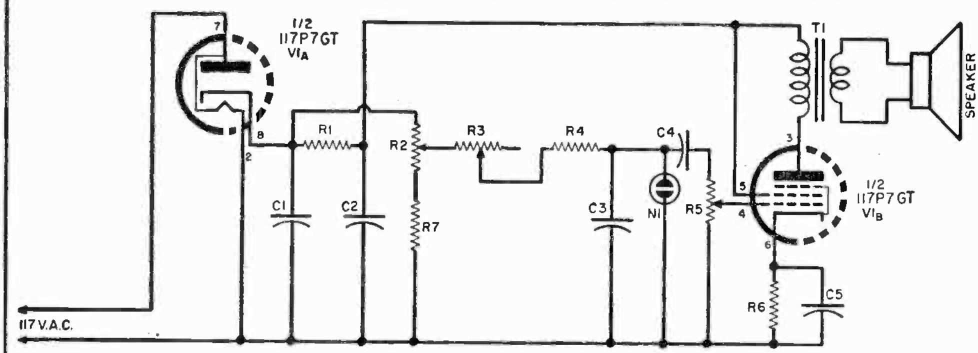
Front view showing timing dial and neon lamp.

THE dependable electronic metronome pictured and described here was constructed for about half the cost of a similar commercial unit. The speed of its beat is governed by the setting of a single knob on the front panel, each click being accompanied by a short flash of the neon lamp just under the timing knob. Although traditional metronome design calls for a range from 40 to 208 beats-per-minute, this model was provided with a somewhat greater range to permit other applications requiring higher click frequencies.

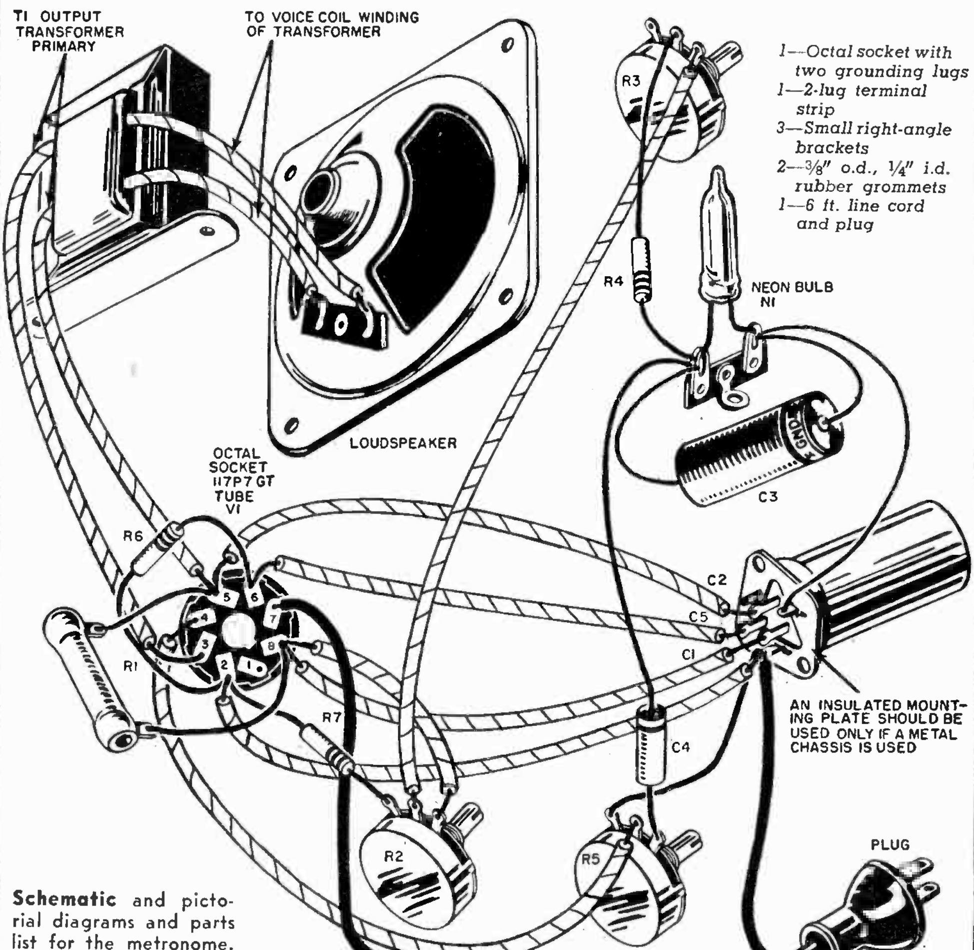
The rectifier section of a 117P7GT vacuum tube provides a source of d.c. which is filtered by *C1, R1,* and *C2*. *R2,* the *calibration control,* governs the voltage applied to the capacitor, *C3,* through *R3* and *R4*. *R3,* the main *timing control, R4,* and *C3* form a timing circuit, in which *C3* charges slowly or rapidly depending upon the setting of *R3*. As the voltage across *C3* builds up, the neon tube suddenly "fires" and discharges *C3,* after which the charge-discharge cycle begins once more. The change in voltage across *C3* is transmitted to the beam-power section of the 117P7GT and is heard as a click in the loudspeaker. *R5,* the *volume control,* permits the sound to be varied in volume or eliminated entirely if desired, leaving only the flashing of the neon lamp. *T1* is a standard type of output transformer to match the speaker used to the 117P7GT.

The metronome is housed in a 6" x 5" x 4" aluminum utility case. Most of the components are mounted on a small Masonite shelf secured to the case by small right-angle brackets. The speaker, output transformer, calibration potentiometer, and volume control are fastened to the rear of the case itself, while the neon tube is visible through a hole in the front panel.

The first step in construction is to drill

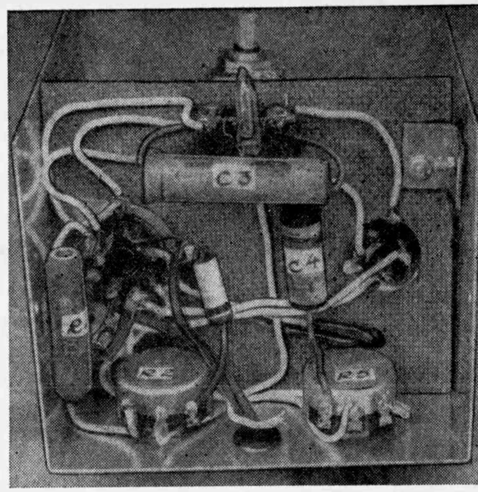


R1—300 ohm, 10 w. wirewound res.
R2—20,000 ohm linear taper pot
R3—5 megohm pot
R4—470,000 ohm, ½ w. res.
R5—500,000 ohm audio taper pot
R6—390 ohm, 1 w. res.
R7—47,000 ohm, 1 w. res.
C1, C2, C5—20/80/40 µfd., 150 v. elec. capacitor (Sprague TVA-3455 in a single can)
C3—.25 µfd., 600 v. capacitor
C4—.001 µfd., 600 v. capacitor
N1—Neon lamp, Type NE-2 with pigtails
T1—Output trans. 4000 ohms to 3.5 ohm voice coil (Stancor A-3328)
Speaker—3.2 ohm, 3½" loudspeaker
V1—117P7GT tube
1—6" x 5" x 4" aluminum cabinet
1—pc. Masonite 4¾" x 3¾" x ⅛"
1—Small knob (Vol. Control)
1—Medium knob with pointer



1—Octal socket with two grounding lugs
1—2-lug terminal strip
3—Small right-angle brackets
2—⅜" o.d., ¼" i.d. rubber grommets
1—6 ft. line cord and plug

Schematic and pictorial diagrams and parts list for the metronome.



View of lower rear section of cabinet showing calibration control, R2, and volume control, R5. One mounting bracket for the Masonite shelf is hidden by resistor, R1, at left.

the holes needed to mount the speaker, transformer, and two potentiometers on the back of the case. At the same time, drill five 3/8" holes for sound passage and one for the line cord grommet. Next, lay out and drill the Masonite shelf for the octal socket, the filter unit, the angle bracket which supports the timing control, and the terminal strip on which the timing capacitor and neon lamp are mounted. These are shown in photo above.

Once the various components are in position, hold the shelf in position inside the case and mark it for angle brackets. Doing it this way will help avoid overcrowding and will assist in locating the timing control shaft so that the knob will occupy the position which is shown in the front-view photograph.

When the wiring is complete, test the unit for correct operation as follows: 1. Rotate the calibration control fully clockwise. 2. Set the timing knob at about half-scale (pointer straight up). 3. Rotate the volume control fully clockwise. 4. Plug the unit into an a.c. outlet and allow about one minute for warm-up. The neon tube should start to flash at medium speed and clicks should be heard in the speaker. 5. Rotating the timing control clockwise should now cause the flash and click rate to increase, and *vice versa.*

The front panel may now be marked and drilled with 3/8" holes for the timing control shaft and the neon tube grommet. Assemble the case and fasten the timing knob to the shaft so that the pointer will move the same amount in either direction from a straight-up position. —30—

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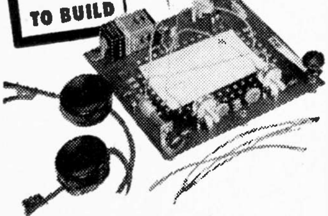

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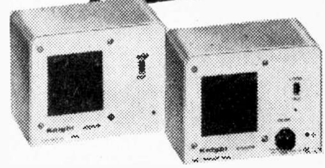

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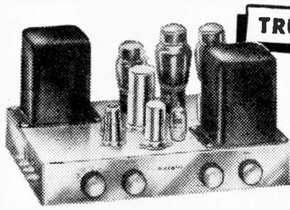

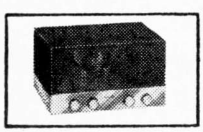

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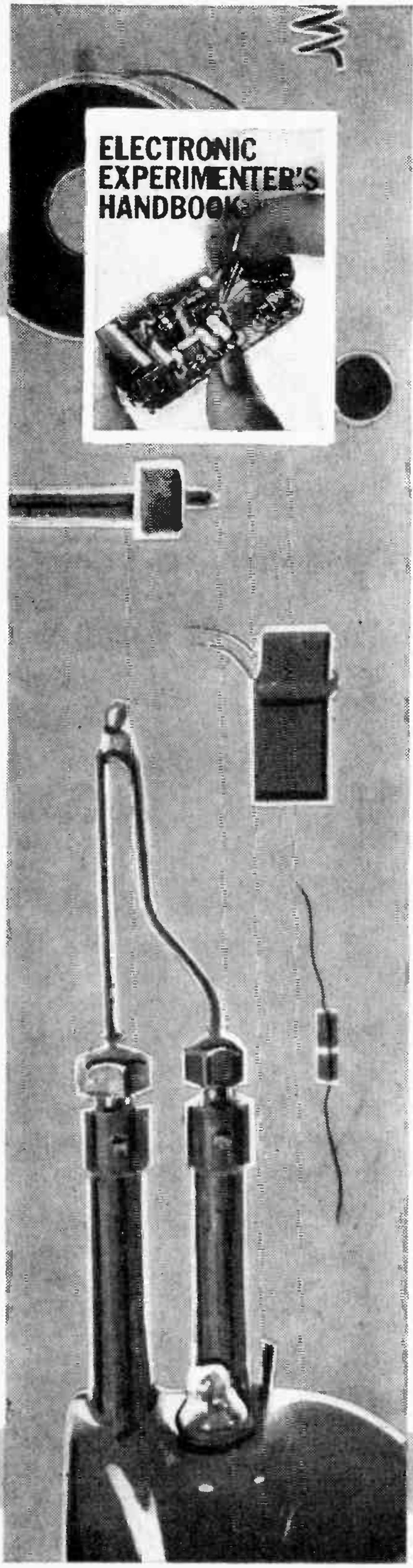


Chapter 8

For the Radio Control Fan

The Lorenz "Sixty-One"

By E. J. LORENZ

An R/C receiver for model boats, airplanes, etc.

IF YOU'VE wanted to control a model airplane, boat, or racing car by radio and want a receiver that is simple but highly efficient and reliable, here's the one for you. When used with the transmitter on page 169, this receiver will enable you to perform remote functions over a ground distance of ½ mile. This equipment operates on the license-free band of 27.255 mc.

