1937
RADIO REFERENCE ANNUAL

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RADIO REFERENCE ANNUAL

A compendium of important radio articles, data and ideas for the experimenter, Service Man and radio "fan"— a useful reference book for all radio men.

H. G. McENTEE

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CONTENTS

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CHAPTER 1

A Variety of Receivers for Any Need

A Beginner's 2-Tube Portable Set

The radio beginner and experimenter who has patience and some mechanical ability can make a tiny radio receiver which fits into a small card-file case, 3 x 6 x 4⅝ ins. high, including everything—batteries and all—and which weighs less than 2 lbs. when ready to operate.

This set is an unusual combination of circuits known as "space charge" circuits in which the screen-grid tubes are worked in reverse—that is, with the screen-grid and control-grid reversed.

The set contains two tubes, both type 49s, one used as a space-charge regenerative detector and the other as a space-charge output tube. Because of this combination, the total plate voltage required is 15 volts with a tap at 7½. This modest voltage can readily be obtained from two tiny 7½ V. "C" batteries, since the current drain is also very low.

The filaments of the two tubes are connected in series, to keep the current drain at a minimum. This filament voltage is obtained from a tiny "A" battery supplying 3 V. Since the tubes are rated at 2 V. each, the normal current drain of 0.12-A. is further reduced by operation at 1½ V. This reduction in filament voltage did not cause any sacrifice in volume or sensitivity in the set—in fact, with the circuit used, the volume was even greater at 1½ V. per tube than when the normal 2 V. was used.

Fig. 2—The set in operation. It is self-contained.

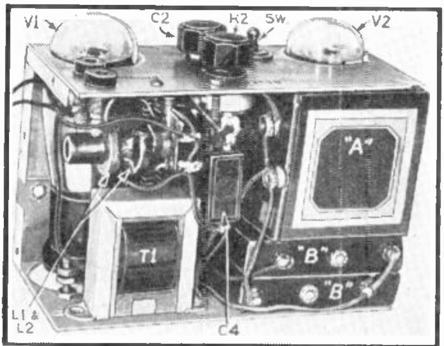


Fig. 1—The chassis withdrawn from the case.

As for results, the set was designed primarily for head-phone operation, as a set for the traveling man or the radio experimenter who resides in the country, where battery costs run high. Due to its small size and light weight it is ideal for anyone who travels. When the set was tried, to the amazement of the designer, there was enough gain on all the local stations to operate a magnetic speaker. Of course, the local stations were all within a radius of about 25 or 30 miles—but even the more distant stations from mid-western states were received with plenty of phone volume.

The construction of the set does not require any particular knowledge of radio, beyond the use of handdrill, screwdriver and soldering iron. However, if the set is to be made as small as the original, the builder must be able to fit parts into the smallest possible space.

For example, the variable condenser in its present position in the set will just pass the corner of the "A" battery; and the batteries had to be placed on their sides to make them fit at all. Also, the tubes had to be built right into the set, installed in their tube sockets for there was no room for removing them. However, they are operated at such conservative filament and plate voltages that, with the exception of dropping them, their life will be extremely long.

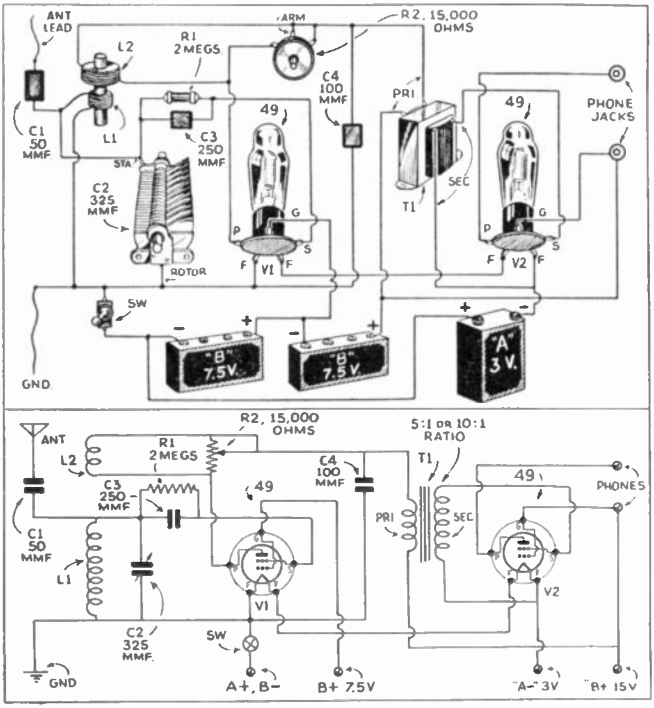


Fig. 3—The circuit. The pictorial circuit above will aid the beginner.

No drilling layouts have been included for the chassis, since the substitution of a single part will necessitate changes in the positions of the components, to make them fit—so the placement of the apparatus has been left to the builder. Just make sure you have everything in such a position that there is enough clearance for moving parts such as condenser plates, variable resistor rotor, etc.

The smallest parts consistent with good results were included in this set. The tuning condenser is an air-dielectric type with tiny plates but the spacing between plates is much less than usual. The volume control resistor is only 1⅛ ins. in diameter. This resistor was made for use in measuring instruments and the highest resistance available is 15,000 ohms; for this reason, the tickler coil is larger than usual.

The coils were made from an aerial coil of the iron-core type taken from a superhet. set. The primary is a high-impedance winding which is sufficient for the tickler, but the secondary was found to have too many turns when the coil shield was removed. It was necessary to remove 12 turns to make it cover the broadcast band, but the actual number can be found best by experiment, in the individual set.

For those experimenters who have difficulty in obtaining a suitable coil or prefer to make their own, the spider-web type of coil will be best. When this type of coil is employed, both coils should be wound the same — with the same number of turns —on cardboard forms 2¾ ins. in diameter and having 9 slots equally spaced around the circumference and cut ¾-in. deep by ⅛-in. wide. The wire, which should be No. 28 single-cotton covered, is wound through alternate slots (every second slot); which makes a compact and rigid coil. The two coils should be mounted with a space of about ⅜- to ½-in. apart. A total of 77 turns of this wire is required for each coil.

The author wishes to credit QST magazine for the ingenious arrangement of the detector circuit. The A.F. amplifier circuit was suggested by Mr. Arthur C. Miller, who has done considerable work on low "A" and "B" drain circuits using sub-normal filament temperatures.

The wiring must be done neatly and parts mounted rigidly, for the spacing between them is so small. These details can be figured best by each builder. Both schematic and picture wiring diagrams are included for the convenience of those who make the set.

List of Parts

One card file case, 3 x 6 x 4⅝ ins. high (inside dimensions);
One piece of aluminum 9½ x 6 ins. for panel and chassis;
One Meissner iron-core aerial coil with secondary changed; or spider-web coils (see text), L1, L2;
One Cornell-Dubilier mica condenser, 50 mmf., C1;
One Hammarlund variable condenser, 325 mmf. type MC325, C2;
One Cornell-Dubilier mica condenser, 250 mmf., C3;
One Cornell-Dubilier mica condenser, 100 mmf., C4;
One Continental Carbon fixed carbon resistor, 2 megs., R1;
One Carter variable resistor (midget type) 15,000 ohms, R2
One Franklin Transformer Co. A.F. transformer, 3:1 ratio or higher, T1;
Two National Union type 49 tubes, V1, V2;
Two 5-prong wafer sockets;
One toggle switch;
Two phone tip jacks;
One Eveready 3 V. "A" battery, type X152;
Two Eveready 7½ V. "C" batteries, type X204;
Wire, screws, solder, knobs, etc.

A Receiver for Use With Any Power Supply

As a portable or home receiver, this compact all-wave unit using two of the latest type metal tubes will be found very effective. It has been designed so that it can be operated from either batteries (6 V. "A," and 135 V. "B"); straight "A" and "B" eliminator, or the familiar 25Z5 A.C.-D.C. eliminator.

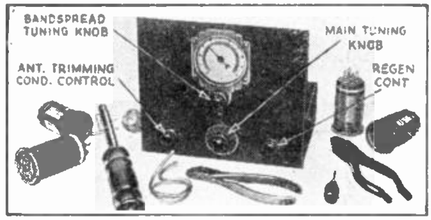
The type 6J7 metal tube is used in the detector circuit. In the A.F. stage is a 6F6, used as a class A pentode power amplifier.

The entire receiver has been built on a steel chassis 6 x 8 x 2 ins. high. The panel is only 7 x 8 ins.

To provide complete efficiency on the short waves, the essential band-spread tuning system has been incorporated, using a 20 mmf. condenser. This has been placed above the chassis and connected to the main tuning dial. A 140 mmf. condenser is used to tune in the particular channels desired. The band-spread condenser is then used to magnify or spread out these channels. To provide selectivity and to increase the sensitivity a 20 mmf. condenser has also been incorporated, in series with the antenna circuit.

A set of 2-winding, 4-prong coils are used to provide coverage of the 17 to 41; 33 to 75; 66 to 150; 135 to 270, and 250 to 560 meter bands with a 140 mmf. condenser across the secondary of the coils.

Since this unit has been designed to operate from practically any type of power supply, a 0.1-mf. fixed condenser has been installed in the ground circuit. Be very certain that this condenser is absolutely perfect; a short here will cause plenty of damage, as you can well imagine! The R.F. choke in the plate circuit is a 2.1 mhy. unit having a capacity of 0.1 mmf., and a D.C. resistance of 35 ohms. With its universal-wound pies and the foregoing characteristics it was found very effective on both broadcast and short waves.



List of Parts

Two Hammarlund variable condensers, 20 mmf., MC20S, C1, C3;
One Hammarlund variable condenser, 140 mmf., MC140M, C;
One Solar fixed condenser, 0.1-mf., C4;
Two Solar mica condensers, 250 mmf., C5, C10;
One Solar fixed condenser, 0.25-mf., C6;
One Solar fixed condenser, 0.01-mf., C7;
One Solar electrolytic condenser, 5 mf., 50 V., C8;
One Solar fixed condenser, 0.001-mf., 300 V., C9;
One I.R.C. gridleak, 2 megs., ¼-W., R1;
One Electrad potentiometer, 50,000 ohms, R2;
One I.R.C. resistor, 0-1-meg., 1 W., R3;
One I.R.C. resistor, 0.25-meg., 1 W., R4;
One I.R.C. resistor, 0.5-meg., ¼-W., R5;
One I.R.C. resistor, 600 ohms, 1 W., R6;
One high-impedance A.F. coupling unit (secondary of mike-to-grid transformer used in set), Ch.;
One set of Hammarlund short-wave plug-in coils, type SWK-4, L1;
One Hammarlund broadcast plug-in coil, type BCC-4, L1;
Two octal wafer sockets, for V1, V2;
One Hammarlund 4-prong socket, type S-4;
One Hammarlund choke, 2.1 mhy., R.F.C.;
One phone strip;
One "Ant-Gnd" terminal strip;
One 7-prong connecting plug;
One metal chassis;
One airplane dial;
One National Union, Sylvania, or RCA Radiotron metal tube, type 6J7, V1;
One National Union, Sylvania, or RCA Radiotron metal tube, type 6F6, V2;
Wire, hardware, etc.

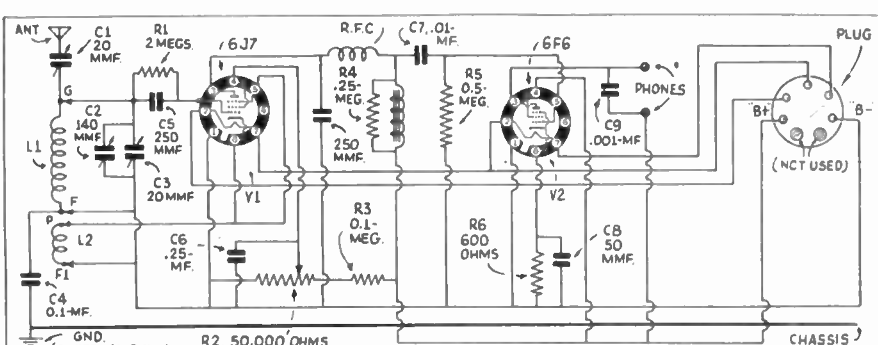


Fig. 5—Circuit of the receiver with plug for use in any of the power supplies of Fig. 7.

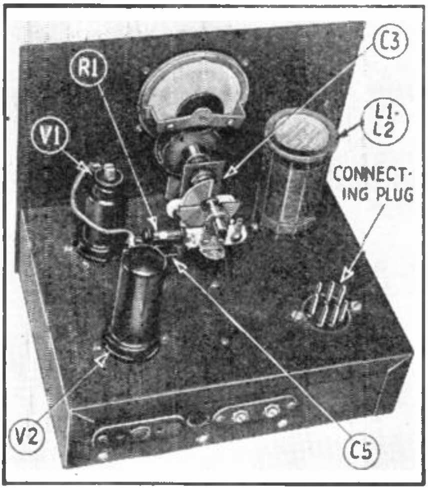


Fig. 6—Arrangement of the parts of the receiver is shown here. Note the power plug at right.

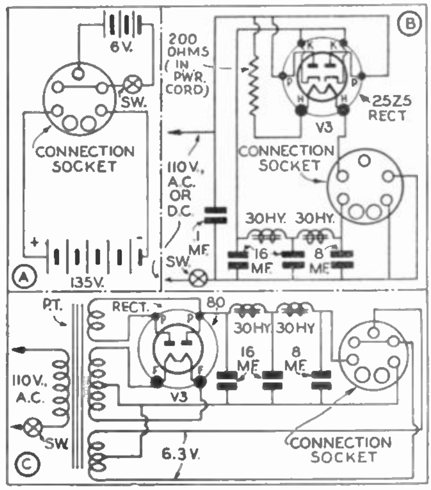
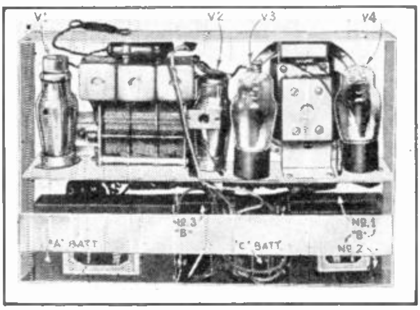


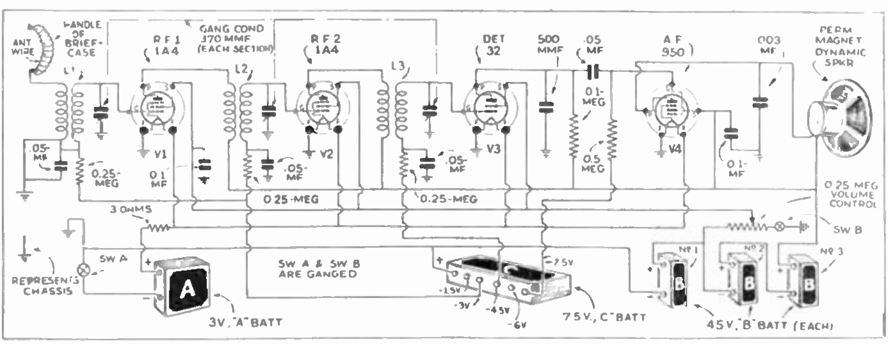
Fig. 7—A shows a battery supply, B an A.C.-D.C. supply, and C is for use with A.C. only.

Music Wherever You Go — Make This Briefcase Radio Set



The novelty and usefulness of this briefcase portable receiver has been well attested to by the hundreds of admiring and envious comments made by spectators and listeners who have seen and heard the set operating, in Brooklyn and Manhattan.

And lest the reader form any hasty conclusions that this set is too bulky, heavy or otherwise impractical (due, probably to previous experience with so-called "portables") let us immediately belay any such erroneous conclusions by citing actual facts and figures concerning this instrument. **Complete, it weighs less than 11 lbs.—and** this includes all batteries, briefcase and receiver chassis. This weight is less than that of any really efficient portable receiver which has ever been built. Its dimensions can be easily visualized, since the briefcase is a commonplace item seen everywhere. This particular case measures 16 x 11½ x 2 ins. deep.



Nothing could be simpler than the operating controls of this receiver. As can be seen in Fig. 10, the controls are only 2 in number—one for tuning-in, the other for turning the power on and off, and regulating volume. The latter is accomplished by means of a combined volume control and switch. A translucent, airplane-type dial with indicating figures and an escutcheon plate, are permanently fastened to the exterior of the briefcase, and facilitate dialing or logging of the stations.

One of the best reasons for selecting the T.R.F. type of circuit is that it is so much easier for constructors to build and requires no lengthy or elaborate aligning procedure.

In this particular receiver, the chassis consists of an aluminum frame, rectangular in shape and home-made, whose dimensions are 14 x 9½ x 2¾ ins. deep. A shelf (also aluminum) is stretched across the "long" side of the chassis 5⅝ ins. from the top. On the shelf are mounted the tubes, speaker, variable condenser and coils. The compartment or area below this shelf is utilized for mounting the "A," "B" and "C" batteries. Also, the volume control protrudes into this compartment, being suspended from the shelf by means of a bracket. The coil shields are fastened above the variable condenser, being soldered to the frame work of the gang so that all coil leads are as short as possible. Care must be exercised when mounting the coils so that the condenser trimmers are exposed and accessible for any alignment that may be necessary.

The gear mechanism employed for rotating the variable condenser plates from the "front" is made necessary as a result of the edgewise mounting of the variable condenser. The length of the condenser prohibits mounting it in any other fashion.

Note that the "aerial" for the set consists of a few turns of uninsulated wire wrapped around the briefcase handle.

When the receiver is completely wired and all batteries connected (and carefully checked for errors) then the receiver is ready for operation. Preliminary tests and alignment may be made by connecting a short length of wire to the set lead-in wire which later connects to the handle of the brief case. Alignment of the trimmers can only be performed when the receiver is out of the brief case, so do not install the chassis until this procedure is completed. Keep the volume control turned down low so that a few major stations can be received without oscillation. Adjust the trimmers with the pointer set at approximately 50 deg. or as reasonably close to this point as will permit some station to be tuned in. The trimmers are simply rotated for maximum signal strength. When this procedure is completed, rotate the variable condensers so that they are completely out of mesh (to the low wavelengths) so that a station is received at this point. Keep the volume control turned down as low as necessary to prevent oscillation. Readjust the trimmers for maximum signal strength heard on the loudspeaker.

Fig. 10—The briefcase portable receiver.

List of Parts

One leather briefcase, 16 x 11 ins.;
One Wholesale Radio Service 3-gang variable condenser, smallest dimensions possible;
Two Meissner high-gain R.F. coils, shielded;
One Meissner high-gain Ant. coil, shielded;
Three Eby 4-prong wafer sockets;
One Eby 5-prong wafer socket;
One Electrad volume control, 0.25-meg., with D.P.S.T. switch;
Three Continental Carbon resistors, 0.25-meg., ½-W.;
One Continental Carbon resistor, 0.1-meg., ½-W;
One Continental Carbon resistor, 0.5-meg., ½-W;
One Electrad wire-wound fixed resistor, 3 ohms, for filament circuit;
Four Cornell-Dubilier tubular condensers, .05-mf., (600 V. type);
Two Cornell-Dubilier tubular condensers, 0.1-mf., (600 V. type);
One Cornell-Dubilier mica fixed condenser, 500 mmf.;
One Cornell-Dubilier tubular condenser, 0.003 mf., (600 V. type);
One Best permanent-magnet dynamic speaker, 5 in. O.D., with output transformer to match a 1F4 tube;
Two Raytheon type 1A4 tubes;
One Raytheon type 1F4 tube;
One Raytheon type 32 tube;
One Eveready 3 V. "A" cell, type X200;
One Eveready 7.5 V. "C" Battery, type X204;
Three Eveready 45 V. "B" batteries, type X203;
One Wholesale Radio Service airplane-style tuning dial, with escutcheon plate and 3-in. calibrated circular scale;
One Radio City Products lab. type knob, 1 in. size;
One plain knob for volume control;
Two Paragon bevel gears, 45 deg. type-1-1 ratio;

Miscellaneous parts, such as aluminum for chassis and shelf, brackets, screws, bolts, hook-up wire, solder, etc.

Making A Modern Car Radio

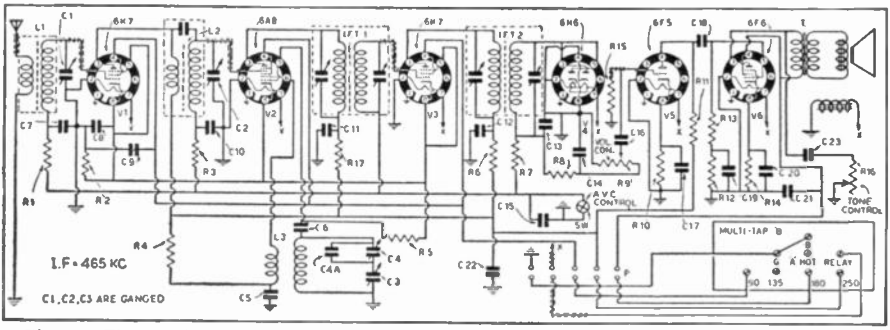


Fig. 11—The terminal board lower left is on the power supply. A cable connects this to the set.

Here's a car superheterodyne featuring some of the more outstanding radio developments of the past year—including the metal tubes, universal control, new type sockets, and iron-core inductances for high R.F. and I.F. gain.

This receiver is a two-piece job—one departure from conventional single-unit practice. The speaker is contained within the cabinet proper, with the vibrator "B" supply separate, to keep the size and weight of the actual set as small as possible and to permit experimental adjustments and powering changes. It is, briefly, a 6-tube superheterodyne, commercial in appearance, of simple and effective design, adequate power output, and excellent tonal quality.

Refer to the schematic for details. A single 6K7 R.F. stage feeds the 6A8 converter, and a single 6K7 I.F. stage amplifies the converted signal at 465 kc. A high-gain diode feeder transformer is used with a type 6H6 second-detector, arranged with plates and cathodes in parallel. The 6H6 detector circuit furnishes an A.V.C. voltage to the R.F., converter, and I.F. stages, a switch being used to shut off A.V.C. when not desired. The rectified modulation is amplified by a 6F5 triode and power amplified by a 6F6 pentode.

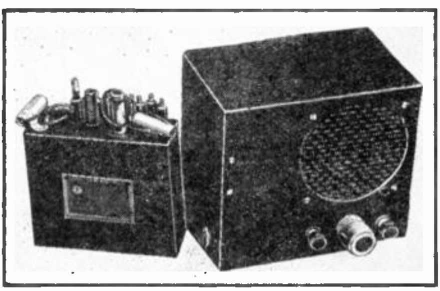


Fig. 12—The set and the separate power supply. The various suppressors and noise filter condensers are on top of the latter.

In the circuit published, note that the R.F., detector, and first audio tubes are wired for operation at full 250 V., while the pentode power amplifier receives only 180 V. The 6F6 does not, of course, give full 3-W. output at these ratings—but 1.5-W. will be found entirely satisfactory for mobile service, especially in this receiver, in which the R.F. gain is such that signals are brought well above noise level.

It should be noted that decoupling resistors are used in the converter and I.F. plate circuits. These are necessary due to the high orders of gain made possible by the iron-core inductances. The lower the resistance of a coil, the greater its tendency to oscillate with ease. Stray coupling between leads, common coupling, and other factors also tend to introduce instability in high-gain circuits. And as we want complete stability — the decouplers are definitely necessary.

The original model was built into a 6 x 9 x 8 in. crackle finished cabinet, designed for use as a shield box. This box had an 8 x 9 in. removable cover—which became our front panel.

First, mount 3 long stove bolts in the holes provided in the cabinet back. Place 1 in. width washers under the heads and under the securing nuts. Mount the power plug receptacle socket, and the A.V.C. switch and tone control on the chassis, being sure to insulate the control shaft from the metal. Fasten the speaker in place on the front, with a black-painted wire-mesh screen between it and the panel. Mount the tube sockets and coils on the chassis. Mount the variable condenser, with rubber washers between it and the chassis. Secure the front panel to the chassis by means of the A.V.C. switch and tone control, adding a chassis-to-front panel angle as shown in the photographs, if extra support is necessary. Methods of mounting the antenna coil and the volume control and switch combination are several. The constructor should simply discover that one which in his mind permits the securing of these items in place safely and definitely. Remember to keep the shaft of the volume control free from any metal (ground).

(Note: In mounting tube sockets, place them in position to provide for short leads to associated apparatus.)

The oscillator pad should be of approximately 370 mf. fixed capacity—bridged by a mica trimmer.

Wire the connector lead to the "B" unit and plug it in. Make sure all tubes are receiving proper voltages at the socket terminals. Adjust the I.F. transformers for 465 kc. on service oscillator, then line up the R.F. circuits for proper tracking, making sure to adjust both the main trimmers on the 3-gang variable condenser and the oscillator pad trimmer below chassis.

If the tubes are receiving proper voltages and the circuit is properly aligned, with no bypass condensers open or shorted, and all R.F. leads short, direct, and properly placed in relation to each other, no I.F. oscillation should result. If such oscillation is experienced and nothing short of reduced screen or plate voltage stops it—try plate decoupling resistors of increased value. The 1,000 ohm decouplers specified should entirely do away with oscillation—and without seriously reducing voltages as applied at the plate terminals of I.F. sockets.

When the set is operating properly and signals are tuned in with ease, it is ready for installation.

Fig. 14—Rear of the set with cover removed.

List of Parts

One cabinet, 6 x 9 x 8 ins., (MSB-2);
One chassis to match, (MSC-2);
One dynamic speaker for 6F6;
One flexible coupler, ¼ in.;
One cond., 20-100 mmf., C4;
One SPST switch;
One Polyiron coil, TR-1;
One Polyiron coil, TR-2;
One Polyiron coil, TR-3;
One Polyiron coil, TR-4;
One Polyiron coil, TR-5;
One Polyiron coil, TR-6;
One 3 gang cond., 370 mmf., C1, C2, C3 trimmers on left, clockwise rotation;
One mica condenser, 370 mmf., C4A;
Two mica condensers, 100 mmf., C13; C14;
One mica condenser, 75 mmf., C6;
One paper bypass condenser, 0.25 mf., C17;
Four paper condensers, 0.1 mf., C11, C12, C21, C22;
Three condensers, 0.1 mf., C8, C9, C19;
Three condensers, .02 mf., C5, C18, C23;
Four condensers, 0.5 mf., C7, C10, C15, C16;
One elect. Cond., 10 mf., 25 V., C20.
Resistors as follows: 2—0.1 meg., R1, R3; 1—15,000 ohms, R4; 1—60,000 ohms, R5; 1—150 ohms, R2; 2—1000 ohms, R6, R17; 1—0.5 meg., R7, R15; 1—.05 meg., R8; 1—0.25 meg., R13; 1—0.1 meg., R12; 1—600 ohms, R14; 1—2000 ohms, R10; 1—variable 0.5 meg., R9; 1—variable 25,000 ohms., R16.

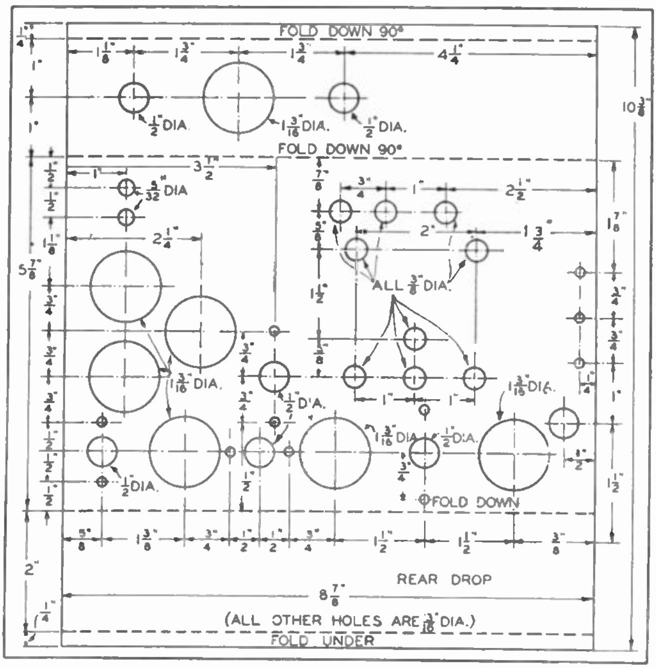
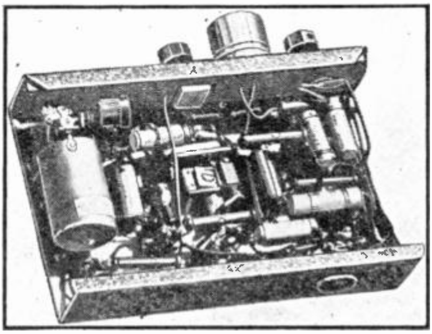


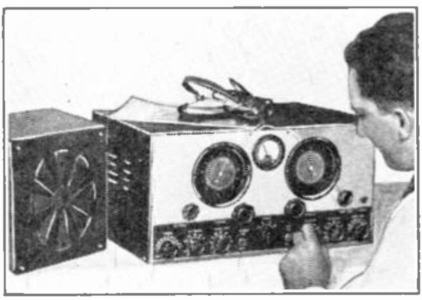
Fig. 13—Dimensions for cutting and bending the subpanel.

Fig. 15—Parts placement under the chasis.



One General Transformer, tube-type multi-tap "B" supply;
One Raytheon 6A8 metal tube;
Two Raytheon 6K7 metal tubes;
One Raytheon 6H6 metal tube;
One Raytheon 6F5 metal tube;
One Raytheon 6F6 metal tube;
One remote control head, 6-1 ratio, for condenser closing right, (600);
One gear reduction for attachment to condenser, (104);
One steering column, instrument, or dash mounting units for 600 head;
Two flexible shafts to chassis mounting brackets (optional), (P-3119);
One coupling for volume control to flexible shaft, (P-4524);
One shielded 5-connector cable, 3 ft., (1166);
One low-capacity cable, ½-in., 3 ft., (1196), OD;
One shielded cable, 3 ft., (1205);
One piece of large-mesh screening, black-painted, about 6 x 6 ins.;
Six Amphenol 8-prong octal sockets;
One Amphenol 5-prong socket, (RS-5), P;
One Amphenol 5-prong cable connector, (PM-5);
One Amphenol connector cover, (C-CHA);
Three Amphenol washers, (203);
Three Amphenol washers, (212);

How to Make A 12-Tube All-Wave DX Receiver



There has been such a great variety of all-wave receivers dumped upon the market in the last year or so, that the prospective buyer is at a complete loss as to what will best fit his needs. Those that are undeniably "high-class," are just as undeniably high-priced — much more so than the average S.W.L. (short-wave listener) or "ham" can afford. And those more reasonably-priced often omit features the purchaser wants.

Then, too, he quite often has his own ideas as to just what features he wants in such a receiver. The writer has gone through all this, and finally arrived at a list of features somewhat as follows:

(1) Bandswitching. For flexibility, compactness, and the greatest possible convenience.
(2) High selectivity. Achieved here by means of a crystal filter and iron-core I.F. transformers.
(3) Noise suppressor. This development of Lamb enables reception under very bad conditions.
(4) Effective A.V.C. This receiver uses a system developed by F. Offner. An extra tube but not an extra I.F. transformer is needed.
(5) Adequate band spread. The parallel condenser system handles this requirement very nicely.
(6) Good tone quality and moderately high audio level. A 6N6 output tube together with the permanent magnet dynamic speaker assures this.

There are, of course, other points to consider, such as sensitivity, overall flexibility and last, but by no means least, good appearance.

The tuner unit finally chosen is a very compact and well-designed job. It comes complete with switch, tuning condenser, padding condensers and all. The tuning condenser was removed from the tuner and

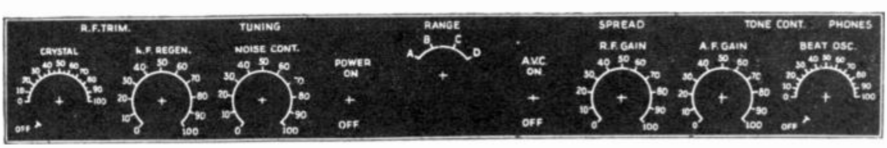


Fig. 17—Layout of the panel photostat. Overall size is 17$\frac{11}{16}$ x 2$\frac{9}{16}$ ins. high. Outside controls are 1⅛ ins. from each end; next 2 are 3$\frac{9}{16}$ ins. in; next are 5$\frac{3}{16}$ ins. in and the 2 switches are 7 ins. from the ends. All are ⅞ in. up from the bottom, except range switch hole, in the center.

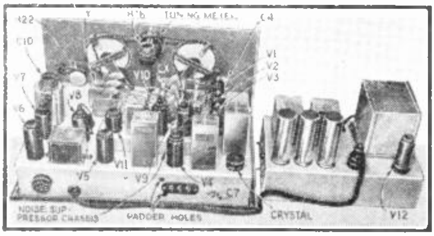


Fig. 18—Separate power supply chassis is at left.

mounted on the receiver chassis, the change being made to reduce the overall height of the set. The original leads to this condenser are retained, as they are simply passed through holes in the set chassis and resoldered to the correct lugs.

The set is so laid out that regeneration may be added to the R.F. stage simply by adding a cathode coil on the R.F. coils. The regeneration control is in the screen-grid lead of V1 and it acts as a very good sensitivity control, to prevent 1st detector overload when the A.V.C. is not in use.

Next we come to the crystal filter circuit. Two air-tuned iron-core I.F. transformers couple V2 and V3 through the crystal. The selectivity control is a midget condenser operated from the front panel and which, when turned fully counter-clockwise, operates a switch to short out the crystal.

The beat oscillator has all its under-chassis components in a separate shield, the beat note control being mounted on this shield and controlled from the front panel. This control, when turned all the way to the counter-clockwise position, cuts out the oscillator.

