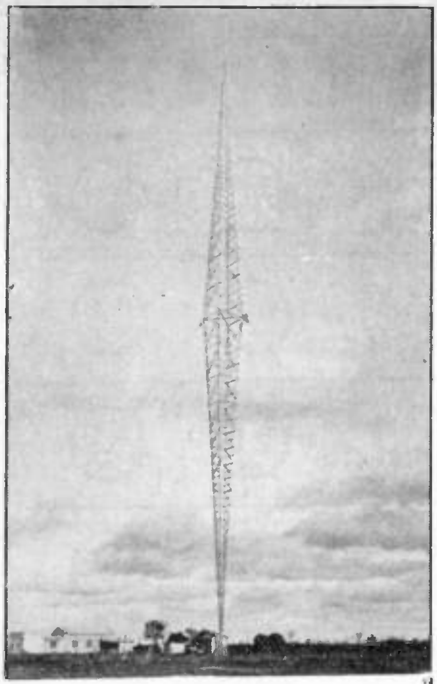
1935 Radio Man's Guide

PUBLISHED BY

RADIO NEWS
AND
SHORT WAVE RADIO



LS2

Radio Prieto, Buenos Aires

This book is dedicated to the tens of thousands of radio men, located throughout the world, who read RADIO NEWS each month. The 1935 Radio Man's Guide has been compiled and edited from the works of many outstanding radio experts and the editors feel certain that it will prove to be one of the year's outstanding radio publications. Your comments will be appreciated.

▲

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Teck Publications, Inc.

461 Eighth Avenue

New York, N. Y.

Printed in the U. S. A.

1935 RADIO MAN'S GUIDE

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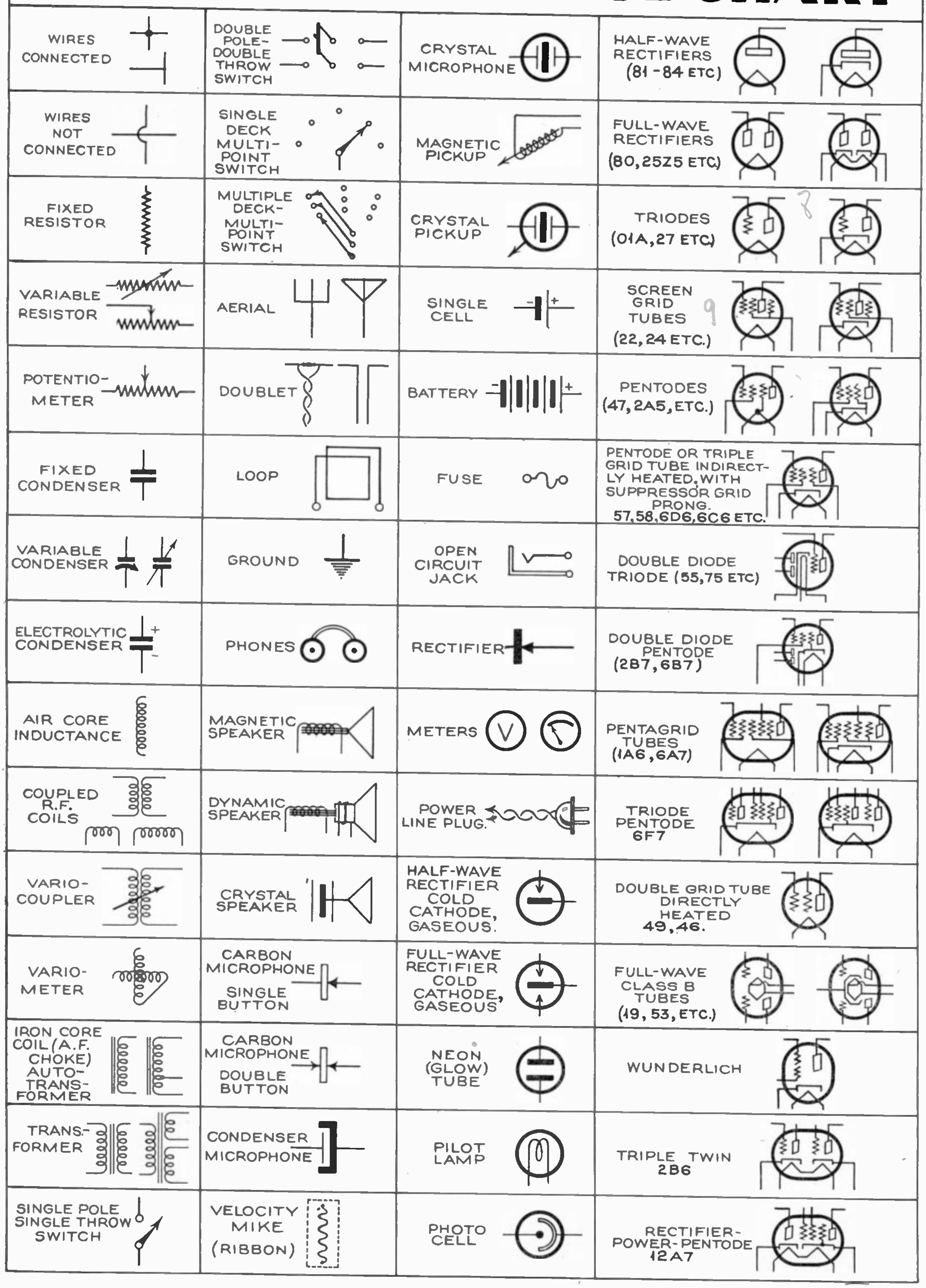
RADIO NEWS SYMBOL CHART



Radio Set Building

MOST Americans really enjoy doing things with their own hands and co-ordinating their workmanship with their own individual brain power. That is why Americans have always been interested in radio construction. Recently set-building has been growing in popularity, in leaps and bounds; at least, that is how it is with RADIO NEWS readers.

In fact, set-building as a hobby seems to have engaged the interest of more radio fans recently than at any time since the popular home-construction days of 1924. People, young and old, are turning to set-building at home to enable them to listen in to short-wave transmissions from all over the world. It is true that the increase of activity on the short waves has had a lot to do with this revival of interest, but it is also true that people want to build not only short-wave sets, but sets that will bring in the regular broadcast-band transmissions.

Realizing these needs of a large number of radio experimenters who have been "steady customers" in the more experienced set-building field as well as the thousands of new recruits who have been turning to set-building during the past year. RADIO NEWS has specialized in the better designs incorporating these latest principles. Our technical staff maintains steady contact with America's foremost designers in the "How to Build" field.

Herein we are giving to our readers a number of designs in different fields, some simple and some more complicated. The Editors feel that these designs are the finest that have been put before the set-building public for some time and that they offer the set-builder the chance he has been waiting for to build a receiver really worth while and one that will produce results in both distance reception and in high quality of reproduction.

RADIO NEWS' policy of putting out blueprints of its main designs will also be found to be a help to set constructors, and as the list of available blueprints grows, the Editors promise that efficient receivers for *any kind of use and fitting any pocketbook* will be adequately covered. Follow RADIO NEWS designs in your experimental set-building, and you cannot go far wrong!

The Pelham

(1-Tube Short-Wave Set)

THE circuit shown in Figure 1 is a modern version of the "Junk Box" circuit, made so famous by RADIO NEWS in 1928, and found to be, by thousands of fans, one of the most popular single-tube short-wave sets.

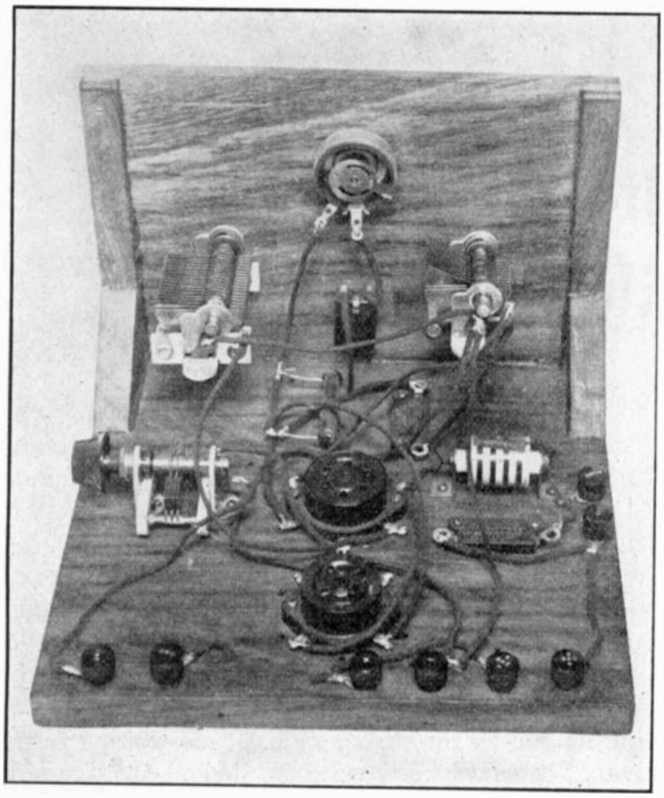
It uses a standard set of triple-winding, short-wave coils shown as L1, L2 and L3. It has an antenna condenser, C1, for adjusting the antenna frequency. This is placed on the baseboard. Another condenser, C2, the left-hand control on the panel, is used for tuning. It is very sensitive to adjust. The third condenser, C3, which is the right-hand control on the panel, is used for controlling volume through regeneration. The condenser, C4, is the grid condenser, while resistance R1 is the grid leak. Variable resistance R2, which is the central upper control on the panel, adjusts the filament current which should be kept as low as possible consistent with good results. The switch SW is the lower central control on the panel and is used for turning the set "on-and-off." The tube used is a type-30 three-element tube in the plate circuit of which is found a choke coil, RFC, and a condenser, C5, which act as a filter to keep redio-frequency currents out of the 'phone circuit so that the set will not have "hand capacity."

Going back to coil L1, this is the antenna coil, while L2 is the grid coil and L3 is the feed-back coil.

The set is powered by dry cells and all that is necessary is two ordinary bell-ring batteries, connected in series across the two terminals marked A (plus) and A (minus), where A (plus) goes to the positive terminal and A (minus) goes to the negative terminal. A standard 45-volt B battery may be connected to the plate power terminals, B (minus) and B (plus), where B (minus) is connected to the negative terminal and B (plus) to the positive terminal. In the building of this set, these four terminals are brought out to binding posts on the back edge of the baseboard, as are also the two terminals for the antenna and the ground. This may be seen clearly in the photographic illustrations, Figure 2 and 3. Two more binding posts are used for the phones.

In building the set, the first job is to make the frame, consisting of front panel and baseboard. Details and sizes of this framework are shown in Figure 4.

After the framework has been put together with a good grade of glue and small screws and given a coat of shellac (if desired), the next job is to mount the parts in their proper places. The spacing for these is indicated in the picture-wiring diagram in Figure 5. Two sockets must be obtained, one is a standard four-prong socket (for the tube) and the other a six-prong socket (for mounting the coils).



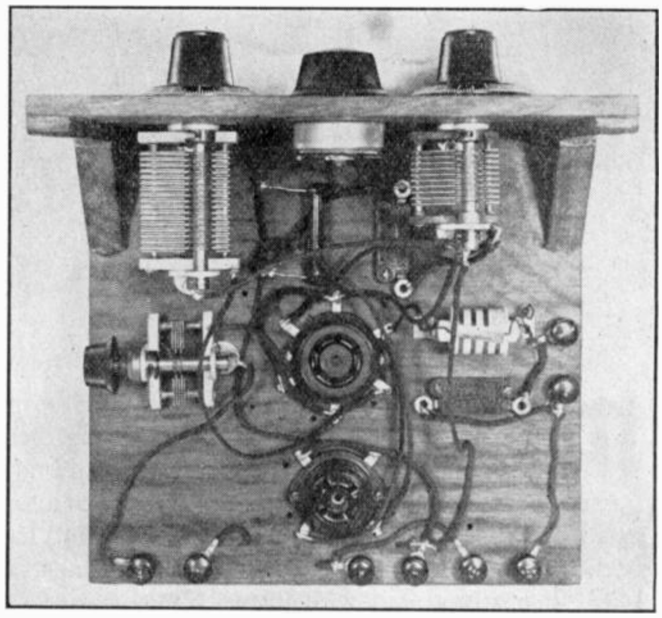


Fig. 2—Left Fig. 3—Above

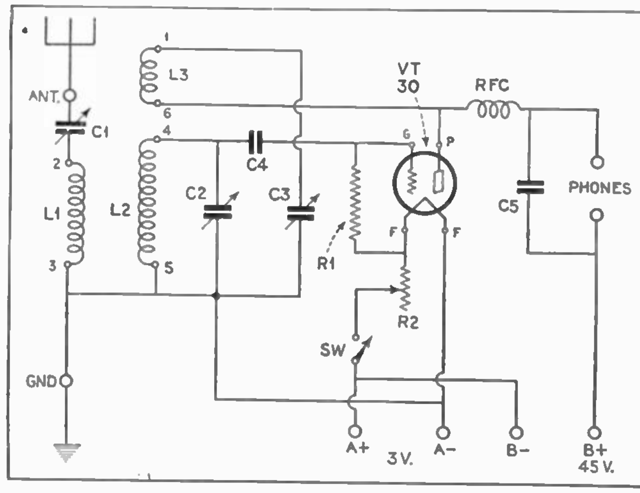


Figure 1—Above

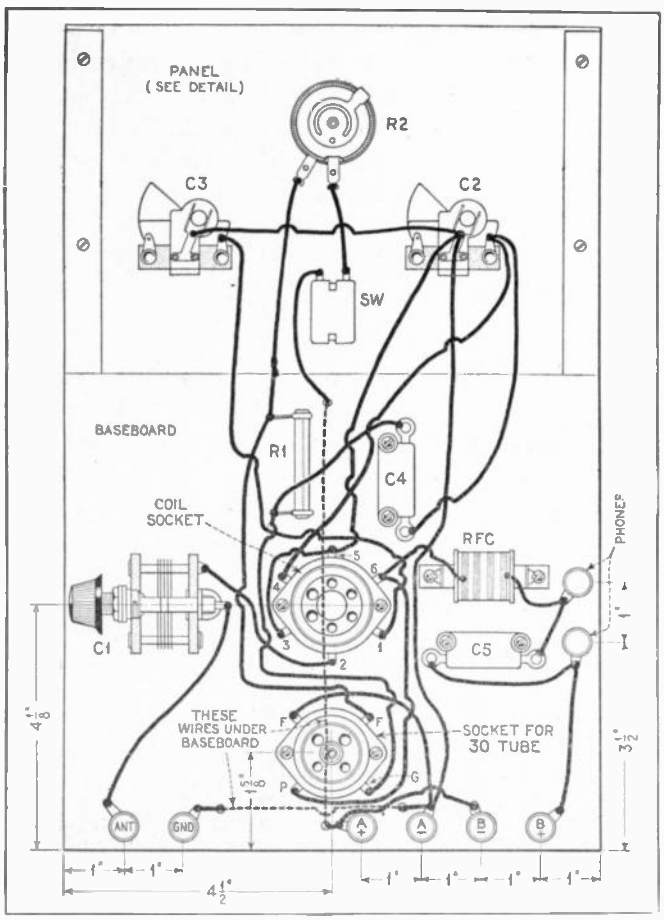


Figure 5

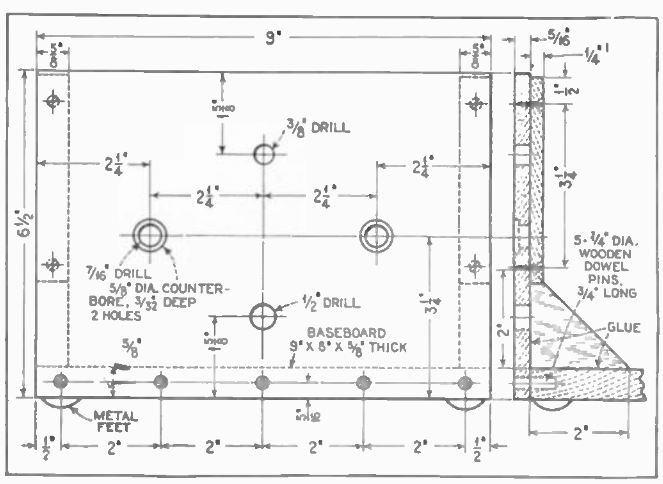


Figure 4

Otherwise follow the directions as shown in Figure 5 and in the photographs.

When all the parts have been mounted in their proper places, the next job is to connect up the wiring, as is also clearly shown in the picture-wiring diagram, Figure 5. You can do it in about an hour, using flexible cloth-insulated connection or hook-up wire, obtainable from any radio dealer or serviceman. Lugs should be attached to the connections where they end under the binding posts.

When the set is finished it may be hooked up to the batteries, as already described. An antenna of somewhere between 50 and 75 feet is found to give good results. It should be placed as high up as it is possible to erect it. A ground can be made to a suitable water pipe or gas pipe, whichever happens to be the most convenient position, although, if there is a choice, it should be tried out with a distant station tuned in.

Parts List

C1—Hammarlund 5-plate midget variable condenser, .000025 mfd. with mounting lugs.
C2—Hammarlund 19-plate variable condenser, .00014 mfd.
C3—Hammarlund 35-plate variable condenser, .00025 mfd.
C4—Aerovox fixed condenser, .001 mfd.
C5—Aerovox fixed condenser, .001 mfd.
L1, L2, L3—Standard 3-winding, 6-prong, short wave coils for the type -30 tube.*
R1—Carbon variable resistance, 3 megohms.
R2—Yaxley 30-ohm rheostat.
RFC—Hammarlund type CH-8 r.f. choke, 8 millihenries.
SW—Cutler-Hammer, single-circuit toggle switch.
1 type -30 triode vacuum tube.
1 Standard 4-prong socket for the type -30 tube.
1 Standard 6-prong socket for mounting s. w. coils.
8 binding posts, suitably marked for connections as shown in Figure 5.
Miscellaneous—wood screws, wood for base, four gliders or mounting feet, hook-up wire, etc.

*These coils can be obtained in sets of four. They cover the various wavelength ranges in steps about as follows: Coil No. 1 covers the 19, 25 and 31-meter bands. Coil No. 2 covers from approximately this upper wavelength to around 70 meters. Coil No. 3 goes from approximately 70 to 130 meters. Coil No. 4 goes somewhere from 130 to 200 meters. These frequency ranges vary slightly with the make.

A standard set of 2000- or 3000-ohm phones is suitable for use with this receiver. Tuning is accomplished with condenser C2, after an approximate setting of condenser C1 for the aerial used. Regeneration is controlled with condenser C3. It should be rotated to the point just below the "oscillation point" for maximum loudness. When a station is tuned in, condenser C1 can be readjusted for best results. A slight variation of C2 may have to be made after adjusting the other two condensers.

Switch SW turns the set on and off.

The Skyscraper

(3-Tube T. R. F. Short-Wave Receiver)

THE advantages of a really good stage of r.f. amplification, ahead of a regenerative detector are not fully appreciated by the average short-wave constructor. The outstanding ability of some commercial receivers is widely recognized but as a rule the home constructor has not been very successful in applying r.f. tubes in regenerative receiver circuits. The outstanding reason for this failure has been the lack of proper shielding and filtering, and a contributing cause has been the use of coils of unsuitable design.

In the "Skyscraper" receiver the single stage of tuned r.f. amplification provides decidedly worthwhile gain and at the same time is absolutely stable. These advantages have been gained through careful attention to design details. First of all the parts employed were carefully selected to avoid losses; then these parts were laid out in such a way as to keep leads short and avoid undesirable coupling. Finally the shielding was planned to provide maximum isolation of the r.f. and detector stages, at the same time introducing as little loss as possible. (Some loss is always introduced by the metal mass of shields.)

The tuned r.f. stage, as used in this receiver, provides greatly improved selectivity, as would be expected from the addition of another tuned circuit. The control of regeneration is made much more consistent and stable, due to the presence of the r.f. tube which acts as a buffer ahead of the regenerative circuit and thus prevents antenna absorption. Thus several distinct advantages are gained through the use of the r.f. stage.

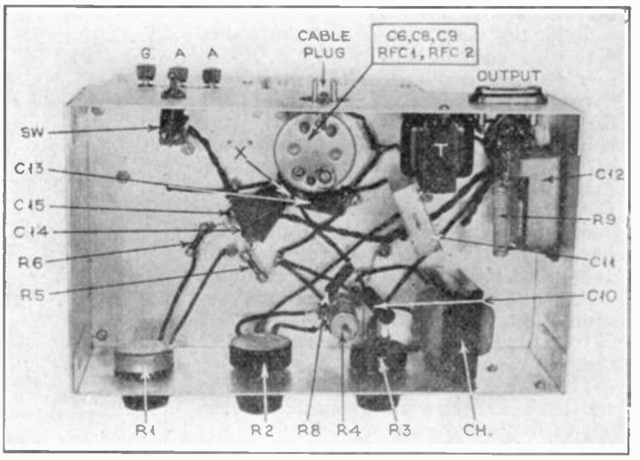
At first glance at Figure 6, it may seem that an unnecessarily large number of controls are included on the front panel. If this receiver were designed exclusively for the use of inexperienced short-wave listeners this would perhaps be true. However, for the experienced "ham" or short-wave broadcast fan each one of these controls will be found to offer a definite advantage, as will be seen from the following description of their functions.

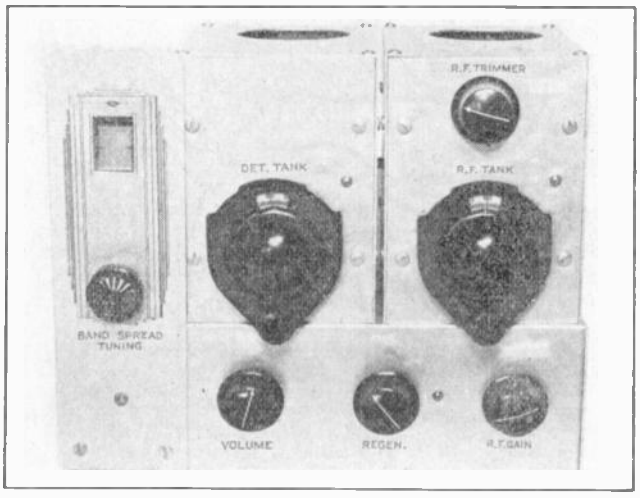
The two vernier dials control the

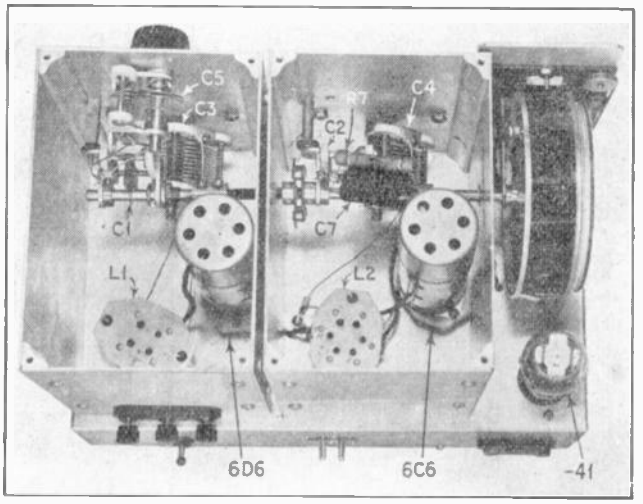
Figure 6
Lower Left

Figure 7
Lower Right

Figure 8
Upper Right







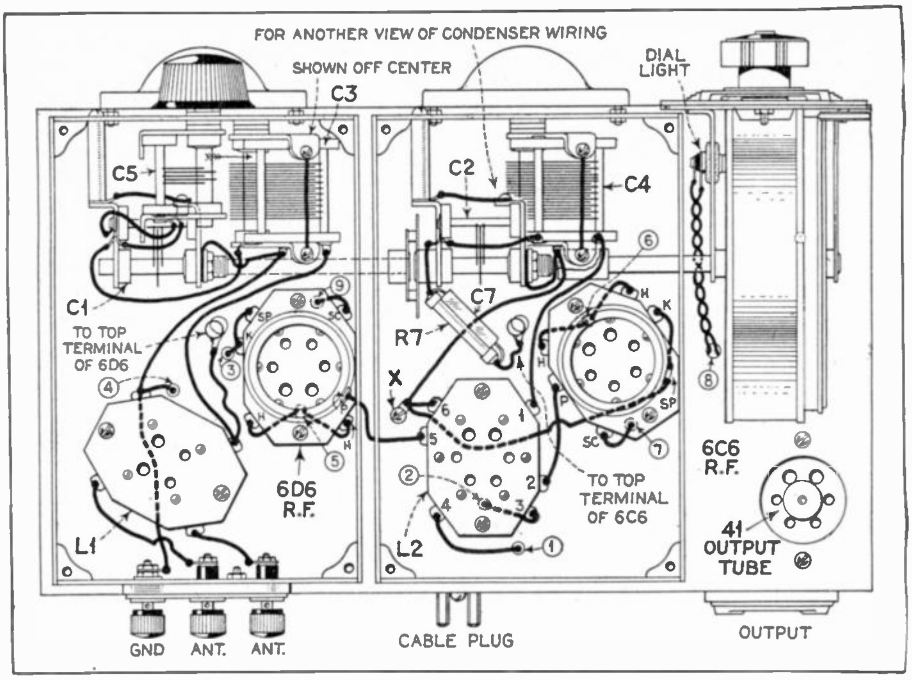


Figure 9

tank condensers of the r.f. and detector stages. These are the band-setting condensers (C3 and C4) and are employed only in bringing the circuits into resonance at the particular range in which it is desired to tune. The illuminated drum dial at the left is the band-spread tuning control. This controls the two small condensers C1 and C2 which are ganged on one shaft. The actual selection of individual stations is accomplished with this control and tuning is therefore "single dial" after the tank condensers have once been set for any desired range. Above the r.f. tank control is a vernier (C5) the purpose of which is to permit such slight variations of the r.f. tuning as may be necessary to maintain exact resonance when tuning through wide ranges with the band-spread control, and to make the tank dials read alike. This condenser is not absolutely essential but will be found helpful, due to the sharp tuning characteristics of the r.f. circuit.

The three knobs along the bottom control sensitivity and volume. At the left is the audio-volume control, in the center the regeneration control and at the right the r.f. gain control. The reasons for employing both regeneration and r.f. gain controls will be explained later.

The tubes employed are all of the 6-volt heater type. These have several features which make them preferable to the 2½-volt type. They may be operated (in parallel) from either a storage battery or a 6-volt transformer winding; or their low current drain makes it practical to operate the filaments in series from a d.c. line, using a suitable series voltage dropping resistance and a shunt across each of the .3 ampere filaments to by-pass the extra current required by the heater of the type -41 tube. When operated on alternating current the hum level is very low—considerably lower than with equivalent tubes of the 2½-volt heater type.

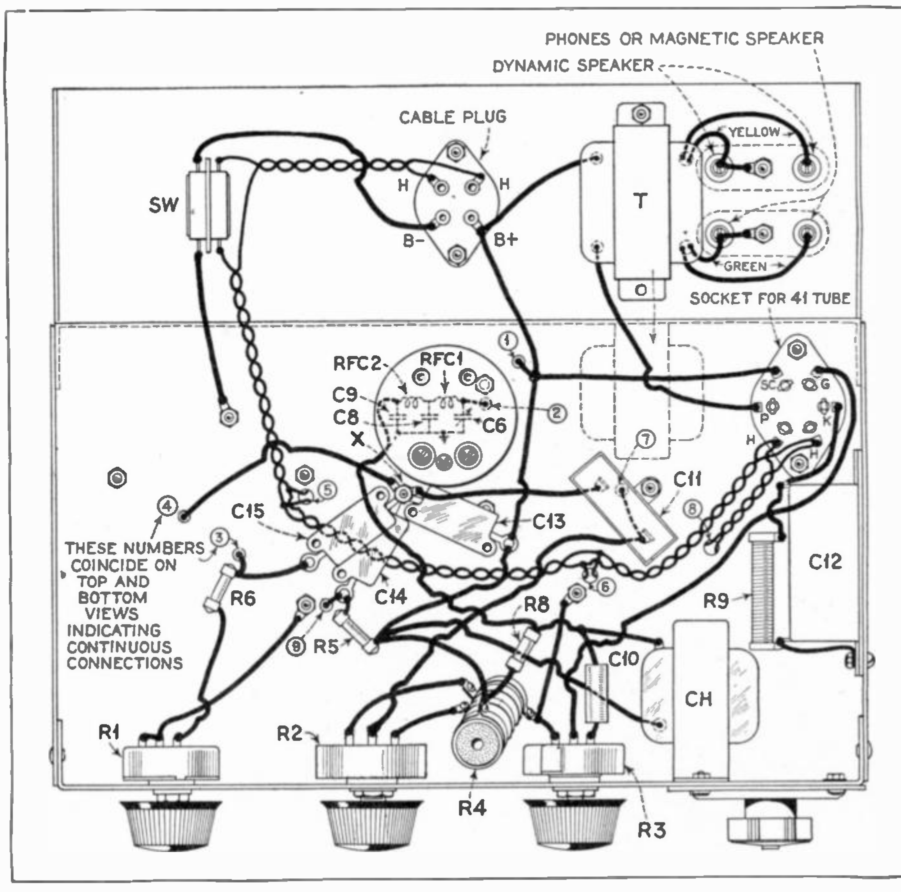
As this receiver is designed, the heaters are connected in parallel for operation from a 6-volt a.c. source or a storage battery. For the high voltage supply either B batteries or a power pack may be used. In either case only one high-voltage lead is needed, as a voltage-divider network is included in the receiver, and the tubes are all self-biased. If the receiver is to be operated permanently from B batteries, the voltage-divider resistor R4 may be eliminated and the potentiometer, R2, connected across a 45-volt section of the battery if desired.

If complete freedom from hum is to be obtained when operating from the a.c. line it will be necessary to employ a power pack having a good filter. An inexpensive power pack suitable for this use is described elsewhere in this book. This power pack will supply both the high voltage and the heater voltage and will permit absolutely humless operation.

The excellent operating characteristics of the "Skyscraper" are accounted for to a considerable extent by the coils employed. These are the new Hammarlund plug-in coils in which XP-53, a newly developed dielectric, is employed for the forms. This new material rates among the best, yet is sufficiently inexpensive to permit the coils and forms to be marketed at ordinary prices. The XP-53 is moulded in the shape of a ribbed form which permits air spacing of the windings. The windings themselves are carefully designed for maximum efficiency, with proper attention to the kind of wire (silver-plated in the case of the high-frequency coils), wire sizes, turns spacing, form factor, coefficients of coupling, etc. With the receiver in operation different types of coils were tried and the selection of the Hammarlund coils was based on the fact that with them greater signal strength was obtainable on test stations than with any of the other coils tried. It was rather surprising that so much difference was actually found among the standard coils of recognized makes.

In addition to the efficiency of the coils themselves, the frequency ranges covered have been selected to provide

Figure 10



the most favorable L/C ratios on the more important short-wave bands. Thus all of the amateur bands and the broadcast bands are tuned in at low capacity settings of the tank condensers—a condition which provides for the highest signal voltages and therefore the greatest signal strength.

Constructional Details

The special "Skycraper" chassis is 12⅛ inches long, 7 inches wide, and 3½ inches deep, over all. This chassis is formed by bending down the four sides to make a complete enclosure with an open bottom. The two box shields are each 4½ inches wide, 6¾ inches long, and 6 inches high. These boxes are built up on special corner posts. These are of triangle cross-section and are drilled and tapped on two sides and on both ends. The walls and tops of the shields are of plain aluminum and are drilled to correspond with the holes in the corner posts. (Figures 7 and 8.)

Space did not permit including complete construction and drilling layouts for the chassis and shields in this article. However, such drawings have been prepared and are available, from the Radio News blueprint department, in full size blue print form, at a price of 25c. These drawings include detailed specifications for the location and sizes of all drill holes, etc.; also a full-size enlargement of the picture wiring diagram shown in Figures 9 and 10. The circuit diagram is shown in Figure 11.

In the construction of the receiver, the coil and tube sockets are mounted first and the entire chassis is wired without the metal shield cans in position. Sub-chassis mounting is employed only for the audio tube. All the leads are made as short as possible, but it is important that all the r.f. grounds be made at the same point on the chassis. All the grounds are brought to the centrally located machine screw (marked "x" in the bottom view). Most of the small by-pass condensers are mounted directly on this screw.

The detector plate filter, consisting of a mica compression condenser C6, two fixed condensers C8-C9 and two

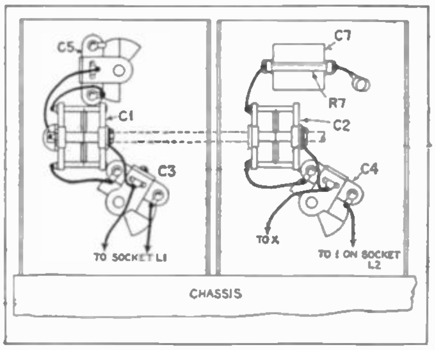


Figure 12

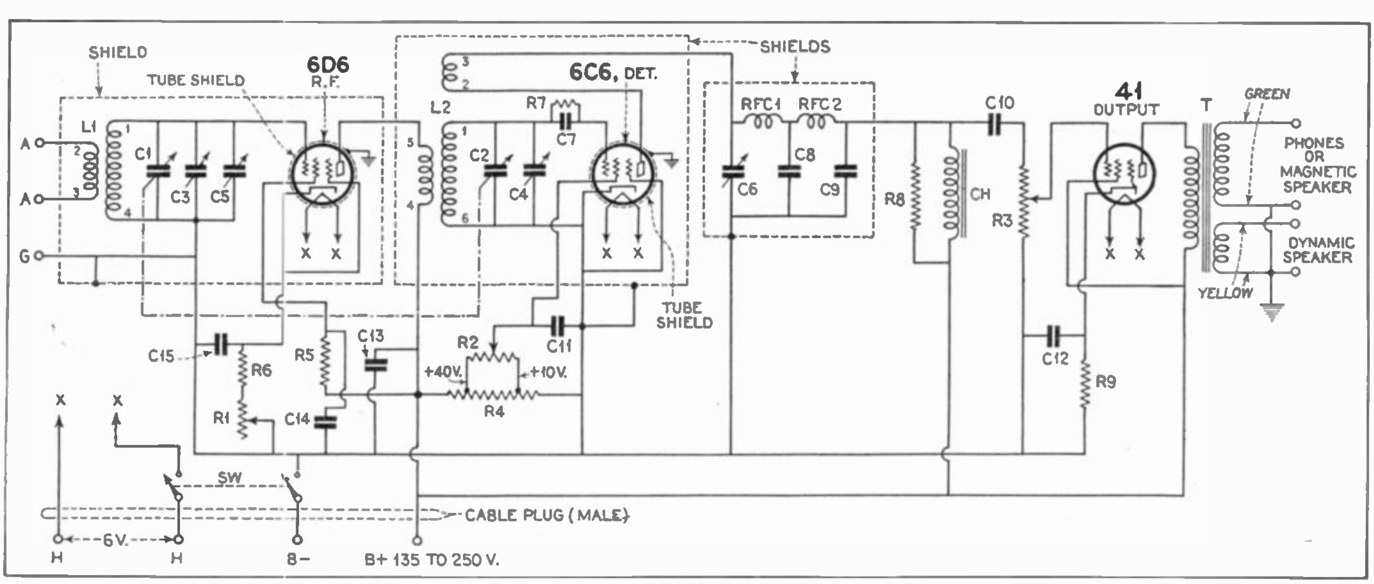
r.f. chokes, RFC1-RFC2, is mounted in a small shield can placed under the chassis directly beneath the detector coil socket. The screw type condenser C6 is actually an auxiliary regeneration adjustment but once set may be forgotten. In the particular unit employed in this model receiver C8 is also a compression type condenser but a fixed condenser will serve as well.

After the chassis has been wired, the shield boxes should be placed in position and the drum dial and tuning condenser mounted as shown in Figure 12. Note that the two short lengths of shaft, one between the condensers and one between C2 and the drum dial are of bakelite. In addition to avoiding one possible source of coupling between the r.f. and detector stages, the bakelite shaft will not introduce noise, as would a metal shaft should it rub against the shields at the holes through which it passes. The condensers and the shafts are connected by means of two solid couplings and one flexible coupling, as the photograph shows. Note should be made that the two bearings of each of the variable condensers have been connected together, and that wire connections are made to each of the condensers. No dependence whatever should be placed on returning the condensers to the coils through the metallic shielding. Good contacts to aluminum are always difficult to make, and should never be depended upon in t.f. circuits. The photograph shows that the small tuning condensers are mounted on posts fastened to the front of the shield cans instead of by means of the front bushing.

Parts List

C1, C2—Hammarlund midget condensers, type MC-20S, 20 mmfd.
C3, C4—Hammarlund midget condensers, type MC-140M, 140 mmfd.
C5—Hammarlund midget condenser, type MC-35S, 35 mfd.
C6—Hammarlund adjustable padding condenser, type MICS, 70-140 mmfd.
C7, C8, C9—Aerovox type 1460 mica condensers, .0001 mfd.
C10—Aerovox tubular paper by-pass condenser, .01 mfd. 400 volts
C11—Aerovox can type paper condenser, 1 mfd., 200 volts.
C12—Aerovox type PB-25 cardboard electrolytic condenser, 10 mfd. 25 volts.
C13, C14, C15—Solar mica condensers, .01 mfd.
CH—Thordarson a-f. choke, type T-2927
L1—Hammarlund 2-circuit, 4-prong plug-in coils (4 required).
L2—Hammarlund 3-circuit, 6-prong plug-in coils (4 required)
R1—Electrad potentiometer, 25,000 ohms
R2—Electrad potentiometer, 50,000 ohms, type 205-D
R3—Electrad potentiometer, 500,000 ohms
R4—Electrad voltage divider, type B, 50,000 ohms, 25 watts
R5—100,000 ohms, ½ watt
R6—250 ohms, ½ watt
R7—4 megohms, ½ watt
R8—.5 megohm, ½ watt
R9—Electrad Truvolt resistor, 700 ohms, 10 watts (1-watt resistor suitable)
RFC1—Hammarlund r.f. choke, type CH-8, 8 millihenries
RFC2—Hammarlund r.f. choke, type CH-X, 1.2 millihenries
SW—Toggle switch, d.p.s.t.
T—Thordarson output transformer, type T-6806, single-pentode primary, 10-ohm and 2000-ohm secondaries
1 Hammarlund isolantite 4-prong socket, type S-4 (for coil L1)
3 Hammarlund isolantite 6-prong sockets, type S-6 (for 6C6 and 6D6 tubes and coil L2)
1 Eby wafer socket, 6-prong (for -41 tube)
1 Blan the Radio Man "Skyscraper" chassis assembly consisting of chassis, 2 box shields and dial panel
1 National illuminated drum dial, type H
2 Kurtz-Kasch vernier dials, 2¾-inch size
1 Eby chassis mounting, 4-prong cable connector (male)
1 4-wire cable (3 feet)
1 Eby 4-hole cable plug (female)
1 Eby moulded 3-gang binding post
1 Eby moulded twin jack marked "Speaker"
2 Hammarlund tube shields, type TS-50
1 Hammarlund flexible-shaft coupling
2 Blan solid-shaft couplings
1 3-inch length of ¼-inch-diameter bakelite rod
1 shield can, 2-inch diameter (cut length to approximately 2 inches) for detector plate filter shield

Figure 11



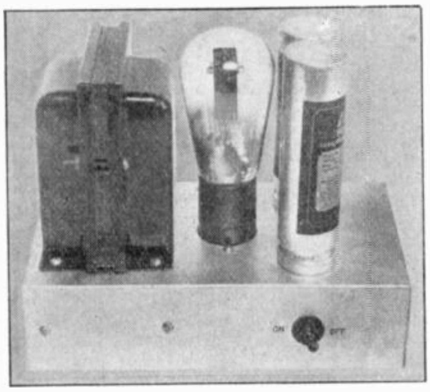
The "Skyscraper" Power Pack

(For Small Short-Wave Sets)

THE power pack shown in Figures 13 and 14 can be used for converting any type of battery-operated receiver to full a.c. operation—providing the receiver employs 6-volt tubes (and not more than five of these). The 6.3-volt filament winding on the transformer is designed to deliver not more than 1.5 amperes. It is this fact that limits the use of the power pack to receivers in which the filament current required does not exceed this figure.

This unit supplies the necessary plate voltage and the filament voltage for the type –80 rectifier and the receiver. The plate supply is 220 volts at 25 ma., and varies somewhat above or below this figure for receivers having smaller or greater current drains. While the high-voltage secondary of the power transformer is rated at 340 volts (55 ma.), this value is, of course, too high for the plate supply of the type of receivers with which the power pack is to be used. Power transformers having a rated output of less than 300 volts are difficult to obtain, and the solution of the problem of using a high-voltage transformer to supply a lower voltage lies in simply eliminating the condenser ordinarily employed across the output of the rectifier and ahead of the first filter choke. Reference to Figure 15 shows the filter circuit employed. C1 and C2 are the filter condensers of 8 mfd. each. C6 appears in the circuit in the position usually occupied by the first filter condenser. In this case, however, this condenser has the value of only .006 mfd. and is used in conjunction with the choke (RFC) as an r.f. filter—a material aid in eliminating so-called "tunable" hum.

The voltage divider R2 is provided with three adjustable intermediate taps so that three different output voltages are available where needed. In the case



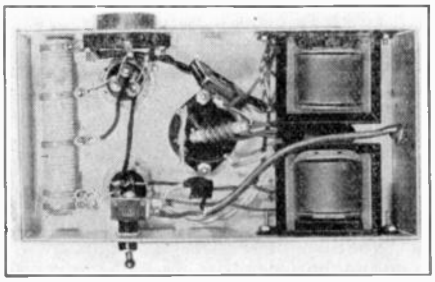


Fig. 13—Top Fig. 14—Bottom

of the "Skyscraper" receiver there is a voltage-divider network in the receiver itself, therefore only the high voltage and negative leads need be brought out to the receiver. However, the socket type output terminal of the power pack is one of the 6-prong type. When used with the "Skyscraper," a 6-prong cable plug is employed, but there are only four wires in the cable, the prongs corresponding to two of the intermediate taps of the voltage divider being left unconnected. Where the power pack is intended for permanent use with the "Skyscraper" or with any other receiver having a built-in voltage divider, by-pass condensers C4 and C5 can be eliminated. Also R2 can be eliminated, entirely, if the voltage-divider network in the receivers is adjustable to permit obtaining the proper plate voltage for the tubes. If not adjustable it will be found desirable to employ the voltage divider, R2, to reduce the output voltage of the power pack, adjusting tap A (Figure 15) until the correct plate voltage required by the receiver is obtained.

The 6.3-volt winding of the transformer T is center-tapped, the center-tap being connected to the B– terminal in the wiring. For this reason the filament wiring of the receiver should be completely isolated, electrically, from all other circuits. When using the power pack with receivers which have heretofore been battery-operated, the filament wiring should be checked over carefully to make sure that it connects to no other circuits. Also, if it doesn't already consist of a twisted pair, the circuit should be rewired in this manner. If this precaution is followed, humless operation will be obtained even though the receiver include a regenerative circuit.

The details of construction are clearly shown in Figures 15 and 16. In Figure 16 the front and rear sides of the chassis are shown in a flattened out position to clarify the wiring. All leads from the power-transformer are brought down through the two holes marked T, Figure 16. These leads are color-coded as shown.

Parts List

C1, C2—Aerovox 2-section electrolytic condenser, type GG, 8-8 mfd, 450 v.

Figure 15

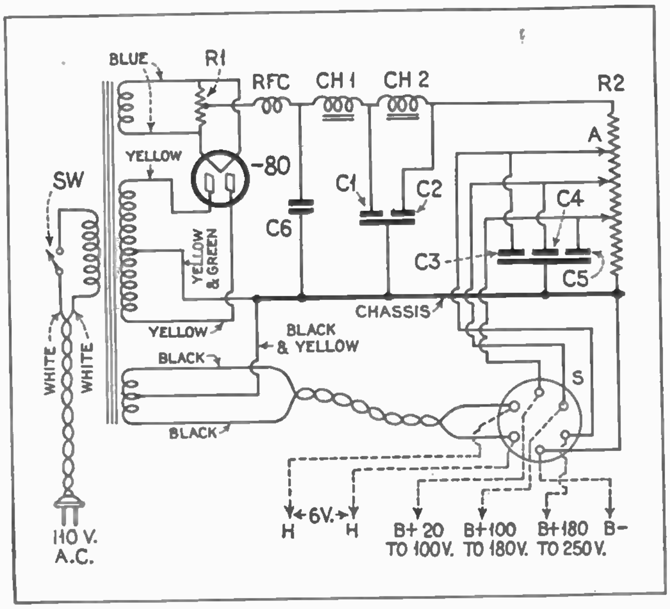
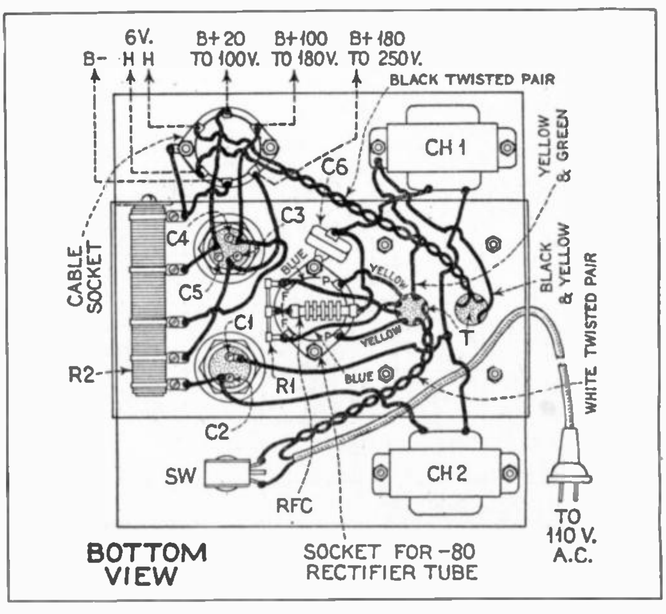


Figure 16



C3, C4, C5—Aerovox 3-section electrolytic condenser, type GGG,4-4-4 mfd, 450 v.
C6—Aerovox mica condenser, .006 mfd.
CH1, CH2—Thordarson chokes, type T-4402
RFC—Hammarlund r.f. choke, type CH-X
R1—Electrad center-tapped filament resistor, 30 ohms
R2—Electrad, type C-200, Truvolt voltage divider, 20,000 ohms, 50 watts; with 3 adjustable intermediate taps
SW—Toggle switch, s.p.s.t.
T—Thordarson power transformer, type T-5472; secondaries 340-0-340 volts (55 ma.), 5v (2 amps.), 6.3 v. (1.5 amps.)
1—Eby 4-prong socket, type 12
1—Eby 6-prong socket, type 12
1—Eby 6-prong cable plug, male
1—6-conductor cable
1—Line cord and plug
1—"Blan the Radio Man" drilled chassis, type RN-12. 8½ inches long, 4½ inches wide and 2¼ inches high
1—Rubber grommet (⅜ inch) for power cord hole in chassis

The Trophy Winner

(4-Tube Short-Wave Set)

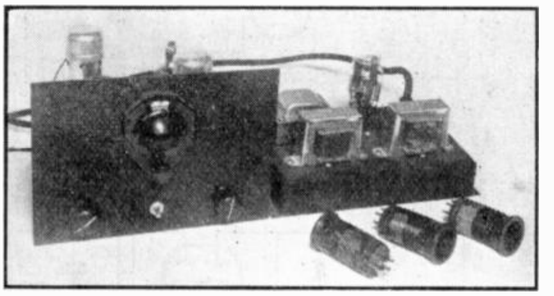
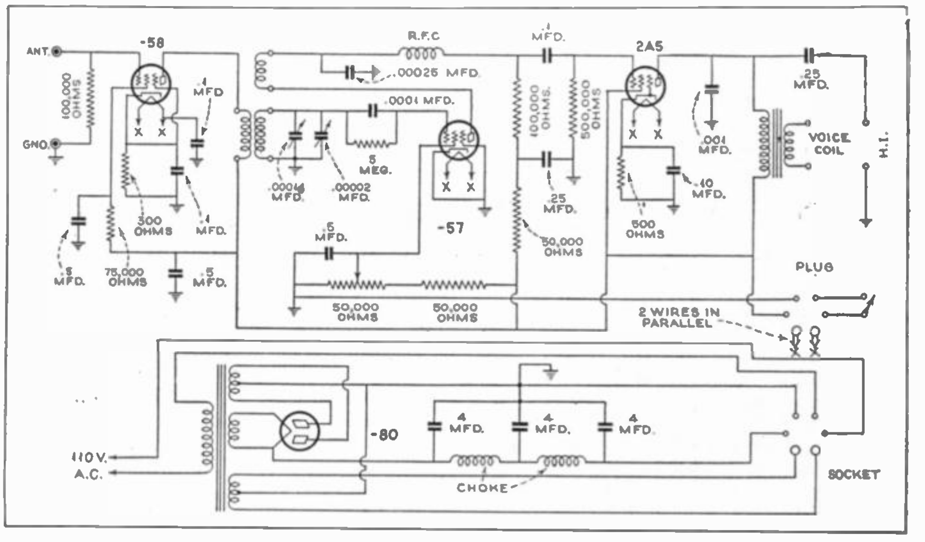


Fig. 17—Left
Fig. 18—Below



THE "Trophy-Winner", shown in Figure 17, bridges the gap between the small and large short-wave sets. It employs four tubes, including the rectifier; the highly efficient a.c.-operated pentodes make it possible to receive foreign short-wave stations on the loudspeaker. The parts are available in kit form, which comes with complete instructions, requiring no experience to assemble and wire.

The receiver covers the range from 15 to 200 meters in four overlapping bands, employing plug-in coils of special design. Ranges for the individual coils are: 15-36 meters, 34-65 meters, 62-115 meters and 110-200 meters.

Figure 18 shows a schematic diagram of the circuit with the values of condensers and resistors. The set employs a –58 type tube as an untuned radio-frequency stage, a –57 as a regenerative detector and a 2A5 as output stage; the rectifier is a type –80.

The untuned radio-frequency stage adds considerably to the sensitivity of the set. However, it serves another very important function in that it isolates the regenerative detector from the antenna, thereby preventing radiation when the detector is oscillating. Such a blocking tube is highly desirable with regenerative sets for without it receivers of this type create interference over large areas.

The –57 is at present the most sensitive tube available for detector service; it is used here in a circuit which has proven to be highly satisfactory. Regeneration is controlled by varying the screen voltage because this method has the least effect on the tuning.

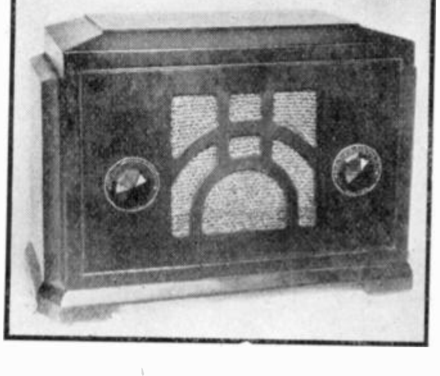
Now we come to the tuning arrangements. There are two condensers used in the tuned circuit: a 140 mmfd. main condenser and a 20 mmfd. vernier or trimmer. These two condensers can be hooked up in two ways. In the standard model, the larger condenser is controlled by the main tuning dial and the smaller condenser serves as a trimmer for the fine adjustments. The special model employs the same condensers but the smaller one is controlled by the main dial and the large condenser occupies the lower position on the panel, thereby serving as a band-setting condenser. This arrangement allows continuous band-spreading. Amateurs and other who wish to spread certain bands can use this system to advantage.

Special 6-prong plug-in coils have been designed for use with the "Trophy-Winner." They have three windings: primary, secondary and tickler.

The output stage can deliver ample power for a dynamic or magnetic speaker. As shown in the diagram, two sets of output terminals are supplied. Those marked "H. I." (high impedance) are connected directly to the tube through a blocking condenser. The primary of the output transformer then serves as choke. These terminals should be used for a magnetic speaker or for headphones. The secondary of the transformer connects to the other set of terminals. These should be used for a 10 ohm voice coil. A special a.c. operated dynamic speaker is available for use with the set.

The power unit is connected to the set through a 8-wire cable and a 6-prong plug. Each filament lead consists of two wires in parallel, so as to minimize losses in the cable. The power line itself is fed through the cable, connecting to the on-off switch on the receiver panel. This concentrates all controls at one point.

Figure 19



An A.C.-D.C. Midget

(4-Tube Broadcast Receiver)

FIGURE 19 shows a 4-tube receiver that takes advantage of the good features of the new 25Z5 rectifier tube. The receiver operates on 110 volts, either a.c. or d.c., line supply. By means of a switch the rectifier can be used either as a voltage doubler or as a regular half-wave rectifier. In one position of the switch the plate voltage is approximately equal to that

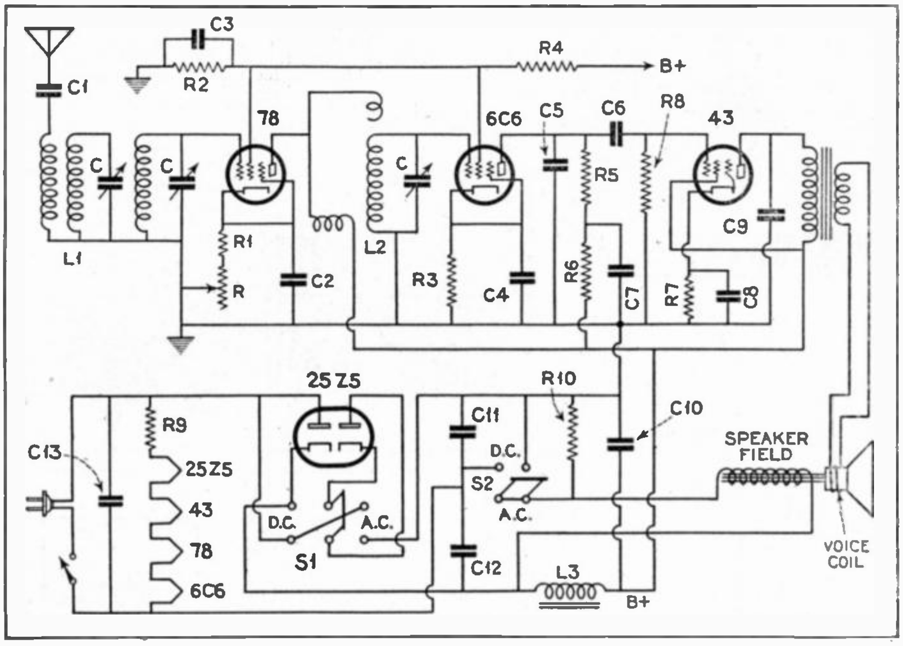


Figure 20

of the line and it can be used this way on either a.c. or d.c. supply. With the switch in the other position and the receiver plugged into an a.c. line the voltage doubling feature is employed and a voltage approximately double that of the line is available. The circuit is shown in Figure 20.

It is very important that in changing from d.c. to a.c. light lines to turn off the line switch before setting tumbler switches S1 and S2 at the required position. Otherwise there will be a heavy drain through the 25Z5 tube which will damage the tube permanently. So, for the sake of safety, always set S1 and S2 at proper positions before turning on the power.

The receiver chassis is one of the smallest found on the market; its dimensions are 9 inches by 4½ inches by 1½ inches high.

To obtain a maximum output from this receiver an outdoor aerial 60 ft. in length is recommended. With an aerial of this size the probable output of this receiver when operating on a.c. light lines is on the order of 3 watts. This latter value will answer the demand of any household.

Considering the results obtained and the low construction expenses, this receiver (in saving an additional stage due to the voltage doubling circuit) should prove to be an additional source of income to custom set builders.

Construction Data

Specifications for cutting and drilling the chassis are shown in Figure 22. Any equivalent layout chassis will answer the purpose. If this is not available, an Electralloy (radio metal) 16 gauge piece 9 inches by 8⅛ inches will suffice. Before bending the piece along lines 5/16 inches and 1½ inches from both sides as illustrated in the mechanical layout diagram, it is necessary to cut, with a cold chisel, an opening for mounting the speaker. In the case of the Beaudette speaker, the space shown by the mechanical layout diagram was found satisfactory. However, for a different manufacturer's speaker, a different cut may be necessary. The speaker is mounted on two 1¼ inch studs and fastened to the chassis by means of 8-32 machine screws and nuts.

The three-gang variable air condenser C is placed on the extreme right as shown in Figure 21, and the proper holes necessary for mounting are indicated in the mechanical layout diagram. The volume control, R, is located at the extreme left. An L-shaped bracket provides the necessary mounting for it.

The high gain unshielded interstage coil L2 is mounted on top of the chassis between 6C6 tube and the 78 r.f. tube. This interstage coil as recommended in the list of parts is RFB No. 4 interstage coil of General Manufacturing Co. of Chicago. However, in this case, as well as in any other, electrically equivalent parts from other reputable manufacturers can easily be substituted. A large hole underneath this interstage coil provides a conduit to the leads. (See Figure 22.)

The preselector coil L1 is mounted on the bottom of the chassis as shown in Figure 23, directly underneath the three gang variable air condenser C.

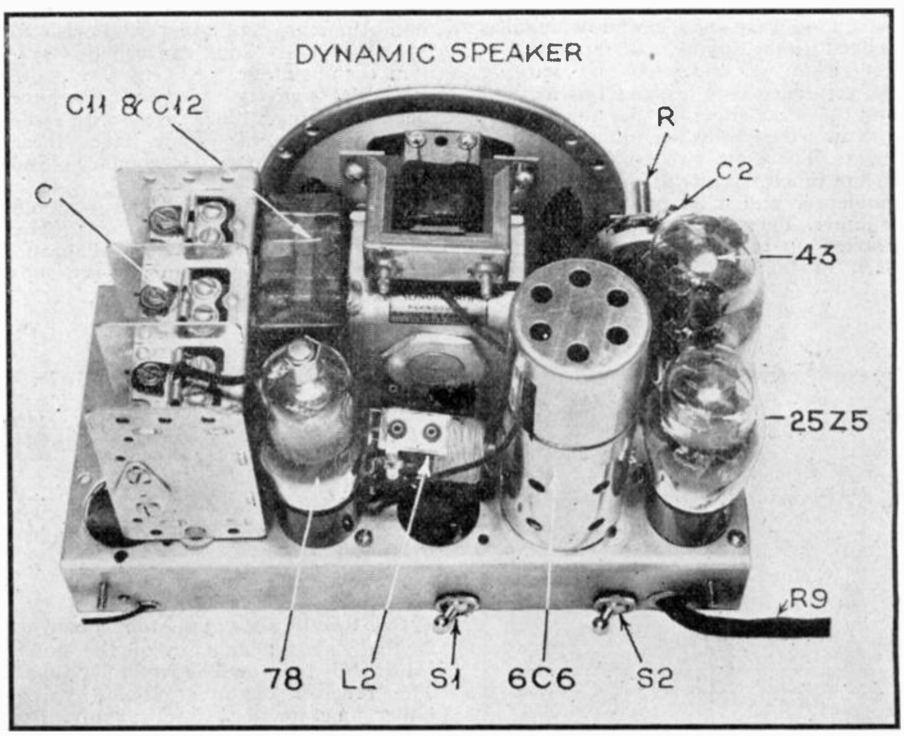
The dual dry electrolytic condenser C11, C12 can be easily mounted on top of the chassis between the three gang condenser and the dynamic reproducer.