The receiver is a completely new circuit designed around the *Sigma* 8000-ohm CDS 26F relay. This is a very stable superregenerative gas-tube circuit, simple to construct and operate. The RK61 gas tube has a relatively short life when used in regular circuits, as compared to a high-vacuum tube. However, it is easier to work with and is more sensitive than the average single vacuum-tube receiver. Due to the characteristics of the *Sigma* 26F relay, it is possible to operate the RK61 tube at a reduced plate current setting, thus adding measurably to its life.

And now to begin construction. It is important to use the exact components specified, if the originator's operating characteristics are to be obtained. The chassis is cut from a piece of 1/16" Micarta, or similar material, and drilled as shown in Fig. 4. Next, wind coil *L2*, as shown in the inset drawing of Fig. 1 and according to the specifications in the parts list.

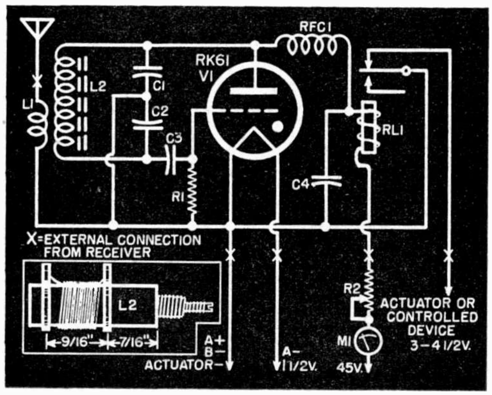
The tube socket and eyelets are pressed into place, as shown in Fig. 4. Following the schematic diagram in Fig. 1 and the top view in Fig. 3, solder capacitors *C1*, *C2* and *C3* in place. A short piece of small-size insulated wire is jumpered from the coil end of the 15-μμfd. capacitor, *C1*, to the outside terminal of the tube socket. This outside terminal should be indicated by a small dot of red nail polish or paint to indicate the plate connection for the tube and provide proper positioning of the tube. The 10-μhy. r.f. choke is next soldered in place between the plate terminal of the socket and the eyelet shown in Fig. 2. The .03-μfd. (*C4*) plate bypass capacitor is also soldered in place.

The 2-megohm resistor, *R1*, is soldered in place between the third terminal connection on the socket (from the red dot side) and the ground connection eyelet. Incidentally, the tube connections as taken from the red dot on the tube base, are: plate, filament, grid, and filament.

A short piece of insulated wire is soldered between the ground eyelet and the second terminal connection from the red dot on the socket. Be sure the center connections between the 15-μμfd. and 47-μμfd. capacitors are soldered to the eyelet near the coil, and a short insulated lead run from the eyelet to the second socket terminal which has been grounded by a jumper to the ground eyelet.

Before mounting the relay and the power wires or cable, check your connections again, using the schematic and Figs. 2 and 3. Mount the relay as shown in the photographs. Note that this receiver will function with peak performance *only* with the

Fig. 1. Schematic and parts list for the radio control receiver.



R1—2 megohm, ½ w. res.
R2—25,000 ohm subminiature pot
C1—15 μμfd. tubular ceramic capacitor
C2—47 μμfd. tubular ceramic capacitor
C3—100 μμfd. tubular ceramic capacitor
C4—.03 μfd., 200 v. tubular paper capacitor
RFC1—10 μhy. r.f. choke (National)
RL1—8000 ohm relay (Sigma CDS 26F)
L1—4 t. lightweight plastic covered wire (see text)
L2—15 t. No. 26 en. copper wire wound on Cambridge Thermionic 3/8" dia. coil form with red dot slug (see text) Powdered iron slug to have no brass slug attached
M1—0-2 or 0-3 d.c. milliammeter
V1—RK61 tube (Raytheon)
Misc. Parts:
1—6-prong subminiature socket (Cinch)
1—4-prong miniature plug and socket (Cinch or Amphenol)
1—1/16" x 1¾" x 2½" Micarta chassis (see text)
5—3/32" dia. eyelets

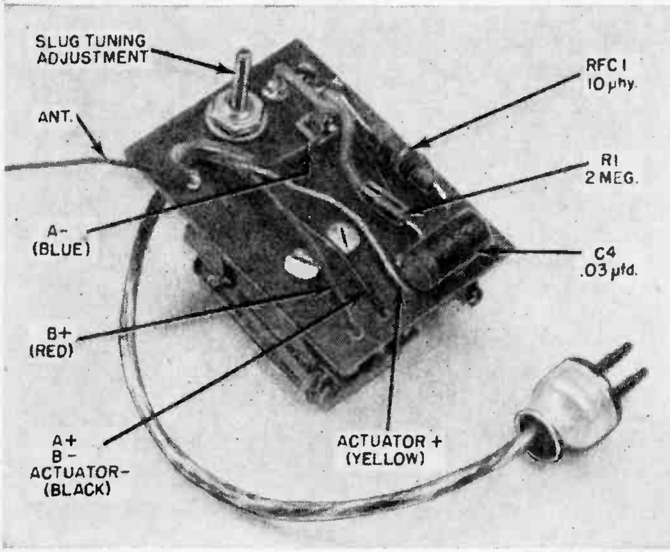
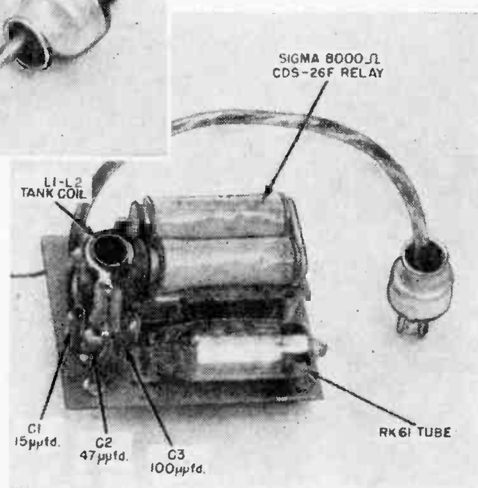


Fig. 2. Bottom view of the radio control receiver, showing the tuning adjustment and some of the parts.

Fig. 3. Top view of the chassis showing locations of the Sigma 26F relay, RK61 tube, and tuning coil.



Sigma 26F relay. A slightly larger *Sigma* relay, the 10,000-ohm 5F, will also work fine, but due to its larger size and weight, a new chassis layout would have to be made.

The power cable is inserted from the top side of the chassis. It is desirable to use color-coded wire for this work. The cable we used contained red, black, blue, and yellow wires, and we'll follow this color code in making the hook-up. The red wire, which is "B+" and goes to 45 volts positive, is connected to one side of the relay coils. (Of the three in-line terminals on the relay, the two outside ones are coil connections and the center one is the common for the relay points.) The other outside coil connection is connected by a short piece of insulated wire to the junction of the r.f. choke and the .03-μfd. capacitor. The black wire, which is "A+" "B−" and the minus side of the relay points, goes to the ground connection eyelet and the center of the three in-line terminals on the relay. The yellow wire goes to the normally-closed relay point. The blue wire, which is "A−," goes to the 4th tube socket terminal. (Note that only 4 of the 5 tube socket terminals are used; the fifth is left blank.) Now attach a four-prong plug to the other end of the cable, making sure you identify each pin with the proper wire before applying voltage.

The antenna coil, *L1*, is made from lightweight plastic-covered wire and wound near the grid end of coil *L2*. Wind in the same direction as *L2*, and solder one end to the eyelet next to the coil which has been grounded. The other end is soldered to the antenna eyelet. The antenna coil may be held in place by several small dabs of nail polish. The leads of the RK61 tube should be cut off to a length of about ½" and then bent at a 90-degree angle. Be sure to keep the red dot on the tube towards the outside terminal of the tube socket, since the red dot on the tube indicates the plate lead. This completes the receiver.

The 1½ volts for the filament may be obtained from a medium-size flashlight cell, or larger. The plate voltage of 45 volts may be obtained from two 22½-volt hearing-aid cells connected in series, or a 45-volt portable radio battery. An "on-off" switch (not shown) should be placed in the black lead. A 25,000-ohm potentiometer is placed in series with the red lead. For tuning purposes, a 0-2 or 0-3 d.c. milliammeter is also placed in series with the potentiometer in the red lead, and *R2* set for maximum resistance before the 45 volts are applied.

After turning the "on-off" switch "on," check to see if the filament is glowing in the tube; if not, check the wiring again (black and blue wires and the tube socket). Upon applying the 45 volts to the receiver, the plate current reading should be about .4 to .6 milliampere. Touching the antenna should raise the current slightly. The relay will close when the current gets up to about

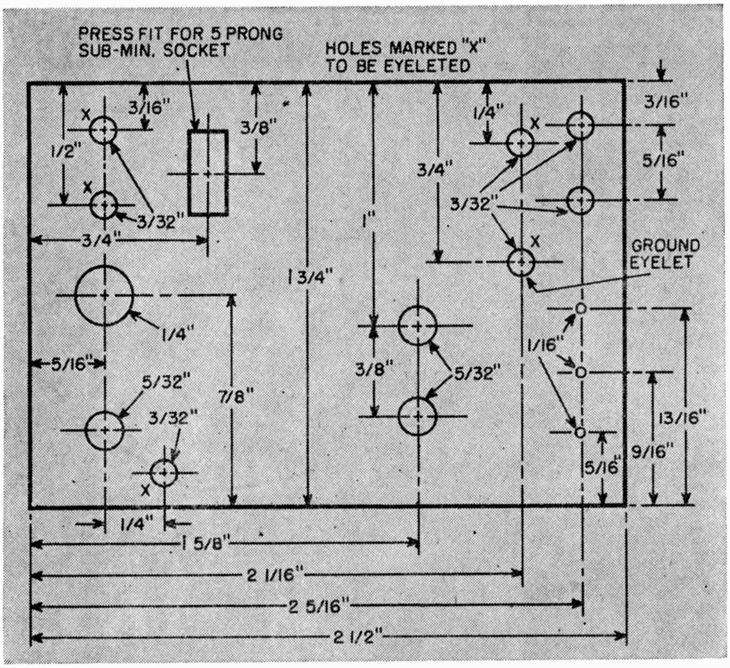


Fig. 4. The chassis for the receiver is a rectangular piece of Micarta drilled and cut for the various components as shown.

.7 to .9 ma. A small flashlight bulb and battery connected between the yellow and black wire will go on when the relay is not picked up, and will go out when the plate current increases to .7 to .9 milliamperes.

Your receiver is now in working order and needs only to be tuned to a 27 mc. signal to actuate it. —30—

R/C Battery Rejuvenator

By PAUL F. RUNGE

IN PRACTICE, as a dry cell is used, the carbon electrode gathers hydrogen. If the drain is fairly high, hydrogen gathers faster than the battery can dissipate it during the "off" periods. Consequently, when it is used again, only a little of the hydrogen has been removed. Continued operation adds more hydrogen, with the result that the battery becomes useless long before the chemical agents in it have been fully used.

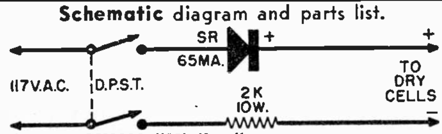
Ideal operation of dry cells calls for intermittent use spaced out over a period of time. In this way, the zinc container will be well used up when the battery shows signs of wearing out. In radio control, batteries are employed fairly frequently and the drain is high, so that the zinc is barely touched and the chemicals only slightly used. However, the hydrogen keeps the battery from functioning the way it should.

To rejuvenate a battery, the carbon electrode should be depolarized. This depolarization assists the battery chemicals in removing the hydrogen after each use.