The A.V.C. tube grid and the grid and cathode circuits of the 2nd detector are about 100 V. more negative than the chassis. This voltage is obtained from a drop across the 1,500-ohm resistor in the power supply, and is also used through a potentiometer to control R.F. gain.

Due to the necessity for 100 V. of bias, the power supply must furnish a total of 350 V. under full-load. This is easily taken care of by the transformer selected, which

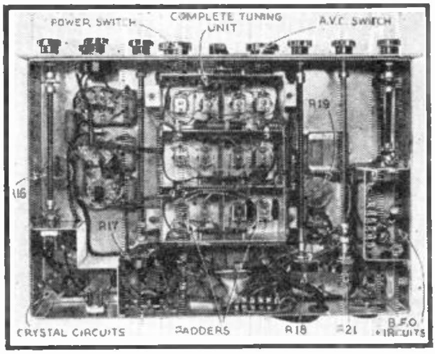


Fig. 19—Note the tuner in the center of the chassis. The B.F.O. circuits are well isolated.

is designed for use in receivers with class "B" output. Two filter chokes and 3 large electrolytic condensers assure very smooth D.C. so that hum can hardly be heard at full volume with the ear right on the speaker! Two switches are provided, one for the A.C. line and one to break the center-tap lead of the secondary, the latter making the entire high-voltage system "dead."

The noise silencer circuit is complete and self-contained on its own little chassis. This affords good shielding and prevents possible feedback troubles. It may be left off and added at any future time without spoiling the appearance or operation of the receiver in the meantime.

The black plate on the lower part of the front panel (Fig. 17) is what is commercially called a "glossy photostat." The first step in preparing this is to draw to exact size on regular white drawing paper an exact facsimile of the desired plate. This is then inked with regular India drawing ink. The glossy photostat is made from this and has a fine shiny finish that looks excellent and wears very well. It is fastened to the front panel with a good grade of rubber cement.

There are many parts that need slight alterations to be usable for our purpose and these changes will be taken up now.

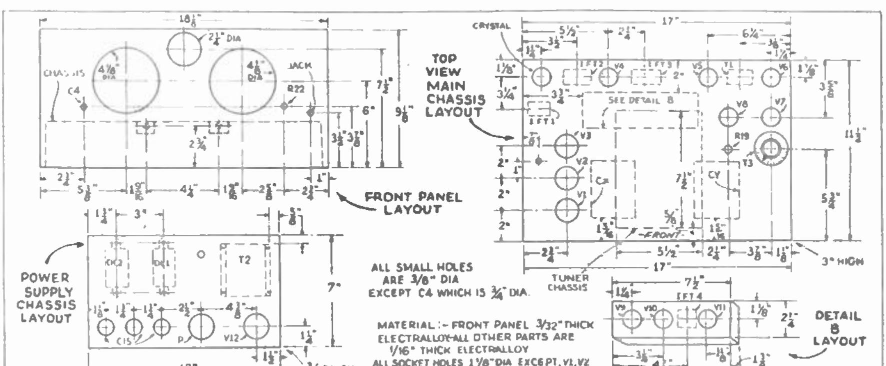
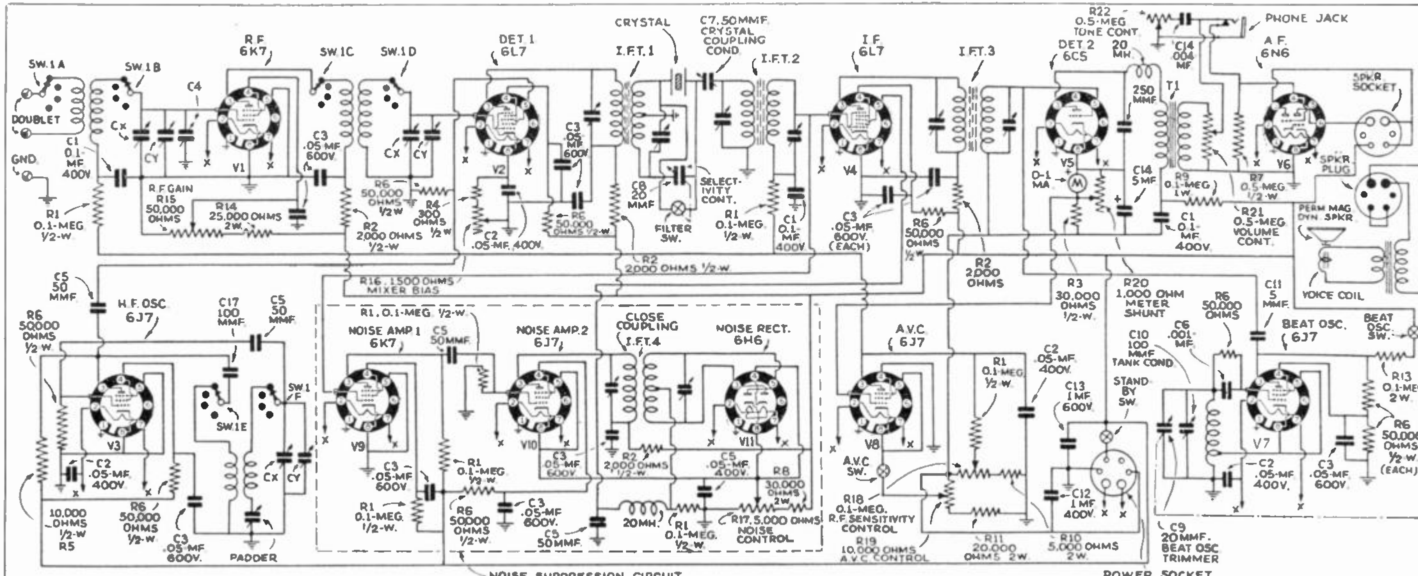


Fig. 20—Layout directions for the various parts of the receiver. All material is Electraloy.



The most important is the tuner-unit change. Here we remove the tuning condenser from the tuner chassis, leaving all leads connected to the precision components of the tuner as it originally comes. The condenser is mounted flat on the receiver chassis by means of 3 small brackets.

The band-spread condenser is cut down from a standard 3-gang unit of 140 mmf. capacity, leaving only 1 rotor and 1 stator plate in each section. This condenser is also mounted flat, but by means of screws run into tapped holes already in the frame.

The tuner chassis is mounted in place on bushings so that its switch shaft comes at the proper level to pass through the front panel.

The beat oscillator tuning inductance, T3, comes equipped with a mica compression-type trimmer. This must be removed and a 100-mmf. air trimmer, C10, installed in its place . All components of this beat oscillator circuit under the chassis are contained in a shield can, as shown in Fig. 19, the front end of which serves to hold C9 and the beat oscillator switch. The latter is operated by a pin projecting from the rear flexible coupling of the panel control of C9, the pin engaging in a slot in the switch knob when the control is turned fully counter-clockwise.

The "noise-silencer" transformer, I.F.T.4, needs a slight change, as the coupling has to be increased as much as possible.

This is done by disassembling the unit and removing the coil unit. Cut the cardboard tube on which the coils are mounted and bring them next to each other, holding the two portions with a wood dowel which fits tightly into both. Then assemble as before.

The tuning meter in the original receiver is illuminated and this is easy to do by cutting a slot about ¼ x ½ in. long in the top of the bakelite case. Cement a strip of celluloid over this hole to keep out dust. The variable shunt resistor, R20, is mounted directly on the meter.

After a thorough checking of the wiring, alignment is the next process. The first step is to make sure the voltage from the power supply is correct. This should be about 250 from chassis to "B+", and 100 from chassis to "B—".

With the beat oscillator, the crystal filter and the A.V.C. switches off, a rough alignment of the I.F. transformers may be tried, starting with I.F.T.3, then I.F.T.2, and finally I.F.T.1. Coupling condenser C7 should be set at about ½ full capacity. If the circuits seem to line up properly, the I.F. amplifier may be aligned to the crystal frequency. To do this, set up a simple crystal oscillator, using any handy tube such as a 30, 99, 01A, 27, etc., and about 45 V. plate supply.

When this alignment is finished, the beat oscillator is tested, and with C9 set at about mid-scale, C10 is turned until a loud whistle shows that this circuit is producing a beat with the incoming crystal-oscillator signal.

Now the R.F. end of the receiver must be aligned and this process is too well known to require description. Proper tracking over the 2 lower frequency bands is secured by their respective variable padding condensers, while the remaining bands have fixed padders.

By this time it should be possible to receive stations on any band and the A.V.C. control, R19, should be adjusted with the A.V.C. switch on, until all stations are held to the desired level as indicated on the tuning meter.

The noise-suppression circuit requires adjustment only of the trimmers in I.F.T.4. Turn control R17 to the ground end, then start a vacuum cleaner or other such appliance, and adjust these trimmers until the noise is at its lowest. As resonance is reached, the control will have to be advanced to prevent cut off of V4. In operation, R17 is turned as far as possible towards the ground end, while retaining the desired signal. When R17 is turned too far, the signal will start to cut off.

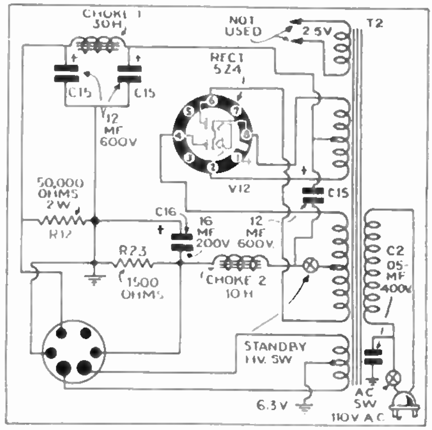


Fig. 22—Diagram of the power supply.

List of Parts

One Tobe all-wave tuning unt;
One 3 gang condenser, CY;
One Alladin trans., type G101c, IFT 1;
Two Alladin trans., type G101a, IFT 2, 3;
One B.F.O. coil, T3;
One Suppressor trans., IFT4;
Two Shielded R.F. chokes;
Three Padder conds., C4, C8, C9;
One Padder cond., C7;
One Padder cond., C10;
Nine Octal sockets;
Three Isolantite octal sockets;
One panel, 18½ x 9⅛ x 3/32 ins. thick;
One chassis, 11½ x 17 x 3 ins. deep;
One chassis, 2¼ x 1⅜ x 7½ ins. long;
One chassis, 9 x 12 x 3 ins. deep;
Ten flexible couplings, insulated;
One steel case, 9 x 12 x 18 ins. long;
One 5 prong socket;
One mounted filter crystal, type BC3;
One power transformer, 400 V. D.C.;
One 30 H filter choke;
One 10 H filter choke;

Resistors as follows: one var., 50000 ohms; one var., 1500 ohms; one var., 5000 ohms; one var., 0.1 meg.; one var., 10000 ohms; one var., 1000 ohms; two var., 0.5 meg.; one wire wound, 1500 ohms; nine carbon 0.1 meg.; four 2000 ohms; two 30000 ohms; one 300 ohms; one 10000 ohms; ten 50000 ohms; one 0.5 meg.; one 5000 ohms; one 20000 ohms; one 25000 ohms.

Three Cornell-Dubilier tubular condensers, 0.1-mf., 400 V., C1;
Six Cornell-Dubilier tubular condensers, .05-mf., 400 V., C2;
Nine Cornell-Dubilier tubular condensers, .05-mf., 600 V., C3;
One Cornell-Dubilier midget mica condenser, 5 mmf., C11;
One Cornell-Dubilier midget mica condenser, .001-mf., C6;
Four Cornell-Dubilier midget mica condensers, 50 mmf., C5;
One Cornell-Dubilier midget mica condenser, 100 mmf., C17;
One Cornell-Dubilier metal-case paper condenser, 1 mf., 400 V., C12;
One Cornell-Dubilier metal-case paper condenser, 1 mf., 600 V., C13;
One Cornell-Dubilier tubular electrolytic condenser, 5 mf., 50 V., C14;
Three Cornell-Dubilier metal-case electrolytic condensers, 12 mf., 600 V., C15;
One Wright-DeCoster Nokoil speaker, 8-in. type;
One Wright-DeCoster speaker case;
One Triplett bakelite-case meter, 0-1 ma., 2 in. case;
Two Crowe vernier dials, 3¾ ins. dia.;
Two Arcturus Coronet tubes, type 6K7, V1, V9;
Two Arcturus Coronet tubes, type 6L7, V2, V4;
One Arcturus Coronet tube, type 6C5, V5;
One Arcturus Coronet tube, type 6N6, C6;
One Arcturus Coronet tube, type 6H6, V11;
One Arcturus Coronet tube, type 5Z4, V12;
Four Arcturus Coronet tubes, type 6J7, V3, V7, V8, V10;
Wire, hardware, spaghetti, etc.

CHAPTER 2

Test Equipment

How to Make
A MODERN SET ANALYZER

Fig. 1—Appearance of the tester panel.

A study of the diagram in Fig. 2 will give a clear picture of the design and the adaptability of this new analyzer to modern test requirements. The listing of the voltage, current and resistance ranges is given in Table I for ready reference.

TABLE I

Voltage Ranges (A.C.-D.C.)	*Current Ranges (D.C.)*	*Ohmmeter Ranges*
0-5 V.	0-500 ma.	0-2,000 ohms
0-50 V.	0-5 ma.	0-0.2-meg.
0-250 V.	0-50 ma.	0-2 megs.
0-750 V.	0-250 ma.	

The flexibility of circuit design permits the use of this analyzer in many ways. In fact, the listing in Table II will give a better idea of the possibilities with greater clarity.

TABLE II

Uses of the Analyzer

1. Conventional voltage measurements.
2. Conventional current measurements.
3. Conventional resistance measurements.
4. Point-to-point resistance measurements.
5. Point-to-point voltage and resistance measurements with fixed reference point.
6. Point-to-point voltage and resistance measurements with floating reference point.
7. External use of voltmeter, milliammeter and ohmmeter ranges.

A.C. Voltage Measurements: Throw the switch marked A.C.-D.C. to the A.C. position. The toggle switch marked E-I should be in the E position. This switch, in this position, removes all possibility of interconnection between the voltage and current circuits. The switch should be in the E position when making D.C. voltage measurements as well. **Be SURE that the voltage range selected** (Range Selector Switch) **for test is greater than any possible circuit voltage.** Whenever possible, start with the 750 V. scale and then change to a lower scale, if necessary, for accurate reading. **Do not try to read D.C. voltages when the A.C.-D.C. switch is in the A.C. position.** The A.C. scale and D.C. scale on the meter are identical and the compensation for the rectifier is accomplished by using a special set of resistors for the A.C. multipliers.

D.C. Voltage Measurements: Turn the switch marked A.C.-D.C. to the D.C. position. Toggle switch E-I should be in the E position. This removes the current shunts as stated above. It is impossible to read A.C. voltages as the rectifier is removed from the circuit in the D.C. position. Be sure that the voltage range of the meter is greater than the voltage under test. Start with the 750 V. scale and work down until the reading falls near the center of the dial.

Current Measurements: Throw the switch marked A.C.-D.C. to the D.C. position. Throw the E-I switch to the I position. This will cut out all of the circuit selector switches except the meter range selector switch and will connect the push-button switches to the shunts and to the meter.

Resistance Measurements: Throw the switch marked A.C.-D.C. to the D.C. position. Have the E-I switch in the E position. Select the ohmmeter range desired on the meter-range selector switch. Set the circuit reference switch to the same number as indicated by the circuit-selector switch. If the circuit-selector switch is on the No. 2 tap then set the reference switch

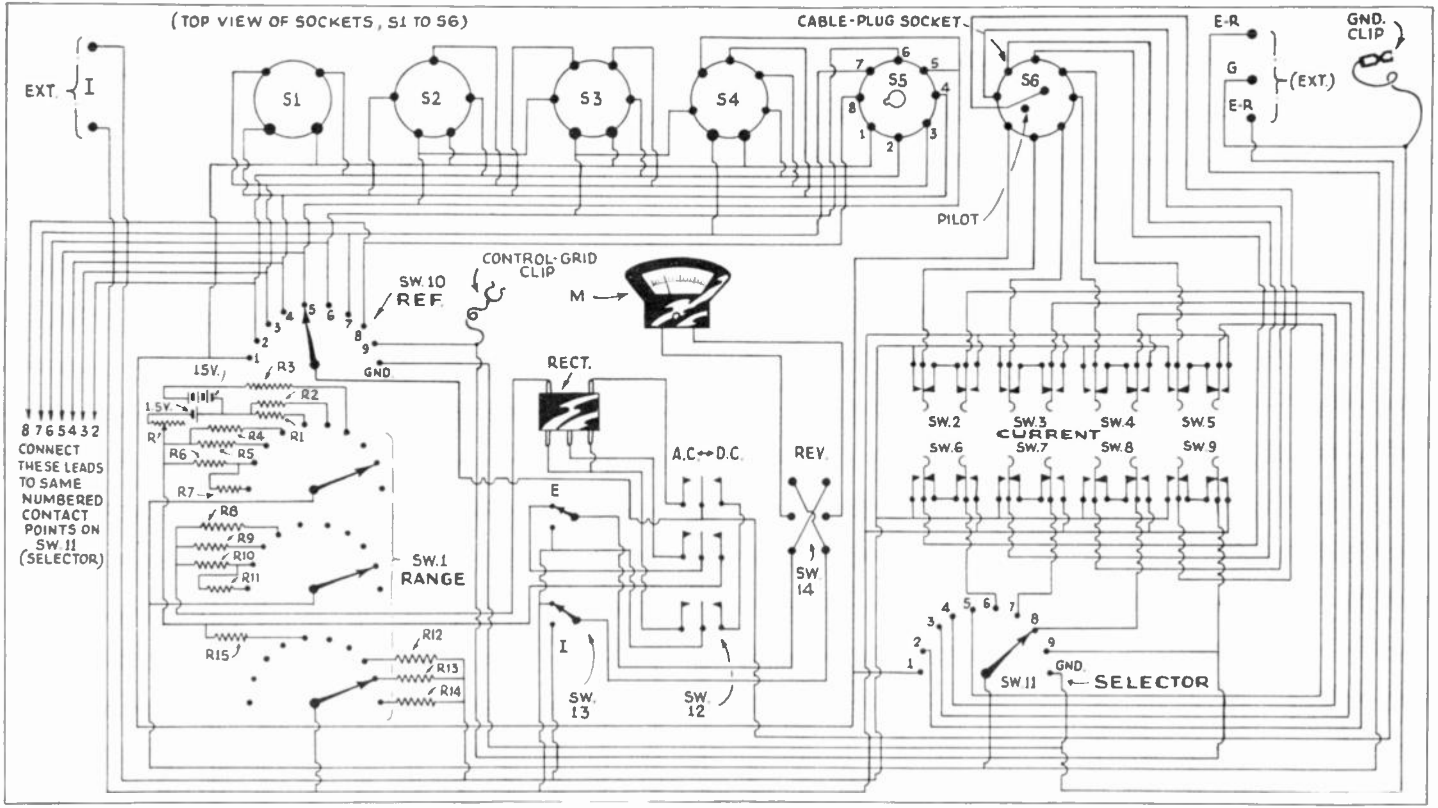


Fig. 2—Here is the circuit of the complete analyzer. For simplicity and to avoid complication of the diagram, the wires at the left are not shown connected. They should be run to the corresponding numbered contacts of Selector Sw. 11. When using for external measurements, be sure that the setting of Sw. 2 is not the same as that of Sw. 10. Note that the diagram is laid out so that parts are in the same respective locations as they are on the panel.

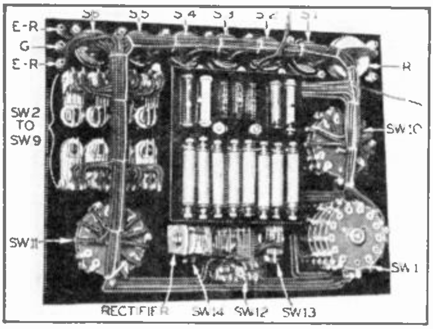


Fig. 3—Locations of parts behind the panel.

to the 2 tap. This will short the ohmmeter circuit and then adjust the Zero Set rheostat for 0 resistance.

Reverse Readings: It is a simple matter to reverse the meter scale. Throw the Rev. switch and that will change the direction of current flow through the meter. The meter reverse is in the circuit at all times and can be used under any test condition.

Point-to-Point Voltage Measurements: Both A.C. and D.C. analyses are accomplished by means of the circuit-selector switch and the reference switch. Set the reference switch to the point of common measurement such as the ground or the cathode and proceed to read the voltages applied to the various tube elements by selecting the circuit with the selector switch and changing the voltage range of the meter as required. If the ground or chassis of the receiver is the point of reference, the reference switch will be set to 10 and a wire must be connected to the G terminal (upper right hand side of panel) and the chassis of the receiver.

Point-to-Point Resistance Measurements: Follow the same procedure as described in the paragraph covering point-to-point voltage measurements, except that the ohm ranges are used instead of the voltage ranges on the range selector switch and the 0 set is adjusted whenever the range is changed.

External Use of Meter: If it is desired to make current measurements without using the analyzer cable, connect two leads to the terminals located on the panel. They are at the upper left hand side near the Ohm-Set rheostat, and are marked I. Voltage and resistance measurements are made by connecting two wires to the two terminals located on the upper right hand side of the panel and are marked E. When making current measurements be sure that the E-I switch is in the I position. Set the E-I switch to the E position when reading E. External R measurements are made with the E-I switch in the E position and the procedure indicated under the heading of Resistance Measurements is followed.

Output Meter: The A.C. voltage scales can be used as an output meter. Be sure that the method of connection to the output tube of the radio set is made in such a manner that no direct current will flow through the rectifier. In most cases it is wise to use a condenser in series with one of the leads to prevent any possibility of rectifier damage.

The black bakelite panel is 9 x 12 x 1/8-in. and should be drilled and engraved. All parts are mounted on the panel except the small bakelite panel used to hold the multipliers and shunts in place. The rectifier is fastened on the panel as well. It is important to follow the placement of the parts as shown in the photographs and make all connections mechanically good before soldering to prevent open circuits or shorts after the meter has been handled in service for a short time.

All voltage feed circuits can be wired with No. 18 copper wire. The wire should have a very good grade of insulation. A poor wire will spoil an otherwise good instrument particularly in damp weather. The filament leads should be wired in with No. 14 wire to insure low voltage drops in these circuits.

Care must be exercised in wiring in the current circuits: use busbar wherever possible, especially between the range-selector switch, the shunts and the meter. If it is too difficult to use busbar, then use the largest and best insulated wire available. High-resistance contacts in the shunt switching and connecting circuits will cause false meter readings no matter how accurate the shunts and the meter may be. A little care in the actual wiring will insure the maximum accuracy.

Keep the 9-wire test cable in good condition and make sure that all connections to the cable socket are mechanically and electrically good. Clean the contacts of the test sockets and adapters every once in a while and when placing an adapter in position be sure that the two locking devices on the plug are properly seated in the adapter side walls.

Carefully clean all soldered connections with alcohol and wipe with a clean rag. Do not let dirt or high-resistance connections interfere with the accuracy of the instrument.

The case which houses the instrument is large enough to carry the cable with its associated adapters in the cover. While the batteries necessary for the operation of the ohmmeter can be carried in the bottom under the panel.

Extra equipment that will be useful in the operation of this instrument will be a pair of test leads equipped with clips or prods. A flexible, rubber-covered wire with the tip plug on one end and an alligator clip on the other will be necessary whenever it is required to make voltage and resistance measurements between the elements of the tubes and the chassis. This lead cannot be carried to the chassis through the 9-wire cable as all of these leads are necessary for connection to the various tube elements.

It should go without saying that the success of such an instrument depends on the care used in assembly and soldering as well as the selection of good parts.

Of course, it is very important to know the numbers assigned to the various tube elements before the analyzer can be used with any speed. For this reason a chart showing the numbers assigned to the various elements of the tubes (RMA standard) in use today should be obtained from a tube manual. The numbering of the various switches and current jack switches is in accord with the RMA tube number marking and terminal No. 2 (plate of the 6C6) connects to No. 2 position on the Reference and Selector switches used for voltage and resistance analysis. Current jack switch No. 2 will read the current in the circuit as well. That is, when the E-I switch is in the I position.

In use, the analyzer plug with the proper adapter is inserted in the tube socket of the receiver under test. The tube removed from the socket of the receiver is placed in the correct socket provided on the panel of the analyzer. After this is done, turn the set ON if voltage and current tests are to be made. Leave the set turned OFF if resistance measurements are to be made.

Let us make a voltage test. The power switch is turned on. Sufficient time is allowed for the tubes to warm up. Determine the number of the plate terminal. In the case of the 6C6 this is No. 2. If the voltage is to be read, to ground it will be necessary to connect the extra lead to terminal G (upper right hand corner of the panel) and clip the other end of the lead to the receiver chassis. Set Reference Switch to GND, and Selector Switch to No. 2. Set meter-range selector switch to proper voltage scale and read voltage. If it is desired to read the voltage from the plate to the cathode of the tube, then it is necessary to change the Reference Switch to the contact marked 5.

This sounds difficult but it is amazing how simple it really is. If a resistance reading is desired, turn off the power and set meter-range selector switch to Ohm range desired. Turn Reference Switch to the same setting as that of the circuit-selector switch and adjust the Zero set located at the top left hand side of the panel. Reset Reference Switch to grid or terminal No. 5 for a plate-to-cathode resistance reading. You are now ready to use point-to-point analysis to any portion of the receiver that is associated with that particular tube. Ten minutes operation of this instrument will surely show new possibilities in the way of speed and convenience in circuit analysis; something that has never been available in equipment which can be built by every Service Man and experimenter.

The simplest method of capacity measurement involves the use of an A.C. voltmeter connected in series with the unknown capacity across a 110 V. A. C., 60-cycle line. Fig. 4A illustrates the circuit. Here the capacity Cx can be considered as a "multiplier" of the voltmeter reading. The voltmeter, especially when it is desired to measure condensers having a capacity of 1 mf. or more, as indicated in Fig. 4A, cannot be used directly.

Figure 4B shows the final circuit used for capacity measurements. Condenser C may have a capacity of 0.5-mf. and condenser C1 a capacity of 2 mf. These condensers function as capacity shunts across the voltmeter and are superior for this purpose as their use tends to make the capacity formula more direct reading and simplifies determination of the capacity as represented by the voltmeter reading. When the switch Sw.1 is open only capacity C is shunted across the voltmeter terminals. The capacity Cx is then in series with the A.C. line and the shunt capacity C. Closing switch Sw. shunts condenser C1 across C and extends the capacity range of the meter up to 8 mf.

TABLE III—VOLTS vs. DB.

Power DB.	Power, W.	Voltage	Power, DB.	Power, W.	Voltage
−10	0.0006	0.55	16	0.23	10.9
−9	0.0007	0.61	17	0.30	12.2
−8	0.0009	0.69	18	0.38	13.7
−7	0.0012	0.77	19	0.47	15.4
−6	0.0015	0.87	20	0.60	17.3
−5	0.0019	0.97	21	0.75	19.4
−4	0.0024	1.00	22	0.95	21.8
−3	0.0030	1.20	23	1.2	24.5
−2	0.0039	1.37	24	1.5	27.4
−1	0.0048	1.50	25	1.9	30.8
0	0.006	1.73	26	2.3	34.5
1	0.007	1.90	27	3.0	38.7
2	0.009	2.20	28	3.8	43.5
3	0.012	2.40	29	4.7	48.8
4	0.015	2.70	30	6.0	54.7
5	0.019	3.0	31	7.5	61.4
6	0.024	3.4	32	9.5	69.0
7	0.030	3.9	33	11.9	77.3
8	0.039	4.3	34	15.0	86.8
9	0.037	4.9	35	18.9	97.4
10	0.060	5.5	36	23.8	109.2
11	0.075	6.1	37	30.0	122.6
12	0.095	6.9	38	38.7	137.5
13	0.119	7.7	39	47.6	154.0
14	0.15	8.7	40	60.0	173.2
15	0.19	9.7			

It is aparent from a study of Fig. 4 that the A.C. line voltage will divide in direct proportion to the reactances of the two condensers. It can also be stated that the voltage divides in inverse proportion to the condenser capacities (providing that the frequency remains constant). For example, if a 1 mf. condenser is connected in series with a 2 mf. condenser across a 100 V. line then 66 2/3 V. will appear across the 1 mf. condenser and 33 1/3 V. across the 2 mf. condenser.

Thus, knowing the capacity of one condenser C, and the voltages across the two condensers, C (or C and C1) and Cx, it is an easy matter to determine by means of the following formula the capacity of the "unknown" (Cx). Substitute the readings taken from the voltmeter and substitute them in the following formula

$$Cx = \frac{Em \times Cs}{El - Em}, \text{ where}$$

Cx is the unknown capacity under test.

El is the line voltage (read with the terminals of Cx, Fig. 4A, shorted).

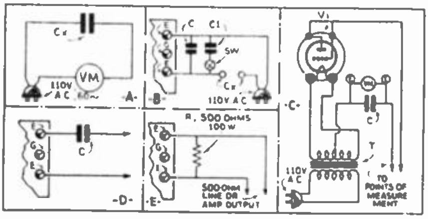


Fig. 4—Illustrating various uses of the unit.

Cs is the capacity of the voltmeter shunt.
Em is the voltage read on the voltmeter with the unknown capacity connected to the test terminal.

While this circuit arrangement requires, and this may be an objection to its use, a certain amount of arithmetic to determine the value of the unknown capacity, the advantages of low cost and a capacity measurement range of 80 to 1 are well worth the simple calculation necessary. (The 0-250 V. A.-C. scale is used for these measurements.)

The high sensitivity voltmeter used in this instrument lends itself to a very satisfactory and simple set-up for peak voltage measurements in filter circuits.

The circuit is shown in Fig. 4C. Here a 3-element tube, V, is used, as a half-wave rectifier, in series with the condenser C; which must be rated at a voltage greater than the possible circuit peak voltage. Tube V should be selected for its ability to withstand any possible voltage from the circuit under test.

In operation the circuit will permit current to flow in one direction only and the condenser C will become charged to the peak value of the voltage appearing across the test terminals. (As this particular voltmeter has a high internal resistance there will be a very slight discharge from the condenser during that time of the cycle when the voltage is less than the peak value. If condenser C is selected to have a capacity of 4 mf., then the error will be about 5 V. in 500.) Voltages will be read on the 750 V. D.C. scale.

The next time that you encounter breakdowns in filter circuits use this simple method to determine the "peak" voltage, in this portion of the circuit, **before replacing the defective units.** The only requirement for filament transformer T is that it delivers the correct voltage to tube V. (Most of the better filament transformers available today are well insulated between windings and consequently the probability of breakdown is slight.)

A circuit that is familiar to most Service Men, showing the use of the A.C. voltmeter as an output meter, will be found in Fig. 4D. Condenser C in this figure has a capacity of 2 mf. or larger and rated at 600 V. (working) when used in radio receiver testing and 1,000 V. (working) for P.A. work, should be of the non-inductive type. This condenser eliminates the danger of D.C. flowing in the meter rectifier circuit. Any voltage scale may be used when the "A.C.-D.C." switch is in the A.C. position.

The A.C. voltmeter scales also may be used to determine the power output of audio amplifiers by reference to Table III, which lists Volts versus DB. The circuit of Fig. 4E shows the method of connecting across the meter a fixed resistance, R, of 500 ohms.

After connecting the resistor as shown, place the test prongs on the 500-ohm output winding of the amplifier, pass a signal and read the peak swing of the meter. Refer to the chart and, on the equivalent Volts line, read the value in Watts; and the level in "DB. above (or below) '0' level of 0.006-W. (6 milliwatts)." A range of —10 to +9 db. can be obtained on the 5-V. scale. Up to +29 db. on the 50-V. scale and over 40 db. on the 250-V. scale. Do not permit D.C. to flow through the meter when the rectifier is in the circuit.

List of Parts

One Na-Ald 9-wire octal locking-type analyzer plug and adapters (this kit includes octal socket S6);
One Na-Ald 4-prong socket, S1;
One Na-Ald 5-prong socket, S2;
One Na-Ald 6-prong socket, S3;
One Na-Ald composite large and small base 7-prong tube socket, S4;
One Na-Ald 8-prong socket (octal), S5;
One Na-Ald double-contact control-grid cap with flex. lead;
Eight Na-Ald D.P.D.T. push-button jack switches, 1 to 9, inclusive;
One Na-Ald triple-pole, double-throw jack switch, A.C.-D.C.;
Two D.P.D.T. toggle switches, E-I, Rev.;
One Radio City Products Co. micrometer, 0 to 500 microamps., with universal dial, M;
Four Radio City Products Co. small bar knobs;
Two Radio City Products Co. single-pole, twelve-position selector switches, Ref., Selector;
One Radio City Products Co. three-pole, twelve-position selector switch, Range;
One Dependable rheostat for zero set 6,610 ohms, Ohm Set, R;
One Dependable full-wave, copper-oxide rectifier for meter, Rect.;
One Dependable shunt for meter, 5 ma., R12;
Two Dependable shunts for meter, 50 ma., R13, R15;
One Dependable shunt for meter, 250 ma., R14;
Four Radio City Products Co. voltage multipliers for 5, 50, 250 and 750 V., D.C., R4, R5, R6, R7, respectively;
Four Radio City Products Co. voltage multipliers for 5, 50, 250 and 750 V., D.C., R8, R9, R10, R11, respectively;
Three Dependable current-limiting resistors for ohmmeter circuits, with resistance of 25, 2,500 and 25,000 ohms, R1, R2, R3, respectively;
One Blan drilled and engraved panel;
Five Na-Ald insulated tip jacks for external use of meter ranges;
Wire, solder, screws, etc.
One instrument case 9 x 12 x 4 ins. (inside dimensions) with a cover depth of 1¼ ins.

HOW TO MAKE AN ELECTRONIC EYE OUTPUT METER

The electronic output meter is a device which should find ready acceptance among the service fraternity. It is not only a useful tool for the shop, but can be carried and used anywhere, because of its compactness, light weight and ruggedness. Like its big brother, the cathode-ray oscilloscope, this unit operates electronically, which means no moving parts, no inertia, no time lag, and no appreciable load imposed on the circuit under test.