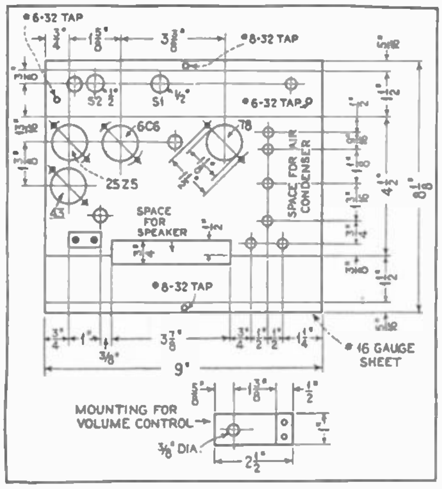
No ballast resistor is used in this design. A resistor built in the line cord is used to bring down the line voltage to the required heater voltage. It is more satisfactory than a ballast resistor mounted in the chassis as it excludes the excessive heat from the chassis, thereby minimizing the damage to the receiver parts and affording a larger ventilating surface for this heat.

List of Parts

C—General Instrument 3 gang variable air condenser, counterclockwise type, 365 mmfd.
C1—Solar high grade mica condenser, 0.001 mfd., 300 volt peak.
C2, C3, C7—Solar tubular paper condensers, 0.1 mfd., 300 volt peak.
C4—Solar tubular electrolytic condenser, 10 mfd., 35 volt peak.
C5—Solar high grade mica condenser 0.0005 mfd., 300 volt peak.
C6—Solar tubular paper condenser, 0.03 mfd., 300 volt peak.
C8—Solar tubular electrolytic condenser, 25 mfd., 35 volt peak.
C9—Solar tubular paper condenser, 0.006 mfd., 300 volt peak.
C10—Solar dry electrolytic condenser, 8 mfd., 300 volt peak.
C11, C12—Solar dry electrolytic dual condenser 16—16 mfd., 220 volt peak.
C13—Solar tubular paper condenser, 0.05 mfd., 175 volt peak.
R—Clarostat 250,000 ohm potentiometer with line switch.

Figure 21





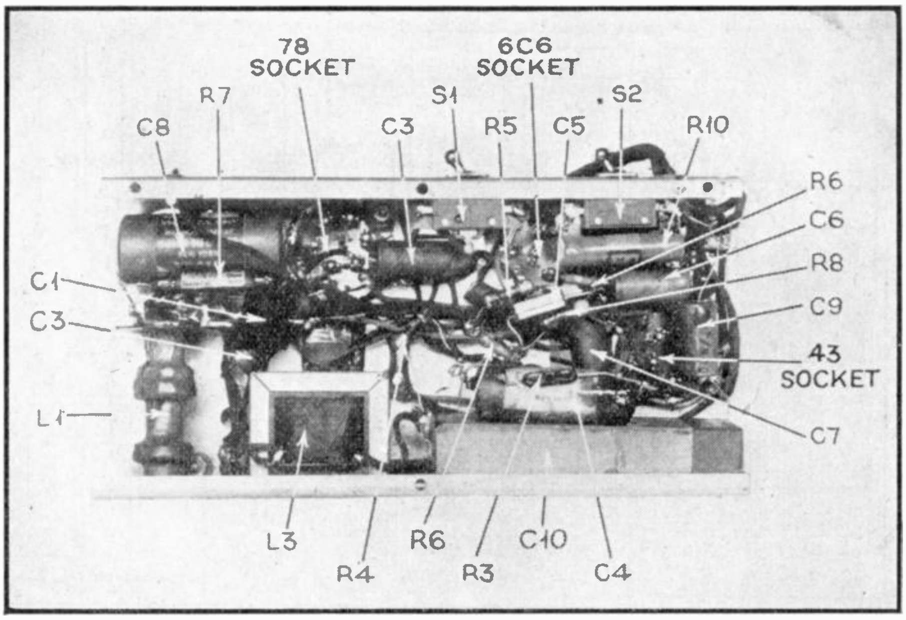


Fig. 22—Above; Fig. 23—Right

R1—Micamold resistor, 300 ohms, ⅓ watt.
R2, R5—Micamold resistors, 0.5 megohms, ⅓ watt.
R3—Micamold resistor, 15,000 ohms, ⅓ watt.
R4—Micamold resistor 0.25 megohms, ⅓ watt.
R6—Micamold resistor, 0.1 megohms, ⅓ watt.
R7—Micamold resistor, 500 ohms, 2 watts.
R8—Micamold resistor, 2 megohms, ⅓ watt.
R9—Gavitt line cord with built-in resistor, 170 ohms, 20 watts.
R10—Electrad wire wound vitreous enameled resistor, 2000 ohms, 10 watts.
L1—Gen Ral C X 100 D preselector coil.
L2—Gen Ral RFB No. 4 interstage coil.
L3—Kenyon, 20 henry, 300 ohm, 60 milliampere choke.
S1—Arrow, Hart & Hegeman d.p.d.t. tumbler switch.
S2—Arrow, Hart & Hegeman d.p.s.t. tumbler switch.
4 Eby six-prong sockets.
1 type -78 tube.
1 type 6C6 tube.
1 type -43 tube.
1 type 25Z5 tube.
1 Beaudette dynamic reproducer, 5-inch diameter, field resistance 3000 ohms.
1 Insuline "Electralloy" chassis, 9 inches by 4½ inches by 1½ inch high.
1 Crowe plate for volume control.
1 Crowe plate for station selector.
2 Kurz-Kasch knobs for volume control and station selector.
1 tube shield.
2 grid caps.
1 antenna reel 25 feet long.
1 roll of solid hook-up wire.
1 cabinet.

The All Star Senior

(6-Tube All-Wave Receiver)

THE "All-Star" has a frequency range of from 10 to 550 meters (30,000 kc. to about 550 kc.), without gaps.

It is completely band-spread for all frequency bands within its usable spectrum. These bands can be adjusted quickly for any particular band by setting two dials. Each band chosen is automatically spread over 270 degrees on the central tuning control (which is of the airplane fine-pointer type).

For any given band, once set, the tuning is thereafter single-controlled through that band and the operator can come back to the same band by again setting two dials to the proper logging. Tracking errors and misalignment are therefore eliminated. The reason for this is that there is an initial separate control to be made for the first detector and for the oscillator tuning.

Three sets of coils are used to cover the short-wave band from 10 to 100 meters. Optional and additional coil equipment is available and consists of a pair of coils for 100-200 meters and two pairs of coils for the broadcast band. These coils can be easily in-

Figure 24

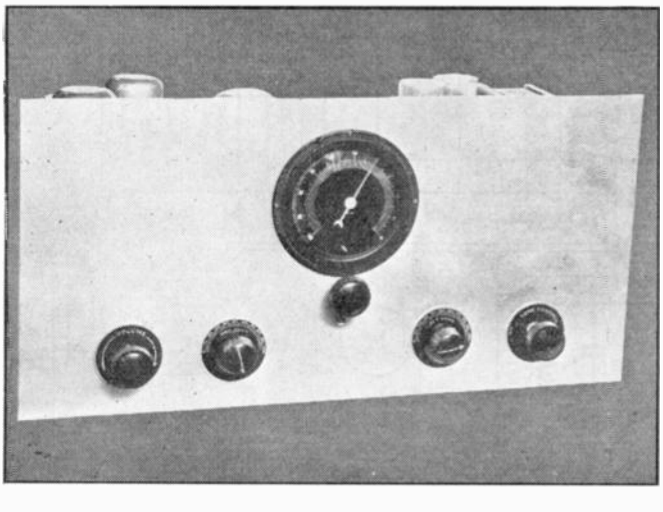
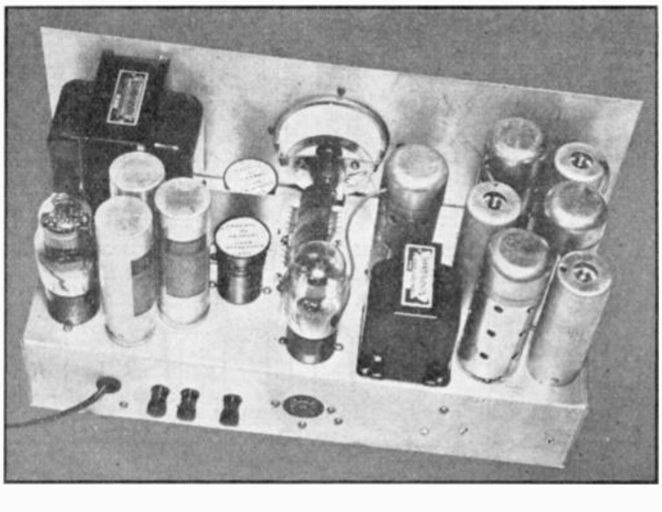


Figure 25



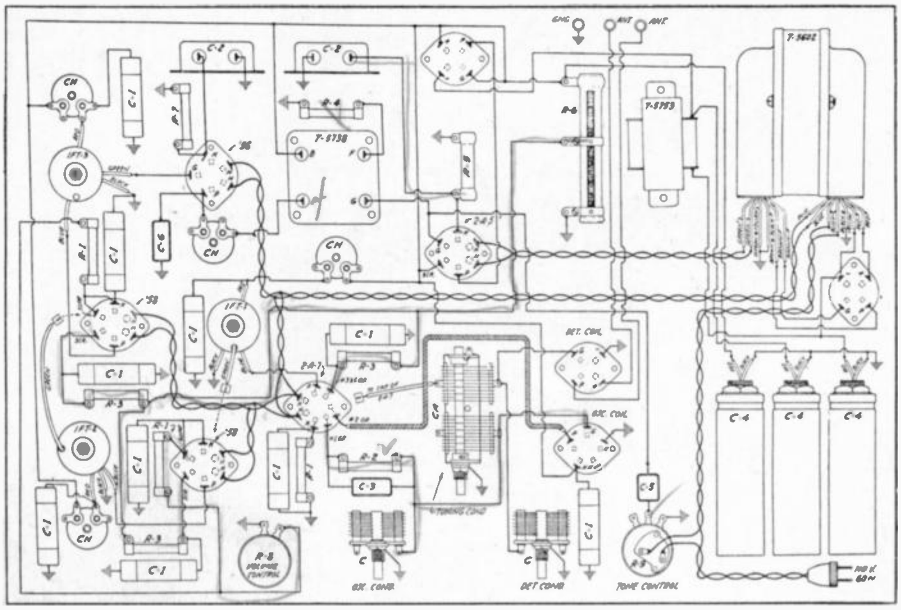
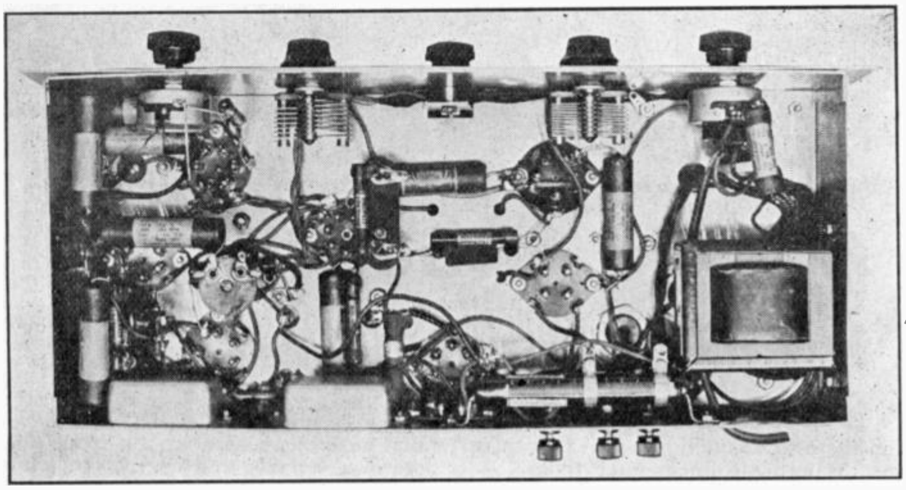


Figure 26—Center Figure 27—Above

Figure 28—Bottom



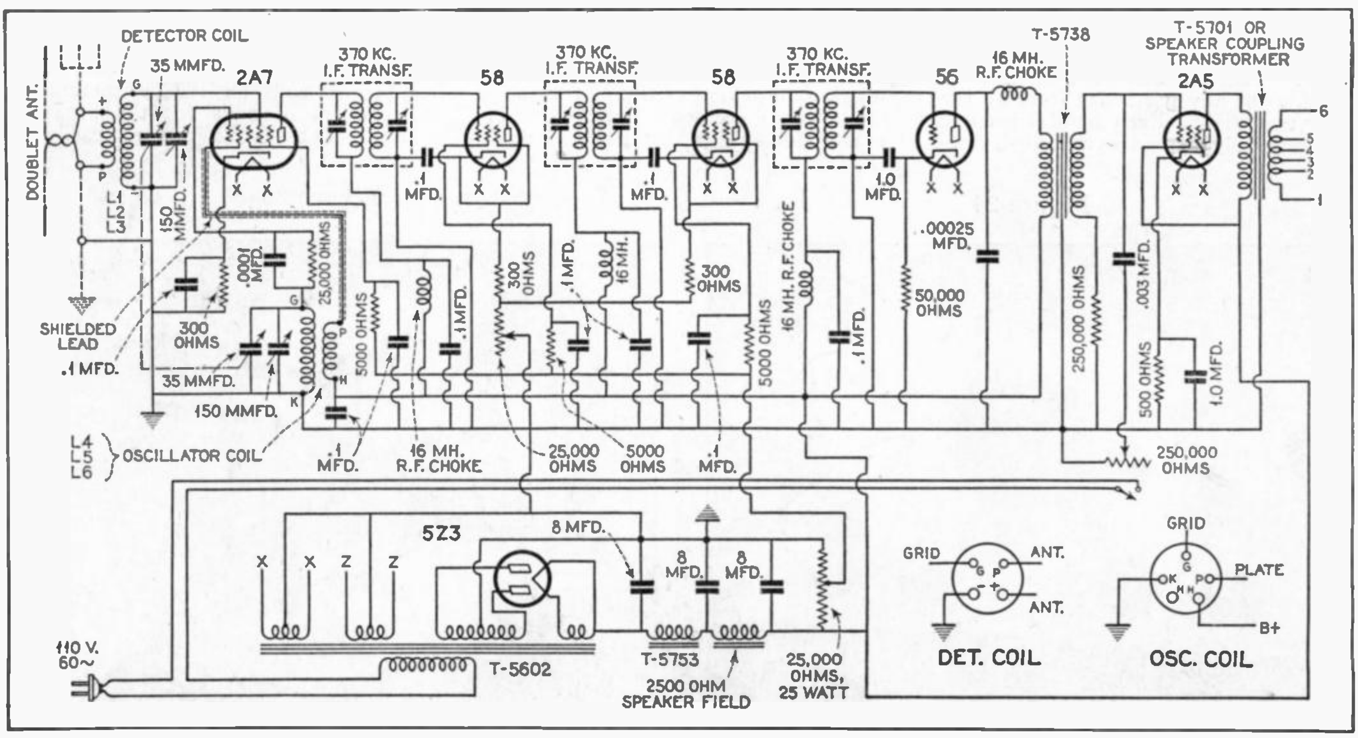
serted without the nuisance of removing shields necessary in some earlier types of sets.

The receiver was designed by experts who have specialized in laying out sets to be built by radio enthusiasts of small experience. Practically no technical knowledge is necessary to build it. An actual test has shown that it can be assembled and wired in less than three hours by a person who has only a speaking acquaintance with a screw-driver or a soldering iron. There are no adjustments or calibrations to be made after the set has been correctly put together and wired for operation. The front panel and sub-base may be obtained completely drilled for the mounting of the specified parts. No other drilling, filing or fitting is necessary.

The set is to be used with a standard dynamic loudspeaker having an input transformer for a 2A5 output pentode and having a field winding of 2500 ohms and connected to a four-prong loudspeaker socket. This is also obtainable through regular trade channels.

Looking at the front view of the panel, Figure 24, we see (at the lower left) a control for volume; turning it to the right, it increases the volume. The next knob in line is the oscillator "tank" condenser with its own scale, from 0-100, for logging purposes. Next in line, to the right, is the detector "tank" condenser, also with its scale, from 0-100, for logging. The extreme right-hand dial is the combination "on-off" switch and tone control, which is useful in lowering static noise when the noise level is high. The central dial is the single-control, band-spread dial set in 0-100 divisions, to actually cover a rotary range of 0-270 degrees.

Looking at the rear view of the set, Figure 25, we see (at the left) the power transformer, in front of which stands the rectifier tube. Next to this are the three tubular electrolytic filter condensers. Next (to the right) we can see the oscillator and detector coils, in their sockets, separated by an



electrostatic metal shield. Next in line is the gang condenser, attached to the airplane-type dial and in front of which stands the 2A5 output tube. Alongside of this tube is the audio-frequency transformer and to the right of this stands the shielded –56 second detector tube, with its shielded third i.f. transformer. In back of these two we see the second i.f. –58 tube and transformer in reversed positions. In back of this we see the first i.f. –58 tube and transformer again in reversed positions. Directly in back of the audio-frequency transformer, we see the shielded 2A7 tube, which serves as first detector and oscillator. At the back of the chassis is seen the power-cable-and-plug extension, the three binding posts, for the doublet antenna and ground, and the four-prong socket for the loudspeaker. A simple but efficient-looking lay out — anyone will agree.

Looking at the bottom view of the receiver, Figure 26, we see (at the left) the choke-coil assembly and the instruments connected to the front panel controls, as well as the distribution of the sockets, the resistors and the filtering condensers. Notice that practically all of the wiring is done below the sub-base and that it is simplicity itself. The circuit diagram is shown in Figure 28 and a pictorial wiring diagram in Figure 27.

A complete foundation kit, consisting of a drilled and punched metal base and panel for the All-Star Super-Six six-tube superhetrodyne circuit has been prepared and distributed throughout the trade for your convenience and will cost you but $2.50. Next you will want complete instructions for building the set. These can be obtained by writing to RADIO NEWS, care of the Blueprint Department and asking for the complete four-page descriptive folder including a large-size schematic-wiring diagram, a large-size pictorial-wiring diagram, a complete parts list, complete instructions for assembly, instructions for wiring, instructions for final adjustments and tuning. This will be sent you free of charge.

A High Fidelity Receiver

(8-Tube T. R. F. Broadcast Set)

INDIVIDUALS differ in their idea of the "perfect" receiver. Some want the best of quality and never listen to anything farther away than 50 miles while others want to receive stations from the Antipodes regardless of quality. The designer of the set illustrated here wanted to build a receiver which would have the best tone quality possible within a price range of approximately $100. Incidental requirements were attractive appearance and ease of operation.

Most people do not like to get up out of a comfortable chair to change the tuning of the receiver or adjust the volume control. Although it is possible to have a remote control conveniently placed, this system has its complications. It was therefore decided to separate the loudspeaker from the set, to place the receiver where it would be convenient to tune, and locate the loud speaker where it sounded best. This arrangement also eliminates one source of microphonism.

For high fidelity it is undesirable to have too much selectivity, and therefore no attempt was made to reach any greater degree of selectivity than was necessary for adequate separation of "local" stations.

So it was decided to employ a t.r.f. circuit, a diode detector and as few audio stages as possible with an output stage of Class A triodes in push-pull (See Figure 30). The r.f. section consists of three tuned stages employing the 58 type tubes. Sensitivity is controlled both in the antenna and in

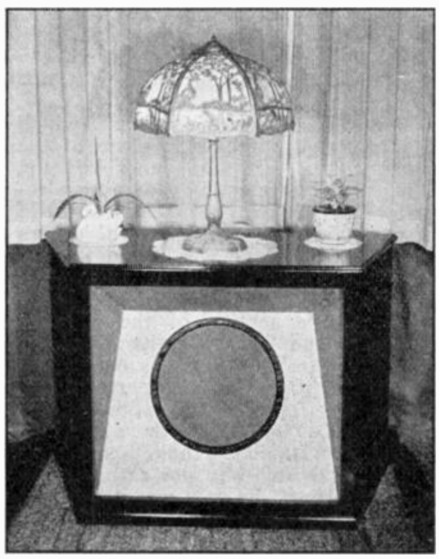
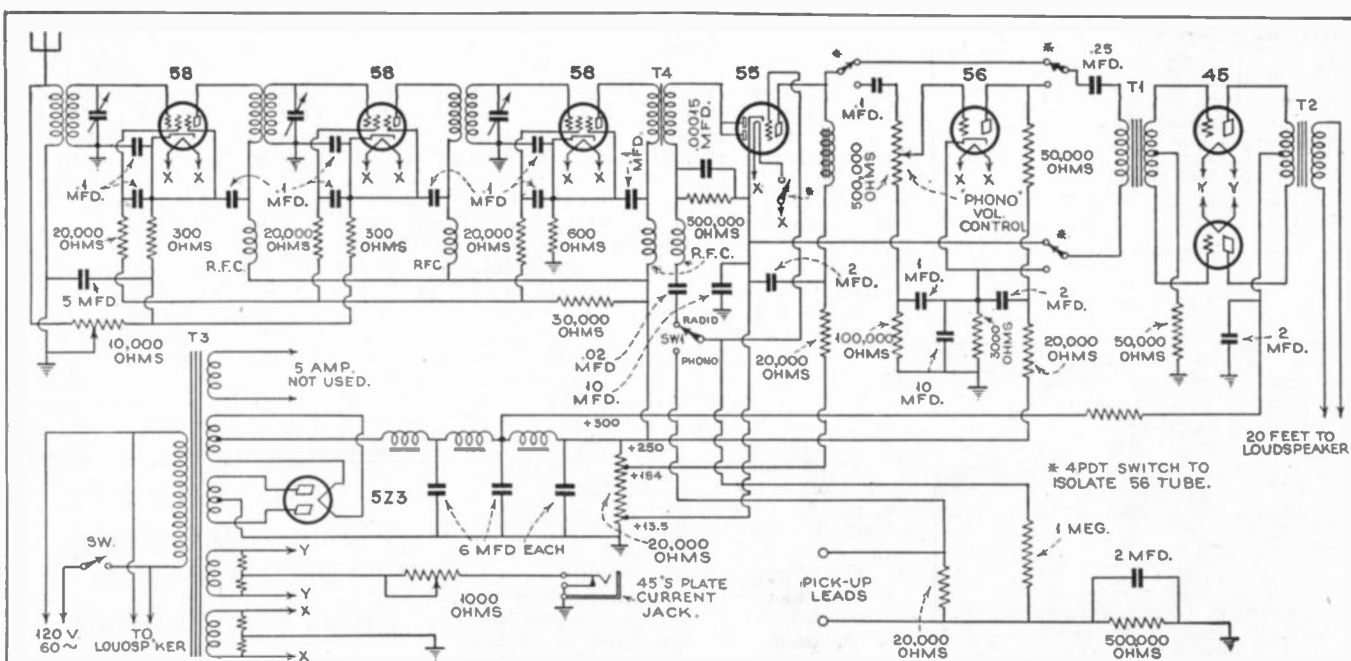
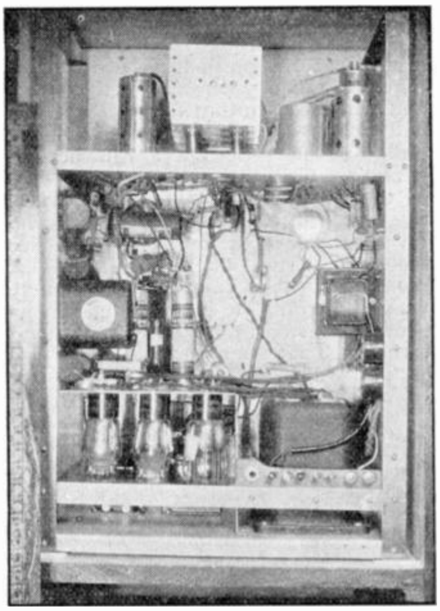


Figure 29—Right

Figure 30—Below





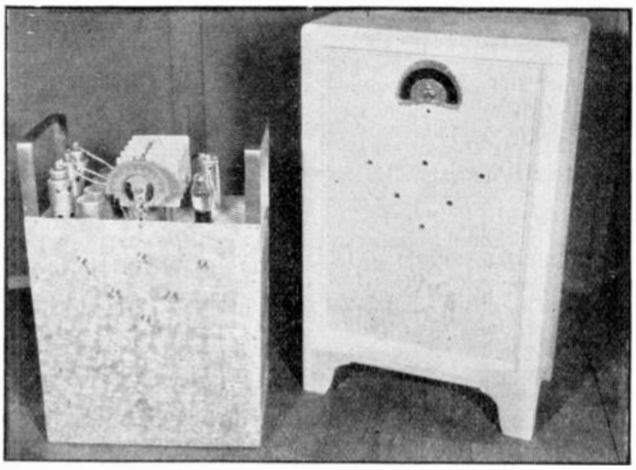


Figure 31—Left Figure 32—Above

Figure 33—Below

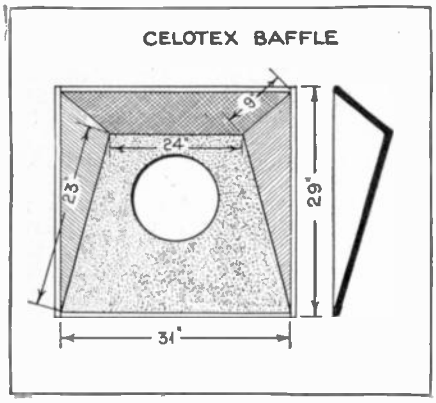


Figure 34—Below

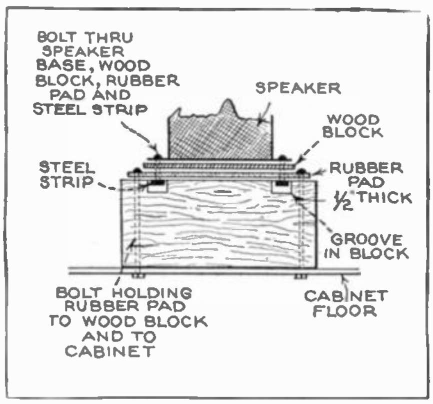
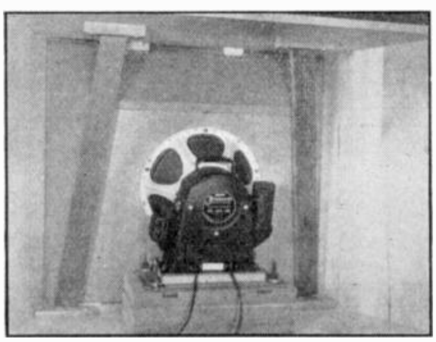


Figure 35—Below



the cathode circuit of the first two stages. It is essential that a good potentiometer be used here in order to avoid noise. All plate, screen and cathode circuits are filtered.

Since the diode detector places quite a load on the circuit, the selectivity of this stage is usually so poor that an untuned circuit can logically be employed. The three previous stages give satisfactory selectivity to receive the best local station and more was not required.

There have been receivers which used untuned stages and some of the transformers can still be picked up. The transformer employed in this receiver was a DeForest D2 iron core r.f. transformer. After several others were tried this one was found to give the most even response at frequencies between 550 and 1500 kc.

The triode section of the 55 tube serves as the first audio amplifier. It works at a fixed bias and is coupled to the output stage by an Amertran D21 input transformer. The transformer primary does not carry the plate current; a shunt feed arrangement being employed. Note that the cathode circuit is bypassed by a 10 mfd condenser and that resistance-capacity filters are employed in grid and plate circuit.

When the phonograph is used, it is necessary to cut in an extra audio stage. This is accomplished by SW2 (Figure 30). The switch is a four-pole-double-throw Yaxley switch. It changes the input and output of the 56 stage and also turns on the 56 filament. There is then a second switch to change over from radio to phonograph (SW1). Since the volume of radio programs is regulated by a control in the r.f. amplifier, a second volume control is incorporated in this second a.f. stage. With this system of switches it is possible to add one a.f. stage when receiving radio programs —by moving SW2 only—but this is not needed.

The output stage is quite conventional except that the bias resistor is adjustable so one can set it for minimum harmonic distortion. The output transformer is a Jensen, the one that comes with the speaker. It is mounted inside the set, and 20 foot leads run to the voice coil.

The power pack is also quite conventional. The power transformer is an Amertran WA321, the chokes are Thordarson and the condensers are made by Aerovox. However, other makes of good quality can be substituted.

The construction of the set itself as shown in the photographs (Figures 31 and 32) includes some noteworthy ideas. The chassis carries a pair of steel brackets on top. These serve as a stand when the set is turned upside down so that one can work on it without hunting for supports to fit the irregular height of various parts above the chassis.

It will be noticed in the rear view that the power tubes and rectifier hang upside down. This was done to keep the heat of the tubes away from the electrolytic condensers and yet have the connections short.

The speaker is a Jensen type M-10 auditorium speaker with an a.c. field. This speaker had to be supplied with a baffle large enough and yet reasonably good looking.

Figures 33 and 34 and the photographs, Figures 29 and 35, show how this was accomplished. The speaker has been mounted in an inclined position and the baffle consists of four pieces of celotex, cemented together. The odd angles are clearly shown in Figure 33 and in the illustrations. This celotex baffle was placed into a wooden cabinet, but insulated from it by strips of sponge rubber. The cabinet is not a square box but the opening at the back is much wider than at the front.

The speaker itself was bolted to a piece of wood having the proper slant to fit against the inclined baffle. This wood rests on a sponge rubber mat which in turn is fastened to the wooden blocks below. The speaker itself is thereby mechanically insulated from the cabinet. This is shown in Figure 34.

The cabinet is constructed of approximately ¾-inch oak. It is 48 inches wide at the rear, 34 inches wide in front, 32½ inches high and 18 inches deep. The special baffle is cut to order and cemented, the cabinet finished in black and the celotex given a coat of gold paint.

Servicing and Laboratory Instruments

Ohmmeter Design

THE chart in Figure 37 is a table of values for the construction of ohmmeters with various ranges from .1 ohm to 50 megohms, using meters usually found on the experimenter's bench. They are listed by center scale reading, instead of range; because the portion of the scale, where accurate readings may be obtained, of any ohmmeter, is from about .3 to 3 times the center-scale reading. The useful portion is from about 1 to 10 times the center-scale reading where additional inaccuracy of about 4 per cent will be introduced, due to error in adjusting the pointer to the ends of the scale, and errors in reading. The portion that may be used for approximate indications, from about .02 to 50 times the center scale reading, where additional error of about 24 per cent will be introduced, the increase in error being caused by the decrease in the size of the divisions, and the decrease in the distance to the ends of the scale. Obviously an ohmmeter is almost useless beyond these limits, unless a laboratory type meter with a long scale is used, and then very little can be gained, compared to the increased accuracy made possible by the incorporation of additional ranges.

It can be seen from the above, that a manufacturer conveys little information when he states that his ohmmeter has a range of 0-500,000 ohms, for example; as the center scale reading might be anything from 5,000 to 20,000 ohms, with almost any accuracy from 6% to 30% or worse. When we say, "This is a 1,000 ohm-per-volt meter, reading 0-100 volts d.c. 2%", we know quite definitely what to expect from it. Had we known that the movement only was accurate to 2%, but knew nothing about the resistor, we would know very little. In order to make ohmmeter designations definite, and eliminate the present ohmmeter confusion, it is suggested that a representative ohmmeter range be listed as:

1,000—10,000 (3,500) ohms 8%

3,500 ohms being some value within 10% of center scale and 8% being the greatest calculated circuit error (including resistor tolerances) between 1,000 and 10,000 ohms (which in this case is approximately .3 to 3 times center scale), plus the meter and reading errors (about 5% for a 2% meter accuracy).

Returning to Figure 37, values are given for ranges in decimal steps. This allows the experimenter to choose ranges most suitable for his work. For each range, values are given for three or more popular meters. In the E column, reference is made to several notes. These notes should be followed because accuracy of measurement on some ranges is effected by the internal resistance of the battery, and the resistors in the table have been corrected for the batteries specified in the notes, RFA, RVA, etc., at the heads of the columns, refer to the corresponding letters in the proper diagram of Figure 37. The values given for RMA, in the upper half of the column, include the meter resistance; so the meter resistance, at room temperature must be

VALUES OF R_{VA}	CATALOG No. AND RATING OF YAXLEY AIR-COOLED RHEOSTAT
1 OHM	102K (2 OHMS) WITH 2 OHM 5% FIXED RESISTOR IN PARALLEL
10 OHMS	110K (10 OHMS)
100 "	199P (100 "
1000 "	1000P (1000 ")
3.5 - 6.2 OHMS	106K (6 ")
2.6 - 4.65 "	103K (3 ")
2.5 - 4.4 "	103K (3 ")
7.5 - 15.0 "	110K (10 ")
10.4 - 18.4 "	115K (15 ")
12.1 - 21.4 "	120K (20 ")
25 - 44 "	140K (40 ")
29 - 52 "	140K (40 ")
35 - 62 "	150P (50 ")
75 - 150 "	199P (100 ")
104 - 184 "	200P (200 OHMS) WITH 500 OHM 5% FIXED RESISTOR IN PARALLEL
121 - 215 "	200P (200 OHMS)
200 - 350 "	200P (200 ")

Figure 36

known, or the total resistance (meter and resistor in series) must be adjusted to the value shown. If any reader has difficulty in getting this work done, an inquiry addressed to RADIO NEWS will bring information as to where the job can be done at a very reasonable price.

Other resistors in the table are standard stock items of the Precision Resistor Co. In ordering these resistors, both the resistance value and the tolerance (given at the top of the column) should be specified. RVA is a rheostat, and may be any resistance between the values shown. If a rheostat near the low limit is selected, adjustment will be provided down to 1.2 volts per cell. If a rheostat near the high limit is selected adjustment will be provided down to 1.13 volts per cell. A rheostat should be used that has a large number of turns, in order to provide a fine adjustment. The Yaxley air-cooled rheostat is very satisfactory, and most of the values in the table, may be found among their stock items as shown in Figure 36.

On the low ranges Note 1 (Figure 37), should be carefully followed, and the switch in Figure 39 (D) should be of very low contact resistance. On the 1 ohm and 0.1 ohm ranges, the switch should be rated 5 amperes and 30 amperes or more respectively. All joints should be securely soldered, where possible, and test leads should be fastened to heavy terminals. Eby "Commander" binding posts are satisfactory. Weston test leads are satisfactory, except on the lowest ranges, where new, larger leads must be added, in accordance with Note 1, Figure 37.

The errors listed in Figure 37 are the maximum possible errors, providing instructions are followed. According to the theory of probabilities, however, the errors will be between zero and half the value listed, 70 per cent of the time, and less than two-thirds of the value listed, 90 per cent of the time.

Figure 38 is a scale which has had all the sources of error minimized, and which will fit the meters listed in the table. For Jewell type 88 cut on dotted line; for Weston type 301 cut on solid line; and for Jewell type 54 cut on dot-dash line. This may be fastened to the scale as follows: Remove the scale carefully, so as not to bend the pointer. Do not leave the meter without the protection of the glass. Give the back of the metal scale a thin coat of shellac and allow it to dry over night.

Cut out the paper scale through the center of the proper outline, and place it scale side down on a clean blotter which is laying down on a flat surface. Place the metal scale on the paper scale with the shellac side down. Heat a flatiron to the point where the moistened finger will just sizzle and turn it off. Hold the scale; place the flatiron on the exposed half and hold it in place until the heat is felt in the other half, then remove iron. Hold the scale in place until it cools a little. Repeat with the other half. The .1 ohm center-scale range, and the 100 ohm center-scale range, using Figure 39(C), will be read directly on the lower and upper scales respectively. Other ranges

CENTER SCALE READING (OHMS)	BASIC CIRCUIT ACCURACY (DOES NOT INCLUDE METER AND READING ERRORS BUT INCLUDES RESISTOR TOLERANCES).	ACCURATE RANGE (OHMS) AND MAXIMUM POSSIBLE ERROR, INCLUDING 5.05% POSSIBLE METER AND READING ERROR AT ONE END OF RANGE (MAXIMUM ERROR 1% LESS AT CENTER).	USEFUL RANGE (OHMS) AND MAXIMUM POSSIBLE ERROR, INCLUDING 8.83% POSSIBLE METER AND READING ERROR AT ONE END OF RANGE (MAX. ERROR 1% LESS AT OTHER END)	INDICATING RANGE (OHMS) AND MAXIMUM POSSIBLE ERROR, INCLUDING 28.6% POSSIBLE METER AND READING ERROR AT ENDS OF RANGE.	METER USED (SEE RANGE) →	RANGE OF METER (MILLIAMPERES)	DIAGRAM USED	E (VOLTS) (FOR SIZE OF BATTERY SEE PROPER NOTE)	R_{FA} (OHMS) ±2% (±1% IS OF COURSE O.K.)	R_{VA} (OHMS) MAY BE ANY RESISTANCE BETWEEN VALUES SHOWN.	R_{MA} (OHMS) ±½ of 1% OR ±1% IF OTHER IS NOT AVAILABLE (R_M MUST BE KNOWN TO SAME ACCURACY)	R_{FC} (OHMS) ±½ of 1% OR ±1% IF OTHER IS NOT AVAILABLE.
0.1	1.15%	0.03-0.3 ±6.2% SEE NOTE 1	0.01-1 ±10%	0.002-5 ±29.8%	WESTON MODEL 301 OR JEWELL PATTERN 54 OR 88	1	D	1.5 NOTE 2	2.48	1 ±10%	43.24 $-R_M$	0.1002
"	"	"	"	"	WESTON MODEL 301 ONLY	1.5	"	"	"	"	28.83 $-R_M$	0.1003
"	"	"	"	"	"	2	"	"	"	"	21.62 $-R_M$	0.1005
1	"	0.3-3 ±6.2% SEE NOTE 1	0.1-10 ±10%	0.02-50 ±29.8%	WESTON MODEL 301 OR JEWELL PATTERN 54 OR 88	1	"	1.5 NOTE 3	25.0	10 ±10%	43.24 $-R_M$	1.024
"	"	"	"	"	WESTON MODEL 301 ONLY	1.5	"	"	"	"	28.83 $-R_M$	1.036
"	"	"	"	"	"	2	"	"	"	"	21.62 $-R_M$	1.049
10	"	3-30 ±6.2%	1-100 ±10%	0.2-500 ±29.8%	WESTON MODEL 301 OR JEWELL PATTERN 54 OR 88	1	"	1.5 NOTE 4	254	100 ±10%	43.24 $-R_M$	13.01
"	"	"	"	"	"	1.5	"	3 NOTE 5	251	"	57.65 $-R_M$	12.10
"	"	"	"	"	"	2	"	"	"	"	43.24 $-R_M$	13.01
"	"	"	"	"	"	3	"	"	"	"	28.83 $-R_M$	15.31
"	"	"	"	"	"	5	"	"	"	"	17.30 $-R_M$	23.75
"	"	"	"	"	"	10	"	4.5 NOTE 6	247	"	12.97 $-R_M$	43.65
"	3.7%	3-30 ±8.75%	1-100 ±12.5%	0.2-500 ±32.3%	WESTON MODEL 301 ONLY	100	C	1.5 NOTE 3	1.5	3.5-6.2	NOT USED	8.66
"	3.5%	3-30 ±8.55%	1-100 ±12.3%	0.2-500 ±32.1%	JEWELL PATTERN 88 ONLY	"	"	"	1.15	2.6-4.65	"	8.84
"	"	"	"	"	JEWELL PATTERN 54 ONLY	"	"	"	1.08	2.5-4.4	"	8.89
100	1.15%	30-300 ±6.2%	10-1,000 ±10%	2-5,000 ±29.8%	WESTON MODEL 301 OR JEWELL PATTERN 54 OR 88	1	D	15. NOTE 7	2,529	1,000 ±10%	432.4 $-R_M$	130.1
"	1.85%	30-300 ±6.9%	10-1,000 ±10.7%	2-5,000 ±30.5%	WESTON MODEL 301 ONLY	"	C	1.5 NOTE 8	4.15	7.5-15.0	3.0	95.78
"	1.88%	30-300 ±6.93%	"	"	JEWELL PATTERN 88 ONLY	"	"	"	4.6	10.4-18.4	3.333	95.57
"	1.93%	30-300 ±6.98%	10-1,000 ±10.8%	"	JEWELL PATTERN 54 ONLY	"	"	"	5.4	12.1-21.5	3.888	95.22
"	2.8%	30-300 ±7.85%	10-1,000 ±11.6%	2-5,000 ±31.4%	JEWELL PATTERN 88 ONLY	10	"	1.5 NOTE 4	10.8	25-44	NOT USED	90.18
"	3%	30-300 ±8.05%	10-1,000 ±11.8%	2-5,000 ±31.6%	WESTON MODEL 301 ONLY	"	"	"	13	29-52	"	89.08
"	3.1%	30-300 ±8.15%	10-1,000 ±11.9%	2-5,000 ±31.7%	JEWELL PATTERN 54 ONLY	"	"	"	15.4	35-62	"	88.08
1,000	1.25%	300-3,000 ±6.3%	100-10,000 ±10.1%	20-50,000 ±29.9%	WESTON MODEL 301 ONLY	1	"	"	41.5	75-150	"	973.0
"	1.3%	300-3,000 ±6.35%	"	"	JEWELL PATTERN 88 ONLY	"	"	"	46	104-184	"	971.0
"	1.35%	300-3,000 ±6.4%	100-10,000 ±10.2%	20-50,000 ±30%	JEWELL PATTERN 54 ONLY	"	"	"	53.85	121-215	"	967.5
"	3.8%	300-3,000 ±8.85%	100-10,000 ±12.6%	20-50,000 ±32.4%	WESTON MODEL 301 ONLY	10	"	15. NOTE 7	13	29-52	"	929.5
"	"	"	"	"	JEWELL PATTERN 88 ONLY	"	"	"	10.8	25-44	"	930.5
"	"	"	"	"	JEWELL PATTERN 54 ONLY	"	"	"	15.4	35-62	"	928.4
10,000	1.05%	3,000-30,000 ±6.1%	1,000-100,000 ±9.9%	200-500,000 ±29.7%	WESTON MODEL 301 ONLY	1	"	"	41.5	75-150	"	9,878
"	1.06%	3,000-30,000 ±6.11%	"	"	JEWELL PATTERN 88 ONLY	"	"	"	46	104-184	"	9,876
"	"	"	"	"	JEWELL PATTERN 54 ONLY	"	"	"	53.85	121-215	"	9,872
100,000	0.64%	30,000-300,000 ±5.69%	10,000-1 MEGOHM ±9.5%	2,000-5 MEGOHMS ±29.2%	WESTON MODEL 301 ONLY	200 MICRO-AMPERES	"	30. NOTE 9	75	200-350	"	99,700
"	0.9%	30,000-300,000 ±5.95%	10,000-1 MEGOHM ±9.7%	2,000-5 MEGOHMS ±29.5%	"	1	"	150. NOTE 10	41.5	75-150	"	99,200
"	"	"	"	"	JEWELL PATTERN 88 ONLY	"	"	"	46	104-184	"	"
"	"	"	"	"	JEWELL PATTERN 54 ONLY	"	"	"	53.85	121-215	"	"
1 MEGOHM	0.6%	300,000-3 MEGOHMS ±5.65%	100,000-10 MEGOHMS ±9.4%	20,000-50 MEGOHMS ±29.2%	WESTON MODEL 301 ONLY	200 MICRO-AMPERES	"	300. NOTE 10	75	200-350	"	998,000

NOTE 1: TO OBTAIN ACCURATE READINGS AT THE LOW END OF THESE RANGES, THE WIRES SHOWN BY HEAVY LINES IN THE DIAGRAM SHOULD BE THREE #14 "BUSS" WIRES TWISTED TOGETHER OR SIMULAR, AND TEST LEADS SHOULD BE OF LIKE SIZE.

NOTE 2: USE TWO #6 DRY CELLS IN PARALLEL (WILL GIVE 4 OR 5 TIMES THE SERVICE OF A SINGLE CELL).

NOTE 3: USE ONE #6 DRY CELL (BECAUSE OF IT'S LOW RESISTANCE).

NOTE 4: USE ONE #2 (REGULAR SIZE) FLASH LIGHT CELL.

NOTE 5: USE TWO #2 (REGULAR SIZE) FLASH LIGHT CELLS OR THE 3 VOLT TAP OF A 4½ VOLT "C" BATTERY.

NOTE 6: USE 4½ VOLT "C" BATTERY.

NOTE 7: USE TWO BURGESS #5540-7½ VOLT "C" BATTERIES.

NOTE 8: USE #6 DRY CELL WITH R_{FC} AS SHOWN; OR USE #2 (REGULAR SIZE) FLASHLIGHT CELL AND SUBSTRACT 2.6 OHMS FROM R_{FC} (WILL INCREASE THE ERRORS 2.5% BUT WILL BE MORE PORTABLE).

NOTE 9: USE ONE BURGESS #5540-7½ V. "C" AND ONE #5156-22½ V. "C" BATT.

NOTE 10: USE MEDIUM SIZE "B" BATTERIES AND 4½ V. "C" BATTERIES (SUITABLE FOR BENCH USE ONLY).

AR6147

using Figure 39(D) will be read on the lower scale and other ranges using Figure 39(C) will be read on the upper scale by merely moving the decimal point, one, two, three or four places to the right. Of course a metal scale would look better and be less subject to errors.

Duplicates of this scale, printed on strong paper, may be obtained by sending ten cents to RADIO NEWS, Blueprint Department, 461 Eighth Avenue, New York City.

Because Jewell half-scale current is at exactly half-scale, and Weston half-scale current is 1.7 per cent above half-scale, the upper scale will read 4 per cent and the lower scale will read 4 per cent low when used on Jewell meters.

The values in Figure 37 will cover most conditions, but should the internal resistance of the meter be 10 to 20 per cent below the rated value, a condition could be obtained when using Figure 39(C), where it would be impossible to adjust to full scale. Should this occur, bring the meter resistance nearer normal, by putting a fixed resistor in series. The resistor could even be a portion of an old rheostat with the wires soldered or bolted in place (do not use the arm), as it need only be approximately 5 ohms for 1, etc.

Figure 40 shows the legend for the letters used in the text and illustrations. Figure 41 gives information on meters to be used on the 10 ohm range.

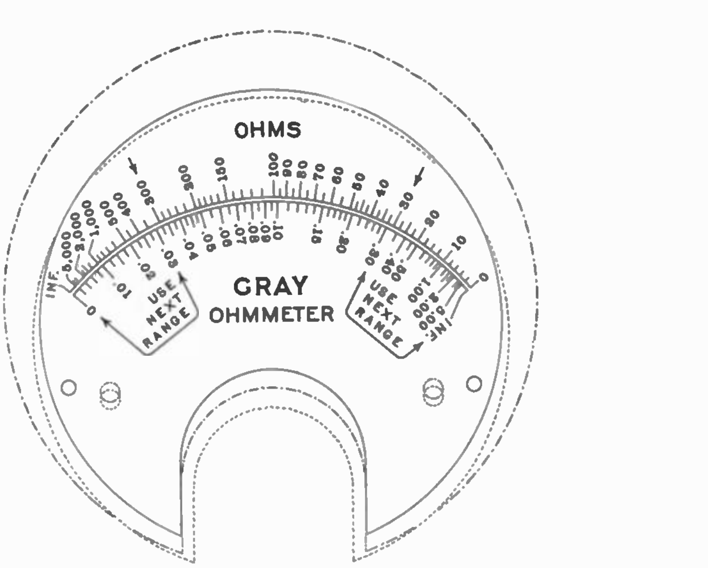


Diagram C Diagram D

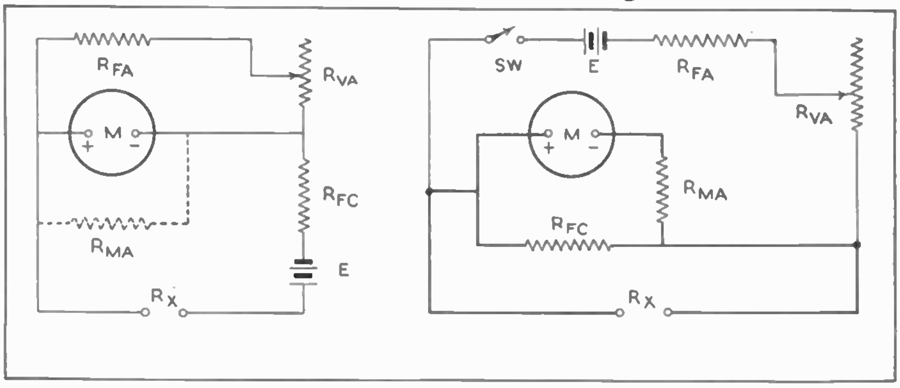


Figure 37—See P. 16
Figure 38—Top Right
Figure 39—Middle Right
Figure 40—Lower Right
Figure 41—Below

RANGE	METER USED	POSSIBLE ERROR
10 OHM	0-1 MA	.87 OF 1%
10 "	0-1.5 OR 2 MA	2.34%
OTHER RANGES USING ANY METER		.23 OF 1% OR LESS
NOTE THEREFORE, USE AN 0-1 MILLIAMMETER, IF AVAILABLE, ON THE 10 OHM RANGE		

LEGEND FOR TEXT AND ILLUSTRATIONS

I_M - (IN TEXT) FULL SCALE CURRENT (RANGE) OF METER (MILLIAMPERES)
E - BATTERY (VOLTS)
R_{FA} - ADDITIONAL FIXED RESISTOR (OHMS)
R_{VA} - ADDITIONAL VARIABLE RESISTOR (OHMS)
R_{MA} - RESISTOR FOR ADJUSTMENT OF METER RESISTANCE (OHMS)
R_{FC} - FIXED CALIBRATING RESISTOR (OHMS)
R_{VC} - VARIABLE CALIBRATING RESISTOR (OHMS)
R_M - (IN TEXT) INTERNAL RESISTANCE OF METER (OHMS)
R_X - RESISTANCE BEING MEASURED (OHMS)

A Portable Tube Checker

UNQUESTIONABLY the most essential part of a serviceman's equipment is a reliable instrument for testing tubes. When the set to be serviced is inoperative, immediate information as to the condition of the tubes is often required. In such cases a tube checker alone can supply this information and in all other cases it furnishes the quickest and most convenient means of determining a tube's condition.

Considering the large number of tube testers on the market, relatively little concerning their design and construction has been written. Often the serviceman or experimenter will want to build his own tester, either to form part of a test kit or as a separate unit. The instrument shown in Figures 42 and 45 is of the utmost simplicity in design and operation, yet is based on a fundamental test method which has been the standard for years in laboratories as a means of keeping an effective check on tube depreciation during life test runs. It does not, of course, provide an infallible indication as to a tube's capabilities. In the final analysis, the performance of any tube is dependent not only upon its electrical and mechanical condition, which this tester indicates, but also upon the specific portion of the circuit in the particular set in which it is to function, factors which no tube tester can precisely duplicate. Yet, in spite of its simplicity of design and low cost, it provides a highly accurate and complete analysis of the condition of any tube.

Figure 44 shows a complete schematic diagram of the completed tube tester. Switches 1, 2, 4, 5, 6 and 10 are single-pole-double-throw toggle switches. These switches have three terminals, two on one side and one on the other. The single terminal side corresponds to the moving arm of the usual type of switch. Each socket terminal, with the exception of the filaments or heaters, is wired to the moving-arm terminal of its switch. The other terminals at the same end of the switches are connected together and brought over to SW3, which closes the circuit to the filament and one side of the transformer secondary. The terminals at the opposite end on the switches mentioned are also joined together and brought over to R3, through which they connect to the other side of the transformer. Switch

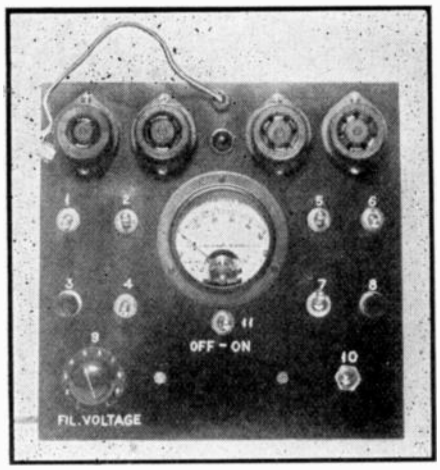


Figure 42

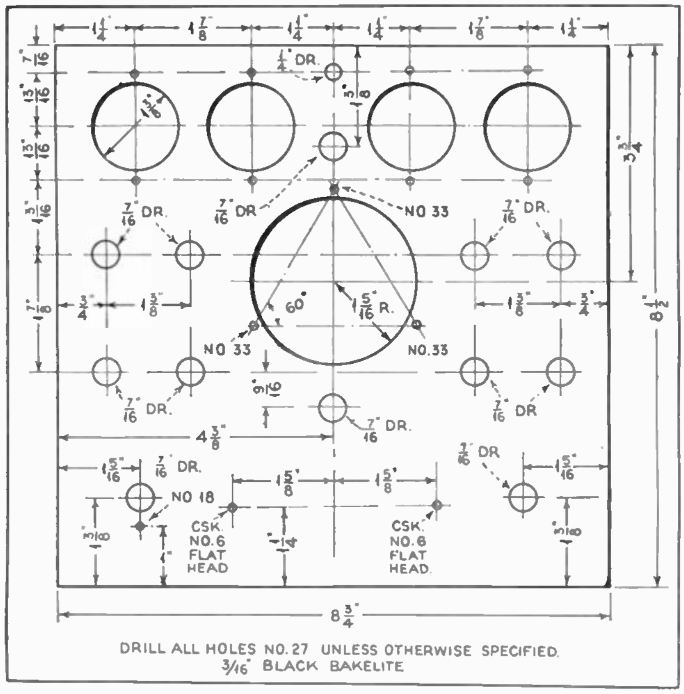


Figure 43

10 is mounted in the lower right-hand corner and arranged to throw right and left rather than up and down. This switch should be wired as shown in the drawing, so the plate is connected to the meter circuit when the switch is thrown to the left. If we start to test, then, with switch 10 thrown to the left, we need only to throw the cathode switch to its upper position, with all other element control switches down, to obtain our quality test. If the tube to be tested is a multi-purpose affair, such as the duo-diode-triode, we may test each element separately by placing the cathode and all other element switches in the upper position and moving each element switch down and up in turn, noting each reading, while switch 10 is thrown to the right. It is thus possible to determine if the diode sections are accurately balanced. Many testers are designed to test only the triode sections of such tubes.

Since we are, in effect, measuring the internal resistance of the tube by this method, the resistance of the test circuit has been kept as low as is practical.

Let us assume that the internal resistance of the tube under test should normally be 500 ohms under such test conditions, but as a result of loss of emission due to long-continued use, has increased to 1000 ohms. The measuring circuit should then indicate a 50% drop in current. If, however, our measuring circuit should have a resistance in itself of 1000 ohms, the percentage change in circuit resistance would be the ratio of 500 ohms to 2000 ohms or 25%. Thus the current change as indicated by the meter would be only 25%. This point has been analyzed in detail because the failure of certain tube tester designs to reject weak –80's is due to this cause. This may also account for the fact that relatively few –80's are replaced in the field until complete failure has occurred. The series resistors R1 and R3 have been included to protect the meter when measuring mercury-vapor tubes. For all other tubes the switch S8 short-circuits R3; R1 is just enough to keep all readings within the range of the meter.

To construct this tester, drill the panel in accordance with the layout shown in Figure 43. It is well to drill the holes for the toggle switches undersize and then ream them out just enough to make a tight fit. This will tend to remove any strain on the wiring due to the switches turning out of position. Mount the sockets, bending the terminals so they will project through the socket holes. It is a good idea to mark the underside of the panel opposite each terminal with the terminal designation, using a glass pencil or scriber, to avoid mental confusion in wiring. Try out the meter holes to make sure the meter will fit, but do not mount the meter until the

Figure 44

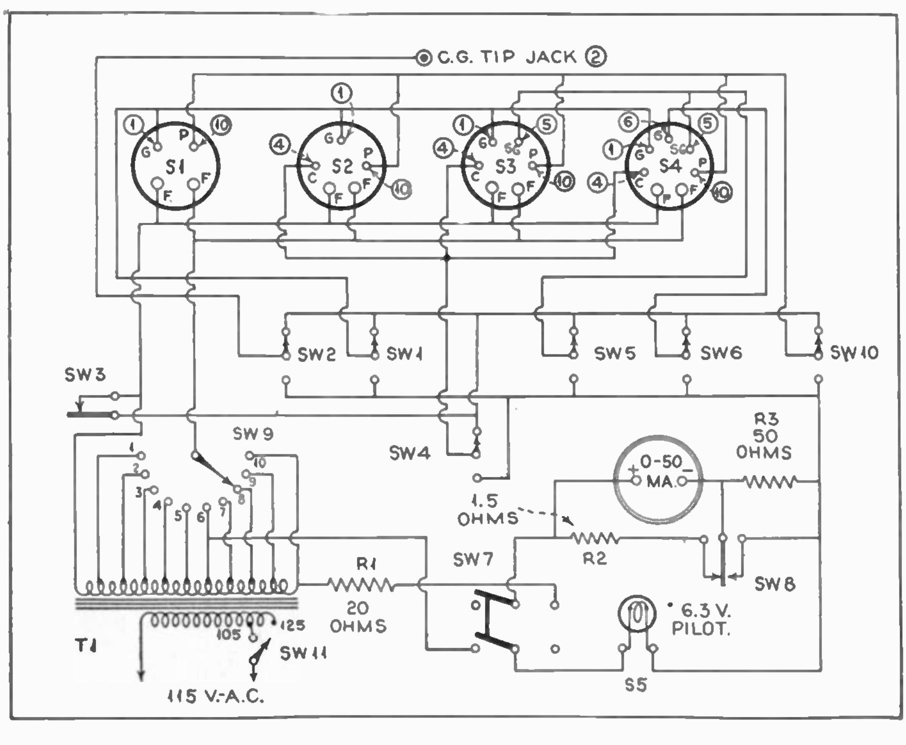
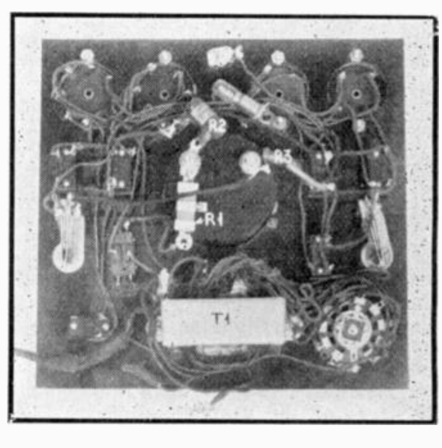


Figure 45



wiring has been completed, to avoid risk of damage in handling. Mount the remainder of the apparatus and proceed with the wiring. It is best to wire the rotary switch controlling the filament voltages first. The transformer has 12 voltage taps, but only 10 are used. The 1.1-volt tap is required only for 864's and WD11's. If you expect to test these types, this tap may be wired in and 25-volt tap omitted; 25-volt tubes may be tested on the 30-volt tap. The 15-volt tap is also not used; 15-volt tubes may be tested on the 12.6-volt tap. There are primary line voltage taps for 105, 115 and 125 volts. It is best to wire in the 115-volt tap unless the line voltage is consistently below this value. The bracket for the pilot light socket is mounted on one of the socket retaining screws.