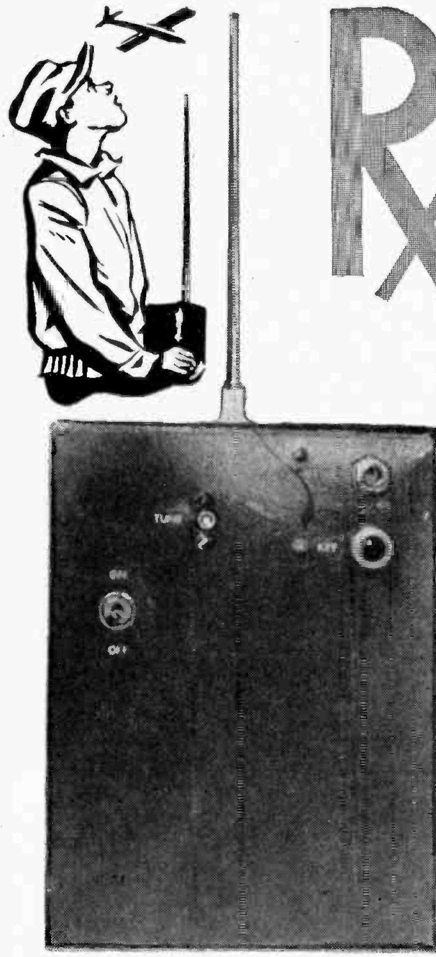
Because R/C batteries are generally small in size, the design of the rejuvenator can be considerably simplified. The charger shown below uses the battery itself as a capacitor, and thus will automatically adjust its voltage and current to the size of the battery being charged.

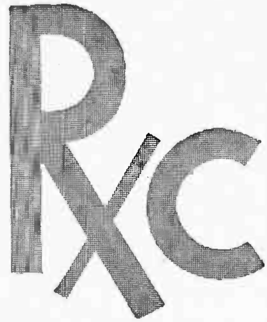
As each battery is charged, it should be touched occasionally for warmth. If the battery is a great deal warmer than body temperature, the rejuvenator should be turned off for a short period. Charging should be resumed if the voltage is still below normal for the battery. —30—

Schematic diagram and parts list.



1—Bud CU2101 "Minibox"
1—6' a.c. line cord with plug
1—18" length of #20 red flexible hookup wire
1—18" length of #20 black flexible hookup wire
2—Alligator clips (one red, and one black)
1—65 milliampere Federal selenium rectifier
1—2000 ohm, 10 watt wirewound resistor
1—D.p.s.t. toggle switch
1—Toggle "on-off" switch plate
2—3/8" mounting hole grommets





The Lorenz Transmitter

By
E. J. LORENZ

THIS transmitter, which is operated on the license-free frequency of 27.255 megacycles, enables the operator to send out a signal which remotely controls model planes, boats, cars, or other mechanical units. It is designed to be used with the Lorenz "Sixty-One" receiver described on p. 166. The only FCC regulation on operating this, or any other crystal-controlled transmitter in the Citizens band, is that an FCC form 505 be filled out and sent to the nearest FCC office. First of all, the chassis should be cut, drilled, and bent from .040-inch, ½ hard aluminum, or equivalent, as in Fig. 1. Next, the case, which is a 3½" x 6" x 8" "Minibox," has its cover drilled according to Fig. 2. The chassis holes on the bottom flange, shown in Fig. 1, should be drilled after the front cover holes are drilled. Hold the chassis against the cover and mark holes on the flange as per front

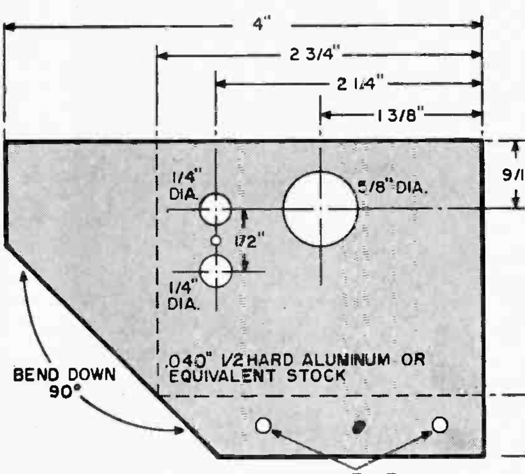


Fig. 1. Dimensional diagram of the subchassis on which the 3A4 tube and crystal are mounted.

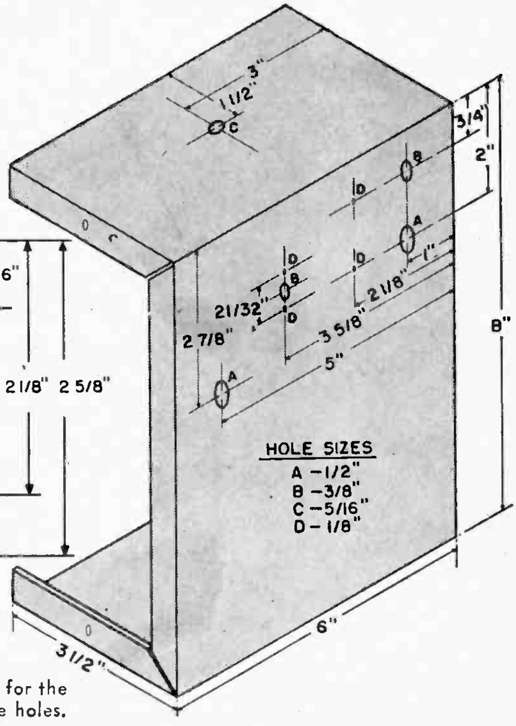


Fig. 2. Cover of the "Minibox" used for the transmitter showing the position of the holes.

R1—33,000 ohm, ½ w. res. ± 10%
C1—35 μμfd. variable capacitor
C2—.005 μfd. disc capacitor
L1—30 t., #20 en. on ⅜" form (see text)
L2—11 t., #16 en. on ⅝" form (see text)
L3—See text
L4—See text
S1—S.p.s.t. "on-off" toggle switch
V1—3A4 tube
J1—Meter jack
Xtal—27.255 mc. (Peterson Z-9)
1—Crystal socket (Johnson #126-105)
1—7-pin miniature socket
1—Keying switch
1—1½ v. battery plug
4—15" lengths of hookup wire (4 colors)
25"—#16 copper enameled wire
25"—#18 solid copper plastic-coated wire
36"—#20 copper enameled wire
4—67½ v. battery clips
3—4-40 ⅜" machine screws and nuts
1—Antenna feedthrough (Johnson #135-44)
1—Case (ICA 29444 or Bud CU-3009)
1—Set of batteries

All of the above parts may be obtained in kit form from Electronic Specialties, 58 Walker St., N.Y.C.; Control Research, Box 9, Hampton, Va.; Ace Radio Control, Higginsville, Mo.; and Gyro Electronics Co., 325 Canal St., N.Y.C.

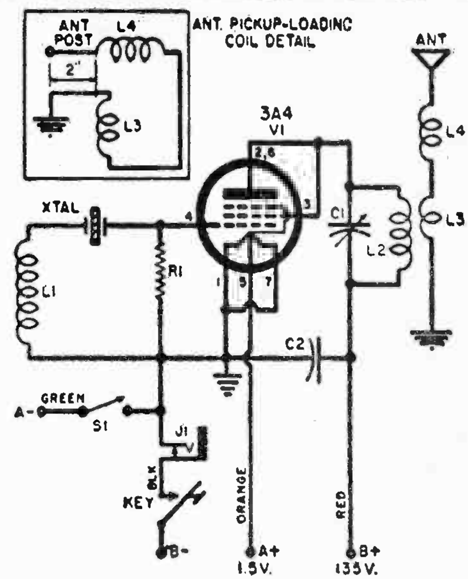
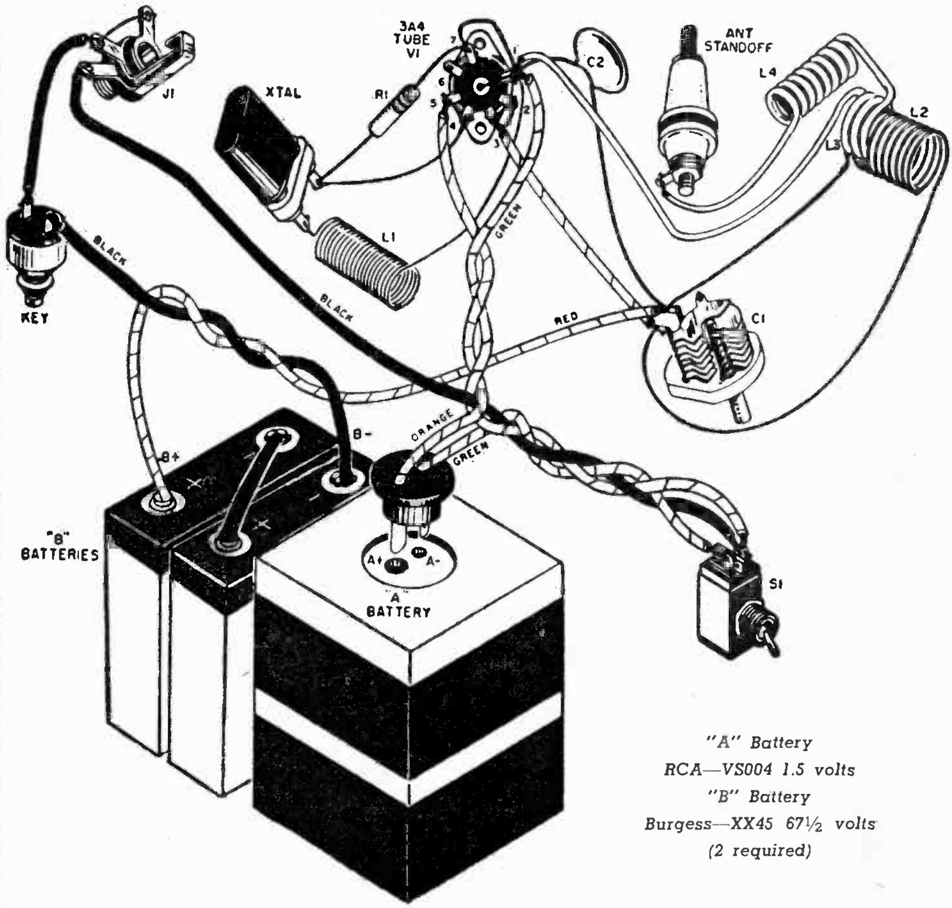


Fig. 3. Schematic diagram and parts list for the complete R/C transmitter. The pictorial diagram below shows the way the antenna pickup and loading coils are positioned.



"A" Battery
RCA—VS004 1.5 volts
"B" Battery
Burgess—XX45 67½ volts
(2 required)

cover holes. Mount the tube and crystal socket on the chassis before bolting the chassis to the cover with 4-40 ⅜″ machine screws.

Mount the antenna feedthrough, the 35-μμfd. variable capacitor, the "on-off" switch, meter jack, and keying switch.

Wind coil *L1* (see Fig. 3) according to the parts list, leaving leads about ½″ long. Be sure the winding is tight and the turns fit tightly against each other. After removing the coil from the form, give it a coat of clear nail polish. Wind the tank coil, *L2,* as specified in the parts list, leaving the leads about ⅜″ long. Space the turns evenly after winding, until the length of the coil is 1″.

The antenna and loading coils, *L3* and *L4,* are made from a 24″ length of #18 solid plastic-coated wire. Leave 1¼ to 1½ inches between the two windings. *L3* consists of 3 turns wound on a ⅝″ diameter form; *L4* is 10 turns closewound on a ⅜″ diameter form.

For final assembly, follow the schematic in Fig. 4. It is desirable to have four color-coded wires for hookup. The colors used are: black for "B—," red for "B+," green for "A—," and orange for "A+." About 15″ of each are used.

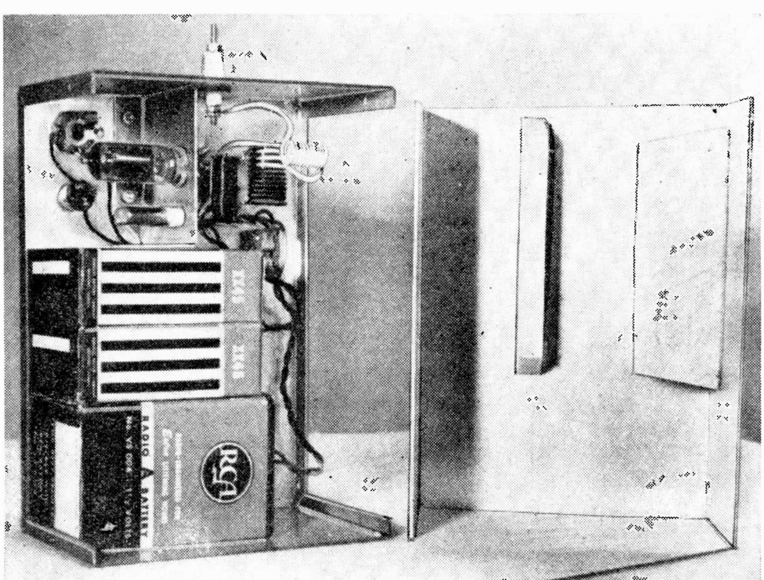
Solder the "A+" filament wire to pin 5 of the socket. (Remember that all socket connections refer to the underside of the socket.) The "A—" wire is soldered to pins 1 and 7 and also to the center eyelet of the socket. Twist the "A+" and "A—" wires together for about 3 inches, cut the "A—" lead and solder it to one side of the single-pole, single-throw switch. The other piece of "A—" lead is soldered to the other side of the switch. Now twist the "A—" and "A+" leads together again for about 6 to 7 inches, then cut, and solder to the "A" battery plug. The large pin on the plug goes to "A+." Place the tube in the socket and check to see that the filaments light when the switch is turned on.