The unit which is about to be described was built to take the place of the conventional output meter.

The miniature cathode-ray tube, designated as the 6E5, can be utilized in a number of ways. This unit, in addition to its use as an output meter, can also be used as a tuning indicator or voltmeter.

Referring to the circuit schematic, it will be noticed that the 6E5 is coupled to a 6B7 tube which serves as a voltage amplifier and diode rectifier. The purpose of the 6B7 is to boost very weak voltages to the point where a satisfactory swing is obtained on the 6E5 grid. The diode rectifier receives the amplified A.C. voltage and converts it to pulsating D.C., which is filtered into smooth D.C., before it is applied to the 6E5 grid.

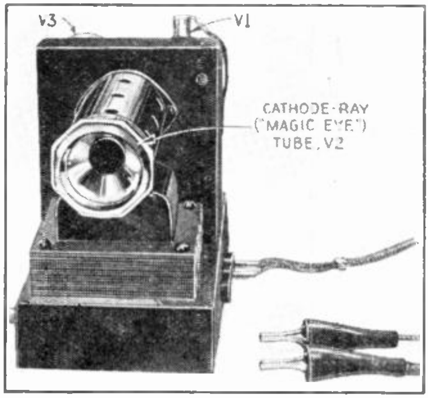


Fig. 5—Note tube shield and lens case.

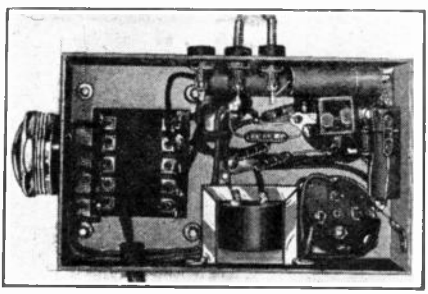


Fig. 6—The choke is mounted below the chassis.

The power supply is of the conventional type using choke input for good regulation.

Three tip-jacks are provided for high and low voltage input with the center tip-jack as the common point.

A shielded lead with small clips and phone tips is used to prevent stray magnetic fields from affecting the width of the shadow.

A standard size flashlight lens and focusing shell is used over the 6E5 tube shield to enlarge the image. This is not strictly necessary, but it does help prevent accidental breakage of the tube dome.

Due to the high input resistance of the 6B7, and because of the blocking condenser used on the HI tip-jack, the shielded lead, when plugged into the HI side, can then be attached anywhere from antenna to loudspeaker.

Starting from the antenna, with the shielded lead clips from antenna to ground, very little decrease of shadow is noted—the same result is noted from grid to

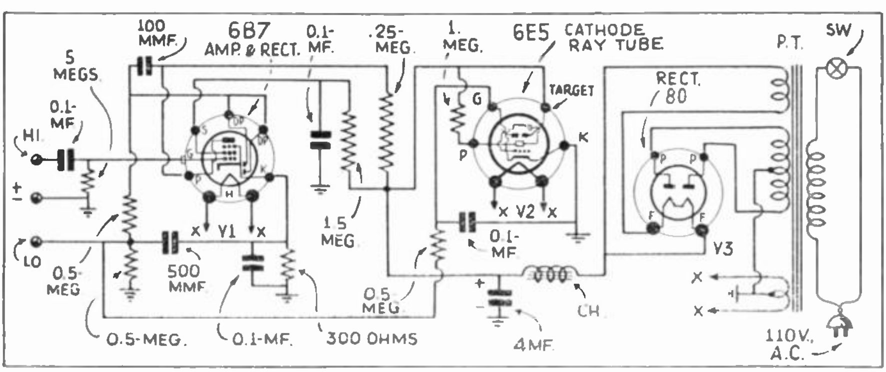


Fig. 7—Choke input is used in the power supply. Note connections for high and low inputs.

ground on the first R.F. tube—but from grid to chassis, and from plate to "B plus" of the following stages there should be a progressive decrease in shadow width as the amplification of the receiver increases, stage by stage.

Putting a D.C. voltage, fluctuating or otherwise, on the grid of the 6B7, will cause that voltage to be amplified, and when applied to the diode plates will flow through unchanged (since you cannot rectify D.C.). Therefore, a fluctuating D.C. voltage will cause a fluctuating shadow width. It is very interesting to watch the shadow follow the variations in audio voltage. It is obvious that with 2 of these units connected to input and output stages of a receiver, many useful tests can be performed. For instance, a crackling A.F. transformer with a defective secondary, would cause the shadow of unit No. 2 to jerk open and shut while unit No. 1, connected across the primary would remain steady. If the primary, only, should happen to be defective, both units would show a jerky shadow.

List of Parts

One chassis, drilled, black crystalline finish;
One Stancor power transformer, 600 V. C.T., 6.3V., 5.V.;
One Stancor filter choke;
One Aerovox 4 mf. condenser;
Two tube shields with bases, for dome-type tubes;
Three Eby wafer sockets, 1—4-prong, 1—6-prong, 1—small 7-prong;
Three Eby insulated tip-jacks (1—Black, 1—Red, 1—Green);
One 36-in. shielded lead, with clips and phone tips;
Four Aerovox 0.1-mf. bypass condensers;
Two Aerovox mica condensers, 1—100 mf. and 1—500 mmf.;
One Aerovox 5-meg., ½ W. carbon resistor;
One Aerovox 1.5-meg., ½ W. carbon resistor;
One Aerovox 1-meg., ½ W. carbon resistor;
Three Aerovox 0.5-meg., ½ W. carbon resistor;
One Aerovox .25-meg., ½ W. carbon resistor;
One Aerovox 300-ohm, ½ W. carbon resistor;
One 5 ft. rubber-covered A.C. line cord with cap;
One roll hookup wire;
One RCA-Radiotron, Sylvania, or National Union 6E5 tube;
One RCA-Radiotron, Sylvania, or National Union 6B7 tube;
One RCA-Radiotron, Sylvania, or National Union 80 tube;
One standard size flashlight lens and holder.

A COMPACT MULTI-TESTER

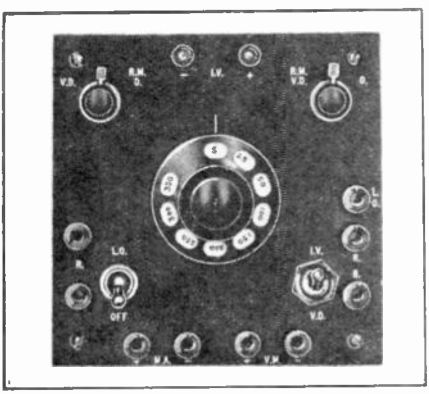


Fig. 8—This unit has an attractive appearance.

A combination ohmmeter, voltage drop and breakdown tester is shown in Fig. 8.

This new device was developed primarily as a means of securing the "low-down" on those resistors which, due to their location—such as in the grid circuit of resistance-coupled stages, A.V.C. circuits and some bias resistors—cannot easily be tested.

Here is a device which, in the course of giving a resistor a break-down test, will: (1) indicate how many ohms a resistor is off value (and with greater accuracy than an ohmmeter); (2) allow a potential to be applied across a registor, and permit the voltage drop in the resistor to be measured; (3) allow a variable load to be applied to the resistor in order to bring it up within a few seconds to its watts rating, and then permit a voltage drop or resistance test to be made. The same complete test may be given to transformer or choke-coil windings.

The facilities permit a Service Man to quickly locate a noisy resistor or transformer winding; or one that is breaking down at intervals, thus causing the various "intermittent" troubles so common in present-day receivers.

Referring to Fig. 9, voltages of various values are taken from a 10,000-ohm divider which is connected across the 350 V. D.C. output of a "B" power supply. By means of Sw. 1, any desired value may be fed to the positive test lead pin-jack via Sw. 2 and Sw. 4, through the resistor under test to the negative pin-jack; through Sw. 2 again to a suitable resistance box for balancing-out purposes; back through Sw. 4, through meter No. 1; through Sw. 4, through Sw. 2 to the negative leg of the power supply.

The voltage drop is measured on meter No. 2 which connects to a D.P.D.T. toggle switch (Sw. 3). Meter No. 2 measures either the applied potential or voltage drop.

Meter No. 1 connects to a 4-pole, 4-throw, 3-position key switch (Sw. 4) and is used as an ohmmeter (when used in conjunction with a resistance box), with

Sw. 2 and Sw. 4 thrown to position 1. When Sw. 4 is in position 2, meter No. 1 is cut in the circuit as a milliammeter for breakdown test; Sw. 2 in position 2 for breakdown test. Meter No. 1 showing the current through resistor under test and meter No. 2 the voltage drop. By applying Ohm's Law, the watts rating (or higher) may be applied to the resistor. Placing Sw. 4 in position 1 also shorts the positive leg through to the positive pin-jack, while in position 2 it shorts the negative leg from the resistance box to the negative supply lead when meter No. 1 is used as a milliammeter. This simplifies the operation and does away with 2 extra shorting switches.

To use the unit as an ohmmeter, Sw. 2 and Sw. 4 are placed in position 1. Switch Sw. 1 is set on 5 V. with 5,000 ohms cut in on the resistance box to give the standard-scale ohmmeter (that is, from 100 ohms to 0.1-meg.). The remaining values are multiples—that is, the 10 V. with 10,000 ohms will read double the resistance of the above range. The 100 V. with 0.1-meg. will read 20 times the resistance of standard range, etc. When Sw. 5 is closed we have the old familiar "shunt" method: that is, the test lead pin-jacks come directly from the meter; the potential and resistance are in series across the meter; meter reads full scale. This range covers from ¼-ohm to 100 ohms.

Figure 9A. First let us find the value in ohms a resistor is high or low. Say the value is 15,000 ohms; with Sw. 1 set on 25 V.; Sw. 2 thrown to position 2; Sw. 4 to position 1; and Sw. 3 to applied potential. Noting values involve 25 V. of applied potential, resistor under test is 15,000 ohms. Since meter No. 1 is a 1,000 ohms-per-volt meter, 10,000 ohms addition resistance is required for full-scale deflection. This is cut in on the resistance box. Now close line Sw. of the power supply unit and note the deflection on meter No. 2; adjust this to exactly 25 V. using the line adjustor. Now note meter No. 1 deflection. Since it is known that the resistors of the resistance box are correct, if the 15,000 ohm unit is correct in value full-scale deflection is obtained. The amount of resistance cut in is the value in ohms that the resistor is low.

If meter No. 1 reads less than full-scale deflection, the 15,000 ohm resistor is high in value and it is simply necessary to cut out resistance from the box until the meter reads full-scale. The amount cut out will be the value in ohms that the resistance is high.

To give the resistor a voltage drop and breakdown test, refer to Fig. 9C. When switches are thrown to respective position, you have this hookup. The procedure is then as follows:

First connect a pair of test leads across the terminals of the resistor. It is 15,000 ohms with a 1-W. rating. Set Sw. 1 to 300 V.; Sw. 2 to position 2; Sw. 3 to the applied potential; Sw. 4 to position 2. Now cut in 285,000 ohms resistance on the resistance box. Close the line switch and adjust the

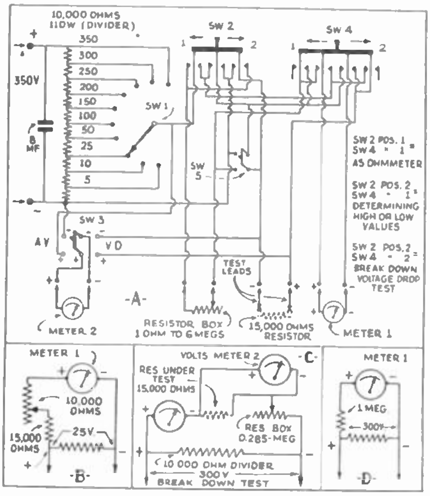


Fig. 9—Circuit as used with external meters.

applied potential to exactly 300 V. on meter No. 2. Now flip Sw. 3 to Voltage Drop. Meter No. 2 should read approximately 15 V.

To apply a breakdown test simply begin to cut out resistance on resistance box. The current in meter No. 1 will begin to increase as will the voltage drop on meter 2 and by simply applying Ohm's Law, W = ExI and noting the readings of meter No. 1 and No. 2 the watts being dissipated through the resistor as resistance is cut out may be determined.

The same procedure used for resistors can be used for transformer windings and choke coils. A transformer winding of 3,000 ohms D.C. resistance will show a 3 V. drop on the 10 V. scale of meter No. 2, while a choke coil of 400 ohms D.C. resistance will show a voltage drop of 0.4-V. on the 1 V. scale of the meter.

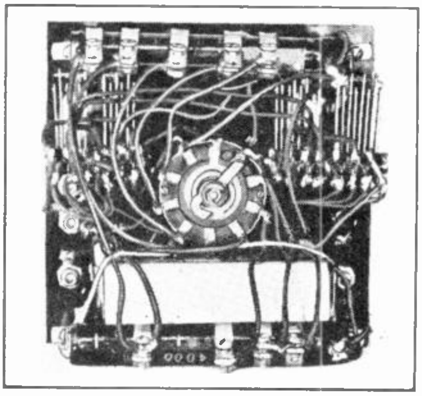
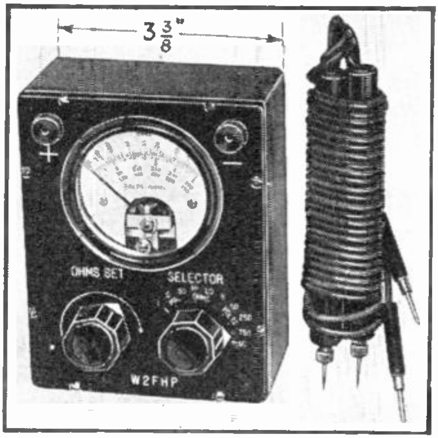


Fig. 10—Underside of the unit. The large white object on the lower side is the 8 mf. condenser. The voltage divider is in 2 parts.

One case (see text);
One bakelite panel, $4\frac{1}{2}$ x 7 x $\frac{1}{4}$ in.

Make This Midget MULTIMETER



Service men and experimenters have often felt the need for a small, compact test instrument, particularly one with which to test continuity. This means one or more ohmmeter ranges, and since the meter is required for these, we may as well have a really handy piece of apparatus by adding several volt and milliampere ranges.

The ranges should be selected by the builder according to what he is most apt to need. For example, the country Service Man would have no need for the 750 V. scale used in the original since his field is mainly among battery receivers. On the other hand, those who work with transmitting apparatus may require the 750 V. or even a higher scale.

The A.C. range is not calibrated, but was added as an afterthought and is useful for output tests and alignment work. It is connected in a rather peculiar manner, but this was necessitated by the fact that only 2 poles are available on the rotary switch and it was felt undesirable to add a separate switch for the A.C. range. (In fact, there was no room!)

The box is made of 3/16 in. bakelite throughout and is held together with 2-56 screws. The panel, on which the lettering is engraved, is of course removable and all parts are fastened to it so that the "works" may be removed as a unit. The box may be assembled to fit as closely as possible, then all edges and corners should be sanded off smooth. The best finish is a dull one, obtained by rubbing with very fine sandpaper, then waxing. When the panel has been drilled, an exact scale plan should be drawn on paper. The engraver will follow this exactly, so make sure it is right. No panel layout for engraving is given because most builders will want to use their own wording.

The selector switch is the heart of the instrument. Dimensions are given in Fig. 18 for this unit. Do not make it any larger or it will not fit in the box. When the bakelite disc has been cut out, the 20 holes around the rim are drilled and tapped for 2-56 round head screws. These are then screwed in tightly and the heads all filed off flat. The connecting wires are soldered directly to the other end of the screws.

The shaft is of ¼-in. brass with a hole drilled and tapped in one end for a 6-32 screw. This screw holds the ⅝-in. insulating washer to which are fastened the two bronze contact arms. One arm is connected to the shaft, while contact to the other is by means of the flexible lead. A standard ¾-in. threaded bushing serves as the bearing and also holds the unit to the panel. A strong bronze spring fastened to the center shaft serves to stop the switch arms when they are centered on the contact. This is done by an indentation on the outer end of the spring, which drops into holes drilled in the bakelite disc.

The wiring is all done with No. 18 tinned bare wire over which pieces of small diameter spaghetti are slipped. This provides ample insulation in the close quarters.

After the multipliers are connected, the shunt panel is fastened to the bracket which holds the meter. The shunts are pieces of resistance wire taken from old wire-wound resistors, and should be cut to size by experiment. This is easily done by connecting the meter across the terminals of another ohmmeter making sure to open the circuit when the shunt is not in place.

The wiring of the rectifier circuit is now finished and two flexible leads are taken from the proper points in the circuit to connect to the battery which is a standard 2-cell midget, the smallest 2-cell battery generally sold.

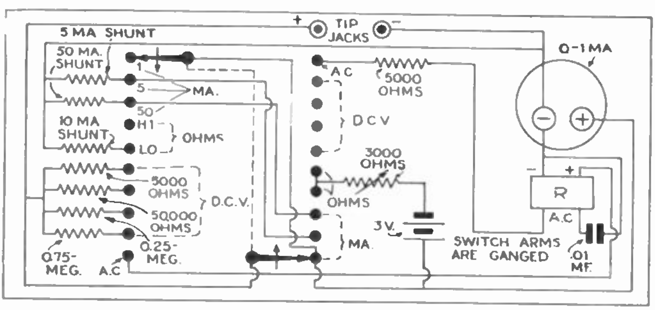


Fig. 17—The rows of dots represent the rotary switch.

Sw. 2 and Sw. 4 thrown to position 1. When Sw. 4 is in position 2, meter No. 1 is cut in the circuit as a milliammeter for breakdown test; Sw. 2 in position 2 for breakdown test. Meter No. 1 showing the current through resistor under test and meter No. 2 the voltage drop. By applying Ohm's Law, the watts rating (or higher) may be applied to the resistor. Placing Sw. 4 in position 1 also shorts the positive leg through to the positive pin-jack, while in position 2 it shorts the negative leg from the resistance box to the negative supply lead when meter No. 1 is used as a milliammeter. This simplifies the operation and does away with 2 extra shorting switches.

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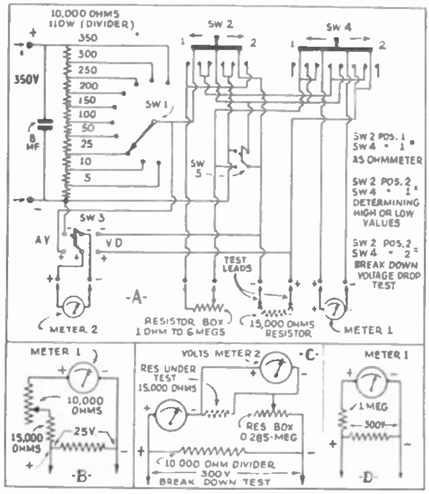

Fig. 9—Circuit as used with external meters.

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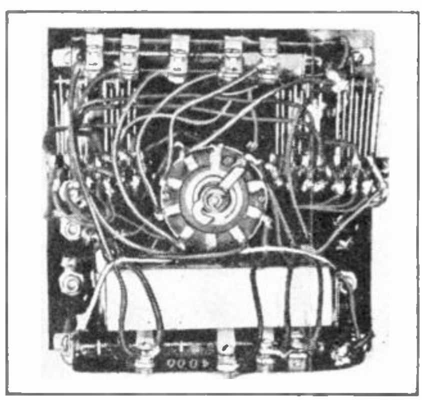


Fig. 10—Underside of the unit. The large white object on the lower side is the 8 mf. condenser. The voltage divider is in 2 parts.

A BRIDGE-TYPE CAPACITY ANALYZER

Fig. 11—The complete capacity analyzer.

This device tests all kinds of condensers—mica, paper, electrolytic and air, from 100 mmf. to 50 mf. The polarizing voltage can also be used wherever an external variable "B" source is needed up to 40 ma. This is sufficient energy to power a 3- or 4-tube receiver, and due to the good filtering is quite noiseless and hum-free.

The circuit used for measuring the capacity is the well known "bridge" method, which is one of the finest in use today. In this arrangement the A.C. voltage is balanced across a known condenser and is made to equal the same value of voltage across the unknown condenser being tested. This is accomplished by adjusting the variable resistance R1 until there is no sound in the headphones. Now, by calibrating this potentiometer it is possible to have a scale reading directly in microfarads: for the benefit of those desirous of duplicating this analyzer a 3½-in. scale (see Fig. 13) can be pasted to a piece of cardboard and then mounted on the front panel of their instrument. Of course, it is essential that the same type of potentiometer be used as the one specified otherwise the calibration will not check.

After the unit is wired, plug into the phone terminal a headphone set and obtain a known condenser of one of the following sizes: 500 mmf., 0.005-, 0.5- or 5 mf. Attach the selected condenser to the terminals marked X in the diagram and select the proper capacity range by rotating switch Sw. 1 to the desired scale. If wired as shown the positions of the selector switch SW. 1 will be as follows: (1) 100 mmf. to 0.005-mf.; (2) 0.001- to 0.005-mf.; (3) 0.01- to 0.5-mf.; (4) 0.1- to 5-mf.; and, (5) 1 to 50 mf. Use a range such that the condenser being used for the preliminary test will have a null point in the phones when the potentiometer knob is almost pointing to the centre of the scale. When the hum disappears fasten the pointer knob securely, with the pointer indicating the capacity on the inner scale, and the tester is calibrated.

To test the value of unknown condensers connect the unit into the circuit at terminals "X"; then select a scale from the selector switch Sw. 1, and rotate the dial knob on the potentiometer until the hum disappears. The reading on the dial will be the capacity in mf.

While the above test applies to paper and mica condensers, it is necessary to apply a polarizing voltage to an electrolytic type of condenser. To do this proceed as follows: Close switch Sw. 3; this closes the filament circuit of the type 80 tube. Rotate selector switch Sw. 2 to the position marked No. 2. When used from this position a polarizing voltage of 100 V. is available. Care should be exercised that the electrolytic condenser is connected to the unknown terminals as shown, that is the polarity must be observed. The remainder of the test is then the same as if a paper or mica condenser were being tested.

To test for leakage, open switch Sw. 5 and rotate the switch Sw. 2 to the test voltage under which the condenser is rated. The voltages thus obtained, as drop values across R2, are as follows: 50, 100, 200, 300 and 400 V. Now connect the condenser to the unknown terminals and observe the neon bulb. A good condenser will light and immediately go out (the initial light merely indicates that condenser has become charged). If the light blinks, it indicates condenser leakage, and that the unit therefore is in all probability no good for radio work. If the neon is continually aglow, it indicates that the condenser is shorted. An open-circuited condenser will not light the neon on the initial charge.

List of Parts

One Blan, The Radio Man, Inc., power

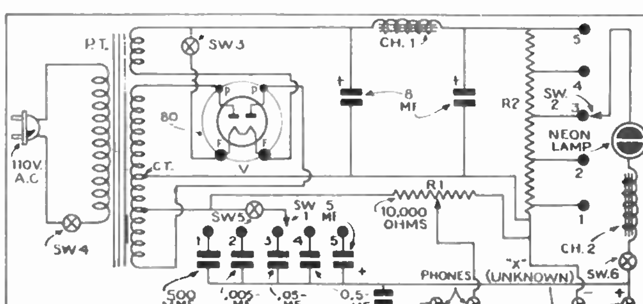


Fig. 12—The circuit is quite simple and troubleproof.

transformer, tapped for calibrated potentiometer (R1), P.T.

Two Blan, The Radio Man, Inc., filter chokes, Ch. 1, Ch. 2;

Two Cornell-Dubilier electrolytic condensers, 8 mf.;

One Electrad resistor, 50 W., 25,000 ohms, with 4 contact rings;

One Centralab potentiometer, wire-wound (with switch, Sw. 4), 10,000 ohms R1;

One neon bulb and socket;

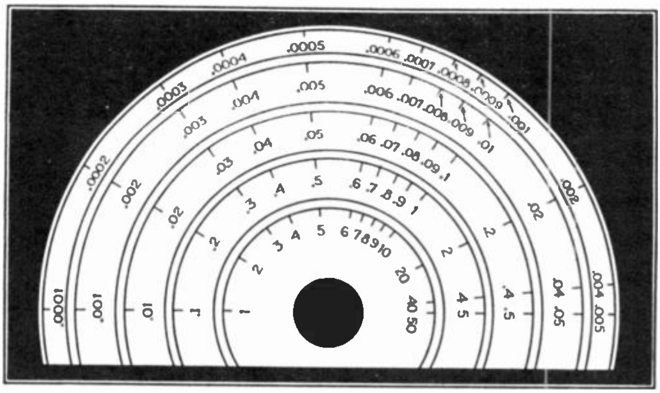


Fig. 13—This scale may be copied or cut out and used on the panel.

Six Aerovox paper condensers, 1—500 mmf., 1—0.005, 1—0.05, 2—0.5 and 1—5 mf.;

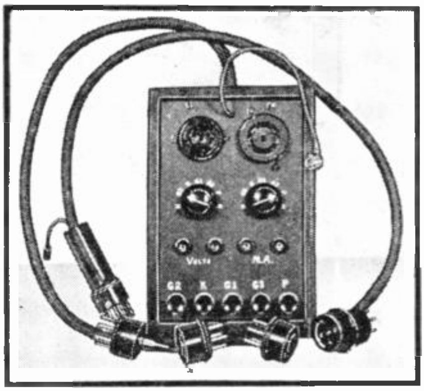
One Blan, The Radio Man, Inc., drilled and stamped metal cabinet 5 x 9¾ x 7 ins. high and chassis (to fit);

Two Yaxley selector switches, Sw. 1, Sw. 2;

Three Yaxley on-off switches, Sw. 3, Sw. 5, Sw. 6;

Two bakelite phone-tip terminals.

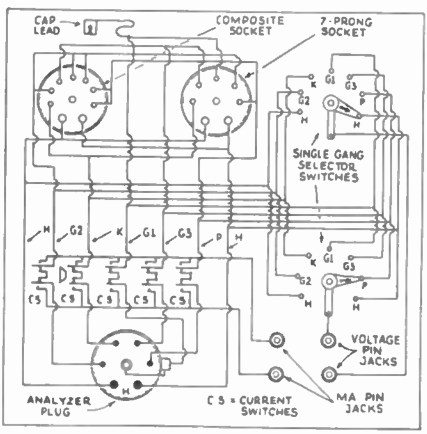
A POCKET SIZE ANALYZER ADAPTER



The "adapter unit" is useful and speeds up test analyses. Its small size is due to the fact that only two sockets are used. These sockets accommodate 4-, 5-, 6- and 7-prong tubes, as shown in the schematic circuit.

Current tests are speeded up by the fact that it is only necessary to plug the milliammeter into the pin-jacks and then depress buttons one after another in the circuits to be read.

Potential measurements are made in a similar manner, by plugging the voltmeter leads into the pin-jacks marked Volts; all voltage readings may be made by using the selector switches located under the tube sockets. These jacks and selector switches may be used for circuit resistance measurements; be sure the set is "dead."



A box for this unit may be made of metal or wood, and the depth to suit the builder.

List of Parts

One Na-Ald 6-prong plug, 5-ft. 7 conductor cable, type 906 WLC;

One Na-Ald adapter, type 964 DS;

One Na-Ald adapter, type 965 DS;

One Na-Ald adapter, type 967 DS;

One Na-Ald 7-contact socket, type 6130;

One Na-Ald composite socket, type 6127 (or 7-contact, large-small base socket, type 477E);

Four Na-Ald insulated pin-jacks, type 1096-B;

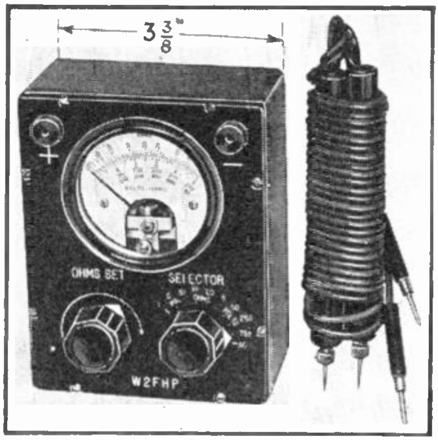
Two Na-Ald 7-point, single-gang switches;

Five Na-Ald pushbutton D.P.D.T. switches;

One case (see text);

One bakelite panel, 4½ x 7 x ¼ in.

Make This Midget MULTIMETER



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The ranges should be selected by the builder according to what he is most apt to need. For example, the country Service Man would have no need for the 750 V. scale used in the original since his field is mainly among battery receivers. On the other hand, those who work with transmitting apparatus may require the 750 V. or even a higher scale.

The A.C. range is not calibrated, but was added as an afterthought and is useful for output tests and alignment work. It is connected in a rather peculiar manner, but this was necessitated by the fact that only 2 poles are available on the rotary switch and it was felt undesirable to add a separate switch for the A.C. range. (In fact, there was no room!)

The box is made of 3/16 in. bakelite throughout and is held together with 2-56 screws. The panel, on which the lettering is engraved, is of course removable and all parts are fastened to it so that the "works" may be removed as a unit. The box may be assembled to fit as closely as possible, then all edges and corners should be sanded off smooth. The best finish is a dull one, obtained by rubbing with very fine sandpaper, then waxing. When the panel has been drilled, an exact scale plan should be drawn on paper. The engraver will follow this exactly, so make sure it is right. No panel layout for engraving is given because most builders will want to use their own wording.

The selector switch is the heart of the instrument. Dimensions are given in Fig. 18 for this unit. Do not make it any larger or it will not fit in the box. When the bakelite disc has been cut out, the 20 holes around the rim are drilled and tapped for 2-56 round head screws. These are then screwed in tightly and the heads all filed off flat. The connecting wires are soldered directly to the other end of the screws.

The shaft is of ¼-in. brass with a hole drilled and tapped in one end for a 6-32 screw. This screw holds the ⅝-in. insulating washer to which are fastened the two bronze contact arms. One arm is connected to the shaft, while contact to the other is by means of the flexible lead. A standard ¾-in. threaded bushing serves as the bearing and also holds the unit to the panel. A strong bronze spring fastened to the center shaft serves to stop the switch arms when they are centered on the contact. This is done by an indentation on the outer end of the spring, which drops into holes drilled in the bakelite disc.

The wiring is all done with No. 18 tinned bare wire over which pieces of small diameter spaghetti are slipped. This provides ample insulation in the close quarters.

After the multipliers are connected, the shunt panel is fastened to the bracket which holds the meter. The shunts are pieces of resistance wire taken from old wire-wound resistors, and should be cut to size by experiment. This is easily done by connecting the meter across the terminals of another ohmmeter making sure to open the circuit when the shunt is not in place.

The wiring of the rectifier circuit is now finished and two flexible leads are taken from the proper points in the circuit to connect to the battery which is a standard 2-cell midget, the smallest 2-cell battery generally sold.

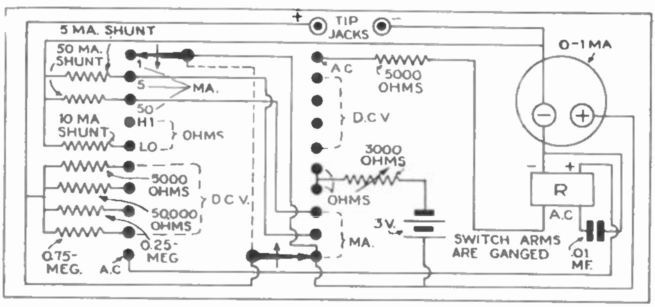


Fig. 17—The rows of dots represent the rotary switch.

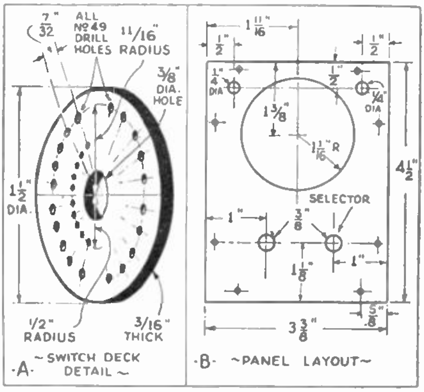
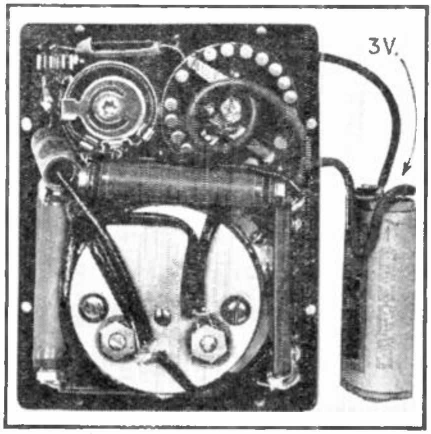


Fig. 18—Switch and panel details.



List of Parts

One engraved panel, 3/16 in. thick;
One Beede milliammeter with universal scale, 0-1 ma., 2 ins. dia.;
One Radio City Products W. W. resistor, 5,000 ohms;
One Radio City Products W. W. resistor, 50,000 ohms;
One Radio City Products W. W. resistor, 0.25-meg.;
One Radio City Products W. W. resistor, 0.75-meg.;
One Carter midget potentiometer, 3,000 ohms;
Two Eby pin tip-jacks;
One Cornell-Dubilier midget paper condenser, .01-mf.;
One meter rectifier;
One I.R.C. resistor, 5,000 ohms, ½-W.;
One case, 4½ x 1⅝ x 3⅜ ins. wide;
Wire, hardware, knobs, etc.

A Self-Contained V.T. VOLTMETER

The many uses of this instrument are well known and will not be described in detail. The instrument which was constructed as described below has proven very useful for making voltage measurements on resistance-coupled A.F. amplifiers, voltage gain of A.F. and R.F.. amplifiers, voltage gain and turns-ratio of A.F. transformers, power output and noise levels of A.F. amplifiers and many other applications.