Operating Instructions

If the tube is known to have no shorted elements proceed as follows:

(1) Set switch 9 for rated filament voltage of tube (see tube characteristic chart on pages 32 and 33), the voltage applied at each setting being indicated in the following table:

Switch Position	*Filament Voltage*
1	1.5 volts
2	2.0 "
3	2.5 "
4	3.3 "
5	5.0 "
6	6.3 "
7	7.5 "
8	12.6 "
9	25.0 "
10	30.00 "

(2) Throw switch 11 to right, switch 10 to left and switch 7 to UP position. All other switches, DOWN.

(3) For all filament type 4-, 5- and 6-prong tubes, simply read meter. If reading is below 20, depress shunt switch 8 and read.

(4) For all heater type tubes, proceed as above but throw switch 4 to UP position and read. If no reading results, the tube is of a special type and the cathode is not in the usual place. If the location of the cathode is unknown, move each switch up and down, one at a time, until the maximum reading is secured.

(5) For duo-diode-triodes, the diodes should be tested independently by throwing the switch connected to one diode down, switch 10 to right and all other switches UP. Then test the other diode the same way. The triode can be tested independently (see notes accompanying the chart below).

(6) For all full-wave rectifier tubes, proceed as in (5) above. For half-wave rectifiers, proceed as in (3) above. Do NOT depress shunt button when testing mercury-vapor rectifiers, such as the –82 and –83. For all others, depress shunt.

Short-Circuit Test

Throw switch 7 to DOWN position. With switches set as specified in (2) above, if bull's-eye glows, some element is shorted to the filament. If not, throw switches 1, 2, 5 and 6 successively to UP position. If bull's-eye blows, some other inter-element short-circuit is present.

Cathode-Heater Leakage Test

Depress switch 3 while reading meter for tube condition test. If pointer does not drop to zero, cathode-heater leakage is present. A list of readings obtained with this tester is given in the chart below. All tests were made at a line voltage of approximately 120 volts, using the 115-volt tap on the transformer. The last column gives the readings obtained with all elements except the filament and cathode connected to the plate. With the switches set for this reading, the other readings are obtained (except as otherwise noted) by moving each switch in turn to the UP position. After the reading has been noted by doing this with switch 1, for instance, return the switch to the DOWN position and repeat this operation with switch 2 in the UP position, etc., until all readings have been obtained. The blank columns indicate that the operation does not affect the reading, due to the switch being out of the circuit for the particular tube being tested.

The table does not contain all tube types because at the time of making it, there were not sufficient tubes of certain types on hand to establish an average reading. All figures given are averages of several tubes which are known to be good.

It is suggested that, unless his readings check reasonably well with those given below, each constructor prepare his own chart in the manner described, as variations in average line voltage conditions, individual parts, etc., coupled with the normal production variations in tubes, may affect the readings considerably.

Tube Test Chart

Type	*SW1*	*SW2*	*SW4*	*SW5*	*SW6*	*SW10*	*Total*
24A	23	2				32	35
26	2					16	25
27	2					17	29
34	17	2				22	23
35	21	2				29	32
36	22	2				29	32
37	2					19	28
38	23	2				28	32
40	27	2				33	36
41	3			21		30	30
42	3			22		28	28
45	7					18	42
46	5		23			30	37
47	3		26			32	40
53(d)	33		43(a)	33	(c)	43(b)	20(s)
55(d)	6	14		6			35
56	2					24	35
57	37	2		32		37	43
58	38	2		32		38	42
59	36			24	3	34	40
71A	7					14	34
75(d)	4	27		4		1	37
77	33	2		27		34	37
78	24	2		18		25	28
79	(c)	36	56	38		17(S)	20(S)
80	18					18	36
82	32(S)					32(S)	R
83	33(S)					33(S)	R
84	40					40	R
2A3	12					42	22(S)
2A5	2			22		26	28
2A6(d)	10	28		12			42
2A7	2	40		32	42	42	44
2B7(d)	6	14		2	6		30
6F7	18	8		20	22	24	24

Notes

Test –30, –31, –32 and –33 tubes at 1.5 filament volts, not at their normal filament voltage. This is recommended because these tubes are subject to deterioration if all elements are made highly positive at full filament emission.

(a) SW1 DOWN also.
(b) SW5 DOWN also.
(c) UP for all readings.
(d) Start readings with all switches UP. Move alternately downward, read, and return to UP position.
(R) Rectifier—Readings of both plates unnecessary.
(S) Shunted.

Variations of 15-20% in these readings are normal.

Tubes reading 40% below these readings are doubtful.

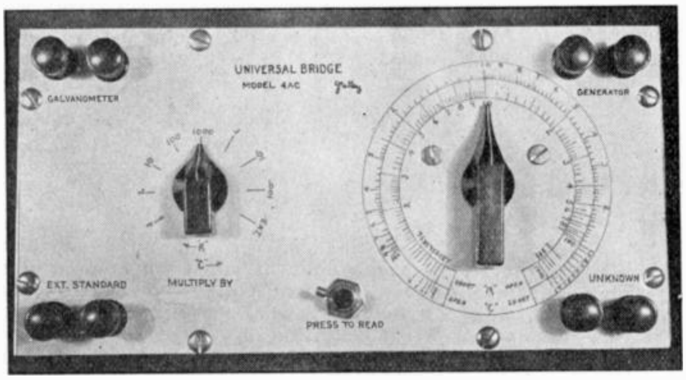
Tubes reading 50-60% below these readings should be replaced.

As the foregoing description has indicated, this tube checker will test any tube on the market, regardless of design, provided only that the tube fit one of the four sockets provided. Since the 7-prong socket is of the composite type, the only tube which will not fit is the obsolete WD11. There is plenty of room on the panel for an 8- or 9-prong socket and the single additional switch required, should such type tubes appear.

Intelligently used, this tester will prove an invaluable component of any serviceman's equipment. On the basis of results per dollar cost, it is believed that it is unsurpassed by any instrument on the market.

Parts List

M—Weston model 301, d.c. milliammeter, 0-50 ma.
R1—20-ohm resistor, 1 watt
R2—1.5-ohm wire-wound resistor, 5 watts
R3—50-ohm resistor, 1 watt
S1, S2, S3, S4—Eby type 12 moulded 4-, 5-, 6- and composite 7-prong sockets
SW1, SW2, SW4, SW5, SW6, SW10—Cutler-Hammer s.p.d.t. nickled toggle switches.
SW3—Yaxley s.p.s.t. push-button switch, non-locking
SW7—Cutler-Hammer d.p.s.t. 2-circuit toggle switch
SW9—Yaxley 10-point, single-deck, non-shorting rotary switch
SW11—Cutler-Hammer single-circuit, on-off nickeled toggle switch
T1—One Wholesale Radio Service Company tube tester filament transformer
One Yaxley pilot light socket and mounting bracket
One Yaxley s.p.d.t. push-button switch, non-locking
One Yaxley red bull's-eye
One Yaxley pin-jack
One control grid cap, with 8-inch lead and phone-tip terminal
One 6.3-volt pilot light
One bakelite panel 8½ x 8¾ by 3/16 inches
6 feet double conductor lamp cord
One a.c. plug



A Direct-Reading Slide-Wire Bridge

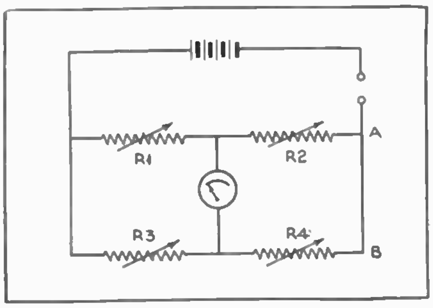


Fig. 46—Above; Fig. 47—Top

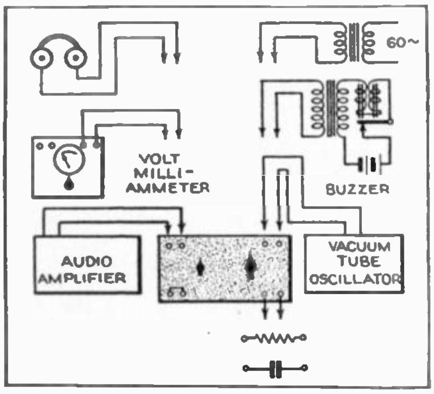
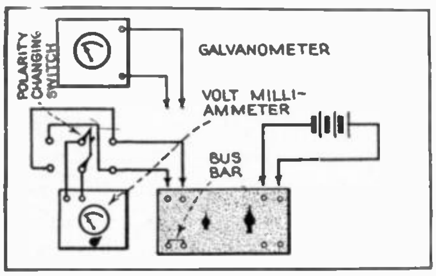
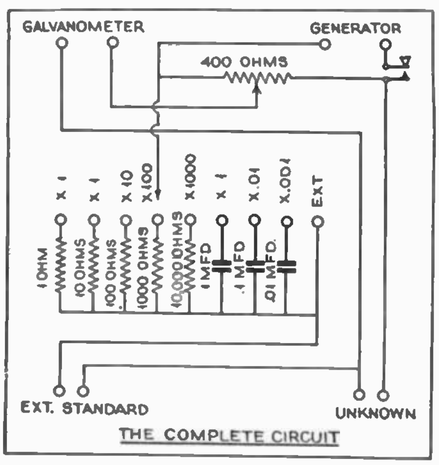


Fig. 48—Above; Fig. 49—Below
Fig. 51—Bottom





THERE are very few men engaged in radio who at some time or other have not wished to have a bridge handy. A bridge is an instrument which allows an unknown unit to be measured in terms of a known value. In Figure 46 is shown a network composed of two branch circuits each containing two separate variable resistances connected in series and the two branch arms are connected in parallel across the battery. At the point of junction between R1 and R2 in arm A one side of a voltmeter is connected. The other side is connected to the similar point between R3 and R4 in arm B.

When one of the four resistors is variable, it can be so adjusted that there is no voltage difference between the two aforementioned junctions and the indicating meter reads zero. The bridge is then said to be balanced.

When balance is reached, the value of one resistor can be computed if the value of the other three is known. This is expressed by:

$$R4 = R3 \times R2 \div R1$$

This form of bridge requires three separate known resistance groups. R1 may be a fixed value; R2, a group of resistances, 10, 100 and 1000 times greater or less than R1; and R3 a decade-box, variable in steps of 10 ohms up to 1000 ohms. The accuracy of useful measurement is dependent upon the accuracy of the three known resistances. In laboratory instruments these resistances are adjusted to 1/10 of 1 per cent, and, as there are a number of resistors this form of bridge is quite high in cost.

For general use in the experimenter's shop and service work there is no need of such extreme accuracy. For this purpose the simple inexpensive bridge shown in Figures 47 and 50 was designed. It may be used with a source of a.c. for measuring resistors and capacity, or with d.c. for measurement of resistors.

For a.c. measurements, the 60 cycle line, a telephone buzzer, a microphone hummer, or a vacuum tube oscillator may be used as a voltage source. To indicate balance, a pair of phones, a copper oxide volt- or current-meter, or an audio amplifier may be employed. In order to secure the greatest sensitivity of a copper oxide (rectifier type) voltmeter may be connected in the output of an audio amplifier, as per Figure 48. For d.c. a battery of 1.5 to 9 volts is used as the voltage source, and a galvanometer or a volt-milliammeter with a polarity changing switch as shown in Figure 49.

This bridge depends upon the known standard arm R3 which consists of 1 per cent wire-wound resistors, and selected fixed condensers. Provision is made to allow an external standard to be used, such as higher resistance, or inductance. A series resistance may also be used here connected in series with the standard capacities to measure power factor. Balance is secured by varying the ratio between R1 and R2 and the value of the unknown is read directly from the calibrated scale. As the standards are in multiples of 10 the scale is calibrated to read: .01 to 100 times the standard in use. Resistance standards of 1, 10, 100, 1000, and 10,000 ohms give a resistance range of .01 to 1,000,000 ohms. For capacity a second scale is necessary, calibrated for .01 to 100 times the standard value, giving a range of .001 to 100 mfd. for the three standards of 1, .1 and .01 mfd. While it is possible to secure this extreme range of capacity at 1000 cycles, due to the high ratio used, the accuracy outside of a 10-to-1 range is not satisfactory. The greatest accuracy is secured in the range of .3 to 3 times the standard. In this range an accuracy of 3% may be secured.

The construction and assembly are simple. The complete circuit is shown in Figure 51. The most important point is to have connections of low resistance. In order to secure this, number 12 tinned copper wire was used. No directions are given regarding layout, as it is assumed that this will fit in with the constructor's own ideas, or that he will purchase one of the kits being offered, which include a drilled and calibrated panel. The first parts to be assembled on the panel are the binding post and their insulated washers. Be sure to tighten the holding nut to prevent turning. The push-button switch is now placed on the panel. This is set with a slight angle toward the potentiometer in order to clear the bank of condensers. In mounting the push-button switch it is necessary to use a bushing to clear the panel. The next unit to be mounted is the range selector switch. Set the stop control on this so that it stops the blade in the ninth position. This switch is mounted also with a bushing on the shaft and is fastened so that the fifth contact from the start is on top. The two-terminal strip is now mounted on the pillar opposite the switch blade connection. The last unit mounted is the potentiometer; in fact, this should not be mounted till all the rest of the unit is wired. This is to prevent breaking or scratching the winding. The calibration of the bridge depends upon this unit. Do not use lugs for making the wire connections; bend the bus-bar around the screws and tighten the holding nuts, then solder.

Place the small knob on the range selector switch and adjust it so it indicates the proper position, then tighten securely to shaft. Adjust the large knob on the potentiometer and set it so that the pointer lines up with the two end stops, but do not fasten securely to shaft.

Connect the bridge as per Figure 49, but short the terminals marked "unknown." Set the range selector on .1 and the ratio point about .1. Then press the button lightly and observe the galvanometer. If necessary, adjust the ratio arm till a balance is secured. Do not hold the battery button down longer than necessary, as large amounts of current are drawn from the battery. With practice it will be possible to slightly touch this button and note deflection on galvanometer. A balance should be secured between .2 and short. This indicates a resistance of .02 to .008 of an ohm. Now set range selector on Ext. and ratio arm about 3 and adjust for balance. If a balance is secured below 4, the wiring of the bridge is satisfactory. Now connect a rheostat as the unknown and set range selector on 1 and ratio dial on 10. Adjust rheostat until a balance is secured, then change range switch to .1. A balance should then be secured at 100. If a balance is secured at some other point, correct the knob to indicate properly; then check at 10, and repeat. If it indicates properly, set range switch at 10 and secure a balance at .1. By readjusting the potentiometer on some other range, the standards may be checked against each other. If the setting agrees satisfactorily, the knob may be fastened securely and, as per Figure 48, the capacity range checked on a.c.

The bridge may be calibrated in the following manner. Secure General Radio 1- and 10-ohm standard decade boxes. Set the range switch on 1, the unite decade on 1, the 10 decade on 0, and have the two decade boxes connected in series at all times. Secure a balance for 1 ohm and mark the panel or paper, being careful to locate the point exactly. Repeat this till the 10-ohm position is secured. Now set unit decade dial at 0 and secure points for each of the 10-ohm decade steps. Then set the range selector switch at 10 and check the unit point by means of the 10-ohm box. Then set the range selector switch at .1 and check the points secured from the 10-ohm decade boxes by means of the unit decade. If there is a large error in these points, set the range selector switch at the external position, and connect one of the decade boxes as an external standard, the other as the unknown value. Adjust them to equal values and then secure a balance by means of the ratio arm. Then connect both decades as unknown and measure the value of the standards. With only two boxes it will be possible to check the 100 ohms standard to 1%. Do not change the position of the ratio arm while checking standards.

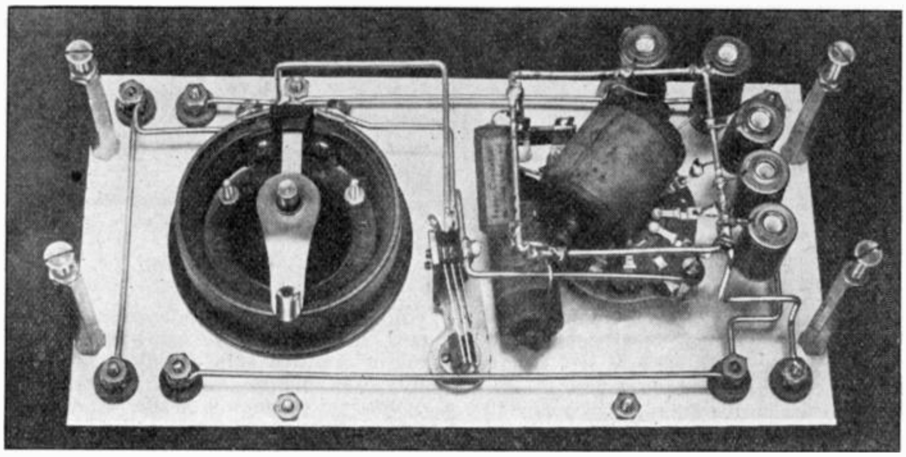


Figure 50

If the different ranges check after taking the first twenty points, it is now possible to calibrate the rest of the bridge. Set the 10-ohm decade at 10 ohms, range selector switch at 1, and secure the 10 points required from 10 to 20. Then setting the 10-ohm decade at 20, secure the next 10 points between 20 and 30. Between 30 and 40 it is only necessary to secure 4 additional points; 40 to 50 is also calibrated in 2-ohm steps. From 50 to 100 it is only necessary to check each 5 ohms. Now set the range selector switch at 10 and with the unit box secure the .1 scale calibration points; that is, the first 10 points required, then setting the 10-ohm decade box for 10, 20, etc., secure the additonal calibration points required from 2 to 10. It is only necessary to secure a point for every 2 ohms. A total of 110 calibration points is required for the resistance scale.

The equivalent calibration is secured for capacity, using a.c. for the generator, and a decade capacity box for the unknown. The capacity scale is in opposite direction to the resistance. The accuracy of the bridge depends upon the accuracy of the standards used and the care taken to secure the necessary points. After the calibration is secured, the panel should be inked in and covered with celluloid to prevent wear and soiling.

For the convenience of our readers who wish to avoid the job of calibration, a kit has been made available for this bridge, by a New York radio company. A complete list of parts follows:

Parts List

Parts of equivalent quality and accuracy may be substituted.

1—General Radio, type 214A potentiometer, 400 ohms
1—Lafayette aluminum panel, etched and calibrated, 4½ inches by 9 inches
1—Lafayette steel case
5—Trutest special 1% wire wound resistors: 1, 10, 100, 1000 and 10,000 ohms
3—Trutest special bridge condensers: 1, .1 and .01 mfd.
1—Yaxley, type 1211 selector switch, 1 circuit, 11 point
1—Yaxley push button switch
1—Analyzer pointer knob, large type
1—Analyzer pointer knob, small type
8—Insulated binding posts
8—Sets of insulated bushings for binding posts
2—3/16 inch bushings for switches
5 feet number 12 tinned copper bus bar

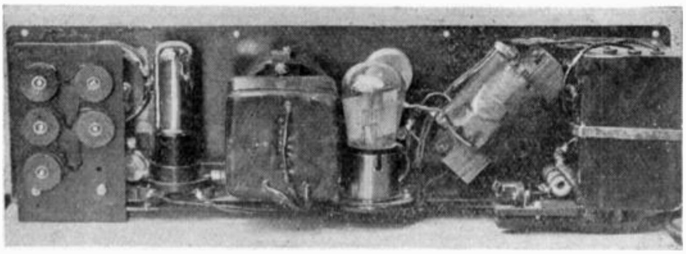
A Vacuum Tube Voltmeter

(All-Purpose, A.C. Operated)

FOR the man who is experimentally inclined, a vacuum-tube voltmeter is a highly desired if not most essential piece of measuring equipment in a well-appointed radio laboratory.

On the other hand, the radio serviceman who is in business to repair and test commercial radio equipment as a means of livelihood, customarily considers the vacuum-tube voltmeter as being something that is too expensive, elaborate, and not adapted to his particular needs. However, when it is considered that this form of voltmeter is the best and simplest form of output meter that can measure accurately a.c. voltages from .1 volt up to any desirable values, some consideration is deserved. Among other uses to which the meter is adapted, because of its high input-impedance, is the measurement of overall gain of an audio-frequency amplifier, from the detector to the output or by individual stages; obtaining the selectivity and gain performance of the radio-frequency stages; measurement of hum in receivers, etc.

Using the type -30 tube as the basis for design, the voltmeter circuit was evolved as shown in the schematic diagram, Figure 54. It will be noticed that the tube filament is in series and an



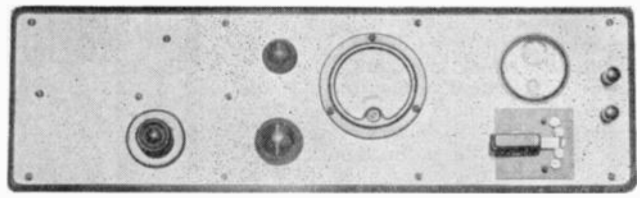


Figure 52—Above Figure 53—Left

integral part of the power supply voltage divider, the electrical position being such that the plate and grid voltage may be readily obtained.

In order to maintain the proper voltage on the circuit, a 3-volt meter is placed in shunt across the tube filament. With this method of indication, a constant current can be maintained in the divider resistors, with the result that identical voltages are always applied to the tube when in operation.

It is well to bear in mind that the tube selected for the meter might well be one that has been used for a period of 40 or 50 hours. In this way, certain irregularities will be eliminated which are due to change of the characteristics with use. In order to facilitate the final design of the power supply, tests were conducted on eight type –30 tubes in order to determine the proper operating voltages for the average tube. These final operating potentials are indicated on the calibration curve, Figure 55. Generally speaking, a slightly used tube of the –30 type will operate most satisfactorily at these potentials, thus making it unnecessary for the builder to work out new values.

The power pack is conventional, with the exception that, due to the fact that a relatively low d.c. voltage is to be delivered, the input condenser has been eliminated. The rectifier, which can be either an –80, –82 or BH tube, is fed into a filter consisting of a 30-henry choke and a single 4 or 8-microfarad condenser in the output or voltage-divider side. This type of filter has been found sufficient for the purpose, gives fine regulation, minimum ripple and is economical.

Building the Voltage Divider

In building the voltage-divider network, it will be wise to invest in the best wire-wound resistors. All of these resistors used are stock sizes, and their place in the circuit should be clear from Figure 54. The 800-ohm plate-voltage resistor and the 100-ohm grid-voltage resistor are shown with an arrow through them to indicate that they might well be semi-variable. In this way, the builder can secure different operating potentials, if he so desires, and the resistor can be set and clamped in suitable manner to maintain a fixed voltage.

In the voltage divider, two 400-ohm, wire-wound potentiometers are used. The first one is connected in shunt with a 50-ohm resistor and placed just ahead of the 800-ohm plate-voltage resistor. This provides a small "bucking" voltage which feeds current through a 10,000-ohm protective resistor to the plate side of the microammeter. By adjusting this 400-ohm potentiometer, the residual plate current taken by the vacuum tube can be done away with, giving the full scale of the meter over to measuring purposes. The second 400-ohm potentiometer is in the divider circuit proper and is connected as a rheostat just ahead of the previously mentioned 50-ohm fixed resistor. The function of this variable resistor is to control the setting of the filament voltmeter in order to maintain the same value of current through the divider at all times.

The 0.5 mfd. condensers, shown on the diagram, are purely for by-pass purposes. Under no conditions should the builder place a by-pass condenser from the plate side of the microammeter to the negative side of the filament unless some means is provided to prevent the charging current of the condenser from passing through the meter.

The input to the vacuum-tube voltmeter (grid-to-filament) is shunted with a series combination of precision resistors, which serve the purpose of a voltage-divider network, in order to secure various ranges of the meter. This network must be reasonably high in value so that the power consumed by the instrument shall be of negligible quantity. For economic purposes this network was made to have a total of 1,000,000 ohms. The network is made of six individual precision resistors, each of such a value as to give a suitable multiplying factor to increase the voltage range of the instrument; the value of these resistors is given in Figure 56.

It will be noticed that the sizes listed are carried in stock by several of the good precision resistor manufacturers. It is advisable to pay a slight premium and secure the resistors that are rated to an accuracy of 0.5 percent of their rated value.

This voltage divider provides a permanent path for the bias voltage, and the a.c. voltages to be measured are applied to the divider through a 2 or 4 mfd. condenser. Smaller values of condensers should not be used, and it is well to be sure that the condenser is a high-quality paper condenser. One other point that should receive careful consideration is the selection of a suitable switch to change the range of the instrument. The General Radio low-contact-resistance switch is very good. It is known as model 202-A.

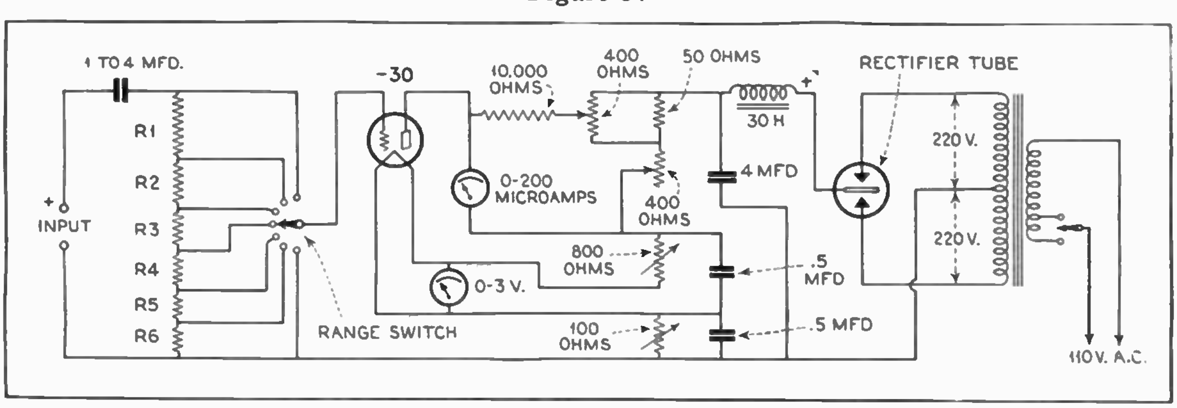
The layout used is self-explanatory from the photographs and any deviation that is desired can be made. However, in order to make the instrument portable and self-contained, use one of the neat cabinets which were used by A. K. on their battery sets. There is adequate space and the cabinets can be picked up very cheaply.

Simple Operation

From the foregoing it is clear that there is no complication in design outside of a reasonable amount of care on the part of the builder. From an operating standpoint, the adjustment of the filament voltmeter is all that is necessary to maintain proper operating conditions and automatically fixes all operating potentials. Furthermore, this adjustment is independent of the a.c. voltage fluctuations and aging of the rectifier tube. Also there is only one curve for all ranges of the meter.

With the operating potentials and the tube selected, the voltmeter is ac-

Figure 54



curate to 5 per cent at the extreme lower portion of the scale, with a sensitivity of less than 0.1 volt. On the upper portion of the scale, the accuracy and sensitivity is increased to 0.5 percent and 0.01 of a volt, respectively.

By using a resistance-network voltage divider the range of the instrument is increased to more than necessary for normal use.

Next, the input resistance is kept sufficiently high for average purposes so that the amount of power consumed is practically nil.

By taking a set of aged tubes and by curves and associated data, average operating potentials were selected so as to operate the tube on the quadratic portion of the characteristic curve. This resulted in an instrument reasonably free of frequency and wave-form error.

Last, but not least, the cost of the instrument has been kept as low as possible consistent with good workmanship. In an instrument of this type, quality should be paramount, but it is not necessary to be extravagant. The meters and resistors are the principal cost. The power-supply equipment is good, but with replacement parts at the price they are, this is a small item. The instrument, excluding workmanship, costs approximately $40.00.

With precision resistors used in the network, calibration may be carried on at any voltage within range of the instrument. If a precision voltmeter with 0-2 volts range is available, it is slightly more accurate to calibrate at this range in order to reduce the personal error.

Calibration is facilitated if magnifying lenses are used to read the two meters. From the photograph, Figure 52, a lens can be seen on the filament voltmeter and covers the portion of the scale which is always used. This is a small lens, plano on one side, with a focal length of about 1½ inches. A drop of water will cement the lens to the glass on the meter.

The instrument should be calibrated at least three times and the average results used. At least a dozen points should be taken at each calibration. It is well to perform the calibrations at intervals of at least several hours or better and still take three days and calibrated once on each of the days, or have some other person run a calibration. The calibration curve is self-explanatory and the same curve is used for all ranges, the only essential being to multiply the voltage by the proper factor similar to reading various ranges on an ordinary voltmeter. It will be found that if the potentials indicated are used, the lowest range will be in the vicinity of 2 volts, a.c. In other words, approximately 2 volts, a.c., applied to the grid of the tube will give full-scale deflection of the microammeter.

Unless the tube characteristics should change suddenly, the meter, with the operating potentials selected, ought to go from 800 to 1000 before an appreciable error would be noticeable. It is wise, however, to check the calibration at several points, say after every 40 or 50 hours of use. It will be noticed that the last switch contact is used to short out the voltage divider used across the tube input (grid to filament); in this way the bucking-out voltage, used to bring the plate-current meter reading to zero, can be checked without removing the a.c. that is being measured.

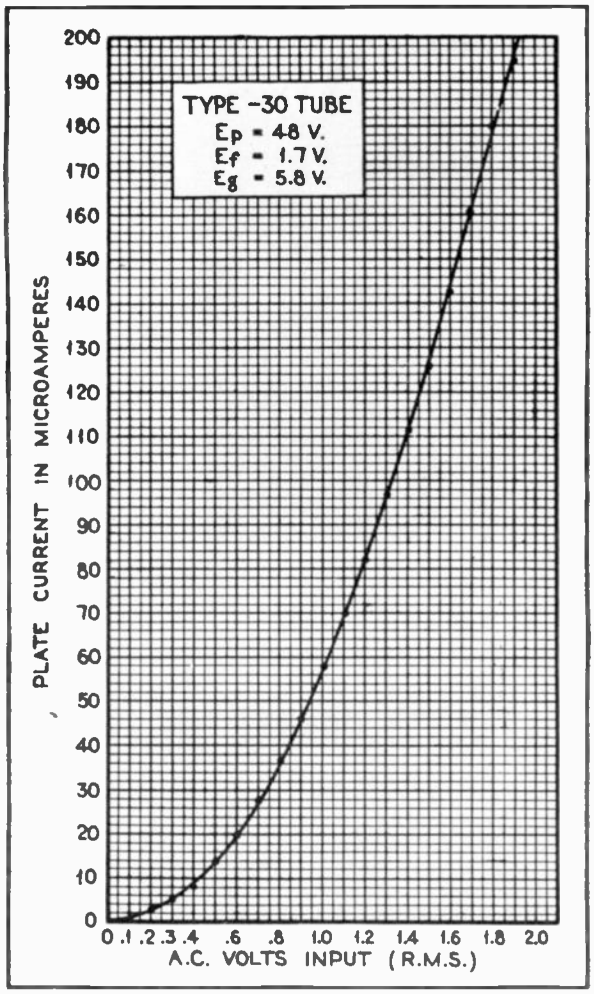


Figure 55

To place the instrument in operation, the plug is inserted in the customary 110-volt, 60-cycle a.c. socket and the rectifier circuit is then energized. The 400-ohm rheostat should then be adjusted until the voltmeter, which is across the filament of the type -30 tube reads 1.7 volts; this reading should be maintained at all times and should be adjusted if necessary when the vacuum-tube voltmeter is in use. With 1.7 volts potential on the filament, the 0-200 microampere meter in the plate circuit should register between 20 and 50 microamperes, if there is no bucking current flowing. This residual plate current can be done away with by adjusting the 400-ohm potentiometer until the microammeter shows zero. When this adjustment is made, the 0-3 voltmeter should be set at 1.7 volts.

With these adjustments made, the a.c. voltage to be measured can be applied to the input binding posts, with the high-potential side attached to the positive end of the input voltage-divider circuit. It is good judgment, when measuring an unknown voltage, to have the switch arm on the contact which is connected to lower end of R5 and the upper end of R6; this gives a multiplying of 100. If the applied voltage is insufficient to give any or suitable deflection of the microammeter, the switch arm should be moved to one of the other contacts until the desired amount of deflection is obtained. The value of voltage measured can then be taken from the calibration curve, remembering to multiply by the proper factor.

Figure 56

	VALUE IN OHMS	MULTIPLYING FACTOR
R TOTAL	1,000,000	1
R1	500,000	2
R2	300,000	5
R3	100,000	10
R4	80,000	50
R5	10,000	100
R6	10,000	-

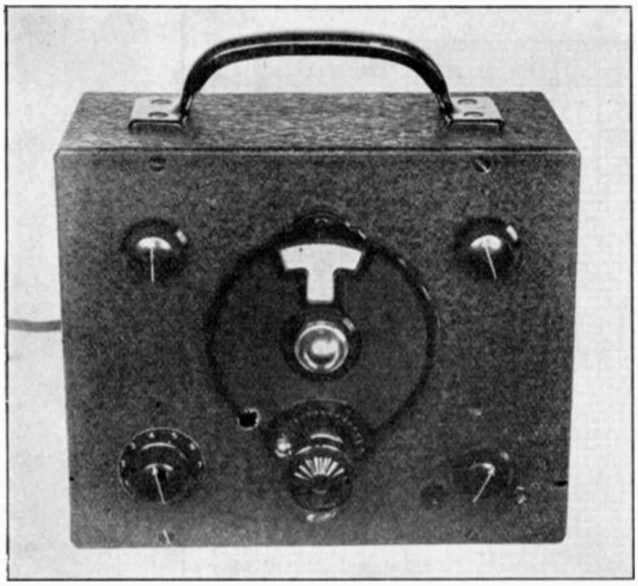


Figure 58

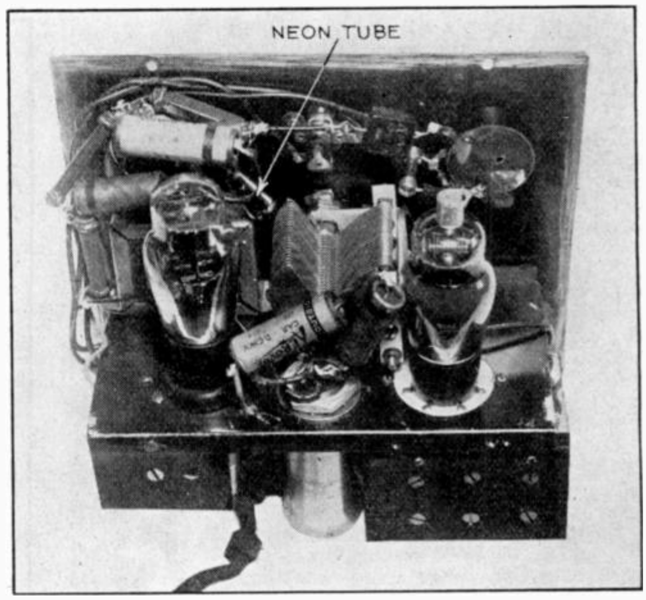


Figure 59

A 100-22,000 Kc. Signal Generator

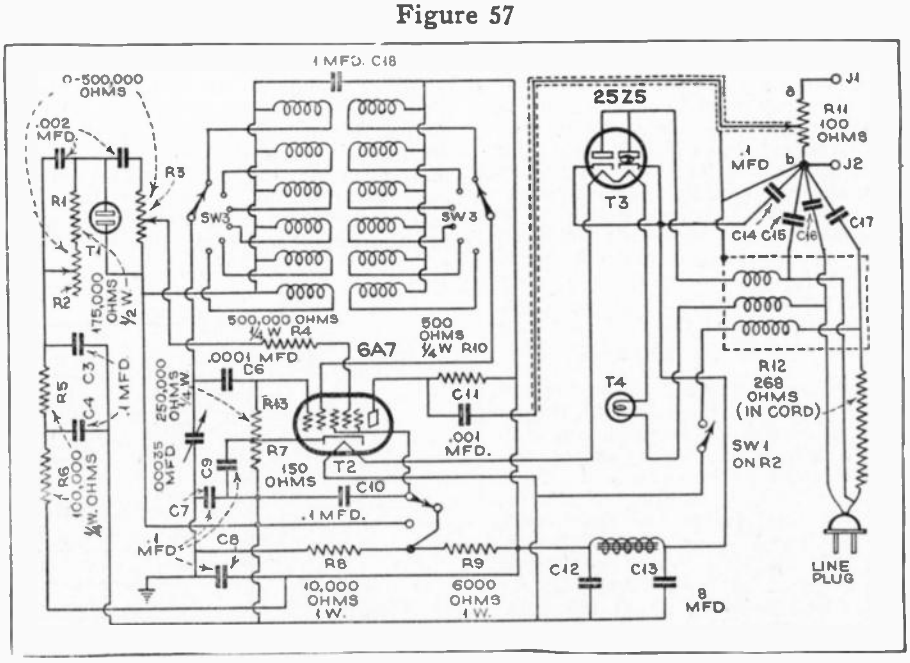
UNTIL recently, the majority of good signal generators designed for radio service work have been battery-operated. Such instruments must of necessity use fragile, filament-type tubes and require frequent battery replacement to hold calibration. As a result, there has been an insistent demand for a good line-operated device of this type, sufficiently rugged in design to withstand the hard usage to which a service instrument is subjected, yet capable of maintaining calibration over the extreme ranges of line voltage variation likely to be encountered.

The popularity of the all-wave receiver, with low image-frequency selectivity on the short-wave bands, makes it necessary that the instrument cover all bands on fundamental frequencies. Increased efficiency of modern a.v.c. circuits requires a high degree of attenuation control of the signal generator output. Some methods of aligning sets require an unmodulated signal which is likewise valuable for many tests of component parts.

In the apparatus shown in Figures 58, 59 and 60, an electron-coupled, high-C circuit of extraordinary stability maintains calibration exact to within 1/20 of 1 percent on either a.c. or d.c. over a line voltage variation of more than 20 volts. The percentage modulation may be varied from 0 to approximately 100 percent. The modulation frequency may also be varied over a portion of the audio range and, if desired, an external beat-frequency oscillator may be used for modulation in testing high-fidelity receivers. The attenuator, usually the weak spot of a.c.-d.c. signal generators, is an original design which, while simple and inexpensive, provides exceptionally effective attenuation at even the highest frequencies. The range of the instrument extends from below 100 kc. to above 22,000 kc. with adequate overlap between bands. A pilot light provides brilliant illumination of the dial calibrations, reducing eye-strain and giving an instant indication of filament, circuit continuity. The vernier dial operates without backlash and is provided with a convenient means of regulating the vernier ratio. The metal case, manufactured especially for this instrument is finished in durable crackle enamel. All joints are welded, providing a highly effective shield. The metal handle is manifestly an improvement over the usual leather strap. The case, exclusive of the handle, measures but 8¾ by 7 by 4 inches, making the instrument probably the most compact of equivalent performance, offered to date for experimenters.

The circuit is shown in Figure 57. This may seem rather complicated at first glance, but is really simple. Let us consider the 6A7 as a composite of two tubes, a triode r.f. oscillator and a four-element a.f. amplifier, as employed in this circuit. These are shown in Figures 62A and 62B. The oscillator circuit will be at once recognized as the reliable tickler feed-back circuit, with G1, the grid nearest the cathode, acting as control grid, and G2, immediately adjacent, serving as anode grid, or plate. In Figure 62B the output voltage of the choke and condenser filter circuit of the 25Z5 is applied to the resistance-capacity filter composed of R6-C4 and R5-C3, which smooths out the residual hum of the half-wave rectifier, thence to the audio-frequency control circuit composed of R2, R1 and C1. Variation of R2 changes the voltage applied to the neon tube and also the time constant of the resistance-capacity circuit, thus varying the oscillation period of the neon tube. The

Figure 57



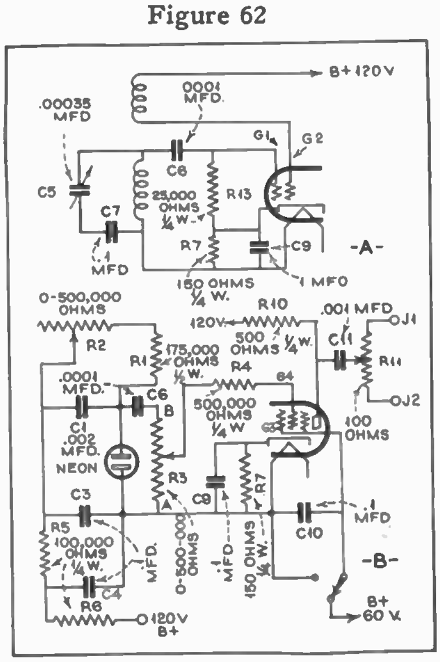
resulting a.f. voltage is applied across R3, d.c. being blocked from the grid by C6. With the slider at point A, no audio voltage is impressed on G4, and none appears in the plate circuit. With the slider at point B, the voltage applied to G4 is a maximum, limited by R4 and the input resistance of the tube. Combining electronically with the r.f. voltage developed in the circuit of 3A, variable modulation percentage is secured without loading the r.f. oscillator directly.

R4, in series with the control grid, G4, serves to counteract many undesirable effects in oscillation over the high-frequency bands and to facilitate operation with such a high tuning ratio, in the megacycle ranges. R4 also serves to minimize any slight frequency shift resulting from applying too high voltage to G4. If it is desired to go above 22 megacycles, G2, G3 and G5 may be paralleled, affording higher feed-back voltage with less tickler, and thereby enabling the tube to operate at higher frequencies. Since this would involve the construction of an additional coil and a different method of attenuation, this system was not used in this design.

The attenuator circuit is shown in Figure 61. The output of the 6A7 is fed through the condenser, C11, and the shielded lead to the moving arm of the 100-ohm potentiometer, R11. The shielding over the lead is insulated from the signal generator case. A single point r.f. ground is established at the output terminal, J2, likewise insulated from the case, to which the lead shielding and line filter shield are connected. The lead from point b of the potentiometer to J2 is very short, likewise all leads from the line filter by-pass condensers and C15. In any a.c.-d.c. signal generator we must set up a point of minimum r.f. potential, since the case cannot be directly grounded to the B– without danger. By using the system described above, the lowest attainable r.f. potential, with the amount of filtering used, is secured at point **b**. When this point is joined to the ground post of the receiver under test, an extraordinary degree of attenuation is secured.

For the extreme high frequency

Figure 62



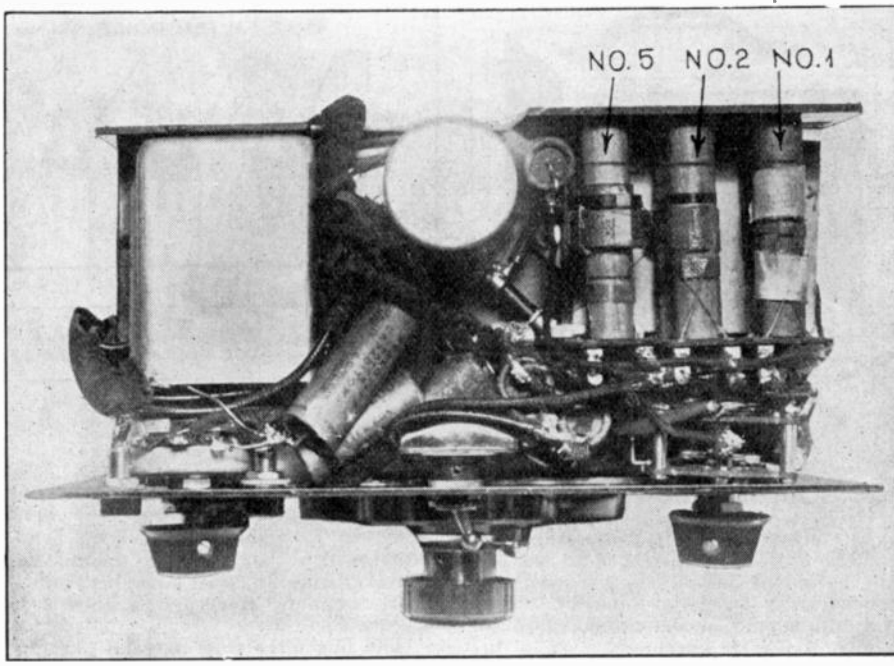


Figure 60

bands, complete attenuation was found difficult. Attempts to vary the cathode bias to decrease the r.f. voltage generally resulted in a frequency shift which could not be tolerated. The solution was found by switching the screen-grid to ground. This causes a considerable decrease in r.f. output and results in complete attenuation over the standard broadcast band, with negligible frequency shift, and very satisfactory, but not complete, attenuation at the highest frequencies, without additional filtering.

Attention is also called to the fact that the output circuit of this attenuator provides a reasonably constant load across the receiver input terminals. If the moving arm of the attenuator were connected to the high, or antenna, output terminal the load on the receiver input circuit would change over a very wide range at different settings of the attenuator. A receiver, therefore, with a very low impedance input circuit, but relatively insensitive, might conceivably test as more sensitive than a much better set. We do not wish to give the impression that this signal generator is suitable for laboratory measurements of sensitivity. Such tests require a non-inductive, hand-constructed design if a resistance type attenuator is used, and are unnecessary for service work and impractical for the serviceman to attempt without special equipment.

The band-switching arrangement is shown in Figure 63. An ordinary 2-deck, 6-point Yaxley switch may be used. Switch a represents the deck farthest removed from the panel. The oscillator coils are all wound on half-inch wooden dowels and are carefully designed to eliminate the usual "double hump" characteristic common to many signal generators designed for radio service work. The tuning condenser employed is one of National's 270 degree line. This has the advantage of spreading and making more accurate calibration and reading possible.

The line filter coils may be constructed without difficulty, being also wound on half-inch dowels. They are designed to be effective over the highest frequency band, since they are not required for the other bands.

Figure 61

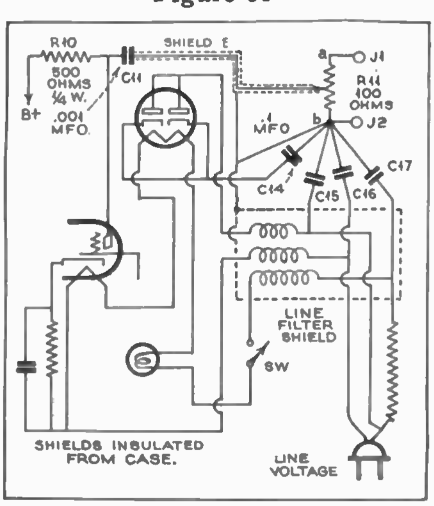
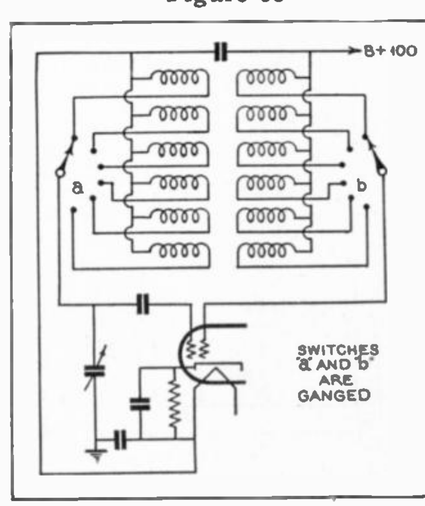


Figure 63



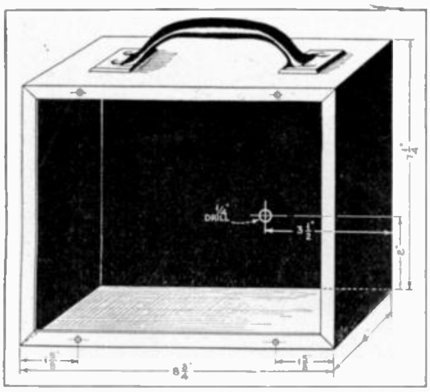


Figure 64

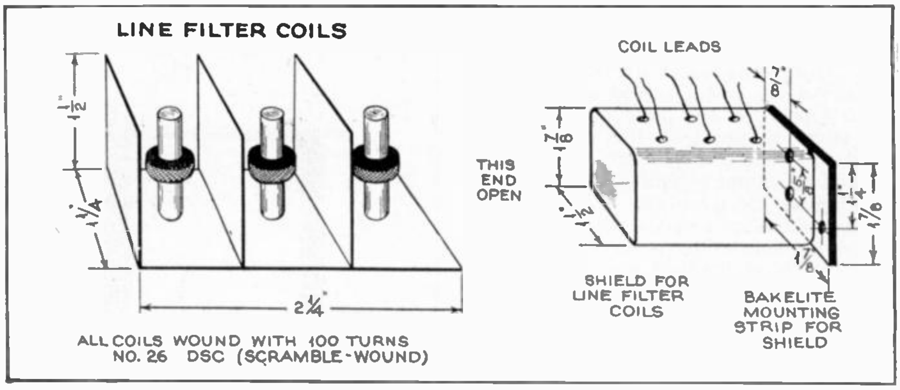


Figure 65

Construction Data

In spite of its compactness, the construction of the signal generator will not be found difficult if the assembly procedure is carefully followed. It is recommended that the cabinet and oscillator coils be purchased unless the constructor is equipped to do this type of work.

For those who wish to make the cabinet, specifications are given in Figures 64, 66 and 70. The flange of the cabinet and the portion of the back of the front panel making contact with the flange should be gone over with emery cloth to remove all traces of enamel and assure good electrical contact when the instrument is assembled.

The oscillator coils are wound in impregnated wooden dowels according to the specifications given in Figure 67. Coil number 1 must be carefully constructed if oscillation over the entire tuning range is to be achieved. The tickler winding must start as closely as possible to the secondary winding. After construction, the leads should be anchored in place with thin strips of fabric dipped in coil dope and the entire coil thoroughly impregnated with this same moisture-resistant dope. The coils should then be assembled on the mounting panel which is constructed according to the specifications of Figure 69. The individual coil assemblies have their terminals brought out to thin bakelite terminal panels for convenience in wiring. Flat head brass wood screws are used to fasten the dowel forms to the assembly panel. The complete assembly is shown in Figure 68.

The line filter coils may be conveniently constructed by following the specifications shown in Figure 65. The mounting for these coils consists of thin sheeet copper with partitions soldered to the mounting to shield the coils from each other. The can in which the filter coil assembly is installed may consist of a discarded shield from an i.f. transformer.

The oscillator coil assembly and the line filter apparatus should not be mounted on the sub-panel until the other parts have been assembled and wired in to the circuit. This method of assembly will leave plenty of room to work around in. After the panel and sub-panel wiring have been completed as far as possible, the oscillator coil assembly may be temporarily mounted in position and a few bus-bar leads, insulated with spaghetti tubing, soldered to the range switch. These leads will serve to support the gang switch which may now be removed from the panel and the wiring from the coil assemly to the switch terminals completed without difficulty. When this is done, the switch and coil assembly may be installed as a unit in the signal generator circuit.

The line filter assembly is handled in like manner. When the line filter is permanently installed care should be taken that its shield does not touch the signal generator shield. The line filter condensers should be installed last of all.

The output tip jacks are both carefu'y insulated from the panel. The lead from C11 to the moving arm of the attenuator is shielded and the shielding is insulated from the signal generator, which may be done by taping it or with a large diameter piece of insulating tubing. This shielding is connected to J2.

The variable condenser is mounted with the isolantite stator support perpendicular to the sub-panel to afford room for the pilot light assembly. The stator lead to Sw 3 should be as short as possible and passes to the switch through a hole in the sub-panel. The usual single-hole mounting is reinforced by drilling and tapping the rotor support so that a 6/32 screw may be passed through the front panel and a spacing bushing to the condenser frame and thereby relieve strain on the single-hole mounting, which otherwise might loosen causing the condenser to shift position and ruin the calibration.

The modulation frequency control is mounted at the right above the filter

Figure 66

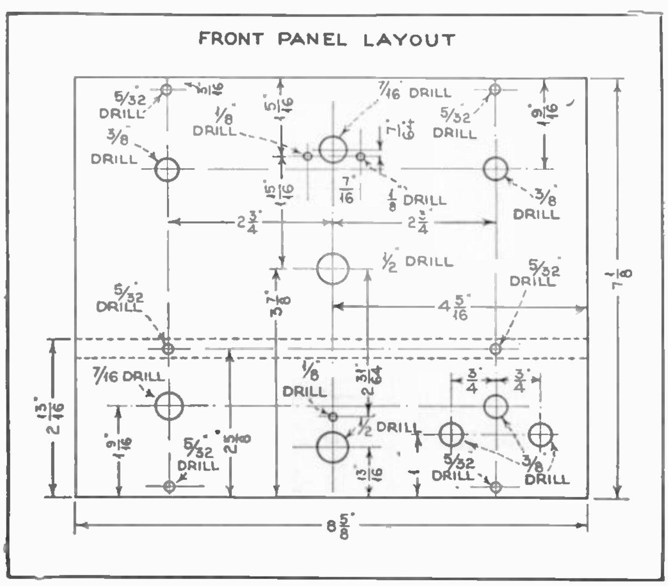
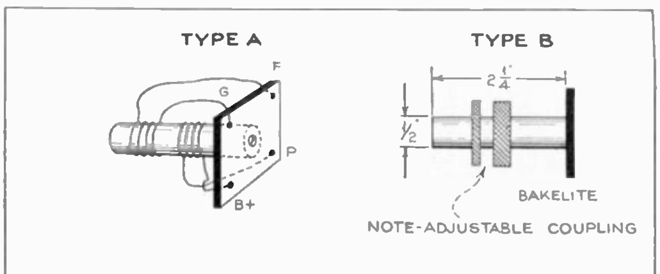


Figure 67



COIL NO.		1	2	3	4	5	6
PLATE	SIZE	36 ENAM	36 ENAM	36 ENAM	34 ENAM	34 ENAM.	NOTE A
	TURNS	12	18	45	75	150	NOTE A
GRID	SIZE	28 D.C.C.	28 D.C.C	30 ENAM	30 SSE	30 SSE	NOTE A
	TURNS	5	20	65	110	300	NOTE A
RANGE		22 TO 9 MC.	9.7 TO 2.9 MC.	3.5 TO 1.49 MC.	1580 KC TO 570 KC.	600 KC. TO 220 KC.	250 KC TO 100 KC
FORM OF WINDING		A	A	A	B	B	B
SPACE BETWEEN WINDINGS		LESS THAN 1/64"	1/32"	1/32"	1/8" TO 1/16"	3/16" TO 1/16"	

NOTE A - DATA ON MANUFACTURED COIL NOT AVAILABLE AT TIME OF WRITING; CAN BE MADE FROM 115 KC. I.F. TRANS COIL choke and the percentage modulation control in a corresponding position at the left. The associated condensers and resistors are wired in as closely as possible to these controls. The condenser leads from the variable condenser rotor should be kept as short as possible. C18 should be installed beneath the sub-panel, close to the oscillator coil assembly, likewise the voltage divider resistors, R8 and R9.

The neon tube employed as the modulator is a special miniature type. It is supplied without a base and is wired directly into the circuit by its pigtail leads. The positive lead is indicated by a red dot. The lamp is located beside the modulation frequency control potentiometer, R1.

This lamp should not be confused with the miniature neon lamps (known as the ¼ watt type) generally available. These standards lamps will not work satisfactorily as audio-frequency oscillators because they are not sufficiently stable in their frequency characteristics. Also the presence of a base on a lamp of this type introduces leakage, and it is for that reason that the special type specified here is supplied without a base.

Incidentally, these are the only miniature neon lamps available, to the writer's knowledge that are sufficiently stable for use in experimental electrical organs and other audio oscillator applications. These lamps, known as the type T-4½ may be obtained by individuals or dealers direct.

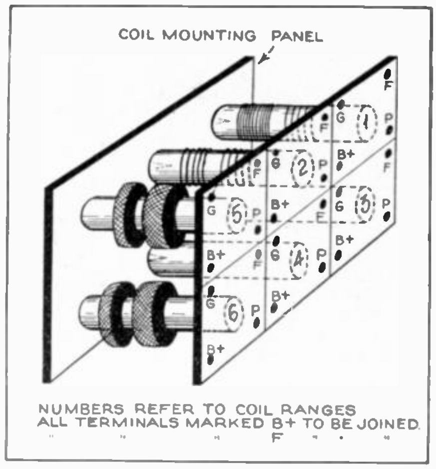
When the assembly and wiring have been completed, the oscillator coils may be conveniently checked for operation by connecting a 1 ma. meter in series with the grid-leak, R13. The reading secured will be proportional to the strength of oscillation. A less sensitive method is to connect a 5 ma. meter in series with the output plate circuit and note the change in plate current when the variable condenser stator is touched with a moistened finger. Since the change produced at the low frequency end of coil No. 1 is very small, this latter method, though more convenient is not quite as reliable. If oscillation is not secured on all coil bands, the connections to either grid or plate should be reversed. Do not reverse both windings. All coils must be wound in the same direction. Otherwise oscillation may be secured over a portion of the band only, or none at all. Coils must be assembled in the rotation shown in Figure 68 or absorption effects will be indicated by abrupt peaks in the curves. They should have an exceptionally uniform strength of oscillation except for the very high frequency ranges.

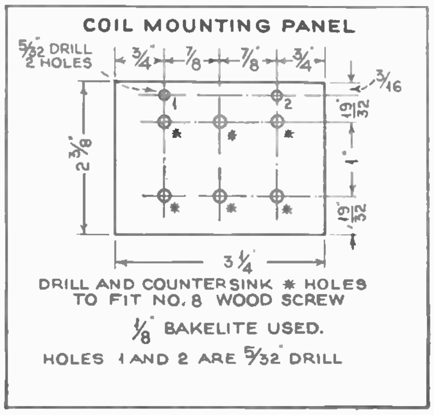
The instrument may be calibrated over the broadcast ranges by setting the modulation percentage control to zero and bringing the oscillator to zero beat with broadcast stations of known frequency. For the short-wave bands, harmonics of calibrations obtained on standard broadcast bands may be tuned in on an all-wave receiver and, with the receiver left at the point secured, the oscillator is adjusted to a higher range and the calibration point secured. The first harmonic is of course the fundamental, the second harmonic will be double the frequency of the fundamental, the third harmonic, three times the fundamental frequency, and so on. This job must be carefully done if the calibration is to be reliable. It is wise to spot in on the curves thus secured at the higher frequency range short-wave stations of known reliable frequency. The i.f. ranges can be calibrated only by harmonics in the broadcast band, but if several harmonics are noted for each low-frequency oscillation point the difference in frequency between the harmonics will be the fundamental frequency and may be obtained with a reasonable degree of accuracy.