Solder coil *L1* between the ground point at pins 1 and 7 and the outside crystal-socket terminal. Resistor *R1* is soldered between pins 1 and 7 on the tube socket and the inside crystal terminal. Extend the resistor lead from the crystal socket to pin 4 of the tube socket and solder. The .005-μfd. plate bypass capacitor, *C2,* is soldered between the ground point and the rotor (movable plates) terminal of the 35-μμfd. variable capacitor, *C1.*

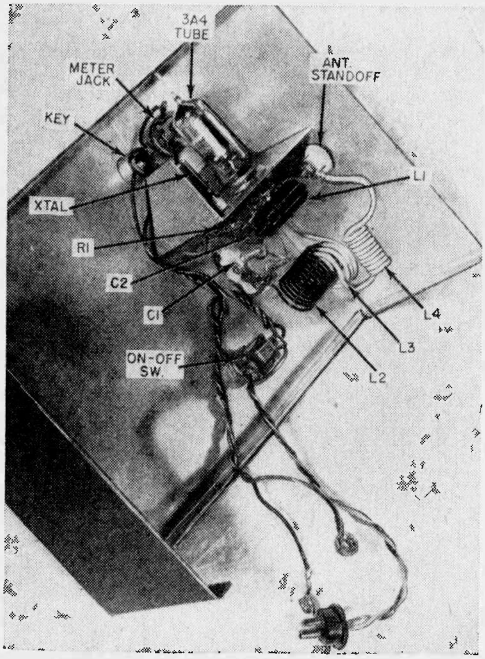
Solder the tank coil, *L2,* between the rotor and stator (fixed plates) terminals of the 35-μμfd. variable capacitor. Solder a short piece of wire between the stator end of the coil and pins 2 and 3 of the tube socket.

This completes the basic oscillator. Before starting the final hookup, be sure the meter jack is insulated, by means of insulated washers, from the case cover. Use a short piece of black wire to connect one of the sleeve terminals of the jack to one side of the keying switch. Connect the two jack sleeve terminals together. Another short length of black wire is soldered between the other jack terminal and the "on" side of the "on-off" switch. The "B—" black lead is soldered to the remaining terminal of the keying switch.

A 6- to 8-inch length of red wire is sol-



Back view of the R/C transmitter showing the position of the batteries, the subchassis bolted in place, and the position of the antenna loading coil, L4 above the tank coil.



Back view of the transmitter without the batteries, showing location of the various parts.

dered to the junction of the tank coil, *L2*, and the .005 μfd. capacitor. Twist the black and red leads together, cut, and attach battery clips.

Now insert the tube and crystal in their respective sockets and attach a 0-25 or 0-50 milliampere d.c. meter to a meter-jack plug and insert in the meter jack. Be sure the polarity is correct—the plus terminal of the meter going to the side of the jack connected to the "on-off" switch.

To tune the transmitter, turn the switch on and set the variable capacitor to minimum, or until the plates are unmeshed. Depressing the key will give a current reading of 25 milliamperes or more. Rotate the variable capacitor until the current drops sharply to about 5 to 6 milliamperes. This indicates that the oscillator is functioning properly. Failure to obtain a current drop indicates an incomplete connection or a short to ground through the meter jack.

Next, install the antenna coil by inserting the three turns of *L3* between the turns of *L2* near the plate end of the coil. Insert *L3* only about two-thirds of the way into the tank coil. The free end of *L3* is soldered to the ground connection of the tube socket, and the free end of *L4* is soldered to the antenna post lug. Upon depressing the key, the variable capacitor will have to be readjusted to give a minimum reading, which will be about 2 milliamperes more than that obtained with the coils not in place. After the minimum reading is obtained, set the variable capacitor to obtain a current rise of about 1 to 2 milliamperes. For bench testing, your transmitter will now operate the receiver on p. 166.

Note the two wood blocks screwed onto the bottom portion of the "Minibox" as seen in the photo on page 171. These blocks serve to hold the "A" and "B" batteries in place. The center strip is about five inches long and one inch wide. It is so placed as to press down on the batteries and hold them in place. The other block is also about five inches long but is 2¼ inches wide. This screws onto the side of the case and hits up against the batteries.

The antenna is made from telescoping brass tubing, using 1/16", 3/32", ⅛" and 5/32" diameters with a short piece of 3/16" to reinforce the base. Tap the base section (5/32" diameter) for a 6-32 screw and lightly crimp the ends of the sections to obtain a good press fit. Attaching the antenna, the current reading should be about 12 milliamperes. Increasing the coupling between *L2* and *L3* and/or adding length to the antenna will increase the current and, hence, the output. Properly adjusted, this transmitter will give a ground range of about ½ mile, and is fairly insensitive to hand capacity. —30—

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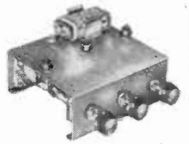

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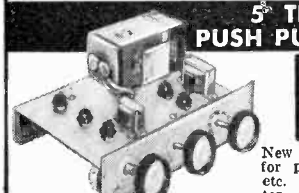

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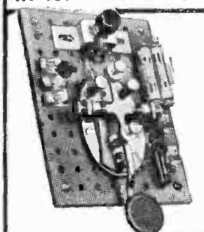

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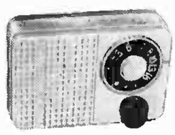

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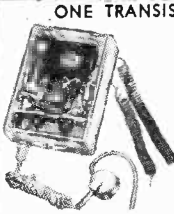

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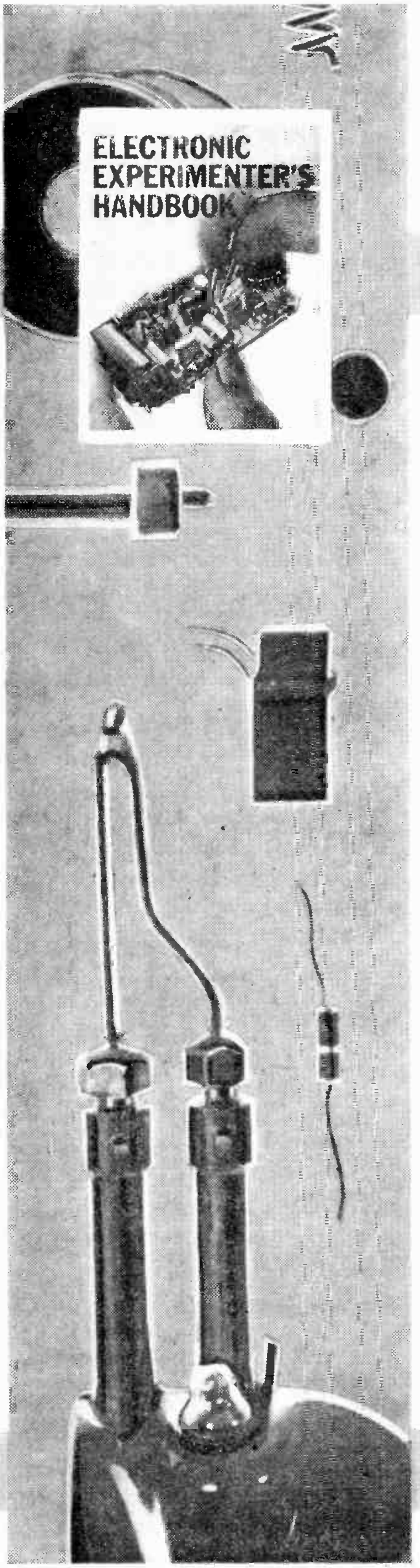
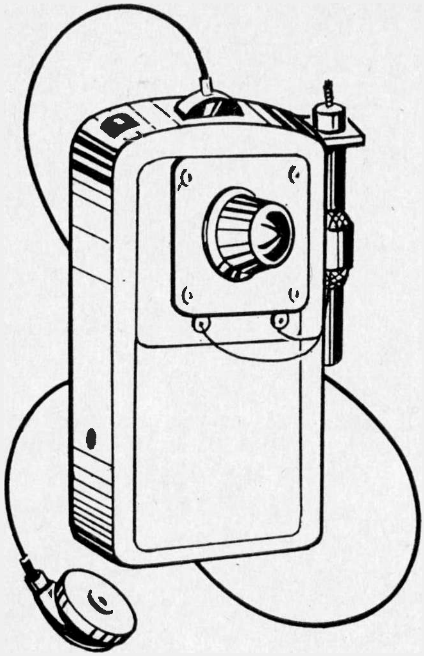


Chapter 9

Try Your Hand at These



This Acousticon hearing aid was modified by adding a loopstick and a midget tuning capacitor.

With minor alterations and additions, you can make a radio from a hearing aid

Radios Made From Hearing Aids

RADIOS that can be put in a pocket, worn on the wrist, or carried in a purse are extremely popular these days. You can go out and buy one of these pocket—or purse-size units, but you'll find it rather expensive. Besides, who wants to *buy* something that you can *make?*

Here are two versions of a midget radio built around a hearing aid. Perhaps you can pick up a used model for a reasonable price at your local hearing-aid dealer.

In both cases, the hearing aid is used as an audio amplifier and is preceded by a simple tuned circuit to select various broadcast stations. Range will depend on the power of nearby stations, and on the length of antenna employed.

In each of the units described, the major work is mechanical rather than electrical, so you have plenty of leeway to use your own ingenuity. Different hearing aids will present different problems—the basic suggestions included here should enable you to convert practically any of the hearing aids now on the market to a suitable receiver.

UNIT ONE

By Gary Edson

The first unit involves the conversion of an Acousticon hearing aid. The tuned circuit consists of a Vari-loopstick with midget tuning capacitor such as the Lafayette part No. MS-215 connected in parallel with it. This capacitor is mounted in the space usually occupied by the microphone grille, which is removed; to fill in the extra space between the edges of the capacitor and the edges of the hole in the case, solder in a piece of sheet metal previously cut to shape. For other models, you can easily design a suitable mounting system. Cut off the threaded sleeve on the capacitor unless it is used for mounting purposes, and shorten the shaft so the tuning knob will not stick out too much.

Mount the loopstick by means of an L-shaped bracket bolted to the side of the hearing-aid case. Mount a binding post for an antenna, or merely solder a wire in place after you have determined the proper length.

Connect the parallel coil and capacitor combination to the microphone terminals as shown in the schematic. You will probably note that no detector is employed—detection of the radio signal takes place in the grid circuit of the first audio stage. Volume and tone controls on the hearing aid are undisturbed; they can be used to control sound coming from the earphone. Adjust the coil slug for best performance over the whole band.

A more compact receiver may be devised by using a coil from a 456-kc. i.f. transformer. The coil can be mounted inside the hearing-aid enclosure (without the i.f. can, of course) but performance will be inferior to that provided by the loopstick. An external antenna is a "must" with this scheme.

UNIT TWO

By F. E. Bassett

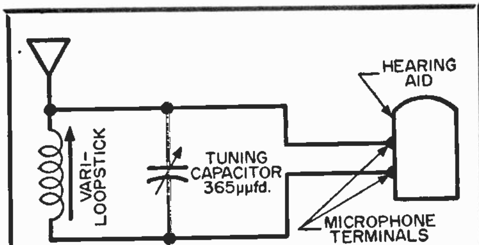
The second conversion is somewhat more involved mechanically, but has the advantage that you can unplug the tuned circuit and use the hearing aid for what it was originally intended—a hearing aid. Proper switching for this purpose is accomplished in the plug and jack arrangement, as shown in the schematic diagram.