The instrument as described is operated directly from a 110 V. 60 cycle source, is portable and lends itself to rapid manipulation. The circuit employed makes use of the well known slide-back feature as described by Waller, Richards and others.

The panel is 6-3/16 x 10-3/16 ins. All parts except the power supply are mounted directly on the panel and on a small subpanel mounted 3¾ ins. below the main panel. The subpanel is supported from the main panel by 2 brackets. A spacing block is used under the 6E5 socket so as to extend it through the panel to the same height as the 6C6. Connection is made directly to the control-grid terminal of the 6C6; this keeps the input capacity at a minimum, an important feature when making R.F. measurements.

For the same reasons, a switch was not incorporated to control a blocking condenser and gridleak circuit when such are necessary as when measuring the A.C. potential of a circuit which also has a D.C. component. When making such measurements the blocking condenser and control-grid lead must be connected to the input circuit as indicated by dotted lines in the schematic, Fig. 21. If an accurate calibration on R.F. is not needed, the blocking condenser and gridleak may be wired in permanently so as to be controlled by a switch.

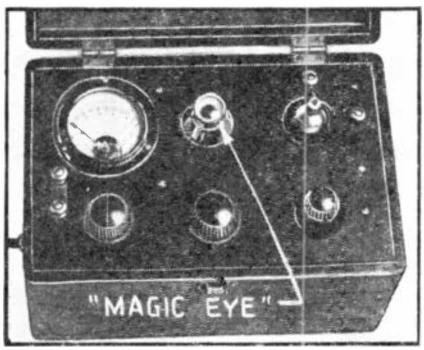


Fig. 20—A portable V.T. voltmeter.

In order to afford ease of adjustment on the low-voltage ranges it was found desirable to incorporate a 500-ohm rheostat, R5, as a vernier in series with R4. To keep the number of control positions at a

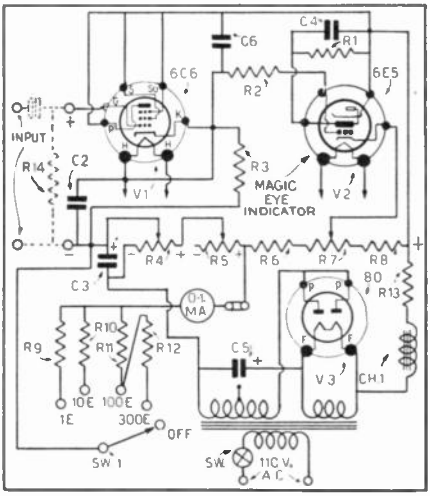


Fig. 21—The circuit is simple but effective.

minimum, a duplex control incorporating R5 and R4 was constructed. The shaft of the potentiometer R4 was replaced with a section of hollow tubing. As shown in Fig. 22, the rheostat R5 was mounted by a bracket directly below R4 and a small-diameter extension shaft passed through the hollow shaft of R4 to a small control knob mounted on top of the larger control knob for R4. This enables the final adjustment to be made from the same control position used in making the coarse adjustment by R4.

Connect to a 110 V. line for a sufficiently long time to allow the tubes and circuit elements to reach their normal operating temperatures. Set R4 and R5 at the positive end of their voltage ranges. For convenience these controls should be wired so that this condition is obtained with both controls turned to the extreme end of their ranges in a clockwise direction. Next, adjust R7 so as to almost completely close the magic eye. This is the normal reference point for making all measurements. Connect the input terminals to a source of voltage and the "eye" will open by an amount proportional to the applied voltage peak. Controls R4 and R5 are now turned until the opening of the "eye" is returned to the normal reference point. The voltmeter multiplier switch is now turned from the OFF position to the proper scale to read the voltage drop across R4 and R5 which represents the voltage required to balance the peak value of voltage applied to the input.

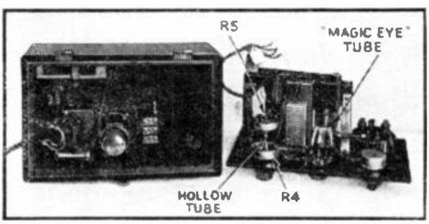


Fig. 22—Most parts are panel mounted.

TABLE I

VOLTAGE

To Input Posts	Read On V.T.VM.	To Input Posts	Read On V.T.VM.
240	240.0	15.	14.20
220	222.0	10.	9.90
200	201.0	9.	9.00
180	180.3	8.	8.00
170	170.3	7.	7.02
160	160.2	6.	6.10
150	150.0	5.	4.95
140	139.8	4.	3.90
130	129.9	3.	2.90
120	120.0	2.	2.10
110	109.5	1.	1.00
100	99.9	0.9	0.92
90	90.0	0.8	0.80
80	80.4	0.7	0.70
70	69.0	0.6	0.62
60	59.7	0.5	0.54
50	48.5	0.4	0.48
40	38.5	0.3	0.44
30	29.5	0.2	0.35
20	19.0	0.1	0.26

List of Parts

One I.R.C. resistor, 1 meg., R1;
One I.R.C. resistor, 0.1-meg., R2;
One I.R.C. resistor, 2 megs., R3;
One Electrad taper ww pot., 10,000 ohms, R4;
One Electrad ww rheostat, 100 ohms, R5;
One I.R.C. carbon resistor, 500 ohms, R6;
One Electrad linear ww pot., 1,000 ohms, R7;
One I.R.C. 5 W. resistor, 10,000 ohms, R8;
One Shallcross precision resistor, 1,000 ohms, R9;
One Shallcross precision resistor, 10,000 ohms, R10;
One Shallcross precision resistor, 0.1-meg., R11;
One Shallcross precision resistor, 0.2-meg., R12;
One I.R.C. resistor, 4,000 ohms, 5 W., R13;
One I.R.C. gridleak, 2 megs., R14;
One Aerovox paper condenser, 0.1-mf., C1;
One Aerovox paper condenser, 4 mf., C2;
One Aerovox electrolytic condenser, 8 mf., C3;
One Aerovox paper condenser, 0.1-mf., C4;
One Aerovox electrolytic condenser, 16 mf., 500 V., C5;
One Aerovox paper condenser, .01-mf., C6;
One Kenyon power transformer, T-7020, T1;
One Yaxley single gang, 5-point switch, Sw1;
Two 6-prong sockets;
One 4-prong socket;
One 20 hy. filter choke, Ch. 1;
One type 6C6 tube, V1;
One type 6E5 tube, V2;
One type 80 tube, V3;
One Weston 0 to 1 ma. meter;
One bakelite panel;
One carrying case;
Four binding posts;
One terminal strip or socket with plug.

CHAPTER 3

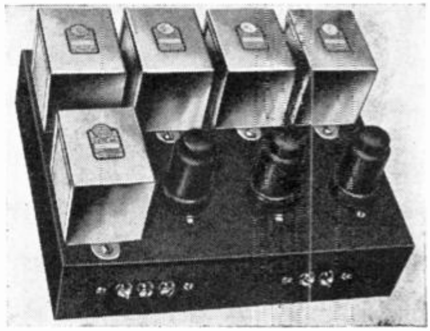
Audio Developments

An A.C. Operated Metal Tube PREAMPLIFIER

The last few years have seen a very great increase in the frequency range of audio equipment, from microphone to loudspeaker. However, there has been practically a proportional decrease in the sensitivity of input devices requiring additional gain in the amplification circuits. This is readily apparent when a number of modern types of microphones are compared. A fairly accurate check on modern input devices indicates the average output levels given in Table I. Only average values are indicated, as there is quite a difference in output level for the same type microphones as manufactured by different organizations. Another factor to consider is the variation in output of microphones due to distance from the sound source and directional effects.

Considering the above as a whole, the necessity for preamplification becomes evident. To allow sufficient range in gain control, an amplification system should have at least 10 db. greater gain than the difference between normal input and output powers. For comparison, let us now consider (see Table II) the output of a number of power amplifiers, commonly used.

Based on this method of determining required amplifier gain, the gain required between a dynamic mike and the output of a pair of 2A3s would be 34 + 88 + 10, or a total of 132 db. If (a) the power amplifier has a gain of 80 db., it is seen that (b) an additional gain of 52 db. is required in the preamplifier.



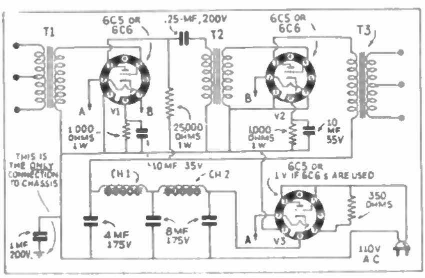


Fig. 2—A 6C5 is used as a rectifier.

There is no doubt by this time that metal tubes eventually will replace glass tubes in most radio receivers. While the cost of metal tubes is at present somewhat above that of comparable glass tubes, the several valuable performance characteristics of the former have caused "iron" tubes to take the radio industry by storm. This does not mean that glass tubes should be retired to obsolescence, but merely that the use of iron tubes reflects the general progressiveness of the radio field as a whole. The advantages of metal tubes in P.A. work are here enumerated.

1. Reduction in tube noise and microphonics.
2. Compactness, which lends itself to the modern trend toward simplified equipment.
3. Positive self shielding.
4. Simplified self-aligning base plug.
5. Increased strength.

Increased tube strength is of great importance in P.A. work due to the great abuse tubes normally receive in such service. In addition to the unbreakable shell, these tubes have a more rugged internal structure as the elements are supported by at least 7 short leads that go directly to the base pins. The psychological effect of metal tubes and the obvious "latest" effect on the ultimate purchaser or user of P.A. equipment, also play important roles.

Keeping in mind all the aforementioned metal tube advantages, the low-level preamplifier described below was designed and developed to form a unit which would be ideal from the engineering standpoint and at the same time inexpensive.

Five major factors determined the design of this amplifier, as follows:

1. Adaptability to metal, metal-glass, and glass tubes.
2. High efficiency.
3. Low harmonic distortion and phase shift.
4. Low hum level.
5. High power output.

The preamplifier may use any type of tubes, 3 of the 6C5s being preferred. The power output is + 7 db., and the overall gain is +55 db. Input and output terminals are arranged for either 200 or 500 ohm lines. The hum level is extremely low even though the entire unit measures only 8⅝ x 7 x 4⅛ ins. high. An output of 30 milliwatts is possible without exceeding a negligible value of total harmonics.

It has always been somewhat difficult to mix microphones, pickups and tuners of widely different output. In many of the less expensive sound systems a single gain control is used with a switching arrangement to throw in mike, pickup or tuner. Most inexpensive gain controls show a marked frequency discrimination at the maximum attenuation point. To compensate for this effect, a fixed attenuator can be inserted between the pickup or tuner and the input to the variable gain control. This attenuator will bring the pickup level down to the same output as a microphone, so that the original gain control will cover the entire volume range.

An ideal attenuator must maintain proper impedance on both input and output termination and must show no frequency discrimination throughout the A.F. range. It is customary to use either a T- or H-type pad to obtain the above results. With the chart shown in Table III any person can make a pad of either of these types.

Inasmuch as the most common impedance for transmission lines is 500 ohms, this chart has been plotted for 500-ohm input and output termination. The method of application is very simple. The value of attenuation desired is read on the left side. This value is then carried across to the corresponding resistance values. These values, which are read directly in ohms, are inserted in the circuits at the top of the chart. If it is desired to attenuate a circuit of an impedance other than 500 ohms, both A and B values should be multiplied by the ratio of the desired impedance to 500 ohms.

For example, let us assume that our preamplifier is designed to operate from an input level of —80 db. with a gain control covering a working range of 40 db. It is desired to operate into this amplifier a 200-ohm pickup with an output level of —20 db., and it is evident that the original gain control would not be effective. However, by using a fixed attenuator of 40 db. between the pickup and amplifier input, proper volume control can be obtained. The chart indicates that for 40 db. attenuation, resistance values of A = 245, B = 10. Inasmuch as these values are based on 500 ohms, to reduce the impedance to 200-ohm values, both A and B are multiplied by $\frac{200}{500}$. This gives us corrected values of approximately 100 ohms and 4 ohms. The H-type attenuator is generally used only where it is necessary to maintain perfectly balanced lines. Inasmuch as in most cases balance is not of prime importance, a T pad is suitable.

TABLE I

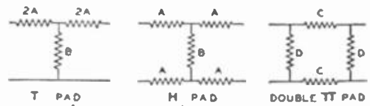
Carbon Microphone	—34db.
Condenser Microphone	—82db.
Dynamic Microphone	—88db.
Velocity Microphone	—97db.
"Diaphragm" Crystal Microphone	—60db.
Magnetic Pickup	—25db.
Crystal Pickup	—15db.
"Sound-Cell" Crystal Microphone	—90db.

TABLE II

TUBES	CLASS	GAIN
1 45	class A	plus 24db.
1 50	" A	" 28db.
2 45s or		
1 53	" B	" 32db.
2 50s	" A	" 33db.
2 2A3s	" A	" 34db. (Fixed Bias)
2 WE300As	" A	" 35db. (Fixed Bias)
2 46s or 59s	" B	" 36db.

TABLE III

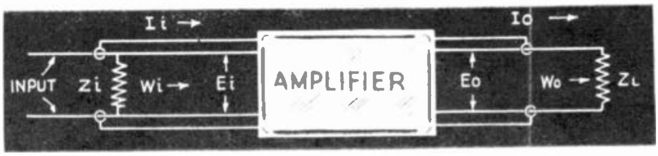
ATTENUATION NETWORK DATA



NOTE Z_0 (LINE IMPEDANCE) = 500 OHMS; N = 11513

ATTENUATION	$A = \frac{Z_0}{2} \times \tanh\left(\frac{N}{2}\right)$	$B = \frac{Z_0}{\sinh(N)}$	$C = \frac{Z_0}{2} \times \sinh(N)$	$D = \frac{Z_0}{\tanh\left(\frac{N}{2}\right)}$
NO DB	A	B	C	D
.1	1.440	43420	2.879	86850
.2	2.878	21720	5.755	43440
.3	4.318	14480	8.635	28950
.4	5.758	10850	11.52	21710
.5	7.193	8685.	14.40	17380
.6	8.635	7232.	17.29	14480
.7	10.07	6198	20.17	12420
.8	11.51	5421.	23.06	10870
.9	12.95	4818.	25.95	9656.
1.0	14.38	4333.	28.35	8690.
2.0	28.65	2152.	58.08	4364.
3.0	42.75	1420.	88.08	2925.
4.0	56.58	1049.	119.3	2209.
5.0	70.03	822.4	152.0	1785.
6.0	83.08	669.4	186.8	1505.
7.0	95.65	558.0	224.0	1308.
8.0	107.7	473.1	264.3	1162.
9.0	119.1	405.9	308.0	1050.
10.0	129.9	351.3	355.8	962.5
15	174.5	183.6	680.8	756.3
20	204.5	101.0	1238.	611.2
25	223.5	56.40	2216.	559.5
30	234.7	31.65	3949	532.7
35	241.3	17.79	7027.	518.0
40	245.1	10.00	12500	510.1
45	247.2	5.624	22230	505.7
50	248.5	3.163	39530	503.2
55	249.2	1.775	70300	501.8
60	249.5	1.0	125000	501.0
65	249.8	.5623	222300	500.5
70	249.8	.3163	395400	500.4
75	249.9	.1779	703000	500.2
80	249.9	10	1250000	500.1
85	250.0	.05620	2223000	500.1
90	250.0	.03161	3954000	500.0
95	250.0	.01879	7027000	500.0
100	250.0	.010	12500000	500.0

THE DECIBEL



Before the gain (amplification) of an amplifier can be measured it is necessary to select some unit of measurement. As the output of the amplifier is rated in terms of watts it would be logical to measure the input in terms of watts also. Now the effect of sound energy on the ear is not a direct (arithmetic) function but varies in an exponential way. Therefore, the gain of an amplifier is expressed in the same way, by means of logarithms. The expression is given by the formula:

$$\text{db.} = 10 \log_{10} \frac{W_0}{Wi}$$

where db. represents the unit of transmission or amplification—the decibel; W_0 is the power output, and Wi is the power input. Efficiency is here used in connection with sound energy and does not mean the electrical efficiency which is usually very low.

Amplifiers can also be rated in terms of currents and impedances. Referring to the heading illustration, the formula is

$$\text{db.} = 10 \log_{10} \frac{I^2_0 R_L}{I^2 i Ri} \text{ or}$$

$$\text{db.} = 20 \log_{10} \frac{I_0}{Ii} + 10 \log_{10} \frac{R_L}{Ri}$$

If the resistance of the input impedance equals the load resistance, the last term becomes zero and the first term gives the decibel gain. In some designs, however, the second term may be considerable and must not be neglected in such cases.

The gain may also be rated in terms of input and output voltages, provided the input and output reactances are equal to zero; that is, when both impedances are resistance only. The formula is:

$$\text{db.} = 10 \log_{10} \frac{\dfrac{E^2_0}{R_L}}{\dfrac{E^2 i}{Ri}} \text{ or}$$

$$\text{db.} = 20 \log_{10} \frac{E_0}{Ei} + 10 \log_{10} \frac{Ri}{R_L}$$

Again the last term equals zero, if the input and output resistances are equal.

Sound and noise levels are usually expressed in decibels and not in watts, therefore, a reference level of zero decibels must be set. For convenience, engineers have arbitrarily taken the output of a common battery telephone transmitter (when spoken into with a loud voice) as zero level. This equals 0.01-watt or 10 milliwatts. Thus in telephone work zero level has been set at 10 milliwatts, but in radio work it will be noticed that the articles in the past have always mentioned the reference level and it is not universally standard. The tendency among radio engineers is to refer the system to a zero level of 0.006-watt or 6 milliwatts and throughout this article all levels will be with respect to 6 milliwatts. It is of very little importance whether the level is 10 or 6 milliwatts as long as one or the other is taken as standard!

By using 6 milliwatts as zero level, amplifiers may be rated at an energy level of a certain number of decibels. This is desirable because the ear responds to sound in a logarithmic manner. This can be illustrated by the following example. If an amplifier delivers 6 watts output it has a level of:

$$\text{db.} = 10 \log \frac{6}{0.006} \text{ or db.} = 10 \log 1{,}000$$

$$\text{or db.} = 30.$$

Now, if the output is doubled, the ear will notice an increase in volume but not twice as great as the 6 watts output because the ear will respond as the increase in decibels and not as the increase in watts output. Thus,

$$\text{db.} = 10 \log \frac{12}{0.006} \text{ or db.} = 10 \log 2{,}000$$

$$\text{or db.} = 33.0.$$

The ear did not detect the increased volume in a direct ratio, but as the logarithm of the ratio. Therefore, if this zero reference level were not used, the amplifier control set at 30 db. gain would not give any indication of the volume of the output unless the input were known. With the control marked in decibels above zero level, the 30 db. setting would indicate an output of 12 watts.

A commercial amplifier rated at 26 watts output has an energy level, at full output, expressed in decibels equal to:

$$\text{db.} = 10 \log \frac{26}{0.006} \text{ or db.} = 10 \log 4{,}333$$

$$\text{or db.} = 10 \times 3.64 \text{ or } 36.4 \text{ db.}$$

TABLE I

Per cent eff. for a db. gain	*Number of Decibels*	*Per cent eff. for a db. loss*
100	0	100
112	½	89.1
126	1	79.4
158	2	63.1
200	3	50.1
251	4	39.8
316	5	31.6
398	6	25.1
501	7	20.0
631	8	15.8
794	9	12.6
1,000	10	10.0
10,000	20	1.0
100,000	30	0.1
1,000,000	40	0.01
10,000,000	50	0.001

Efficiency related to DB. gain or loss.

Now, it is stated in the catalog that this amplifier has a gain of 96.4 db. Where do the extra 60 decibels come from? The answer to this question will become evident after the microphone output has been considered.

Different types of microphones have different energy output levels, but most commercial type carbon-button microphones give an energy level of —50 to —80 db. When the speaker (source of sound) is near the mike, a good average is the —60 db. level. The mike, therefore, lowers the energy level that it receives and it is the function of the amplifier to raise the voice level from —60 db. back to zero level and still higher in order to have appreciable output at the loud-speaker. After the sound has passed through the mike, it is at a very low level and has very little energy. The actual power impressed on the amplifier input, after passing through the mike, can be found as follows: $-60 = 10 \log R$; where R is the ratio of mike output to mike input, and here it is assumed that zero level is impressed upon the mike. $40.0000 - 100 = 10 \log R$ or $4.0000 - 10 = \log R$ or $R = 0.000001 = \frac{W_0}{0.006}$. Therefore $W_0 = 0.006$-microwatt.

Thus the input of zero level to the mike is lowered to —60 db. in passing through the mike and the power that the amplifier begins with is very small. The entire gain is therefore 96.4 db. as the amplifier ends up with a 36.4 db. level. In amplification work it is desirable to know what level above zero the amplifier will raise the sound of the speaker's voice, and, therefore, the maximum reading on the control should be 36.4 db. and not 96.4 db. A high-gain amplifier when used with a very poor mike may give but little amplification. For example, suppose the mike had a loss of 76.4 db. This would leave a gain of 20 db. above zero. The output would be far below the rated 26 watts and would be equal to:

$$20 = 10 \log R \text{ or } 2.0000 = \log R$$

$$\text{or } R = 100 = \frac{W_0}{0.006}$$

or the output W_0 equals 0.6-watt. After all, the decibel gain is not so important. **It is the decibel level above zero that counts.** It is well to point out here that there is a limit to the over-all gain that an amplifier may have.

The energy required to operate the amplifier is 90 watts, while the output is but 26 watts. The efficiency is therefore

$$\frac{26}{90} \times 100 = 28.8 \text{ per cent.}$$

This may be expressed in decibels as would be done if used in connection with telephone work. $\text{db.} = 10 \log \frac{26}{90}$ or $\text{db.} = 10 \log 0.288$ or $\text{db.} = 10 \times (9.4594-10)$ or $\text{db.} = 94.4594 - 100$ or $\text{db.} = -5.54$, which represents a loss.

The accompanying Table I lists the efficiency for certain decibel gains or losses.

Try This New BASS BOOSTER

This unit is intended to be added to any existing receiver or amplifier to raise the level of the bass response for higher fidelity.

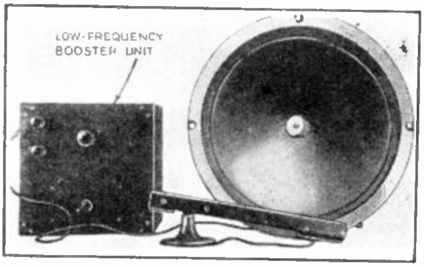


Fig. 5—A special speaker is used.

The most obvious and annoying shortcoming of contemporary amplifying systems is the almost total absence of "depth" (power) in the reproduced music. The reasons for this are manifold, and include such factors as: (1) speaker inefficiency in the lower regions; (2) lack of baffle area; (3) losses in the amplifier; and, (4) distortion in the "incoming signal"—whether it be microphone, phonograph or radio.

Despite a great deal of discussion on the subject, it is obvious to an observer that very little is really known by the general technical world about the matter or its importance. When the topic of low notes is brought up in relation to an amplifying system, the average technician will point to what he considers a good example of high fidelity, whether it be a commercial set or one constructed by himself, and reply that it does bring out the "lows."

What he refers to are a few indefinable noises that do resemble low notes to a limited extent. They consist, for the most part, of harmonics with a very small percentage of the fundamentals. Enough of the lower frequencies are present to give an illusion that these notes are really heard when they are supplemented by the additional volume gained by the amount of fundamental sounds reconstructed aurally from the harmonics. This property of the ear which enables us to recreate a small part of a note when nothing but its harmonics are present accounts for more of the depth found in radio sets than some people imagine. However, these sounds are

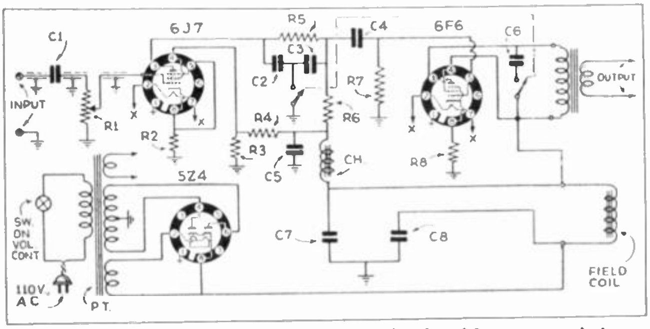


Fig. 7—The circuit. Note the filter circuit with cutout switch.

without "body," although production of this effect is by far the most important function of the low notes in establishing the sense of true depth.

No radio receiver or amplifier can give the same sense of depth unless it, too, can bring out these low notes with the same power to actually vibrate heavier bodies, that the original instrument produces. The lower notes must be FELT as well as heard, and as the frequency lowers the former function becomes of greater importance until finally the threshold of hearing gives way to a soul-stirring feeling of power in the deep vibrations. Herein lies much of the majesty of an organ which is entirely lost in the feeble pipings of contemporary sound systems. It requires POWER to produce a low note.

This is readily shown by a comparison of the amounts of air required by organ pipes at opposite ends of the musical scale, or by considering the comparatively little amount of exertion required to play a fife when compared with the lusty blows dealt a bass drum.

Perhaps the most critical factor in a low frequency booster is the overall shape of the response curve. Upon it depends the amount of possible gain we may give the low notes without excessive boominess or distortion of the voice, and whatever the conditions which tend to reduce the sharpness of the cut-off, the response above 70 cycles must be kept at an absolute minimum.

The "amplitude distortion" of the speaker chosen for this purpose by the writer is very low and the cleanness of the low notes is striking. This is due largely to the use of a thick and comparatively soft cone which can be driven to a wide excursion without break-up and consequent harmonic distortion.

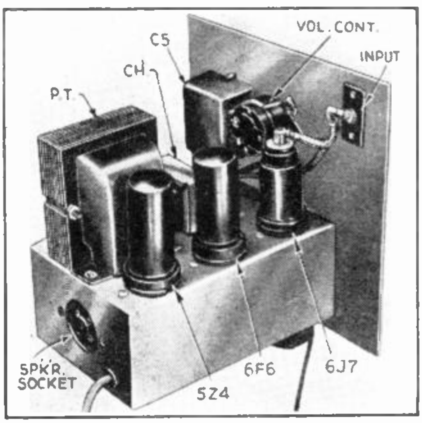


Fig. 6—Placement of the parts on chassis.

Inasmuch as the frequency discrimination of the speaker and of the human ear become more pronounced at low volume, it has become the policy to make provision for additional attenuation of the middle musical range at low-volume levels. This has usually been aimed at by means of a tap on the volume control from which the higher frequencies are shunted off through a tone control condenser wher the volume control is at a low setting. With the L.F. booster, the same object is attained by increasing the "gain" (amplification) of this supplementary amplifier.

If, beginning at the microphone and ending with the speaker, every component of the electrical reproducing system were absolutely linear; and sufficient power output were available, no bass boosting would be required. In practice, however, such rigid ideals cannot at the present time be met and we find frequency discrimination at every turn. Usually this is in the lower end of the audio scale.

Not only do we find losses to be prevalent in the actual amplifier, but even more so in the associated apparatus. It is true that our aural perception is insensitive to the loss of a decibel or two, but in the writer's opinion a trained individual can actually feel a power loss of an even less amount in the lower reg ster.

It so happens that the cone producer of today has a decided tendency towards discrimination against the lower notes. Therefore this characteristic must be counteracted by increased gain in the amplifier in the corresponding regions. Accordingly, an amplifier having perfectly linear (uniform, or "flat") response over the entire scale would still not produce the desired results.

It has often been found necessary to use the full output of 2 high-gain stages following the "normal" power stage of an amplifier in order to properly bring up the level of the low notes! This gain is achieved in the present instance by the use of a 6J7 and a 6F6 in cascade arrangement.

An inspection of the schematic diagram,

Fig. 7, discloses a 2-stage amplifier, resistance-capacity coupled, with a 6J7 and a 6F6 for maximum gain. The current supply is obtained from a typical power circuit utilizing a 5Z4. Every effort has been made to keep the unit as simple as possible, yet every source of possible extraneous noise has been checked.

The low-frequency filtering is accomplished by means of the resistance-capacity trap circuit R5, C2 and C3. This provides for a rather sharp cut-off and allows only those notes below (about) 75 cycles to play any prominent part in the reproduced music. While the response tapers off above this point, the strength of the signals is not great enough to interfere to any considerable extent with the voice. Further filtering action is had by resonating the output transformer with C6 to approximately 30 cycles. This increases the efficiency in these regions by several decibels.

By means of the D.P.S.T. switch, Sw. 2, mounted on the front panel, we are able to cut out these filtering sections and convert the L.F. booster into a very efficient little amplifier. Considering the simplicity of the circuit, the overall frequency characteristics are excellent, holding up very well at both ends, and actually surpassing many circuits having much more pretentious claims. When used with a crystal pickup and the speaker for which it is designed, the unit has suprisingly good tone as judged by conventional standards.

The proper point in the amplifier to attach the L.F. booster is best determined by experiment. In the majority of the newer radio sets, the writer has had greatest success in tapping on to the plate prong of an output tube. Usually the hum level is low enough to permit this, and enough gain is had overall to permit the L.F. unit to be partially attenuated in output. In some cases, the L.F. response of the radio receiver, which includes the detector, is so low that the L.F. booster, despite its high gain, is unable to bring it up to a high enough level unless operating from the output stage. In other instances the second, or even the first audio stage will furnish the best L.F. signal, both from the standpoint of hum and amplitude distortion.

In all instances, the correct setting of the booster output is that point where the voice approaches boominess, although this is of course up to the personal tastes of the listener.

List of Parts

One Lansing chassis and cabinet;
One Kenyon power transformer, 700 V., C.T.; 5 V.; and 6.3 V.; 60 ma., PT;
One Lansing choke, 300 hy., 20 ma., Ch.;
Two Aerovox bypass cond. 0.25-mf., C1, C4;
Two Aerovox mica condensers, 0.01-mf., C2, C3;
One Aerovox shielded condenser, 1mf., C5;
One Aerovox bypass condenser, 0.5-mf., C6;
Two Aerovox electrolytic condensers, type P-5, 8-8 mf., C7, C8;
One Centralab volume control with switch, ½-meg., R1;
One Centralab carbon resistor, 2,000 ohms, R2;
One Centralab carbon resistor, 0.1-meg., R3;
One Centralab carbon resistor, 0.15-meg., R4;
One Centralab carbon resistor, 10,000 ohms, R5;
One Centralab carbon resistor, ¼-meg., R6;
One Centralab carbon resistor, ½-meg., R7;
One Centralab carbon resistor, 600 ohms, R8;
One Blan D.P.S.T. switch;
Three Wholesale Radio Service metal-tube sockets:
One RCA type 6J7 tube;
One RCA type 6F6 tube;
One RCA type 5Z4 tube;
One Lansing 12-in. speaker, 2,500-ohm field.

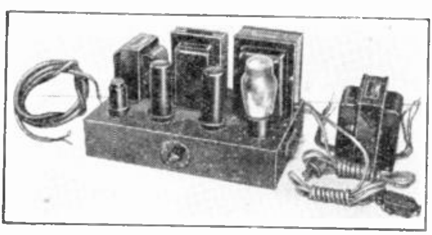


Fig. 8—Appearance of the amplifier.

Building a HIGH FIDELITY AMPLIFIER

So much has been written and said about "high-fidelity reproduction" that most people are beginning to believe that there must be something to it.

Its practical application, however, is something which is not generally understood. Furthermore, just as soon as "high fidelity" is mentioned the man in the street recoils for the reason that he has been led to believe that it cannot be had without going to considerable expense.

The 6L6 beam power tube forms the real basis for the improvement which is provided by this new amplifier and if high-grade components are accompaned by rea-

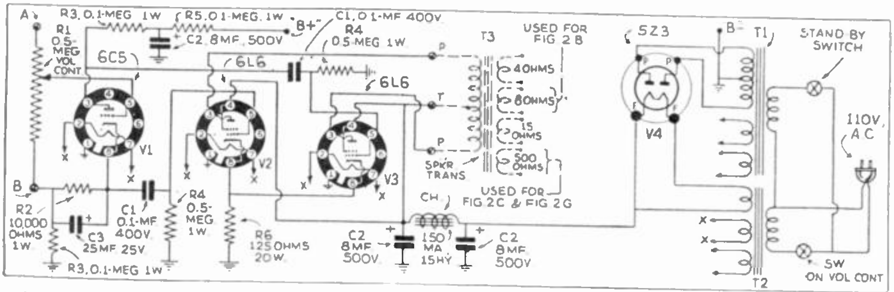


Fig. 9—The circuit is extremely simple but will produce remarkable results in undistorted output.

sonable care in its construction we will be able to provide ourselves with approximately 15 W. of what most manufacturers would be ready to call "undistorted" reproduction. It is well known that the beam power tube is rich in second-harmonics and, ordinarily, this would provide second-harmonic distortion which would be serious. This distortion is practically eliminated by using a pair of these tubes in push-pull.

The output transformer that is shown here is provided with several matching impedances. Selection of the proper loud-speaker or speakers is just about as important (if the real merits of this system are to be secured) as the selection of suitable material for use in the amplifier itself.

Much greater volume is available from this amplifier than is usable in the average living room. Therefore, instead of using a single speaker and having it droning in our ears in one part of the house and being unheard in others, we can provide ourselves with adequate volume for the "whoopie room" in the cellar, the living room and two or more of the upstairs chambers.

Briefly, the full details of the circuit for the "Kathodyne"—the name given to this type of amplifier in England and Australia where it has been in use for several years—may be had from the circuit diagram appearing in Fig. 9, the accompanying picture and the parts list. This type of amplifier circuit has been named the Kathodyne for the reason that a voltage drop, inverse in character, is provided by the voltage drop across the resistor, R 3, thus changing the amplifier from the single-ended type to the push-pull type. The importance of maintaining the cathode of the first amplifier tube—a 6C5 in this case—above the potential of the chassis on which the amplifier is built cannot be stressed too much because failure to do so will convert the amplifier, from the push-pull unit for which it is designed to the ordinary type of amplifier.