For use in aligning receivers, a shielded lead, with the shield connected to J2, should be used. A dummy antenna which, for standard broadcast bands should consist of an inductance, capacity and resistance in series, should be connected to the antenna post of the set. For short-wave aligning, a 400-ohm resistor is used instead of the standard dummy antenna. While a portion of the attenuator resistance becomes a part of the dummy antenna circuit, effect is not of consequence in service work. When the receiver to be aligned is very insensitive, preliminary aligning may be done with an unshielded lead from J1 alone to the antenna post, which will cause a decided increase in the signal generator voltage at the receiver. If the receiver under test has a tuned trap circuit, adjusted to the i.f. frequency, in the antenna circuit, a .00025 condenser should be placed in series with J1 and the antenna post, since the line voltage by-pass condensers have to discharge to ground through the attenuator when the shielded lead is not used. This discharge current may be sufficient to damage the trap circuit unless the small blocking condenser is used. Aligning of the more modern sets should preferably be done using an unmodulated signal, in accordance with the manufacturer's recommendations as given in service manuals. If modulation is used, the modulation percentage control should be kept about one-third "on." The modulation frequency control may be adjusted to give the most agreeable note, which will vary with the line voltage. If a double peak is noted on the modulation note, which may occur with home-made, universal-wound, coils, it is indicative that critical coupling between the secondary and tickler coils has not been achieved. The tickler coils should be adjusted, by varying the coupling to the secondary coils, until only a single peak occurs. A double peak on the high-frequency coils, occurring with or without modulation, is due to poor image-frequency ratio and is normal with practically all present-day superheterodyne receivers on the ultra-high frequency bands. The proper point for aligning and calibration is the higher or highest frequency to which the receiver can be resonated.

Parts List

C1, C2—Aerovox mica condenser, type 1467, .002 mfd.
C3, C4, C7, C8, C9, C10, C14, C15, C16, C17, C18—Aerovox cartridge condensers, .1 mfd., 200 volts
C12, C13 (in one can)—Aerovox duel electrolytic condenser, 8-8 mfd., type GG2, 200 volts
C6—Aerovox mica condenser, type 1467, .0001 mfd.
C11—Aerovox mica condenser, type 1467, .001 mfd.
C5—National type SEH335 variable condenser, 270 degrees, 335 mmfd.
J1, J2—Na-Ald pin jacks, with insulating bushings
R1—Lynch fixed resistor, 100,000 ohms, ¼ watt
R2—Electrad type 203, taper F, volume control, with switch, 500,000 ohms
R3—Electrad type 203, taper F, volume control, 500,000 ohms





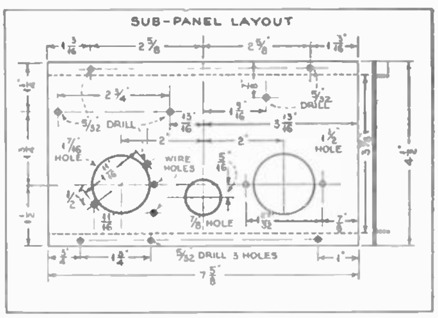


Fig. 68—Top; Fig. 69—Center
Fig. 70—Bottom

R4—Lynch fixed resistor, 500,000 ohms, ¼ watt
R5, R6—Lynch fixed resistor, 100,000 ohms, ¼ watt
R7—Lynch fixed resistor, 150 ohms, ¼ watt
R8—Lynch fixed resistor, 10,000 ohms, 1 watt
R9—Lynch fixed resistor, 6000 ohms, 1 watt
R10—Lynch fixed resistor, 500 ohms, ¼ watt
R11—Electrad type 272W, taper F, volume control, 100 ohms
R12—Ohmite power cord resistor, 268 ohms
R13—Lynch fixed resistor, 25,000 ohms, ¼ watt
SW1—(See R2)
SW2—Toggle switch, s.p.d.t.
SW3—Yaxley gang switch, 2, deck- 6-point
T1—General Electric special type T-4½ neon bulb
T2—6A7 tube
T3—25Z5 rectifier tube
T4—Pilot light, 3.2 volts, .3 amp.
1 National velvet vernier dial, type B, for 270-degree condenser, with pilot lamp bracket
1 National "Radio News Signal Generator" cabinet
National "Radio News Signal Generator" coils (set of 6)
1 line plug
1 rubber grommet, ½-inch
Miscellaneous screws, wire and spaghetti tubing
1 National small 7-prong isolantite tube socket
1 Eby 6-prong tube socket, base-mounting type
1 Kenyon miniature 30-henry choke
1 piece bakelite, 3¼ inches by 2⅜ inches, ⅛ inch thick (for coil mounting)
1 piece bakelite, 1⅞ inches by 2⅛ inches, ⅛ inch thick (for line filter mounting)
1 shielded output lead

Radio Trouble Shooting

THROUGH the courtesy of the National Radio Institute, Washington, D. C., the editors present herewith information which should prove extremely valuable to all servicemen and equally helpful to every radio man.

The first part is devoted to a list of common causes for receiver breakdown under which are noted probable reasons. The numbers in parenthesis after each item refer to paragraphs in the second part of this article.

Part Two of Radio Trouble Shooting covers service procedure for repairing common ailments in radio receivers, in addition to outlining various simple devices for testing purposes.

Part One

Symptoms of Defective Receivers

Tubes Do Not Light

Poor Tube and Socket Contact. (1)
Loose Connections. (2)
Tubes, Defective. (3)
Open or Short Circuits. (4 and 6)
Grounded Filament Circuit. (5)
Open Primary Power Transformer. (7)
Open Secondary of Power Transformer, Low Voltage. (7)
Open Lead in A.C. Plug Cord. (4)

Tubes Light But No Signal

Poor Connections or High Resistance Joints in Antenna or Ground. (8)
Short Circuited Lightning Arrester. Replace
Grounded Lead-in or Antenna. (9)
Short-circuited Antenna Coil. (10)
Short-circuited Tuning Condenser. (11)
Poor Tube and Socket Contact. (1)
No Plate Voltage on A.F., Detector or R.F. Tube. (12 and 13)
Open in Grid Circuit. (14)
Speaker Demagnetized or Coil Burned Out. (15 and 16)
Defective Speaker Cord. (17)
Loose Connections. (2)
Defective Rectifier Tube in Eliminator. (18, 19 and 20)
Tubes, Defective. (3)
Transformers, Defective. (7)
Incorrect Grid Voltage. (21)
Open Circuits. (4)
Choke Coils, Defective. (22)
Defective Filter Condensers. (23)
Open or Shorted By-Pass Condenser. (23)
Variable Condenser Shorted or Stator Grounded. (5 and 23)
Grid Condenser Shorted, Open or Grounded. (5 and 23)
Grid Leak Grounded. (5)
Plates of Rectifier Tube Red Hot. (24)
No Field Current in Loudspeaker. (16)
Defective Speaker. (25, 26, 27 and 28)

Weak Signals

Poor Connections or High Resistance Joints in Antenna or Ground. (8)
Line Voltage Low. (29)
Short-circuited Lightning Arrester. Replace
Tube in Wrong Socket. (30)
Aerial Too Short. (31)
Microphonic Tube. (32)
Grounded Lead-in or Antenna. (9)
Defective Filter Condenser in Power Supply. (33)
Receiver Not Neutralized. (34)
Condensers Not Matched. (35)
Excessive Oscillation. (36)
Poor Tube and Socket Contact. (1)
No Plate Voltage on R.F. Tube. (13)
Defective Grid Leak. (37)
Grid Leak of Improper Value. (38)
Leaky Fixed or By-pass Condenser. (39)
Speaker Demagnetized or Coil Open. (15)
Poor Ground Connection. (40)
Excessive Voltage on Detector Tube. (41)
Defective Speaker Cord. (17)
Defective Buffer Condenser. (42)
Loose Connections. (2 and 43)
Improper Voltage on Power Tube. (44)
Defective Rectifier Tube. (45)
Tubes, Defective. (3)
Incorrect Voltages. (46)
Open in Ground System. (47)
Open Circuits. (4)
Variable Condensers. (48 and 49)
Volume Control, Defective. (50)
Grounded Circuits. (5)
Choke Coils, Defective. (22)
Open Bias Resistance. (4)
Open Secondary R.F. Transformer. (7)
Shorted Primary Transformer. (7)
Shorted Secondary Power Trans. (7)
Audio Transformer Defective. (7)
Open Grid Circuit. (4)
Open Antenna Choke. (22)
Open or Shorted By-pass Condenser. (23)
Variable Condenser Shorted or Stator Grounded. (5 and 23)
Speaker Field Circuit Open or Shorted. (4)
Speaker Voice Coil Grounded. (5)
Control Grid Clips Loose or Grounded. (51)
Defective Rectifier Loudspeaker Unit. (52)
Open in Grid Circuit. (14)

Distorted or Muffled Signals

Tube in Wrong Socket. (30)
Excessive Power Supply Voltage. (53)
Receiver Not Neutralized. (34)
Defective Grid Leak. (37)
Grid Leak of Improper Value. (38)
Speaker Demagnetized, Coil Open. (15, 16)
Excessive Voltage on Detector Tube. (41)
Excessive Filament Voltage. (54)
Improper Voltage on Power Tube. (44)
Defective Rectifier Tube. (45)
Grid Resistance Shorted. (56)
Tubes Defective. (3)
Incorrect Voltages. (46)
Incorrect Grid Voltage. (21)
Too Great Signal Strength. (57)
Volume Control, Defective. (50)
Open Bias Resistance. (4)

Open Grid Circuit. (4)
Grounded or Open Resistor. (5)
Open. Shorted By-pass Condenser. (23)
Grounded, Open Biasing Resist. (5, 56)
Half of Push-Pull Transformer Secondary Open, Shorted, Grounded. (5, 7)
Speaker Voice Coil Grounded. (5)
Defective A.F. Transformer. (58)
Defective Loudspeaker Rectifier Unit. (52)
High Resistance Across Secondary of Audio Frequency Transformer. (59)
Motorboating. (60)
Thermostatic and Other Make-and-Break Connections. (61)
High Resistance Connections. (43)
Speaker Voice Coil Off Center. (62)
Defective Speaker. (25 to 28, 63 to 66)
Electrolytic Defect. Condenser. (67, 68)
Push-Pull Tubes Not Matched. (69)

Poor Distance Reception

Aerial Wire Loose or Swaying. (70)
Aerial Close to High Voltage Wire. (71)
Poor Connections or High Resistance Joints in Antenna or Ground. (8)
Short-circuited Lightning Arrester. Replace with new one.
Tube in Wrong Socket. (30)
Aerial Too Long. (72)
Aerial Too Short. (31)
Grounded Lead-in or Antenna. (9)
Excessive Power Supply Voltage. (53)
Short-circuited Antenna Coil. (10)
Short-circuited Tuning Condenser. (11)
Receiver Not Neutralized. (34)
Condensers Not Matched. (35)
Poor Tube and Socket Contact. (1)
Open in Grid Circuit. (14)
Poor Ground Connection. (40)
Excessive Voltage on Detector Tube. (41)
Loose Connections. (2, 4, 43, 61)
Defective Rectifier Tube. (45)
Tubes, Defective. (3)
Incorrect Voltages. (46)
Open in Ground System. (47)
Variable Condensers. (48 and 49)
Volume Control, Defective. (50)
Open Secondary R.F. Transformer. (7)
Audio Transformer Defective. (7)
Open Grid Circuit. (4)
Open Antenna Choke. (22)
Defective R.F. Tube. (3)
Variable Condenser Shorted or Stator Grounded. (5, 23 and 49)
Control Grid Clips Loose, Grounded. (51)
Outside interferencee. (74)

Howls and Oscillations

Poor Connections or High Resistance Joints in Antenna or Ground. (8)
Tube in Wrong Socket. (30)
Aerial Too Short. (31)
Microphronic Tube. (32)
Excessive Power Supply Voltage. (53)
Receiver Not Neutralized. (34)
Excessive Oscillation. (36)
No Plate Voltage on R.F. Tube. (13)
Grid Leak of Improper Value. (38)
Inductive Coupling Between Circuits. (75)
Howling as Tubes Heat Up. (76)
Filament Not Grounded. (77)
Grid Leads Too Long. (78)
Poor Ground Connection. (40)
Excessive Voltage on Detector Tube. (41)
Excessive Filament Voltage. (54)
Improper Voltage on Power Tube. (44)
Speaker Too Close to Receiver. (79)
Motorboating. (60)
Tubes, Defective. (3)
Incorrect Voltages. (46)
Grid Suppressor Shorted. (56)
Excessive R.F. Voltage. (46)
Open Secondary R.F. Transformer. (7)
R.F. By-Pass Poorly Grounded. (5)
Open or Shorted By-Pass Condenser. (23)
Shorted R.F. Choke Coil. (22)
Defective R.F. Tube. (3)
Inductive Effect From Aerial. (80)
Thermostatic and Other Make-and-Break Connections. (61)
High Resistance Connections. (5, 43)
Speaker Cord Close to Tubes. (32, 79)

Fading Signals

Aerial Wire Loose or Swaying. (70)
Poor Connections or High Resistance Joints in Antenna or Ground. (8)
Poor Tube and Socket Contact. (1)
Fading Signals. (Natural.) (81)
Defective Rectifier Tube. (45)
Resistances, Defective. (56)
Tubes, Defective. (3)
Volume Control, Defective. (50)
Variations in Electric Line Voltage. (82)
Defective Rectifier Loudspeaker Unit. (52)
Thermostatic and Other Make-and-Break Connections. (61)

Hum

Aerial Close to High Voltage Wire. (71)
Conductive Coupling Between Circuit. (75)
Microphonic Tube. (32)
Short-circuited Tuning Condenser. (11)
Defective Filter Condenser in Power Supply. (33)
Open in Grid Circuit. (14)
Speaker Too Close to Receiver. (79)
Defective Rectifier Tube. (45)
Tubes Defective. (3)
Incorrect Voltages. (46)
Open in Ground System. (47)
Tubes in Push-Pull Transformer. (69)
Loose Connections. (2, 4, 43, 61)
Volume Control, Defective. (50)
Power Transformer Center Tap Incorrect. (83)
Lack of Ground on Core, Chassis. (84)
Loose Lamination in Power Pack or Audio Transformers. (85)
Hum in Dynamic Speakers. (86)
Resonant Effect in Room. (87)
Sensitive Detector Tube. (88)
Variations in Electric Light Current. (82)
Resonant Effect in Cabinets. (89)
R.F. Tube Oscillating. (90)
Induction From Nearby A.C. Lines. (91)
Open Secondary R.F. Transformer. (7)
Improperly Grounded Filament Circuits. (5)
Open Filament Mid-Tap Resistors. (56)
Defective Filter Condensers. (23)
Shorted Filter Choke. (22)
Open Grid Circuit. (4)
Grounded A.F. Transformer. (5)
Open Antenna Choke. (22)
Ground Binding Post Not Making Good Contact with Chassis Frame. (47)
Grounded or Open Choke Coil. (5)
Grounded or Open Plate Circuit. (5)
Grounded or Open Resistor. (5)
Hum Adjuster Defective. (56)
Open or Shorted By-pass Condenser. (23)
Open Grid Bias Resistance By-pass Condenser. (92)
Lack of Grid Resistance By-pass Condenser. (92)
Open Grid Circuit Filter By-pass Condenser. (23)
Grid Bias Resistance By-pass Condenser Capacity Too Low. (92)
A.C. Plug Reversed. (93)
Pilot Lamp Grounded. (5)
Speaker Field Coil Defective. (5, 22)
Defective Loudspeaker Rectifier Unit. (52)
Defective Rectifier Condenser in Loudspeaker. (94)
Localizing Hum. (95)
Thermostatic and Other Make-and-Break Connections. (61)

Broad Tuning

Aerial Too Long. (72)
Receiver Not Neutralized. (34)
Condensers Not Matched. (35)
Poor Tube and Socket Contact. (1)
No Plate Voltage on R.F. Tube. (13)
Grid Leak of Improper Value. (38)
Filament Not Grounded (77)
Grid Leaks Too Long. (78)
Excessive Voltage on Detector -Tube. (41)
Excessive Filament Voltage. (54)
Loose Connections. (2 and 43)
Wave Trap Necessary. (96)
Defective (R.F.) Tubes. (3)
High Resistance in Grid Circuit. (97)
Open Bias Resistance. (4)
Open or Shorted By-pass Condenser. (23)
Partially Open Grid Circuit. (4)
Variable Condenser Partially Shorted, Stator Partially Grounded. (5, 23, 49)
Control Grid Clips Loose, Grounded. (51)

Noise

Crackling and Scratching

Aerial Wire Loose or Swaying. (70)
Aerial Rubbing or Close to High Voltage Wire. (71)
Poor Connections or High Resistance Joints in Antenna or Ground. (8)
Partially Grounded Lead-in or Antenna. (9)
Short-circuited Tuning Condenser. (11)
Defective Filter Condenser in Power Supply. (33)
Receiver Not Neutralized. (34)
Excessive Oscillation. (36)
Poor Tube and Socket Contact. (1)
Defective Grid Leak. (37)
Leaky Fixed or By-pass Condenser. (39)
Partial Open in Speaker. (15)
Poor High Resistance Leak Across Secondary of Audio Transformer. (59)
The Filament Should be Grounded. (77)
Poor Ground Connection. (40)
Defective Speaker Cord. (17)
Defective Buffer Condenser. (42)
Loose Connections. (2, 4, 43, 61)
Outside Interference. (74)
Motorboating. (60)
Defective Rectifier Tube. (45)
Resistances, Defective. (56)
Tubes, Defective. (3)
Transformers, Defective. (7)
Condenser, Defective. (23)
Variable Condensers. (48, 49, 98)
Volume Control, Defective. (50)
Grounded Circuits. (5)
A.C. Plug Elements Loose. (2)
Audio Transformer Defective. (7)

Condenser Plate Bent. (48)
Leaky Condensers. (23)
Defective Filter Condensers. (23)
Ground Binding Post Not Making Good Contact with Chassis Frame. (47)
Loose Shields or Improperly Grounded Shields. (47)
Open or Shorted By-pass Condenser. (23)
Noisy Resistors in Power Pack. (99)
Pilot Lamp Loose in Socket. Tighten.
Defective Audio Transformer. (58)
Thermostatic and Other Make-and Break Connections. (61)
Undesirable Contacts in Tuning Condensers. (49)
Control Grid Clips Loose, Grounded. (51)
Defective Speaker. (25 to 28, 63 to 66)
Defective Electrolytic Condenser. (67, 68)
Speaker Voice Coil Grounding. (5)

Noise
Hissing

Leaky Fixed or By-pass Condenser. (39)
Defective Rectifier Tube. (45)
Open or Shorted By-pass Condenser. (23)

Noise
Periodic

Aerial Wire Loose or Swaying. (70)
Poor Connections or High Resistance Joints in Antenna or Ground. (8)
Microphonic Tube. (32)
Grounded Lead-in or Antenna. (9)
Poor Tube and Socket Contact. (1)
Poor Ground Connection. (40)
Defective Speaker Cord. (17)
Loose Connections. (2, 4, 43, 61)
Outside Interference (Static). (74)
Thermostatic and Other Make-and-Break Connections. (61)

Oscillations
(Screen Grid Receivers Only)

Open Screen Grid By-pass Condenser. (23 and 92)
Open R.F. Plate By-pass Condenser. (23 and 100)
Open Grid Bias Condenser. (23)
Variable Condenser Not Grounded. (47)
Rotor Plates of Condenser Making Poor Contact. (43 and 98)
Poor Ground Connection. (8)
High Resistance Connection in Series with a By-pass Condenser. (2 and 43)
Chassis Base Plate Loosely Attached to Chassis. (47)
Tube Shields Not Secure and Not Grounded. (47)
High Line Voltage. (46)
Too High Screen Grid Voltage. (101)
Open Grid Circuit. (4)
Control Grid Clips Loose, Grounded. (51)
Inductive Effect from Aerial. (80)
Undesirable Contacts in Tuning Condensers. (49)

Line Fuse Blows

Defective Rectifier Tube. (45)
Defective Power Tube. (3)
A Power Line Wiring Ground to the Chassis. (5)
A Defective Power Transformer. (7)
Line Voltage D.C. Instead of A.C. (102)

No Signals
(Superheterodyne Receivers)

Incorrect Voltages on the Oscillator, Detector, Intermediate or Audio Frequency Tubes. (46)
Oscillator Tube Not Oscillating. (103)

Weak Signals
(Superheterodyne Receivers)

Incorrect Plate Voltage. (46)
Oscillator Tube Not Functioning Properly. (103)
Intermediate Frequency Transformers Not Properly Matched. (104)
Radio Frequency Compensating Condensers Out of Adjustment. (105)
Oscillator Tuning Condensers Out of Adjustment. (106)

Howling
(Superheterodyne Receivers)

Defective Volume Control. (50)
Poor Ground Connection. (8)
Intermediate Frequency Transformers Not Properly Matched. (104)
Incorrect Adjustment of Radio Frequency Compensating Condenser. (105)
Open Grid Circuit.. (4)
Open Loop Aerial. (4)
Open Detector Plate Circuit. (4)
High Resistance in Grid Circuit. (2, 43)
High Resistance Connection. (43)
Excessive Plate Voltage. (46)

Receiver Oscillates
(Superheterodyne Receivers)

Too High Plate Voltage on Intermediate Frequency Stage. (46)
By-pass Condenser Not Grounded. (43, 47)
Open By-pass Condenser. (4, 23)
Loop Aerial Lead Too Close to Intermediate Frequency Trans. (80)

Poor Distance Reception
(Superheterodyne Receivers)

Intermediate Frequency Transformers Improperly Adjusted. (104)
Loop Aerial Not Connected. (4)
Oscillator Not Functioning Properly. (103)
Radio Frequency Compensating Condensers Out of Adjustment. (105)
Oscillator Tuning Condenser Out of Adjustment. (106)

Broad Tuning
(Superheterodyne Receivers)

Intermediate Frequency Transformers Improperly Adjusted. (104)
Defective Tube. (3)
Oscillator Not Working Properly. 103)

Common Causes of Incorrect Voltages and Currents

High Plate Potential

Insufficient load upon power pack due to weak tubes. (3)
Open high current load in receiver. (14, 56)
Short circuited voltage reducing resistance. (56)
High line voltage. (46)
High grid bias voltage. (21)
Incorrect power pack divider tap. (46)
Open bleeder resistance between circuits. (14 and 56)
Open bleeder resistance in divider. (4)
Shorted filter choke in power pack. (22)

High Plate Voltage On All Tubes
(Output Tube Plate Current Low)

Excessive grid bias resistor (output stage). (21)
Defective output tube or tubes. (3)

Low Plate Potential

Excessive current drain upon power supply. (3 and 5)
Open or leaky filter condenser. (33)
Insufficient grid bias. (46)
Shorted bleeder resistance. (56)
Low line voltage. (46)
Defective operation of line ballast. Replace with a new one.
Leak thru by-pass condenser. (23)
Shorted or defective section of voltage divider. (56)
Defect in power transformer. (7)
Defective rectifier. (45)
Defective filter choke. (22)

Low Plate Voltage On All Tubes
(High Plate Current in Rectifier)

Defective filter condenser. (33)
Short in voltage divider system. (56)
High resistance short in output tube plate circuit. (5)
Resistance short in eliminator filter chokes. (22)
Gassy tube in output system. (3)

Low Plate Voltage
(High Plate Current in Output Tube)

Shorted or grounded grid bias resistor. (5 and 56)
Shorted or grounded grid bias resistor bypass condenser. (5 and 92)
Ground connection to input push-pull secondary winding open. (7, 47)
Open grid bias resistance. (56)
Open grid circuit. (14)
Gassy output tube or tubes. (3)

No Plate Voltage On All Tubes

Shorted power transf. winding. (7)
Shorted filted condenser (23)
Defective rectifier tube. (45)
Open filter choke. (22)
Open in —B circuit. (14)
Ground in output tube plate circuit. (5)

No Plate Voltage Upon One Tube and Reduced Plate Voltage Upon Other Tubes

Open R.F. choke in plate circuit which does not secure plate voltage. (14, 22)
Shorted bypass condenser. (23)
Grounded plate circuit. (5)

Shorted voltage divider bleeder section if it is the detector tube. (56)
Grounded plate coupling unit in plate circuit. (5)
Shorted plate element in tube. (3)

No Plate Voltage On Output Tubes
(Plate Voltage Available on Other Tubes)

Open in plate circuit. (14)
Open in output unit. (14)
Open in —B connection to grid bias resistance. (14)
Open in grid bias resistor. (84)

Excessive Plate Current

Gaseous tube. (3)
Insufficient grid bias. (21, 46)
Excessive plate voltage. (3, 21)
Excessive positive bias upon screen grid. (46 and 56)
Open grid circuit. (14)

No Plate Current

Open plate circuit. (14)
No plate voltage. (See above.)
Open filament circuit, cathode circuit. (14)
Defective tube. (3)
Very high negative bias. (21, 46)

Insufficient Plate Current
(Normal or High Plate Voltages)

Defective tube. (3)
Low filament voltage. (See above.)
High grid bias. (See next par.)
Low screen grid voltage. (14, 56)

High Grid Bias

High plate current. (See "Excessive Plate Current.")
High value of bias resistance. Use correct value.
Defective bias resistance. (56)

Low Grid Bias

Low plate current. (See "Low Plate Voltage.")
Shorted bias resistance or bypass condenser. (23 and 56)
Defective resistance or incorrect value. (56)

No Grid Bias
(High Plate Current)

Shorted grid bypass condenser. (23)
Grounded cathode. (5)
Grounded filament. (5)
Open grid circuit. (14)

Low or No Screen Voltage

Open variable control for screen grid voltage. (14 and 56)
Open screen grid circuit. (14)
Open resistance in screen grid circuit. (14 and 56)

No Screen Voltage Upon One Tube
(Low Plate Voltage Upon Other Tubes)

Grounded variable control. (5)
Shorted screen grid bypass cond. (23)
Grounded bypass condenser in screen grid circuit. (5 and 23)
Short in voltage divider across bleeder or screen grid control resistance. (56)
Shorted screen grid in tube. (3)

Excessive Filament or Heater Potential

Incorrect adjustment of voltage reducing resistance. (46)
High line voltage to power pack. (46)
Insufficient load upon filament or heater winding; open filament circuit, or defective tubes. (3 and 14)
Wrong tube. Use correct tube.
Short circuit in power transformer primary. (46)

Insufficient Filament Or Heater Voltage

Too great load on heater or filament winding.
Low line voltage. (46)
Wrong tube in socket causing excessive current drain.
Incorrect line voltage reducing resistance. (46)
Defective operation of ballast. Replace.
Short circuit in transformer. (7)
Short circuit in filament circuit. (14)

Part Two

Service Procedure

1. **POOR CONTACT BETWEEN TUBE AND SOCKET.** Intermittent reception frequently is the result of loose contacts or faulty joints. Keep prongs of all tubes clean, bright and well polished with fine emery cloth, also the springs in the tube sockets. The springs should make firm contact with the prongs of the tubes. If necessary to adjust the springs, use a small stick of wood. **Never use a metal object while the power is connected to the set, or in the case of battery sets, without disconnecting the B negative power lead.**

2. **LOOSE CONNECTIONS.** Loose or improperly soldered connections can usually be located by touching the various joints in the receiver with a wooden stick. An orange wood stick can be used which is very durable and can be bought at drug stores. Press firmly on each joint. Very often joints that appear to be well soldered are held only by resin. If the receiver is properly connected for operation, the pressure on a suspected joint will usually produce a clicking sound in the loudspeaker. Another frequent cause of trouble is broken wiring under the insulation of flexible wire. Manipulation of the wire from side to side will usually indicate where the trouble occurs.

Trouble shooting for intermittent reception is the hardest job and must be done progressively from one end of the receiver to the other. Random tests may find the fault but results are not so certain. Also see pars. 43 and 61.

3. **TUBES, DEFECTIVE.** All tubes should be tested in a tube tester and defective tubes replaced. Any dealer in tubes will test them free of charge. Tubes that give poor results in the R. F. sockets will sometimes give good results as audio amplifiers. Occasionally a "soft" tube, that is, one that oscillates easily when used in a R. F. amplifier, will cause the amplifier to oscillate. In this case the tube should be replaced or possibly used in another socket. An extremely sensitive detector tube will cause an A. C. hum if the receiver is extremely critical.

Sometimes a tube that tests perfect will not work satisfactorily in any socket. Try new tubes that are known to be in good condition.

Important: In changing tubes in a receiver, always be sure that the correct tube is placed in the correct socket. That is, never place a *226* type tube in a 171 type socket, or vice versa, as the tube will burn out. Also it is advisable to turn the power off when changing tubes because removing two or three tubes will result in increased filament voltage overloading the tubes remaining in the circuit and may thus shorten their lives or change their characteristics.

In some cases this may cause the filter condenser to burn out due to the removal of the plate load. Also see paragraph 55.

4. **OPEN CIRCUITS.** Test all circuits for continuity, using voltmeter and battery method. If possible check with schematic diagram of receiver or power unit.

5. **GROUNDED CIRCUITS.** All receivers using a metal chassis generally have the chassis grounded. For this reason, a careful inspection should be made to see that no piece of apparatus or bare wire is touching the chassis that is not supposed to be connected to the chassis. This can be determined by comparing all connections with the schematic diagram and making continuity test.

6. **TUBES DO NOT LIGHT.** Trace circuit diagram and locate broken wire or open circuit. If the circuit seems to be correct, examine the switch and rheostat and see that they are making proper contact.

7. **TRANSFORMERS, DEFECTIVE.** A voltmeter and "B" battery should be used for testing the continu-

Tube Charact

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS MAXIMUM OVERALL LENGTH x DIAMETER	CATHODE TYPE ■	RATING: FILAMENT OR HEATER VOLTS	FILAMENT OR HEATER AMPERES	PLATE MAX. VOLTS	SCREEN MAX. VOLTS	USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID VOLTS ■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
1A6	PENTAGRID CONVERTER ●	SMALL 6-PIN	FIG. 20	4 11/32" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	67.5	CONVERTER	180	− 3.0 min.	67.5	2.4	1.3	500000	Anode-Grid (#2) 135 max. volts, 2.3 ma. Oscillator Grid (#1) Resistor, 50000 ohms. Conversion conductance, 300 micromhos.				1A6
1C6	PENTAGRID CONVERTER ●	SMALL 6-PIN	FIG. 20	4 11/32" x 1 9/16"	D-C FILAMENT	2.0	0.12	180	67.5	CONVERTER	180	− 3.0 min.	67.5	2.0	1.5	750000	Anode Grid (#2) 135 max. volts, 3.3 ma. Oscillator Grid (#1) Resistor, 50000 ohms. Conversion conductance, 325 micromhos.				1C6
2A3	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	5 5/8" x 2 1/16"	FILAMENT	2.5	2.5	250	—	CLASS A AMPLIFIER	250	−45	—	—	60.0	800	5250	4.2	2500	3.5	2A3
								300	—	PUSH-PULL AMPLIFIER	300 300	−62 −67	Self bias Fixed bias		40.0 40.0	Power Output is for 2 tubes at stated load, plate-to-plate			5000 3000	10.0 15.0	
2A5	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	4 11/16" x 1 13/16"	HEATER	2.5	1.75	250	250	CLASS A AMPLIFIER	250	−16.5	250	6.5	34.0	100000	2200	220	7000	3.0	2A5
2A6	DUPLEX-DIODE HIGH-MU TRIODE	SMALL 6-PIN	FIG. 13	4 11/32" x 1 9/16"	HEATER	2.5	0.8	250	—	TRIODE UNIT AS CLASS A AMPLIFIER	250 ✖	− 1.35	—	—	0.4	—	—	Gain per stage = 50-60			2A6
2A7	PENTAGRID CONVERTER ●	SMALL 7-PIN	FIG. 20	4 11/32" x 1 9/16"	HEATER	2.5	0.8	250	100	CONVERTER	250	− 3.0 min.	200	2.2	3.5	360000	Anode Grid (#2) 200 max. volts, 4.0 ma. Oscillator Grid (#1) Resistor, 50000 ohms. Conversion conductance, 520 micromhos.				2A7
2B7	DUPLEX-DIODE PENTODE	SMALL 7-PIN	FIG. 21	4 11/32" x 1 9/16"	HEATER	2.5	0.8	250	125	PENTODE UNIT AS R-F AMPLIFIER	100 250	− 3.0 − 3.0	100 125	1.7 2.3	5.8 9.0	300000 650000	950 1125	285 730	—	—	2B7
										PENTODE UNIT AS A-F AMPLIFIER	250┼	− 4.5	50	—	0.65	—	—	—	—	—	
6A4 also LA	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 6	4 11/16" x 1 13/16"	FILAMENT	6.3	0.3	180	180	CLASS A AMPLIFIER	100 180	− 6.5 −12.0	100 180	1.6 3.9	9.0 22.0	83250 45500	1200 2200	100 100	11000 8000	0.31 1.40	6A4 also LA
6A7	PENTAGRID CONVERTER ●	SMALL 7-PIN	FIG. 20	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	100	CONVERTER	250	− 3.0 min.	100	2.2	3.5	360000	Anode Grid (#2) 200 max. volts, 4.0 ma. Oscillator Grid (#1) Resistor, 50000 ohms. Conversion conductance, 520 micromhos.				6A7
6B7	DUPLEX-DIODE PENTODE	SMALL 7-PIN	FIG. 21	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	125	PENTODE UNIT AS R-F AMPLIFIER	100 250	− 3.0 − 3.0	100 125	1.7 2.3	5.8 9.0	300000 650000	950 1125	285 730	—	—	6B7
										PENTODE UNIT AS A-F AMPLIFIER	250┼	− 4.5	50	—	0.65	—	—	—	—	—	
6C6	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	FIG. 11	4 11/16" x 1 9/16"	HEATER	6.3	0.3	250	100	SCREEN GRID R-F AMPLIFIER	250	− 3.0	100	0.5	2.0	exceeds 1.5 meg.	1225	exceeds 1500	—	—	6C6
										BIAS DETECTOR	250	−1.95	50	Cathode current 0.65 ma.		—	Plate coupling resistor 250000 ohms. Grid coupling resistor 250000 ohms.**				
6D6	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	FIG. 11	4 11/16" x 1 9/16"	HEATER	6.3	0.3	250	100	SCREEN GRID R-F AMPLIFIER	250	− 3.0 min.	100	2.0	8.2	800000	1600	1280	—	—	6D6
										MIXER IN SUPERHETERODYNE	250	−10.0	100	—	—		Oscillator peak volts = 7.0.				

● Grids #3 and #5 are screen. Grid #4 is signal-input control-grid.

┼ Applied through plate coupling resistor of 200000 ohms. **For grid of following tube.
✖ Applied through plate coupling resistor of 250000 ohms.

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS	CATHODE TYPE	FIL. VOLTS	FIL. AMPERES	PLATE MAX. VOLTS	SCREEN MAX. VOLTS	USE	PLATE SUPPLY VOLTS	GRID VOLTS	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICROMHOS	AMPLIFICATION FACTOR	LOAD OHMS	POWER OUTPUT WATTS	TYPE
6F7	TRIODE-PENTODE	SMALL 7-PIN	FIG. 27	4 11/32" x 1 9/16"	HEATER	6.3	0.3	100	—	TRIODE UNIT AS AMPLIFIER	100	− 3.0	—	—	3.5	17800	450	8	—	—	6F7
								250	100	PENTODE UNIT AS AMPLIFIER	250	− 3.0 min.	100	1.5	6.5	850000	1100	900	—	—	
								250	100	PENTODE UNIT AS MIXER	250	−10.0	100	0.6	2.8	Oscillator peak volts = 7.0. Conversion conductance = 300 micromhos.					
'00-A	DETECTOR TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	45	—	GRID LEAK DETECTOR	45	Grid Return to (−) Filament			1.5	30000	666	20	—	—	'00-A
01-A	DETECTOR★ AMPLIFIER	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	D-C FILAMENT	5.0	0.25	135	—	CLASS A AMPLIFIER	90 135	− 4.5 − 9.0	—	—	2.5 3.0	11000 10000	725 800	8.0 8.0	—	—	01-A
10	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	5 5/8" x 2 3/16"	FILAMENT	7.5	1.25	425	—	CLASS A AMPLIFIER	350 425	−31.0 −39.0	—	—	16.0 18.0	5150 5000	1550 1600	8.0 8.0	11000 10200	0.9 1.6	10
11 12	DETECTOR★ AMPLIFIER TRIODE	WD 4-PIN MEDIUM 4-PIN	FIG. 12 FIG. 1	4" x 1 3/16" 4 11/16" x 1 3/16"	D-C FILAMENT	1.1	0.25	135	—	CLASS A AMPLIFIER	90 135	− 4.5 −10.5	—	—	2.5 3.0	15500 15000	425 440	6.6 6.6	—	—	11 12
19	TWIN-TRIODE AMPLIFIER	SMALL 6-PIN	FIG. 25	4 1/2" x 1 9/16"	D-C FILAMENT	2.0	0.26	135	—	CLASS B AMPLIFIER	135 135	0 − 3.0	—	—	Power output value is for one tube at stated load, plate-to-plate.				10000 10000	2.1 1.9	19
'20	POWER AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4 1/8" x 1 3/16"	D-C FILAMENT	3.3	0.132	135	—	CLASS A AMPLIFIER	90 135	−16.5 −22.5	—	—	3.0 6.5	8000 6300	415 525	3.3 3.3	9600 6500	0.045 0.110	'20
22	R-F AMPLIFIER TETRODE	MEDIUM 4-PIN	FIG. 4	5 11/32" x 1 13/16"	D-C FILAMENT	3.3	0.132	135	67.5	SCREEN GRID R-F AMPLIFIER	135 135	− 1.5 − 1.5	45 67.5	0.6* 1.3*	1.7 3.7	725000 325000	375 500	270 160	—	—	22
24-A	R-F AMPLIFIER TETRODE	MEDIUM 5-PIN	FIG. 8	5 11/32" x 1 13/16"	HEATER	2.5	1.75	275	90	SCREEN GRID R-F AMPLIFIER	180 250	− 3.0 − 3.0	90 90	1.7* 1.7*	4.0 4.0	400000 600000	1000 1050	400 630	—	—	24-A
										BIAS DETECTOR	250●	− 5.0 approx.	20 to 45	—	Plate current to be adjusted to 0.1 milliampere with no signal.						
26	AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16" x 1 13/16"	FILAMENT	1.5	1.05	180	—	CLASS A AMPLIFIER	90 180	− 7.0 −14.5	—	—	2.9 6.2	8900 7300	935 1150	8.3 8.3	—	—	26
27	DETECTOR★ AMPLIFIER TRIODE	MEDIUM 5-PIN	FIG. 8	4 1/4" x 2 1/16"	HEATER	2.5	1.75	275	—	CLASS A AMPLIFIER	135 250	− 9.0 −21.0	—	—	4.5 5.2	9000 9250	1000 975	9.0 9.0	—	—	27
										BIAS DETECTOR	250	−30.0 approx.	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						
30	DETECTOR★ AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4 1/8" x 1 9/16"	D-C FILAMENT	2.0	0.06	180	—	CLASS A AMPLIFIER	90 135 180	− 4.5 − 9.0 −13.5	—	—	2.5 3.0 3.1	11000 10300 10300	850 900 900	9.3 9.3 9.3	—	—	30

★For Grid leak Detection—plate volts 45, grid return to + filament or to cathode.

● Applied through plate coupling resistor of 250000 ohms or 500-henry choke shunted by 0.25 megohm resistor. *Maximum.

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS	CATHODE TYPE	FIL. VOLTS	FIL. AMPERES	PLATE MAX. VOLTS	SCREEN MAX. VOLTS	USE	PLATE SUPPLY VOLTS	GRID VOLTS	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICROMHOS	AMPLIFICATION FACTOR	LOAD OHMS	POWER OUTPUT WATTS	TYPE
31	POWER AMPLIFIER TRIODE	SMALL 4-PIN	FIG. 1	4 1/8" x 1 9/16"	D-C FILAMENT	2.0	0.13	180	—	CLASS A AMPLIFIER	135 180	−22.5 −30.0	—	—	8.0 12.3	4100 3600	925 1050	3.8 3.8	7000 5700	0.185 0.375	31
32	R-F AMPLIFIER TETRODE	MEDIUM 4-PIN	FIG. 4	5 11/32" x 1 13/16"	D-C FILAMENT	2.0	0.06	180	67.5	SCREEN GRID R-F AMPLIFIER	135 180	− 3.0 − 3.0	67.5 67.5	0.4* 0.4*	1.7 1.7	950000 1200000	640 650	610 780	—	—	32
										BIAS DETECTOR	180♥	− 6.0 approx.	67.5	—	Plate current to be adjusted to 0.2 milliampere with no signal.						
33	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 6	4 11/16" x 1 13/16"	D-C FILAMENT	2.0	0.26	180	180	CLASS A AMPLIFIER	180	−18.0	180	5.0	22.0	55000	1700	90	6000	1.4	33
34	SUPER-CONTROL R-F AMPLIFIER PENTODE	MEDIUM 4-PIN	FIG. 4A	5 11/32" x 1 13/16"	D-C FILAMENT	2.0	0.06	180	67.5	SCREEN GRID R-F AMPLIFIER	135 180	− 3.0 min.	67.5 67.5	1.0 1.0	2.8 2.8	600000 1000000	600 620	360 620	—	—	34
35	SUPER-CONTROL R-F AMPLIFIER TETRODE	MEDIUM 5-PIN	FIG. 8	5 11/32" x 1 13/16"	HEATER	2.5	1.75	275	90	SCREEN GRID R-F AMPLIFIER	180 250	− 3.0 min.	90 90	2.5* 2.5*	6.3 6.5	300000 400000	1020 1050	305 420	—	—	35
36	R-F AMPLIFIER TETRODE	SMALL 5-PIN	FIG. 9	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	90	SCREEN GRID R-F AMPLIFIER	100 180 250	− 1.5 − 3.0 − 3.0	55 90 90	— — 1.7*	1.8 3.1 3.2	550000 500000 550000	850 1050 1080	470 525 595	—	—	36
										BIAS DETECTOR	100● 250●	− 5.0 − 8.0	55 90	—	Plate current to be adjusted to 0.1 milliampere with no signal.						
37	DETECTOR★ AMPLIFIER TRIODE	SMALL 5-PIN	FIG. 6	4 1/4" x 1 9/16"	HEATER	6.3	0.3	250	—	CLASS A AMPLIFIER	90 180 250	− 6.0 −13.5 −18.0	—	—	2.5 4.3 7.5	11500 10200 8400	800 900 1100	9.2 9.2 9.2	—	—	37
										BIAS DETECTOR	90 250	−10.0 −28.0	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						
38	POWER AMPLIFIER PENTODE	SMALL 5-PIN	FIG. 9A	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	250	CLASS A AMPLIFIER	100 180 250	− 9.0 −18.0 −25.0	100 180 250	1.2 2.4 3.8	7.0 14.0 22.0	140000 115000 100000	875 1050 1200	120 120 120	15000 11600 10000	0.27 1.00 2.50	38
39-44	SUPER-CONTROL R-F AMPLIFIER PENTODE	SMALL 5-PIN	FIG. 9A	4 11/32" x 1 9/16"	HEATER	6.3	0.3	250	90	SCREEN GRID R-F AMPLIFIER	90 180 250	− 3.0 min.	90 90 90	1.6 1.4 1.4	5.6 5.8 5.8	375000 750000 1000000	960 1000 1050	360 750 1050	—	—	39-44

★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode.
■Either A. C. or D. C. may be used on filament or heater, except as specifically noted. For use of D. C. on A-C filament types, decrease stated grid volts by ½ (approx.) of filament voltage.

● Applied through plate coupling resistor of 250000 ohms or 500-henry choke shunted by 0.25 megohm resistor.
♥Applied through plate coupling resistor of 100000 ohms.
*Maximum.

TUBE SYMBOLS AND BOTTOM V

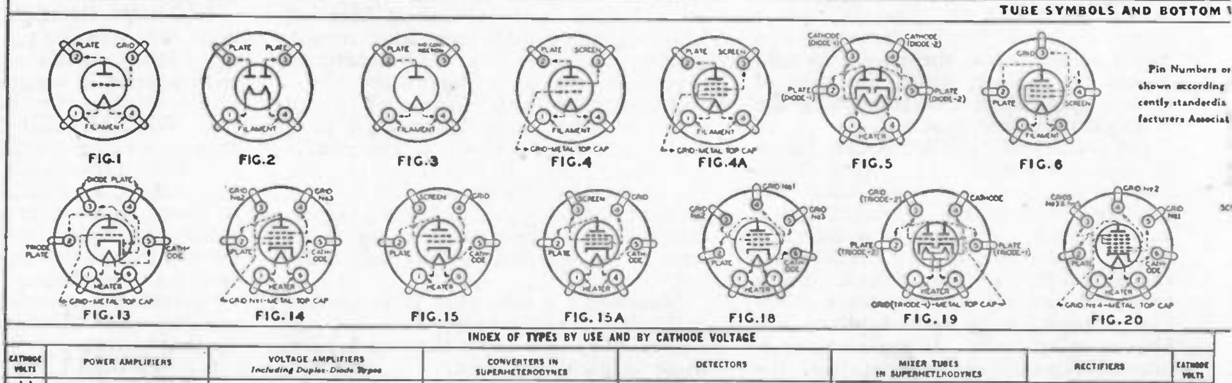


FIG.1 FIG.2 FIG.3 FIG.4 FIG.4A FIG.5 FIG.6

FIG.13 FIG.14 FIG.15 FIG.15A FIG.18 FIG.19 FIG.20

Pin Numbers or
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INDEX OF TYPES BY USE AND BY CATHODE VOLTAGE

CATHODE VOLTS	POWER AMPLIFIERS	VOLTAGE AMPLIFIERS Including Duplex-Diode Types	CONVERTERS IN SUPERHETERODYNES	DETECTORS	MIXER TUBES IN SUPERHETERODYNES	RECTIFIERS	CATHODE VOLTS
1.1	—	11, 12		11, 12			1.1
1.5	—	26	—	—	—	—	1.5
2.0	19, 31, 33, 49	30, 32, 34	1A6, 1C6	30, 32	1A6, 1C6, 34	—	2.0
2.5	2A3, 2A5, 45, 46, 47, 53, 59	2A6, 2B7, 24-A, 27, 35, 55, 56, 57, 58	2A7	2A6, 2B7, 24-A, 27, 55, 56, 57	2A7, 24-A, 35, 57, 58	82	2.5
3.3	'20	22, '99	—	'99	—	—	3.3

Technical Bulletins on these type

COMMERCIAL ENGINEERING SECTION, RCA RADIO

Figure 71

teristic Chart

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS MAXIMUM OVERALL LENGTH x DIAMETER	CATHODE TYPE■	RATING: FILAMENT OR HEATER VOLTS	FILAMENT OR HEATER AMPERES	PLATE MAX. VOLTS	SCREEN MAX. VOLTS	USE Values to right give operating conditions and characteristics for indicated typical use	PLATE SUPPLY VOLTS	GRID VOLTS■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICRO-MHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD FOR STATED POWER OUTPUT OHMS	POWER OUTPUT WATTS	TYPE
40	VOLTAGE AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16″ x 1 13/16″	D-C FILAMENT	5.0	0.25	180	—	CLASS A AMPLIFIER	135■ 180■	− 1.5 − 3.0	—	—	0.2 0.2	150000 150000	200 200	30 30	—	—	40
41	POWER AMPLIFIER PENTODE	SMALL 6-PIN	FIG. 15A	4 1/4″ x 1 9/16″	HEATER	6.3	0.4	250	250	CLASS A AMPLIFIER	100 180 250	− 7.0 −13.5 −18.0	100 180 250	1.6 3.0 5.5	9.0 18.5 32.0	103500 81000 68000	1450 1850 2200	150 150 150	12000 9000 7600	0.33 1.50 3.40	41
42	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	4 11/16″ x 1 13/16″	HEATER	6.3	0.7	250	250	CLASS A AMPLIFIER	250	−16.5	250	6.5	34.0	100000	2200	220	7000	3.00	42
43	POWER AMPLIFIER PENTODE	MEDIUM 6-PIN	FIG. 15A	4 11/16″ x 1 13/16″	HEATER	25.0	0.3	135	135	CLASS A AMPLIFIER	95 135	−15.0 −20.0	95 135	4.0 7.0	20.0 34.0	45000 35000	2000 2300	90 80	4500 4000	0.90 2.00	43
45	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16″ x 1 13/16″	FILAMENT	2.5	1.5	275	—	CLASS A AMPLIFIER	180 250 275	−31.5 −50.0 −56.0	180 250 275	—	31.0 34.0 36.0	1650 1610 1700	2125 2175 2050	3.5 3.5 3.5	2700 3900 4600	0.82 1.60 2.00	45
46	DUAL-GRID POWER AMPLIFIER	MEDIUM 5-PIN	FIG. 7	5 5/8″ x 2 3/16″	FILAMENT	2.5	1.75	250	—	CLASS A AMPLIFIER □	250	−33.0	—	—	22.0	2380	2350	5.6	6400	1.25	46
								400	—	CLASS B AMPLIFIER ♦	300 400	0 0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				5200 5800	16.0 20.0	
47	POWER AMPLIFIER PENTODE	MEDIUM 5-PIN	FIG. 6	5 5/8″ x 2 3/16″	FILAMENT	2.5	1.75	250	250	CLASS A AMPLIFIER	250	−16.5	250	6.0	31.0	60000	2500	150	7000	2.7	47
48	POWER AMPLIFIER TETRODE	MEDIUM 6-PIN	FIG. 16	5 5/8″ x 2 1/16″	D-C HEATER	30.0	0.4	125	100	CLASS A AMPLIFIER	96 125	−19.0 −20.0	96 100	9.0 9.5	52.0 56.0	— —	3800 3900	— —	1500 1500	2.0 2.5	48
49	DUAL-GRID POWER AMPLIFIER	MEDIUM 5-PIN	FIG. 7	4 11/16″ x 1 13/16″	D-C FILAMENT	2.0	0.12	135	—	CLASS A AMPLIFIER □	135	−20.0	—	—	6.0	4175	1125	4.7	11000	0.17	49
								180	—	CLASS B AMPLIFIER ♦	180	0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				12000	3.5	
50	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	6 1/4″ x 2 11/16″	FILAMENT	7.5	1.25	450	—	CLASS A AMPLIFIER	300 400 450	−54.0 −70.0 −84.0	—	—	35.0 55.0 55.0	2000 1800 1800	1900 2100 2100	3.8 3.8 3.8	4600 3670 4350	1.6 3.4 4.6	50
53	TWIN-TRIODE AMPLIFIER	MEDIUM 7-PIN▰	FIG. 24	4 11/16″ x 1 13/16″	HEATER	2.5	2.0	300	—	CLASS B AMPLIFIER	250 300	0 0	—	—	Power output value is for one tube at stated load, plate-to-plate.				8000 10000	8.0 10.0	53
55	DUPLEX-DIODE TRIODE	SMALL 6-PIN	FIG. 13	4 17/32″ x 1 9/16″	HEATER	2.5	1.0	250	—	TRIODE UNIT AS CLASS A AMPLIFIER	135 180 250	−10.5 −13.5 −20.0	—	—	3.7 6.0 8.0	11000 8500 7500	750 975 1100	8.3 8.3 8.3	25000 20000 20000	0.075 0.160 0.350	55
56	SUPER-TRIODE AMPLIFIER DETECTOR★	SMALL 5-PIN	FIG. 8	4 1/4″ x 1 9/16″	HEATER	2.5	1.0	250	—	CLASS A AMPLIFIER	250	−13.5	—	—	5.0	9500	1450	13.8	—	—	56
										BIAS DETECTOR	250	−20.0 (approx.)	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						
57	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	FIG. 11	4 15/16″ x 1 9/16″	HEATER	2.5	1.0	250	100	SCREEN GRID R-F AMPLIFIER	250	− 3.0	100	0.5	2.0	exceeds 1.5 meg.	1225	exceeds 1500	—	—	57
										BIAS DETECTOR	250	− 1.95	50	Cathode current 0.65 ma.		—	Plate coupling resistor 250000 ohms. Grid coupling resistor 250000 ohms**				

★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode
▰Requires different socket from small 7-pin.
□Grid next to plate tied to plate. ♦Two grids tied together. **For grid of following tube.
⌘Applied through plate coupling resistor of 250000 ohms.

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS	CATHODE TYPE■	FIL. VOLTS	FIL. AMPERES	PLATE MAX. VOLTS	SCREEN MAX. VOLTS	USE	PLATE SUPPLY VOLTS	GRID VOLTS■	SCREEN VOLTS	SCREEN MILLI-AMP.	PLATE MILLI-AMP.	A-C PLATE RESISTANCE OHMS	MUTUAL CONDUCTANCE MICRO-MHOS	VOLTAGE AMPLIFICATION FACTOR	LOAD OHMS	POWER OUTPUT WATTS	TYPE
58	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	FIG. 11	4 15/16″ x 1 9/16″	HEATER	2.5	1.0	250	100	SCREEN GRID R-F AMPLIFIER	250	− 3.0 min.	100	2.0	8.2	800000	1600	1280	—	—	58
										MIXER IN SUPERHETERODYNE	250	−10.0	100	—	—	Oscillator peak volts = 7.0.					
59	TRIPLE-GRID POWER AMPLIFIER	MEDIUM 7-PIN▰	FIG. 16	5 5/8″ x 2 3/16″	HEATER	2.5	2.0	250	—	AS TRIODE ¶ CLASS A AMPLIFIER	250	−28.0	—	—	26.0	2300	2600	6.0	5000	1.25	59
								250	250	AS PENTODE ** CLASS A AMPLIFIER	250	−18.0	250	9.0	35.0	40000	2500	100	6000	3.00	
								400	—	AS TRIODE ● CLASS B AMPLIFIER	300 400	0 0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				4600 6000	15.0 20.0	
71-A	POWER AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16″ x 1 13/16″	FILAMENT	5.0	0.25	180	—	CLASS A AMPLIFIER	90 180	−19.0 −43.0	—	—	10.0 20.0	2170 1750	1400 1700	3.0 3.0	3000 4800	0.125 0.790	71-A
75	DUPLEX-DIODE HIGH-MU TRIODE	SMALL 6-PIN	FIG. 13	4 17/32″ x 1 9/16″	HEATER	6.3	0.3	250	—	TRIODE UNIT AS CLASS A AMPLIFIER	250⌘	−1.35	—	—	0.4	—	—	Gain per stage = 50-60			75
76	SUPER-TRIODE AMPLIFIER DETECTOR★	SMALL 5-PIN	FIG. 8	4 1/4″ x 1 9/16″	HEATER	6.3	0.3	250	—	CLASS A AMPLIFIER	250	−13.5	—	—	5.0	9500	1450	13.8	—	—	76
										BIAS DETECTOR	250	−20.0	—	—	Plate current to be adjusted to 0.2 milliampere with no signal.						
77	TRIPLE-GRID DETECTOR AMPLIFIER	SMALL 6-PIN	FIG. 11	4 15/16″ x 1 9/16″	HEATER	6.3	0.3	250	100	SCREEN GRID R-F AMPLIFIER	100 250	− 1.5 − 3.0	60 100	0.4 0.5	1.7 2.3	650000 1500000	1100 1250	715 1500	—	—	77
										BIAS DETECTOR	250	− 1.95	50	Cathode current 0.65 ma.		—	Plate coupling resistor 250000 ohms. Grid coupling resistor 250000 ohms**				
78	TRIPLE-GRID SUPER-CONTROL AMPLIFIER	SMALL 6-PIN	FIG. 11	4 17/32″ x 1 9/16″	HEATER	6.3	0.3	250	125	SCREEN GRID R-F AMPLIFIER	90 180 250 250	− 3.0 min.	90 75 100 125	1.3 1.0 1.7 2.6	5.4 4.0 7.0 10.5	315000 1000000 800000 600000	1275 1100 1450 1650	400 1100 1160 990	—	—	78
79	TWIN-TRIODE AMPLIFIER	SMALL 6-PIN	FIG. 19	4 17/32″ x 1 9/16″	HEATER	6.3	0.6	250	—	CLASS B AMPLIFIER	180 250	0 0	—	—	Power output value is for one tube at stated load, plate-to-plate.				7000 14000	5.5 8.0	79
85	DUPLEX-DIODE TRIODE	SMALL 6-PIN	FIG. 13	4 17/32″ x 1 9/16″	HEATER	6.3	0.3	250	—	TRIODE UNIT AS CLASS A AMPLIFIER	135 180 250	−10.5 −13.5 −20.0	—	—	3.7 6.0 8.0	11000 8500 7500	750 975 1100	8.3 8.3 8.3	25000 20000 20000	0.075 0.160 0.350	85
89	TRIPLE-GRID POWER AMPLIFIER	SMALL 6-PIN	FIG. 14	4 17/32″ x 1 9/16″	HEATER	6.3	0.4	250	250	AS TRIODE ¶ CLASS A AMPLIFIER	160 180 250	−20.0 −22.5 −31.0	—	—	17.0 20.0 32.0	3300 3000 2600	1425 1550 1800	4.7 4.7 4.7	7000 6500 5500	0.300 0.400 0.900	89
										AS PENTODE ** CLASS A AMPLIFIER	100 180 250	−10.0 −18.0 −25.0	100 180 250	1.6 3.0 5.5	9.5 20.0 32.0	104000 80000 70000	1200 1550 1800	125 125 125	10700 8000 6750	0.33 1.50 3.40	
										AS TRIODE ● CLASS B AMPLIFIER	180	0	—	—	Power output values are for 2 tubes at indicated plate-to-plate load.				13600 9400	2.50 3.50	
V-'99 X-'99	DETECTOR★ AMPLIFIER TRIODE	SMALL 4-NUB SMALL 4-PIN	FIG. 10 FIG. 1	3 1/2″ x 1 3/16″ 4 1/8″ x 1 3/16″	D-C FILAMENT	3.3	0.063	90	—	CLASS A AMPLIFIER	90	− 4.5	—	—	2.5	15500	425	6.6	—	—	V-'99 X-'99
112-A	DETECTOR★ AMPLIFIER TRIODE	MEDIUM 4-PIN	FIG. 1	4 11/16″ x 1 13/16″	D-C FILAMENT	5.0	0.25	180	—	CLASS A AMPLIFIER	90 180	− 4.5 −13.5	—	—	5.0 7.7	5400 4700	1575 1800	8.5 8.5	—	—	112-A

★For Grid-leak Detection—plate volts 45, grid return to + filament or to cathode.
■Either A. C. or D. C. may be used on filament or heater, except as specifically noted. For use of D. C. on A-C filament types, decrease stated grid volts by ½ (approx.) of filament voltage.
▰Requires different socket from small 7-pin.
**Grid #1 is control grid. Grid #2 is screen. Grid #3 tied to cathode.
¶Grid #1 is control grid. Grids #2 and #3 tied to plate. ⌘Applied through plate coupling resistor of 250000 ohms.
●Grids #1 and #2 connected together. Grid #3 tied to plate. **For grid of following tube.