A glance at the photos and diagrams will give you a general idea of the jack and plug assembly. The tuned circuit components, *L1* and *C1,* and the rectifier *CR1* are all mounted inside a plastic tube about 3″ long, having an inside diameter of ½″. Suitable plugs and washers for the assembly are cut from ⅛″-thick Lucite.

To reduce the size of the coil, remove the solder lugs. Then carefully slit and remove the cardboard tube supporting the lugs. Pry open the adjusting screw mounting slightly so that the screw turns freely. This screw, with a suitable tuning knob made from the cap on a can of lighter fluid or other suitable device, is used for tuning the receiver.

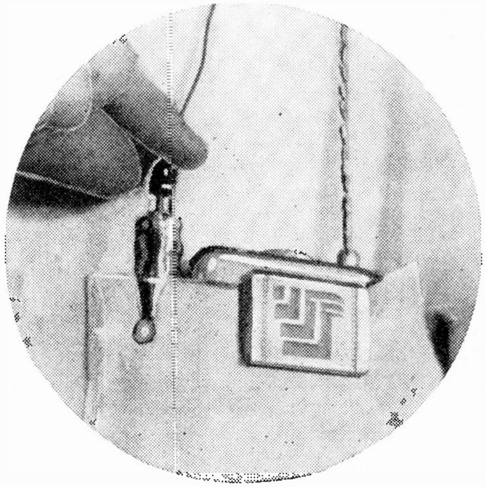
Mount and solder the tuner components as shown in the pictorial diagram, being careful not to overheat the rectifier. Cut washers for the plug end and for the snap-in end of the coil, slip the whole assembly inside the plastic tube, and glue the washers firmly in place with plastic cement or acetate liquid. Be sure to bring the antenna lead outside the case before final assembly. Mount a pen clip as shown below.

Now wire up the jack as shown in the cross-sectional view, cut suitable washers from the Lucite sheet, and assemble inside a ⅝″ length of plastic tubing—gluing the washers firmly in place. It is a good idea



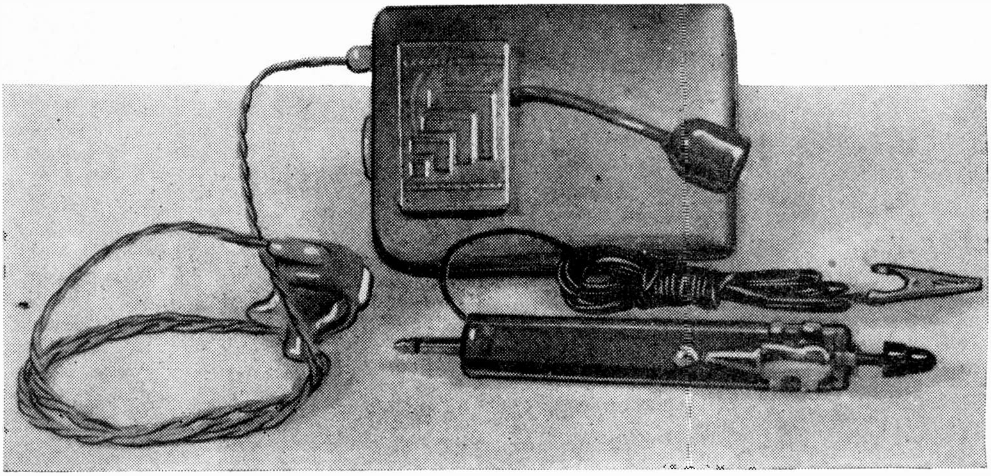
C1—10-365 µµfd. midget tuning capacitor (Lafayette MS-215)
L1—Vari-loopstick with mounting bracket (Graybourne or equivalent) or the coil from a 456-kc. i.f. can (see text)

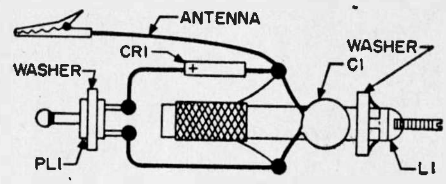
Schematic and parts list for the first unit.



The converted unit mounted in a shirt pocket, and being tuned by adjusting the loopstick screw.

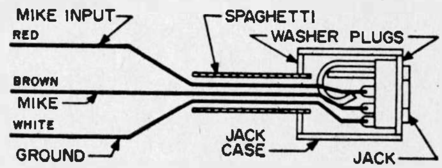
Complete assembly, including loopstick tuning unit and antenna with clip, the hearing aid with jack added for radio operation, and the earphone.





Pictorial diagram of the tuning unit (above). This assembly mounts inside of a plastic tube.

Cross section of jack assembly (below) shows various connections. Lead colors are optional.

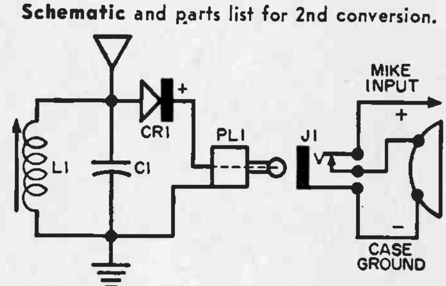


to use color-coded leads to make certain that you wire the plug to the hearing aid correctly.

Remove the hearing aid assembly from its case. Unsolder the microphone input lead, and connect the three leads from the plug as shown in the cross section and in the schematic. Protect these three leads with spaghetti tubing. Re-install assembly in case.

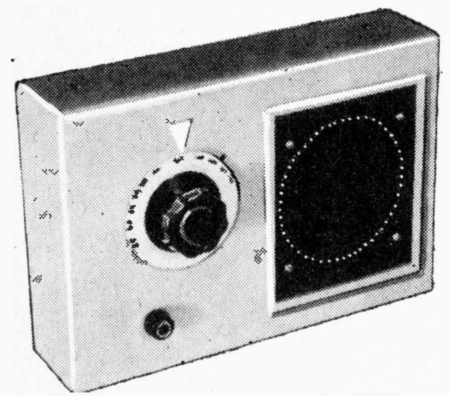
With the tuner unplugged, the hearing aid should operate normally. Plug in the tuner, and clip the antenna lead to a metal lamp shade, phone finger stop, or outside antenna. Then turn up the volume, and hunt for stations by turning the coil adjusting screw. You should receive several stations with good volume. —30—

Schematic and parts list for 2nd conversion.



C1—330-µµfd. subminiature ceramic capacitor
CR1—Crystal diode rectifier (CK707, 1N34, etc.)
J1—Miniature closed-circuit phone jack (Telex or Switchcraft)
L1—Slug-tuned loop antenna with threaded shaft (Walsco or equivalent)
PL1—Miniature phone plug (Telex or Switchcraft)
1—Alligator clip
1—Tuning knob
1—Pen clip
1—Plastic tube, approx. ½" i.d. x 4" long
1—Piece of Lucite, 2" square (for washers)

Transistor Portable with a *Punch*



By **RUFUS P. TURNER**

HERE IS something a little out of the ordinary in a transistorized radio receiver. Although it avoids the complications of a superhet design, it still has good selectivity and does not require an external antenna for quality performance. And it provides loudspeaker operation.

Heart of the receiver is a long, high-*Q*, ferrite-cored coil which serves as an excellent antenna without any external antenna wire. Tuning is accomplished by a 365-$\mu\mu$fd. capacitor in parallel with the whole of the antenna coil, and selectivity is main-

HOW IT WORKS

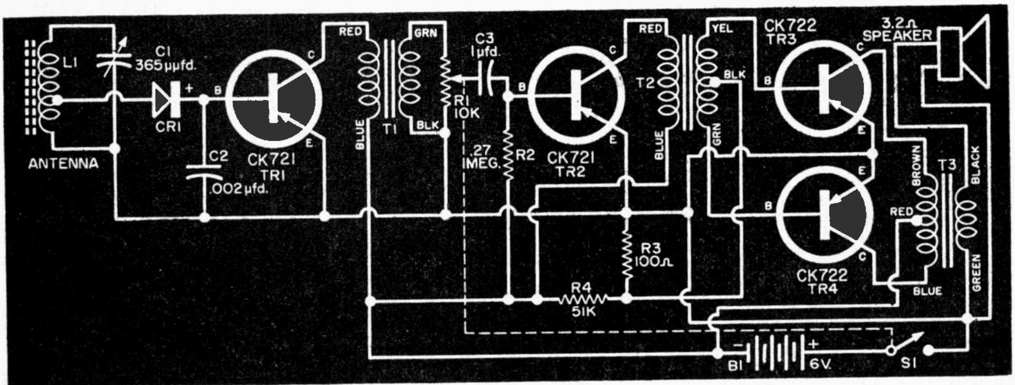
Most crystal receivers are lacking in selectivity because the crystal detector loads down the tuned circuit, reducing its *Q*. In the antenna arrangement used here, a long core is employed to intercept a maximum of r.f. energy from broadcast stations, and the coil is tapped down to match the low impedance of the detector. Thus, a high *Q* is maintained, and good selectivity results. The coil is wound with litz wire, which is made up of a number of strands of fine insulated wire twisted together. This type of construction reduces the r.f. resistance of the coil, and helps in maintaining a high *Q*.

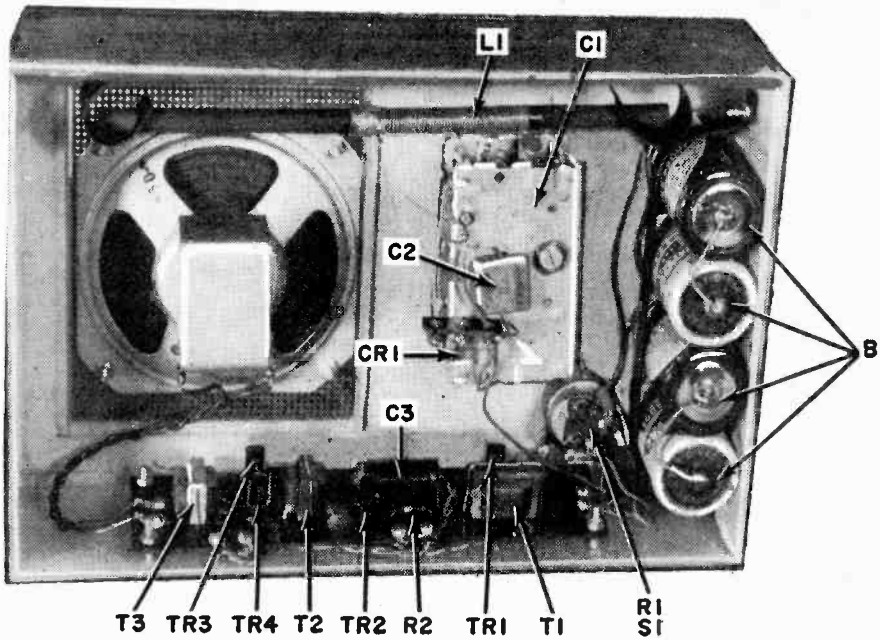
Capacitor *C2* bypasses the r.f. from the detected signal, and the audio passes through the base-emitter circuit of transistor *TR1*. Amplification takes place in this stage, and the signal is coupled to the next stage by transformer *T1*. This transformer matches the output impedance of *TR1* to the input impedance of *TR2*, resulting in maximum power transfer.

The desired portion of the audio signal is selected by volume control *R1* and is passed to *TR2* through *C3*. A high value of capacity is required here because of the low impedance of the base-emitter circuit of *TR2*. Further amplification is provided by *TR2*, which is biased by means of resistor *R2*. Transformer *T2* again matches the output of *TR2* to the input of the push-pull output stage *TR3-TR4*. Base bias for Class B operation of the output stage is provided by the voltage divider *R3-R4*. *T3* matches the output of the push-pull stage to the voice coil of the loudspeaker.

Transistors *TR1* and *TR2* may be replaced by the cheaper CK722's, with somewhat decreased gain. Other transistors could also be substituted, with possibly some change in performance. If such substitutions are made, *R2* should be selected for optimum performance of *TR2*, and *R3-R-4* for optimum performance of the output stage *TR3-TR4*.