Reference to Fig. 10, particularly to the dotted line, indicates that a direct connection between the grouped portion of the radio set, used to feed the amplifier, and the chassis itself would result in the resistor R3 being short circuited.

If the builder happens to live within 10 or 15 miles of a powerful broadcasting station very satisfactory results may be obtained by applying the circuit which is shown in Fig. 11A. This circuit is very easily assembled by utilizing one of the old 3-circuit tuners, designed for use in connection with the regenerative type of receiver which was so popular many years ago. It will be observed that the normal primary of such a 3-circuit unit is not used and the coil which was normally provided for use as a tickler is now employed as an untuned antenna circuit. The rotation of this coil makes it possible for us to secure a desirable degree of coupling between the antenna circuit and the secondary tuning circuit which feeds directly into the amplifier itself. (It should be borne in mind that the 500-mmf. fixed condenser which is shown between the lower end of the circuit and the ground is absolutely essential. If it is not used the resistor, R3, will be shorted and the push-pull character of the amplifier will be eliminated, as outlined previously.)

On the whole, it is believed that this type of amplifier finds its greatest application and produces the greatest satisfaction when it is used in conjunction with modern, high-fidelity phonograph records and a good electrical pickup. The use of a crystal pickup has been found very satisfactory as well as very simple and the arrangement for employing it is shown diagramatically in Fig. 11B.

List of Parts

One Thordarson power transformer, No. 6793, 550 V., 150 ma., center-tapped, T1;
One Thordarson filament transformer, No. 7984, 5 V.-3A, 6.3 V., 2.5 V., T2;
One Thordarson output transformer, No. T-8458, push-pull 6L6s to 4, 8, 15, 500 ohms, T3;
One Thordarson choke coil, No. 17005, 150 ma., 15 hy., Ch.;
One Electrad volume control, 0.5-meg., R1;

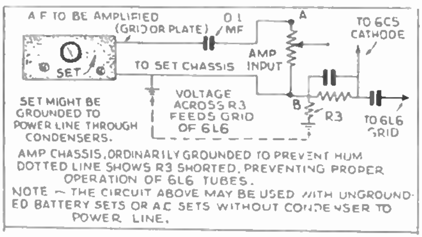


Fig. 10—Connections for use as A.F. amplifier.

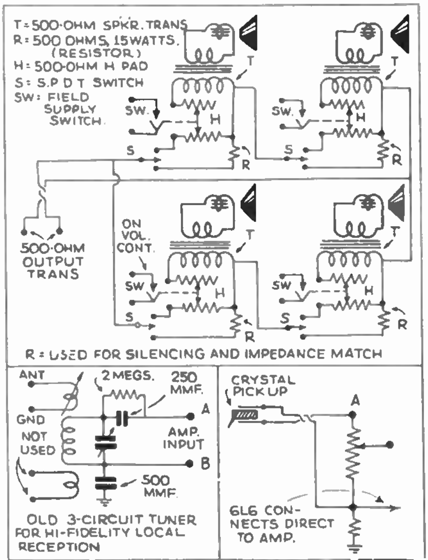


Fig. 11—Above left A. Above right, B. Below, C.

One IRC resistor, 10,000 ohms, 1 W., R2;
One IRC resistor, 0.1-meg., 1 W., R3;
One IRC resistor, 0.1-meg., 1 W., R4;
One IRC resistor, 50,000 ohms, 1 W., R5;
One IRC wire-wound resistor, 125 ohms, 20 W., R6;
One Aerovox tubular cond., 0.1-mf., 400 V., C1;
One Aerovox electrolytic cond., 8 mf., 500 V., C2;
One Aerovox electrolytic cond., 25 mf., 25 V., C3;
One Blan cord switch, Sw. 1;
One Triad 6C5 tube, V1;
Two Triad 6L6 tubes, V2, V3;
One Triad 5Z3 tube, V4;
Three ICA octal sockets;
One ICA 4-prong socket;
One chassis, 7 x 12 x 2½ ins. deep, or larger;
Two Wright-DeCoster model 982 reproducers.

35 WATTS FROM 6F6's

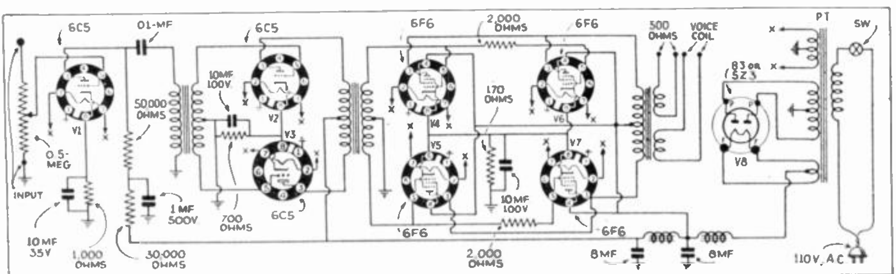


Fig. 12—Circuit of the amplifier using 4 6F6's in push-pull parallel to supply 35 W.

The amplifier described here was designed to take advantage of the benefits offered by metal tubes. It employs a high-gain circuit with an output stage consisting of 4—6F6s in push-pull parallel. Its rugged construction throughout and the fine quality of its reproduction make it particularly suitable for P.A. work.

As a starting point in the design of the amplifier, the requirements for a modern system were noted, namely:

(a) High gain (sufficient for the new microphones);
(b) High power output;
(c) Low distortion (under 5 per cent);
(d) Low hum level;
(e) Simplicity of construction.

To take care of the low output-level microphones encountered today, it was found that a gain of about 95 db. would be necessary. While this gain will take care of crystal and high-level velocity and dynamic microphones, a preamplifier should be used with the extremely low-level unit. To take care of the varied power requirements met up with in P.A. work, a power output of 35 W. was decided upon. The average amplifier available in the past to meet the specifications in the preceding paragraph would be quite a complex unit. However, through proper application of the new metal tubes, it was found possible to accomplish all this with only 3 stages, and on a single compact chassis incorporating newly-developed chromshield A.F. filter power components.

Figure 13 illustrates the appearance of the final amplifier. Figure 12 is the corresponding wiring schematic.

The input feeds directly into the first grid, with a 0.5-meg. grid-circuit volume control. Tube V1 is a 6C5. This tube is an ideal voltage amplifier as it has an appreciably higher amplification factor than the 56 or 76 (20), and has a plate resistance of only 10,000 ohms, which means that practically the entire amplification factor is made available. This tube is parallel-fed and transformer-coupled to a pair of 6C5s which in turn drive the output tubes through a special driver transformer.

Four 6F6s in push-pull parallel are used in the output stage. It was found that these tubes can deliver more power and at less distortion connected as pentodes, rather than as triodes. In the circuit shown, the available power output is 35 W. at 5 per cent distortion, and 40 W. at 7 per cent. The 6F6s in A prime operate somewhat differently than the type 42 glass tubes, and appreciably more power can be obtained from these tubes as pentodes than as triodes, and at low distortion. Due to the higher mu of the tubes operated as pentodes, low bias is required (21 V.) for A prime operation, and also less driving power is necessary. A pair of 6C5s were found capable of driving the 4 pentodes to maximum output with self-bias.

It will be noted that 1,000-ohm resistors are used in series with 1 pair of grids to stabilize the push-pull parallel combination. The input and output transformers are very important in this A prime circuit and should be perfectly matched, or the power output will be considerably reduced. The output transformer shown is universal in nature, having both a 500-ohm line termination and also a tapped voice-coil winding which will take care of any number of reproducers up to 20. The hum level is kept at a negligible volume through the use of a good 2-stage, choke-condenser filter and an additional resistance-capacity filter in the first stage.

All in all, it is apparent that the metal tubes lend themselves well to the construction of high-quality P.A. equipment.

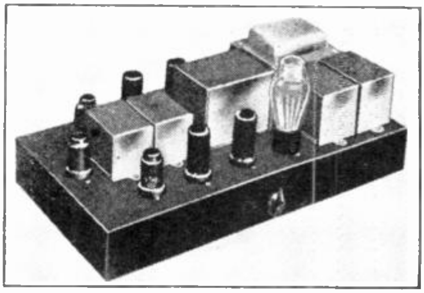


Fig. 13—The appearance of the powerful unit.

AN ADD-ON DUAL-CHANNEL AMPLIFIER

Within a few minutes' time, your present radio receiver can be changed into the most modern of all radio sets, by installing an improved simple type of Dual-Channel Audio Amplifier exactly as it is used in the higher-priced radio sets. It is a marvelous means of correcting the deficiency of bass notes which are sacrificed in amplification and transmission at many points.

The tube required for this work is the new 6L7, which is designed as a mixer tube and which has an extra grid for injecting the oscillator energy necessary for conversion. In this case, the injector-grid is used as the normal amplifier, receiving the entire audio signal, which it amplifies at a lower degree of amplification. The higher-amplification grid located at the top of the tube receives selected low-frequency audio tones in order to boost these back to their proper relationship with the rest of the music. These lower-frequency audio tones are selected by means of resistance R2 and the 0.02-mf. condenser shown in Fig. 14.

It will probably be necessary to drill a hole through the chassis to take the grid lead up to the top of the tube and it will also be necessary to use one of the new octal-type tube sockets for installation of this modern 6L7 tube.

A 2A7 or 6A7 may be used with no change in circuit constants. The low frequency channel connects to grids 1 and 2, and the high to grid 4. Grid 3 and 5 go to the 100 V. plus supply as usual.

List of Parts

One I.R.C. resistor, 2,000 ohms, ¼-W.;
One I.R.C. resistor, 0.2-meg., ¼-W.;
Two I.R.C. resistors, 0.1-meg., ¼-W.;
One Electrad potentiometer, 0.5-meg., No. C-58;
One Electrad potentiometer, 0.5-meg., No. C-59;
One Aerovox condenser, 0.02-mf., 400-V., type 484;
Two Aerovox condensers, 0.05-mf., 400-V., type 484;
One Aerovox electrolytic condenser, 60 mf., 10 V. (or use 25 mf., 25 V.), type PR-25;
One I.C.A. 8-prong octal socket;
One RCA type 6L7 tube.

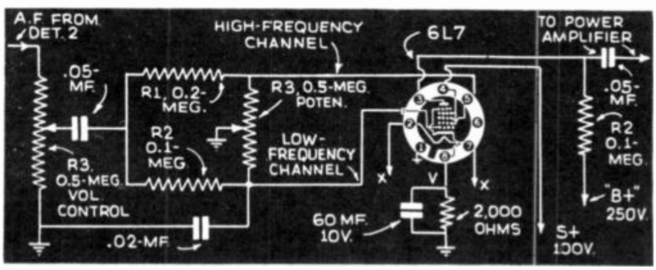


Fig. 14—A single 6L7 tube does the job. A 6A7 may also be used.

CHAPTER 4

Radio Servicing

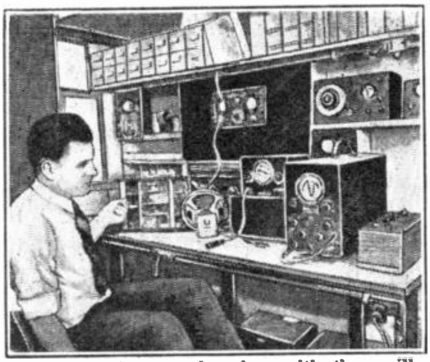


Fig. 1—A modern service shop with the oscilloscope telling the story of proper alignment.

Alignment of all-wave receivers by the cathode-ray oscilloscope method brings to light some interesting facts that are not usually noticeable in ordinary broadcast receivers.

One of the most interesting observations that can be made with the oscilloscope is in seeing the changes in the shape of the sensitivity curve of a receiver that takes place as the set heats up after it is turned on.

To observe this phenomenon it is only necessary to connect the oscilloscope and its associated equipment to the receiver under observation as shown in Fig. 1, remembering of course that in making an experiment of this kind it is necessary to use a service oscillator and frequency modulator of known stability.

Use of the OSCILLOSCOPE In Radio Servicing

Carefully align the receiver so as to obtain a good sensitivity pattern on the oscilloscope screen, then turn the receiver off and allow it to cool.

After the set has cooled completely, turn it on again and watch the shape of the alignment curve change!

From this observation we may learn a valuable lesson: Before attempting to align an all-wave receiver it should be allowed to heat thoroughly.

The variations in all-wave receiver alignment sometimes caused by imperfect variable condenser contacts and bearings are readily seen with the oscilloscope.

These variations may be observed by first aligning the R.F. and oscillator stages of the receiver in the usual manner; then detune the receiver by turning the variable condenser rotor a few degrees and return it to its original setting. If the condenser contacts and bearings are not making perfect contact, the oscilloscope screen will show that the receiver is again out of alignment.

On some receivers, it will be found that no matter how much care is taken in cleaning the condenser contacts, it still

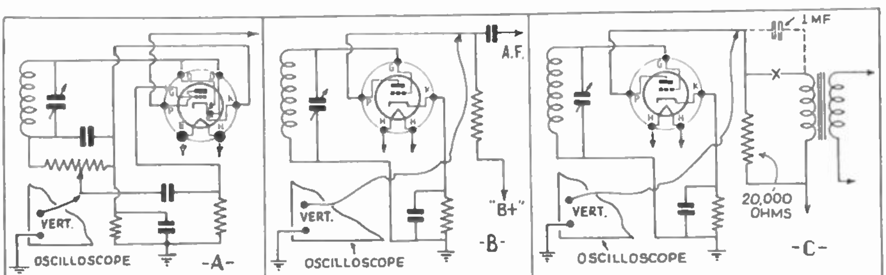


Fig. 2—A shows connections to the vertical plates. B shows connections to a resistance coupled detector, while at C are the connections for use with a transformer-coupled detector.

will be impossible to maintain a perfect alignment curve after the condenser rotor has been turned.

These sets require a slightly different method of alignment.

The correct procedure is similar to the method usually followed except that the variable condenser rotor is rocked slowly back and forth across the signal frequency while the trimmers are being turned (in much the same manner as in adjusting the oscillator padder on the ordinary broadcast receiver). If this procedure is carefully followed there will be little or no change in the alignment of the receiver after the condenser rotor has been turned.

This method of balancing receivers is now being used by many of our largest set manufacturers and is a good one for any Service Man or set builder to follow.

The choice of oscillator and frequency modulator equipment is extremely important if it is to be used for all-wave alignment purposes. The oscillator should be stable and of sturdy construction. If the motor-driven type of frequency modulator is chosen, the motor preferably should be of the induction type. The electrical disturbances sometimes caused by brush-type motors, unless elaborate filtering is employed, make them unsuitable for short-wave alignment purposes.

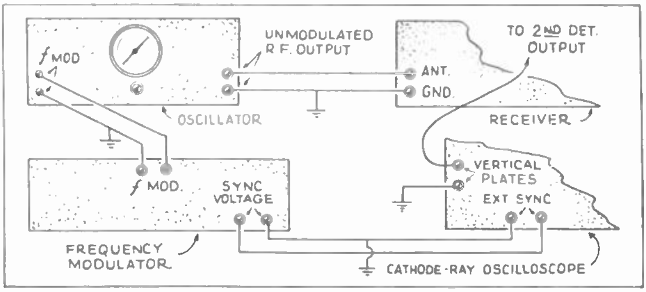


Fig. 3—Connections when a frequency modulator is used.

Those types of synchronizing voltage generators which are operated by a commutator mounted on the wobbler-condenser shaft are generally to be avoided. The slight sparking which occurs as it charges and discharges its condenser can sometimes cause considerable electrical interference in the receiver under observation.

If physically possible, the oscillator and frequency modulator should be mounted together so as to form one complete unit, with the leads from the wobbler-condenser to the oscillator made as rigid as possible. A slight change in the relationship of these leads can sometimes cause an appreciable shift in oscillator frequency on short waves.

SUPERHET SERVICING WITH ONE TEST METER

The writer has built radio sets for years and, like many others, after completing a set and not having oscillators, output meters, analyzers, etc., has been at a loss to know if the set was working efficiently.

As the meter in Fig. 4 will only react to a "tuned-in" signal, any change in the component parts of the set will cause a deflection in the meter, which indicates either increase or decrease of signal strength.

Many tests can be performed, as Table I indicates.

Table I

(1) Tuning meter.
(2) Align I.F. transformers.
(3) Align ganged condenser.
(4) Align split-rotor-plate condenser.
(5) Indicate efficiency of different antennas and grounds.
(6) Indicate "R" signal, or strength of station being received.

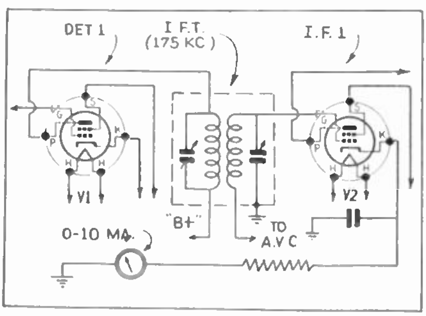


Fig. 4—Where the meter is connected.

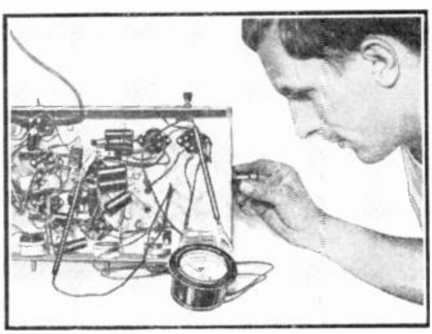


Fig. 5—The single meter in use.

(7) Indicate signal swing or extent of fading.

(8) Indicate automatic volume control action.

(9) Indicate most efficient coil for the different circuits.

(10) Indicate most efficient bias and voltages to apply to various circuits.

(11) Indicate most efficient values to use in fixed condensers and resistors.

(12) Indicate efficiency of tubes by comparison.

In detail, these various tests are made as indicated below:

(1) As a tuning meter: by rotating the tuning dial of set the meter will deflect toward zero when signal is tuned in and again return to maximum when signal is detuned; the greatest deflection towards zero indicates the station is correctly tuned.

(2, 3, 4) Tune in a station with a steady signal. Adjust I.F. transformer trimmers, the greatest deflection towards zero on the meter being the resonance point. The trimmers on the tuning condensers can then be adjusted for greatest deflection.

(5) By connecting different antennas to the set, the meter will show by the greatest deflection the antenna giving best collective results.

(6) As various stations will have a different deflection and the deflection is in direct relation to the speaker output, a volume value can be determined such as weak, poor, good, strong, very strong, etc.

(7) The meter shows at a glance whether the station turned-in is worth listening to in relation to fading; sudden drops to maximum scale reading indicate entire absence of signal.

(8) With the set tuned-in on a fading signal and the reproducer at room volume, the meter when swinging towards maximum indicates a decreased signal input.

(9) By trying different coils and windings the greatest deflection will indicate the most efficient coil.

(10) As tubes and circuits will work best at certain voltages, these voltages can be adjusted to get greatest signal strength on the meter. The bias values can be treated in the same manner.

(11) Fixed condenser and resistor values can be determined as these units directly effect the signal strength and therefore the meter will indicate best values.

(12) Tube performance can be determined as the meter will show the difference between a good and poor tube.

The Tapers and Uses of MODERN POTENTIOMETERS

In most volume-control circuits, the **taper of the variable resistor used is far more important than its maximum resistance.**

Nevertheless, countless orders for variable resistors are placed every day with just the maximum resistance specified. If the order comes from a distance, the jobber must delay it several days while writing for additional information or fill the order promptly with the taper he considers most universal. Should the taper so selected give poor service, the make of control is condemned rather than the method of ordering which was really at fault.

Several years ago one company standardized upon 6 variable resistance tapers as suited to any probable radio need. About a year ago, however, curve No. 5

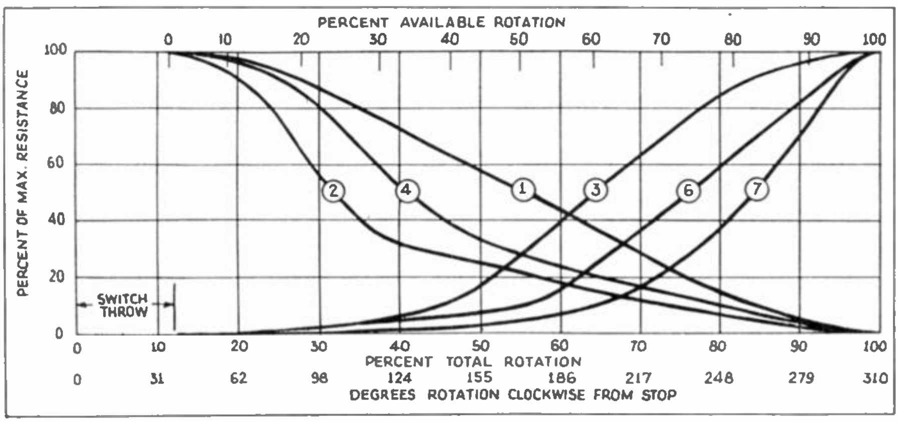


Fig. 6—Standardized curves widely used potentiometers.

was omitted as unnecessary, and curve No. 7 was added. These curves are shown in Fig. 1.

Resistance tapers 1, 2 and 4 are illustrated with the low end of the taper at the right side of the chart, because they are intended for circuit locations where smooth resistance change from the right terminal is most important, and are tested from that end in manufacture. Curves 3, 6, and 7 are commonly used in circuits where smooth resistance change from the left end is most important, and are therefore tested from the left terminal.

Figure 2 illustrates the 18 basic circuits that are commonly used for volume or tone control.

Taper 1 has uniform resistance change from either end. It has a uniform load characteristic dissipating 1 W. through the total resistance, ½-W. through the total resistance, etc. It is the safest taper to use when in doubt since fair control may be obtained with it in almost every circuit, although the taper properly designated will give better control. Commonly used in circuits 4, 5, and 15.

Taper 2 has slow resistance change at maximum volume. The rate of change progressively increases as the knob is rotated counter-clockwise. This is sometimes termed a **reverse log** taper. Principally used as a series rheostat in the cathode or plate circuit where the current carried may be heavy at maximum volume but very small at minimum volume. Recommended for circuits Nos. 4, 8, or 9.

Taper 3 has very slow resistance change from the left or minimum volume end with a smooth change from the right end. This taper was especially developed for the many receivers using a single potentiometer to control both the antenna and "C-bias" circuits. Use where the control changes the bias of 1 or 2 tubes with the maximum resistance not exceeding 25,000 ohms. Do not use when controlling the bias of more than 2 tubes or with heavy bleeder current, for this taper may then be overloaded and eventually burned out. Taper 3 may be used in circuits Nos. 1, 3, or 6.

Taper 4 has slow resistance change from the right or maximum volume end with a short taper from the left end. Like curve 3, it is intended for antenna—"C-bias" circuits. With the same overall resistance as taper 3, taper 4 will carry much more current in the "C"-bias circuit because of the more gradual resistance change from the right end. Use where "C-bias" change gives the principal volume-control effect. Commonly used in circuits Nos. 7, 8, or 9.

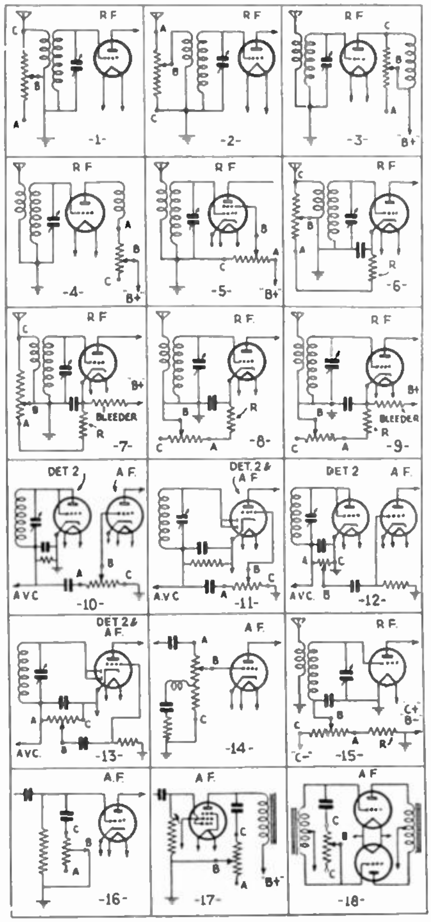


Fig. 7—Variable resistance circuits.

Taper 6 is a **semi-log.** curve with slow resistance change from the left or minimum volume end. Used as an antenna shunt, as a tone control, and as a volume level control in the A.F. control-grid or in most A.V.C. circuits. Recommended for circuits Nos. 1, 2, 3, 10, 11, 12, 13, 16, 17, and 18.

Taper 7 is a **true log.** curve providing straight line attenuation over a range of 60 decibels. It is a very expensive taper to manufacture.

Resistance in Series

$R = R_1 + R_2 + R_3 \ldots . R$

Where: R is the total value of all resistors connected in series.

R_1, R_2, etc. are the individual resistors.

Resistance in Parallel

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{R_1 \times R_2}{R_1 + R_2}$$

THE VARIABLE IMPEDANCE OUTPUT TRANSFORMER

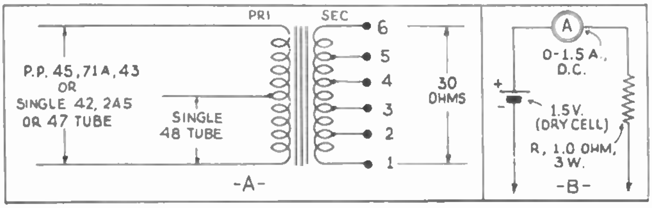


Fig. 8—At A is shown the connections for use of the output transformer. At B is the low range ohmmeter. A low priced meter may be used satisfactorily.

There is on the market a "universal output" transformer so designed that it enables the Service Man to service a large number of radio sets with a single unit in the event of output transformer failure.

The novel feature of the transformer is that although the primary is untapped, it matches almost any single tube or push-pull output stage. For push-pull operation, correct primary matching is obtained when 71A, 45, 50, or 43 type tubes are used. For single tube output using the total primary, correct matching will be obtained with the 33, 47, 41, 42, or 2A5 tubes. One-half of the primary can be used to match to a single 48 tube.

The various load impedances and their respective terminal connections are given below:

Impedance (ohms)	Terminal numbers	Impedance (ohms)	Terminal numbers
1	4-5	14	2-4
2	4-6	16	1-4
3	3-4 or 2-3	22	2-5
4	1-3	25	1-5
8	3-5	28	2-6
12	3-6	30	1-6

The Service Man usually does not have the facilities for direct measurement of the voice-coil impedance of a speaker. For all practical purposes the impedance of a voice coil is 30 per cent greater than the D.C. resistance. Then to determine the impedance of a voice coil, it is merely necessary to measure the D.C. resistance and multiply this value by 1.3.

A resistance bridge is not necessary for measuring the D.C. resistance of a voice coil. A low-range ohmmeter is sufficient to give the necessary accuracy. The essential parts of such an ohmmeter are: a single dry cell, a 1.5A. D. C. ammeter, and a 1-ohm, 3-W. resistor.

For example ,let us suppose that a certain voice coil gives a reading of 0.55-A. on the ohmmeter mentioned. The D.C. resistance is then equal to $\frac{(1.5-1)}{0.55}$ or 1.73 ohms. Multiplying 1.73 by 1.3, the impedance is 2.25 ohms. Terminals 4 and 6, from the chart, would then be the correct terminals to which the voice should be connected.

In addition to being universal electrically, this output transformer is also universal from a mounting standpoint.

Many Service Men have found it to their advantage to carry in their stock one of these versatile transformers because of its adaptability to a large proportion of the radio receivers in use.

HOW TO ALIGN MULTI-BAND RECEIVERS

Present day receivers present many problems not the least of which is proper alignment.

All-wave receivers like their brothers of the broadcast group can and will get badly out of alignment in a comparatively short period of time. Lack of sensitivity due to this condition was not so apparent in broadcast receivers where local reception still continued to be satisfactory.

As approximately 95 per cent of the all-wave receivers are of the superheterodyne type, first consideration should be given to the intermediate frequency amplifier as this part contributes most of the gain.

A well-designed test oscillator having constant-impedance attenuation characteristics (such as found in the Weston Model 692) should be connected from the control-grid of the first-detector tube, to the chassis of the receiver. A shorting clip in the form of a piece of metal or a small screwdriver should be carefully placed between the plates of the receiver oscillator gang condenser, thus shorting this unit and causing the receiver oscillator section to stop functioning. The test oscillator should then be turned on, and set to the exact frequency shown on the calibration curve as being the I.F. called for by the manufacturer. It is important that the oscillator be furnished with accurate calibration surves as further alignment of the receiver will be almost impossible unless the I.F. setting is in accord with the manufacturer's specification. Put the radio set in operation. The oscillator should then be turned on, and the attenuator turned up to a position where a signal is heard in the receiver speaker. The volume-control should be placed in the "maximum" position, and an output meter of a copper-oxide rectifier type (Weston Model 571 or 695, or equivalent) connected either from plate-to-plate of the output tubes, or through the series condenser from the single output tube plate to chassis.

If, when the oscillator is turned on, no signal is heard in the speaker and no indication is shown on the output meter, the oscillator control should not be disturbed.

Instead, the trimmers in the I.F. transformer should be adjusted until a signal is heard, or is indicated on the output meter. The trimmers should then be adjusted for peak output indication starting from the first-detector I.F. transformer and working back to the second detector. As higher and higher peak indications are obtained on the output meter the oscillator attenuator should be turned down, while still keeping the output meter "on scale." **Do not make this adjustment by turning down the receiver volume control.** If the receiver is equipped with automatic volume control, it is best to eliminate this action by removing the A.V.C. tube. If this cannot be done without stopping the functioning of the receiver, the A.V.C. lead connecting to the return grid circuits of the I.F. tubes should be grounded to the chassis. If neither of these arrangements is convenient, alignment should be made below the voltage level where the A.V.C. operates. This can be done by turning the attenuator down to a very low value and working at this point.

Connect the service (test) oscillator to the antenna and ground posts of the receiver and remove the shorting clip on the receiver oscillator gang section. If possible the A.V.C. action should be stopped as mentioned above under I.F. alignment. Turn the receiver to broadcast band and set the oscillator tuning control at 1,400 kc. Turn on the oscillator and tune in the signal on the receiver. Adjust the shunt padders on the oscillator and first-detector circuits (also, the R.F. section if there is one) in the order mentioned. If there are trimmers for each band available, make sure that the ones adjusted are those for the broadcast band. The shunt trimmers can be differentiated from series padders by noting the number of foil sections, shunt padders having only one pad while the series padders have several, the capacity being somewhere around 800 mmf.

Turning the oscillator tuning control to the 600 kc. point, again tune in the signal. Most all-wave sets manufactured today are equipped with an **oscillator series padder** indicated for reference in Fig. 9. Having tuned in the signal while obtaining a reading on the output meter adjust the series padder for maximum reading. **As the oscillator frequency practically determines the whole tuning of the receiver this adjustment should be made very carefully.** To make sure that it is correctly aligned the receiver dial should be moved either to the right or to the left approximately 5 kc. The oscillator series padder should again be adjusted and a notation made as to whether the reading was higher on the output meter than before. If this is found to be the case, the receiver dial should be moved another 3 or 4 kc. and a third adjustment made. If it is found that lower readings are being obtained the dial should be turned in the reverse direction and the same procedure gone through.

Turn the receiver to the first short-wave band and tune the oscillator to a frequency indicated by the receiver dial as being approximately 10 per cent of the highest frequency for that particular range. Locate the shunt trimmer for this band by touching a screwdriver to each of the trimmer condensers and notice which one causes a change in signal intensity indicating that it is in the R.F. circuit. Make sure that this is the shunt trimmer for the band as indicated by the very small capacity of the unit. Having tuned in the oscillator signal correctly adjust this trimmer for a maximum indication on the output meter. Examine the other trimmers and note whether or not there is a series padder for this band. If there is, tune the receiver and oscillator to a point 10 per cent up from the lowest frequency for the band and make the same type of adjustment as covered by the directions given for aligning the low-frequency end of the broadcast band.

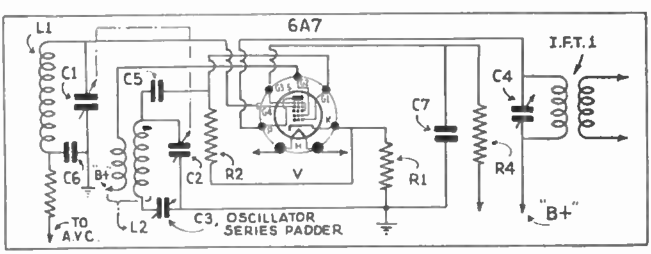


Fig. 9—The various condensers associated with the oscillator.

SERVICE SHOP IDEAS

Contests, such as the "Ideal Radio Service Shop" contest sponsored by **Radio-Craft** recently, always brings to light a great many interesting ideas which the participants never fail to incorporate in their letters. The hundreds of letters which the judges of this particular contest were called upon to read revealed an unusually large crop of these clever shop hints or "kinks" which the men had mentioned along with their description of their ideal service shops. Some of these ideas were so interesting that it was thought worthwhile to record them here for the benefit of the large number of Service Men who are always on the alert for new ways to improve their shops and their service. The "kinks" listed here may not be original, or they may not even be new to many readers—no such claims are made for them. They are presented here mainly for completeness, and for their general interest. Here they are:

(1) Build and equip a small combination "test" and "work" bench especially for auto-radio work, and mount it on castors so that it may be brought right up to the car. A discarded "tea wagon" serves nicely for this purpose. It may also be wheeled to any part of the shop to serve as an "auxiliary" or "emergency" test panel.

(2) Have your test panel hinged at the bottom so that if anything goes wrong, it can be swung forward and the connections checked or the repairs made. It is good policy to have all panels enclosed at the rear for protection against dust.

(3) The complete test panel rack can be mounted on four rollers, free to run on a pair of rails embedded in the entire length of the bench top. In this way one set of test units can serve two men working on a test bench.