RECTIFIERS

TYPE	NAME	BASE	SOCKET CONNECTIONS	DIMENSIONS	CATHODE TYPE	FIL. VOLTS	FIL. AMPERES	PLATE MAX. VOLTS	SCREEN MAX. VOLTS	RATINGS	TYPE
5Z3	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 2	5 5/8″ x 2 3/16″	FILAMENT	5.0	3.0	—	—	Maximum A-C Voltage per Plate 500 Volts, RMS Maximum D-C Output Current 250 Milliamperes	5Z3
12Z3	HALF-WAVE RECTIFIER	SMALL 4-PIN	FIG. 22	4 1/4″ x 1 9/16″	HEATER	12.6	0.3	—	—	Maximum A-C Plate Voltage 250 Volts, RMS Maximum D-C Output Current 60 Milliamperes	12Z3
25Z5	RECTIFIER-DOUBLER	SMALL 6-PIN	FIG. 5	4 1/4″ x 1 9/16″	HEATER	25.0	0.3	—	—	Maximum A-C Voltage per Plate 125 Volts, RMS Maximum D-C Output Current 100 Milliamperes	25Z5
1-v*	HALF-WAVE RECTIFIER	SMALL 4-PIN	FIG. 22	4 1/4″ x 1 9/16″	HEATER	6.3	0.3	—	—	Maximum A-C Plate Voltage 350 Volts, RMS Maximum D-C Output Current 50 Milliamperes	1-v*
80	FULL-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 2	4 11/16″ x 1 13/16″	FILAMENT	5.0	2.0	—	—	A-C Voltage per Plate (Volts RMS) 350 400 550 D-C Output Current (Maximum MA.) 125 110 135 The 550 volt rating applies to filter circuits having an input choke of at least 20 henries.	80
'81	HALF-WAVE RECTIFIER	MEDIUM 4-PIN	FIG. 3	6 1/4″ x 2 3/16″	FILAMENT	7.5	1.25	—	—	Maximum A-C Plate Voltage 700 Volts, RMS Maximum D-C Output Current 85 Milliamperes	'81
82	FULL-WAVE RECTIFIER▸	MEDIUM 4-PIN	FIG. 2	4 11/16″ x 1 13/16″	FILAMENT	2.5	3.0	—	—	Maximum A-C Voltage per Plate 500 Volts, RMS Maximum D-C Output Current 125 Milliamperes Maximum Peak Inverse Voltage 1400 Volts Maximum Peak Plate Current 400 Milliamperes	82
83	FULL-WAVE RECTIFIER▸	MEDIUM 4-PIN	FIG. 2	5 5/8″ x 2 3/16″	FILAMENT	5.0	3.0	—	—	Maximum A-C Voltage per Plate 500 Volts, RMS Maximum D-C Output Current 250 Milliamperes Maximum Peak Inverse Voltage 1400 Volts Maximum Peak Plate Current 800 Milliamperes	83
84 also 6Z4	FULL-WAVE RECTIFIER	SMALL 5-PIN	FIG. 23	4 1/4″ x 1 9/16″	HEATER	6.3	0.5	—	—	Maximum A-C Voltage per Plate 350 Volts, RMS Maximum D-C Output Current 50 Milliamperes	84 also 6Z4

▸Mercury Vapor Type. * Interchangeable with Type 1.

IEWS OF SOCKET CONNECTIONS

Socket Diagrams are
to the new system re-
d by the Radio Manu-
on.

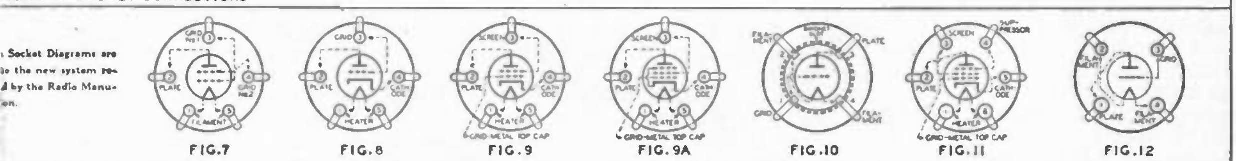


FIG.7 FIG.8 FIG.9 FIG.9A FIG.10 FIG.11 FIG.12

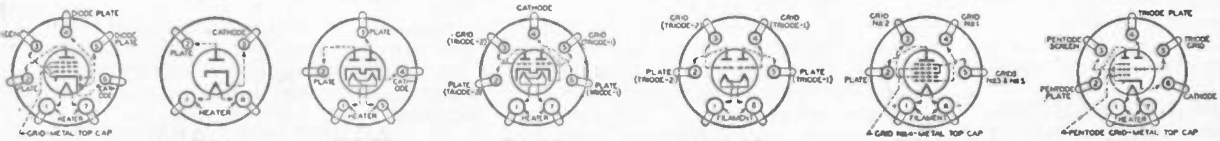


FIG.21 FIG.22 FIG.23 FIG.24 FIG.25 FIG.26 FIG.27

INDEX OF TYPES BY USE AND BY CATHODE VOLTAGE

CATHODE VOLTS	POWER AMPLIFIERS	VOLTAGE AMPLIFIERS *Including Duplex-Diode Types*	CONVERTERS IN SUPERHETERODYNES	DETECTORS	MIXER TUBES IN SUPERHETERODYNES	RECTIFIERS	CATHODE VOLTS
5.0	112-A, 71-A	01-A, 40, 112-A	—	00-A, 01-A, 40, 112-A	—	5Z3, 80, 83	5.0
6.3	6A4, 38, 41, 42, 79, 89	6B7, 6C6, 6D6, 6F7, 36, 37, 39-44, 75, 76, 77, 78, 85	6A7, 6F7	6B7, 6C6, 6F7, 36, 37, 75, 76, 77, 85	6A7, 6C6, 6D6, 6F7, 36, 39-44, 77, 78	1-v, 84	6.3
7.5	10, 50	—	—	—	—	'81	7.5
12.6	—	—	—	—	—	12Z3	12.6
25.0	43	—	—	—	—	25Z5	25.0
30.0	48	—	—	—	—	—	30.0

e may be obtained by writing to

DTRON COMPANY, INC., HARRISON, NEW JERSEY

Courtesy of
R.C.A. Radiotron Co.

ity of the windings in any type of transformer, such as R.F., A.F. and Power transformers. A high resistance voltmeter should be used for testing audio frequency transformers; while a low resistance voltmeter should be used for testing radio frequency and power transformers. In the case of A.F. transformers that winding which has the least resistance, that is, gives the highest voltage reading, is the primary winding. The various sections of push-pull transformers should also be tested for continuity.

In testing power transformers, make sure that there are no resistors connected across the filament taps as otherwise the reading would indicate a complete winding, when in reality the winding might be open.

A test should be made between the transformer taps or terminals and the core and shield of the transformer. No reading should be obtained. If the voltmeter shows a reading, it indicates that the winding is grounded to the core or shield and the trouble should be repaired at once. No voltage reading should be obtained when testing between any secondary winding and the primary winding. The center tap on the secondary of the power transformer is usually grounded.

As in the case of testing short circuits in resistances, considerable experience and the use of highly accurate voltmeter readings are necessary to determine if transformer windings are short circuited. This is especially true in the case of step-down secondary windings. Under actual operating conditions, a short circuit in the primary winding of a power transformer will increase the voltage output of the secondary windings. A short circuit in the secondary windings will reduce the voltage output of the transformer.

8. POOR CONNECTIONS OR HIGH RESISTANCE JOINTS IN ANTENNA OR GROUND SYSTEMS. The ends of all wires to be joined should be scraped clean and then soldered and taped. The ground wire should be connected by means of an approved ground clamp to the cold water pipe, or a pipe driven into damp ground. Scrape the surface of the pipe under the clamp so as to form a good electrical connection. The ground wire should be soldered to the ground clamp.

9. GROUNDED LEAD-IN OR ANTENNA. Keep antenna wires free from contact with other objects. Do not let the wire touch trees or side of building. Use stand-off insulators to hold wires away from the building, and be sure to take lead-in wire into the house through a porcelain tube or by use of an approved "lead-in strip" provided especially for that purpose. Remember, the better the antenna installation, the stronger and clearer will be the reception. It pays to take time to erect the antenna system in a workmanlike manner.

10. SHORT-CIRCUITED ANTENNA COIL. Be sure when connecting an antenna lead to the receiver that the end of the wire does not make contact with the metal chassis or any other part of the receiver. See that all connections are securely fastened.

11. SHORT-CIRCUITED TUNING CONDENSER. Straightening plates in variable condensers is a rather difficult job. However, if the offending plate can be located easily, it should be straightened with the fingers, flat nose pliers, or other non-metallic object. **Do not use a screw driver, or pliers, unless the power is disconnected from the set.** In battery sets, disconnect the negative B terminal of the power supply.

12. NO VOLTAGE AT ELIMINATOR TAPS. This may be due to a defective power transformer, a short circuited or broken down condenser or an open resistor or choke coil in eliminator. See pars. 4, 7, 22, 23 and 56.

13. NO PLATE VOLTAGE ON R.F. TUBE. Check receiver with wiring diagram for broken wires or defective by-pass condenser. Solder broken connection. See pars. 4 and 23.

14. OPEN CIRCUIT. Check the wiring with the circuit diagram for continuity and solder any broken wires.

15. SPEAKER DEMAGNETIZED OR COIL BURNED OUT. If possible, try the speaker on another set. If it doesn't work correctly or the volume is weak, check it over and replace defective parts.

16. NO FIELD CURRENT IN LOUDSPEAKER. The field coil or leads to it may be open, short circuited or grounded. To determine if field current is being supplied, turn on receiver and hold a screwdriver about ¼ inch from pole piece of magnet. If current is being supplied to field coil, the pole piece will have a strong attracting force for the screwdriver. No field current will necessitate checking the continuity of the field coil circuit. In case of a burned out field coil, obtain a new one from the distributor or manufacturer. Also see par. 4.

17. DEFECTIVE SPEAKER CORD. Loose or defective speaker cords cause continuous crackling noises. Replace with a new one.

18. DEFECTIVE "DRY DISC" TYPE RECTIFIER. This type of rectifier will give little trouble unless too much current is taken from the unit. Do not overload the rectifier by taking more current than is recommended by the manufacturers. If defective, replace with a new unit.

19. DEFECTIVE RAYTHEON TUBE RECTIFIER. This rectifier should give satisfactory service for about a year of normal use. After serving its full life, the voltage output of the tube begins to drop off. The voltage controls can then often be adjusted to bring the voltage up again to the desired value, many more hours of good reception obtained before it is necessary to discard the tube. If in doubt as to the condition of the tube, try a new tube.

20. DEFECTIVE ELECTROLYTIC RECTIFIER. The electrolyte in the Philco and Balkite eliminator will in time evaporate and the solution will not function properly. The electrodes will also be eaten away. In cases of this kind, it is necessary to obtain new electrodes and new electrolyte and replace the defective parts. The electrolyte solution and electrodes used in various chargers and eliminators differ considerably, therefore, it is very important when replacing them to get the proper kind from an authorized service station or direct from the manufacturer of the unit.

21. INCORRECT GRID VOLTAGE. See paragraph 46 and apply the tests outlined in paragraphs 23 and 56.

22. CHOKE COILS, DEFECTIVE. The method of testing choke coils is the same as that used for testing resistances and the same instructions as given in paragraph 56 can be used.

23. CONDENSER, DEFECTIVE. In order to find out whether or not a fixed condenser is defective, it is first necessary to remove it from the set and short circuit the two terminals together to discharge it. Then charge the condenser by connecting a "B" battery to its terminals, being careful not to touch either the condenser terminals or the ends of the leads while doing this. A condenser should be able to hold such a charge for a few minutes. The cord tips of a head-set are then touched to its terminals, care being exercised not to touch the cord tips or the condenser terminals with the fingers for this will discharge the condenser through the body, and then the test is incorrect. A sharp click in the phones at the moment the condenser terminals are touched shows that it is in good condition as the condenser holds its charge. If no click is heard or the click is very faint, the condenser is defective and should be replaced with a new one. To conduct this test, it is absolutely necessary that the condenser be disconnected from any other piece of apparatus to which it may be attached.

For small condensers, the above method is not very accurate and the ordinary voltmeter and battery continuity test should be used. No reading on the voltmeter should be obtained other than a momentary deflection when the test points are applied to the condenser terminals. See 67 and 68 for instructions on electrolytic condensers.

24. PLATES OF RECTIFIER TUBE GET RED HOT. This is an almost sure indication that one of the filter condensers is defective and short-circuited (see paragraph 23). A grounded choke coil or a short-circuited or grounded power resistance may also cause this trouble.

25. DEFECTIVE MAGNETIC CONE SPEAKER. In a magnetic speaker we have several moving mechanical parts. If any of these get out of adjustment, different types of noises will result. Examine the small nut that holds the driving pin to the cone. If this is loose, or if threads are worn, rattles and buzzes will be heard. In some magnetic cone speakers there are several soldered connections to the moving parts. See that none of these are loose, especially where the driving pin is soldered to the armature. If the armature does not vibrate freely, see if dust or rust is between armature and pole pieces. If any is found, run a strong thread between them to remove dust. In case of rust, clean the surfaces by thoroughly rubbing them with a gasoline soaked string. If the unit is dismantled, the job can be done better. After cleaning, appliy a coating of amylacetate clear lacquer, which will prevent rust forming later. Also see par. 26.

26. ADJUSTING ARMATURE IN MAGNETIC AND INDUCTOR SPEAKERS. Loosen screws that hold armature and pole pieces in place. Do not remove entirely. Obtain a good grade of paper from a stationery store about .005 inch thick. Cut out two or four spacers, depending on type of speaker. Place these spacers between armature and pole pieces. The screws are then tightened and the spacers removed. If this operation has been done carefully, the armature will be properly spaced.

27. NO FIELD CURRENT IN A. C. OPERATED DYNAMICS. Speakers of this type usually have an electrolytic condenser connected across the input to the field. This condenser in time will become defective and cause current to be passed to the negative side of the circuit, thus current does not enter the field coil and we have little or no magnetism for the operation of the speaker. Unsolder one lead of the condenser, if it is defective, volume and hum will increase. In making replacements, use a 2,000 mfd. dry electrolytic condenser. Also see par. 52.

28. CONDENSER SPEAKERS. Before testing a speaker of this type, be sure the switch of the receiver is turned off. There are about 500 volts across the speaker plates and it is possible to get a bad shock from this voltage. The most common defect in speakers of this type is puncturing of the thin aluminum film on the condenser plates. It may be mechanical or electrical break-down caused by the high voltage from the rectifying tube. With the switch of receiver off and leads disconnected from rectifying tube, a continuity test will tell if the condenser plates are punctured. There will be several plates in parallel. Use care in determining which section is defective. Try reversing polarizing voltage leads from rectifier. The speaker has polarity the same as a battery.

29. LINE VOLTAGE FLUCTUATES. Fluctuations or changes in value of line voltage can be corrected by the use of a line voltage stabilizer. Several good comercial types are now on the market. Also see 82.

30. TUBE IN WRONG SOCKET. Special purpose tubes (special detector tubes, power and rectifier tubes) should never be placed in any sockets except those especially intended for their use.

31. AERIAL TOO SHORT. The aerial on any receiving set should have a length approximately that suggested by the manufacturer of the receiver. Generally speaking, an aerial 60 to 80 ft. long will give excellent results. Indoor aerials and light socket antennas never give the same results as good outdoor antennas. Such installations usually give good results on local or nearby stations, but are not of much value for distant reception. If possible, always use an outdoor antenna system.

32. MICROPHONIC TUBE. Changing tubes (*of the same type*) from one socket to another sometimes corrects this annoyance. Moving the speaker several feet from the receiver also proves helpful. The loudspeaker cord should not be allowed to come close to the radio frequency or detector tubes. A microphonic tube can sometimes be overcome by placing "howl" arresters on the tube. Different types of such "howl" arresters can be found in practically any radio store. This trouble can sometimes be overcome by placing a lead cap on the tube or by wrapping several layers of friction type around the tube.

33. DEFECTIVE FILTER CONDENSER IN POWER SUPPLY. It is very poor economy to use any except the highest grade filter condensers in a power supply. When they become defective, it is always necessary to replace them with new condensers. Also see pars. 23 and 24.

34. RECEIVER NOT NEUTRALIZED. Follow general neutralizing methods.

35. CONDENSERS NOT MATCHED. Multiple tuned circuits require carefully matched condensers. Tuning may be sharpened by using a midget or trimmer condenser connected in parallel with the tuning condenser. Adjust all condensers until all circuits tune alike.

36. EXCESSIVE OSCILLATION. Use of complete stage shielding is very desirable in some receivers to prevent inter-stage coupling and thus minimize the tendency to self-oscillation.

37. DEFECTIVE GRID LEAK. Substitute a new grid leak for the old one as it is practically impossible to test grid leaks with any degree of accuracy.

38. GRID LEAK OF IMPROPER VALUE. Try various grid leaks ranging in value from 2 to 6 megohms until you find the one giving strongest and clearest signals. If the set is used for distant reception, a high resistance leak gives best results. If on local or nearby stations, a low value resistance should be used.

39. LEAKY FIXED OR BY-PASS CONDENSER. Hissing, scraping noises are sometimes due to leaky condensers. See also section 23.

40. POOR GROUND CONNECTION. A short straight wire connected to the cold water pipe makes the most practical ground connection. **Avoid use of steam or gas pipes.**

41. EXCESSIVE VOLTAGE ON DETECTOR TUBE. If batteries are used, try the next lowest voltage tap. If a power unit is used, reduce the voltage by increasing the size of the plate resistance.

42. DEFECTIVE BUFFER CONDENSER. The condensers which are placed across the terminals of the Raytheon rectifier tube are subjected to excessive strain due to voltage surges. Consequently, nothing but the highest type condenser should be used in any power supply. See section 23.

43. HIGH RESISTANCE CONNECTIONS. What is commonly called a high resistance connection need not be very high in actual value, to be troublesome. An undesirable resistance of just a few ohms may cause a great deal of trouble, especially in oscillatory circuits. In fact, the connection resistance may be so small that a continuity test will not detect it. If you have any doubts at all about a connection, go over it carefully with a hot soldering iron. Never take chances on poor connections.

44. IMPROPER VOLTAGE ON POWER TUBE. Follow the manufacturer's specifications regarding proper filament, plate and grid bias voltages. If the voltage on the filament of the power tube is not that specified by the manufacturer, it will not handle the power. Likewise, the grid and plate voltage should be in strict accordance with the recommendations. If the grid bias voltage is not adjusted to the proper value, the amplifier tube will give distorted or improperly amplified signals. If the "B" battery or power unit is not delivering its rated voltage, the signals will become choked and weak. Also see 46 and 55.

45. DEFECTIVE RECTIFIER TUBE. If the various elements of a rectifier tube are loose, the tube may cause intermittent reception or a microphonic howl. Low output of the tube may cause weak signals and A. C. hum. A new tube should be substituted in place of the suspected tube in order to determine its condition.

46. INCORRECT VOLTAGES. This trouble in the correctly designed electric receiver is caused by incorrect A. C. line voltage or a defective rectifier tube (see paragraph 45). This is, of course, supposing that the receiver is in good condition. If the voltage is too high it can be reduced by inserting a resistance, capable of carrying the necessary current (approximately 1 ampere), in series with one side of the A. C. line, or by using a voltage regulator manufactured by a reliable company. If the A. C. line voltage is low, it will be necessary to take the matter up with the Power Company, as they will be very glad to remedy the condition.

Many receiving sets have special voltage taps which can be adjusted for the correct voltage.

Excessive plate voltage may be due to incorrect or defective grid bias resistor and plate resistors in the power pack; also an open in the voltage divider system between the detector and B– tap and to shorted filter chokes.

Insufficient plate voltages may be due to: Defective rectifier; excessive plate current; defective plate by-pass condenser.

Incorrect filament voltage may be due to wrong value of voltage reducing resistance (in modern sets such resistances are rarely used).

Incorrect grid voltage may be caused by incorrectly designed or defective grid bias resistors or defective grid bias by-pass condenser. Also see par. 73.

47. OPEN IN GROUND SYSTEM. Make the usual careful inspection for open circuits in the entire ground system. In many receivers using a metal chassis, many connections that are at ground potential are connected to the chassis and this is in turn connected to the ground binding post. Such connections should be carefully inspected to see that they are making good contact.

48. VARIABLE CONDENSERS. Always keep the plates of variable condensers clean and free of dirt. The ordinary pipe cleaners, obtainable from any cigar store, can be used to clean the plates of the condensers.

Make sure that the rotor or movable plates are not bent and not making contact with the stator plates.

49. UNDESIRABLE CONTACTS IN TUNING CONDENSERS. Remove any shield or cover from tuning condensers and carefully examine the condensers for a possible piece of foreign material or dirt between the plates. Rotate the movable section and see that it does not come in contact with other apparatus.

Testing with a low resistance ohmmeter should show considerable resistance between the stator and rotor plates. This indication varies with the kind of set and in some sets may also be changed by the setting of the volume control. Remove the tubes from the sockets when making this test.

Should no resistance be registered on the meter it will be due either to a grounded set of stator plates, a grounded R.F. coil or a short-circuit in the tuning condenser.

50. VOLUME CONTROL, DEFECTIVE. Volume controls used on electric receivers almost always are some form of variable resistance. The ordinary test for the continuity of resistances should be used and also all variable contacts should be inspected. If the volume control is defective, it is generally the best policy to replace the control with a new one rather than to attempt to repair the old one.

51. CONTROL GRID CLIPS LOOSE OR GROUNDED. Be sure that the control grid clips on all screen grid tubes are making good contact. Do not let them touch any grounded object such as the metal chassis or tube shields.

52. DEFECTIVE RECTIFIER UNIT IN LOUDSPEAKER. Some types of dynamic speakers use a separate rectifying unit to supply the field current for the speaker. These units are generally the dry disc type although a rectifying tube is sometimes used.. When these rectifiers become old and worn out, they may develop a hum. Such units should be replaced with new ones.

53. EXCESSIVE VOLTAGE FROM THE POWER SUPPLY. If equipped with variable voltage control, try reducing the voltage by turning the knob counter-clockwise. Check voltage with high resistance voltmeter. See also section 46.

54. EXCESSIVE FILAMENT VOLTAGE. Tubes should never be operated at a higher temperature than that specified by the manufacturer. If the tube burns out quickly, check the filament voltage and adjust the power supply so that the voltage recommended by the tube manufacturer is not exceeded. If necessary, place a small resistance in the filament circuit capable of carrying the current required by the tube or tubes. In the case of A. C. tubes, the same amount of resistance must be placed in each filament lead.

55. BLUE GLOW IN AMPLIFYING OR DETECTOR TUBE. This indicates that the tube is defective and that it should be replaced. This may also be due to too high plate voltage, or low grid voltage. See paragraph 46.

56. RESISTANCES, DEFECTIVE. The most accurate method of testing resistances is by the use of the high resistance voltmeter and "B" battery test. The reading obtained when placing the test points on the resistor to be tested should be less than the voltage reading when the test points are connected together, the exact difference, of course, depending upon the value of resistance being tested. A small resistance will make little change in the reading, while a high resistance will reduce the voltage reading considerably. No voltage, of course, indicates an open circuit in the resistance.

If a high reading is obtained when testing a high resistance, it shows that the resistance is short-circuited. A short circuit on a low resistance is harder to determine since the difference in the voltage readings will be very small.

In the case of tapped resistors such as those used in many power packs and also the hum adjustors on many sets, it is necessary to test each individual section of the resistance.

It is not a good policy to use the lamp test method of testing resistances. There is danger of burning out resistances of small current carrying capacities such as grid resistances. Also this test is not nearly as accurate as the voltmeter test.

In testing any resistance, always be sure that it is not connected to other apparatus, such as an inductance coil, as this would give a short-circuit reading. If the resistance is in a receiving set this can be determined by very carefully checking over the entire circuit to which the resistor is connected, using the schematic diagram if one is available. In case of doubt on this subject, it is the best policy to remove the resistance from the circuit and test it separately.

57. TOO GREAT SIGNAL STRENGTH. Too much volume from local stations will often overload the detector or audio tubes, thus causing distortion. The volume control should be inspected to see that it is functioning properly. The grid and plate potentials should be checked to see that they are correct. If the signal strength is still too great, the aerial can often be disconnected and satisfactory results secured on local stations.

In the case of shielded receivers a short aerial approximately 10 or 15 feet long can be used.

58. DEFECTIVE AUDIO FREQUENCY TRANSFORMERS. Test transformer according to paragraph 7. It sometimes happens that an audio transformer that tests O. K. will cause distortion. As a last resort, try a new transformer.

59. HIGH RESISTANCE LEAK ACROSS SECONDARY OF AUDIO TRANSFORMER. It is often possible to eliminate an audio howl by placing a high resistance across the grid and filament terminals of the audio transformer. Try various values ranging from 100,000 to 500,000 ohms. If this value is incorrect or if there is an undesirable high resistance across these terminals, it may muffile the signals or cause a hissing noise.

60. MOTOR BOATING. Motor boating is a term describing the sound produced in some radio installations, resembling the put-put-put of a small gas engine and is usually continuous while the receiver is in operation. This is in reality a low frequency oscillation produced by high common impedance in the plate circuit of the audio amplifier. A 1 to 2 mfd. condenser connected from the B negative terminal to each of the B positive terminals will generally eliminate this trouble.

61. THERMOSTATIC AND OTHER MAKE-AND-BREAK CONNECTIONS. Check the receiver carefully for open or grounded circuits. Opens are usually found at improperly soldered connections. Heat generated in the receiver when in operation will often cause a poorly made joint to separate.

Heat may also result in grounding a circuit due to the expansion of parts, or connections, which are too close to other parts or the metal on which the receiver is mounted. Examine the receiver carefully for too closely associated parts and wiring.

Try all soldered connections to see that they are firmly made. Go over all soldered connections about which you have any doubts with a hot soldering iron. Parts, or wiring, too closely associated should be separated or insulated from each other carefully.

Sound vibrations from the speaker or jarring the receiver may result in open circuits. These defects will show up in the same manner as opens, due to heat generated in the receiver and should be corrected in the same manner.

62. SPEAKER VOICE COIL OFF CENTER. Check the centering of the speaker by pushing the diaphragm (cone) gently back and forth to determine whether or not the voice coil is rubbing at any point. To re-center with one type of dynamic speaker loosen the center screw and move the voice coil back and forth till centering is obtained and reset screw. With another type loosen the extended supporting arms or spider at the point of support and move the voice coil from side to side until centered and then retighten. Failing in this, it may be necessary to remove the diaphragm entirely to see that there is no foreign material in the space where the speech coil moves.

63. PAPER RATTLE ON ALL TYPES OF CONE SPEAKERS. Examine seam of paper, outer edge of cone, and apex of cone. If loose joints are found, apply Ambroid cement. If outer edge of cone is attached to a leather, be sure all edges are properly cemented to cone. If leather has hard spots, rub until it is soft and pliable.

64. TROUBLE IN DYNAMIC SPEAKER. Rattling and blasting noises in a dynamic speaker are often caused by iron filings and dust collecting in the air gap, between voice coil and pole piece slot. One good way to remove this collection is to use the blower of a vacuum cleaner. Allow the full force of the air to blow between voice coil and pole piece. This will usually remove all foreign particles. It is understood, of course, that the speaker is to be disconnected from receiver during this operation.

In extreme cases, it may be necessary to remove cone from speaker frame to remove iron filings which may cling to the pole piece due to the inherent magnetism. This is done by removing screws at outer edge of cone frame. Then unsolder voice coil leads and remove cone. In some cases it may be necessary to remove frame which holds cone to chassis of speaker before one can get at air gap and pole piece.

65. BOOMY EFFECTS AND CABINET RATTLES. If the speaker is boomy, emphasizing low notes, look for by-pass condensors connected across grids of audio amplifiers. Removing these will sometimes restore the higher frequencies. If the cabinet is of the console type, lining it with "Celotex" will also prevent the boomy effects. Rattles may be heard with full volume. These may be due to loose screws and nuts on cabinet doors, speaker frame and chassis of receiver. Tighten all that you find are loose. This noise can sometimes be eliminated by moving the cabinet a few inches away from the wall or by making several large holes in the bottom of cabinet.

66. FUZZY LOW NOTE REPRODUCTION FROM SPEAKER. Examine voice coil turns. If they appear to be loose, remove cone from frame and unsolder voice coil leads. Then apply a thick, even coating of Ambroid cement, which can be obtained from speaker manufacturers. After allowing this to dry, replace cone and solder on voice coil leads. In the case of magnetic speakers a paper cone may sometimes become torn at the edges. In this case it will be necessary to carefully repair the cone by gluing light weight paper over the torn places or obtaining a new cone from the manufacturer. Sometimes the apex becomes separated from the paper cone. In this case Ambroid cement should be thoroughly applied to the cone and the apex placed in position.

67. ELECTROLYTIC CONDENSER PASSING EXCESSIVE CURRENT. This will result in low plate voltage at tube sockets. The reproduction will be distorted. Connections at the condenser terminals are likely to become corroded due to the chemicals in the condenser. This will result in noises and possible high plate voltage due to the absence of a condenser action. Hum will generally be greater, also. For details on testing, see paragraph 68.

68. DEFECTIVE MERSHON OR ELECTROLYTIC CONDENSERS. This type of condenser in time becomes defective, but is easily tested. The current through it is normally 2 or 3 milliamperes. If it is appreciably more than this, a new condenser should be used. To test it, connect an 0-100 milliammeter in series with the negative lead to it. Then turn on the receiver for an instant, noting the current at the same time. If the needle of meter goes all the way over, turn off the receiver at once so as not to damage meter. The black lead to the condenser is usually negative. In some receivers, the condenser can is mounted to receiver chassis and makes the negative contact from can to chassis. Under such conditions, remove can from chassis and touch one side of meter to chassis and the other to condenser can.

69. TUBES IN PUSH-PULL TRANSFORMER. For best results the tubes in push-pull amplifiers should be as nearly matched as possible. Do not use one exceptionally good tube and one that is not so good in the amplifier as it will probably cause distortion.

70. AERIAL WIRE LOOSE OR SWAYING. Keep the aerial and lead-in wire pulled tight so it cannot sway excessively in the wind. By using an aerial spring or pulley and weight, the antenna may be kept tight.

71. AERIAL CLOSE TO HIGH VOLTAGE WIRE. To minimize interference, it is advisable to install the aerial so that the wires are at right angles to any power lines and as far away as possible.

72. AERIAL TOO LONG. Cut the length of the aerial to size suggested by the manufacturer of the receiver or insert a condenser in series with the aerial. A small fixed condenser of approximately .0025 mfd. or .0001 mfd. is usually helpful. A variable condenser permits finer adjustment.

73. WRONG CONNECTIONS TO TRANSFORMER SECONDARY. Check connections with a schematic diagram of the receiver. If necessary, check A. C. voltage output of transformer with an A. C. voltmeter capable of reading the highest voltage output of the transformer.

When provided with a center tap the two outside terminals will always indicate the maximum voltage.

74. OUTSIDE INTERFERENCE (STATIC). Noises originating outside the receiver can usually be determined by removing the aerial and ground wires. If the noise still persists, it is an indication that the noise originates *in* the receiver or accessories (batteries, tubes, power unit or loose connections). Natural interference (static) presents itself in varying sounds, usually loud crackling or crashes. Static is a natural phenomenon, and up to the present time no means of overcoming it successfully has been devised.

Disturbances from electrical devices sometimes can be remedied through the cooperation of the owners of these devices.

75. INDUCTIVE COUPLING BETWEEN CIRCUITS. The grid and plate circuits should not be in inductive relation. Do not let these leads be close to each other and always keep them as near right angles as possible. Do not place these circuits near A. C. conductors — for instance, in battery sets using eliminators, do not place the C battery on or near the eliminator. Do not let aerial or loop leads come near the tube circuits.

76. HOWLING. If an A. C. receiver howls or squeals for a few seconds after being turned on, the trouble, in the majority of cases, is due to defective tubes. However, where it is certain that the tubes are in first-class condition, the trouble may sometimes be cleared up by reversing the primary of the first audio frequency transformer. At the same time, it might be well to check any fixed condenser across the grids of the power tubes to see that they are in good condition. Always try new tubes first.

77. THE FILAMENT SHOULD BE GROUNDED. If the filament circuit is not grounded, then connect one side to the ground connection. However, before doing this, be absolutely sure that the filament is not grounded through some part of the circuit directly connected to the ground binding post. If you cannot definitely determine whether or not the filament circuit is grounded, then place a .1 mfd. condenser in series with the ground connection to the filament.

78. GRID LEADS TOO LONG. All wires in the grid circuit should be as short as possible and separated at least one inch from plate leads. The grid leads should also be at right angles to the plate leads.

79. SPEAKER TOO CLOSE TO RECEIVER. Built-in speakers often cause continuous howling. Frequently this can be corrected by insulating the speaker from the cabinet with soft rubber sponges. Also see paragraph 32.

80. INDUCTIVE EFFECT FROM AERIAL. Do not allow the aerial lead-in to come close to the detector or R.F. tubes, as this may cause howls and oscillations. This is especially true in very sensitive sets.

81. FADING SIGNALS (NATURAL). This is a natural phenomenon which the use of super-power broadcasting has reduced to a minimum. It is noticeable only on certain stations and nothing can be done to the receiver installations which will correct it. Sometimes nearby stations will fade only at night. Fading is, however, sometimes caused by another aerial in close proximity to the receiving aerial. For this reason, receiving aerials should be placed as far as possible from each other and at right angles to each other.

82. VARIATIONS IN ELECTRIC LIGHT CURRENT. In a few localities light current is very unreliable and may cause excessive hum or fading. In a case of this nature similar results will be had in various installations in the neighborhood. It is obviously impossible to eliminate this trouble by any adjustment of the receiver or speaker when the cause of the trouble is defective current. When this trouble is experienced, get in touch with the Power Company and tell them of your experience. Whenever it is possible to correct these conditions the Power Companies are always glad to do so. Before you complain to the Power Company, however, be sure that the trouble is with the line. Find out whether or not your friends and neighbors have the same trouble and if they do you can be pretty sure the trouble is with the line.

83. TRANSFORMER CENTER TAP INCORRECT. Secondary filament windings on power transformers sometimes have center taps to which the grid-returns are connected. If these taps are not exactly in the center of the winding, then A. C. hum is apt to be present. This trouble is seldom encountered in transformers manufactured by reliable companies. In such cases it is, of course, impractical to reconstruct the transformer. It is possible, however, to use small center-tapped resistances especially built for this purpose. The two ends of the resistance are connected directly across the filament taps on the transformer and the grid-return is connected to the center-tap of the resistance. The center-tap on the transformer is not used and should be disconnected.

84. LACK OF GROUND ON CORE AND CHASSIS. In many receivers A. C. hum is reduced by grounding the cores and shields of choke coils and transformers. If such connections are open or poorly made A. C. hum will result. Carefully inspect all connections and see that they are good and tight.

85. LOOSE LAMINATION IN POWER PACK OR AUDIO TRANSFORMERS. This is usually due to faulty construction and the defective piece of apparatus should be returned to the manufacturer. In some cases the laminations can be tightened by tightening the bolts holding the apparatus together.

86. HUM IN DYNAMIC SPEAKERS. Dynamic speakers require either high or low voltage direct current to excite the field coil. This produces the electromagnetic field necessary for the operation of the speaker. This current is supplied by either a battery, the power supply in the radio receiver or by a rectifier operating directly from the light line. The two latter type of dynamic speakers have the disadvantage, however, in that they produce a slight amount of hum. Under normal conditions, this will not be objectionable but in localities where excessive hum is had, it is advisable to use the magnetic type of speaker in preference to the dynamic speaker.

A 200 microfarad condenser connected across the field of a low voltage (6 volt) field type of speaker will often stop undesirable hum. Do not place such condensers across a high voltage field as the condenser will burn out instantly; use an 8 mmfd. condenser in high voltage speakers which have separate field excitation. Also see paragraph 52.

87. RESONANT EFFECT IN ROOM. You will find that in some installations, the hum will sound very much louder than in others. This may be due entirely to a resonant effect in the room which tends to build up the low notes and make them sound loud in proportion to music or speech. By standing in various parts of the room, you will notice that the hum is louder in some places than others. The only remedy for this condition is to place the instrument in different positions in order to find the one where the best effect is had. Sometimes placing a receiver on a heavy rug will decrease the hum.

88. SENSITIVE DETECTOR TUBE. The UY-227 and UY-224 tubes are extremely sensitive and will pick up hum from any lamp cord or wire carrying alternating current near it. It is extremely important that all wires be kept as far away from this tube as possible. This is especially true of the cords which supply the receiver.

89. RESONANT EFFECT IN CABINETS. A resonant condition may occur in a cabinet which will exaggerate hum. This is most apt to occur when the compartment in which the speaker is placed is entirely closed. When possible, it is therefore advisable to leave the back of the cabinet off entirely. If the speaker is placed on top of the cabinet, trouble is likely to be had, so it is best to place the speaker a short distance from the cabinet.

90. R. F. TUBE OSCILLATING. An obectionable hum can be caused by the R. F. circuit oscillating which is characterized by a loud, steady hum. Taking one of the R. F. tubes out or placing a finger on the tuning condenser plates will locate trouble in the R. F. circuits. See also paragraph 3.

91. INDUCTION FROM NEARBY A. C. LINES. If the aerial or ground wires run close to or parallel with any wire carrying alternating current, an A. C. hum will be present. Run all such wires as far from the A. C. line as possible and perpendicular to the A. C. lines if possible.

Likewise, any wires carrying alternating current that are in close proximity to the receiver or speaker may cause interference. Keep such wires as far as possible from all radio circuits, especially the detector circuit.

92. GRID BIAS RESISTANCE BY-PASS CONDENSER. By-pass condensers connected across the grid bias resistors should be tested the same as any other condensers. (See paragraph No. 23.) An open condenser or one of incorrect value may cause an A. C. hum. These condensers are not always used and it is sometimes possible to eliminate A. C. hum by the addition of such a condenser.

93. A. C. PLUG REVERSED. An A. C. hum can sometimes be reduced by placing two 2 mfd. condensers in series across a line and grounding the midpoint. These condensers should be capable of withstanding 600 volts.

94. RECTIFIER CONDENSER IN LOUDSPEAKER. A defective condenser across the output of a rectifying unit used in some types of dynamic speakers will cause a hum. This condenser should be tested and replaced if found defective. See paragraph 23.

95. HUM LOCALIZING. In addition to the paragraphs just given on HUM the following information will be useful for locating this trouble. It is essential to isolate the source of hum before attempting to reduce it. Short-circuiting the first A.F. grid to the ground will stop the hum if it is coming from the detector tube. Shorting across the primary of the second A.F. transformer will stop hum originating in the first A.F. stage or ahead of it. Shorting across the grids of both power tubes in a push-pull amplifier will stop all hum starting in the input audio transformer or in the circuit ahead of it. If the total hum is made up of a number of smaller ones throughout the circuit, it may be due to a defective speaker field coil, filter choke or center tap resistance. It is very rarely due to the condenser block.

96. WAVE TRAP NECESSARY. On some sets, interference and broad tuning can be eliminated by the use of a wave trap which can be made by using an ordinary R.F. transformer with a variable condenser of the proper capacity (usually .0005 mfd.) connected across the secondary; the primary of the transformer should be connected in the antenna circuit. This will help tune out undesired signals.

97. HIGH RESISTANCE IN GRID CIRCUIT. A high resistance joint in the grid circuit of any radio frequency stage will tend to make that stage tune broad. Make sure that all joints are well made.

98. ROTOR PLATES OF CONDENSER MAKING POOR CONTACT. Poor contact is sometimes made between the variable condenser frame of the rotor plates due to the lack of tension spring clips or pigtail conections. See that all such connections are tight. Also see 43.

99. NOISY RESISTORS IN POWER PACK. This trouble can be generally located only by substituting a resistance known to be in good condition, or by the use of laboratory instruments. See pars. 43, 56 and 61.

100. DEFECTIVE R.F. CONDENSERS. Oscillation may be caused by an open R.F. by-pass condenser. The connections to these parts should be thoroughly inspected. An open condenser may be easily found by connecting a .5 mfd. condenser known to be good across the terminals of any condenser to be tested. This should be done when the set is turned on and adjusted to oscillate. The testing condenser is momentarily placed across each of the radio frequency by-pass condensers, a defective condenser being indicated when the test stops or reduces oscillation.

101. TOO HIGH SCREEN VOLTAGE. Too high a voltage applied to the screen grid of screen grid tubes will often cause the tube to oscillate. This can be eliminated by placing a resistance in series with this circuit, thus cutting down the voltage applied to the screen grid. This should not be attempted unless all other means of keeping the tube from oscillating have been ineffective.

102. LINE VOLTAGE D. C. INSTEAD OF A. C. Never connect an alternating current receiver to a direct current line or a receiver designed for 60 cycle alternating current to a 25 cycle A. C. supply; there is great danger of burning out the power pack of the receiver. If you do not obtain a reading on a high resistance voltmeter which is connected across the line the current is alternating.

103. OSCILLATOR TUBE NOT FUNCTIONING PROPERLY. One of the simplest tests is to touch the grid terminal of the oscillator tube socket with a moist finger. A click in the loudspeaker should result when the terminal is touched and also when the finger is removed; if only one click is heard, the tube is not oscillating. Another test is to tune in a station and pull out the oscillator tube. If the signal can still be heard, the oscillator tube is not functioning.

104. INTERMEDIATE FREQUENCY TRANSFORMERS NOT CORRECTLY ADJUSTED. It is essential that the intermediate frequency transformers be accurately and properly adjusted if long distance reception and good selectivity is desired. In the majority of cases poor selectivity in a superheterodyne receiver is the direct result of the intermediate frequency transformer not being properly matched. This requires the use of a special oscillator adjusted to the particular frequency of the intermediate frequency amplifier and can only be carried on by those service stations which are especially equipped for such work. This adjustment is made by varying the capacity of small variable condensers across the intermediate frequency transformers until the signal from the oscillator, as indicated by a meter placed in the second detector plate circuit, is greatest. This is very similar to adjustment of the regular radio frequency stages of a tuned R.F. receiver. In such cases special service information should be obtained from the manufacturer of the receiver.

105. ADJUSTMENT OF RADIO FREQUENCY COMPENSATING CONDENSERS. The adjustment of these condensers should not be changed unless you are positive that they need adjusting. The exact procedure in making these adjustments depends upon the type of receiver. The adjustment generally consists of varying a small condenser placed in the circuit unit until the loudest signals are received and the receiver does not oscillate. Complete information should be obtained from the manufacturer of the set.

106. ADJUSTMENT OF OSCILLATOR TRIMMING CONDENSER. The correct adjustment of these condensers requires the use of a modulated oscillator. The exact procedure to follow depends on the type of receiver being serviced. On modern receivers there are generally two such trimming condensers; one for the high frequencies and the other for the lower broadcast frequencies. They are used so that the oscillator can be kept "in step" with the tuning unit, thus securing one dial tuning effect. Complete instructions on this subject can be obtained from the manufacturer of the particular receiver you are servicing.

DX Aids

Fundamentals of Short-Wave Radio

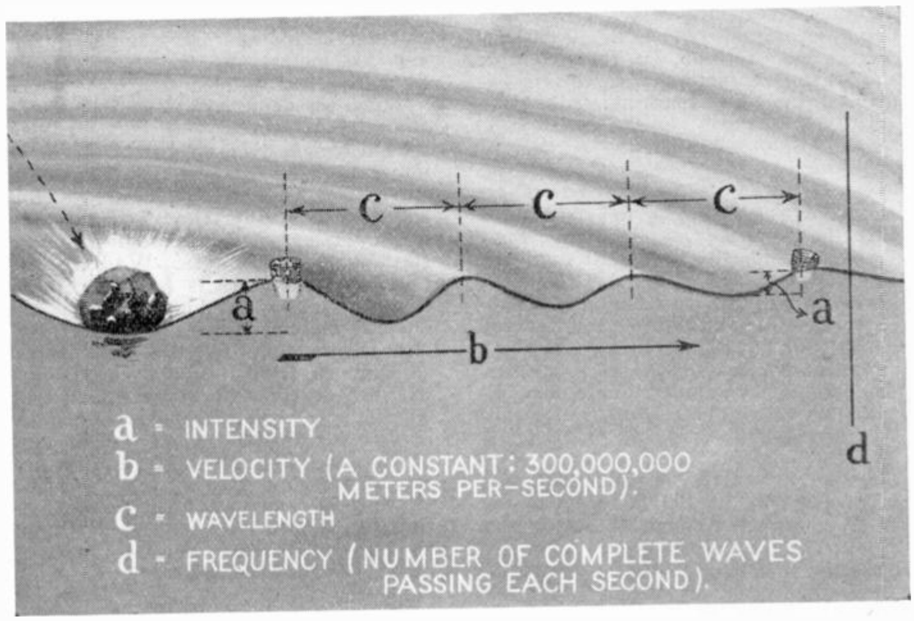


Figure 72

IN speaking of short waves—or long waves, for that matter—it is a good idea to have some definite conception of just what a *wave* is. The short-wave beginner, who is probably a broadcast enthusiast, is familiar with the term wavelength; but it usually means nothing more to him than a secondary identification of different stations. It would help a little, even in the operation of a broadcast receiver, if wavelengths held, for the operator, a bit more significance than the mere etching on a tuning dial. And in short-wave reception it is definitely desirable that operation be assisted by an intelligent appreciation of what wavelengths are and how they affect reception.

We are all familiar with wave-forms of some type or another: ripples on the water, the visible waves of a vibrating string and the wavy convolutions of a rope when it is "snaked." These are all illustrative of the general principle, and the water-wave picture (Figure 72) has often been evoked to create, in the non-technical mind, a conception of radio waves. When a stone is cast into a pond, visible water waves are set up and travel in all directions from the point where the stone went down—in a manner somewhat similar to the way radio waves travel from the antenna of a wireless transmitting station. (Wireless, by the way, is exactly the same as radio.) This analogy has been objected to by technical purists on two grounds. First, it shows only a two-dimensional wave—on the surface of the water—while a radio wave leaves the antenna in all directions (up and down as well as horizontal), more after the manner of the gases leaving a bursting shell. Secondly, it presupposes the existence of some medium (analogous to water) in which the waves may travel, which, up until recent years, had been called the "ether." Recent investigations by Einstein, Morley and Michelson have thrown considerable doubt on the reality of this ether, and they prefer to consider the waves as undulations in an energy field created simultaneously with the wave motion. However, be all this as it may, the water analogy creates the most substantial idea of wave action, and we shall stick to it.

All wave-motion has four predominant characteristics: *intensity, velocity, wavelength* and *frequency*. Wavelength and frequency, as will be seen, are closely interrelated. In the water wave there is a vertical distance between the crests of the waves and the troughs. This corresponds to *intensity* in a radio wave. Close to where the stone strikes the water (the transmitting aerial), a cork will bob up and down through a greater vertical distance (a strong signal) than it will twenty feet farther away (a weak signal). The waves recede from the point of generation at a certain *velocity* which—to keep as close to radio as possible—can be measured in *meters per second.*

The distance between two adjacent crests (or any similar points on successive waves) is considered the *length of the wave*—or *wavelength*. The number of waves which pass a given point in a given period of time (in radio a second is taken as the unit of time) is the *frequency*. As the action effected on the cork, when the water wave slides under it from crest to crest, completes one cycle of up-and-down motion, the phrase *frequency in cycles per second* is often employed, and words *frequency* and *cycles* are loosely synonymous.

It is obvious that if the *velocity* is constant and the *wavelength* shortened, the *frequency* must increase. For instance, let us assume a water velocity of ten meters per second, and a distance between crests of two meters. In one second five of these crests will have passed our cork (or receiver), which will have gone through five up-

Figure 73

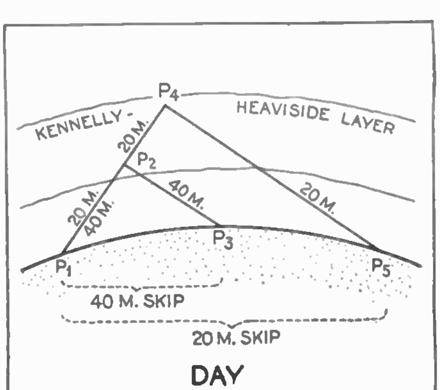
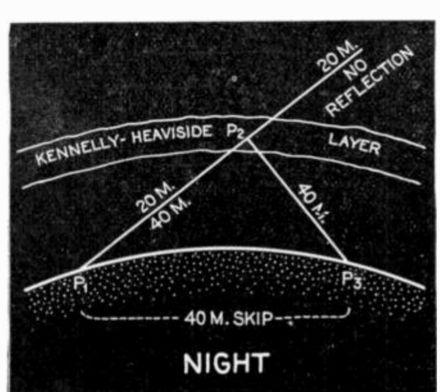


Figure 74



and-down cycles in that period. In other words, the frequency is five cycles per second. If now we shorten the wavelength to one meter (maintaining the same ten-meter-per-second velocity), the cork will go through ten cycles per second and our frequency will have been doubled.

Wavelength Frequency

This illustrates the important relationship between wavelength and frequency. When the wavelength is lengthened, the frequency becomes lower, and vice versa. The *frequency* is always equal to the *velocity divided by the wavelength*, and the *wavelength* equals the *velocity divided by frequency*. This assumes a constant velocity, which, in the case of radio waves, is 300,000,000 meters per second. In the scientific short-hand of mathematics this is expressed by the equations:

$$\lambda = \frac{v}{f} \text{ and } f = \frac{v}{\lambda}$$

—where v = *velocity* in *meters per second*, λ = *wavelength* in *meters* and f is the *frequency in cycles per second*.

It is generally accepted that the short waves are those between the lower end of the conventional broadcast band, at 200 meters, and the top of the ultra-short-wave region which starts, on the way down, at 10 meters. The frequency of 200 meters is 1,500,000 cycles per second, and that corresponding to 10 meters, is 30,000,000 cycles per second. The short-wave field therefore encompasses a wave spread of 190 meters and the vastly larger frequency band (or spectra) of 28,500,000 cycles.

As the wavelength drops, the increasing frequency in cycles-per-second becomes a clumsy figure to handle. Even on the broadcast band the *unit of one thousand cycles*, the *kilocycle*, or "kc" is more convenient. Below 100 meters the kilocycle in turn becomes cumbersome and the *megacycle*, "mc," takes its place. One megacycle equals 1,000 kilocycles and 1,000,000 cycles.

While frequency and wavelength necessarily go hand in hand, the former quality is the more important from the standpoint of convenience in analyzing radio phenomena.

For example, the majority of engineers are agreed that all radio-telephone stations within interfering distance at the point of reception should be separated by a frequency band or spectrum, 10,000 cycles (10 kc.) wide, to prevent cross-talk and whistles. In other words, using a highly sensitive receiver, all stations within a thousand-mile radius should not be placed closer together than 10,000 cycles (10 kc.)—i.e., one station for each 10 kilocycles in the band allocated for broadcasting. If we want to find out how many such stations there is room for between 100 and 200 meters, we shall first have to change to frequency—3,000,000 (3 mc.) and 1,500,000 cycles (1.5 mc.), respectively—and establish the width of the band in frequency. Subtracting the latter figure from the former, we find that between 100 and 200 meters there is a frequency band 1,500,000 cycles wide. Dividing this by 10,000 (10 kc.), we determine that there is room for exactly 150 stations within interfering distance of each other. The reader must *not* jump to the conclusion that *there is room for* 150 *stations*

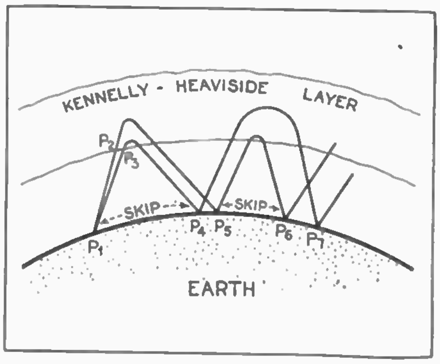


Figure 76

for every 100 *meters!* Making a similar calculation for the band between 200 and 300 meters, *we find room for only* 50 *stations!*

Thus we demonstrate both the desirability of dealing with cycles rather than wavelengths, and one of the most important advantages of the short waves—or high frequencies. As the wavelength is shortened and the frequency rises, there is room for *more* stations per wavelength. We have just observed that there is room for three times as many stations between 100 and 200 meters as there is between 200 and 300 meters. There is *ideal etheric space* for just 100 stations over the entire broadcast band between 200 and 600 meters, while the short-wave spectra, from 10 to 200 meters, will accommodate 2850 stations! Figure 77 shows this graphically.

Thus the short waves have been enthusiastically proposed as the solution to the congested conditions existing on the air.

Skip-Distance Effect

The multiplicity of available channels, however, is by no means the sole advantage of short-wave communication. The fact that extremely long distances can be spanned at a great economy of power contributes the real commercial utility of the high frequencies. This characteristic of short-wave transmission is due to the *skip-distance effect*.

The phrase "skip-distance effect" is accurately descriptive of the phenomenon. A station broadcasting in New York City on about 30 meters (10 mc.) will be heard locally, on a direct *ground wave* (wave following the ground), within a radius of some twenty-five miles—the signal rapidly becoming weaker as this limit is approached. Outside of this zone, for a skip-distance of approximately one thousand miles, the signal cannot be heard, while at Chicago excellent reception may be had. Proceeding westward, the signal disappears, to pop up again at Salt Lake City. Approaching the Rockies, it is lost once more.

The skip-distance effect is a reflection phenomenon caused by an ionized stratum of rarified air—possibly a hundred or so miles up. It is known as the *Kennelly-Heaviside layer*, after the American and British scientists whose research demonstrated the manner in which these effects are produced.

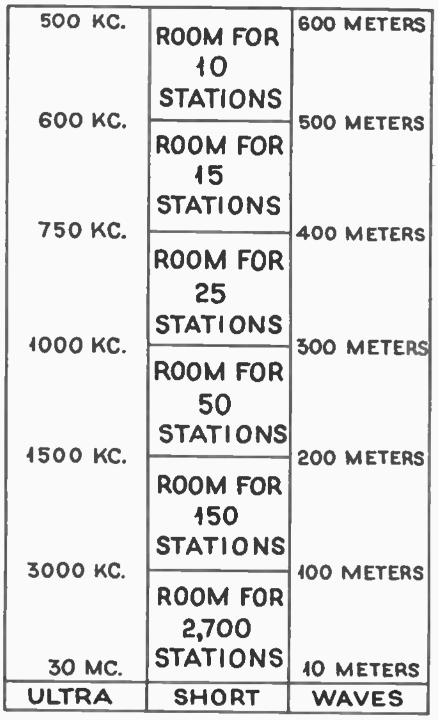
The term *ionized* describes an electrified condition of a gas or liquid. The state of ionization can be produced artificially in many ways, and the red neon light signs are an example of its commercial application. In the upper strata of our atmosphere it is thought to be induced by solar radiation, and often becomes visible as the Aurora Borealis. The Kennelly-Heaviside layer acts as a *reflector* of radio waves—sending them back to the earth at a point far beyond the local area serviced by the ground wave. The earth itself functions as a mirror to a high-frequency signal, shooting it skyward again for another skip—the phenomenon being repeated until the wave is attenuated into oblivion (dies out). Only the first two, three or four skips are usually of communication utility.

The drawing of Figure 76 presents a graphic conception of the skip-distance effect. A signal starting at point P_1 fans out after the manner of any radiated wave, entering the Kennelly-Heaviside layer between points (P_2 and P_3). The spreading effect is increased during reflection, due to the fact that reflection is diffuse rather than sharp—being gradual as the signal enters the layer. The signal returns to the earth and may be heard between points P_4 and P_5. The phenomenon is repeated and the signal may again be received over an increased area limited by P_6 and P_7.

It is obvious that the higher the point of reflection the greater will be the skip-distance. In other words, the skip-distance is a function of the depth to which the signal penetrates the layer before being sent back to the earth, which in turn depends upon the frequency or wavelength. Variation in penetrating power with wavelength is a familiar optical phenomenon. For instance if we increase *light* frequency sufficiently, far beyond the visible portion of the spectrum, we have the X-ray which passes readily through opaque substances.

Below 10 meters, the penetration is so great, that the radio signal *passes through* the ionized layer. There is then no reflection and communication

Figure 77



seems to be ordinarily limited to the range of the direct ground wave.

It is obvious that the skip-distance will be influenced by the height and density (or thickness) of the Kennelly-Heaviside stratum. As this is the result of solar emanation, it follows that its characteristics will change from day to night and with seasonal variations, accounting for the difference in reception *before* and *after* dark, and between *summer* and *winter* results.

Day and Night Effects

At night the earth's shadow prevents the ionization of the lower part of the layer. Thus the layer is much thinner and its average height is increased. The very high frequencies that were reflected over great distances during the day now penetrate through the layer into inter-stellar space and are lost as far as earthly reception is concerned. But the lower frequencies, which were relatively ineffective in day time, now skip across the continent by virtue of the higher reflector, as shown in Figures 73 and 74.

The skip-distance effect contributes its greatest utility below 60 meters (5 mc). At 50 meters (6 mc) the ground range, day and night skip-distances are all about 50 miles. At 40 meters (7.5 mc) the ground range is approximately 40 miles, the day skip-distance is 150 miles and the night skip is about 300 to 400 miles. Dropping to 30 meters (10 mc), our ground range is limited to 35 miles, the day skip-distance has jumped to 250 miles and the night span to 500 miles. At 20 meters (15 mc) we are at the tail-end of night reflection, but we have a daytime skip-distance of around 550 miles and a ground mileage of 25 or thereabouts. Just above the ultra-short-wave region, the local range is 10 miles and the sunlight skip-distance well over 1,000 miles. There is, of course, no night reflection.

Summing it all up, our best short-wave reception will be had between 10 and 30 meters (30-10 mc) during the day, and between 30 and 50 meters (10-6 mc) at night. As may be imagined, the Kennelly-Heaviside layer is in a state of more or less constant motion (agitation), resulting in slow and rapid shifts of the reflected beam, giving rise to the phenomenon we know as *fading*.

International Call Letters

CALL letters of code stations as well as broadcasters heard are of special interest to the short-wave fan because from these it is possible to tell the nationality of the transmitter. Thus any call beginning with K, N or W indicates a station in the United States, its territories or its ships. The larger countries of the world have similar assignments: G for Great Britain; F for France, D for Germany, etc. Smaller countries with fewer transmitters have more limited assignments. Morocco, for instance, is assigned all calls which employ CN as the first two letters. The list of these "International Call Letter Assignments" is given below.

In code transmission the call letters are always preceded by — . . . (de). The letters of the station called are usually repeated 3 times, followed by the letters of the caller, also repeated 3 times, thus: XAB, XAB, XAB de KNL, KNL, KNL, would indicate a U. S. Station calling a Mexican station.

Inasmuch as c.w. (code) transmissions carry further than 'phone or broadcast signals, and as many c.w. stations employ high power, it is possible to log many countries in this way, who either do not have broadcast transmitters or whose broadcast transmitters do not reach out.