Schematic diagram of the portable radio receiver. The pictorial diagram for the set appears on page 182, the complete parts list is on page 183.





Interior view of complete receiver, showing location of the major components.

tained by connecting the crystal detector to a low-impedance tap on this coil. All of the amplification takes place at audio frequencies, so you don't have to worry about poor transistor performance in the r.f. or i.f. region.

Transformer coupling is used in the audio amplifier to provide maximum gain.

The push-pull Class B output stage will provide about 110 milliwatts of audio, which is adequate for the average room.

Construction

You can't use a metal cabinet with this receiver, as metal would shield the antenna coil and greatly reduce signal pickup. Use a plastic box about 10½" long, 7" high and 3" deep, or build a wooden box about this size and finish it as desired. (One experimenter built the receiver in a cigar box!) Size is not all critical, except that the length must be at least 10" so that the horizontally mounted antenna will fit in it.

Mount the amplifier section on a strip of plastic ⅛" thick, 7" long and 2" wide. Components are held in place by passing their leads through small holes drilled in the strip, and bending the leads over on the other side. Fasten the transformers in place with a loop of wire passed around the core, and through holes in the strip. Twist the ends of the wire together under the strip for good anchoring. Then, pass the transformer leads through separate small holes in the plastic strip. Make all connections under the strip by soldering appropriate pigtails and leads together.

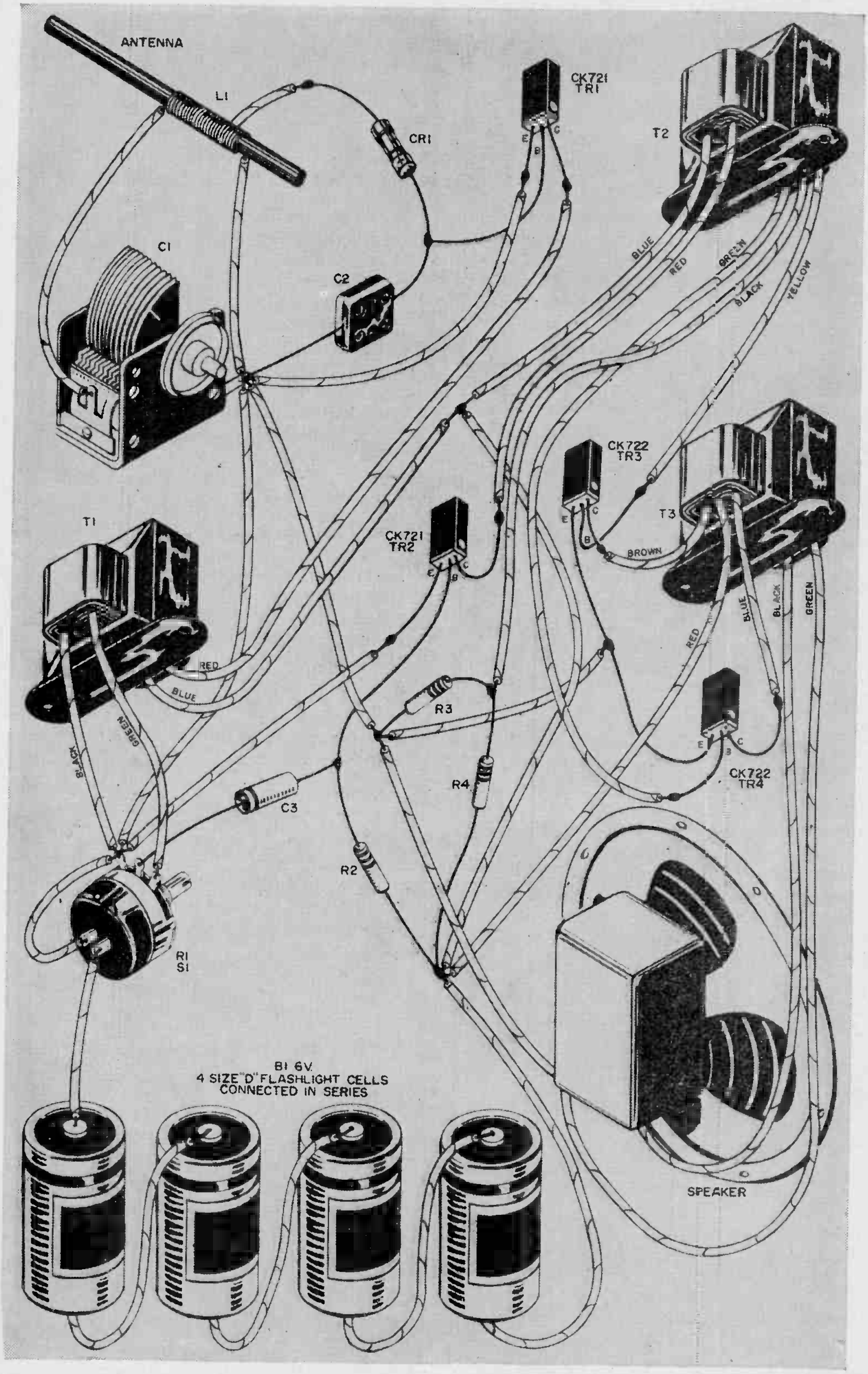
Check and double-check the transistor connections, because wrong wiring can ruin them. Hold the transistor pigtails tightly between the jaws of long-nose pliers when soldering, to avoid damage due to heat. Observe the color coding on the transformer leads; incorrect connections could cause the amplifier to oscillate.

After assembly, mount the amplifier on the floor of the enclosure.

Now mount the loopstick antenna lengthwise in the top of the case. Use the fiber mounting strips provided for this purpose. Don't use metal brackets of any kind. Install the tuning capacitor *C1* immediately below the antenna, and mount the diode detector and capacitor *C2* on the frame of *C1*. For the tuning dial, fasten a white plastic disc to a skirted Bakelite knob and inscribe it with the broadcast frequencies. Or use a commercial dial.

Cut a hole of the appropriate size for the loudspeaker which you are using, and cover inside with suitable grille cloth. Mount the speaker with *6-32* screws.

You can use your ingenuity in mounting the batteries. The author wired them in series, and then secured them in place with a metal strip fastened to the case at each end with a *6-32* machine screw. Install the volume control (with switch attached) in the approximate location shown in the photo. Wire up the various components according to the schematic and pictorial.


ANTENNA
L1
CR1
CK721
TR1
E
B
C
T2
C1
C2
BLUE
RED
GREEN
BLACK
YELLOW
CK722
TR3
T1
CK721
TR2
T3
BROWN
RED
BLUE
BLACK
GREEN
RED
BLUE
BLACK
GREEN
R3
C3
R4
CK722
TR4
R2
R1
S1
B1 6V.
4 SIZE "D" FLASHLIGHT CELLS
CONNECTED IN SERIES
SPEAKER

Pictorial diagram (on opposite page) and parts list (below) for the complete transistorized receiver.

Operation

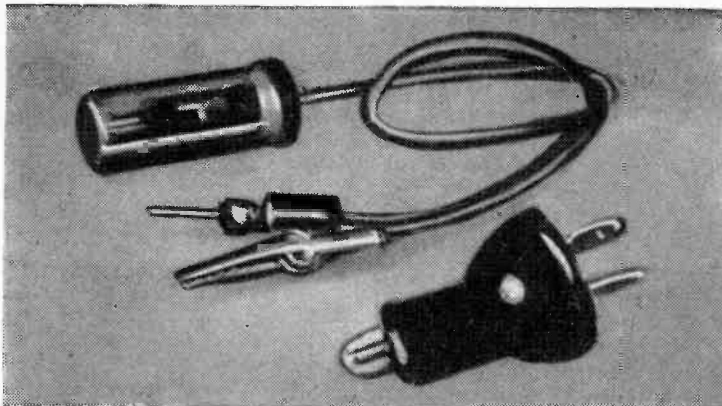
Calibrate the tuning dial by tuning in various local stations and marking their frequencies on the dial. Or, if you have an amplitude-modulated signal generator available, calibration can be easily carried out by laying the "hot" output lead of the generator across the middle of the antenna. Then set the generator successively to different broadcast-band frequencies, set the receiver tuning dial for peak output at each of these frequencies, and mark the dial accordingly. Adjust the generator output and receiver volume for best audible signal without overloading, as this sharpens receiver response and increases accuracy of the dial calibration.

Actual battery drain in this receiver varies with the sound output, since the final stage operates Class B, but drain will be much less than with a tube set. The specified batteries should give very long life—approaching shelf life if the receiver isn't used more than a few hours each day.

Volume of this little set is adequate to make it useful for the home, in a car, or on the beach. The antenna is slightly directional, so try rotating the receiver for best reception. You'll get many hours of enjoyment as a reward for the few evenings it will take you to build the set. —30—

PARTS LIST

B1—6-volt battery (four Size-D flashlight cells connected in series)
C1—365-µµfd. variable capacitor
C2—0.002-µfd. mica capacitor
C3—1.0-µfd., 200-volt, miniature, metalized tubular capacitor (Aerovox P-82Z)
CR1—Germanium diode (Raytheon CK705 or 1N34)
L1—Ferrite-type transistor loop antenna (Miller Type 2000)
R1—10,000-ohm potentiometer
R2—0.27-megohm, ½-watt carbon resistor
R3—100-ohm, ½-watt carbon resistor
R4—51,000-ohm, ½-watt carbon resistor
S1—S.p.s.t. switch installed on potentiometer R1
T1—Transistor driver transformer: primary, 15,000 ohms; secondary, 200 ohms (Argonne AR-107)*
T2—Transistor Class B driver transformer: primary, 10,000 ohms; secondary, 2000 ohms, c.t. (Argonne AR-109)*
T3—Transistor Class B output transformer: primary, 500 ohms, center-tapped; secondary, 3.2 ohms (Argonne AR-119)*
TR1, TR2—CK721 transistors (Raytheon)
TR3, TR4—CK722—transistors (Raytheon)
1—Plastic cabinet, 10½" x 7" x 3" (see text)
1—Plastic strip, 1/16" x 7" x 2"
Misc. machine screws, wire, solder, etc.
**Argonne transistor transformers are obtainable from stock at Lafayette Radio, 100 Sixth Ave., New York 13, N. Y.*



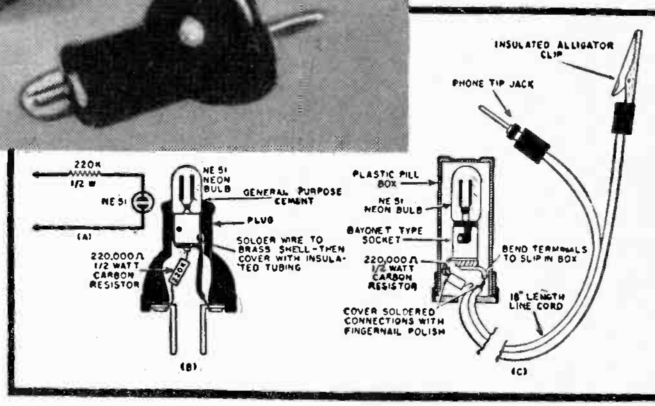


Fig. 1. A general purpose tester (rear) and power line tester (foreground). (A) Schematic for both units. (B) Construction details on power line tester. (C) Details on the general purpose tester. Parts values shown on diagram.

Fun WITH NEON BULBS

NEON bulb circuits have been popular with experimenters for years. Home builders, particularly, have liked them because of their simplicity and versatility. Beginners find that such circuits are easy to wire and quite inexpensive, since so few parts are needed for the average circuit, and the cost of the individual items is generally low.

Five interesting neon bulb gadgets are shown in the photographs and sketches. They are neither complicated nor expensive to build, and the average experimenter should have no difficulty in wiring several of the items shown in a single evening. The circuits shown are not all new. Several have been favorites with experimenters for years and have proven their reliability through the "test of time."

Three different types of neon bulbs are used in the circuits shown, the NE-2, the NE-51 and the NE-48. Of these three, the NE-2 and the NE-51 are interchangeable in the circuits where they are used. The chief difference between these two bulbs is in the basing. The NE-2 has no base, only wire leads, while the NE-51 has a miniature bayonet base.

A *general purpose tester* (background) and a combination *night light* and *power line tester* (foreground) are shown, along with circuits and construction data, in Fig. 1. Note that both devices are electrically the same, with the schematic diagram given in Fig. 1A applying to both.