(4) Have small compartments or drawers below the test panel for keeping replacement resistors, condensers, etc., within convenient reach while working on sets.

(5) Have a "substitution" panel, which consists of various common replacement components, with their terminals brought out to tip-jacks, so that any of these can quickly be hooked into its respective place in a receiver circuit. These units may be various values of resistors, condensers, R.F. and I.F. coils, R.F. and A.F. chokes, transformers, tuning condensers, and coils (all-wave and broadcast band), universal input and output transformers, etc.

(6) Have lights (with conical shades or reflectors) so arranged that they can be slid along a trolley wire to any position over the test panel.

(7) Have a small, flexibly-mounted spotlight arranged on an arm attached to the bench for concentrating light on any job.

(8) Have various types of aerials available at the service bench with outlets at various points on the bench.

(9) Keep a clock right in front of you on the service bench for accurate estimation of the time spent on service jobs.

(10) Use an "adjustable" chassis cradle mounted on castors, with a light over it, so that it can be raised or lowered. The angle should be adjustable.

(11) Use a fixed crystal detector and phone unit for quickly checking the operation of the various R.F. stages.

(12) Build a small "signal detector" consisting of a small all-wave 1-tube oscillating circuit receiver with a calibrated dial and an amplifier. It is capable of being used as a grid-dip meter, or oscillating-type wavemeter for detecting the exact frequency of the oscillator in any superheterodyne receiver under test, or as a means of determining if a signal is being received through any tubes up to the demodulation of the radio under test by clipping the lead from the signal detector to the proper place.

(13) Use a phonograph record in place of an A.F. oscillator to modulate the R.F. signal for adjusting high-fidelity receivers.

(14) Have a set of A.F. test records that cover the entire high-fidelity A.F. range. When these are played through a good pickup and A.F. amplifier they may be used for checking the performance of A.F. amplifiers, loudspeakers, photo. pickups (used alone), etc.

(15) Have felt or sponge-rubber pads on which to rest the set chassis while it is being repaired. This prevents damage to frail coils, wiring, etc.

(16) Build a service manual holder, which will hold the manual open at any desired page, and can be mounted above the bench panel on a ball and socket joint so that it can be swung or tilted to any position.

(17) Have an electrically heated, well-insulated chassis heating and cooling oven, in which the entire receiver may be placed in order to locate thermal abnormalities which are causing intermittent reception, noises, etc.

(18) Have a D.C. powerpack at hand for supplying high voltage to test condensers for shorts, breakdowns, leakage, etc.

(19) Have a small portable 6 V. D.C. to 110 V. A.C. "inverter" for furnishing the power to test equipment such as tube checkers, etc., when working in districts where battery-operated receivers are found.

(20) Have a small motor-driven hair drier for blowing out the dust from set chassis and loudspeakers.

(21) Have one or two midget receivers at hand for customers' use while sets are being repaired.

(22) Have a good receiver in the shop at all times to use as a standard of comparison in pointing out to the customer the fault of, or deficiencies in his own set.

(23) Keep a cross-index reference system filed on large sheets in letter files containing clippings from magazines, house organs, etc., which contain useful service information.

COMMON RADIO TROUBLES

The following listing of common radio troubles gives a general idea of where to look for a certain fault. It is of necessity rather general, but may well be used as a rough outline when attempting to locate radio troubles.

ALIGNMENT OF STAGES
- Lack of sensitivity
- Spotty sensitivity
- Poor tone quality
- Circuit oscillation
- Code interference
- Off-calibration of dial
- Poor selectivity
- Spotty selectivity

A.F. TRANSFORMERS
- Noisy reception
- No reception
- Reduced volume
- Intermittent reception
- Poor tone quality

FILTER CONDENSERS
- Excessive hum
- No reception
- Low volume
- Intermittent reception
- Circuit oscillation

TUBES
- No reception
- Distortion
- Hum
- Off-calibration of dial
- Lack of sensitivity
- Loss of selectivity
- Microphonics
- Intermittent reception
- Fading
- Poor A.V.C. action
- Noisy reception
- Circuit oscillation

POWER TRANSFORMER
- No reception
- Intermittent reception
- Excessive noise
- Excessive hum
- Short tube life

LINE CORD AND PLUG
- Intermittent reception
- No reception
- Noisy reception

HOUSE WIRING
- Intermittent reception
- No reception
- Noisy reception

PIPES IN HOUSE
- Intermittent reception
- Noisy reception

ATMOSPHERIC CONDITIONS
- Fading
- Noisy reception
- Distortion
- Lack of short-wave reception
- Cross-talk

WAVE-CHANGE SWITCH
- Loss of volume on short waves
- Intermittent operation
- No reception
- Noisy reception
- Short-wave dead spots
- Fading
- Loss of volume
- A.V.C. not functioning

RESISTORS
- Intermittent reception
- Distortion
- Poor A.V.C. action
- Fading
- Circuit oscillation
- No reception
- Low volume
- Short tube life

REPRODUCER
- Distortion
- Tinny sounds
- Scratching and grating
- Excessive hum
- Intermittent reception
- No reception
- Low volume

VOLUME AND TONE CONTROLS
- Noisy reception
- No control of volume
- Sudden change in volume
- No control of tone
- Sudden change in tone
- Intermittent reception
- No reception
- Loss of sensitivity
- Circuit oscillation

LOCAL MACHINERY AND APPLIANCES
- Noisy reception
- Clicks
- Sudden change in volume

BYPASS CONDENSERS
- Circuit oscillation
- Poor tone quality
- Cross-talk
- Intermittent reception
- Poor A.V.C. action
- Fading
- Loss of volume
- Hum
- Excessive hiss
- Noisy reception
- Off-calibration of dial
- No reception
- Short-wave dead spots

SHIELDING OF SET AND COMPONENTS
- Circuit oscillation
- Microphonics
- Noisy reception
- Lack of sensitivity
- Cross-talk
- Fading
- Intermittent reception

ANTENNA, GROUND AND LIGHTNING ARRESTER
- No short wave reception
- Intermittent reception
- Poor reception
- Lack of volume
- Excessive noise
- Fading

I.F. WAVETRAP
- Code interference
- Intermittent reception

R.F. AND I.F. COILS
- Intermittent reception
- Off-calibration of dial
- Poor selectivity
- Spotty selectivity
- Lack of sensitivity
- Spotty sensitivity
- Poor fidelity
- No reception
- Fading
- Cross-talk
- Circuit oscillation

TUNING CONDENSERS
- Noisy reception
- Dead spots
- Intermittent reception
- Microphonic howls
- Off-calibration of dial
- Fading

RADIO CABINET
- Resonance
- Tinny sounds
- Rumbles

WIRING OF SET
- Noisy reception
- Excessive hum
- Circuit oscillation
- Lack of short-wave reception
- No reception
- Cross-talk

OSCILLATOR SECTION
- Lack of sensitivity
- Excessive hiss
- Distortion
- Erratic operation
- Dead spots on short waves
- Frequency instability
- Intermittent operation

(Original compilation courtesy Radio Today; modifications by Radio-Craft.)

CHAPTER 5

Articles of General Interest

The Design of CLASS B TRANSFORMERS

In order to get the best results from a class A prime (AB) or class B amplifier system, it is essential that the power supply unit deliver a constant voltage to the amplifier. In other words, the power supply must be capable of delivering the same voltage under full-load as under no-load conditions, which is commonly expressed as "good voltage regulation." Not only does the amount of voltage regulation affect the total power that may be derived from an AB or B system, but it also controls the total harmonic distortion as well.

The heart of the power supply is, of course, the power transformer, which should have a voltage regulation close to 2 per cent, which means that in the case of a unit supplying 400 V. A.C. plate volts the value should not vary more than about 8 V. This is easily accomplished by using a relatively heavy wire in the primary and the high-voltage windings, and by employing a 50-cycle core for 60-cycle operation.

Next in importance is the filter system. It is essential to use choke input to obtain a relatively constant output voltage. This input choke should have a relatively low resistance—the lower the better. A choke of not more than 100 ohms should be employed for a 20 W. class B amplifier and not more than a 50 ohm choke for a 50 W. amplifier. This choke input not only reduces any peak voltages and surges from the power supply output, but also greatly reduces the strain on the filter condensers. The first filter condenser should be about 16 mf. for best results. The input choke itself, however, should have enough inductance so that the "B" voltage for the output tubes can be taken directly after this first choke. This inductance should be 20 hys. or more at the maximum current drain.

The selection of the rectifier tube itself is quite important, and wherever possible the use of a mercury tube rectifier is recommended as its terminal voltage drop is not only very small (in the neighborhood of 16 V.) but it remains constant and is independent of the load while the rectifier tubes such as the type 80 rectifiers vary between 320 V. and 180 V. with a corresponding load of 0 to 150 ma. In other words, the type 80 rectifier tube has very poor voltage regulation while the mercury vapor tube, such as the 83, 866, etc., has excellent voltage regulation.

In order to design and build a satisfactory (A.F.) transformer for class AB or B operation, it is important to realize that grid current is drawn by the output tubes, which in the case of a type 46 class B tube, for instance, is about 10 ma. at full load. To prevent this grid current from introducing a degenerative voltage into the transformer, it is essential to keep the D.C. resistance of the secondary winding at a low value. (In the case of the transformer specifications given in Fig. 1 the resistance of the total secondary is only about 300 ohms.)

TABLE I

Class B Power Transformer for 4—6A6 tubes in a 50 W. Amplifier

Core Stack: 1½ x 2 ins.

Winding Space: 2¼ x ¾ in.

Primary: 113 V. 60 cycles; 245 turns No. 20 enameled wire. Secondary Shield.

Secondary winding: 360-360 V. at 210 ma.; 825 x 825 turns No. 30 enameled wire.

Rectifier winding: 5 V. at 3 A.: 5½ x 5½ turns No. 16 enameled wire.
6.3 V. at 8 A.: 7 x 7 turns No. 13 enameled wire.

TABLE III

CLASS B OUTPUT TRANSFORMER

Plate-to-Plate Load Impedance: 5,000 ohms.

Core: 1⅛ x 1⅛ ins.

Window: 1-11/16 x 9/16 in.

Primary: 2 windings side-by-side, 1,300 turns (each) No. 32 enameled.

Secondary: 500-ohm winding: 865 turns No. 27 enameled.

TABLE II

Input	Plate Volts	Pri. to ½ Sec. Ratio	Output Tube Set-up	Power Output Watts	Total Harmonics (per cent)
1—56	250	5.0	1—6A6 B	10.5	9
1—59	250	4.0	2—6A6s B	20	10
1—46	300	2.2	2—46s B	16	5
1—59	400	3.0	2—59s B	21.5	4.8
2—56s	250	3.33	2—45s AB	17.2	5
1—56	250	1.48	2—45s AB	11.5	5

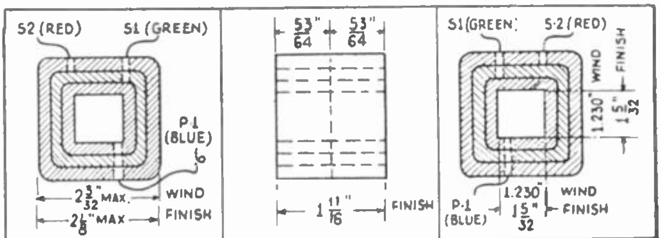
This grid current has a tendency to drive the driver tube (plate voltage, either up or down) if the latter hasn't enough driving power by itself or if the step-down ratio from the driving tube to the output tubes is not large enough. The greater the step-down ratio and the greater the undistorted output power of the driver tube, the greater the maximum undistorted output that may be obtained from the output tubes. Thus in the case of one 53-tube as a class B output stage, from 8 to 13 W. may be obtained from it with the same maximum harmonic distortion, by using different driver tubes.

It should also be noted that when D.C. flows through the primary winding, the transformer core should be assembled in such fashion that a small air gap is provided, as the D.C. might easily saturate the core and thus produce harmonic distortion. Table II gives some of the recommended transformer step-down ratios for various applications.

As you see from the specification diagram, Fig. 1, the transformer is made up of 2 separate coils. This construction results in an identical resistance, capacity and inductance in each grid circuit, and by reducing the distributed capacity thereby the losses at the higher frequencies are automatically decreased.

The primary consideration in the design of class A prime (or AB) and class B output transformers is the insulation between winding, winding and core, etc. If the load is accidentally disconnected from the secondary winding of the output transformer such high voltages may be induced at full load that breakdown might occur between the output leads, between the windings, between the windings and core, or, if the transformer is well insulated, there might be arcing between the tube terminals (resulting in the breakdown of the tube socket or of the tube itself).

Naturally, the transformer should not only handle the output power without overheating, but also without appreciable losses. This, again, makes it necessary to use the heaviest possible wire in all windings. As pointed out above under "Power Supply," any resistance introduced into the plate circuit of the output tubes will cause a decrease in the maximum available undistorted output. Thus the D.C. resistance and the total primary winding in the output transformer should also be kept as low as possible and should not be more than about 300 ohms in the case of 246s or two type 59 tubes, in class B. Table III gives full specifications for an output transformer employing 2—6A6s in the output stage of a 20 W. output class B amplifier.



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COIL SECTION	PRIMARY	SECONDARY	TERTIARY
TURNS	2 SECTIONS 560 PER SECT.	2 SECTIONS 840 PER SECT.	2 SECTIONS 610 PER SECT.
SIZE OF WIRE	Nº 32 ENAM	Nº 32 ENAM.	Nº 32 ENAM.
WINDING LENGTH	41/64-IN. PER SECT.	41/64-IN PER SECT.	41/64-IN PER SECT
KIND OF LEAD	16 & Nº 34 SIL BRD. D.C BRD LACQUERED		
LENGTH OF LEAD	10 INS	10 INS	10 INS.
TURNS PER LAYER	63--- 89% 9 LAYERS	63-- 89% 14 LAYERS	63---89% 10 LAYERS
WRAPPER	2 LAYERS, .002 IN.	2 LAYERS, .002 IN.	1 LAYER, .005 IN.
TREATMENT	PARAFFIN AND RESIN		
TESTS	CONTINUITY, TURNS, POLARITY AND SHORT-CIRCUITS		

Fig. 1. Constructional data for building a Class B input transformer.

Build This NEW TREASURE LOCATOR

Although designated as a "treasure locator" this apparatus will be valuable for many less "romantic" uses, such as finding buried pipes and other metallic objects.

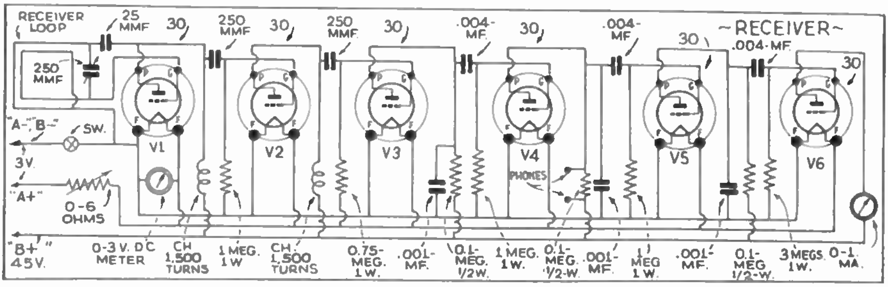


Fig. 2. Circuit of the receiver. A meter enables constant check of filament voltage.

Many circuits and descriptions have been published dealing with so-called metal or "treasure" locators; but most attempts by the amateur to build such an instrument result in an instrument with instability of circuits, very little penetrating power, and, in general, very poor results. When attempting to experiment with a locator using the principle of a radio balance, it is most necessary to understand the electrical fundamentals of such equipment.

In general, the radio balance consists of a modulated transmitter (working on a frequency anywhere between 50 and 3,000 kc.), the output of which is coupled to a balanced loop antenna; and a very sensitive loop receiver coupled to a headphone set and some form of tube voltmeter. It is most essential that there shall exist no coupling between the transmitter and receiver, except through the loop antennas.

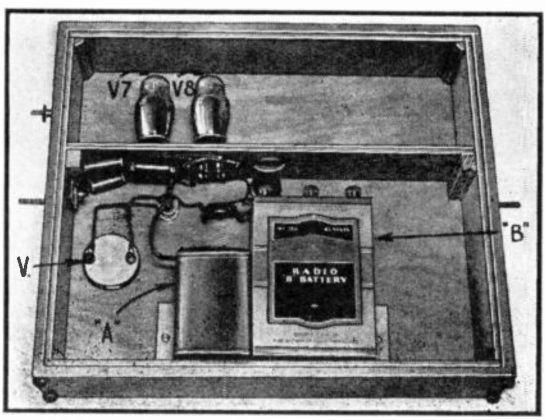


Fig. 3. The transmitter. The loop antennt surrounds the case.

To insure proper position, the transmitter and receiver are connected by handles; the closer they are placed to each other, the more sensitive the arrangement for small objects but, also, the less its actual depth range. Increasing the length of the handles increases the depth range, but objects to be located must be much larger. This phenomenon is the most puzzling one to experimenters, who want to get a great depth range, yet locate very small objects. A compromise must be reached, most effective with about 4 ft. handles (illustrated).

Employing a frequency of about 3,000 kc. will make the arrangement so sensitive that a piece of metal 1 ft. square can be detected through the air to a distance up to 10 ft. (through water, roughly 5 ft.); but, from the point of practicability, such an instrument is by far too sensitive when carried over rough territory and through brush and undergrowth.

For commercial use, a low frequency, seldom more than 200 kc., is used. For satisfactory operation, an instrument of this kind should be carried at least 1 to 1½ ft. above the actual surface. Even in that position the instrument is so sensitive that a change of rock formation (for example, between quartz and schist, or slate and diabase) can be noticed in the headphones—a feature which is most valuable during the process of electrical geophysical prospecting. In addition to taking a reading from directly above, to determine position, the user may wish to take an off-side reading and then, by triangulation, find the depth of the object. This is conveniently accomplished by mounting a simple bubble-level clinometer on top of the receiver, as

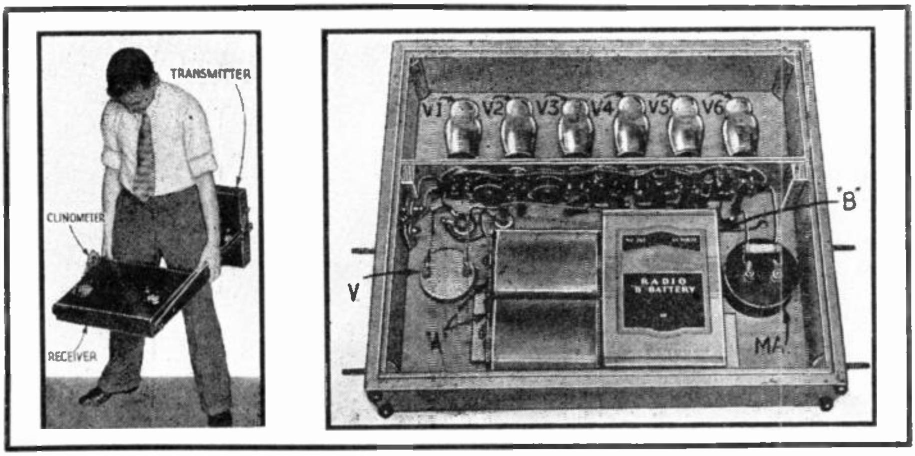


Fig. 4. Left, apparatus in use. Right, inside of the receiver unit. Note triode tubes.

shown in the action photo. Claims far too excessive have been made for instuments of the above nature; but a radio balance built properly will do very exceptional things, with a result that many large companies now make use of the device for different purposes.

The experimenter should consider that tests on newly buried metal objects are nearly always a failure and, before maximum indications from such metal objects can be expected, the same should be buried for a considerable time—long enough to allow the chemical reactions between the metal and the ground to insure proper contact. It should be recognized that the eddy currents, set up in a metal object by the radio transmitter, will create only a small field if the metal is insulated; but in firm contact with the ground, they will cause a great distortion in the electrical field, due to the fact that the ground is a conductor. This conductivity depends on moisture content, and inherent mineralization; it may be rightly assumed that moist ground permits most effective work.

The field for the experimenter is still wide open. For example, a push-pull tube transmitter could be used, and a superheterodyne receiver; but it always should be kept in mind that the simpler the circuits, the fewer batteries need be inserted in the loop antenna and, the less metal used in the construction of the radio balance, the better will be the results. (All the equipment within the loops must be kept as far from the respective loop as possible.) The diagram shown represents a simple and very effective instrument, with full values for the guidance of the constructor. By changing the inductance of the loop antenna, varying the impedance of the choke coils (as used here, they are random wound on a form about ½ in. wide and ½ in. in dia.). and changing the capacities, the frequency range can be changed to suit the experimenter. Using triodes, as shown, in preference to screen-grid or pentode tubes results in least inherent noise level. The completed loop may be impregnated with beeswax.

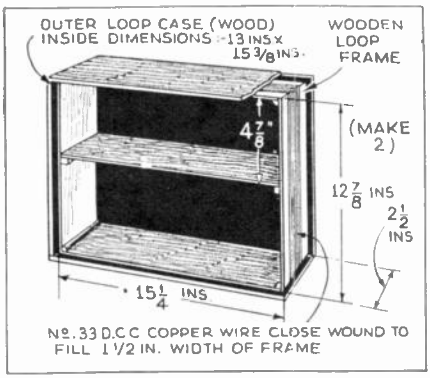


Fig. 5. Dimensions of the cases for the two units. Both cases are built exactly the same.

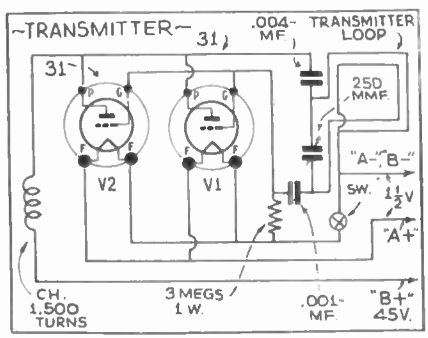


Fig. 6. Two tubes are used in parallel. Filament voltage is only 1½ V.

CONSTRUCTING A 5-METER PORTABLE STATION

This outfit is not a transceiver, since a separate tube and tuning circuit is used for both transmitting and receiving. Interference and radiation are thus cut to a minimum.

This set is quite simple to construct, although it must be admitted there is a lot of work to it. The first job is to cut and bend the subpanel to fit the box. The edges of the subpanel are bent down for ⅜ in. all around, to give strength and provide a means of fastening to the box itself. The 5 x 6 x 9 in. box is a standard size, so a layout (not to scale) of the box is given showing locations of parts on the side and front. It is advisable to cut the holes in the front of the box first, after making sure the parts will fit as shown. Then, with the panel equipment temporarily in place, the parts may be placed and marked on the subpanel. It is strongly recommended that the layout shown in the interior photos be closely followed.

The change-over relay is a special item which fortunately can be procured ready to use. The relay shown was made from the parts of the original, but mounted on a smaller base. In the layout shown, this remounting is unnecessary, the relay being used just as it comes. It may be mentioned here that for some reason the manufacturer provided 4 moving contact arms, but the adjacent arms are not connected together, one arm of both top and bottom pairs being "open." They must be connected in pairs so that the relay becomes, in reality, a double-pole double-throw switch.

A sensitive microphone, and one of low resistance, is needed to pass enough current to operate the relay on the 6 V. filament battery. Such microphones are to be had for a reasonable outlay. (The writer made up a neat hand microphone by fitting a lapel-type "mike" into an earphone case, as shown in Fig. 10; a push button was set into the side of the case.) The 500 ohm relay drops the voltage applied to the low resistance unit to a safe value. The relay winding and condenser C7 also serve to filter the microphone circuit, and to prevent a ripple from the power supply (which sometimes causes trouble).

The input circuit of the 955 detector is of the high "C" (high capacity) type, which gives best results with this tube. It is a simple matter to get well within the 5-meter band with this system, no cutting of coils being necessary. The small compression condenser, C4, will be used at a rather high capacity setting.

The cathode bias resistor of the 41 tube is of high value to reduce the plate current somewhat, since the full power output of this tube is not required and we wish to conserve plate current as much as possible. The 79 tube works as a conventional class B amplifier.

The RK-34 is a dual tube something like the 6A6, but having lower amplification factor. Thus it acts as a conventional tube, the plate current increasing as it is loaded up, and not the opposite as with the 6A6 or 53. Also, it is designed for high-frequency work, and does its job beautifully.

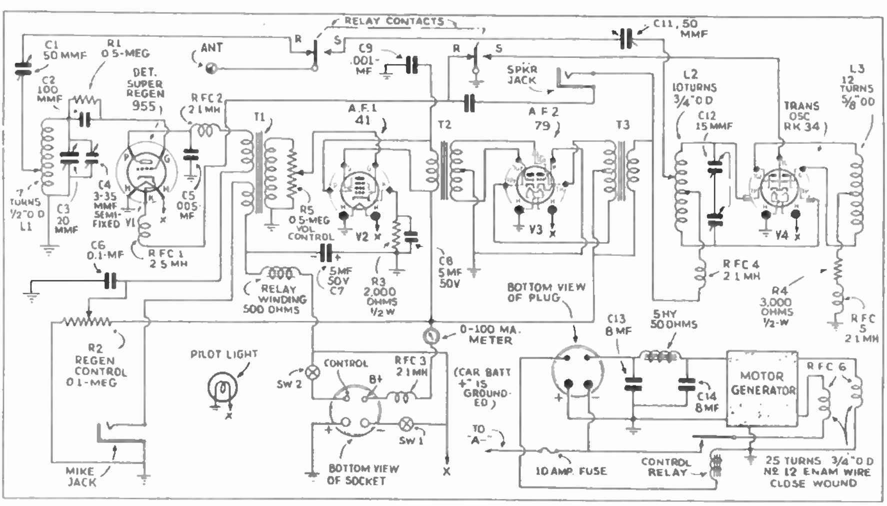


Fig. 7. The complete circuit of the portable station, including the power supply.

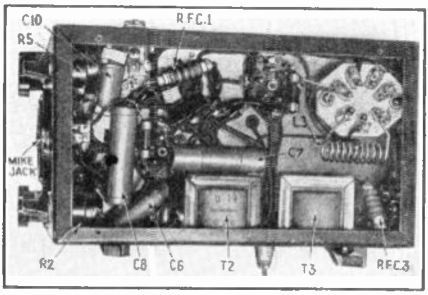


Fig. 8. Underside of the set. Note the oscillator grid coil at the middle left.

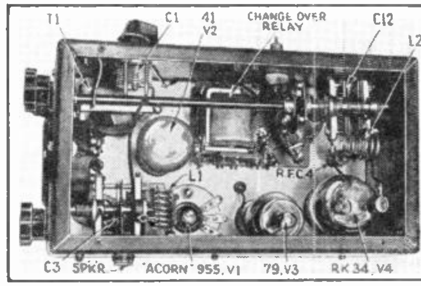


Fig. 9. Top view of the case. The receiver antenna condenser is at the top of the box.

The usual "T.N.T." (capacity-tuned—C12—plate, and inductance-tuned grid) circuit is used and the grid coil must be adjusted so that the plate current is about minimum at center-scale position of the plate tank condenser. This adjustment is made without antenna load. The method of coupling the antenna to the plate tank is not the best, but is simple, and really not as unbalanced as it appears. The oscillator will draw about 20 to 25 ma. unloaded, and this increases to around 30 to 35 ma. fully loaded. This means an input of 6 to 8 W. at 200 V., which is plenty to put a strong signal on the air.

The transmitting condenser shown in the photo (C12 in Fig. 7) is of the split-stator type, made from a 75 mmf. standard model. It was originally intended to ground the rotor but this was found unnecessary, so a single section 15 to 20 mmf. unit (as specified in the list of parts) will do just as well.

The grounded and "hot" filament battery leads, the "B+" and the control relay lead, go to a 4-prong socket on the rear of the box. The control relay which is operated by a switch on the regeneration control serves to turn on the genemotor. This saves running a long lead to the set, which with the 4 A. or so of current taken by the motor-generator, would lower its voltage somewhat. The relay is simply an auto cut-out, re-made slightly.

The power supply, with its filter, is located in another 5 x 6 x 9 in. metal box, with a shielded cable running to the set. The filter choke is a low-inductance unit as shown, but has been found adequate. The R.F. chokes in the power supply leads are all needed, as they serve to prevent the commutator ripple from disturbing the receiver.

The antenna generally used with this set is a 4-foot vertical rod, grounded at the lower end. The single wire feeder taps onto the rod, about 1 ft. from the grounded end. Raising the tap towards the top increases the coupling. It is best to make the antenna in two sliding sections, so that it may be adjusted for proper wave-length.

It is well to mention, in conclusion, that this set is a real transmitter, and as such, requires that the operator hold a Federal Radio License for legal operation. (An inquiry on a postal addressed to Federal Communications Commission, Washington, D. C., will bring the address of your local Radio Supervisor, from whom you will be able to obtain all requisite forms.) The range under certain conditions may be as high as 100 miles, so don't try "bootlegging"!

List of Parts

Two Hammarlund 50 mmf. variable condensers, C1, C11;

Two Hammarlund 20 mmf. variable condensers, C3, C12;

One Hammarlund 3-35 mmf. trimmer, C4;

One Cornell-Dubilier 100 mmf mica condenser, C2;

One Cornell-Dubilier .005-mf. mica condenser, C5;

Two Cornell-Dubilier .1-mf. paper condensers, C6, C10;

Two Cornell-Dubilier 5 mf., 50 V. electrolytic condensers, C7, C8;

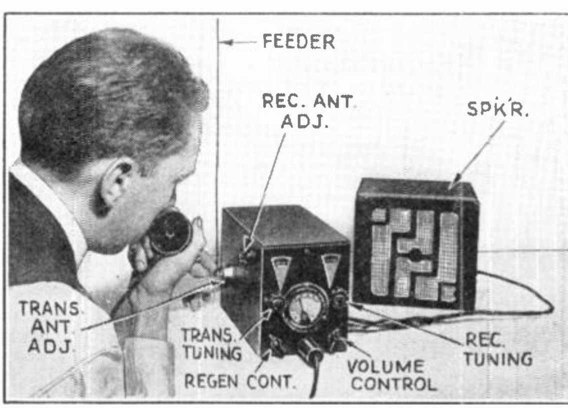


Fig. 10. Appearance of the unit, as set up for operation on a table. The power supply is in a separate case.

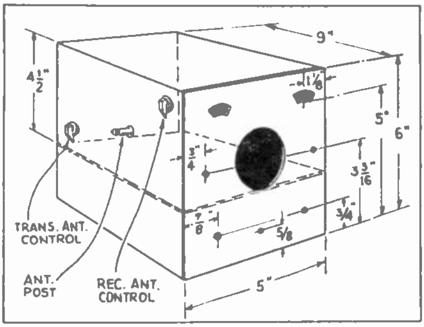


Fig. 11. General dimensions of the case.

One Cornell-Dubilier .001-mf. mica condenser, C9;
Two Cornell-Dubilier 8 mf. filter condensers C,13, C14;
One Electrad .1-meg. variable carbon resistor, R2, with switch, Sw. 1;
One Electrad .5-meg. variable carbon resistor, R5, with switch, Sw. 2;
One IRC .5-meg., ½ W. resistor, R1;
One IRC 2,000 ohm, ½ W. resistor, R3;
One IRC 3,000 ohm, ½ W. resistor, R4;
One RCA type 41 tube, V2;
One RCA type 79 tube, V3;
One motor-generator "B" supply unit, 250 V., 50 ma.;
One Standard Trans. Corp. low-resistance choke;
One Blan generator-control relay No. 2 (see text);
One 2 in., 100 ma. meter;
Wire, hardware and incidental items.
Five Hammarlund midget R.F. chokes, R.F.C1-5;
One Blan changeover ("send-receive") relay No. 1;
One microphone and plate-to-grid transformer, T1;
One class B input transformer, T2;
One class B 79 to 5,000 ohms transformer, T3;
One Hammarlund 955 isolantite socket;
One Hammarlund 7-prong isolantite socket;
One ICA 4-prong socket;
Two ICA 6-prong sockets;
Two ICA 5 x 6 x 9 in. boxes (one for set and one for power supply);
One ICA mounted 5-meter coil;
Four ICA small bar knobs;
Two ICA small fluted knobs;
Two ICA single-circuit jacks;
One RCA type 955 "acorn" tube, V1;
One Raytheon RK 34 ultra-short wave tube, V4;

Tuning for Long Distance
ON YOUR ALL-WAVE SET

A great many of the radio sets in use in the home today are so-called "Broadcast and Short Wave" receivers. These sets generally will cover all wave bands from the regular broadcast band (550 to 200 meters) to about 10 meters. Some receivers of low price do not go below 19 meters and some of the more elaborate ones will cover the bands down to 5 meters. Still other receivers cover the regular broadcast band (200-550 meters) and the short wave bands from 50 to 19 meters, completely skipping the bands from 200 to 50 meters.

A great deal of confusion has been caused by the terms meters, kilocycles and megacycles which are used interchangeably to denote the channels on which various stations operate. Actually they are 3 different ways of saying the same thing. No useful purpose would be served here to go into an involved explanation of the significance of these terms. Simply let it be said that they are units of measurement somewhat as a foot or yard is a unit of length.

For example, broadcast station WLW in Cincinnati operates on a wave length of about 428 meters. Another way of saying this is that WLW operates on a frequency of 700 kilocycles. (To translate meters into kilocycles, divide either into 300,000—which is about the speed in meters with which a radio signal travels; the dividend is the desired figure.—Editor)

The kilocycle (or "kc.") method of figuring is used more often today because it is more convenient than the meter system. The shorter the wave length of a given station, the higher its frequency in kc. will be. A station operating on 200 meters has a frequency of 1,500 kc. while one on 10 meters has a frequency of 30,000 kc.!