Call Signal	Country
CAA-CEZ	Chile
CFA-CKZ	Canada
CLA-CMZ	Cuba
CNA-CNZ	Morocco
COA-COZ	Cuba
CPA-CPZ	Bolivia
CQA-CRZ	Portuguese Colonies
CSA-CUZ	Portugal
CVA-CXZ	Uruguay
CYA-CZZ	Canada
D	Germany
EAA-EHZ	Spain
EIA-EIZ	Irish Free State
ELA-ELZ	Liberia
EPA-EQZ	Persia
ESA-ESZ	Estonia
ETA-ETZ	Ethiopia
EZA-EZZ	Territory of the Saar
F	France and colonies and protectorates
G	Great Britain
HAA-HAZ	Hungary
HBA-HBZ	Switzerland
HCA-HCZ	Ecuador
HHA-HHZ	Haiti
HIA-HIZ	Dominican Republic
HJA-HKZ	Colombia
HPA-HPZ	Republic of Panama
HRA-HRZ	Honduras
HSA-HSZ	Siam
HVA-HVZ	Vatican City
HZA-HZZ	Saudi Arabia
I	Italy and colonies
J	Japan
K	United States of America
LAA-LNZ	Norway
LOA-LWZ	Argentina
LXA-LXZ	Luxemburg
LYA-LYZ	Lithuania
LZA-LZZ	Bulgaria
M	Great Britain
N	United States of America
OAA-OCZ	Peru
OEA-OEZ	Austria
OFA-OHZ, OIA-OJZ	Finland
OKA-OKZ	Czechoslovakia
ONA-OTZ	Belgium and colonies
OUA-OZZ	Denmark
PAA-PIZ	Netherlands
PJA-PJZ	Curacao
PKA-POZ	Dutch East Indies
PPA-PYZ	Brazil
PZA-PZZ	Surinam
Q	(abbreviations)
R	U. S. S. R.
SAA-SMZ	Sweden
SOA-SRZ	Poland
SSA-SSZ, STA-SUZ	Egypt
SVA-SZZ	Greece
TAA-TCZ	Turkey
TFA-TFZ	Iceland
TGA-TGZ	Guatemala
TIA-TIZ	Costa Rica
TKA-TZZ	France and Colonies and Protectorates
U	U. S. S. R.
VAA-VGZ	Canada
VHA-VMZ	Australia
VOA-VOZ	Newfoundland
VPA-VSZ	British colonies and protectorates
VTA-VWZ	British India
VXA-VYZ	Canada
W	United States of America
XAA-XFZ	Mexico
XGA-XUZ	China
XYA-XZZ	British India
YAA-YAZ	Afghanistan
YBA-YHZ	Dutch East Indies
YIA-YIZ	Iraq
YJA-YJZ	New Hebrides
YLA-YLZ	Latvia
YMA-YMZ	Free City of Danzig
YNA-YNZ	Nicaragua
YOA-YRZ	Roumania
YSA-YSZ	Republic of El Salvador
YTA-YUZ	Yugoslavia
YVA-YWZ	Venezuela
ZAA-ZAZ	Albania
ZBA-ZJZ	British colonies and protectorates
ZKA-ZMZ	New Zealand
ZPA-ZPZ	Paraguay
ZSA-ZUZ	Union of South Africa
ZVA-ZZZ	Brazil

Foreign Broadcast DX'ing

IS it necessary for the listener to have special receivers and aerials for this long wave reception? Absolutely not. A super is of course needed to receive Europeans before 1:00 a.m., due to interference from locals.

Slightly better signals can be obtained by using directive antennas, but with the modern supers little important advantage is gained through their use.

Successful broadcast band DX'ing to the extent mentioned, depends on several factors. You must know where to look for the stations, what time they start transmission and how they are identified. If a few words of the language of each country is not known, then you must at least know what their announcements sound like. For the benefit of those wishing to try their luck on long wave DX'ing, we list a few of the better heard Europeans, giving the time they start and how they announce.

At midnight tune to 904 kc. and wait for Hamburg to begin. A man will announce first, "Ach-toong, ach-toong, here Hamboerg." This station can be heard until as late as 2:30 a.m. Cologne, Germany, on 658 kc. is another well heard. Their announcements sound like this: "Ach-toong, here vestdoy-tcher Roondfoonk." Transmissions begin at 12:30 a.m., but due to interference from WEAF, it is well to wait until after 1. Berlin on 841 starting at 12:30 a.m. with gym class is perhaps the easiest of the German to identify. Their announcements are "Ach-toong, here Bear-leen." Between announcements you may hear a few notes from a music box. Budapest is another well heard here. Transmissions begin at 12:45 a.m. and can be identified by the lady announcing, "Allo, here Budapest." Budapest leaves the air at 1:15 a.m. Turin, Italy, I1TO, on 1140, is the best of the Italians, with announcements starting off something like this, "e-yahh rah-de-o nord e-tal-eya Tor-ino."

The easiest of all Europeans to identify and the best heard, is Poste Parisien in Paris, on 959 kc. Their transmission begins at 2:10 a.m. each week day. At 2:10 sharp, you will first hear a bugle blowing reveille. This is repeated twice, with drums coming in on the third time. Our announcement follows, always by a man: "Allo, allo, Poste Pare-ree-sun." One more of the Europeans and we will have finished with them. This is Prague on 638 kc., who comes on at midnight. Their announcements are simply: "Here Praha."

For those wishing South American reception a few tips will be given of the stations that are being received right now. LS2 on 1190 kc. is heard between 7 and 8:30 p.m. YV1RC on 960 kc. is heard best at 7 p.m. TGW on 665 kc. has a special DX transmission each Sunday morning after 2 a.m. HHK, Port au Prince, Haiti, on 920 kc., can be heard each Friday evening between 7:30 and 8:30 p.m. And last, LR4 on 990 kc. when WBZ fades and LR3 on 950 when WRC fades.

The Australians can be received quite easily during the spring and autumn months. To hear these the best time is from 5 a.m. until after daylight. 2BL, Sydney, on 855 kc., is perhaps the best heard on this coast. 3LO, Melbourne, on 800, 5CK, Crystalbrook, on 635, and 2UE, Sydney, on 1025, are others that are heard well.

Comparing this to short-wave reception, many radio fans say there are more thrills on the broadcast band, for the simple reason there are so many new places that one can hear. Every country in Europe that has a short-wave station can be logged on the broadcast band and in addition such countries as Hungary, Ireland, Scotland, Austria, Czechoslovakia, Denmark, and others.

To assist broadcast-band DX'ers in getting foreign stations, RADIO NEWS publishes an up-to-date time table in each issue. This list is compiled by official Broadcast Band Listening Post observers located thruout the world.

Also of considerable value is the station list which appears at the end of this book.

"Double-Doublet" Antenna System

THE only principle which has been successfully employed at the receiver for the reduction of "man-made" static is to locate the antenna in a comparatively noise-free area and to employ a lead-in of such a type that pick-up by the lead-in is eliminated. There are two general types of such lead-ins—the shielded lead-in and the balanced transposed line. Experience, in most cases, shows the shielded line to be unsuitable for high frequencies. The balanced line, however, is eminently suitable for many reasons. When used in conjunction with a well-designed transformer at the set, the pick-up on the line is almost completely eliminated. No grounding is necessary and losses are practically negligible if the design is right.

In designing the line the space between the wires and the size of the wires is important. The farther apart they are, and the smaller they are, the higher is the characteristic impedance of the line. If a line is terminated at each end with its characteristic impedance, its transmission is nearly constant at all frequencies. However, when the terminating impedances are widely different from the proper value, the transmission effectiveness varies greatly with frequency, the curve passing through a series of peaks and valleys corresponding to resonance points in the line.

For the RCA "World-Wide" antenna system a line having 180 ohms impedance was chosen because this value is about the average input impedance of most short-wave receivers and because it is about the average impedance of the "double-doublet" antenna over the short-wave frequency spectrum.

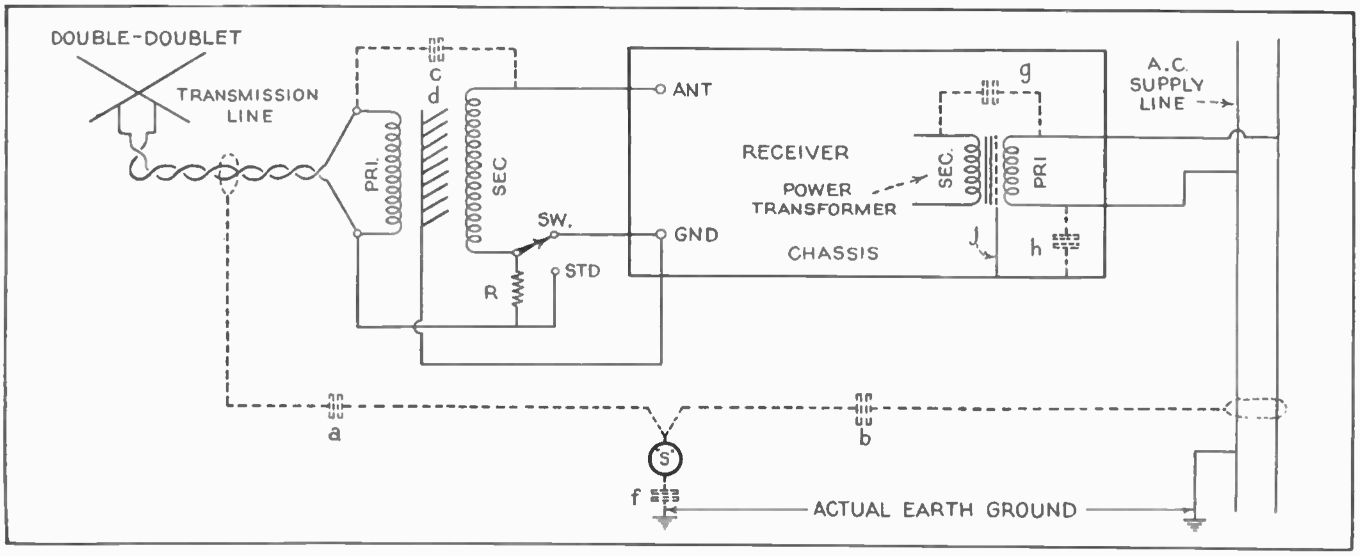
Because the antenna does not represent an impedance exactly equal to the line impedance at all frequencies, the transmission curve does have a series of minor peaks and valleys, varying in efficiency two or three to one. The line length was adjusted experimentally by throwing short lengths in and out of the circuit until a length was found such that a transmission peak occurred at each of the important short-wave broadcast bands.

Mechanically, the line consists of a rubber-covered, twisted pair, with stranded, tinned copper wire for each conductor. After many tests, special submarine cable rubber was specified for insulation of the transmission line, due to its low losses and long life. While twisted pair was indicated to produce a line of the proper impedance, it was also important that the wires be close together with frequent transpositions to effectively balance out any pick-up.

In order to keep the losses low when

(*Continued on Page* 44)

Figure 84



World Time Conversion Chart

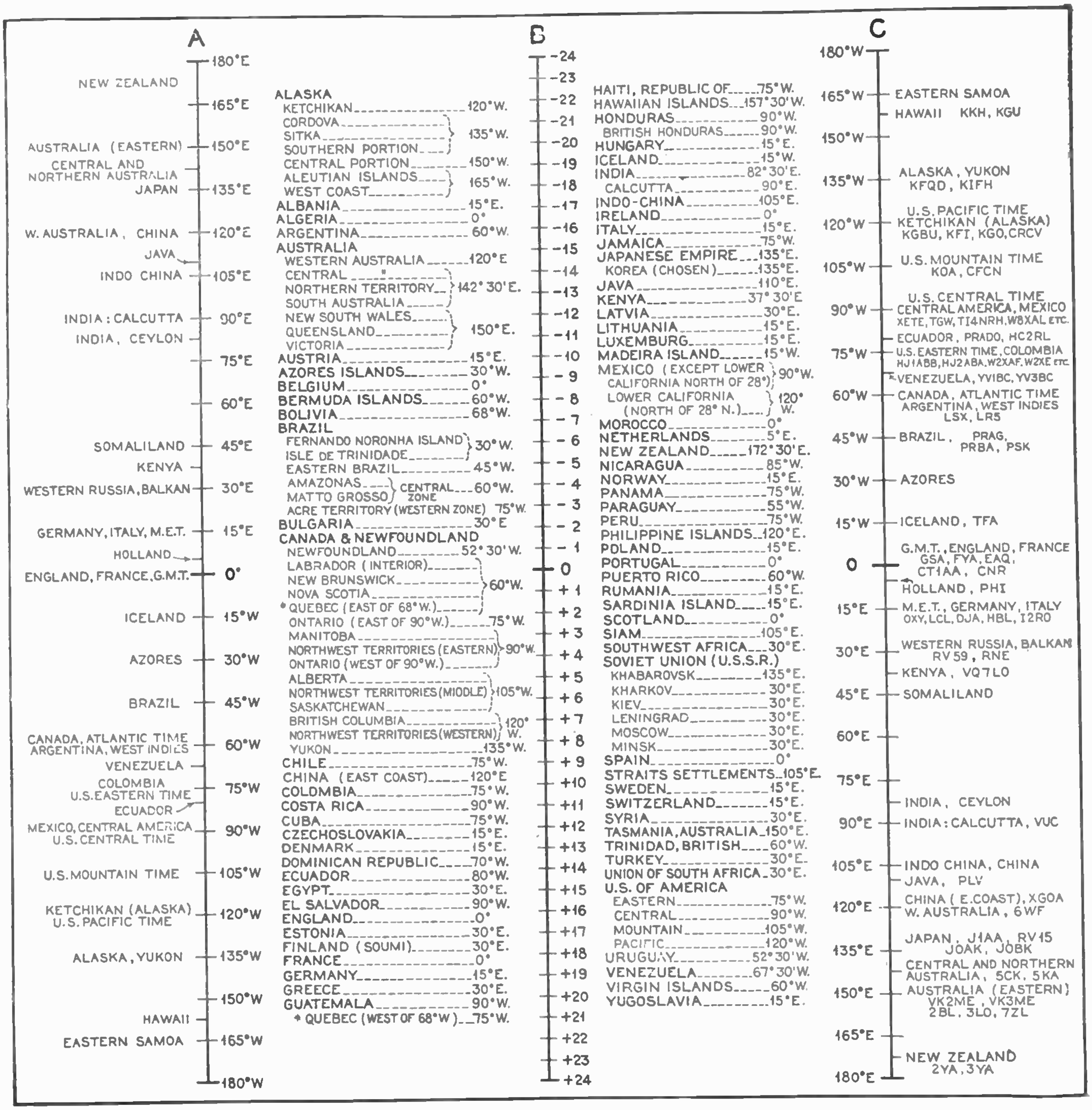


Figure 78

FIRST locate your country, or your section of your country, in the alphabetical list in Figure 78 to find its longitude. Then locate this longitude on line A. Next consult the alphabetical list to determine the longitude of the country whose time you want to find, and locate this longitude on line C. Now lay a ruler or other straightedge across the chart so that it connects these two points on lines A and C. The point at which it crosses line B shows the time difference between these points. If the hour is preceded by a plus sign, add this figure to the time in your locality. If a minus sign is shown, deduct the hours

The following concrete example will illustrate the simplicity of the procedure: Suppose a New York City listener wants to determine the time in New Zealand. He first consults the list (U. S. A.—Eastern Time) and finds his longitude to be 75 degrees West. This he locates on line A. He again consults the list and finds the longitude of New Zealand to be 172 degrees, 30 minutes East (60 minutes equals 1 degree, therefore New Zealand lies 172½ degrees, East). This point is then located on line C. A ruler laid across the chart to connect 75 on line A with 172½ on line C intersects line B at plus 16½ hours. He therefore adds this number of hours to his own time to find the corresponding New Zealand time. Thus if it is 9 a.m. in New York, he finds that in New Zealand the clock shows 1:30 a.m. of the next day.

From the foregoing it is evident that the use of this chart represents an utterly simple method of accurately determining the time in any part of the world, corresponding with that in any other part. If desired, a strip of cardboard may be employed in place of a ruler, pivoting one end on line A in a position corresponding to one's own location so that the straightedge may be swung through an arc sufficiently long to reach all points on line C. This will still further simplify the use of the chart.

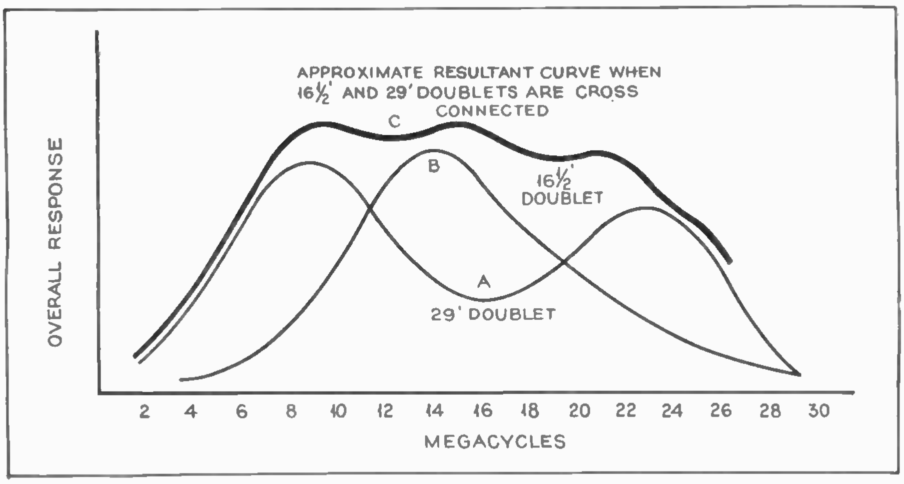


Figure 82

The "Double-Doublet" Antenna

(*Continued from Page* 42)

the line is wet, it is important that no cotton be used as insulation. Even when a cotton wrap is well impregnated, the impregnating material soon evaporates and moisture then gets in, increasing the line losses.

It is well known that a half-wave doublet is an efficient collector of short-wave signals. However, it is at its best only at or near its resonance point. Obviously, if two dissimilar doublets can be connected to the same transmission line without either harming the performance of the other, the overall performance of the combination will be better over a wider range of frequencies than that of a single doublet.

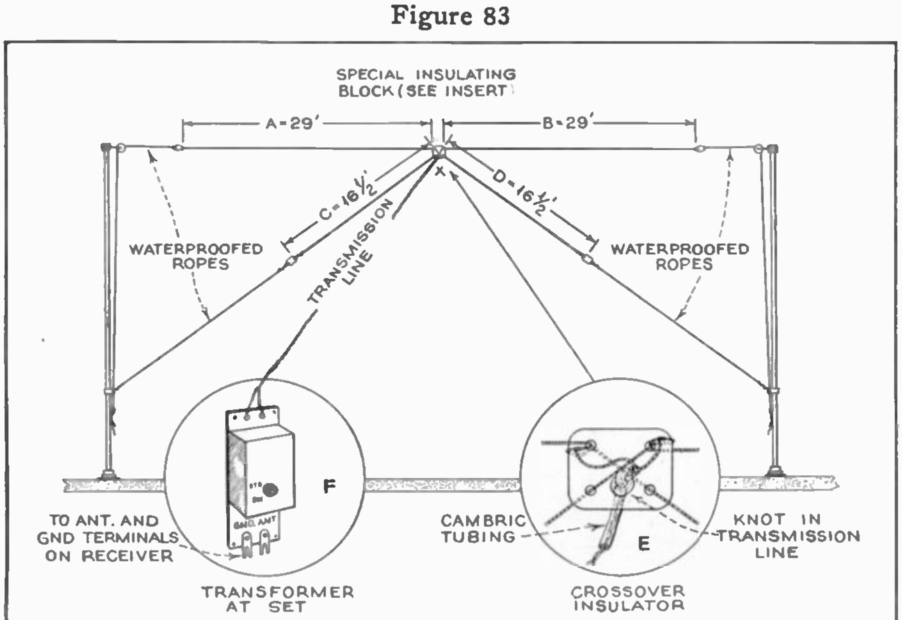
The secret of the "double-doublet" is the much discussed "cross-connection." That is, the left arm on the longer doublet connects to the same side of the transmission line as the right arm on the short doublet (see Figure 83). The connection must be made in this way in order for the output of the short doublet to be additive to the output of the long doublet at a frequency midway between their resonance points.

In order to understand this apparent paradox, consider the fact that the long and short arms connected to a given side of the line form a single, nearly straight wire which is resonant in the half-wave "node" at the frequency mentioned.

At the frequency of the resonance of either the long or the short doublet, the impedance of the antenna system is somewhat lower than the line impedance. Thus it can be seen that the line impedance chosen is a good compromise value. The performance of the "double-doublet" is compared to that of single doublets in the curves of Figure 82.

The long doublet is resonant in the half-wave node at about 8 mc. and in the 3/2 node at 24 mc., as in Curve (A), Figure 82. The short doublet is resonant at about 14 mc., Curve (B). The response of the combination is relatively flat over the important part of the short-wave spectrum, as in Curve (C).

Figure 83



The Coupling Transformer

The noise-eliminating feature of the system depends entirely on the design of the transformer which couples the line to the set. The purpose of this transformer. "Out-of-phase" signals signals while transmitting out-of-phase signals. The expression "in phase" means that the voltages of the two sides of the line go positive together and then go negative together. Obviously, this type of signal will produce no current in the primary of the are those which cause one side of the line to go negative when the other goes positive and then reverse. This type of signal does produce primary current. The mere presence of a transformer does not eliminate the in-phase signals (or noise), because if there is capacity coupling, the noise will be transmitted to the set through that capacity.

In the transformer under discussion a special and highly efficient static shield (Figure 84 [d]) is used to completely eliminate capacity coupling. As a result, the in-phase signals and noise picked up by the line are eliminated while the out-of-phase signals picked up by the antenna are transmitted to the receiver.

The circuit diagram of the complete antenna system connected to a receiver is shown in Figure 84.

When the switch is on position marked "SW," operation is as described above. When the switch is on "STD" position, the antenna and lead-in both act as antenna, and it is so used for broadcast-band reception.

A resistor (R) is connected from one side of the primary to ground to prevent the antenna system from collecting a high potential and sparking to ground, which would cause disturbing and periodic clicks in the receiver.

When choosing a noise-free area to locate the "double-doublet" antenna it is well to keep in mind the generally accepted theory that the strength of noise interference varies inversely as the square of the distance from the source of noise. Since the signal strength of the received broadcast signal is usually considered to increase in a direct proportion to the height above ground, it is recommended that the antenna be installed as high as possible.

On the short-wave signals originating at relatively short distances from the receiver it is often found with this antenna system that greater signal strength is obtained with the "SW-STD" switch in the "STD" position. This is to be expected, as the signal being received is probably the ground wave (that portion of the transmission vertical polarized) rather than the sky wave. The ground wave does not develop much signal voltage in the "double-doublet" but does develop a voltage on the transmission line. Thus since both "in phase" and "out of phase" signals are transmitted with the switch in the "STD" position, greater signals are received from the local short-wave broadcasting station at this "STD" position.

The receiver coupling transformer of the system described here eliminates automobile ignition noise almost com-

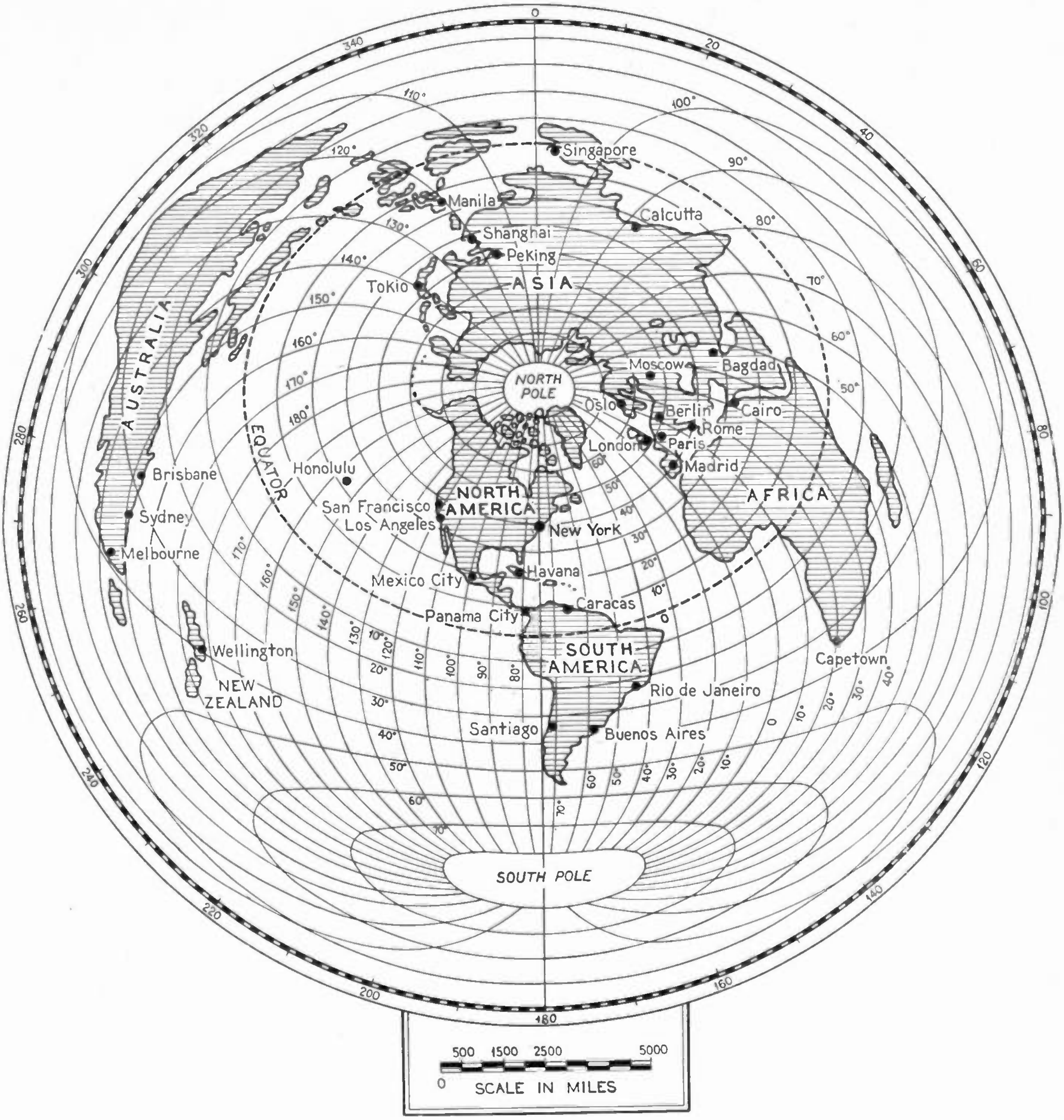


Figure 79—See Page 46

pletely. This can best be explained by the following paragraphs and illustrations by again referring to Figure 84.

"S" represents a signal generator such as a source of auto-ignition noise. (a) represents the capacity coupling from "S" to the transmission line. (b) represents the capacity coupling from "S" to the power supply line. (h) represents the capacity coupling from one side of the power supply line to the metal chassis. (f) represents the capacity coupling from "S" to actual earth ground.

(A) The noise voltage that would be induced by capacity coupling (a) into the transmission line would correspond to an "in-phase" signal and therefore would be coupled or fed through to the secondary of the receiver coupling transformer by the capacity (c) if this capacity were not eliminated by the special and highly efficient electrostatic shield (d). If it were not for shield (d) a noise voltage would be developed across "ant" and "gnd" of the receiver due to a completed circuit from "gnd" to chassis frame through (h) to the power supply line which is usually grounded on one side, and thence back to "S" through (f).

(B) The noise voltage that would be induced by capacity coupling (b) causes current to flow through the power transformer and develop a noise voltage from ground to the chassis through capacity (h). If no receiver coupling transformer were used this voltage would occur across the input terminals of the receiver and hence cause noise. When the antenna system includes a receiver-coupling transformer this voltage occurs between the primary and the electrostatic shield since capacity (c) has been eliminated. However, this does not produce primary current. Therefore this noise voltage does not induce a voltage in the transformer secondary.

(C) The electrostatic shield (j) provided with most power transformers serves to offset the capacity coupling (g) and thus prevents the introduction of r.f. noise voltages into the voltage supply of the receiver directly.

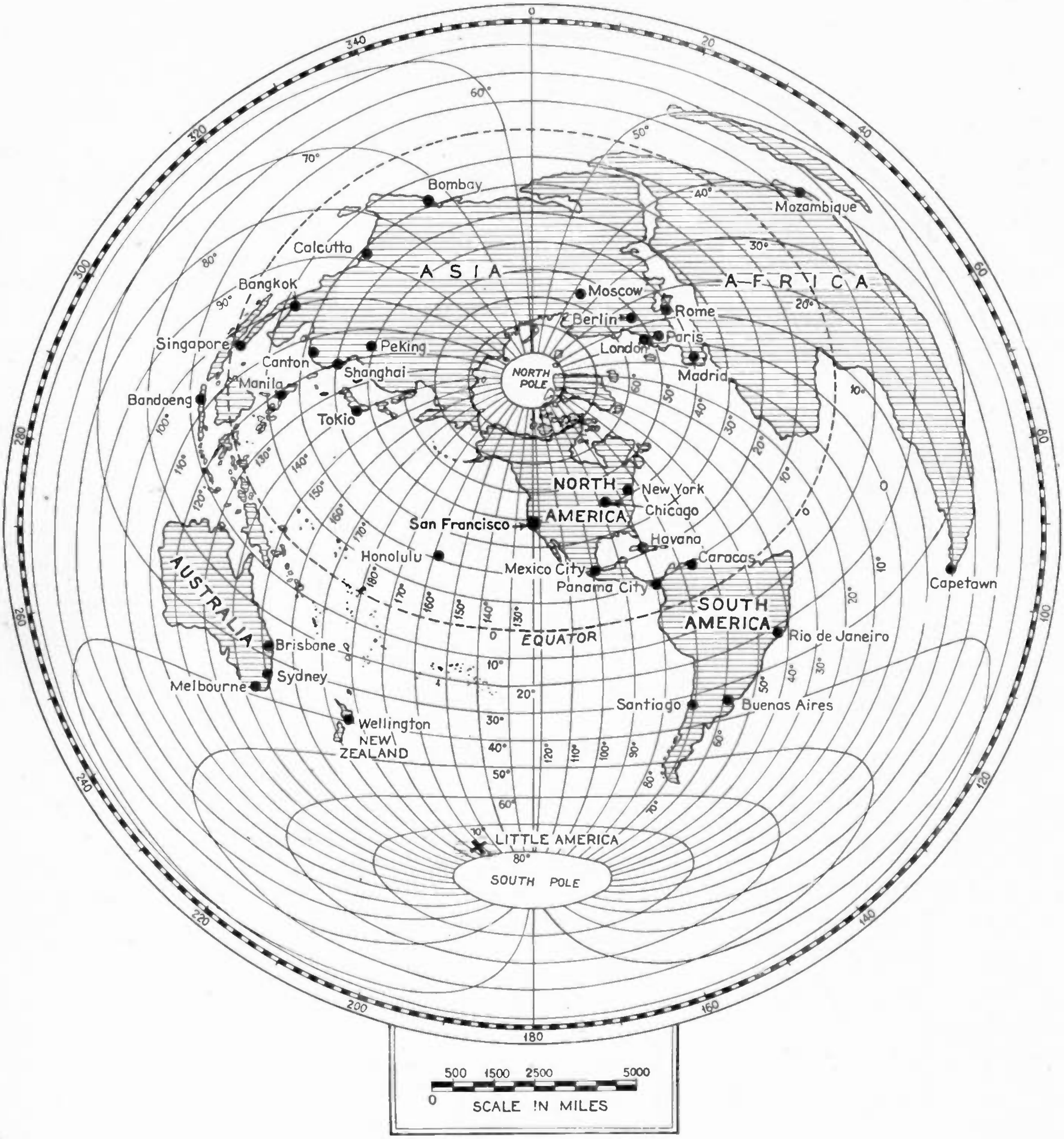


Figure 80

World Distance Maps

IN the realm of "DX," the actual distance in miles is the yardstick of accomplishment. The distorted map shown in Figure 79 permits direct measurement of the mileage between New York and any point in the world, or from any point in the world to New York, with an ordinary ruler the only instrument needed. To use the map, first find the distance in inches between New York and the desired point, multiply this figure by the miles per inch shown on the scale on the chart and the answer will be a close approximation to the exact airline distance between the two points.

The distorted map shown in Figure 80 permits direct measurement of the mileage between San Francisco and any point in the world.

Distances from points other than New York or San Francisco can in many cases be closely approximated by reference to New York. To determine the distance between Cleveland and Melbourne, Australia, for instance, the distance from Melbourne to New York is found and from this is subtracted the distance from Cleveland to New York. The distance between Cleveland and a point in Africa would be obtained in the same manner, except that the mileage between Cleveland and New York would be added to the distance from New York to the African point. An important feature of these maps is found in the fact that one can easily see the shortest straight-line path from any point in the world to New York or San Francisco, and the exact direction of such a path. Thus, it is surprising to learn that radio signals from Tokio or Manila pass almost directly over the North Pole in their path to New York, whereas most people think of such signals as coming to New York from a westerly point, probably passing over Los Angeles.

"Ham" Notes

Radio Amateur Abbreviations

ABL—able
ABT—about
ACCT—account
AER—aerial
AGN—again
AHD—ahead
AMT—amount
ANI—any
ANS—answer
ART—all right
B—be
B4—before
BCL—broadcast listener
BD—bad
BI—by
BIZ—business
BK—back, break
BKG—breaking
BLV—believe
BN—between
BPL—Brass Pounders League
BST—best
BTR—better
BT—but
BUG—vibroplex key
C—see
CANS—phones
CHGS—charges
CK—check
CKT—circuit
CL—closing station call
CLD—called
CLG—calling
CM—communications manager
CMG—coming
CN—can
CNT—can't
CONGRATS—congratulations
CQ—General call
CRD—card
CUD—could
CUL—see you later
CUM, CM—come
CW—continuous
CY—copy
DA, DY—day
DD—did
DG—doing
DH—dead head message
DLD—delivered
DLR—deliver
DLY—delivery
DN—done
DX—distance
DWN—down
EM—them
ES—and
EVY—every
EZ—easy
FB—fine business
FIL—filament
FM—from
FONES—telephones
FR—for
FREQ—frequency
GA—go ahead
GB—goodbye
GD, GUD—good
GE—good evening
GES—guess
GG, GNG—going
GM—good morning
GN—good night
GND—ground
GQA—Give quick answer
GSA—give some address
GT—get, got
GTG—getting
GVG—giving
HAM—amateur
HD—had, head
HI—laughter, high
HM—him, home
HR—here, hear, hour
HRD—heard
HV—have
HVG—having
HVY—heavy
HW—how
ICW—interrupted continuous wave
LID—a poor operator
LST—last, lost
LTR—later
LV—leave
LVG—leaving
MA—milliampere
MG—master generator
MI—my
MILS—milliamperes
MIM—high power, exclamation
MIN—minute
MK—make
MNG—morning
MNI, MNY—many
MO—master oscillator
ND—nothing doing
NG—no good
NIL—nothing
NITE—night
NM—no more
NR—near, number
NT—not
NTG—nothing
NW—now
OB—old boy
OFS—office
OM—old man
OO—official observer
OP—operator
OPN—operation
ORS—Official Relay Station
OT—old timer
OTR—other
OW—old woman
PLS, PSE—please
PUNK—poor operator
PWR—power
PX—press
QRM—interference
QRN—static
QSA—What is the strength of my signals? Your signals are (QSAL to QSA5)
QST--General call to all A. R. R. L. stations
RECD, RCD—received
RCVR—receiver
RI—radio inspector
RITE—right
RM—route manager
RPT—report, repeat
RUF—rough
SA—say
SCM—Section Communications Manager
SEC—second
SED—said
SEZ—says
SIG, SG—signal, signature
SINE—sign
SKED—schedule
SUM—some
TC—thermocouple
TKU, TU—thank you
TM—time, them
TMW—tomorrow
TNG—thing
TNX, TKS—thanks
TR—position, there
TS—this
TT—that
TY—they
U—you
UR—your
URS—yours
VT—vacuum tube
VY—very
WA—word after
WB—word before
WD—would, word
WDS—words
WI—with
WK—work, week
WKG—working
WL—well, will
WN—when
WO—who
WR—where
WS—was
WT—what, wait
WUD—would
WV—wavelength
WX—weather
XMTR—transmitter
YDA—yesterday
YL—young lady
YR—your, year
73—best regards
88—love and kisses
99—keep out

"Q" Readability System

QSA1—Signals hardly perceptible; unreadable
QSA2—Signals weak; readable only now and then
QSA3—Signals fairly good; readable with difficulty
QSA4—Good readable signals
QSA5—Very good signals — perfectly readable.

"R" Audibility System

R1—Faint signals; just readable.
R2—Weak signals; barely readable.
R3—Weak signals; but can be copied.
R4—Fair signals; easily readable.
R5—Moderately strong signals.
R6—Good signals.
R7—Good strong signals, that come thru QRM & QRN.
R8—Very strong signals; heard several feet from the phones.
R9—Extremely strong signals.

"T" Tone System

T1—("Ur tone 1, R6") Poor 25 or 60 cycle AC tone.
T2—Rough 60 cy. AC tone.
T3—Poor RAC tone O Sounds like no filter.
T4—Fair RAC,—small filter.
T5—Nearly DC tone, good filter but has key thumps, or back wave, etc.
T6—Nearly DC tone, Very good filter; keying OK.
T7—Pure DC tone, but has key thumps, back wave, etc.
T8—Pure DC, not equal to T9.
T9—Best steady, pure, crystal controlled DC tone.

Hints on R. F. Amplifiers

For Amateur Transmitters

ANY modern transmitter contains at least one stage of r.f. amplification —the power amplifier—following some type of master oscillator, either crystal or self-controlled. The better transmitters (especially in phone work, where it is very advisable) use a buffer amplifier between the oscillator and power amplifier to prevent frequency variation due to a varying load on the oscillator. The buffer stage also permits the oscillator to be run at a light load, which is a particular advantage when using crystal control, as the temperature rise of the crystal with its consequent frequency drift will be reduced. Where high power is used, an additional stage may be necessary to bring the r.f. voltage up to a proper level for exciting the power stage. These are all straight r.f. amplifiers which are called upon to amplify not only r.f. voltage but also r.f. power. Unlike audio (Class A) amplifiers, the r.f. (Class B) amplifier grid draws current and, therefore, takes power to excite it

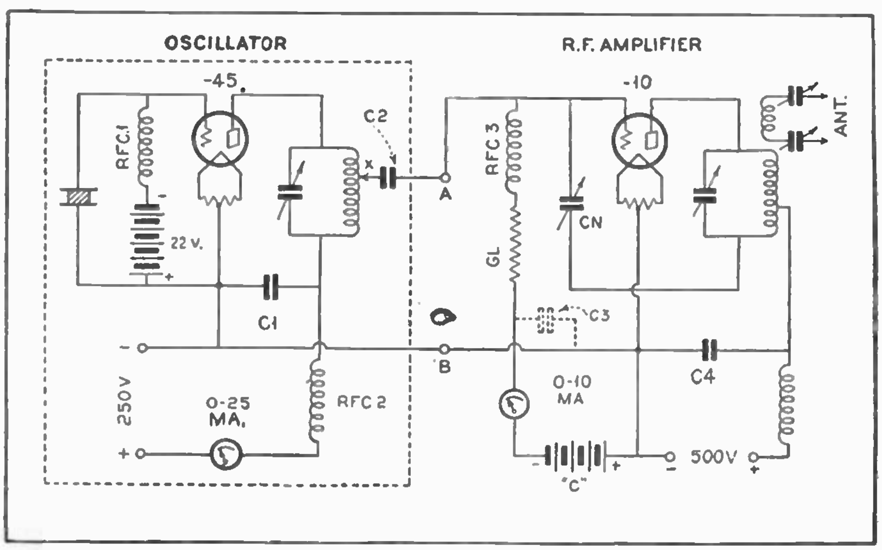
Straight r.f. amplification of one frequency in transmitters has a great deal in common with r.f. amplification in receivers. Each stage must be neutralized unless screen-grid tubes are used, and even then it is sometimes desirable to neutralize the control grid-plate capacity to improve stability. When improperly neutralized or not carefully designed, the amplifier stages are inclined to oscillate, exactly as in receivers. This must be carefully guarded against, for when an amplifier oscillates it is usually on some frequency other than that of the master oscillator—and it is a very serious offense for a transmitter to be off its assigned frequency. The first part of this article will be devoted to straight amplifiers which operate on the same frequency as the stage feeding them. A later part of this article will be given over to amplifiers which amplify at some harmonic of the stage which feeds them (frequency multipliers).

Tubes used as radio-frequency amplifiers are usually operated as Class B stages. This type of amplifier operates with a high grid bias such that, when there is no excitation, the plate current is practically zero. The reason for using Class B amplifiers in place of the more familiar Class A or audio amplifiers is that the efficiency of a Class A amplifier is only around 15%, while 80 to 85% efficiency is obtainable from a Class B stage.

For efficient operation with normal output, it is imperative that the amplifier be given sufficient excitation from the preceding stage. Screen-grid and pentode tubes require somewhat less r.f. power to operate them than do the more familiar triodes and are, therefore, to be preferred. For the present we will consider the operation of r.f. amplifiers from the theoretical viewpoint, to become familiar with some of the working tools of the engineer and experimenter and to be "all set" to find out the whys and the wherefores of the practical arrangements that follow. For the beginner or the non-technical amateur or experimenter, read the following discussion through carefully.

Let us first consult Figure 85, where, for the purpose of discussion, we will consider the simple transmitter consisting of a type –45 crystal oscillator feeding a type –10 power amplifier—a very reasonable low-power arrangement. The r.f. output from the oscillator is fed through the coupling condenser, C2, via the feeders A and B to the input circuit of our amplifier. This constitutes a shunt-feed arrangement where the choke, RFC3, has practically the entire r.f. input voltage across it. This choke, therefore, must be a good one, or some of the precious input voltage will be shunted into the "C" battery circuit, which, besides being a loss, may cause a great deal of trouble by being coupled into other circuits, especially where the same source of grid bias is used for other tubes as well. As a precaution, we could add a mica by-pass condenser (C3) to offer a low-impedance path to filament to any radio-frequency currents getting through the choke, thereby keeping it from the source of "C" supply. If, on adding this condenser, a change in plate or grid current resulted, it would prove that RFC3 was *not* an effective choke. If, on the other hand, no change of any kind was noticed, the chances are that the choke is O.K. Unforeseen troubles, such as this type of feedback, often make it difficult—and sometimes make it impossible—to neutralize the amplifier. This is fortunate, for a disease with clear symptoms is the easiest to diagnose—and cure! But let us continue our story about the grid or input circuit of the amplifier. Note, in Figure 85, the grid milliammeter which is connected in series with the "C" battery.

Figure 85



Use of the Grid Milliammeter

This meter is a valuable indicator, for when the amplifier and the oscillator are turned on, the meter will indicate relative values of exciting voltage. In other words, it will act as an r.f. voltmeter and will be very useful in neutralizing the amplifier and in getting optimum output from the oscillator. The unidirectional current that operates this d.c. milliammeter comes from the r.f. exciting voltage which is rectified by the grid of the amplifier. In other words, the meter reads "rectified r.f. current." This is one of the most important points that must be grasped if one is to really understand the operation of r.f. amplifiers. In view of this, let us pause a moment to consider the various parts of Figure 87. As we are considering Class B amplifiers just now, no plate current is flowing (and, of course, no grid current) when there is no excitation. Let us turn on the oscillator and couple the amplifier very loosely. This will give us a very small exciting voltage which (a) is supposed to represent. A little plate current will now flow, but there will be no grid current, because we still have ample grid bias. (In order that appreciable grid current may flow, the grid must go positive—that is, the r.f. input voltage must exceed the "C" bias.) The curve (b) pictures the condition where the input voltage peaks are just equal to the bias voltage. This is the point at which grid current just begins to flow. With still closer coupling, we get the condition shown at (c), where the exciting voltage exceeds the "C" bias, and grid current flows during a small part of the cycle (shown shaded. Plate current flows during the entire half cycle). Now the grid, in drawing current from the exciting voltage, raises itself (from a d.c. standpoint) above the "C" bias potential so that, during that part of the cycle where the grid is positive with respect to the filament center-tap, pulses of current are sent into the "C" bias circuit. In other words, the grid actually charges the bias battery and the grid milliammeter reads the rate of charge! Maybe it will be more obvious if we picture it in another way, shown at (d). Let V r.f. be our exciting voltage (it does not have to be a sine wave) which we will feed through the coupling condenser, C2, into our amplifier. When the "top side" of our r.f. generator is positive—as is shown—the grid will draw current if the peak voltage exceeds the grid bias. This current is pictured by the large arrows. None of this r.f. will be shunted into the "C" bias circuit, because the choke, RFC3, presents an infinite impedance to it. If any did get through the choke, the d.c. meter would not indicate it. Now, during that part of the cycle when the grid potential is higher than the "C" bias, a charging current will flow into the "C" battery as already stated. This current, which is represented by the small arrows, is that which the milliammeter records and is what we will refer to as the "grid current."

It is now easy to see that, if we insert a resistance in the "C" circuit, there will be a voltage drop across it equal to RI (the resistance, in ohms, times the current, in amperes, through it). Such a resistor is called a "grid leak" and is included in Figure 85—marked GL. In installations where the "C" voltage is limited, it is economical and sensible to use a grid leak to help supply the bias. It is impossible, however, to get true Class B operation, with its consequent high efficiency, with a grid leak alone. Some "C" voltage must be supplied externally. When using a grid leak, however, the plate current will not drop to zero when the excitation is removed, because the resistor cannot contribute any bias when there is no current flowing through it! The question now comes up—how are we going to know when we have the proper amount of resistance for Class B operation The answer is simple; and this is a beautiful case in which the man who knows a little theory triumphs over the man "who is just an operator." Class B bias $= \frac{Eb}{u}$ where Eb is the plate voltage and u the amplification constant of the tube (which is given in the tube data sheets). This is the total bias. Knowing how much actual voltage we have available, the remainder must be supplied by the grid leak (which is calculated from Ohm's law— $R = \frac{E}{I}$ where I is the current given by our grid milliammeter. In a number of tests run at W2BRB with various tubes, the value of the grid current ranged from 1/10 to 1/30 of the plate current. The actual value of the grid leak is not critical, and it is better to use a little too much resistance than not enough. A good plan might be to use any available resistance, calculate the drop across it and see how it checks with the desired bias. A vacuum-tube voltmeter—such as the one described in this book—would come in handy here in measuring bias voltages.

In connection with the foregoing calculation of grid bias, the author has found that, when using tubes as Class B r.f.. amplifiers, the given value of u is too high, so that it is usually necessary to add about 10% to the calculated bias to get complete "cut-off" (u, the amplification constant, actually varies considerably with different grid and plate voltages and different plate loads).

So far, our discussion has centered on the grid circuit of the amplifier and, more especially, on the grid milliammeter itself. We are now ready to proceed to the next step, which is neutralizing. Here the grid meter plays a very important part.

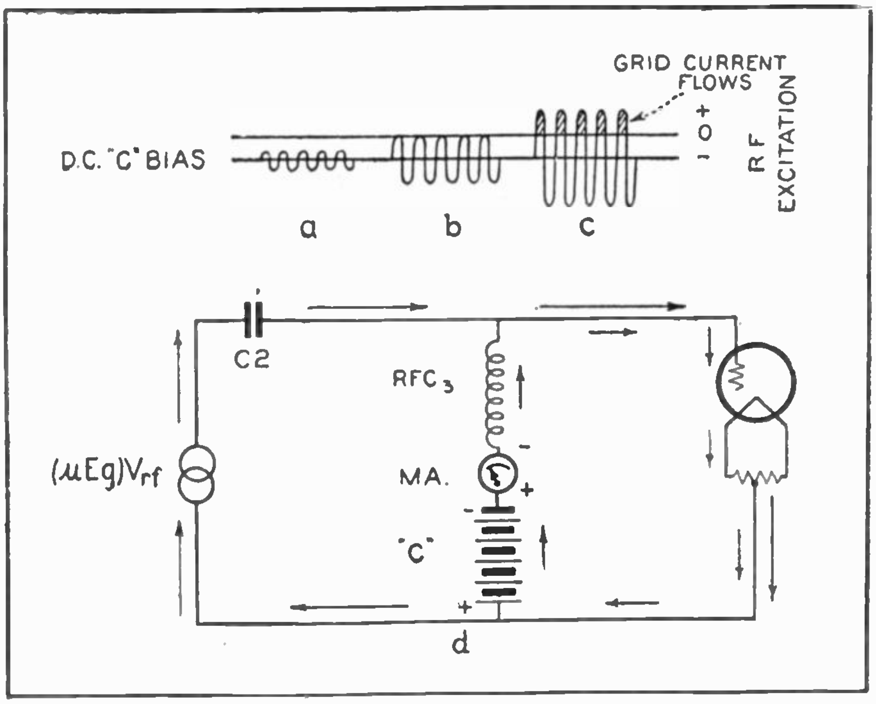


Figure 87

Neutralizing

When our oscillator is functioning properly and our grid meter shows the presence of r.f. in the amplifier stage, the first logical step is to neutralize the amplifier. Starting with the neutralizing condenser at minimum capacity, we tune the amplifier plate condenser until a dip occurs in the grid current. This indicates that the plate circuit is tuned to the oscillator frequency and, furthermore, that the tank (plate) circuit is drawing power, assuring us that the amplifier is *not* neutralized. As these phenomena are important, we will pause a moment to picture the happenings just referred to.

Figure 88 at (a) shows how the amplifier tank-circuit is coupled to the oscillator through the condenser formed by the tube's grid and plate (Cg-p). When the tank is tuned to resonance with the oscillator, it absorbs some energy, which causes a lowering of the grid potential and, therefore, a dip in the grid current. Now if we add a neutralizing condenser and split the plate coil as in (b), we can prevent the plate tank from absorbing any energy by balancing the circuit formed by Cg-p and the top half of the plate coil, with the circuit formed by the bottom half of the plate coil and the neutralizing condenser. The arrows picture a current coming from the source of radio frequency, splitting into the two branches just mentioned, and balancing each other so as to cancel in the tank coil. This is the principle of one method of neutralizing. The plate coil need not be tapped in the center. All that is necessary is that the number

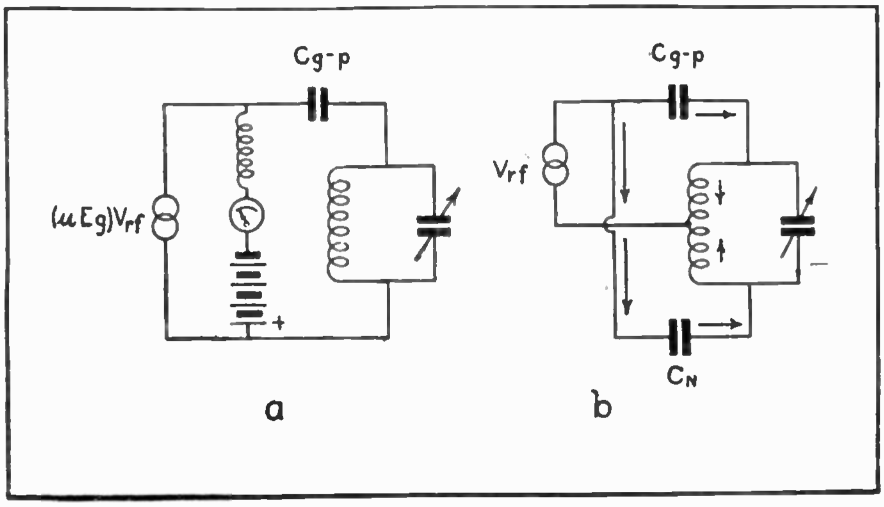


Figure 88

of turns used, with a given capacity neutralizing condenser, be sufficient to balance the voltage arriving in the plate circuit through the grid-plate capacity. The fewer neutralizing turns used, the larger the neutralizing condenser must be—and the greater loading effect the condenser will have on the oscillator tank circuit, as will be subsequently explained.

Now to go on with the process of neutralizing—we must turn on the amplifier tube so that it can draw a load, and we must disconnect the plate voltage to prevent self-oscillation with its dangerous feed-back. Now we start increasing the neutralizing capacity with one hand while we swing the plate condenser through resonance with the other, stopping every few seconds to readjust the oscillator plate condenser so that the r.f. input will not drop off. We should notice the resonance dip gradually diminishing until, at some point on the neutralizing condenser, there should be no dip at all. This is the point of neutralization. To prove that neutralization is really accomplished, we might further increase the neutralizing capacity whereupon the dip should return when we tune the tank circuit to resonance. It frequently happens that the point of what seems to be neutralization will be maximum capacity of the neutralizing condenser which shows us that we either need a larger condenser or, what is usually more reasonable, *more* neutralizing turns on the plate inductance. Then, again, the point nearest neutralization might be the point of minimum neutralizing capacity, which shows we need *less* neutralizing turns. Since the neutralizing condenser is effectively in parallel with the oscillator tank condenser, it may happen that, as we add neutralizing capacity, we get to a point where the oscillator tank condenser is at minimum capacity and will not tune, causing our r.f. input to drop off. This must be answered by removing a few turns from the oscillator inductance. During this process of neutralization it is well to reduce the "C" bias enough to permit full-scale reading on the grid milliammeter so that it will be easy to see the dip. Many amateurs and experimenters balk at the very word of "neutralizing," which is really foolish, seeing how easily it can be accomplished by the foregoing method. Many of the small, cheap voltmeters have a low resistance and a full-scale reading of 8 to 30 milliamperes, which makes it possible to use them for grid milliammeters. Their resistance will act as a grid leak, contributing to the bias as previously explained.

In starting the process of neutralizing, we assumed that the oscillator was functioning properly. However, should the grid meter refuse to read, the trouble is either very low oscillator output or excessive amplifier grid bias. Of course, it may be a combination of the two. Suffice to say that the trouble might rest in the crystal itself (assuming, of course, we are using crystal control) or in the r.f. choke in the grid circuit. A milliammeter in the plate circuit should show a snappy dip as the plate condenser is tuned into resonance with the crystal. If such is the case, the trouble lies in insufficient coupling. If such is not the case, either the crystal is N.G., the coupling excessive, or the plate by-pass condenser, C1, is too small. (Don't forget the grid r.f. choke, which has already been mentioned.) If the oscillator is of the self-controlled type, it should be relatively easy to get it working satisfactorily. Adjusting for proper feedback and grid excitation and, incidentally, watching for inductive grid leaks and defective r.f. chokes, should render the oscillator stable. Of course, a reasonably high C/L ratio should be used to further frequency stability.

Obtaining Optimum Power Transfer

It was previously stated that the grid meter would indicate relative values of exciting voltage and, therefore, might be used to adjust the oscillator for maximum output. In this case, we adjust the amplifier grid bias until the meter reads about 1 to 2 scale divisions, leaving lots of room for improvement! It is desirable that we also have an oscillator plate milliammeter in the circuit when we are making these adjustments so that we can have some idea of the oscillator efficiency. For instance, it would be foolish to double the oscillator input to get less than 20% increase in grid mils. Remember that the grid meter reads output current, and power is I^2 (the current squared), so that it would take four times the oscillator output to double the grid current. Again, if we double the oscillator input, the grid reading should increase 41% (the square root of 2 being 1.41). This was the basis for the previous statement that the reading should increase at least 20%, this figure indicating that the efficiency was dropping off but was still within reason if a little extra power were needed.

In practice, if the source of "C" supply has almost no resistance, this bit of mathematics will hold true, as checked with a vacuum-tube voltmeter at W2BRB. However, if a rectifier is used for grid bias, or if a grid leak is used to contribute to the bias, or if a high-resistance milliammeter is used, this may not hold true. This is because one of the points of the test was to set the "C" bias at some value and let it remain there. If there is any resistance in the circuit at all, increasing grid current will produce greater voltage drops in the resistance which will add to the bias with which we started. This means that we might have to multiply our power by—say, five—to double the grid reading. What actually happens, of course, is that, as the bias is increased, the input impedance rises, and to force a given

Figure 89

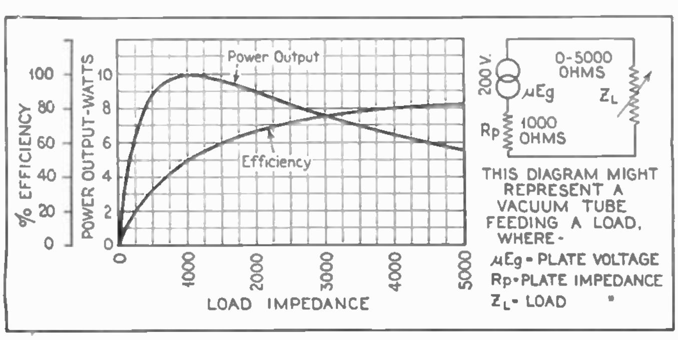
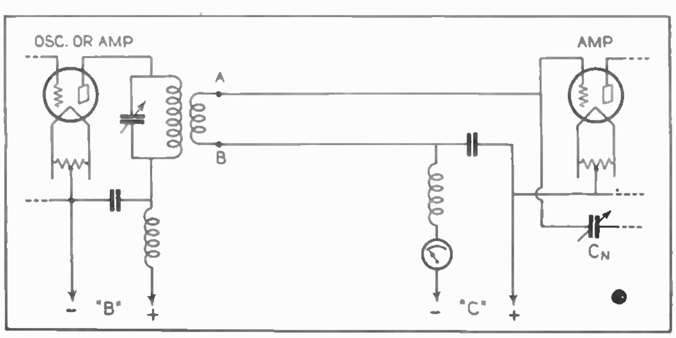


Figure 90



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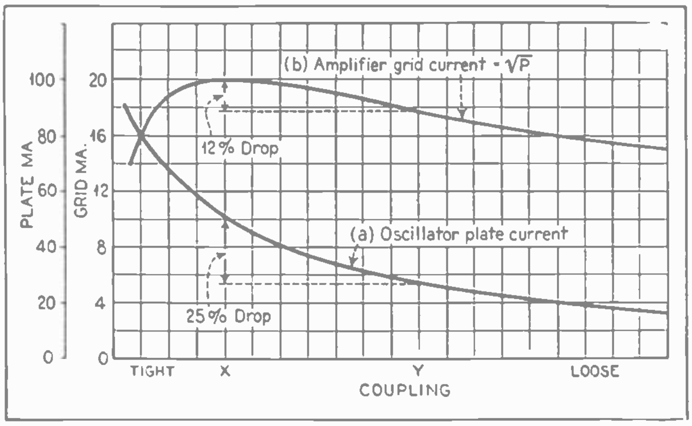


Figure 91

current into a higher impedance requires a higher voltage and therefore, more power.

Now at the maximum power output of the oscillator, the efficiency of power transfer to the amplifier will be about 50%. This is the point at which the load impedance (oscillator tank circuit coupled to amplifier grid circuit) is equal to the oscillator plate impedance. At this point half of our precious r.f. power is being absorbed by the plate. (Incidentally, the plate impedance is not the same as that listed in tube data sheets, because we are dealing with oscillators and Class B and C amplifiers and not with common audio, or Class A amplifiers. This impedance is an elusive thing, that is anything but constant, but we don't care a whole lot just what the value is, because we're looking for an outfit with a decent efficiency, not one where impedances are matched to give only 50% efficiency.) Now, we don't want to use good r.f. power to light up the plate, because, if we need light, a flashlight lamp and a dry cell will do a much better job. Keeping our plate voltage constant, suppose we decrease our power somewhat by loosening the coupling to the amplifier, which may be done by replacing the coupling condenser with a smaller one or by moving the clip X away from the plate. At ¾ maximum power output, the efficiency will rise to 75%; at half power the efficiency will be around 85%, and so on until at—say, one-tenth power—we might expect an efficiency of as much as 95%. However, this is purely theoretical and doesn't always hold good, for it might take one-tenth of our power to overcome the losses in the plate and coupled circuits. At any rate, the reader would do well to become *very* familiar with Figure 89, as the explanation of countless phenomena associated with radio and electrical subjects lies within its borders. In making full use of Figure 89, we would do well to memorize it, always having a picture of it in our minds. First, we will consider a common phenomenon.