Construction details for the *night light* and *power line tester* are given in Fig. 1B. The only parts needed are an NE-51 bulb, a 220,000 ohm, ½ watt carbon resistor, and a small piece of insulated wire, together with a standard rubber plug. Assemble the unit as shown, cementing the neon bulb in the neck of the plug with *Duco* cement (or any equivalent household cement). *Be sure that the brass shell is below the neck of the plug . . . no part of the shell should be exposed.*

To use as a *night light,* simply plug the unit into any standard wall receptacle. The bulb will give off a soft glow with virtually no heat, and may be safely left on all night. Power consumption is almost insignificant.

To use as a *power line tester,* plug the unit into the suspected receptacle. If the bulb glows, power is available. If not, either the receptacle or wiring is defective, or the line fuse is blown. Lamp fixtures may be checked by using a standard screw-type adapter.

The *general purpose tester* operates in much the same manner, with the only difference being in the method of construction. Full details are given in Fig. 1C. If preferred, connections may be soldered directly to the base of the neon bulb and the socket omitted. Once the wiring is completed, cover the connections with fingernail polish or lacquer to prevent accidental shorts.

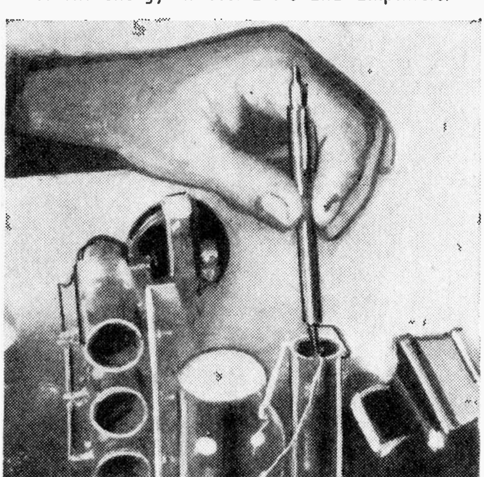
Either a.c. or d.c. voltages from around 90 to 250 volts may be checked with this device. To use the tester, connect the test leads to the points where voltage is to be checked. If both electrodes glow, the voltage is a.c. If only one electrode glows, the voltage is d.c. (the negative electrode is the one that glows). In both cases, the higher the voltage, the brighter the glow obtained.

The "hot" side of a power line (110-220 volts) may be identified by connecting one lead of the tester to a good ground and then touching first one, then the other wire of the power line with the free lead. A glow will be obtained when the "hot" power line wire is touched.

Hams will find the *r.f. tester* shown in Fig. 2 useful. The schematic diagram is given in Fig. 3A, while construction details are given in Fig. 3B.

To check for the presence of r.f. energy in low and medium power oscillators and amplifiers, hold the tester as shown in the photograph of Fig. 2 and touch the metal tip to a "hot" terminal. If r.f. energy is present, the neon bulb will glow. Where a moderate to large amount of r.f. power

Fig. 2. Photo of the r.f. tester for radio amateurs. Use it to check for the presence of r.f. energy in oscillators and amplifiers.



may be present, *do not touch any terminals with the metal point,* instead, simply bring the *bulb end* of the tester in close proximity to the hot terminal. If sufficient energy is present, the bulb will glow without actual contact.

Radio service technicians will be able to use the *60-cycle stroboscope* shown in Fig. 4 when testing and adjusting phonograph motors. The audiophile, too, will find the gadget useful for checking the speed of his favorite record player.

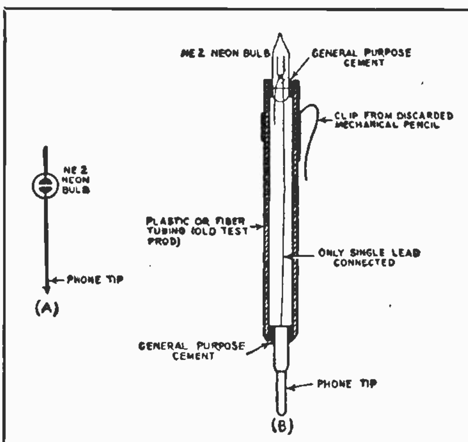
The schematic diagram of the unit is given in Fig. 4A, while construction details are shown in Fig. 4B. An ordinary plastic pill box or vial is used for housing the device. The NE-48 neon bulb is simply forced through a hole in the flexible plastic cap of the pill box. Take care that the brass shell is not exposed outside the box, however. If necessary, a little cement might be used when assembling the unit.

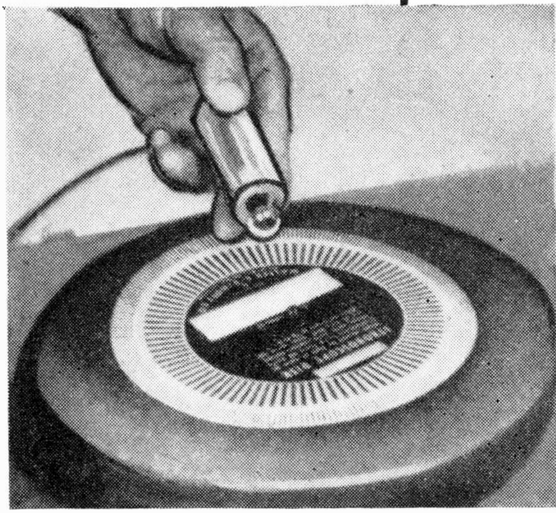
The completed *stroboscope* is used with a standard "stroboscope disk" (available at most radio supply houses) when checking the speed of a phonograph turntable. The proper technique is shown in the photograph of Fig. 4. When the turntable is rotating at proper speed, one of the circles will appear stationary when viewed in the light of the *stroboscope*. One circle is for 33⅓ rpm, while the other is for 78 rpm turntables.

Learning the radiotelegraph code may be a little easier for the beginner if the *code practice oscillator* shown in Fig. 5 is used. The neon bulb "blinks" each *dot* and *dash* at the same time that the tone is heard in the earphone. The schematic diagram for the unit is given in Fig. 6A, while the pictorial wiring diagram is given in Fig. 6B.

Construction is simple and straightfor-

Fig. 3. Schematic and pictorial diagrams for the r.f. tester for hams. A discarded ball point pen may be used for this tester, as shown in (B).





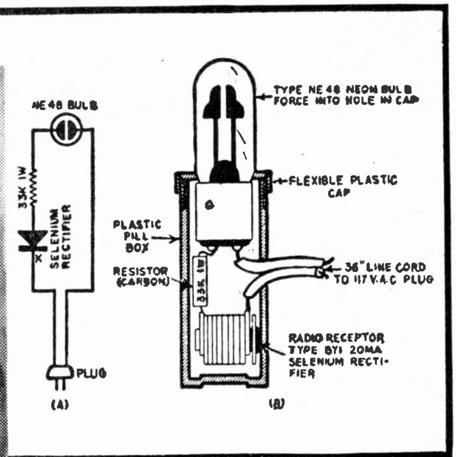


Fig. 4. Proper way to use the 60-cycle stroboscope diagrammed above. Technicians and audiophiles will find this handy for checking the speed of their phonograph turntables.

ward and no difficulty should be encountered if the wiring diagrams are followed carefully. The *hand-key* may be connected in series with either the positive or negative lead of the battery, and on either side of the 470,000 ohm, ½ watt resistor. In the model shown in the photograph, it is connected between the 470,000 ohm resistor and neon bulb. The tone may be changed by varying the value of the series resistor. A lower value resistor will give a higher pitch, a higher value resistor a lower pitch.

All of the devices described and pictured in this article are easy to build, offer a practical solution to some specific problem,

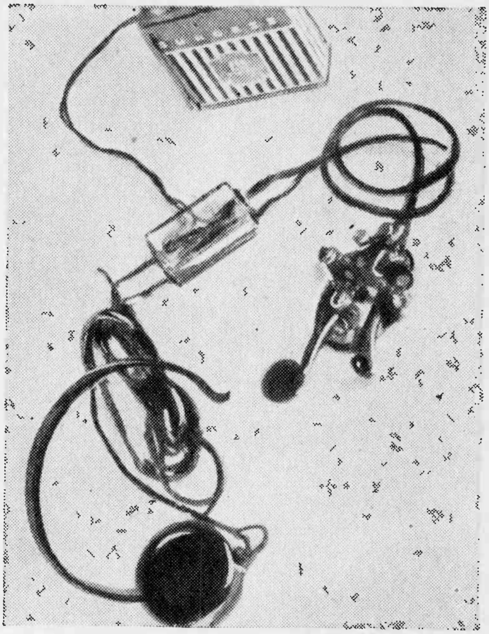
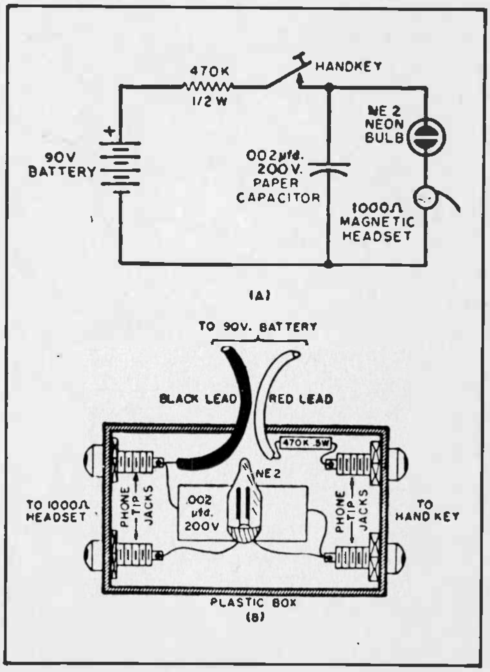
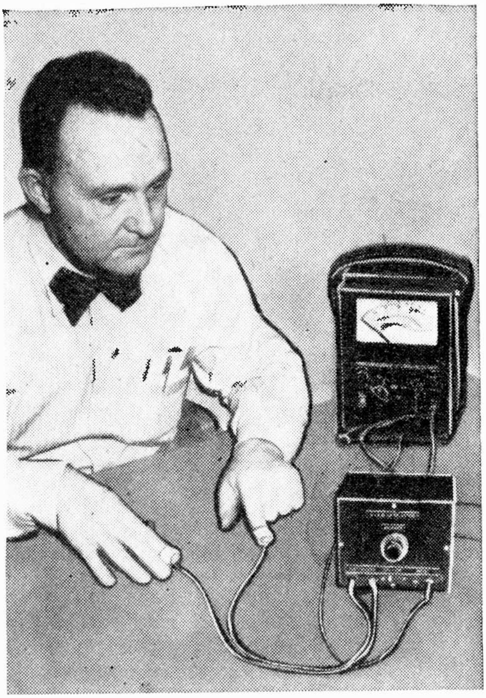


Fig. 5. A simple code practice oscillator. Neon bulb in box blinks each dot and dash at the same time that tone is heard in earphones.

and present a "professional" appearance. Pick your instrument and then have the fun of building it! —30—

Fig. 6. Schematic and pictorial diagrams of code practice oscillator. Follow these exactly for best results. Parts values are included.





Build Your Own

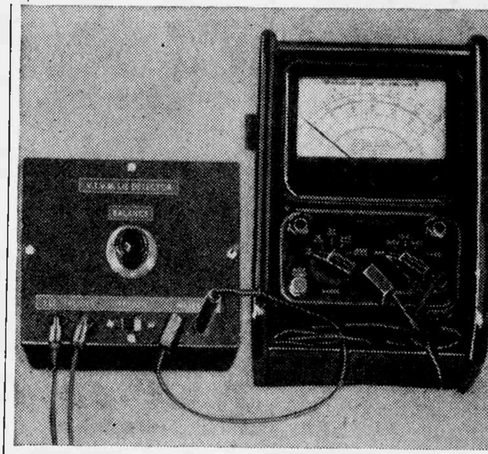
Lie Detector

INTERESTED in a gadget to take to a party? How about something for the classroom? Studying experimental psychology? Want to see what else can be done with electronics? Then here is an interesting answer. A simple circuit consisting of one tube, three batteries, four resistors, and one potentiometer that will convert a v.t.v.m. into a lie detector.