When dealing with these short wave (or higher frequency, if you wish) stations, the use of kilocycles becomes a nuisance. For example, a certain station operates on 25.53 meters. This is equivalent to 11,750 kc. The frequency is a large number. Therefore, it has become the practice when dealing with short wave stations to give their frequency in megacycles instead of kilocycles. Mega means million, while kilo means a thousand. Therefore, a kilocycle is really a thousand cycles and a megacycle is a million cycles. Consequently 1 megacycle (mc. for short) equals 1,000 kilocycles or kc. Thus the station whose frequency is 11,750 kc. can be identified as operating on 11.75 mc. Note that the last figure of the frequency in kilocycles is generally dropped when using kilocycles. Megacycles are not used with regular broadcast band stations because there the kilocycle method is satisfactory since the figures involved are small. Station WLW on 700 kc. could be written as 0.7-mc. if desired. For aid in remembering the difference between these three, a list giving the meters, kc. and mc. of a number of reference points is given as follows: 50 meters equals 6,000 kc. or 6 mc.; 30 meters equals 10,000 kc. or 10 mc.; 24 meters equals 12,000 kc. or 12 mc.; 15 meters equals 20,000 kc. or 20 mc. (Also, see Fig. 12.)

Looking for short wave stations is an entirely different procedure than tuning in stations on the regular broadcast band. On the latter range most persons can be certain of hearing their favorite station at approximately the same loudness and clarity whenever they listen for them.

Short wave reception is not at all like this, however. Certain wave length or frequency bands are suitable for long distance reception from a given point only at certain times of the day. In addition, the season of the year plays an important part in determining what wave lengths will be most suitable for transmission to certain areas at any given time.

Do not expect to be able to turn on your radio set and tune in a certain short wave station at any time of the day. This is impossible. First of all the factors mentioned is the effect of the time of day on reception. (See Fig. 13.)

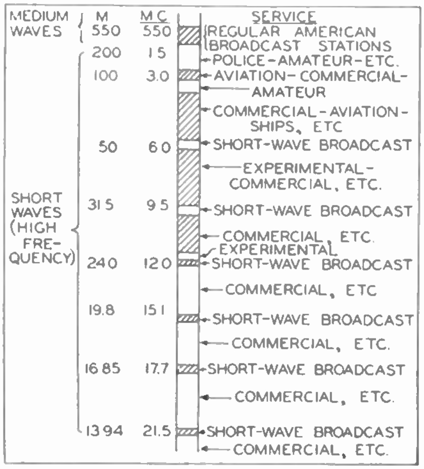


Fig. 12. Relative positions of S.W. stations.

FREQUENCY	LOCATION OF STATIONS	TIME OF DAY IN E.S.T. FOR BEST RECEPTION
30-20 M C	EUROPE SOUTH AMERICA ASIA & AUSTRALIA	7 TO 11 A M 11 A M TO 2 PM 3 TO 6 PM
20-17 M C	EUROPE ASIA & AUSTRALIA SOUTH AMERICA	7 A M TO 1 PM 2 TO 6 PM 10 A M. TO 3 P M.
17-13 M C	EUROPE ASIA & AUSTRALIA SOUTH AMERICA	5 A M TO 9 PM 11 PM TO 9 A M { 7 TO 9 A M, 4 TO 7 PM }
13-11 M C	EUROPE ASIA & AUSTRALIA SOUTH AMERICA	4 PM TO 5 A M { 10 PM TO 3 A M, 6 A M TO 9 A M } { 5 TO 7 A M, 6 TO 8 PM }
11-8 M C	EUROPE ASIA & AUSTRALIA SOUTH AMERICA	4 PM TO 4 A M 4 TO 9 A M. 5 PM TO 7 A M
8-5 M C	EUROPE ASIA & AUSTRALIA SOUTH AMERICA	10 P M TO 2 A M 5 TO 7 A M 7 PM TO 5 A M

Fig. 13. Best times to listen.

Reception Conditions During Daylight. During broad daylight the shorter waves or higher frequencies are the only ones capable of providing long distance reception. Thus the waves from 10 to 20 meters (15-30 mcs.) give best results when there is daylight either at the station, at the receiver, or, at both places. The shorter the wave, the better it is for daylight communication.

The stations operating near 20 meters (15 mc.) are heard best in the Fall and Winter when there is daylight over most of the distance between the station and the listener. The stations below 15 meters or above 20 mc., are heard best during those seasons when there is daylight over the whole path.

Reception Conditions at Night. The stations operating between 25 and 35 meters (12 and 8.5 mcs.) are heard best when there is darkness over most of the path between the listener and the broadcast station. Thus the Europeans in this band are heard best from 4 p.m. to 5 a.m. Asiatic and Australian stations are heard best from midnight until 9 a.m. Wave lengths from 35 to 60 meters (8.5 to 4 mcs.) give best long distance reception when the whole area is in darkness.

MAKING A FLOATING GRID RELAY

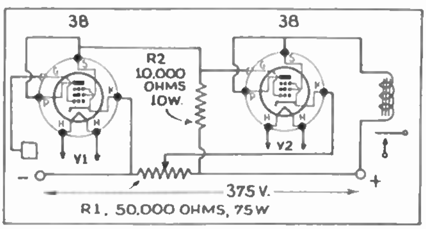


Fig. 14. Reverse action may be had by the use of this direct coupled circuit.

If the grid of an ordinary radio tube is entirely disconnected from circuits outside the tube and the base pin cut off (in the case of 3-element tubes) to prevent leakage, the tube becomes sensitive to body capacity effects, such as objects approaching in the proximity of the tube, or to experimenter.

A large number of tubes were put through tests to determine their characteristics with grid elements thus "floating." The screen-grid tube is obviously best suited for this purpose mechanically, because of its well insulated grid-cap

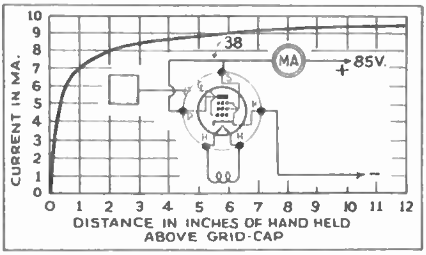


Fig. 15. Fundamental characteristics.

which emerges from the apex of the tube and offers a suitable terminal for external connections. Electrically, too, the tube is to be preferred, the 38 type of tube showing the most desirable characteristics for the purpose, followed closely by other tubes such as the 39, 36, 58, etc. Various circuit arrangements were tried, the most favorable being shown in Fig. 17. The voltages required for maximum sensitivity are fairly critical.

A metal plate 1 in. square was soldered to the grid-cap to increase the effective sensitivity of the tube to outside capacity. (See Fig. 16.)

In experimenting with various hookups it was found that the sensitivity of the tube was considerably reduced if the cathode of the tube was grounded. For this reason the bookup shown in Fig. 17A cannot be expected to have a high degree of sensitivity. In this hookup it would be necessary to use a low resistance type of sensitive relay in the plate circuit if the tube is to function at its best, as a total of 85 V. is required at the plate, leaving only a 15 V. drop for the relay. By using "B" batteries, or a step-up transformer, as shown in Fig. 17B, these difficulties may be overcome. Because of the pulsating rectified current in the plate circuit it is necessary to use a relay of the proper type for this purpose. However, by the addition of a rectifying tube and filter supplying a pure direct current, a conventional magnetic relay may be used. Such a circuit is shown in Fig. 17C, and is the one around which the model pictured in Fig. 16 was constructed.

A relay of the type used in "A" and "B" eliminators was rewound to a resistance of 5,000 ohms, and somewhat revamped for this use. (Some mechanical relays will require a condenser across the coil because of a small A.C. component which exists as the relay throws off at minimum current.) Where great sensitivity is desired, a meter type of relay should be used and is preferred when speed is essential.

If a reverse action of the operating current is desired it may be produced with the arrangement shown in Fig. 14. Here it is possible to obtain only a slight gain in amplification unless the capacity moves with speed as it approaches or leaves the tube's control-grid, due to the dynamic

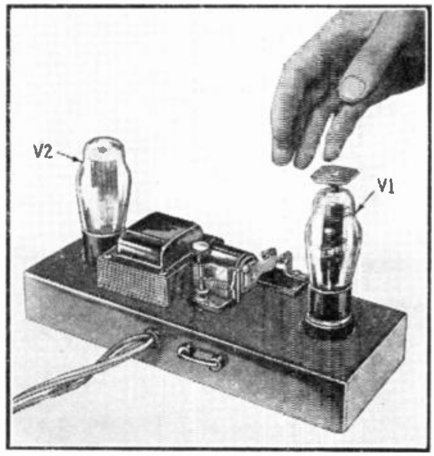


Fig. 16. The unit shown in Fig. 17C.

plate resistance of the tube. This action may be noticed if the hand slowly approaches the tube (until a reading of about 4 ma. is obtained), then suddenly withdrawn. The current will drop to zero before returning to the normal maximum. A slow removal of the hand would cause the current to rise slowly to its former level. (In this experiment the magnetic relay should be shorted out as it acts as a choke to sudden changes.)

If the hand or some other conductive object comes in contact with the control-grid the current drops to zero and some time elapses before it returns to normal. With the model shown in Fig 16 this time amounted to about 3 seconds, varying somewhat with different size plates on the grid-cap. This action seems to offer possibilities in connection with time delay relay systems.

Construction costs of this relay permit it to be used in various instances to replace oscillating circuit relays and grid-glow tube relays.

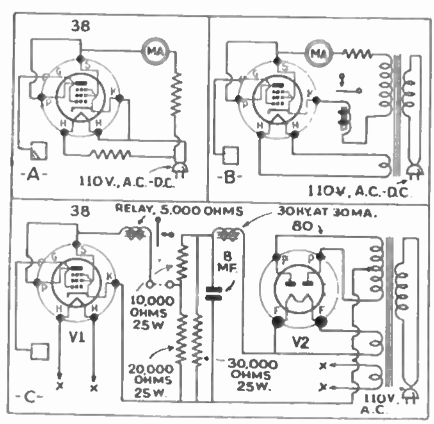


Fig. 17. Various experimental circuits.

The uses to which the relay may be put are limited only by the ingenuity of the experimenter.

List of Parts

One General Transformer Corp. transformer, 675 V. C.T., 6.3 V., 5 V.;
One home-made chassis, 1½ x 4 x 11 ins.;
One Blan relay, optional;
One General Transformer Corp. choke, 30 hys. at 30 ma., midget type;
One Aerovox dry-electrolytic condenser, 8 mf.;
One I.C.A. 4-prong wafer socket;
One I.C.A. 5-prong socket;
One Microhm resistor, 30,000 ohms, 20 W.;
One Microhm resistor, 20,000 ohms, 10 W.;
One Microhm resistor, 10,000 ohms, 10 W.;
Two I.C.A. tip jacks;

Note: If relay is to be used continuously, resistors should be of 75 W. capacity.

The experimenter often needs to know the capacities between tube elements, this need becoming increasingly great at the high and ultra-high frequencies.

The capacities of the glass tubes are given in the table below, printed by the courtesy of National Union Radio Corp., with the glove-type shields over the tubes and throughout the table the figures are given with the shield connected to cathode in both glass and metal types.

PENTODES

TYPE	INPUT		OUTPUT		Cap. MAX.
	Sh.	Unsh.	Sh.	Unsh.	Sh.
6B7+	4.5	3.5	10.5	9.5	0.007
6C6	5.8	5.0	8.9	6.5	0.007
6D6	5.5	4.7	8.9	6.5	0.007
6F7*	4.0	3.2	13.3	12.5	0.007
6J7	7.0		12.0		0.005
6J7G	4.8	4.3	12.5	11.6	0.007
6J7MG	5.2		11.5		0.007
6K7	7.0		12.0		0.005
6K7G	4.6	4.1	12.5	11.6	0.007
6K7MG	5.0		11.5		0.007
6L7†	8.5		12.5		0.0005
6L7G†	6.2	5.4	10.5	8.2	0.002
6L7MG†	7.0		10.5		0.001
77	5.5	4.7	12.1	11.0	0.007
78	5.3	4.5	12.1	11.0	0.007

*Pentode Section. †As Amplifier.

TRIODES

TYPE	Cg—k		Cp—k		Cap.	
	Sh.	Unsh.	Sh.	Unsh.	Sh.	Unsh.
6C5	4.0		13.0		1.8	
6C5G	4.2	3.2	5.5	2.3	2.4	2.8
6C5MG	4.2		5.4		2.4	
6C6**	3.0	2.5	15.8	12.0	1.9	2.0
6F7††	2.9	2.5	3.5	3.0	1.9	2.0
6R7+	5.5		4.0		2.5	
6R7G+	2.8	1.5	6.8	4.0	1.6	1.8
6R7MG+	3.0		5.8		1.7	
76	4.5	3.5	5.1	2.5	2.6	2.8
85+	2.8	1.5	6.9	4.3	1.3	1.5

**Triode Connected. ††Triode Section. Units—mmf. +diodes hooked to cathode.

CONVERSION FACTORS

Multiply	By	To Get
Amperes	× 1,000,000	microamperes
Amperes	× 1,000	milliamperes
Cycles	× .000,001	megacycles
Cycles	× .001	kilocycles
Farads	× 1,000,000,000,000	micromicro-farads
Farads	× 1,000,000	microfarads
Henries	× 1,000,000	microhenries
Henries	× 1,000	millihenries
Kilocycles	× 1,000	cycles
Kilovolts	× 1,000	volts
Kilowatts	× 1,000	watts
Megacycles	× 1,000,000	cycles
Microfarads	× .000,001	farads
Microfarads	× .000,001	micromicro-farads
Microhenries	× .000,001	henries
Microvolts		volts
Micromicro-farads	× .000,000,000,001	
	× .001	farads
Milliamperes	× .001	amperes
Millihenries	× .001	henries
Millivolts	× .000,001	volts
Ohms	× 1,000	megohms
Ohms	× 1,000,000	milliohms
Volts	× 1,000	microvolts
Volts	× 1,000	millivolts
Watts	× 1,000,000	milliwatts
Watts	× .001	kilowatts

R. M. A.
COLOR CODE
For RESISTORS
Unit—OHMS
For CONDENSERS
Unit—mmf.
Micro-microfarad

Body Color		End Color		Dot Color	
Black	0	Black	0	Black	none
Brown	1	Brown	1	Brown	0
Red	2	Red	2	Red	00
Orange	3	Orange	3	Orange	000
Yellow	4	Yellow	4	Yellow	0,000
Green	5	Green	5	Green	00,000
Blue	6	Blue	6	Blue	000,000
Purple	7	Purple	7	Purple	0,000,000
Gray	8	Gray	8	Gray	00,000,000
White	9	White	9	White	000,000,000

CHAPTER 6

Handy Time Savers

The following items have appeared during the past year in Radio-Craft Magazine and have been awarded prizes or honorable mention. They represent ways of doing things which will save the radio constructor time and money:

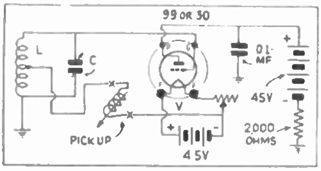


Fig. 1. Simple phono oscillator.

PHONO. OSCILLATOR. This simple unit, the diagram of which is shown in Fig. 1, may be used to reproduce recorded material through any radio receiver, thus utilizing the full amplification of the receiver. Coil L and condenser C are standard units that tune within the wave length range of the set. (If the unit should cause any interference to other set owners—in the same building, for instance—it must be thoroughly shielded, and coupled to the set via a shielded line.)

Freeman R. Tupper, Jr.

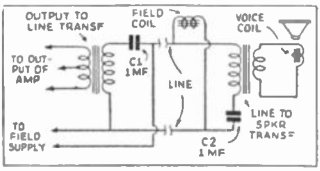


Fig. 2. Connections to speaker.

REMOTE-SPEAKER CONNECTION. A practical transmission line for remote dynamic speakers is shown in Fig. 2. Only 2 wires are used, as the field current and the A.C. signal current both pass over the same wire. Of course, the line drop, resistance, and impedance must be considered. Note that the system is not practical for low voltage field excitation (6 V. field) as the line voltage drop would be too high.

Charles Higginbotham

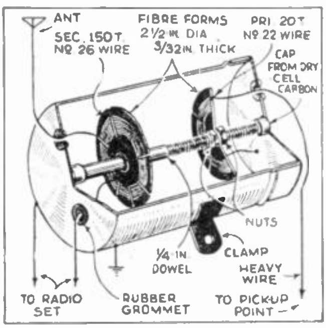


Fig. 3. Balance out noise.

"BALANCING OUT" TYPE OF NOISE ELIMINATOR. The price of a set of suppressors may be saved by the use of this simple device. As seen in Fig. 3, it consists mainly of 2 coils wound on fibre forms. These are mounted on a ¼ in. wood dowel, one being fastened with cement, and the other held with 2 nuts. The rod is threaded by screwing the nuts on. The large coil is connected in series with the antenna lead of the receiver. The other coil is grounded at one end and the other end run to some pick-up point in the engine compartment (the radiator tie-rods are a good spot).

Robert Van Houten

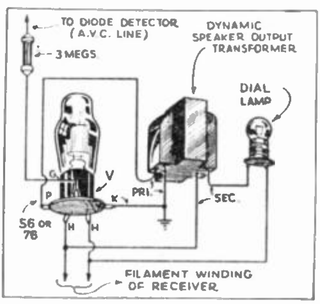


Fig. 4. Novel tuning indicator.

ALL-WAVE SET TUNING INDICATOR. Several of the new all-wave receivers use a simple yet effective tuning indicator in the form of a pilot light which burns brightly between stations and dims when a carrier is in tune.

The circuit, Fig. 4, shows how it is done. A triode, such as the 56, 76 or 27 is connected to the diode detector (A.V.C. line) through a 3 meg. resistor. The secondary of an output transformer from a defunct dynamic speaker is connected in series with a small dial light bulb (2 or 5 volt, depending on filament winding voltage) to the regular filament winding of the set and the primary of this same transformer connects to the plate of the triode.

Emil Kuzsma

IMPROVING TONE. Many varieties of midget sets on the market do not have the tone quality that the owners desire. The combination shown in Fig. 5 has been used to advantage to improve the tone of several of these sets and may be of interest to readers.

F. U. Dillion

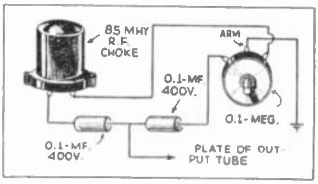


Fig. 5. Double action tone control.

ANTENNA TESTER. After installing an all-wave antenna the Service Man is never sure that it is a perfect job. The device shown enables a test to be made immediately!

It consists of a model T Ford spark coil and a single dry cell. These may be mounted compactly (see Fig. 6), so that they can be put in the tool kit. The apparatus is simply placed near the receiver or lead-in and turned on.

A. Ward Howe

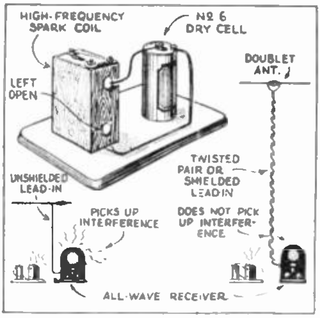


Fig. 6. Antenna efficiency tester.

A CAPACITY BRIDGE. This simple arrangement, shown in Fig. 7, may be made up in portable form as a handy piece of test equipment. The tube, V, may be of any battery type, such as a 99 or 30. The filament is adjusted to the correct value by R. The transformer is a regular 3-to-1 audio unit. Condenser C may be of any size, but its range must cover the capacity of the unknown condenser under test. In operation, the test clips are connected to the unknown, and the test key pressed. Then the switch is shifted to position 2 and the variable condenser turned until the same tone is obtained.

Russell M. Richner

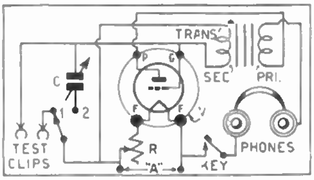


Fig. 7. A portable capacity bridge.

DEFECTIVE METAL TUBES MAKE INEXPENSIVE PLUGS. Defective or burned-out metal tubes make excellent equipment plugs. The 6H6 tubes are best for speaker plugs, while the 6C5, 6F6, and small 5Z4 tubes are best for analyzer plugs. First, bend the metal shell so that the base may be removed, after unsoldering the wire leads, as seen in Fig. 8. Then drill a hole in top and bottom of the tube and run a screwdriver through to clear the elements out of the way. The cable may then be pushed through and soldered to the base prongs, after which the base is again crimped in place.

W. A. Lynch

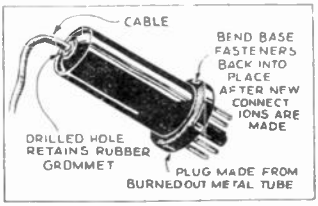


Fig. 8. Plug made from metal tube.

EXTERNAL "SERVICING" CAR RADIO SPEAKER. The 1936 Philco radio sets for Ford cars are used with a speaker which is installed under the header plate. If the set has to be removed for service, it is a long job to take out the speaker. In such cases the speaker shown in Fig. 9 will be found very handy, and may be made up in a short time.

A. E. Pashrig

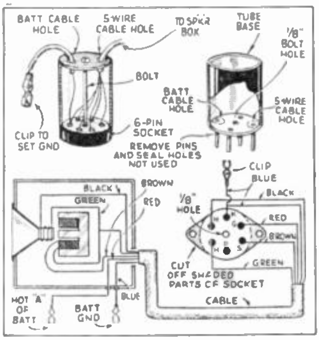


Fig. 9. Auto radio remote speaker.

DIRECT CURRENT SUPPLY. Many uses may be found around the shop for a supply of direct current of about 110 V. at 1 A. Most Service Men are located in A.C. districts, however, and have no access to such a supply.

The circuit shown in Fig. 10 is the answer to this problem and the cost is very low. It has been used to test 110 V. D.C. sets, to excite speaker fields, to charge high-voltage storage batteries, and for many similar purposes.

Rodney E. Reed

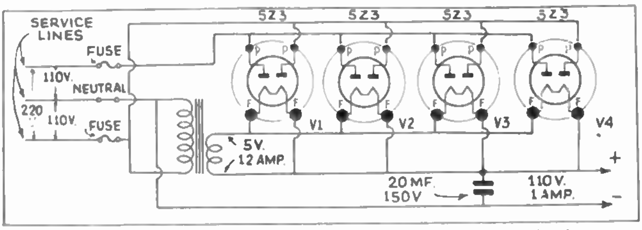


Fig. 10. An inexpensive D.C. power supply for A.C. districts.

CHAPTER 7

The Year's Crop of Tubes

The large number of new tubes which have been presented during 1936 is a bit baffling to even the most experienced radio man. On the following pages is presented a brief resume of the most important of these in the receiving line, together with their outstanding characterdstics.

In some cases the manufacturer who introduced the tube in mentioned, but many of the types are now made by the majority of tube companies.

THE 6Q7 DUO-DIODE TRIODE

This tube has circuit applications corresponding to those used with the type 75 glass tube.

Triode-Section Class A Amplifier
(Operating Conditions and Characteristics)
(Shell tied to Cathode)

Plate voltage	250	100
Grid voltage	—3	—1.5
Amplification factor	70	67
Plate resistance ohms	58,000	84,000
Mutual conductance, mmhos	1,200	800
Plate current, ma.	1.2	0.4

THE 0Z4 RECTIFIER

Since this tube operates through the ionization of a gas contained in a glass inner bulb, it does not require a filament. In basic principles the 0Z4 is closely related to the gas rectifier. The cathode of the new rectifier operates at an emitting temperature thus permitting values of rectifier efficiency and voltage drop comparable to those found in a mercury-vapor tube, equipped with a filament.

The 0Z4 was developed by Raytheon primarily for use in vibrator-type "B" supply units for automobile-radio receivers. It has the typical characteristics of all gas-filled rectifiers—as regards (a) a constant voltage drop; (b) ability to handle peak currents; and, (c) a tendency to generate R.F. noise. The R.F. noise (c) may be eliminated by proper filtering and by connecting the metal shell to the point giving the best shielding. The shielding and filtering commonly used to eliminate vibrator noise will usually be sufficient.

The 0Z4 is filled with a permanent gas rather than a vapor filling. The tube characteristics are independent of the surrounding temperature.

The 0Z4 has the same external form and dimensions as other tubes of the metal line, the size being the same as the 6C5. However, in this tube the metal shell serves chiefly as container and electrostatic shield for the glass bulb, which is required to insulate the contained gas from the grounded shell.

Operating Conditions and Characteristics

D.C. output voltage	300 max.
D.C. output current, ma	30 min.
	75 max.
Peak plate current, ma	200 max.
Starting voltage	300 min.
Voltage drop (dynamic)	24 av'g.

Type 10, special high-frequency tube. The type 10 tube is used extensively for high-frequency work, but the bakelite base is not a very satisfactory insulator. This new Sylvania "special high-frequency" 10, however, is provided with a ceramic base which greatly increases the efficiency for such work. It is otherwise the same in characteristics (even, unfortunately, to the type number) as the "ordinary" 10.

A new range of tubes by Arcturus utilizing what is said to be a new and exclusive principle in receiving tube structure, a "coronet" seal, has been announced as an all-metal tube series. This special "coronet" seal is said to result in material reduction of the input and output capacities and makes possible uniformity in inter-element capacities This seal also precludes the possibility of shorts between wire and ground. The manufacturer of coronet tubes claims that they have a more dependable degree of vacuum than the original metal tube; lower operating temperatures permitting closer arrangement of chassis components; ;and more rugged structure eliminating microphonics.

6Q7 Coronet Duo-Diode Triode. This tube is similar in characteristics to the glass type 75. The triode-section amplification factor is 70. By using a 3 V. "C" bias instead of 2 V. the possibilities of positive grid current are minimized.

6X5 Coronet Full-Wave Rectifier. This is an indirect-heater type of tube for automotive use. Its characteristics are similar to the type 84.

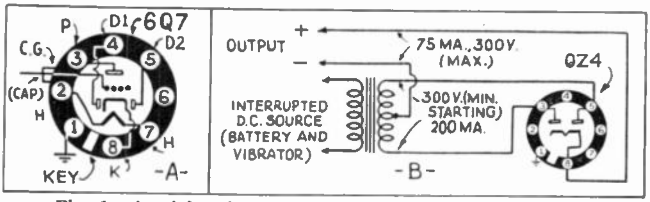
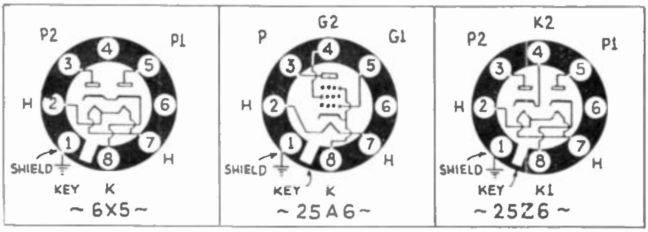


Fig. 1. At right, the connections for the 0Z4 rectifier tube.



The coronet series is now in production in the following tubes: 5Z4, 6A8, 6C5, 6F5, 6F6, 6H6, 6J7, 6K7 and 6L7. All have octal bases.

6X5 Full-Wave Rectifier. This type tube (as well as the 25A6 and 25Z6) are available from Sylvania, Raytheon, RCA and others. Although designed especially for use in automobile receivers in place of the 84 it may also be utilized for compact A.C. operated receivers where the rectifier current drain does not exceed the maximum output current rating of the tube.

Tentative Ratings and Characteristics:
Heater Voltage (A.C. or D.C.)—6.3 V.
Heater Current—0.6 A.
A.C. Voltage per Plate (r.m.s.)—350 V. Max.
D.C. Output Current—75 ma. Max.
Peak Inverse Voltage—1,250 V.
Peak Plate Current per Plate—375 ma. Max.
Voltage between Heater & Cathode—400 V. D.C. Max.

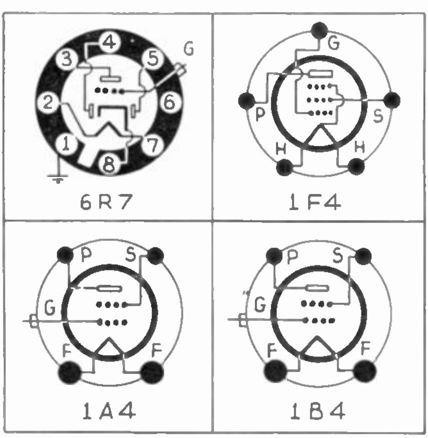
25A6. This metal tube corresponds to the type 43. Characteristics are as follows:

Class A Amplifier Operating Conditions and Characteristics

Plate	95	135	180	max. V.
Screen-grid	95	135	135	max. V.
Control-grid	—15	—20	—20	V.
Amplification Factor	90	99	96	
Plate Resistance	45,000	42,000	40,000	ohms
Mutual Cond.	2,000	2,350	2,400	mmhos.
Plate Current	20	39	40	ma.
Screen-grid Current	4	8.5	8.0	ma.
Load Res.	4,500	4,000	5,000	ohms
Power Output	0.9	2.0	2.75	W.
Dist.	11%	9%	10%	

25Z6 Rectifier. This metal tube corresponds to the glass type 25Z5 tube.

Operating Conditions and Characteristics:



A.C. voltage per plate—125 V. max.
D.C. load current as voltage doubler—85 ma. max.
D.C. load current as rectifier—85 ma. max.
Peak plate current—500 ma. max. per plate

Tests on R.F. coil efficiency have shown that the Q of a really good coil is reduced by an undesirable amount when connected across the control-grid and shield of the metal R.F. amplifier or mixer tubes if certain types of phenolic insulation are used.

To reduce these losses, the engineers in the Raytheon radio tube laboratory, tested all available types of insulation material including ceramics. The material finally selected was developed during the tests. It has the mechanical strength of the strongest material previously used but is near the best ceramic in low losses at the high frequencies.

Type 6R7. The first dual-purpose metal tube was the 6Q7 which duplicated the results obtained by the type 75 glass tube. The second dual-purpose metal tube is known as the 6R7 and is similar in characteristics to the glass type 85 tube. It will be noted that both of the above types are double-diode triode tubes.

Type 6R7 Characteristics—Triode Section

Heater Voltage (A.C. or D.C.)	6.3 V.
Heater Current	0.3-A.
Plate Voltage	250 V. (Max.)
Grid Voltage	—9 V.
Plate Current	9.5 ma.
Plate Resistance	8,500 ohms
Mutual Conductance	1,900 mmhos
Amplification Factor	16
Load Resistance	10,000 ohms
Undistorted Power Output	275 milliwatts

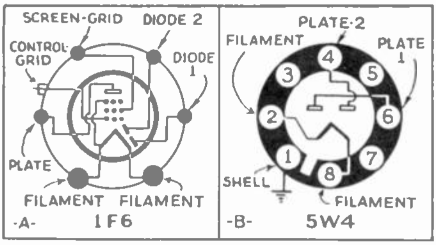
It is interesting to note that the 6R7 is available also in the metal-glass type of construction and is then known as the 6R7MG.

Type 1F4. This tube is a power-output pentode of the glass variety designed for battery (air cell) or rural receivers. This tube has a high power sensitivity and will deliver considerable power output (when the low filament and plate current consumption are considered).

This tube ordinarily is resistance-coupled to the previous tube in the receiver and is operated as a class A amplifier. It can, however, be transformer-coupled to a suitable driver, thus permitting additional power output, in class B, or A prime operation.

Type 1F4—Characteristics

Filament Voltage	2.0 V.
Filament Current	0.12-A.
Plate Voltage	135 V.
Screen-grid Voltage	135 V.



Control-grid Voltage .... —4.5 V.*
Plate Current ....8.0 ma.
Screen-grid Current ....2.6 ma.
Plate Resistance ....0.2-meg.
Mutual Conductance .... ..1,700 mmhos.
Amplification Factor 340
Load Impedance ....16,000 ohms
Power Output ....340 milliwatts**
Distortion ....5 per cent
*Grid-return to negative filament.
**Width 3.5 V. r.m.s. signal on grid.

Type 1A4. This tube, also, is designed for sets using dry-cell or air-cell filament supplies. It is a variable-mu R.F. tetrode with characteristics somewhat similar (though greatly improved) to the type 34.

Type 1A4—Characteristics

Filament Voltage (D.C.).... ....2.0 V.
Filament Current ....0.06-A.
Plate Voltage ....180 max. V.
Screen-grid Voltage ....67.5 max. V.
Control-grid Voltage.......... —3 min. V.
Plate Current ....2.3 ma.
Screen-grid Current (Approx.).....0.7 ma.
Plate Resistance ....0.96-meg.
Amplification Factor 720
Mutual Conductance ....750 mmhos.
Mutual Conductance
(At—15 V. bias)....... ......15 mmhos.
Grid-Plate Capacity
(With shield-can) ......0.007-(max. mmf.
Input Capacity ....4.6 mmf.
Output Capacity .... 11 mmf.
Overall Length ....$4\frac{9}{32}$ to $4\frac{17}{32}$ ins.
Maximum Diameter ....$1\frac{9}{16}$ ins.
Bulb ST-12
Cap ....Small Metal
Base ....Small 4-Pin

Type 1B4. This tube is a companion to the 1A4 just described. It is a screen-grid (normal cut-off) tube designed for detector or R.F. circuits. Its characteristics are similar to the type 32 tube, though it is smaller in size and the interelectrode capacity is somewhat lower than the 32. Use the 1B4 in all-wave sets.