Loose vs. Tight Coupling

How many amateurs have tightly coupled an antenna to their transmitter and found that, if they loosened the coupling, the antenna current would rise? How many have wondered why this was so? An antenna, we'll say, has a resistance of 50 ohms at our particular frequency. The plate circuit of our tube (oscillator or amplifier) has a resistance of several thousand ohms. If we tightly couple the antenna and retune it, we will be operating around the lower left-hand part of the power transfer curve of Figure 89. Most of our r.f. power will be wasted in the tube and the efficiency will be less than 50%; probably much less! Both the plate and antenna circuits will tune very broadly. This is because we have, in effect, short-circuited the plate impedance with 50 ohms—the antenna resistance. Now suppose we loosen the coupling. The input power to the tube will decrease, the tube will operate cooler and the antenna current will increase. We are now around the top of the curve! Loosen the coupling still further, always retuning, and we find that the d.c. input drops a great deal, although the antenna current drops only slightly—and the tube operates *cold!* No question about it—we are now on the right-hand side of the picture—where we should be for decent efficiency. *We can now increase the plate voltage and boost the antenna current much higher than it was when we were operating on the top of the curve without increasing the heat dissipation in the tube over what it was in the former case.* Actually, most amateur operators have found this out by experience, although few are aware of just what goes on.

We now have to apply this last paragraph to our oscillator-amplifier arrangement which we are using as an example. The antenna phenomenon was used simply as a comparison, bearing in mind that most transmitting amateurs would be familiar with the antenna coupling problem, while few would know well the idiosyncrasies of coupling two r.f. units. While most of us use inductive, or magnetic, coupling to our antenna, it has become usual practice to use capacity coupling to r.f. amplifiers. Inductive coupling might well be used, however, as is shown in Figure 90. There is one decided advantage in this system namely, that series feed is used in the grid circuit, which obviates the necessity of having a near-perfect r.f. choke to hold back all the valuable r.f. exciting voltage. Another obvious advantage is the eliminating of the coupling condenser, C2, which must stand the oscillator plate voltage plus the amplifier grid-bias voltage. A still further advantage comes to light when we are working on the real high frequency bands (14 mc. and higher). The reader will remember that the amplifier input and neutralizing circuits, in series with C2 (which is usually quite large), are in parallel with the oscillator plate-tuning tuning condenser. This means that the tuning capacity will have to be much smaller than it would be were the amplifier loading effect removed. It is obvious that, to preserve a sensible ratio of L and C (in the bands mentioned), the tuning capacity would be so small that it would be hard to guess the proper number of turns in the plate coil to properly couple the amplifier and still have the condenser cover the whole band. When working with r.f. amplifiers or crystal oscillators, it is always advisable to use as high an L/C ratio as is possible, because this gives the greatest efficiency. With the capacity-coupled arrangement there is too much loading, already, to permit taking advantage of the high L tank circuit, so that we welcome the change to magnetic coupling which permits us to use greater inductance with consequent greater efficiency. Were we using a self-controlled master oscillator, we should be obliged to use a high C tank circuit to further frequency stability, in which case the foregoing statements would not fit. The inductive-coupled arrangement at the author's station will be described in detail later. However, since the condenser coupled system is so popular, we will continue the story with Figure 85.

Suppose we are working on 3800 kc. and C2 happens to be a 2000 mmfd. condenser (a popular size). Let us put the clip X, right on the plate. This gives us maximum coupling. Carefully recording the oscillator plate current and the amplifier grid current, we proceed to move the clip down toward the "cold" end of the plate coil, stopping at each turn and retuning each time. If we plot the curves, they should resemble Figure 91, although they will differ considerably with different layouts. In curve "a" we note that, as the coupling is loosened, the plate current drops rather fast at first and then more slowly as we come down the curve. On the other hand, the grid current rises rapidly at first, slowing down as it reaches a maximum and then gradually tapering off toward zero. The reader should recall the paragraph on antenna coupling—substituting antenna current for grid current. It might be well worth while to also glance back at Figure 89 and try to correlate these facts and figures. Remember that Figure 91 represents one application of the important Figure 89.

Getting back to Figure 91, it is at once obvious that, with maximum coupling, we are getting poor results, indeed, for our plate input power is very high and our exciting voltage is much below maximum. Under certain conditions, such as, for instance, where we had a limited plate voltage, it might be reasonable to work at point X (Figure 85), where the grid current is a maximum, but, in most cases, it would be much more sensible to work to the right of point X at some such point as Y. It should be noted that, although the grid current is somewhat less at Y than at X (12%), the plate current is a lot less (25%) and, therefore, the efficiency is much better. If the oscillator plate voltage can now be increased, the grid current of the amplifier may be brought as high as it was at the peak, and even higher, with less heating of the tube. This, then, is the proper way to operate an r.f. amplifier—with high voltage and loose coupling.

Public Address Systems

A Powerful 6 Tube P. A. System

(A.C. or Battery Supply)

THE 6-tube, 13-watt universal amplifier described in this article and shown in Figure 94, operates from either 110-volt, 60-cycle a.c. or a 6-volt storage battery and many improvements and developments have been incorporated to recommend it to the sound engineer, serviceman and radio dealer.

In the first place, both the 6-volt and the 110-volt, 60-cycle a.c. supplies are installed and mounted on the same chassis as the amplifier. The chassis, measuring 18½ inches long by 10 inches wide by 9¾ inches high, is of portable size and could be easily transported in a carrying case.

The 6-volt power supply used in this amplifier is the new RCA-Victor vibrator type converter-rectifier, consuming only about one-half the battery current previously required for a 6-volt battery supply of this type. The new vibrator rectifier is noiseless and does not radiate any electrical interference. Farther on in the article the remaining features and the operation of this power device will be discussed. The circuit is shown in Figure 95.

For optional operation on either 6- or 110-volt operation it is only a matter of inserting the amplifier connector plug (ACP) into the socket on which the amplifier is to work. Socket VT7 is the output of the 110-volt supply and socket VT8 delivers all voltages as required under battery operation. Using this design and type of construction, there are no tubes to change or remove, and no alterations are necessary in the circuit.

Phase inverters, resistance push-pull coupling and push-pull driver circuits in the amplifier makes it possible to obtain enjoyable quality from Class B tubes. The -79 and the -53 twin-triode amplifier tubes utilized contain two high-mu triodes combined in one glass envelope.

The amplifier is equipped with a tone control R15, a pilot light, switches for both power supplies and terminal connections to the input grid circuit and to the plate output of the power tubes. The ouput transformer provides proper impedance-matching for single or multiple dynamic type speakers. Figure 97 provides information on multiple speaker connections.

For field excitation of the dynamic speakers, either one of two methods are suggested; one way is to employ 6-volt field speakers exclusively and for their field current use a storage battery or a 6-volt exciter operating from 110-volt a.c. power line. The second method is to use dual-field speakers; that is, one of the field windings could work from a storage battery and the other field could operate from the power pack of the amplifier.

When the amplifier is operated from 110-volt line supply there are provisions for providing field excitation for two 1000-ohm, 110 ma. speakers. Excitation can be supplied to four 1000-ohm, 60-ma. speakers by connecting the field windings in a series parallel arrangement.

Perhaps the outstanding development of this sound system is its efficient operation from a 6-volt storage battery. As previously stated, this is made possible by the use of the RCA-Victor vibrator type converter-rectifier. This unit transforms the 6-volt d.c. battery source into 6 volts a.c. which is impressed on the primary of the step-up power transformer PT1. The secondary of this transformer delivers approximately 295 volts a.c. to the rectifier of the device and its output is 275 volts at 75 ma. It is an extremely compact unit, measuring 4½ inches long with a diameter of 2½ inches. The total weight for the entire device, including the transformer PT1, is 7 pounds. With this high output voltage and current the same power output of 13 watts is obtainable on 6-volt operation as on a.c. operation.

The vibrator rectifier is housed within two metal and felt-lined shields providing quiet operation and preventing interference with the other circuits.

The average power consumed from the battery is only 6½ amperes. A vital advantage in a power amplifier using this type of supply when installed in an auutomobile is that it will not impose a burdensome drain on the car's storage battery for the simple reason that the car generator should have no difficulty in charging back the 6½ amperes required for the P.A. system. This means that for car installation there should be no necessity for removing the battery for overnight boosting.

This compact, high-powered dual amplifying system opens up a new and profitable field, for temporary or permanent installation in boat clubs, steamships, auditoriums and trucks.

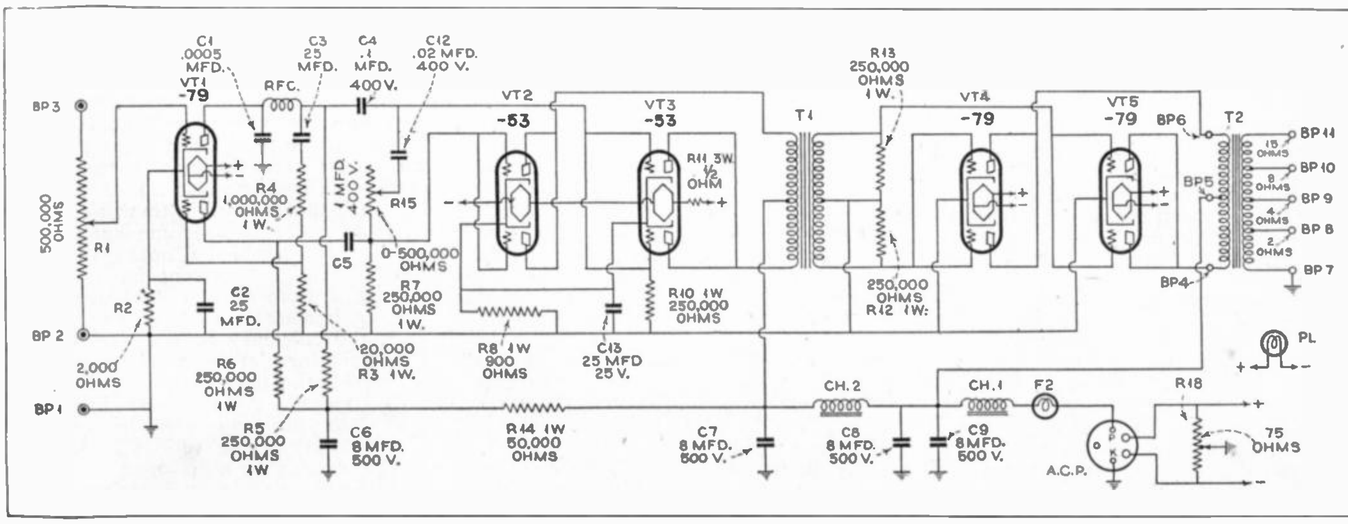


Figure 93

The Circuit

Referring to the circuit diagram, Figure 93, the input posts BP2 and BP3 are connected directly through a 500,000-ohm potentiometer R1 to the first grid G1 of the –79 type tube, VT1. This tube is employed as a phase inverter, which means that part of its audio-frequency output is fed through a blocking condenser, C3, and a series resistor, R4, to the second grid, G2, of the same tube. This makes the output of the second plate, P2, 180 degrees out of phase with respect to the output in the first plate, P1.

The two plates of the two triodes of this first –79 are coupled through two condensers, C4 and C5, to the grids, G3 and G4, of the two –53 tubes which are employed as triodes in resistance-coupled-push-pull operation. The grids of these tubes are alternately excited by two voltages 180 degrees out of phase.

To obtain perfectly balanced push-pull operation, the value of the grid resistor R3 is so chosen that the voltages impressed upon the grids G3 and G4 are identical in magnitude. A large by-pass condenser, C2, is placed across their common cathode to prevent regeneration and motorboating.

Both –53 tubes are used as triodes, in which plates and grids of each tube are placed in parallel. Being in push-pull, their plates are connected to a push-pull input driver transformer, T1. This transformer has a step-down ratio of 5 to 1, which is required to obtain best results and to match the plate impedance of the driver tubes.

The use of this push-pull driver arrangement has the advantage not only of providing more and better driving power, but also of eliminating the distortion usually introduced by the saturation effect caused in medium size transformers by the unidirectional flow of the plate current in single-tube driver arrangement as employed here, driver transformers. In the push-pull the d.c. plate current flows through the primary windings of the transformer in opposite direction and thereby cancels and eliminates the distortion due to that saturation effect.

Grid resistors R12 and R13 are placed across the secondary winding of the transformer T1 to maintain the flat line-overall response curve of the amplifier. Each –79 Class B output tube is connected as an unbiased triode with its grids and plates connected respectively in parallel.

The value of all the resistors and condensers are shown in the circuit diagram, Figure 93 and a bottom view of the chassis appears in Figure 96. The remaining parts and accessories are herewith listed.

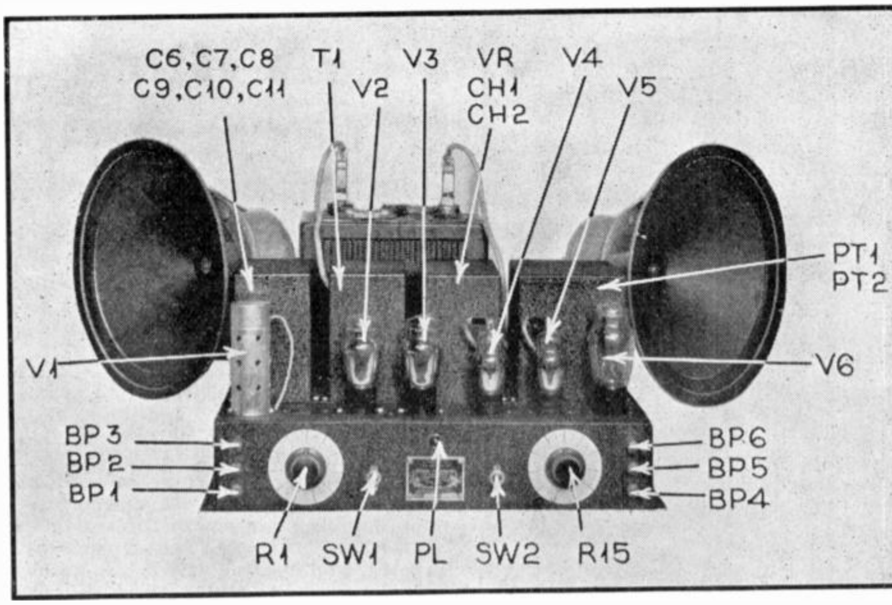


Figure 94

List of Parts

ACP—Type D1194 five-prong connector plug with 2-foot cable.

BP1 to BP12—Eby triple binding posts (in sections shown in diagram)

CH1—Type 6167 filter choke, 200 ohms, 125 ma., 30 henries

CH2—Type D1861 filter choke, 500 ohms, 60 ma., 30 henries

F1—Littlefuse 1-ampere fuse

F2—Mazda pilot lamp, 6 volts

LO1, LO2—Hubbell type 4054 flush outlet receptacles

PL—Mazda pilot lamp, 6 volts

PT1—Type E1044 vibrator power transformer, delivers 275 volts, 75 ma., primary 6 volts

PT2—Type E108-2 power transformer, delivers 280 volts, 180 ma.; 6.3 volts, 4 amperes; 5 volts, 3 amperes

T1—Type E693 Class B input transformer

T2—Type D2395-B Class B output transformer

VR—RCA-Victor RP-108 vibrator type converter rectifier

VT1, VT4, VT5—Cinch 6-prong wafer socket

VT2, VT3—Cinch 7-prong wafer socket

VT6—Cinch 4-prong wafer socket

VT7, VT8—Cinch 5-prong wafer socket

1 type 5767 crystalline-finished, drilled metal chassis with four shield cans and base plate

1 tube shield for VT1

Astatic crystal phono pick-up, type S-8

Universal carbon microphone or Astatic crystal microphone type D104

Racon stormproof speaker

Portable phonograph turntable

Figure 97

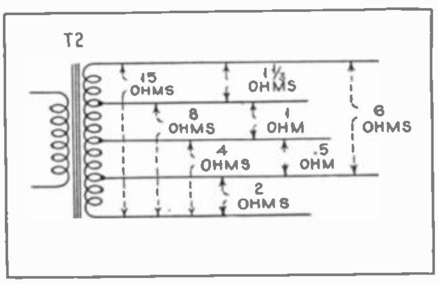


Figure 95

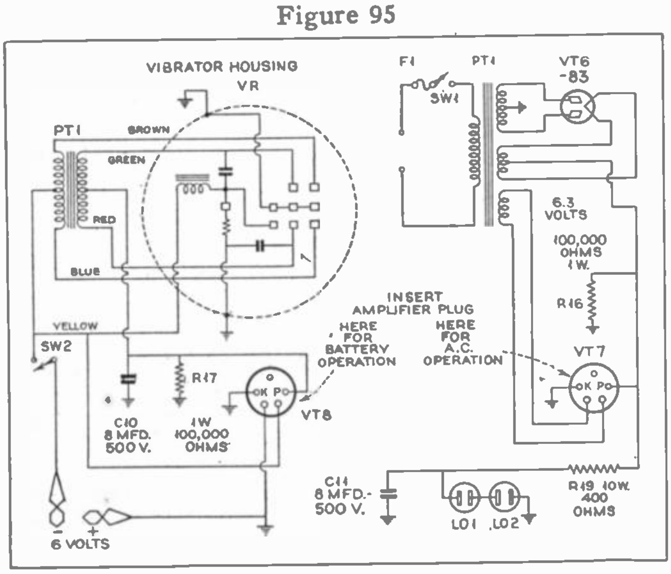
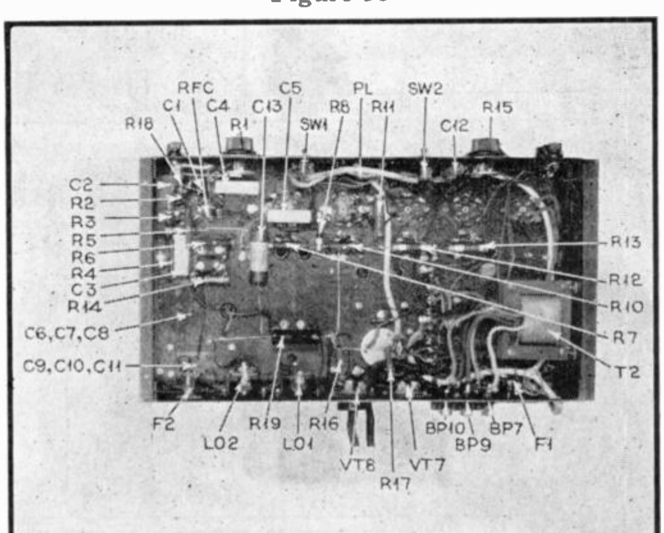
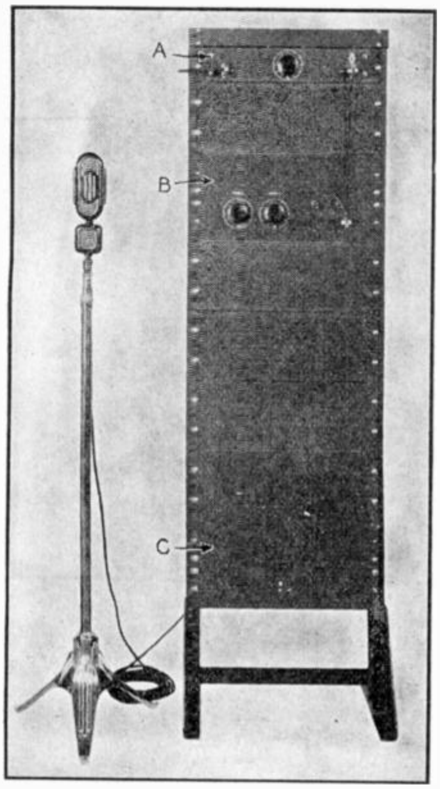


Figure 96

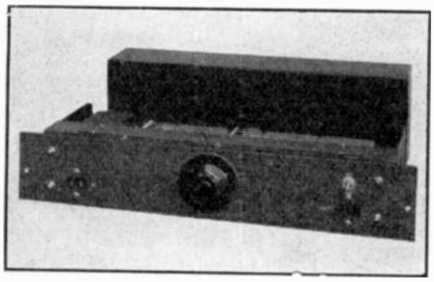


A Rack and Panel Amplifier



PUBLIC-ADDRESS amplifiers can now be constructed so well that very good quality is obtainable with relatively low-cost apparatus. Figure 86 shows such an amplifier, complete with rack, panels and everything, obtainable in kit form and which can be put together by the serviceman.

The complete amplifier consists of a pre-amplifier (Figures 99 and 100), main amplifier (Figures 102 and 103), and powerpack. Moreover, all other accessories, such as the rack, a phonograph shelf equipped with a pickup and a tuner are being made available. The main amplifier consists of three stages of transformer-coupled and impedance-coupled amplification, all being push-pull (see Figure 101). The output stage can be one pair of type -45 tubes in a Class A prime (Class AB) circuit. This stage will deliver 18 watts of power with less than 5 per cent total harmonic distortion. For those who wish more power, two more type -45 tubes can be added, making it a parallel-push-pull stage and doubling the power. The only change and expense for this additional power are the two tubes, the sockets and a different output transformer; the rest of the circuit remains the same. The gain of this amplifier is 80 d.b. and the frequency characteristic is shown in Figure 104. The rating of this amplifier is conservative and is in agreement with the ratings given by the tube manuufacturers in their engineering Bulletins. Special precautions have been taken to insure low-distortion percentage and absence of microphonics. All the voltage-amplifier tubes have sockets equipped with springs to minimize microphonism. The output stage has a fixed bias which is the method recommended for maximum power and minimum distortion.

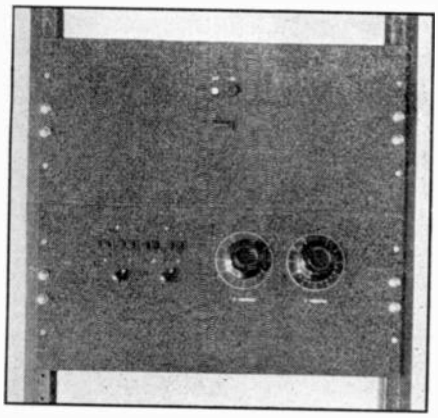


The Power Supply

It is, of course, necessary to have a power supply with good regulation, because the plate current for each -45 tube is only 22 m.a. with no signal, but increases to 70 m.a. for full output. This also explains why self-biasing is not used. The power supply (Figure 101) has been designed to take care of this requirement. The mercury-vapor rectifier has a low, internal voltage-drop which helps to maintain the voltage when more current is drawn. Note the extra type -82 tube which supplies the bias to the type -45 tubes.

The input to the main amplifier consists of two 500-ohm lines or two 200-ohm lines. Each line is connected to a d.p.d.t. switch. So, four sources of signal can be connected to the amplifier, any one of which can be chosen by means of the two switches, and any two sources can be mixed. This circuit is shown in Figure 105. The output transformer accommodates a 500-ohm line or a voice coil (15, 8 and 4 ohms). The total power consumption is 100 watts for the 18-watt amplifier and 150 watts for the 36-watt amplifier.

The amplifier is extremely flexible, both electrically and mechanically. It can be mounted on a rack or used as table mounting with but few changes. Furthermore, when it is mounted on the rack, the panel can be removed without removing the chassis. All the wiring is thus exposed by taking off the panel. The chassis comes prepared for mounting either the push-pull parallel or the single push-pull stage. All the parts and accessories, a radio tuner and a phonograph are available in kit form.

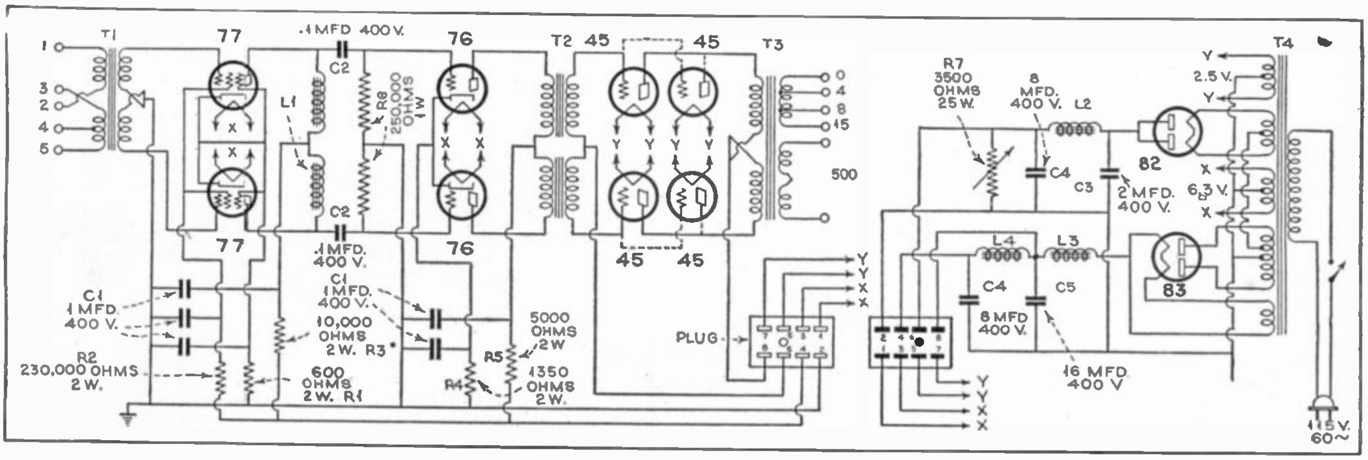


The Pre-Amplifier Unit

From all reports received, many readers are having difficulty with pre-amplifiers. With this pre-amplifier connected ahead of the main amplifier, using phones and having everything turned up full, the hum is noticeable, of course, but remarkably low. The total gain of the two amplifiers is 130 db. A limit of gain must be reached, due to thermal agitation.

The pre-amplifier consists of two transformer coupled stages using 77 or 6C6 tubes as triodes as shown in the circuit of Figure 106. It has been found that connecting the screen and suppressor of a 77 or 6C6 to the plate converts it into an efficient triode. This connection provides a mu of 20 and a relatively low plate resistance. The characteristics for this connection were measured in the laboratory of the

Fig. 98—Top; Fig. 100—Center; Fig. 101—Below; Fig. 102—Left



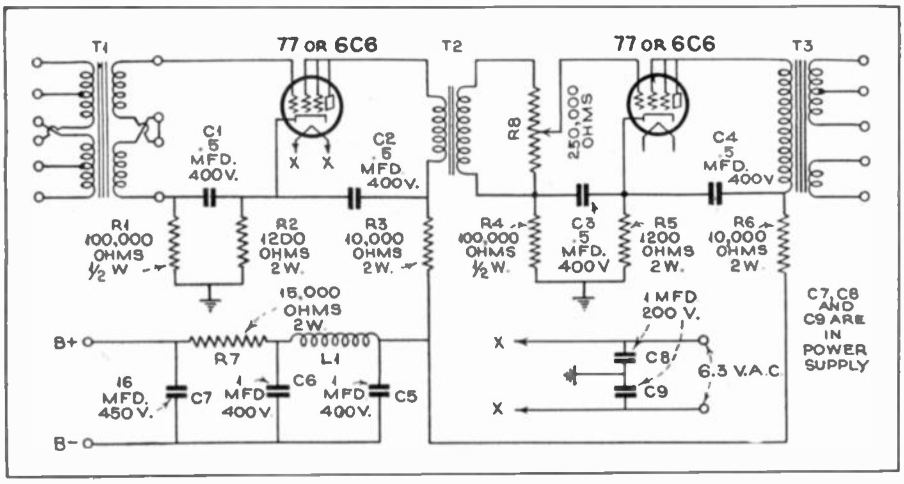


Figure 106

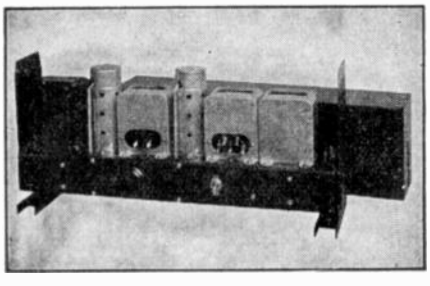


Figure 99

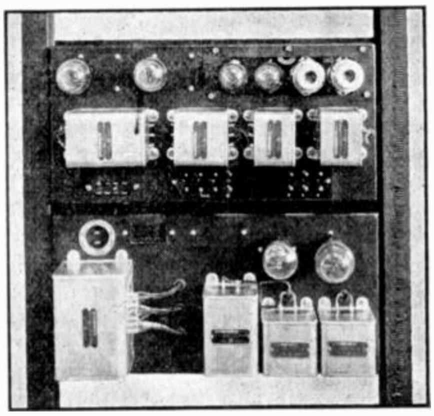


Figure 103

Connecticut State College and are given herewith: Plate voltage, 250 volts; plate current, 7 volts; grid voltage, -8 volts; Amplification factor, 20; mutual conductance, 2000 microohms; plate resistance, 10,500 ohms; load resistance, 15,000 ohms; power output, 300 milliwatts.

Great care has been taken to minimize noises and hum in this unit. Two extra filter sections have been placed in the power supply and the tube sockets are mounted in sockets using non-microphonic springs. The pre-amplifier is, of course, completely shielded and so are all the cables leading to it.

The input transformer has a tapped primary with an impedance of 500 ohms with provisions to accommodate 333, 200, 125 and 50 ohms. Nearly all velocity microphones now have a transformer in the base which will match the input of the pre-amplifier. Those who wish to use a crystal microphone should employ the resistance-coupled input as shown in Figure 107.

The output transformer accommodates 500, 200, and 50 ohm lines.

The construction of the preamplifier is similar to that of the main amplifier. It can be had for rack-mounting or for table-mounting, and the same chassis serves for both. When mounted on the rack, the panel can be removed without touching the mounting of the chassis itself.

Figure 98 shows all three units mounted on one rack. At A is the pre-amplifier, at B the main amplifier and at C the power supply. It is desirable to place the power supply well away from the amplifiers. Figures 99 and 100 show the front and rear views of the pre-amplifier unit.

It is believed that this amplifier system is suitable for practically any public-address job. An audience of 5000 to 7000 people can be covered with a 20-watt amplifier, provided that the right speakers are used and that they are suitably placed. The power will be ample for nearly all occasions.

The fidelity, too, will satisfy most requirements.

The total power consumption is only 150 watts, which makes it possible to use the unit on a sound truck. Moreover, the separate units could be mounted in carrying cases, making the whole outfit portable. However, it is believed the rack-and-panel mounting will be more suitable for permanent installations.

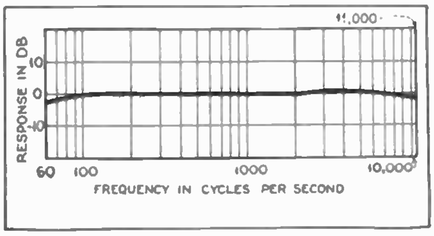


Figure 104

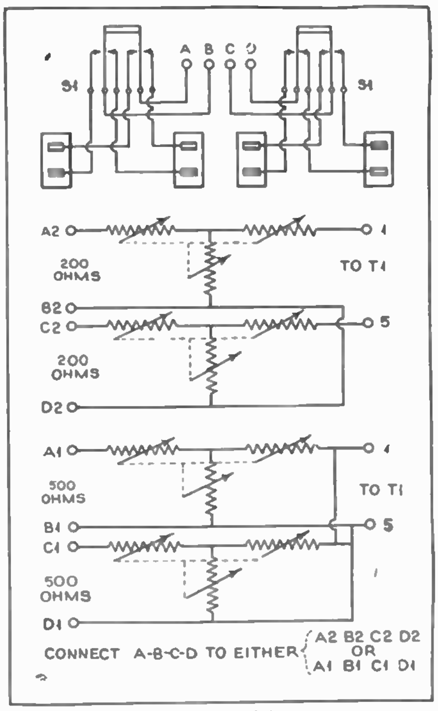
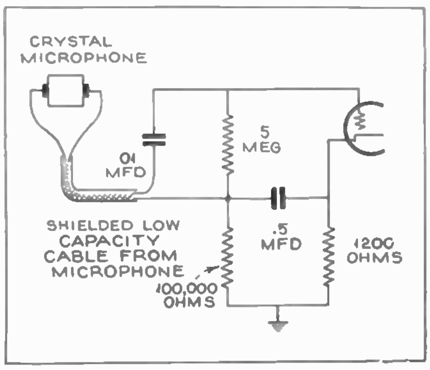


Fig. 105—Above;
Fig. 107—Below



Experimental Radio Data

Charts for Experimenters

THE chart in Figure 112 has been made to facilitate computing the capacity and inductance needed to tune to a given frequency. For example, to find the natural frequency of a circuit having a capacity of 350 mmfd. and an inductance of 240 microhenries, lay a straight edge along the divisions 350 on the capacity scale and 240 on the inductance scale. The intersection on the frequency scale shows the answer, 550 kc.

The chart can be employed in the same way if any two of the three quantities are known.

The range of the chart can be extended by multiplying all frequency values by 10 and dividing *both* the capacity and inductance values by 10, or vice versa.

The second chart, Figure 113, enables you to find the equivalent resistance of two resistors in parallel and also the capacity of two condensers in series. Draw a straight line through the divisions on scale A_1 and A_3 representing the resistance in the two branches, and you will find the resultant resistance on scale A_2. To find the resistance of one branch when the other branch and the total resistance are known, draw your lines through the corresponding points on A_1 and A_2 and find the answer on A_3.

When the resistance of the two branches is widely different, use the chart consisting of scales B_1, B_2 and B_3. B_1 and B_3 are for the unequal branches and the result is on B_2.

The third chart, Figure 114, solves Ohm's Law and also shows the power consumed in the circuit. If any two quantities in a circuit, volts, milliamperes, ohms, or watts are known the other two can be found by drawing a straight line through the corresponding divisions on the respective scales. For instance, in a circuit of 2700 ohms resistance flows 5 ma. Drawing a line (see sample dotted line) from 5 on the ma. scale to 2700 on the ohms scale, the voltage is found to be 13.5 and the power consumption .067 watts.

In order to extend the range, two sets of figures have been used on the scales. Be sure to read all your values under A or all under B.

A Simple Electronic Alarm

THE electronic alarm system described here may be used to sound an alarm; upon the approach of a person within a protected area, with the advent of rainfall, in case of fire, or, whenever such a change occurs as may be utilized to produce a frequency shift of a small magnitude, in a tuned circuit. Only a few parts are used and it may be built in a few hours. The total cost is estimated to be under ten dollars, the major portion of which goes for a sensitive relay which will operate on a few milliamperes change in current.

The principle of operation is as follows. The large percentage change in a vacuum tube's plate current, between an oscillating and non-oscillating condition, is used to operate a relay which closes an alarm circuit. To accomplish this it is necessary to produce a change which will either stop or start an oscillator.

An oscillator may be "stopped" by absorbing sufficient power from it. The method used here is to couple to the oscillator a circuit tuned to a slightly lower frequency and to adjust the coupling, so that when the oscillator is then tuned down to this frequency, sufficient power will be absorbed to stop the oscillation. One side of the tuned circuit used in the oscillator is connected to ground. The other side is connected to a wire strung about the borders of a room (assuming we are protecting a room). Any person entering the room will increase the capacity between this wire and ground, thus shifting the oscillator to a lower frequency which, in turn, will cause it to stop. The resulting change in plate current then operates the relay which closes the alarm circuit. This mode of operation is the more sensitive, as compared to starting the oscillator, because as power is absorbed a change in plate current results so that, with a sensitive relay, operation can be obtained without entirely stopping the oscillator and therefore requiring only a very small shift in capacity.

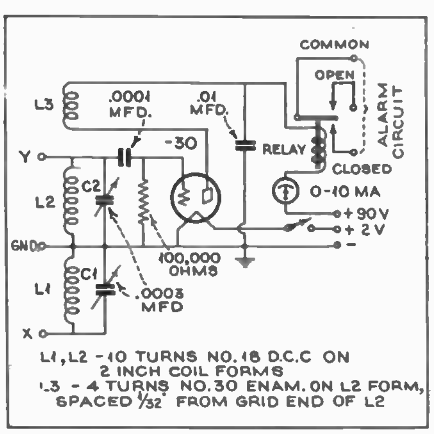


Figure 109

With the search wire connected to the absorption circuit and this circuit tuned so that it absorbs sufficient power to stop the oscillator, then an increase in capacity will detune the absorption circuit allowing the oscillator to start. This mode of operation gives greater stability and avoids the possibility of interference due to radiation of the oscillator.

Figure 109 gives the schematic diagram of the electronic alarm circuit utilizing a type –30 tube. The external search wire is connected to either point X or point Y depending upon which mode of operation is desired. With the circuit constants given, the frequency of oscillation will be between ten and twenty megacycles but the frequency is unimportant and the experimenter may substitute any pair of like coils for L1 and L2, changing L3 so as to obtain oscillation. The coupling between L1 and L2 should be capable of rough adjustment, a variation in spacing of from one-half to two inches being sufficient. The meter in the plate circuit is not essential but is of great value in indicating the strength of oscillation thus showing the optimum setting for the absorption circuit. The tuning condensers may be varied from the sizes given, the only necessity being that they have a capacity somewhat greater than that added to the circuit to which the search wire is connected, this circuit having its condenser set close to minimum capacity. Circuit stability is increased by using parts of like construction for each circuit as then changes due to temperature and humidity will have equal effects. With the voltages given

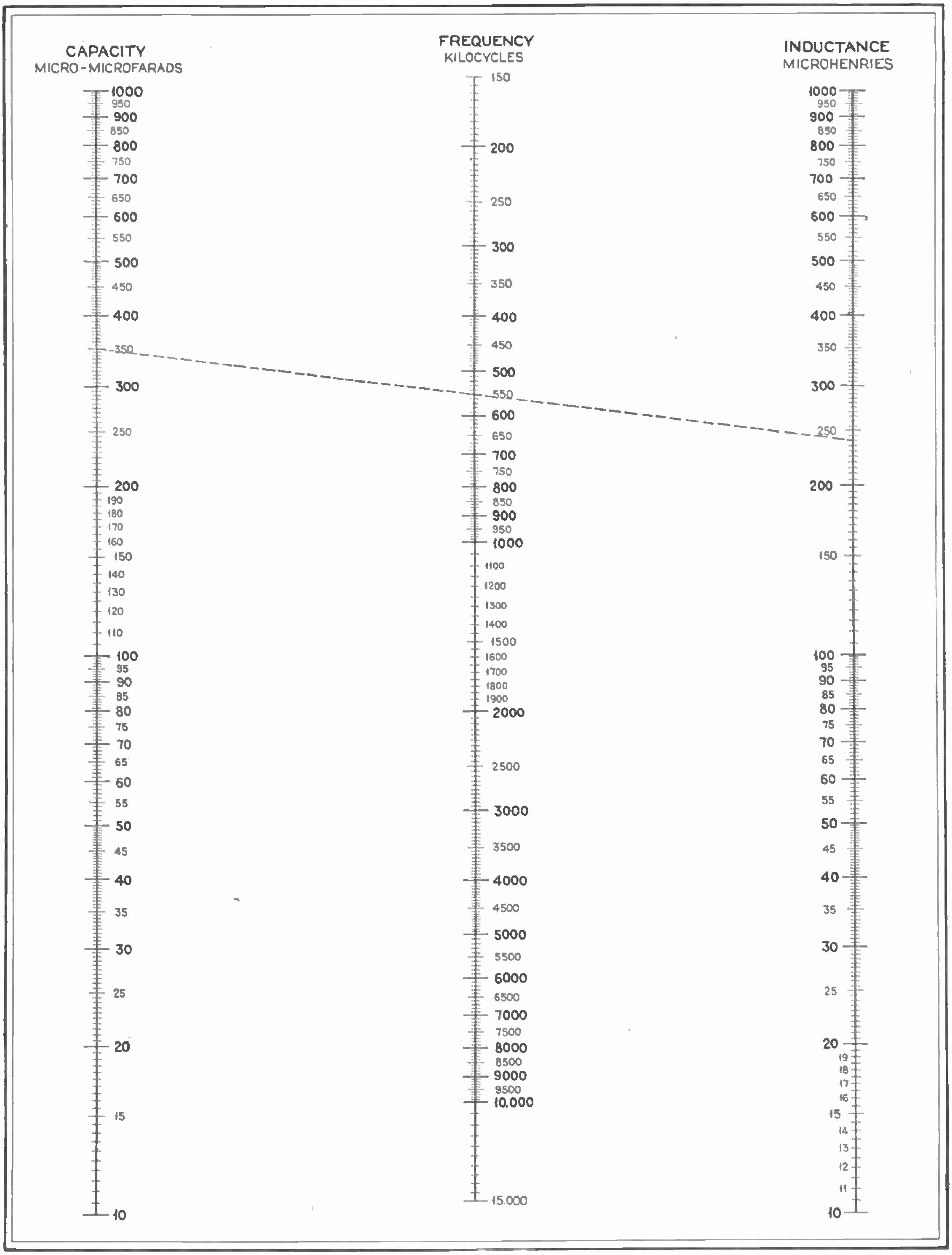


Figure 112—See Page 56

and a typical type-30 tube the oscillating current will be approximately 4 miliamperes and the non-oscillating current approximately seven milliamperes. Thus a relay which will operate on a change of three milliamperes will be required.

Several uses of the alarm device suggest themselves. An arrangement suitable for indicating rainfall would consist of a pie-plate as the grounded electrode with a smaller disc, insulated by a small bakelite spacer, mounted in the center and connected to terminal X of the alarm device. The whole assembly

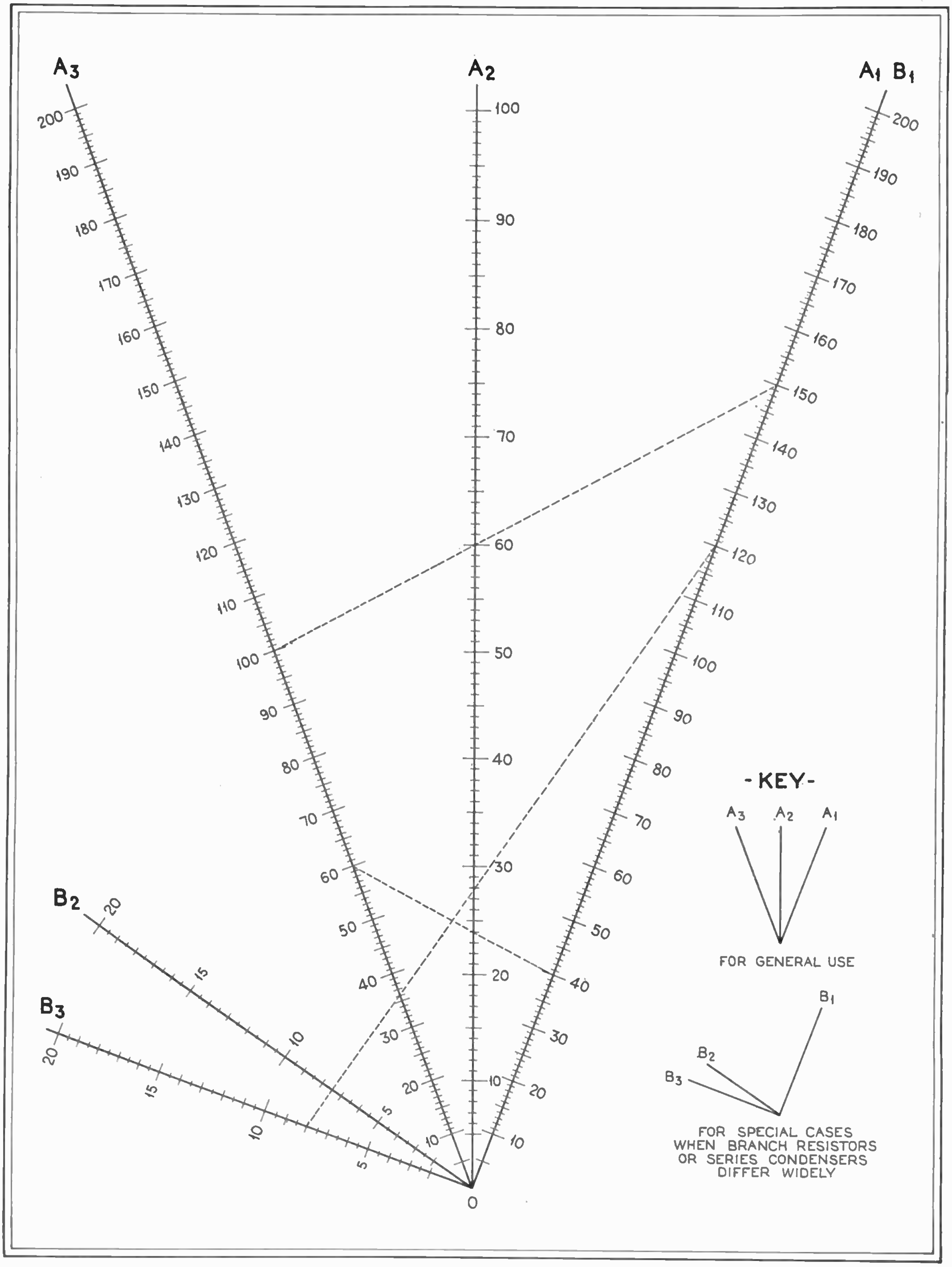


Figure 113
(See Page 56)

is mounted on an extension arm outside of a window in a position such as to collect any rainfall.

A rise in temperature can be made to ring an alarm as follows: a mercury thermometer with its entire lower portion up to the 70-degree F. line is wrapped tightly with tinfoil and connected to the grounded post of the

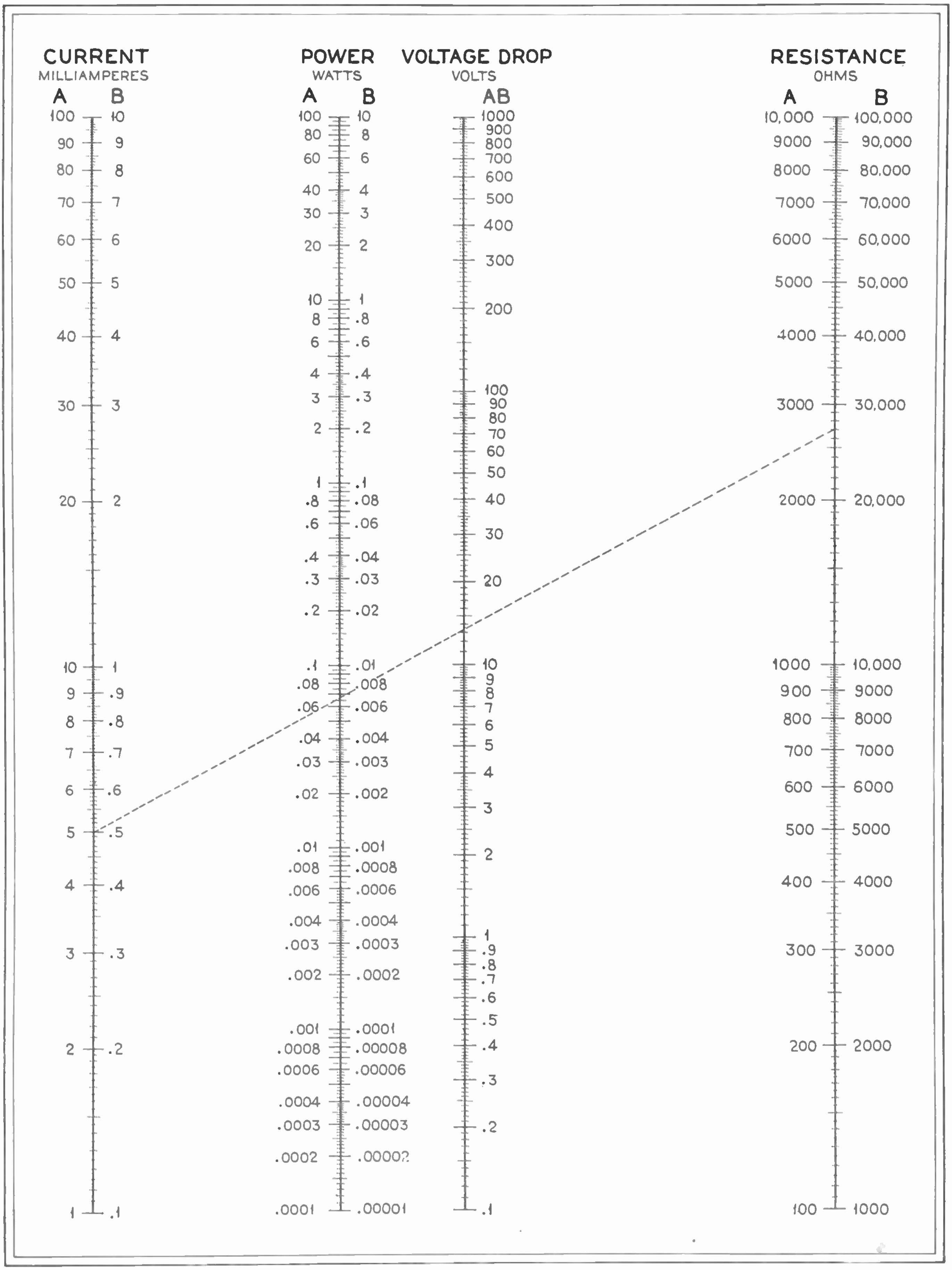


Figure 114
(See Page 56)

alarm device. Then, from 8 or 90 degrees to the maximum of the thermometer another section of tinfoil is wrapped tightly and connected to the high side of the alarm device. This upper electrode could be a split metal sleeve which would allow an adjustment as to the temperature at which the alarm device would work.

Station Lists

U. S. Broadcast Stations

(Alphabetically by Call Letters)

Call	Location	Kc.	Kw.
KABC	San Antonio, Texas	1420	.1
KADA	Ada, Okla. (C. P.)	1200	.1
KALE	Portland, Ore.	1300	.5
KARK	Little Rock, Ark.	890	.25-.5
KASA	Elk City, Okla.	1210	.1
KBPS	Portland, Ore.	1420	.1
KBTM	Paragould, Ark.	1200	.1
	(C.P. to move to Jonesboro)		
KCMC	Texarkana, Ark.	1420	.1
KCRC	Enid, Okla.	1370	.1-.25
KCRJ	Jerome, Ariz.	1310	.1
KDB	Santa Barbara, Calif.	1500	.1
KDFN	Casper, Wyo.	1440	.5
KDKA	Pittsburgh	980	50
KDLR	Devils Lake, N. Dak.	1210	.1
KDYL	Salt Lake City, Utah	1290	1
KECA	Los Angeles, Calif.	1430	1
	(C.P. 2.5 kw-day)		
KELW	Burbank, Calif.	780	.5
KERN	Bakersfield, Calif.	1370	.1
KEX	Portland, Ore.	1180	5
KFAB	Lincoln, Nebr.	770	5
KFAC	Los Angeles, Calif.	1300	1
KFBB	Great Falls, Montana	1280	1-2.5
KFBI	Abilene, Kansas	1050	5
KFBK	Sacramento, Calif.	1310	.1
KFDM	Beaumont, Texas	560	.5-1
KFDY	Brookings, South Dak.	780	1
KFEL	Denver, Colo.	920	.5
KFEQ	St. Joseph, Mo.	680	2.5
KFGQ	Boone, Iowa	1370	.1
KFH	Wichita, Kansas	1300	1
KFI	Los Angeles, Calif.	640	50
KFIO	Spokane, Wash.	1120	.1
KFIZ	Fond du Lac, Wis.	1420	.1
KFJB	Marshalltown, Iowa	1200	.1-.25
KFJI	Klamath Falls, Ore.	1210	.1
KFJM	Grand Forks, N. Dak.	1370	.1
KFJR	Portland, Ore.	1300	.5
KFJZ	Fort Worth, Texas	1370	.1
KFKA	Greeley, Colo.	880	.5-1
KFKU	Lawrence, Kansas	1220	1
KFNF	Shenandoah, Iowa	890	.5-1
KFOR	Lincoln, Nebr.	1210	.1-.25
KFOX	Long Beach, Calif.	1250	1
KFPL	Dublin, Texas	1310	.1
KFPM	Greenville, Texas	1310	.015
KFPW	Ft. Smith, Ark.	1210	.1
KFPY	Spokane, Wash.	1340	1
KFQD	Anchorage, Alaska	780	.25
KFRC	San Francisco, Calif.	610	1
	(C.P. 2.5 kw-day)		
KFRU	Columbia, Mo.	630	.5
KFSD	San Diego, Calif.	600	1
KFSG	Los Angeles, Calif.	1120	.5
KFUO	Clayton, Mo.	550	.5-1
KFVD	Los Angeles, Calif.	1000	.25
KFVS	Cape Girardeau, Mo.	1210	.1
	(C.P. .25 kw-day)		
KFWB	Hollywood, Calif.	950	1
	(C.P. 2.5 kw-day)		
KFXD	Nampa, Idaho	1200	.1
KFXJ	Grand Junction, Colo.	1200	.1
KFXM	San Bernardino, Calif.	1210	.1
KFXR	Oklahoma City, Okla.	1310	.1-.25
KFYO	Lubbock, Texas	1310	.1-.25
KFYR	Bismarck, N. Dakota	550	1-2.5
KGA	Spokane, Wash.	1470	5
KGAR	Tucson, Ariz.	1370	.1-.25
KGB	San Diego, Calif.	1330	1
	(C.P. 2.5 kw-day)		
KGBU	Ketchikan, Alaska	900	.5
KGBX	Springfield, Mo.	1230	.5
KGBZ	York, Nebr.	930	1-2.5
KGCA	Decorah, Iowa	1270	.1
KGCU	Mandan, N. Dakota	1240	.25
KGCX	Wolf Point, Montana	1310	.1-.25
KGDE	Fergus Falls, Minn.	1200	.1-.25
KGDM	Stockton, Calif.	1100	.25
KGDY	Huron, S. Dak.	1340	.25
KGEK	Yuma, Colo.	1200	.1
	(C.P. to move to Sterling)		
KGER	Long Beach, Calif.	1360	1
KGEZ	Kalispell, Mont.	1310	.1
KGFF	Shawnee, Okla.	1420	.1
KGFG	Oklahoma City, Okla.	1370	.1
KGFI	Corpus Christi, Texas	1500	.1-.25
KGFJ	Los Angeles, Calif.	1200	.1
KGFK	Moorhead, Minn.	1500	.1
KGFL	Roswell, N. Mex.	1370	.1
KGFW	Kearney, Nebr.	1310	.1
KGFX	Pierre, S. Dak.	630	.2
KGGC	San Francisco, Calif.	1420	.1
KGGF	Coffeyville, Kansas	1010	1
KGGM	Albuquerque, N. Mex.	1230	.25-.5
KGHF	Pueblo, Colo.	1320	.25
	(C.P. .5 kw full time)		
KGHI	Little Rock, Ark.	1200	.1-.25
KGHL	Billings, Mont.	950	1-2.5
KGIR	Butte, Mont.	1360	1
	(C.P. 2.5 kw-day)		
KGIW	Alamosa, Colo.	1420	.1
KGIX	Las Vegas, Nev.	1420	.1
KGKB	Tyler, Texas	1500	.1
KGKL	San Angelo, Texas	1370	.1-.25
KGKO	Wichita Falls, Texas	570	.25-1
KGKY	Scottsbluff, Nebraska	1500	.1
KGMB	Honolulu, Hawaii	1320	.24
KGNF	North Platte, Nebr.	1430	.5-1
KGNO	Dodge City, Kansas	1340	.25
KGO	San Francisco, Calif.	790	7.5
KGRS	Amarillo, Texas	1410	1
	(C.P. 2.5 kw-day)		
KGU	Honolulu, Hawaii	750	2.5
KGVO	Missoula, Mont.	1200	.1
KGW	Portland, Ore	620	1
	(C.P. 2.5 kw-day)		
KGY	Olympia, Wash.	1210	.1
KHJ	Los Angeles, Calif.	900	1
	(C.P. 2.5 kw-day)		
KHQ	Spokane, Wash.	590	1-2
KICA	Clovis, N. Mex.	1370	.1
KICK	Carter Lake, Iowa	1420	.1
	(To be replaced by WOC)		
KID	Idaho Falls, Idaho	1320	.25-.5
KIDO	Boise, Idaho	1350	1
	(C.P. 2.5 kw-day)		
KIDW	Lamar, Colo.	1420	.1
KIEM	Eureka, Calif.	1210	.1
KIEV	Glendale, Calif.	850	.1
	(C.P. .25 kw)		
KIT	Yakima, Wash.	1310	.1
KJBS	San Francisco, Calif.	1070	.1
	(C.P. .5 kw)		
KJR	Seattle, Wash.	970	5
KLCN	Blytheville, Ark.	1290	.1
KLO	Ogden, Utah	1400	.5
KLPM	Minot, N. Dakota	1240	.25
KLRA	Little Rock, Ark.	1390	1-2.5
KLS	Oakland, Calif.	1440	.25
KLUF	Galveston, Texas	1370	.1
KLX	Oakland, Calif.	880	.1
KLZ	Denver, Colo.	560	1
	(C.P. 2.5 kw-day)		
KMA	Shenandoah, Iowa	930	1-2.5
KMAC	San Antonio, Texas	1370	.1
KMBC	Kansas City, Mo.	950	1
	(C.P. 2.5 kw-day)		
KMED	Medford, Ore.	1310	.1
	(C.P. .25 kw-day)		
KMJ	Fresno, Calif.	580	.5
KMLB	Monroe, La.	1200	.1
KMMJ	Clay Center, Nebr.	740	1
KMO	Tacoma, Wash.	1330	.25
KMOX	St. Louis, Mo.	1090	50
KMPC	Beverly Hills, Calif.	710	.5
KMTR	Los Angeles, Calif.	570	1
KNOW	Austin, Texas	1500	.1
KNX	Los Angeles, Calif.	1050	50
KOA	Denver, Colo.	830	50
KOAC	Corvallis, Ore.	550	1
KOB	Albuquerque, N. Mex.	1180	10
KOH	Reno, Nev.	1380	.5
KOIL	Council Bluffs, Iowa	1260	1
	(C.P. 2.5 kw-day)		
KOIN	Portland, Ore.	940	1
	(C.P. 2.5 kw-day)		
KOL	Seattle, Wash.	1270	1
	(C.P. 2.5 kw-day)		
KOMA	Oklahoma City, Okla.	1480	5
KOMO	Seattle, Wash.	920	1
KONO	San Antonio, Texas	1370	.1
KOOS	Marshfield, Ore.	1200	.1
KORE	Eugene, Ore.	1420	.1
KOTN	Pine Bluff, Ark.	1500	.1
KOY	Phoenix, Ariz.	1390	.5-1
KPAC	Brownsville, Texas	1260	.5
	(C.P Port Arthur)		
KPCB	Seattle, Wash.	650	.1
	(C.P. .25 kw.)		
KPJM	Prescott, Ariz.	1500	.1
KPO	San Francisco, Calif.	680	50
KPOF	Denver, Colo.	880	.5
KPPC	Pasadena, Calif.	1210	.05
KPQ	Wenatchee, Wash.	1500	.1
KPRC	Houston, Texas	920	1-5
KQV	Pittsburgh, Pa.	1380	.5
KQW	San Jose, Calif.	1010	.5
	(C.P. 1 kw.)		
KRE	Berkeley, Calif.	1370	.1
KREG	Santa Ana, Calif.	1500	.1
KRGV	Weslaco, Texas	1260	.5
KRKD	Los Angeles, Calif.	1120	.5-2.5
KRKO	Everett, Wash.	1370	.05
KRLD	Dallas, Texas	1040	10
KRMD	Shreveport, La.	1310	.1
KROW	Oakland, Calif.	930	1
KRSC	Seattle, Wash.	1120	.1
KSAC	Manhattan, Kan.	580	.5-1
KSCJ	Sioux City, Iowa	1330	1-2.5
KSD	St. Louis, Mo.	550	.5-1
	(C.P. 2.5 kw-day)		
KSEI	Pocatello, Idaho	890	.25-
KSL	Salt Lake City, Utah	1130	50
KSLM	Salem, Ore.	1370	.1
KSO	Des Moines, Iowa	1320	.5
KSOO	Sioux Falls, S. Dakota	1110	2.5
KSTP	St. Paul, Minn.	1460	10
KSUN	Lowell, Ariz.	1200	.1
KTAB	San Francisco, Calif.	560	1
KTAR	Phoenix, Ariz.	620	.5-1
KTAT	Fort Worth, Texas	1240	1
KTBS	Shreveport, La.	1450	1
KTFI	West Twin Falls, Idaho	1240	.5-1
KTHS	Hot Springs, National Park, Ark.	1040	10
KTM	Los Angeles, Calif.	780	.5-1
KTRB	Modesto, Calif.	740	.25
KTRH	Houston, Texas	1330	1-2.5
KTSA	San Antonio, Texas	1290	1-2.5
KTSM	El Paso, Texas	1310	.1
KTUL	Tulsa, Okla.	1400	.25-.5
KTW	Seattle, Wash.	1220	1
KUJ	Walla Walla, Wash.	1370	.1
KUMA	Yuma, Ariz.	1420	.1
KUOA	Fayetteville, Ark.	1260	1
KUSD	Vermillion, S. D.	890	.5
KVI	Tacoma, Wash.	570	1
KVL	Seattle, Wash.	1370	.1
KVOA	Tucson, Ariz.	1260	.5
KVOD	Denver, Colo.	920	.5
KVOO	Tulsa, Okla.	1140	25
KVOR	Colorado Springs, Colo.	1270	1
KVOS	Bellingham, Wash.	1200	.1
KWCR	Cedar Rapids, Iowa	1430	.25-.5
KWEA	Shreveport, La.	1210	.1
KWFV	S. Hilo, Waiakea, Hawaii (C.P.)	1210	.1
KWG	Stockton, Calif.	1200	.1
KWJJ	Portland, Ore.	1060	.5
KWK	St. Louis, Mo.	1350	1
	(C.P. 2.5 kw-day)		
KWKC	Kansas City, Mo.	1370	.1
KWKH	Shreveport, La.	850	10
KWLC	Decorah, Iowa	1270	.1
KWSC	Pullman, Wash.	1220	1-2
KWTN	Watertown, S. Dak.	1210	.1
KWTO	Springfield, Mo.	560	1
KWYO	Sheridan, Wyo.	1370	.1
KXA	Seattle, Wash.	760	.25-.5
KXL	Portland, Ore.	1420	.25
KXO	El Centro, Calif.	1500	.1
KXRO	Aberdeen, Wash.	1310	.1
KXYZ	Houston, Texas	1440	.25
KYA	San Francisco, Calif.	1230	1
KYW	Philadelphia, Pa.	1020	10
WAAB	Boston, Mass.	1410	.5
WAAF	Chicago, Ill.	920	.5
WAAT	Jersey City, N. J.	940	.5