How It Works

Practically every experimenter possessing a v.t.v.m. has measured his own skin resistance. Unknown to many is the simple fact that this resistance is an important part of the usual lie detector.

Skin resistance is the measurement in ohms of the actual resistance from one part of the body to another. Usually the measurement is made from hand to hand. Major changes may be easily noted simply by holding the probes in the two hands. If the ohmmeter were sensitive enough, the operator could detect small changes that are related to emotional stresses and which can be used as a so-called lie detector.



Front panel view of the lie detector. Any one of the readily available v.t.v.m. units may be used. The common 1000 or 20,000 ohms-per-volt meter will not permit efficient operation of the detector.

To observe these small changes in the skin resistance an amplifier circuit is required. Because this circuit must be sensitive, a v.t.v.m. must be used as the indicating device.

The basic circuit of the lie detector amplifier is shown in Fig. 1(a). Note that the four resistors, *R1, R2, R3,* and *RX* form a diamond shape, or the properly called Wheatstone Bridge. This circuit is balanced when *RX* is to *R2* as *R1* is to *R3.* These are ratios and not necessarily absolute resistance values. The tube wired into the center of the circuit is used as a detector to find any unbalanced condition of the bridge.

If *RX* is made the skin resistance of the body and the variable resistor, *R2,* is carefully adjusted—then there will be no current flow through the tube and no reading across *R4* by the v.t.v.m. Should the skin resistance decrease, the point shown as "d" will become positive with respect to point "b" and current will flow through the tube and be read on the v.t.v.m. as a voltage drop across *R4.* As the skin resistance increases, or returns to a normal value, the reverse situation occurs and the voltage reading across *R4* drops.

Actually the operation of the circuit is slightly more complex since we have neglected the factor of grid bias. This is considered in the final wiring schematic of the lie detector which is shown in Fig. 1(b).

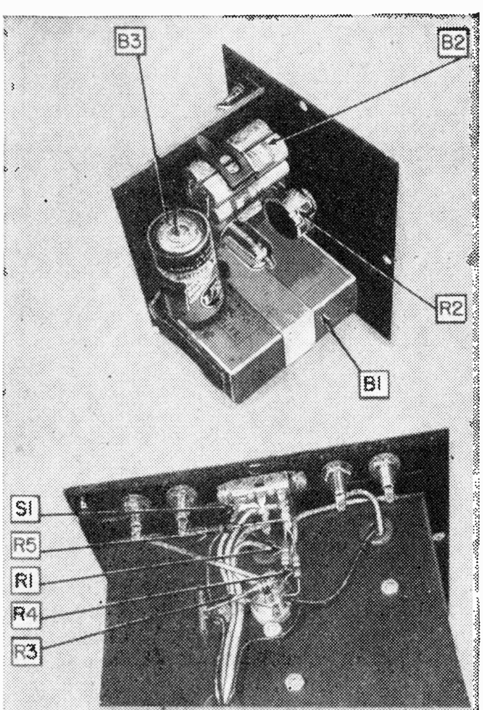
Batteries are used in the lie detector in order to insure freedom from voltage changes that might upset the balance of the bridge. Battery, *B1,* is a 67½-volt unit that supplies the bridge and plate voltages. Resistors, *R1* and *R3,* are adjusted so that they draw about 1.0 milliampere when switch, *S1A*, is closed. Battery, *B2*, consists of four penlite cells in series. These are used to "buck" the voltage drop across *R4* so that the v.t.v.m. may be set upon a sensitive "plus d.c. volts" scale.

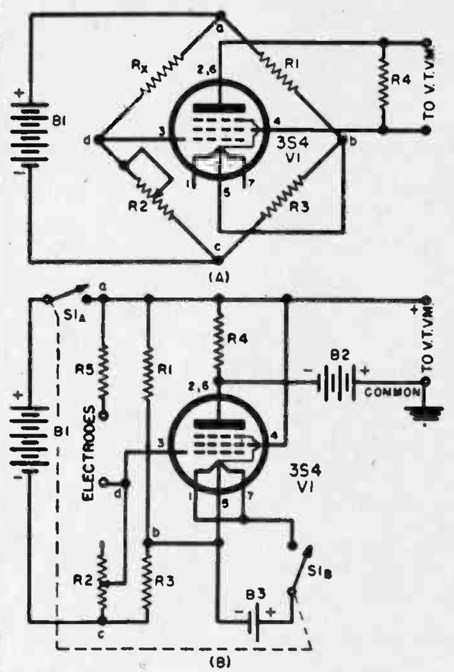
The operating voltages of the bridge may be checked by the v.t.v.m. before the unit is fully enclosed in its case. They should measure: plate-to-cathode 23 volts, screen-to-cathode 30 volts, and grid-to-cathode —6 volts.

Construction

The mechanical layout of the parts and components used in the final wiring diagram Fig. 1(b) and the pictorial schematic Fig. 2 is relatively unimportant. In other words, they can be placed at the discretion of the builder. Some may want to "breadboard" the bridge-style lie detector, while others may want to follow our suggested layout in a *Bud* utility cabinet with the self-contained chassis deck. The two behind-the-chassis photographs show how the parts were laid out. The only exceptional piece of material is the mounting bracket for the 67½-volt battery. The bracket is

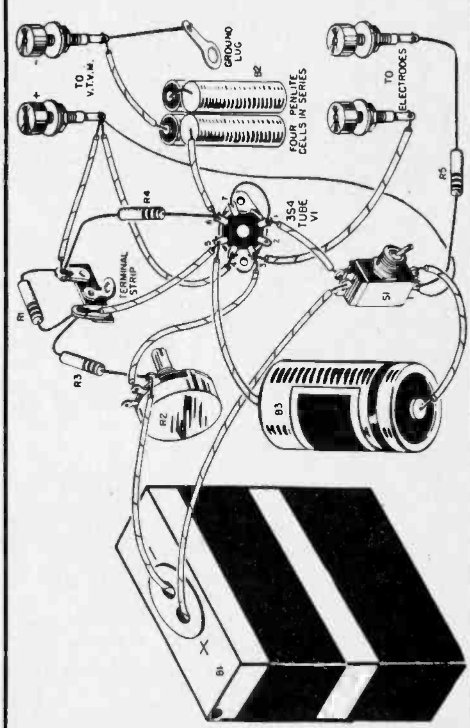
Top: Above-chassis view, showing location of the batteries. Here, instrument is on its side. Below: Under-chassis view, with callouts indicating some important components. Switch between the phone tip jacks may be either slide or toggle.





Above. Fig. 1. Schematic diagram and parts list of home-built lie detector. (A) is a simplified diagram of (B) indicating the resistance bridge.

Below. Fig. 2. Pictorial diagram showing how various parts of the lie detector are connected.



R1—39,000 ohm, ½ w. res.
R2—1.0 megohm pot, Centralab C-1 taper
R3—47,000 ohm, ½ w. res.
R4—10 megohm, ½ w. res.
R5—100,000 ohm, ½ w. res.
B1—67½-volt battery, Eveready #467, or equiv.
B2—Four penlite cells wired in series, Eveready AA #915
B3—Flashlight cell, 1½ volts
S1a, b—D.p.s.t. slide switch, Birnbach #6247
V1—3S4 tube
1—Battery plug for B1, Cinch-Jones #5MFA
2—Capacitor mounting clips, Mallory TH-25, see text
1—Utility cabinet, Bud #C-1797
1—Seven pin miniature tube socket
4—Insulated phone tip jacks, two in red, two in black, ICA #1889 and #1890.
2—Insulated phone tips, ICA #868 and #869. Hookup wire, grommets, tie-points, etc.

Total cost of parts should be about $9.50.

shown in Fig. 3. It may be cut from copper, brass, or aluminum.

Batteries, *B2* and *B3*, are soldered into the circuit. Both of these batteries are held to the chassis by *Mallory* capacitor mounting brackets type TH-25.

The electrodes that attach the lie detector to the "subject" are wired using insulated flexible wire similar to *ICA* #307. At one end of each piece attach an insulated phone tip, *ICA* #868 and #869. At the other end of each length of wire attach a small copper disc about ⅜" in diameter. Solder all of these connections and make sure that the underside of the copper electrode contact is bright and shiny.

Operation

Carefully tape the electrodes to the two index fingers of the "subject." The electrodes must be held firmly in position while the lie detector is in use. If the "subject" attempts to jar the electrodes, or move about, the skin resistance will change violently. Normally with this instrument the skin resistance will be about 250,000 ohms at 70° and 100,000 ohms at 90°. The operator may find it interesting to experiment with the position of the electrodes once he has become familiar with the operation of the lie detector.

After the electrodes have been fully secured to the "subject," turn on the lie detector and at the same time set the v.t.v.m. on the 0 to 5 volt scale. With the "subject" breathing easily, adjust the "balance" control on the lie detector until the meter needle rests in the lower third of the scale. If the room is warm, or if the "subject" is perspiring, it may be necessary to use the v.t.v.m. scale of 0 to 15 volts or higher. The "subject" may be aware of a very slight tingle under the electrodes. This

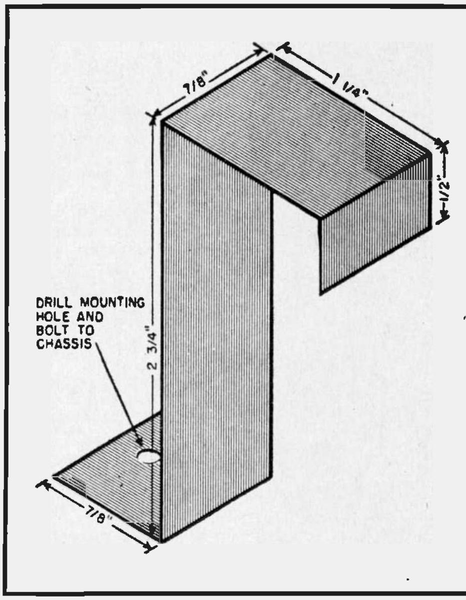


Fig. 3. Bracket for holding the B battery. This part may be made from copper, brass or aluminum.

is not harmful and in most cases will not be felt.

Carry on a normal conversation with the "subject" and note the minor variations of the meter needle. It is often best not to let the "subject" see the meter readings as these may have some influence on the skin resistance.

Ask the "subject" to take ten or twelve very deep breaths. These should cause the meter needle to swing gradually upwards across the scale. This action will be slow and the operator must be ready to re-balance the lie detector after each upward swing. This simple test will assure the operator that the equipment is in operation and that the electrodes are properly attached.

If the operator is aware of some question which might confuse or embarrass the "subject" without being insulting, he might try springing it suddenly on the "subject." If the "subject" has strong emotional feelings, the meter needle will again swing upward after only a moment's hesitation. The strength of the response can be judged by the extent of the swing and how rapidly it occurs. The operator must be ready again to re-balance the lie detector as the skin resistance will not return immediately to its normal value.

Acknowledgement

The original plans for the lie detector were suggested by Joseph A. Fiederer. Additional construction and photographs by Edwin T. Kephart.

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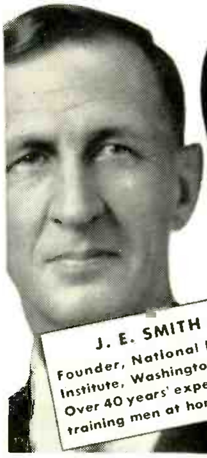

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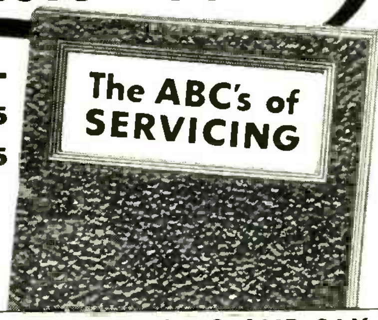

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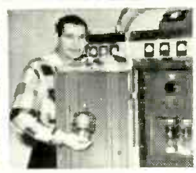

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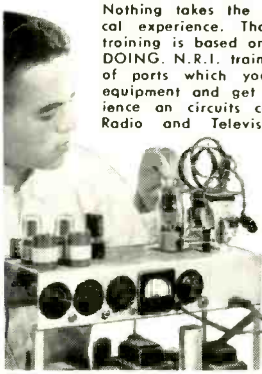

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