Type 1B4—Characteristics

Filament Voltage (D.C.).............2.0 V.
Filament Current ....0.06-A.
Plate Voltage ....180 max. V.
Screen-grid Voltage .... 67.5 max. V.
Control-grid Voltage .... —3 V.
Plate Current ....1.7 ma.
Screen-grid Current (Approx.).....0.4 ma.
Plate Resistance ....1.2 megs.
Amplification Factor 780
Mutual Conductance ....650 mmhos.
Grid-Plate Capacity
(With shield-can) ....0.007-(max.) mmf.
Input Capacity ....4.6 mmf.
Output Capacity .... 11 mmf.
Overall Length..... ....$4\frac{9}{32}$ to $4\frac{17}{32}$ ins.
Maximum Diameter ....$1\frac{9}{16}$ ins.
Bulb ST-12
Cap ....Small Metal
Base ....Small 4-Pin

The 6G5. The 6E5 incorporated a triode, the control-grid of which could handle up to —8 V. bias. Therefore in order for this tube to operate in modern sets when connected in the A.V.C. line, which at times reaches a bias of —22 V., it was necessary to use a voltage-divider network to reduce the voltage applied to the 6E5 grid. The relation between the 6E5 control-grid voltage and the shadow angle is approximately linear; and so, with the proper A.V.C. voltage-divider network, the shadow-angle change on weak signals is small.

The inclusion of a triode unit having a variable -mu characteristic in the cathode-ray indicator permits the application of A.V.C. voltage to produce an appreciable movement of the shadow on weak signals, and still prevent overload on strong signals. The type 6G5 cathode-ray tuning indicator, first announced by the National Union Radio Corp. is of this type. The tube is capable of handling approximately 22 V. negative bias directly on its control-grid, and so, in many instances, it is feasible to connect the control-grid directly to the A.V.C. voltage supply without the necessity of a voltage divider.

6G5 Characteristics

Heater voltage (A.C. or D.C.).......6.3 V.
Heater current ....0.3-A.
Plate supply ....250 V., max.
Target voltage ....250 V., max.
Series triode plate resistor..........1.meg.
Triode plate current for zero
grid voltage ....0.25-ma.
Triode grid voltage to give
zero deg. shadow....... — 22 V., approx.
Triode grid voltage to give
90 deg. shadow ....0 V., approx.

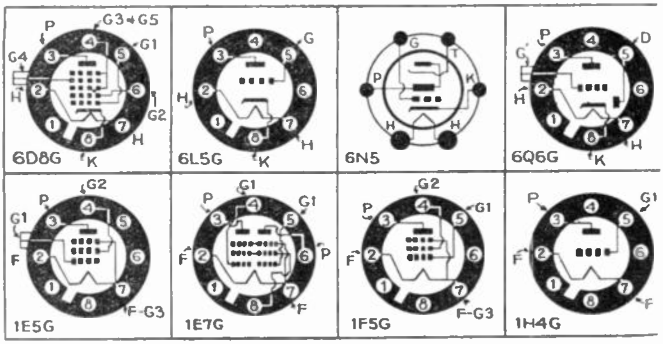
The 6X5MG. This tube is now available in a metal-glass equivalent of the metal type. It is made by National Union Radio Corp., and others.

The 25A6MG. This type is also available in the metal-glass type from National Union. The characteristics of these two tubes are the same as the equivalent metal types.

The MT Line. These "tubes" employ standard metal-tube casings and 8-prong octal bases—but here the resemblance to metal tubes ends. For they are not really tubes at all, but line voltage dropping resistors for the A.C.-H.C. series-filament type of sets, amplifiers, etc.

This new type of resistor which keeps the dissipated heat above the chassis where it belongs, and also eliminates fire hazards, is available in any total voltage drop and for practically all pilot lamp and tube combinations. Ballast action in the pilot lamp resistor section can also be provided.

The 6L6. This is a power-amplifier tube of the all-metal type for use in the output stage of radio receivers, especially those designed to have ample reserve of power-delivering ability. This new tube provides high power output with high power sensitivity and high efficiency. The power output at all levels has low third- and negligible higher-order harmonic ditortion.



These distinctive features have been made possible by the application of fundamentally new design principles involving the use of directed electron beams.

Primary features resulting from this arrangement are that the screen-grid does not absorb appreciable power and that efficient suppressor action is supplied by space-charge effects produced between the screen-grid and the plate. Secondary features are high power-handling ability, high efficiency, and high power sensitivity. Furthermore, large power output is obtainable without any grid current flowing in the input circuit.

In the design of the 6L6, the second-harmonic distortion is intentionally high in order to minimize third- and higher-order harmonics. Experience has shown that second-harmonics are far less objectionable in the audio-frequency output than harmonics of higher order. The second-harmonics can easily be eliminated by the use of push-pull circuits, while in single-tube, resistance-coupled circuits, they can be made small by generating out-of-phase second-harmonics in the preamplifier.

Heater Voltage (A.C. or D.C.) ...... 6.3 V.
Heater Current .... 0.9-A.
Maximum Overall Length .... 4$\frac{5}{16}$ ins.
Maximum Diameter .... 1$\frac{5}{8}$ ins.
Base .. .. Small Octal 7-Pin

Static and Dynamic Characteristics

Heater Voltage .... 6.3 V.
Plate Voltage .... 250 V.
Screen-grid Voltage .... 250 V.
Control-grid Voltage .... —14 V.
Amplification Factor 135
Plate Resistance .... 22,500 Ohms
Mutual Conductance .. .. 6,000 Micromhos
Plate Current .... 72 ma.
Screen-grid Current .... 5 ma.

Depending upon whether it is used with fixed- or self-bias, the tube has various ratings up to 11.5 W. for a single tube. Push pull operation will produce up to 34 W. without need of any driving power, while under class AB_2 conditions, with a plate voltage of 400 V. and with a grid power input of 350 milliwatts, the power output is 60 W. at less than 2% distortion, under proper circuit conditions. (Socket connections are the same as those of the 25B6G, p. 61.)

The 1F6. This tube is a double diode-pentode, with a 2 V. filament, and it is certainly a welcome addition to the battery line. It is similar in usage to the 6B7, in that the pentode section may be used for I.F., A.F., or R.F. amplification. The cut-off characteristics are midway between the sharp and remote types, permitting wide application.

1F6 Characteristics

Filament Voltage (D.C.) .... 2.0 V.
Filament Current .... 0.06-A.
Plate Voltage .... 180 V. max.
Screen-grid Voltage...... .... 67.5 V. max.
Control Grid Voltage............... —1.5 V.
Plate Current .... 2.0 ma.
Screen-grid Current .... 0.6 ma.
Plate resistance (approx.).......... 1 meg.
Amp. Factor (approx.).............. ..650
Mutual Conductance .... 650 micromhos
Mutual Conductance
(at —12 V. bias)........... 15 micromhos

The 5W4. An all-metal full-wave rectifier designed for use where the D.C. requirements are moderate. The applied A.C. voltage should not exceed 350 V. per plate and the load current from the filter output should be under 110 ma. It is a high-vacuum tube of the filament type. The tube is of the same size and has the same base connections as the 5Z4, but is designed for a lighter load.

5W4 Characteristics

Filament Voltage .... 5.0 V.
Filament Current .... 1.5 A.
A.C. Plate Voltage (per plate)
max. .... r.m.s. 350 V.
D.C. output current.......... 110 ma. max.

The 1F4. Here is another tube of the 2.0 V. series, and is similar to the type 33, except that it takes less plate and filament current. It has the same physical dimensions and the same base connections. It is very similar to the 950, although the operating characteristics are somewhat different.

1F4 Characteristics

Filament Voltage (D.C.).............. 2.0 V.
Filament Current .... 0.12 ma.
Plate Voltage .... 135 V. max.
Screen-grid Voltage .... 135 V. max.
Control-grid Voltage .... —4.5 V.
Plate Current .... 8.0 ma.
Screen-grid Current .... 2.6 ma.
Plate Resistance .... 0.2 meg.
Amplification Factor 350
Mutual Conductance..... 1,700 micromhos
Load Resistance .... 16,000 ohms
Undistorted Power Output... 340 Milliwatts

6D8G—Frequency Converter. This tube is a frequency converter type, similar in purpose to the 6A8 metal tube. The characteristics, with the exception of the filament current, are approximately the same as for the 6A8G.

25B5 — Dynamic-Coupled Dual-Triode. This tube is equivalent in characteristics to the well-known 6B5.

It is interesting to note that the new tube, requiring no external bias, takes advantage of the full 110 V. of the "B" supply in A.C.-D.C. sets, thus supplying a maximum output of 2 W. with 9 per cent harmonic content, compared with only 0.9-W. from the 43 in a similar circuit.

25B5 Characteristics

Output Plate (P^2)	110	180 max. V.
Input Plate	110	100 + V.
Control-grid	0	0 V.
Plate Current (P^2)	45	46 ma.
Plate Current (P^1)	7	5.8 ma.
Amplification Factor	25	35
Plate Resistance	11,400	15,200 ohms
Mutual Conductance	2,200	2,300 mmhos
Load Resistance	2,000	4,000 ohms
Power Output	2.0	3.8 W.
Harmonic Distortion	9	9 percent
Signal Volts for Rated Power	21	21 r.m.s.

25N6 — Dynamic-Coupled Dual - Triode. This tube has the same characteristics as the 25B5 described above, the only difference being in the use of an octal base on this tube.

The manufacturer, Triad Mfg. Co., recommends that for best results, a diode-type detector be used before the 25B5 and 25N6. In experimental work, it was found that the 6Q7 supplied the optimum characteristics for use with these tubes.

25B6G—Pentode Power Amplifier.. This tube, also, is an improvement over the type 43. It is a glass tube, with octal base. It is a power pentode, known as the "unipotential cathode" type, according to the manufacturer, Raytheon Production Corp. The output power of 1.75 W. is materially higher than the 0.9-W. supplied by the 43 with 95 V. applied to the plate and screen-grid, and a control-grid bias of —15 V., the plate current is 45 ma. and the screen-grid current is 4 ma.

25B6G Characteristics

Voltage .... 25.0 V.
Current ....0.3 A.

OCTAL-BASE GLASS TUBES AND EQUIVALENTS

Octal Glass Type	Equiv. Type	Octal Glass Type	Equiv. Type
1C7G	1C6	6C5G	6C5
1D5G	1A4	6F5G	6F5
1D7G	1A6	6F6G	42, 6F6
1E5G	1B4	6H6G	6H6
1E7G	1F4	6J7G	77, 6J7
1F5G	1F4	6K6G	41, 6F6
1F7G	1F6	6K7G	78, 6K7
1H4G	30	6L6G	6L6
1H6G	1B5, 25S	6L7G	6L7
1J6G	19 (ex'pt Fil.)	6N6G	6B5, 6N6
5V4G	5Z4	6N7G	6A6, 6N7
5X4G	5Z3	6P7G	6F7, 6P7
5Y3G	5Y3	6Q7G	6B6, 6Q7
5Y4G	80	6R7G	85, 6R7
5Z4MG	5Z4	6X5G	84, 6X5
6A8G	6A7	6Z4G	84, 6X5
6B4B	6A3	25A6G	43, 25A6
6B6G	6Q7	25Z6G	25Z5, 25Z6

Class A Amplifier

Plate Voltage . ...95 V.
No. 2 Grid (screen-grid) Voltage.....95 V.
No. 1 Grid (control-grid) Voltage.. —15 V.
Plate Current ....45 ma.
Screen-grid Current* ....4 ma.
Screen-grid Current** .. ..12 ma.
Plate Resistance (subject to considerable variation)
Load Resistance ....2,000 ohms.
Mutual Conductance ....4,000 mmhos
Power Output ....1.75 W. (10 per cent distortion)

* No signal
** Maximum signal

6J5G General Purpose Amplifier.. This is a new glass tube having an octal base. Also the output capacity is approximately ⅓ that of the 6C5 so that the 6J5G is especially applicable to ultra-high frequency work. With the above exceptions, this tube parallels the characteristics of the 76, 37 and 6C5 tubes.

6J5G Characteristics

Heater Voltage A.C. or D.C...........6.3 V.
Heater Current ....0.3- A.
Direct Interelectrode Capacities
Grid-to-Plate ....3.4 mmf.
Input ....3.8 mmf.
Output ....3.3 mmf.

Class A Amplifier

Heater Voltage ....6.3 V.
Plate Voltage ....250 V.
Control-grid Voltage .... —8 V.
Plate Current ....9.0 ma.
Plate Resistance ....7,700 ohms (app.)
Mutual Conductance ..2,600 mmhos (app.)
Amplification Factor 20

6K5G High-Mu Triode. The characteristics of this new Sylvania tube are similar to the 6Q7G.

The 6K5G operated with a supply voltage of 250 and a plate load resistance of 0.1-meg. to 0.25-meg should have a control-grid bias of 2.5 V. When operated with 100 V. on the plate and a load of 50,000 to 0.1-meg. the grid bias should be about 1.4 V.

6K5G Characteristics

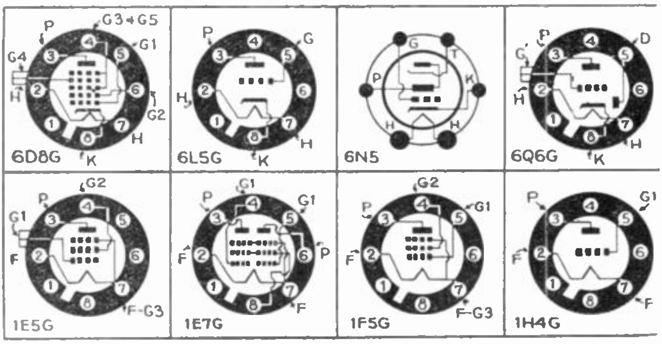
Heater Voltage A.C. or D.C..........6.3 V.
Heater Current ....0.3- A.
Direct Interelectrode Capacities
Grid-to-Plate ....2.0 mmf.
Input .... .2.4 mmf.
Output ....3.6 mmf.

Class A Amplifier

Heater Voltage	6.3	6.3 V.
Plate Voltage	100	250 V.
Control-grid Voltage*	—1.5	—3 V.
Plate Current*	0.35-	1.1 ma.
Plate Resistance	78,000	50,000 ohms (app.)
Mutual Conductance	900	1,400 mmhos (app.)
Amplification Factor	70	70

* These are rating values only and not operating points with coupling resistor.

Dual-Triode 6N7 and 6N7G Class-B Power Amplifier. This tube is the octal equivalent of the 6A6—a glass B twin-triode output tube.



These distinctive features have been made possible by the application of fundamentally new design principles involving the use of directed electron beams.

Primary features resulting from this arrangement are that the screen-grid does not absorb appreciable power and that efficient suppressor action is supplied by space-charge effects produced between the screen-grid and the plate. Secondary features are high power-handling ability, high efficiency, and high power sensitivity. Furthermore, large power output is obtainable without any grid current flowing in the input circuit.

In the design of the 6L6, the second-harmonic distortion is intentionally high in order to minimize third- and higher-order harmonics. Experience has shown that second-harmonics are far less objectionable in the audio-frequency output than harmonics of higher order. The second-harmonics can easily be eliminated by the use of push-pull circuits, while in single-tube, resistance-coupled circuits, they can be made small by generating out-of-phase second-harmonics in the preamplifier.

Heater Voltage (A.C. or D.C.)	6.3 V.
Heater Current	0.9-A.
Maximum Overall Length	4 5/16 ins.
Maximum Diameter	1 5/8 ins.
Base	Small Octal 7-Pin

Static and Dynamic Characteristics

Heater Voltage	6.3 V.
Plate Voltage	250 V.
Screen-grid Voltage	250 V.
Control-grid Voltage	—14 V.
Amplification Factor	135
Plate Resistance	22,500 Ohms
Mutual Conductance	6,000 Micromhos
Plate Current	72 ma.
Screen-grid Current	5 ma.

Depending upon whether it is used with fixed- or self-bias, the tube has various ratings up to 11.5 W. for a single tube. Push pull operation will produce up to 34 W. without need of any driving power, while under class AB_2 conditions, with a plate voltage of 400 V. and with a grid power input of 350 milliwatts, the power output is 60 W. at less than 2% distortion, under proper circuit conditions. (Socket connections are the same as those of the 25B6G, p. 61.)

The 1F6. This tube is a double diode-pentode, with a 2 V. filament, and it is certainly a welcome addition to the battery line. It is similar in usage to the 6B7, in that the pentode section may be used for I.F., A.F., or R.F. amplification. The cut-off characteristics are midway between the sharp and remote types, permitting wide application.

1F6 Characteristics

Filament Voltage (D.C.)	2.0 V.
Filament Current	0.06-A.
Plate Voltage	180 V. max.
Screen-grid Voltage	67.5 V. max.
Control Grid Voltage	—1.5 V.
Plate Current	2.0 ma.
Screen-grid Current	0.6 ma.
Plate resistance (approx.)	1 meg.
Amp. Factor (approx.)	650
Mutual Conductance	650 micromhos
Mutual Conductance (at —12 V. bias)	15 micromhos

The 5W4. An all-metal full-wave rectifier designed for use where the D.C. requirements are moderate. The applied A.C. voltage should not exceed 350 V. per plate and the load current from the filter output should be under 110 ma. It is a high-vacuum tube of the filament type. The tube is of the same size and has the same base connections as the 5Z4, but is designed for a lighter load.

5W4 Characteristics

Filament Voltage	5.0 V.
Filament Current	1.5 A.
A.C. Plate Voltage (per plate) max.	r.m.s. 350 V.
D.C. output current	110 ma. max.

The 1F4. Here is another tube of the 2.0 V. series, and is similar to the type 33, except that it takes less plate and filament current. It has the same physical dimensions and the same base connections. It is very similar to the 950, although the operating characteristics are somewhat different.

1F4 Characteristics

Filament Voltage (D.C.)	2.0 V.
Filament Current	0.12 ma.
Plate Voltage	135 V. max.
Screen-grid Voltage	135 V. max.
Control-grid Voltage	—4.5 V.
Plate Current	8.0 ma.
Screen-grid Current	2.6 ma.
Plate Resistance	0.2 meg.
Amplification Factor	350
Mutual Conductance	1,700 micromhos
Load Resistance	16,000 ohms
Undistorted Power Output	340 Milliwatts

6D8G—Frequency Converter. This tube is a frequency converter type, similar in purpose to the 6A8 metal tube. The characteristics, with the exception of the filament current, are approximately the same as for the 6A8G.

6D8G Characteristics

Heater Voltage ....6.3 V.
Heater Current ....0.15 A.
Plate Voltage ....250 V.
Anode Grid Voltage (Grid No. 2)..250 V.*
Screen-grid Voltage (Grids No. 3 and 5) ....100 V.
Control-grid Voltage (Grid No. 4).. —3 V.
Oscillator-grid Resistor (Grid No. 1) ....50,000 ohms
Conversion Conductance ....325 mmhos
Plate resistance .... 0.40 meg.
Control Grid Bias for Conversion Conductance (10 mmhos)........ —25 V.
Triode Mutual Conductance (Egl 0) ....1,150 mmhos
Cathode Current ... .8 ma.

* Through a 20,000 ohm dropping resistor.

Interlectrode Capacities
(With form-fitting shield)

Oscillator Input ... . 6.0 mmf.
Oscillator Output .... 5.5 mmf.
Oscillator-grid G_1 to Anode-grid G_2 .... 1.0 mmf.
R.F. Input .... 8.0 mmf.
Mixer Output ....11.0 mmf.
Grid G_4 to Plate.................. 0.3 mmf.

6L5G—Triode Voltage Amplifier. This tube is a triode voltage-amplifier, suitable as an audio amplifier of medium gain, low distortion and high output. It is similar to the 6C5 metal triode.

6L5G Characteristics

Heater Voltage...	6.3 V.	6.3 V.
Heater Current..	0.15 A.	0.15 A.
Plate Voltage	135	250 V. max.
Control-grid Voltage	—3.5	8.0
Plate Current ..	3.5	8.0
Plate Resistance	11,300 ohms	9,000 ohms
Amplification Factor	17	17
Mutual Conductance	1,500	1,900

Interelectrode Capacities
(With form-fitting shield)

Grid-to-plate ....2.7 mmf.
Grid-to-cathode ....3.0 mmf.
Plate-to-cathode ....5.0 mmf.

6N5—Cathode-Ray, Tuning Indicator. The cathode-ray tuning indicator of the 6E5, sharp cut-off triode type has been duplicated in the low-filament current tubes and is known as the 6N5. This tube has a wider operating range between zero shadow than the 6E5, requiring 12 V. to produce the change, instead of the 8 V. required for the 6E5 type.

6N5 Characteristics

Heater Voltage ....6.3 V.
Heater Current ....0.15 A.
Plate Supply Voltage..........135 max. V.
Target Voltage ....135 max. V.
Triode-plate Series Resistor. ....0.25 meg.
Triode-plate Current for Grid Voltage = 0.......................0.5 ma.
Triode-grid Voltage to Give 0° Shadow ....—12 approx. V.
Triode-grid Voltage to Give 90° Shadow ....0 approx. V.

6Q6G—Diode-Triode. Here is a diode, high-mu triode tube similar to the 6Q7 metal tube, but having only 1 diode.

6Q6G Characteristics

Heater Voltage	6.3 V.	6.3 V.
Heater Current	0.15 A.	0.15 A.
Plate Voltage	135 V.	250 max. V.
Control-grid Voltage	—1.5 V.	—3.0 V.
Plate Current	0.9 ma.	1.2 ma.
Amplification Factor	65	65
Mutual conductance	1,000	1,050

6S7G—Variable-Mu Pentode R.F. Amplifier. This variable-mu R.F. amplifier is similar to the type 78 metal tube, though having a higher mutual conductance and amplification factor than the latter.

Heater Voltage ...	6.3 V.	6.3 V.
Heater Current	0.15 A.	0.15 A.
Plate Voltage	135 V.	250 max. V.

6S7G Characteristics

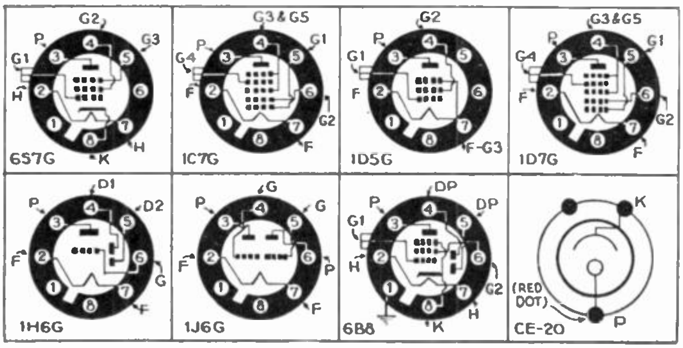
Screen-grid Voltage	67.5 V.	100 max. V.
Control-grid Voltage	—3.0 V.	—3.0 V.
Suppressor voltage (Connected to cathode at socket.)		
Plate Current	3.7 ma.	8.5 ma.
Screen-grid Current	0.9 ma.	2.0 ma.
Amplification Factor	850	1,100
Mutual Conductance	1,250	1,750
Control-grid Voltage for mutual conductance = 10	—25 V.	—38.5 V.

Interelectrode Capacities
(With form-fitting shield)

Grid-to-plate ... .0.007 mmf. max.
Input .... 4.6 mmf.
Output .... 7.8 mmf.

1C7G—Pentode Converter. This tube has identical characteristics to the 1C6 pentagrid converter, with the exception of the base—which fits the octal sockets.

1D5G—Variable-Mu Pentode R.F. Amplifier. The characteristics of this variable-mu R.F. pentode, the direct-filament type, are very similar to those of the 1A4—With the exception of the added suppressor-grid element. The tubes, thus, may not operate the same in certain circuits — for example, in dynatron oscillators. (Late production on the 1A4 also includes the suppressor-grid!)



1D5G Characteristics

Plate	90	180 max. V.
Screen-grid	67.5	67.5 max. V.
Control-grid	—3	—3 min. V.
Amplification Factor	350	705
Plate Resistance	560,000	1,050,000 ohms
Mutual Conductance	700	750 mmhos
Plate Current	2.2	2.3 ma.
Screen-grid Current	.9	.8 ma.
Mutual Conductance at —15 V. control-grid	15	15 mmhos

Interelectrode Capacities (with shield)

Cglp ....007 max. mmf.
Cgl (K plus G2)........... 4.8 mmf.
Cp (K plus G2)........... 11.5 mmf.

1D7G—Pentagrid Converter. This tube is identical in its characteristics to the 1A6 pentagrid converter tube. It is fitted with the octal base and is enclosed in a glass bulb.

1E5G—Sharp Cut-off R.F. Pentode. The characteristics of this tube exactly duplicate those of the 951 and the 1B4 tubes, being a sharp cut-off R.F. pentode. The tube has one element more than the 1B4—a suppressor-grid making it a pentode. This may change the operation in some special cases such as in dynatron circuits, depending on secondary emission from the plate which is reduced by the suppressor. (Late production on the 1B4 also includes the suppressor-grid!)

1E7G—Dual-Pentode Output Tube. THIS IS AN UNUSUAL TUBE, BEING THE FIRST DUAL-PENTODE OUTPUT TUBE TO BE INTRODUCED. The characteristics are identical to the 1F4, with the exception that 2 tubes are included in the same envelope with a single set of filament connections and screen-grid connections being brought out to the base prongs.

1F5G—Output Pentode. The characteristics of this tube are identical with those published for the 1F4. It is similar to one-half of the above-mentioned 1E7G.

1H4G — General-Purpose Triode. The 1H4G is similar in its characteristics to the type 30, being a triode of the 2-V. filament type. However, it has been especially designed to provide operation as a low-current class B output tube and when used in push-pull (2 tubes), a power output of over 2 W. can be obtained without introducing noticeable distortion! It is fitted with an octal base.

1H4G Characteristics

Amplifier Class A
(Operating conditions and characteristics)

Plate	90	135	180 V.
Control-grid	—4.5	—9.0	—13.5 V.
Amp. Factor	9.3	9.3	9.3
Plate Resis.	11,000	10,300	10,300 ohms
Plate Cur.	2.5	3.0	3.1 ma.
Mut. Cond.	850	900	900 mmhos

Amplifier Class B

Plate Voltage	180 max. V.
Peak Plate Current	50 max. ma.
Zero Signal Pl. Cur. (per tube)	1.5 max. ma.

Typical Operation (2 tubes)

Plate	157.5 V.
Control-grid	—15 V.
Zero Sig. Plate Cur. (per tube)	0.5 ma.
Load Resistance (per tube)	2000 ohms
Effective Load Res. (pl. to pl.)	8000 ohms
Max. Sig. Driving Power	260 milli-W.
Power Output (2 tubes)	2.1 W.

Detector
(Operating conditions as biased detector)

Plate	90	135	180 max. V.
Control-grid (approx.)	—9.0	—13.5	—18.0 V.

Plate current adjusted to 0.2-ma. with no signal. With normal signal the average D.C. plate current should be limited to 2.0 ma.

1H6G—Duodiode-Triode. This has characteristics identical with the 1B5 and 25S glass tubes. The only difference is in the use of the octal base.

1J6G—Twin-Triode Power Amplifier. Here is a twin-triode power amplifier. Since the characteristics of the 19 are well known, the figures are not repeated here.

6B8—Duodiode-Pentode. This dual purpose type includes a pentode and two diodes in the same metal container. Thus it may be used similarly to the 6B7.

6B8 Characteristics

Amplifier operation (R.F. or I.F.) pentode section

Plate Voltage	250 max. V.
Screen-grid Voltage	125 max. V.
Control-grid Voltage	—3 V.
Plate Current	10.0 ma.
Screen-grid Current	2.3 ma.
Plate Resistance	0.6 approx. meg.
Amplification Factor	800 approx.
Mutual Conductance	1325 micromhos
*Control-grid Voltage	21 approx. V.

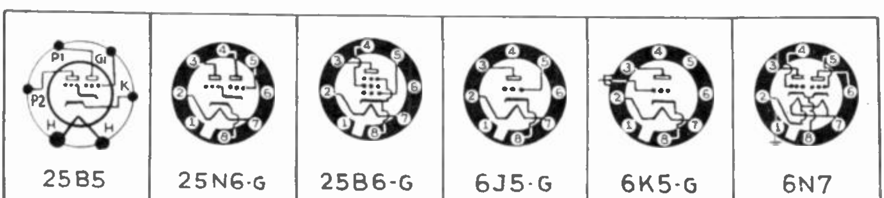
* Voltage for cathode current cut-off.

Interelectrode Capacities

G_1 — P ....0.005 mmf. max.
G_1 — (K + G_2 + G_3).......6.0 mmf.
P — (K + G_2 + G_3).......9.0 mmf.

CE-20—16-MM. "Talkies" PE. Cell. This tube is a new photoelectric cell designed primarily for use with 16 MM. film projectors and other applications where a small but efficient photo-cell is required.

The tube is a caesium-argon type having the standard 3-prong PE. cell film projector base. The tube is 2 ins. high and 1¼-in. in dia. Among other advantages claimed for it are high sensitivity, non-microphonic characteristics and compact envelope.



25B5 — Dynamic-Coupled Dual-Triode. This tube is equivalent in characteristics to the well-known 6B5.

It is interesting to note that the new tube, requiring no external bias, takes advantage of the full 110 V. of the "B" supply in A.C.-D.C. sets, thus supplying a maximum output of 2 W. with 9 per cent harmonic content, compared with only 0.9-W. from the 43 in a similar circuit.

25B5 Characteristics

Output Plate (P^2)	110	180 max. V.
Input Plate	110	100 + V.
Control-grid	0	0 V.
Plate Current (P^2)	45	46 ma.
Plate Current (P^1)	7	5.8 ma.
Amplification Factor	25	35
Plate Resistance	11,400	15,200 ohms
Mutual Conductance	2,200	2,300 mmhos
Load Resistance	2,000	4,000 ohms
Power Output	2.0	3.8 W.
Harmonic Distortion	9	9 percent
Signal Volts for Rated Power	21	21 r.m.s.

25N6 — Dynamic-Coupled Dual - Triode. This tube has the same characteristics as the 25B5 described above, the only difference being in the use of an octal base on this tube.

The manufacturer, Triad Mfg. Co., recommends that for best results, a diode-type detector be used before the 25B5 and 25N6. In experimental work, it was found that the 6Q7 supplied the optimum characteristics for use with these tubes.

25B6G—Pentode Power Amplifier. This tube, also, is an improvement over the type 43. It is a glass tube, with octal base. It is a power pentode, known as the "unipotential cathode" type, according to the manufacturer, Raytheon Production Corp. The output power of 1.75 W. is materially higher than the 0.9-W. supplied by the 43 with 95 V. applied to the plate and screen-grid, and a control-grid bias of —15 V., the plate current is 45 ma. and the screen-grid current is 4 ma.

25B6G Characteristics

Voltage	25.0 V.
Current	0.3 A.

OCTAL-BASE GLASS TUBES AND EQUIVALENTS

Octal Glass Type	Equiv. Type	Octal Glass Type	Equiv. Type
1C7G	1C6	6C5G	6C5
1D5G	1A4	6F5G	6F5
1D7G	1A6	6F6G	42, 6F6
1E5G	1B4	6H6G	6H6
1E7G	1F4	6J7G	77, 6J7
1F5G	1F4	6K6G	41, 6F6
1F7G	1F6	6K7G	78, 6K7
1H4G	30	6L6G	6L6
1H6G	1B5, 25S	6L7G	6L7
1J6G	19 (ex'pt Fil.)	6N6G	6B5, 6N6
5V4G	5Z4	6N7G	6A6, 6N7
5X4G	5Z3	6P7G	6F7, 6P7
5Y3G	5Y3	6Q7G	6B6, 6Q7
5Y4G	80	6R7G	85, 6R7
5Z4MG	5Z4	6X5G	84, 6X5
6A8G	6A7	6Z4G	84, 6X5
6B4B	6A3	25A6G	43, 25A6
6B6G	6Q7	25Z6G	25Z5, 25Z6

Class A Amplifier

Plate Voltage	95 V.
No. 2 Grid (screen-grid) Voltage	95 V.
No. 1 Grid (control-grid) Voltage	—15 V.
Plate Current	45 ma.
Screen-grid Current*	4 ma.
Screen-grid Current**	12 ma.
Plate Resistance (subject to considerable variation)	
Load Resistance	2,000 ohms.
Mutual Conductance	4,000 mmhos
Power Output (10 per cent distortion)	1.75 W.

* No signal
** Maximum signal

6J5G General Purpose Amplifier. This is a new glass tube having an octal base. Also the output capacity is approximately 1/3 that of the 6C5 so that the 6J5G is especially applicable to ultra-high frequency work. With the above exceptions, this tube parallels the characteristics of the 76, 37 and 6C5 tubes.

6J5G Characteristics

Heater Voltage A.C. or D.C.	6.3 V.
Heater Current	0.3- A.
Direct Interelectrode Capacities	
Grid-to-Plate	3.4 mmf.
Input	3.8 mmf.
Output	3.3 mmf.

Class A Amplifier

Heater Voltage	6.3 V.
Plate Voltage	250 V.
Control-grid Voltage	—8 V.
Plate Current	9.0 ma.
Plate Resistance	7,700 ohms (app.)
Mutual Conductance	2,600 mmhos (app.)
Amplification Factor	20

6K5G High-Mu Triode. The characteristics of this new Sylvania tube are similar to the 6Q7G.

The 6K5G operated with a supply voltage of 250 and a plate load resistance of 0.1-meg. to 0.25-meg. should have a control-grid bias of 2.5 V. When operated with 100 V. on the plate and a load of 50,000 to 0.1-meg. the grid bias should be about 1.4 V.

6K5G Characteristics

Heater Voltage A.C. or D.C.	6.3 V.
Heater Current	0.3- A.
Direct Interelectrode Capacities	
Grid-to-Plate	2.0 mmf.
Input	2.4 mmf.
Output	3.6 mmf.

Class A Amplifier

Heater Voltage	6.3	6.3 V.
Plate Voltage	100	250 V.
Control-grid Voltage*	—1.5	—3 V.
Plate Current*	0.35-	1.1 ma.
Plate Resistance	78,000	50,000 ohms (app.)
Mutual Conductance	900	1,400 mmhos (app.)
Amplification Factor	70	70

* These are rating values only and not operating points with coupling resistor.

Dual-Triode 6N7 and 6N7G Class-B Power Amplifier. This tube is the octal equivalent of the 6A6—a glass B twin-triode output tube.

HANDY INDEX

Radio-Craft 1936