Call	Location	Kc.	Kw.
WAAW	Omaha, Nebr.	660	.5
WABC	New York, N. Y.	860	50
WABI	Bangor, Maine	1200	.1
WACO	Waco, Texas	1420	.1
WADC	Tallmadge, Ohio	1320	1
	(C.P. 2.5 kw-day)		
WAGF	Dothan, Ala.	1370	.1
WAGM	Presque Isle, Maine	1420	.1
WAIU	Columbus, Ohio	640	.5
WALA	Mobile, Ala.	1380	.5-1
WALR	Zanesville, Ohio	1210	.1
WAMC	Anniston, Ala. (C.P.)	1420	.1
WAML	Laurel, Miss.	1310	.1
WAPI	Birmingham, Ala.	1140	5
WARD	Brooklyn, N. Y.	1400	.5
WASH	Grand Rapids, Mich.	1270	.5
WATR	Waterbury, Conn.	1190	.1
WAVE	Louisville, Ky.	940	1
WAWZ	Zarephath, N. J.	1350	.25
WAZL	Hazleton, Penna.	1420	.1
WBAA	West Lafayette, Ind.	890	1
WBAL	Baltimore, Md.	1060	10
WBAP	Forth Worth, Texas	800	50
WBAX	Wilkes-Barre, Penna.	1210	.1
WBBC	Brooklyn, N. Y.	1400	.5
WBBL	Richmond, Va.	1210	.1
WBBM	Chicago, Ill.	770	25
WBBR	Brooklyn, N. Y.	1300	1
WBBZ	Ponca City, Okla.	1200	.1
WBCM	Bay City, Mich.	1410	.5
WBEN	Buffalo, N. Y.	900	1
WBEO	Marquette, Mich.	1310	.1
WBHS	Huntsville, Ala.	1200	.1
WBIG	Greensboro, N. C.	1440	.5-1
WBNO	New Orleans, La.	1200	.1
WBNS	Columbus, Ohio	1430	.5-1
WBNX	New York, N. Y.	1350	.25
WBOQ	(See WABC)		
WBOW	Terre Haute, Ind.	1310	.1
dRB	Red Bank, N. J.	1210	.1
WBRC	Birmingham, Ala.	930	1
WBRE	Wilkes-Barre, Pa.	1310	.1
WBSP	Needham, Mass.	920	.5
WBT	Charlotte, N. C.	1080	50
WBTM	Danville, Va.	1370	.1
WBZ	Boston, Mass.	990	50
WBZA	Boston, Mass.	990	1
WCAC	Storrs, Conn.	600	.5
WCAD	Canton, N. Y.	1220	.5
WCAE	Pittsburgh, Pa.	1220	1
WCAL	Northfield, Minn.	1250	2.5
WCAM	Camden, N. J.	1280	.5
WCAO	Baltimore, Md.	600	.5-1
WCAP	Asbury Park, N. J.	1280	.5
WCAT	Rapid City, S. Dak.	1200	.1
WCAU	Philadelphia, Pa.	1170	50
WCAX	Burlington, Vt.	1200	.1
WCAZ	Carthage, Ill.	1070	.1
WCBA	Allentown, Penna.	1440	.25
WCBD	Zion, Ill.	1080	5
WCBM	Baltimore, Md.	1370	.1-.25
WCBS	Springfield, Ill.	1210	.1
WCCO	Minneapolis, Minn.	810	50
WCFL	Chicago, Ill.	970	1.5
WCHS	Charleston, W. Va.	580	.5-1
WCKY	Covington, Ky.	1490	5
WCLO	Janesville, Wis.	1200	1
WCLS	Joliet, Ill.	1310	.1
WCNW	Brooklyn, N. Y.	1500	.1
	(C.P. .25 kw-day)		
WCOA	Pensacola, Fla.	1340	.5
WCOC	Meridian, Miss.	880	.5-1
WCRW	Chicago, Ill.	1210	.1
WCSC	Charleston, S. C.	1360	.5-1
WCSH	Portland, Maine	940	1-2.5
WDAE	Tampa, Fla.	1220	1
WDAF	Kansas City, Mo.	610	1
	(C.P. 2.5 kw-day)		
WDAG	Amarillo, Texas	1410	1
	(C.P. 2.5 kw-day)		
WDAH	El Paso, Texas	1310	.1
WDAS	Philadelphia, Penna.	1370	.1-.25
WDAY	Fargo, N. Dakota	940	1
	(C.P. 2.5 kw-day)		
WDBJ	Roanoke, Va.	930	.5
	(C.P. 1 kw.)		
WDBO	Orlando, Fla.	580	.25
WDEL	Wilmington, Del.	1120	.25-.5
WDEV	Waterbury, Vt.	550	.5
WDGY	Minneapolis, Minn.	1180	1-2.5
WDNC	Durham, N. C.	1500	.1
WDOD	Chattanooga, Tenn.	1280	1-2.5
WDRC	Hartford, Conn.	1330	1
	(C.P. 2.5 kw-day)		
WDSU	New Orleans, La.	1250	1
WDZ	Tuscola, Ill.	1070	.1
WEAF	New York, N. Y.	660	50
WEAN	Providence, R. I.	780	.25-.5
WEBC	Superior, Wis.	1290	1-2.5
WEBQ	Harrisburg, Ill.	1210	.1
	(C.P. .25 kw-day)		
WEBR	Buffalo, N. Y.	1310	.1-.25
WEDC	Chicago, Ill.	1210	.1
WEED	Rocky Mount, N. C.	1420	.1
WEEI	Boston, Mass.	590	1
WEEU	Reading, Penna.	830	1
WEHC	Charlottesville, Va.	1420	.1-.25
WEHS	Cicero, Ill.	1420	.1
WELL	Battle Creek, Mich.	1420	.05
WENR	Chicago, Ill.	870	50
WESG	Elmira, N. Y.	1040	1
WEVD	New York, N. Y.	1300	1
WEW	St. Louis, Mo.	760	1
WEXL	Royal Oak, Mich.	1310	.05
WFAA	Dallas, Texas	800	50
WFAB	New York, N. Y.	1300	1
WFAM	South Bend, Ind.	1200	.1
WFAS	White Plains, N. Y.	1270	.1
WFBC	Greenville, S. C.	1300	1
WFBE	Cincinnati, Ohio	1200	.1-.25
WFBG	Altoona, Pa.	1310	.1
WFBL	Syracuse, N. Y.	1360	1-2.5
WFBM	Indianapolis, Ind.	1230	1
WFBR	Baltimore, Md.	1270	.5
WFDF	Flint, Mich.	1310	.1
WFEA	Manchester, N. H.	1340	.5
	(C.P. 1 kw-day)		
WFI	Philadelphia, Pa.	560	.5
WFLA	Clearwater, Fla.	620	.25-.5
WGAL	Lancaster, Pa.	1500	.1
	(C.P. .25 kw-day)		
WGAR	Cleveland, Ohio	1450	.5-1
WGBB	Freeport, N. Y.	1210	.1
WGBF	Evansville, Ind.	630	.5
WGBI	Scranton, Pa.	880	.25
WGCM	Gulfport, Miss.	1210	.1-.25
WGCP	Newark, N. J.	1250	1-2.5
WGES	Chicago, Ill.	1360	.5-1
WGH	Newport News, Va.	1310	.1
WGL	Ft. Wayne, Ind.	1370	.1
WGLC	Hudson Falls, N. Y.	1370	.1
WGN	Chicago, Ill.	720	50
WGNY	Chester Twp., N. Y.	1210	.1
WGP	Albany, Ga.	1420	.1
WGR	Buffalo, N. Y.	550	1
WGST	Atlanta, Ga.	890	.5-1
WGY	Schenectady, N. Y.	790	50
WHA	Madison, Wis.	940	1
	(C.P. 2.5 kw-day)		
WHAM	Rochester, N. Y.	1150	50
WHAS	Louisville, Ky.	820	50
WHAT	Philadelphia, Pa.	1310	.1
WHAZ	Troy, New York	1300	.5
WHB	Kansas City, Mo.	860	.5
WHBC	Canton, Ohio	1200	.1
WHBD	Mt. Orab, Ohio	1370	.1
WHBF	Rock Island, Ill.	1210	.1
	(C.P. .25 kw-day)		
WHBI	Newark, N. J.	1250	1-2.5
WHBL	Sheboygan, Wis.	1410	.5
WHBQ	Memphis, Tenn.	1370	.1
WHBU	Anderson, Ind.	1210	.1
WHBY	Green Bay, Wis.	1200	.1
	(C.P. .25 kw-day)		
WHDF	Calumet, Mich.	1370	.1-.25
WHDH	Boston, Mass.	830	1
WHDL	Tupper Lake, N. Y.	1420	.1
WHEB	Portsmouth, N. H.	740	.25
WHEC	Rochester, N. Y.	1430	.5-1
WHEF	Kosciusko, Miss.	1500	.1-.25
WHFC	Cicero, Ill.	1420	.1
WHIS	Bluefield, W. Va.	1410	.25
WHJB	Greensburgh, Pa. (C.P.)	620	.25
WHK	Cleveland, Ohio	1390	1-2.5
WHOM	New York, N. Y.	1010	1
WHN	(See WOC)		
WHO	Jersey City, N. J.	1450	.25
WHP	Harrisburg, Pa.	1430	.5-1
WIBA	Madison, Wis.	1280	.5-1
WIBG	Glenside, Pa.	970	.1
WIBM	Jackson, Mich.	1370	.1
WIBU	Poynette, Wis.	1210	.1
WIBW	Topeka, Kansas	580	1
	(C.P. 2.5 kw-day)		
WIBX	Utica, N. Y.	1200	.1-.3
WICC	Bridgeport, Conn.	600	.5-1
WIL	St. Louis, Mo.	1200	.1-.25
WILL	Urbana, Ill.	890	.25-1
WILM	Wilmington, Del.	1420	.1
WIND	Gary, Ind.	560	1
	(C.P. 2.5 kw-day)		
WINS	New York, N. Y.	1180	1
WIOD	Miami, Fla.	1300	1
WIP	Philadelphia, Pa.	610	.5
WIS	Columbia, S. C.	1010	.5-1
WISN	Milwaukee, Wis.	1120	.25-1
WJAC	Johnstown, Pa.	1310	.1
WJAG	Norfolk, Nebr.	1060	1
WJAR	Providence, R. I.	890	.25-.5
WJAS	Pittsburgh, Pa.	1290	1-2.5
WJAX	Jacksonville, Fla.	900	1
WJAY	Cleveland, Ohio	610	.5
WJBC	La Salle, Ill.	1200	.1
	(C.P. to move to Bloomington)		
WJBK	Detroit, Mich.	1500	.1
	(C.P. .25 kw-day)		
WJBL	Decatur, Ill.	1200	.1
WJBO	Baton Rouge, La. (C.P.)	1420	.1
WJBW	New Orleans, La.	1200	.1
WJBY	Gadsden, Ala.	1210	.1
WJDX	Jackson, Miss.	1270	1-2.5
WJEJ	Hagerstown, Md.	1210	.1
WJEM	Tupelo, Miss. (C.P.)	990	.5
WJIM	Lansing, Mich.	1210	.1-.25
WJJD	Chicago, Ill.	1130	20
WJMS	Ironwood, Mich.	1420	.1
WJR	Detroit, Mich.	750	10
WJSV	Alexandria, Va.	1460	10
WJTL	Oglethorpe Uni., Ga.	1370	.1
WJW	Akron, Ohio	1210	.1
	(C.P. .25 kw-day)		
WJZ	New York, N. Y.	760	50
WKAQ	San Juan, Puerto Rico	1240	1
WKAR	East Lansing, Mich.	1040	1
WKBB	East Dubuque, Ill.	1500	.1
WKBF	Indianapolis, Ind.	1400	.5
	(C.P. 1 kw-day)		
WKBH	La Crosse, Wis.	1380	1
WKBI	Cicero, Ill.	1420	.1
WKBN	Youngstown, Ohio	570	.5
WKBO	Harrisburg, Pa.	1200	.1
WKBV	Richmond, Ind.	1500	.1
WKBW	Buffalo, N. Y.	1480	5
WKBZ	Muskegon, Mich.	1500	.1
WKEU	La Grange, Ga.	1500	.1
WKFI	Greenville, Miss.	1210	.1
WKJC	Lancaster, Pa.	1200	.1
	(C.P. .25 kw-day)		
WKOK	Sunbury, Pa.	1210	.1
WKRC	Cincinnati, Ohio	550	.1
	(C.P. 2.5 kw-day)		
WKY	Oklahoma City, Okla.	900	1
WKZO	Kalamazoo, Mich.	590	1
WLAC	Nashville, Tenn.	1470	5
WLAP	Lexington, Ky.	1420	.1-.25
WLB	Minneapolis, Minn.	1250	1
WLBC	Muncie, Ind.	1310	.05-.1
WLBF	Kansas City, Kan.	1420	.1
WLBL	Stevens Point, Wis.	900	2.5
WLBW	Erie, Pa.	1260	1
WLBZ	Bangor, Maine	620	.5
	(C.P. 1 kw-day)		
WLEU	Erie, Pa. (C.P.)	1420	.1-.25
WLIH	Lexington, Mass.	1370	.1-.25
	(C.P. to move to Lowell)		
WLIT	Philadelphia, Pa.	560	.5
WLNH	Laconia, N. H. (C.P.)	1310	.1
WLS	Chicago, Ill.	870	50
WLTH	Brooklyn, N. Y.	1400	.5
WLVA	Lynchburg, Va.	1200	.1
	(C.P. .25 kw-day)		
WLW	Cincinnati, Ohio	700	50
	Special authorization to use 500 kw. experimentally.		
WLWL	New York, N. Y.	1100	5
WMAL	Washington, D. C.	630	.25-.5
WMAQ	Chicago, Ill.	670	5
	(C.P. 50 kw.)		
WMAS	Springfield, Mass.	1420	.1-.25
WMAZ	Macon, Ga.	1180	.5
	(C.P. 1 kw.)		
WMBC	Detroit, Mich.	1420	.1-.25
WMBD	Peoria, Ill.	1440	.5-1
WMBF	(See WIOD)		
WMBG	Richmond, Va.	1210	.1
WMBH	Joplin, Mo.	1420	.1-.25
WMBI	Chicago, Ill.	1080	5
WMBO	Auburn, N. Y.	1310	.1
WMBQ	Brooklyn, N. Y.	1500	.1
WMBR	Jacksonville, Fla.	1370	.1
WMC	Memphis, Tenn.	780	.5-1
WMCA	New York, N. Y.	570	.5
WMEX	Chelsea, Mass. (C.P.)	1500	.1-.25
WMMN	Fairmont, W. Va.	890	.25-.5
WMPC	Lapeer, Mich.	1200	.1
WMT	Waterloo, Iowa	600	.5-1
WNAC	Boston, Mass.	1230	1
	(C.P. 2.5 kw-day)		
WNAD	Norman, Okla.	1010	1
WNAX	Yankton, S. Dak.	570	1-2.5
WNBF	Binghamton, N. Y.	1500	.1
WNBH	New Bedford, Mass.	1310	.1-.25
WNBO	Silverhaven, Pa.	1200	.1
WNBR	Memphis, Tenn.	1430	.5
WNBX	Springfield, Vt.	1260	.5
	(C.P. 1 kw.)		
WNBZ	Saranac Lake, N. Y.	1290	.05
WNEL	San Juan,		
	Puerto Rico (C.P.)	1290	.5
WNEW	Newark, N. J.	1250	1-2.5
WNOX	Knoxville, Tenn.	560	1-2
WNRA	Muscle Shoals City, Ala.	1420	.1
WNYC	New York, N. Y.	810	.5-1
WOAI	San Antonio, Tex.	1190	50
WOC	Des Moines, Iowa	1000	50
WOCL	Jamestown, N. Y.	1210	.05
WOI	Ames, Iowa	640	5
WOKO	Albany, N. Y.	1430	.5-1
WOL	Washington, D. C.	1310	.1
	(C.P. .25 kw-day)		
WOMT	Manitowoc, Wis.	1210	.1
WOOD	Grand Rapids, Mich.	1270	.5
WOPI	Bristol, Tenn.	1500	.1
WOR	Newark, N. J.	710	5
	(C.P. 50 kw.)		
WORC	Worcester, Mass.	1200	.1
WORK	York, Pa.	1000	1
WOS	Jefferson City, Mo.	630	.5
WOSU	Columbus, Ohio	570	.75-1
WOV	New York, N. Y.	1130	1
WOW	Omaha, Nebr.	590	1
	(C.P. 2.5 kw-day)		
WOWO	Ft. Wayne, Ind.	1160	10
WPAD	Paducah, Ky.	1420	.1
	(C.P. .1-.25 kw.)		
WPEN	Philadelphia, Pa.	1500	.1-.25
	(C.P. 920 kc., .25 kw.)		
WPFB	Hattiesburg, Miss.	1370	.1
WPG	Atlantic City, N. J.	1100	5
WPHR	Petersburg, Va.	1200	.1-.25
	(C.P. 880 kc., .5 kw.)		
WPRO	Providence, R. I.	1210	.1
WPTF	Raleigh, N. C.	680	1
	(C.P. 5 kw.)		
WQAM	Miami, Fla.	560	1
WQAN	Scranton, Pa.	880	.25
WQBC	Vicksburg, Miss.	1360	.5-1
WQDM	St. Albans, Vt.	1370	.1
WQDX	Thomasville, Ga.	1210	.1
WRAK	Williamsport, Pa.	1370	.1
	(C.P. .25 kw-day)		
WRAW	Reading, Pa.	1310	.1
WRAX	Philadelphia, Pa.	1020	.25
	(C.P. 930 kc., .5 kw-day)		
WRBL	Columbus, Ga.	1200	.1
WRBX	Roanoke, Ga.	1410	.25-.5
WRC	Washington, D. C.	950	.5-1
WRDO	Augusta, Maine	1370	.1
WRDW	Augusta, Ga.	1500	.1
WREC	Memphis, Tenn.	600	.5-1
WREN	Lawrence, Kansas	1220	1
WRGA	Rome, Ga.	1500	.1
WRJN	Racine, Wis.	1370	.1
WROK	Rockford, Ill.	1410	.5
WROL	Knoxville, Tenn.	1310	.1
WRR	Dallas, Texas	1280	.5
WRUF	Gainesville, Fla.	830	5

Call	Location	Kc.	Kw.
WRVA	Richmond, Va.	1110	5
WSAI	Cincinnati, Ohio	1330	1-2.5
WSAJ	Grove City, Pa.	1310	.1
WSAN	Allentown, Pa.	1440	.25
WSAR	Fall River, Mass.	1450	.25
WSAZ	Huntington, W. Va.	1190	1
WSB	Atlanta, Ga.	740	50
WSBC	Chicago, Ill.	1210	.1
WSBT	South Bend, Ind.	1360	.5
WSEN	Columbus, Ohio	1210	.1-1
WSFA	Montgomery, Ala.	1410	.5
WSGN	Birmingham, Ala. (C.P. .25 kw-day)	1310	.1
WSIX	Springfield, Tenn.	1210	.1
WSJS	Winston-Salem, N. C.	1310	.1
WSM	Nashville, Tenn.	650	50
WSMB	New Orleans, La.	1320	.5
WSMK	Dayton, Ohio	1380	.2
WSOC	Charlotte, N. C.	1210	.1-.25
WSPA	Spartanburg, S. C. (C.P. 1 kw., 920 kc.)	1420	.1-.25
WSPD	Toledo, Ohio (C.P. 3.5 kw. day)	1340	1
WSUI	Iowa City, Iowa	880	.5
WSUN	(See WFLA)		
WSVS	Buffalo, N. Y.	1370	.05
WSYB	Rutland, Vt	1500	.1
WSYR	Syracuse, N. Y.	570	.25
WTAD	Quincy, Ill.	1440	.5
WTAG	Worcester, Mass.	580	.5
WTAM	Cleveland, Ohio	1070	50
WTAQ	Eau Claire, Wis.	1330	1
WTAR	Norfolk, Va.	780	.5-1
WTAW	College Station, Texas	1120	.5
WTAX	Springfield, Ill. (C.P. 1300 kc., .25-1 kw.)	1210	.1
WTBO	Cumberland, Md.	800	.25
WTCN	Minneapolis, Minn.	1250	1
WTFI	Athens, Ga.	1450	.5
WTIC	Hartford, Conn.	1060	50
WTJS	Jackson, Tenn.	1310	.1-.25
WTMJ	Milwaukee, Wis.	620	1-5
WTNJ	Trenton, N. J.	1280	.5
WTOC	Savannah, Ga. (C.P. 1 kw.)	1260	.5
WTRC	Elkhart, Ind.	1310	.05-.1
WVFW	Brooklyn, N. Y.	1400	.5
WWAE	Hammond, Ind.	1200	.1
WWJ	Detroit, Mich.	920	1
WWL	New Orleans, La.	850	10
WWNC	Asheville, N. C.	570	1
WWRL	Woodside, N. Y.	1500	.1-.25
WWSW	Pittsburgh, Pa.	1500	.1-.25
WWVA	Wheeling, W. Va.	1160	5
WXYZ	Detroit, Mich.	1240	1

C.P.—Construction permit. Where two powers are given, the first one is used at night, the second in daytime.

U. S. Broadcast Stations

(By Frequencies)

550 kc., 545.1 m.
KFUO, KFYR, KOAC, KSD, WDEV, WGR, WKRC.

560 kc., 535.4 m.
KFDM, KLZ, KTAB, KWTO, WFI, WIND, WLIT, WNOX, WQAM.

570 kc., 526.0 m.
KGKO, KMTR, KVI, WKBN, WMCA, WNAX, WOSU, WSYR, WSYU, WWNC.

580 kc., 516.9 m.
KMJ, KSAC, WCHS, WDBO, WIBW, WTAG.

590 kc., 508.2 m.
KHQ, WEEI, WKZO, WOW.

600 kc., 499.7 m.
KFSD, WCAC, WCAO, WICC, WMT, WREC.

610 kc., 491.5 m.
KFRC, WDAF, WIP, WJAY.

620 kc., 483.6 m.
KGW, KTAR, WFLA, WSUN, WHJB, WLBZ, WTMJ.

630 kc., 475.9 m.
KFRU, KGFX, WGBF, WMAL, WOS.

640 kc., 468.5 m.
KFI, WAIU, WOI.

650 kc., 461.3 m.
KPCB, WSM.

660 kc., 454.3 m.
WAAW, WEAF.

670 kc., 447.5 m.
WMAQ.

680 kc., 440.9 m.
KFEQ, KPO, WPTF.

690 ks., 434.5 m.
(Reserved for Canadian Stations)

700 kc., 428.3 m.
WLW.

710 kc., 422.3 m.
KMPC, WOR.

720 kc., 416.4 m.
WGN.

730 kc., 410.7 m.
(Reserved for Canadian Stations)

740 kc., 405.2 m.
KMMJ, KTRB, WHEB, WSB.

750 kc., 399.8 m.
KGU, WJR.

760 kc., 394.5 m.
KXA, WEW, WJZ.

770 kc., 389.4 m.
KFAB, WBBM.

780 kc., 384.4 m.
KELW, KFDY, KFQD, KTM, WEAN, WMC, WTAR.

790 kc., 379.5 m.
KGO, WGY.

800 kc., 374.8 m.
WBAP, WFAA, WTBO.

810 kc., 370.1 m.
WCCO, WNYC.

820 kc., 365.6 m.
WHAS.

830 kc., 361.2 m.
KOA, WEEU, WHDH, WRUF.

840 kc., 356.9 m.
(Reserved for Canadian Stations)

850 kc., 352.7 m.
KIEV, KWKH, WWL.

860 kc., 348.6 m.
WABC, WBOQ, WIIB.

870 kc., 344.6 m.
WENR, WLS.

880 kc., 340.7 m.
KFKA, KLX, KPOF, WCOC, WGBI, WQAN, WSUI.

890 kc., 336.9 m.
KSRK, KFNF, KSEI, KUSD, WBAA, WGST, WILL, WJAR, WMMN.

900 kc., 333.1 m.
KGBU, KHJ, WBEN, WJAX, WKY, WLBL.

910 kc., 329.5 m.
(Reserved for Canadian Stations)

920 kc., 325.9 m.
KFEL, KOMO, KPRC, KVOD, WAAF, WBSO, WWJ.

930 kc., 322.4 m.
KGBZ, KMA, KROW, WBRC, WDBJ.

940 kc., 319.0 m.
KOIN, WAAT, WAVE, WCSH, WDAY, WHA.

950 kc., 315.6 m.
KFWB, KGHL, KMBC, WRC.

960 kc., 312.3 m.
(Reserved for Canadian Stations)

970 kc., 309.1 m.
KJR, WCFL, WIBG.

980 kc., 305.9 m.
KDKA.

990 kc., 302.8 m.
WBZ, WBZA, WJEM.

1000 kc., 299.8 m.
KFVD, WHO, WOC, WORK.

1010 kc., 296.9 m.
KGGF, KQW, WHN, WIS, WNAD.

1020 kc., 293.9 m.
KYW, WRAX.

1030 kc., 291.1 m.
(Reserved for Canadian Stations)

1040 kc., 288.3 m.
KRLD, KTHS, WESG, WKAR.

1050 kc., 285.5 m.
KFBI, KNX.

1060 kc., 282.8 m.
KWJJ, WBAL, WJAG, WTIC.

1070 kc., 280.2 m.
KJBS, WCAZ, WDZ, WTAM.

1080 kc., 277.6 m.
WBT, WCBD, WMBI.

1090 kc., 275.1 m.
KNOX.

1100 kc., 272.6 m.
KGDM, WLWL, WPG.

1110 kc., 270.1 m.
KSOO, WRVA.

1120 kc., 267.7 m.
KFIO, KFSG, KRKD, KRSC, WDEL, WISN, WTAW.

1130 kc., 265.3 m.
KSL, WJJD, WOV.

1140 kc., 263.0 m.
KVOO, WAPI.

1150 kc., 260.7 m.
WHAM.

1160 kc., 258.5 m.
WOWO, WWVA.

1170 kc., 256.3 m.
WCAU.

1180 kc., 254.1 m.
KEX, KOB, WDGY, WINS, WMAZ.

1190 kc., 252.0 m.
WATR, WOAI, WSAZ.

1200 kc., 249.9 m.
KADA, KBTM, KFJB, KFXD, KFXJ, KGDE, KGEK, KGFJ, KGHI, KGVO, KMLB, KOOS, KSUN, KVOS, KWG, WABD, WBBZ, WBHS, WBNO, WCAT, WCAX, WCLO, WFAM, WFBE, WHBC, WHBY, WIBX, WIL, WJBC, WJBL, WJBW, WKBO, WKJC, WLVA, WMPC, WNBO, WORC, WPHR, WRBL, WSIX, WWAE.

1210 kc., 247.8 m.
KASA, KDLR, KFJI, KFOR, KFPW, KFVS, KFXM, KGY, KIEM, KPPC, KWEA, KWFV, KWTN, WALR, WBAX, WBBL, WBRB, WCBS, WCRW, WEBQ, WEDC, WFAS, WGBB, WGCM, WGNY, WHBF, WHBU, WIBU, WJBY, WJEJ, WJIM, WJW, WKFI, WKOK, WMBC, WOCL, WOMT, WPRO, WQDX, WSBC, WSEN, WSOC, WTAX.

1220 kc., 245.8 m.
KFKU, KTW, KWSC, WCAD, WCAE, WDAE, WREN.

1230 kc., 243.8 m.
KGBX, KGGM, KYA, WFBM, WNAC.

1240 kc., 241.8 m.
KGCU, KLPM, KTAT, KTFI, WKAQ, WXYZ.

1250 kc., 239.8 m.
KFOX, WCAL, WDSU, WGCP, WHBI, WNEW, WTCN.

1260 kc., 238.0 m.
KOIL, KPAC, KRGV, KUOA, WLBW, WNBX, WTOC.

1270 kc., 236.1 m.
KGCA, KOL, KVOR, KWLC, WASH, WFBR, WJDX, WOOD.

1280 kc., 234.2 m.
KFBB, WCAM, WCAP, WDOD, WIBA, WRR, WTNJ.

1290 kc., 232.4 m.
KDYL, KLCN, KTSA, WEBC, WJAS, WNBZ, WNEL.

1300 kc., 230.6 m.
KALE, KFAC, KFH, KFJR, WBBR, WEVD, WFAB, WFBC, WHAZ, WIOD, WMAF.

1310 kc., 228.9 m.
KCRJ, KFBK, KFPL, KFPM, KFXR, KFYO, KGBX, KGCX, KGEZ, KGFW, KIT, KMED, KRMD, KTSM, KXRO, WAML, WBEO, WBOW, WBRE, WCLS, WDAH, WEBR, WEXL, WFBG, WFDF, WGH, WJAC, WLBC, WLNH, WOL, WRAW, WROL, WSAJ, WSGN, WSJS, WTEL, WJTS, WTRC.

1320 kc., 227.1 m.
KGHF, KGMB, KID, KSO, WADC, WSMB.

1330 kc., 225.4 m.
KGB, KMO, KSCJ, KTRH, WDRC, WSAI, WTAQ.

1340 kc., 233.7 m.
KFPY, KGDY, KGNO, WCOA, WFEA, WSPD.

1350 kc., 222.1 m.
KIDO, KWK, WAWZ, WBNX, WEHC.

1360 kc., 220.4 m.
KGER, KGIR, WCSC, WFBL, WGES, WQBC, WSBT.

1370 kc., 218.8 m.
KCRC, KERN, KFGO, KFJM, KFJZ, KGAR, KGFG, KGFL, KGKL, KICA, KLUF, KMAC, KONO, KRE, KRKO, KSLM, KUJ, KWKC, KWYO, WAGE, WBTM, WCBM, WDAS, WGL, WGLC, WHBD, WHBQ, WHDF, WIBM, WJTL, WLIH, WMBR, WPFB, WQDM, WRAK, WRDO, WRJN, WSVS.

1380 kc., 217.3 m.
KOH, KQV, WALA, WKBH, WSMK.

1390 kc., 215.7 m.
KLRA, KOY, WHK.

1400 kc., 214.2 m.
KLO, KTUL, WARD, WBBC, WKBF, WLTH, WVFW.

1410 kc., 212.6 m.
KGRS, WAAB, WBCM, WDAG, WHBL, WHIS, WRBX, WROK, WSFA.

1420 kc., 211.1 m.
KABC, KBPS, KCMC, KFIZ, KGFF, KGGC, KGIW, KGIX, KICK, KIDW, KORE, KUMA, KWCR, KXL, WACO, WAGM, WAMC, WAZL, WEED, WEHS, WELL, WGCP, WHDL, WHFC, WILM, WJBO, WJMS, WKBI, WLAP, WLBF, WLEU, WMAS, WMBC, WMBH, WNRA, WPAD, WSPA.

1430 kc., 209.7 m.
KECA, KGNF, WBNS, WHEC, WHP, WNBR, WOKO.

1440 kc., 208.2 m.
KDFN, KLS, KXYZ, WBIG, WCBA, WMBD, WSAN, WTAD.

1450 kc., 206.9 m.
KTBS, WGAR, WHOM, WSAR, WTFI.

1460 kc., 205.4 m.
KSTP, WJSV.

1470 kc., 204.0 m.
KGA, WLAC.

1480 kc., 202.6 m.
KOMA, KWBW.

1490 kc., 201.2 m.
WCKY.

1500 kc., 199.9 m.
KDB, KGFI, KGFK, KGKB, KGKY, KNOW, KOTN, KPJM, KPQ, KREG, KXO, WCNW, WDNC, WGAL, WHEF, WJBK, WKBB, WKBV, WKBZ, WKEU, WMBQ, WMEX, WNBF, WOPI, WPEN, WRDW, WRGA, WSYB, WWRL, WWSW.

Foreign Broadcast Stations

(Reported Heard in the U. S.)

Kc.	Kw.	Call	Location
546	120	Budapest	Hungary
556	100	Beromunster	Switzerland
560	7.5	2CB	Corowa, N.S W., Australia
560	7.5	2CO	Corowa, N.S.W., Australia
564	60	Athlone	Irish Free State
565	10	TGW	Guatemala City, Guatemala
570	5	2YA	Wellington, New Zealand
574	100	Stuttgart	Germany
580	1	7ZL	Hobart, Tasm., Australia
590	10	JOAK-2	Tokyo, Japan
592	120	Vienna	Austria
601	6.5	Rabat	Morocco
609	20	Florence	Italy
610	10	JODK-1	Keijo, Korea, Japan
610	4.5	3AR	Melbourne, Vict., Australia
618.5	50	KZRM	Manila, Philippine Islands
620	.5	4ZP	Invercargill, New Zealand
625	.5	JOTK	Matsuye, Japan
629	15	Lisbon	Portugal
630	4.5	LS3	Buenos Aires, Argentina
630	.1	CKDV	Kelowna, B. C., Canada
635	.5	JODG	Hamamatsu, Japan
635	7.5	5CK	Crystal Brook, Australia
638	120	Prague	Czechoslovakia
645	.5	JQAK	Darien, Japan
645	.3	JOUK	Akita, Japan
648	15	Lyons	France
650	.5	1YA	Auckland, New Zealand
655	.3	JOCG	Asahogawa, Japan
658	100	Cologne	Germany
658	100	Lanenburg	Germany
660	75	XGOA	Nanking, China
665	3.5	2FC	Sydney,N.S.W., Australia
668	50	No.Regional	Great Britain
670	10	JFAK	Taihoku, Formosa, Japan
675	...	YV6R V	Valencia, Venezuela
677	25	Sottens	Switzerland
680	.5	JOVK	Hakodate, Japan
681	1	HJN	Bogota, Columbia
690	3.5	6WF	Perth, W. Austr., Australia
695	7	PTT	Paris, France
700	.5	JOKK	Okayama, Japan
704	55	Stockholm	Sweden
710	3	JOJK	Kanazawa, Japan
713	50	IIRO	Rome, Italy
720	1	JFBK	Tainan, Formosa, Japan
720	.5	JORK	Kochi, Japan
720	2.5	3YA	Christchurch, New Zealand
730	2	5CL	Adelaide, Australia
735	1	JOSK	Kokura, Japan
740	100	Munich	Germany
750	10	JOBK-1	Osaka, Japan
750	2.5	KGU	Honolulu, Hawaii
760	2.5	4QG	Brisbane, Qnsld., Australia
767	25	Mid.Regional	Great Britain
770	10	JOHK	Sendai, Japan
780	.5	JOPK	Shizuoka, Japan
780	.25	KFQD	Anchorage, Alaska
785	120	Leipzig	Germany
790	10	JOGK	Kumamoto, Japan
790	8	LR10	Buenos Aires, Argentina
790	.5	4YA	Dunedin, New Zealand
795	5	Barcelona	Spain
800	5	3LO	Melbourne, Vict., Australia
804	50	Scottish Reg.	Great Britain
810	10	JOCK.1	Nagoya, Japan
814	50	Milan	Italy
815	.25	PRA8	Rio de Janeiro, Brazil
820	.065	2ZH	Napier, New Zealand
830	16	LR5	Buenos Aires, Argentina
830	10	JDIK	Sapporo, Japan
832	100	RW39	Moscow IV, U.S.S.R.
840	.2	2YC	Wellington, New Zealand
840	.34	CMQ	Havana, Cuba
840	.4	VOGY	St. Johns, Newfoundland
841	100	Berlin	Germany
845	2	ZBW	Hong Kong, China
850	1.5	Valencia	Spain
850	10	JDFK	Hiroshima, Japan
855	8	2BL	Sydney, N.S.W., Australia
859	15	Strasbourg	France
870	2.1	LR6	Buenos Aires, Argentina
870	10	JOAK.1	Tokyo, Japan
877	50	London Reg.	Great Britain
880	.15	1YX	Auckland, New Zealand
900	10	JODK-2	Keijo, Korea, Japan
900	.5	KGBU	Ketchikan, Alaska
904	100	Hamburg	Germany
910	6	LR2	Buenos Aires, Argentina
910	2	4RK	Rockhampton, Australia
913	60	Toulouse	France
920	.5	JOQK	Niigata, Japan
920	1	HHK	Port-au-Prince, Haiti
922	32	OKB	Brno, Chechoslovakia
930	.4	3UZ	Melbourne, Australia
930	.5	JOAG	Nagasaki, Japan
940	.5	JONK	Nangano, Japan
941	10	Goteborg	Sweden
950	17	Breslau	Germany
950	12	LR3	Buenos Aires, Argentina
950	1	2GB	Sydney, N.S.W., Australia
959	100	PosteParisien	France
960	10	XEAW	Reynosa, Mexico
960	.3	5DN	Adelaide, Australia
960	.3	JODK	Kyoto, Japan
960	5	YV1RC	Caracas, Venezuela
968	15	Grenoble	France
970	.5	JOBG	Maehashi, Japan
977	50	W.Regional	Great Britain
978	1	XGOD	Hangchow, China
980	.5	JOXK	Tokushima, Japan
985	1	CE98	Santiago, Chile
986	10	Genoa	Italy
990	.3	JOFG	Fukui, Japan
990	12	LR4	Buenos Aires, Argentina
995	20	Hilversum	Holland
1000	.05	4GR	Toowoomba,Qnsld.,Australia
1004	13.5	OKR	Bratislava, Chechoslovakia
1010	.3	3HA	Hamilton, Vict., Australia
1013	50	N.National	Great Britain
1025	1	2UE	Sydney, N.S.W., Australia
1030	5	LR9	Buenos Aires, Argentina
1040	2	5PI	Crystal Brook, Australia
1040	10	CP4	La Paz, Bolivia
1031	60	Konigsberg	Germany
1050	50	Scottish Nat'l	Great Britain
1059	20	Bari	Italy
1077	12	Bordeaux	France
1085	10	JDBK-2	Osaka, Japan
1104	1.5	Naples	Italy
1120	.1	CHSJ	St. Johns, NewBrunswick
1125	1	2UW	Sydney, N.S.W., Australia
1131	10	Horby	Sweden
1140	7	Turin	Italy
1145	.75	4BC	Brisbane, Qnsld., Australia
1149	50	W.National	Great Britain
1150	5	LR8	Buenos Aires, Argentina
1158	2.6	OKM	Kosice, Czechoslovakia
1175	10	JOCK.2	Nagoya, Japan
1176	10	Copenhagen	Denmark
1180	.4	3DB	Melbourne, Australia
1190	.01	VE9EK	Montmagny, Quebec, Canada
1190	5	LS2	Buenos Aires, Argentina
1195	17	Frankfurt	Germany
1210	1	2CH	Sydney, N.S.W., Australia
1222	10	Trieste	Italy
1230	2	LS8	Buenos Aires, Argentina
1230	...	CPX	La Paz, Bolivia
1240	1	WKAQ	San Juan, Puerto Rico
1245	2	2NC	New Castle, N.S.W., Aust'l
1258	3	SanSebastian	Spain
1267	2	Nurnburg	Germany
1270	1	2SM	Sydney, N.S.W., Australia
1270	1	HIX	Santo Domingo, Dominican Republic
1290	.5	WNEL	San Juan, Puerto Rico
1320	.25	KGMB	Honolulu, Hawaii
1456	10	Radio-Normandie	Fecamp, France
1474	1	Bournem'th	Great Britain

Municipal Police Radio Stations

Call	Location	Kc.	Watts
KGHG	Las Vegas, Nev.	2474	50
KGHK	Palo Alto, Calif.	1674	20
KGHM	Reno, Nev.	2474	50
KGHN	Hutchinson, Kan.	2450	50
KGHP	Lawton, Okla.	2466	50
KGHS	Spokane, Wash.	2414	100
KGHT	Brownsville, Tex. (C.P.)	2382	100
KGHU	Austin, Tex.	2382	100
KGHV	Corpus Christi, Tex.	2382	50
KGHW	Centralia, Wash. (C.P.)	2414	15
KGHX	Santa Ana, Calif.	2490	400
KGHY	Whittier, Calif.	1712	50
KGHZ	Little Rock, Ark.	2406	100
KGJX	Pasadena, Calif.	1712	400
KGOZ	Cedar Rapids, Iowa	2466	50
KGPA	Seattle, Wash.	2414	250
KGPB	Minneapolis, Minn.	2430	400
KGPC	St. Louis, Mo.	1706	500
KGPD	San Francisco, Calif.	2466	400
KGPE	Kansas City, Mo.	2422	400
KGPG	Vallejo, Calif.	2422	7.5
KGPH	Oklahoma City, Okla.	2450	250
KGPF	Santa Fe, N. M.	2414	25
KGPI	Omaha, Nebr.	2466	400
KGPJ	Beaumont, Tex.	1712	100
KGPK	Sioux City, Iowa	2466	100
KGPL	Los Angeles, Calif.	1712	500
KGPM	San Jose, Calif.	1674	50
KGPN	Davenport, Iowa	2466	50
KGPO	Tulsa, Okla.	2450	100
KGPP	Portland, Ore.	2442	500
KGPQ	Honolulu, T. H. (Temporarily changed to 1712 kc.)	2450	100
KGPR	Minneapolis, Minn.	2430	400
KGPS	Bakersfield, Calif.	2414	50
KGPW	Salt Lake City, Utah	2406	100
KGPX	Denver, Colo.	2442	150
KGPZ	Wichita, Kan.	2450	250
KGZA	Fresno, Calif. (C. P. for 500 watts)	2414	100
KGZB	Houston, Tex.	1712	200
KGZC	Topeka, Kan.	2422	50
KGZD	San Diego, Calif.	2490	100
KGZF	Chanute, Kan.	2450	25
KGZG	Des Moines, Iowa	2466	100
KGZH	Klamath Falls, Ore.	2382	25
KGZI	Wichita Falls, Tex.	2458	50
KGZJ	Phoenix, Ariz.	2430	100
KGZM	El Paso, Tex.	2414	100
KGZN	Tacoma, Wash.	2414	100
KGZO	Santa Barbara, Calif.	2414	100
KGZP	Coffeyville, Kan.	2450	50
KGZQ	Waco, Tex.	1712	50
KGZR	Salem, Ore.	2442	50
KGZT	Santa Cruz, Calif.	1674	50
KGZU	Lincoln, Nebr.	2490	200
KGZV	Aberdeen, Wash.	2414	50
KGZW	Lubbock, Tex.	2458	50
KGZX	Albuquerque, N. M.	2414	50
KGZY	San Bernardino, Calif.	1712	50
KNFA	Clovis, N. M. (C. P.)	2414	50
KNFB	Idaho Falls, Idaho (C. P.)	2458	500
KNFF	Leavenworth, Kan. (C. P.)	2422	75
KNFE	Duluth, Minn.	2382	400
KNFH	Garden City, Kan. (C. P.)	2474	50
KNFJ	Pomona, Calif. (C. P.)	1712	50
KSW	Berkeley, Calif.	1658	400
KVP	Dallas, Texas	1712	500
WCK	Belle Isle, Mich.	2414	500
WKDU	Cincinnati, Ohio	1706	500
WMDZ	Indianapolis, Ind.	2442	400
WMJ	Buffalo, N. Y.	2422	500
WMO	Highland Park, Mich.	2414	50
WNFP	Niagara Falls, N. Y.	2422	135
WPDA	Tulare, Calif.	2414	150

Call	Location	Kc.	Watts
WPOB	Chicago, Ill.	1712	500
WPDC	Chicago, Ill.	1712	500
WPDD	Chicago, Ill.	1712	500
WPDE	Louisville, Ky.	2442	200
WPDF	Flint, Mich.	24o6	100
WPDG	Youngstown, Ohio	2458	250
WPDH	Richmond, Ind.	2442	50
WPDI	Columbus, Ohio	2430	200
WPDK	Milwaukee, Wis.	2450	500
WPDL	Lansing, Mich.	2442	50
WPDM	Dayton, Ohio	2430	400
WPON	Auburn, N. Y.	2382	50
WPDO	Akron, Ohio	2458	100
WPDP	Philadelphia, Pa.	2474	500
WPDR	Rochester, N. Y.	2422	200
WPDS	St. Paul, Minn.	2430	500
WPDT	Kokomo, Ind.	2490	50
WPDU	Pittsburgh, Pa.	1712	400
WPDV	Charlotte, N. C.	2458	50
WPDW	Washington, D. C.	2422	400
WPDX	Detroit, Mich.	2414	500
WPDY	Atlanta, Ga.	2414	150
WPEA	Syracuse, N. Y.	2382	400
WPEB	Grand Rapids, Mich.	2442	500
WPEC	Memphis, Tenn.	2466	400
WPED	Arlington, Mass.	1712	100
WPEE	Brooklyn, N. Y.	2450	400
WPEF	Bronx, N. Y.	2450	400
WPEG	New York, N. Y.	2450	500
WPEH	Somerville, Mass.	1712	100
WPEI	E. Providence, R. I.	1712	50
WPEK	New Orleans, La.	2430	250
WPEM	Woonsocket, R. I.	2466	100
WPEP	Kenosha, Wis. (C. P.)	2450	100
WPES	Saginaw, Mich.	2442	100
WPET	Lexington, Ky.	1706	500
WPFA	Newton, Mass.	1712	50
WPFC	Muskegon, Mich.	2442	50
WPFE	Reading, Pa.	2442	100
WPFG	Jacksonville, Fla.	2442	400
WPFH	Baltimore, Md.	2414	500
WPFI	Columbus, Ga.	2414	50
WPFK	Hackensack, N. J.	2430	200
WPFM	Birmingham, Ala.	2382	400
WPFN	Fairhaven, Mass.	1712	100
WPFO	Knoxville, Tenn.	2474	400
WPFP	Clarksburg, W. Va.	2490	80
WPFQ	Swarthmore, Pa.	2474	50
WPFR	Johnson City, Tenn.	2474	50
WPFS	Asheville, N. C.	2474	200
WPFT	Lakeland, Fla. (C. P.)	2442	50
WPFU	Portland, Me.	2422	100
WPFV	Pawtucket, R. I.	2466	50
WPFW	Bridgeport, Conn.	2466	50
WPFX	Palm Beach, Fla.	2442	50
WPFY	Yonkers, N. Y. (C. P.)	2442	400
WPFZ	Miami Beach, Fla.	2442	100
WPGA	Bay City, Mich.	2466	50
WPGB	Port Huron, Mich.	2466	50
WPGD	Rockford, Ill.	2458	50
WPGF	Providence, R. I.	1712	150
WPGH	Albany, N. Y.	2414	300
WPGI	Portsmouth, Ohio	2430	50
WPGJ	Utica, N. Y.	2414	50
WPGK	Cranston, R. I.	2466	50
WPGL	Binghamton, N. Y.	2442	200
WPGN	South Bend, Ind.	2490	100
WPGO	Huntington, N. Y.	2490	25
WPGP	Muncie, Ind.	2442	100
WPGS	Mineola, N. Y.	2490	400
WPGT	New Castle, Pa. (C. P.)	2482	50
WPGU	Cohasset, Mass.	1712	24
WPGV	Boston, Mass.	1712	500
WPGW	Mobile, Ala.	2382	400
WPGX	Worcester, Mass.	2466	100
WPHA	Fitchburg, Mass.	2466	50
WPHB	Nashua, N. H.	2422	50
WPHO	Steubenville, Ohio (C. P.)	2458	100
WPHF	Richmond, Va. (C. P.)	2450	150
WPHG	Medford, Mass. (C. P.)	1712	50
WPHI	Charleston, W. Va. (C. P.)	2490	50
WPHJ	Fairmont, W. Va. (C. P.)	2490	30
WRBH	Cleveland, Ohio	2458	500
WROQ	Toledo, Ohio	2474	200
WRDR	Grosse Pointe Village, Mich.	2414	50
WRDZ	Ft. Wayne, Ind.	2490	200

State Police Radio Stations

Call	Location	Kc.	Watts
KGHA	State of Washington, Portable-mobile	2490	10
KGHB	State of Washington, Portable-mobile	2490	10
KGHC	State of Washington, Portable-mobile	2490	10
KGHD	Seattle, Wash.	2490	50
KGHE	Snoqualmie, Wash.	2490	50
KGHO	Des Moines, Iowa	1682	400
KGHR	State of Washington, mobile	2490	10
KGHQ	Chinook Pass, Wash.	2490	10
KGZE	San Antonio, Tex.	2482	500
KNFC	State of Washington, S.S. Governor Isaac I. Stevens	2490	50
KNFD	State of Washington, S.S. Gov. John R. Rogers	2490	50
WBA	Harrisburg, Pa.	190	300
WBR	Butler, Pa.	190	300
WDX	Wyoming, Pa.	190	300
WJL	Greenburg, Pa.	190	500
B	W. Reading, Pa.	190	300
WMP	Framingham, Mass.	1666	1000
WPEL	W. Bridgewater, Mass.	1666	1000
WPEV	State of Mass., portable	1666	50
WPEW	Northampton, Mass.	1666	500
WPGC	S. Schenectady, N. Y. (5000 day—1000 w. nite)	1658	5000
WPGG	Findlay, Ohio	1596	500
WPGQ	Columbus, Ohio	1596	400
WPHC	Massilon, Ohio	1596	400
WPHE	Marion County, Ind. (C.P.)	1634	1000
WPSP	Harrisburg, Pa.	1674	1000
WRDS	E. Lansing, Mich. (5000 w. day—1000 w. nite)	1642	5000
	Wilmington, Ohio (C. P.)	1682	400
	Bellingham, Wash. (C. P.)	2490	50
	Shuksan, Wash. (C. P.)	2490	10

World's Leading Short-Wave Stations

Wave-length Meters	Call Letters	Frequency Kc.	City Country
13.9+	W8XK	21540	Pittsburgh, Pa.
13.9+	GSH	21470	Daventry, England
14.2+	LSN	21020	Buenos Aires, Argen.
15.2+	IRW	19700	Rome, Italy
15.9+	PLE	18830	Bandoeng, Java
16.5	LSY	18115	Buenos Aires, Argen.
16.8+	GSG	17790	Daventry, England
16.8+	W3XAL	17780	Bound Brook, N. J.
16.8+	PHI	17775	Huizen, Holland
16.8+	DJE	17760	Zeesen, Germany
17.2+	JIAA?	17380	Kemikawa-Cho., Jap.
17.3+	W3XL	17300	Bound Brook, N. J.
19.4	PRADO	15440	Riobamba, Ecuador
19.5	W2XAD	15330	Schenectady, N. Y.
19.6+	CP7	15300	La Paz, Bolivia
19.6+	DJQ	15283	Zeesen, Germany
19.6+	W2XE	15270	New York, N. Y.
19.6+	FYA	15243	Pontoise, France
19.6+	PCJ	15220	Huizen, Holland
19.7	W8XK	15210	Pittsburgh, Pa.
19.7	DJB	15200	Zeesen, Germany
19.8	GSF	15140	Daventry, England
19.8	HVJ	15123	Vatican City
19.9+	RKI	15040	Moscow, U.S.S.R.
22.0	JYK	13610	Kemikawa-Cho., Jap.
22.3+	TIEP	13420	San Jose, Costa Rica
22.7+	ORP	13200	Ruysselede, Belg.
23.3	CNR	12830	Rabat, Morocco
24.2	CTIGD	12396	Paredo, Portugal
24.8+	CTICT	12082	Lisbon, Portugal
24.9+	RW59	12000	Moscow, U.S.S.R.
25.2	FYA	11900	Pontoise, France
25.2	W8XK	11870	Pittsburgh, Pa.
25.2+	GSE	11860	Daventry, England
25.3+	W2XE	11830	New York, N. Y.
25.4	I2RO	11810	Rome, Italy
25.4	WIXAL	11790	Boston, Mass.
25.5	DJD	11760	Zeesen, Germany
25.5	GSD	11750	Daventry, England
25.5+	PHI	11730	Huizen, Holland
25.6	FYA	11720	Pontoise, France
25.6	CJRX	11720	Winnipeg, Canada
26.0	XGR	11530	Shanghai, China
27.9+	JVM	10740	Nazaki, Jap.
28.1	CEC	10670	Santiago, Chile
28.1+	JVN	10660	Nazaki, Japan
28.3+	FYB	10578	Paris, France
28.9+	LSX	10350	Buenos Aires, Argen.
29.0+	ZFD	10335	Hamilton, Bermuda
29.0+	ORK	10330	Ruysselede, Belgium
30.0	KAZ	9990	Manila, P. I.
30.4	EAQ	9860	Madrid, Spain
30.4+	JYS	9840	Kemikawa-Cho., Jap.
30.5+	IRM	9820	Rome, Italy
30.6+	GCW	9790	Rugby, England
30.7+	I2RO	9760	Rome, Italy
31.1+	CTIAA	9600	Lisbon, Portugal
31.2+	W3XAU	9590	Philadelphia, Pa.
31.2+	VK2ME	9590	Sydney, Australia
31.3	HBL	9580	Geneva, Switzerland
31.3	VK3LR	9580	Lyndhurst, Victoria, Australia
31.3	GSC	9575	Daventry, England
31.3+	WIXAZ	9570	Springfield, Mass.
31.3+	VUB	9565	Bombay, India
31.3+	DJA	9560	Zeesen, Germany
31.4+	DJN	9540	Zeesen, Germany
31.4+	LKJI	9540	Jeloy, Norway
31.4+	W2XAF	9530	Schenectady, N. Y.
31.5	VK3ME	9510	Melbourne, Australia
31.5	GSB	9510	Daventry, England
31.5+	PRF5	9505	Rio de Janeiro, Braz.
31.7+	COH	9428	Havana, Cuba
31.8	PLV	9415	Bandoeng, Java
32.8	CP6	9120	La Paz, Bolivia
36.6+	PSK	8185	Rio de Janeiro, Braz.
37.3	CNR	8035	Rabat, Morocco
37.3+	IRS	8020	Rome, Italy
37.5	HC2JSB	8000	Guayaquil, Ecuador
38.0+	JYR	7880	Kamikawa-Cho., Jap.
38.3	OA4AC	7820	Lima, Peru
38.4+	HBP	7790	Geneva, Switzerland
38.5	YNLF	7788	Managua, Nicaragua
40.5+	HJ3ABD	7402	Bogota, Colombia
40.5+	EA8AB	7403	Teneriffe, C. I.
41.8	CR6AA	7177	Lobito, Angola, Port. West Africa
42.0	HJ4ABB	7138	Manizales, Col.
43.0+	EA4AQ	6976	Madrid, Spain
43.8+	HAS	6840	Budapest, Hungary
44.0	HIH	6814	San Pedro, D. R.
44.5+	JVT	6750	Nazaki, Japan
44.6+	TIEP	6710	San Jose, Costa Rica
45.0+	HC2RL	6668	Guayaquil, Ecuador
45.3	PRADO	6616	Riobamba, Ecuador
45.3+	RW72	6611	Moscow, U.S.S.R.
46.1	HJ5ABD	6504	Cali, Colombia
46.3+	HI4D	6482	San Domingo, D. R.
46.5+	HJ1ABB	6447	Barranquilla, Col.
46.6	W3XL	6425	Bound Brook, N. J.
47.0+	YV4RC	6375	Caracas, Venez.
47.5	HIZ	6315	San Domingo, D. R.
47.8	HJ3ABF	6275	Bogota, Colombia
48.4	CTIGO	6198	Paredo, Portugal
48.4	HIIA	6183	Santiago de Los Cabelleros, D. R.
48.7+	HJ2ABA	6150	Tunja, Colombia
48.7+	CJRO	6150	Winnipeg, Manitoba
48.7	YV3RC	6150	, Venezuela
48.7	VE9CL	6150	, Man.
48.8+	W8XK	6140	Pittsburgh, Pa.
48.9+	ZGE	6130	Kuala Lumpur, F. M. S.
48.9+	ZTJ	6122	Johannesburg, Africa
49.0+	W2XE	6120	New York, N. Y.
49.0+	YDA	6120	Bandoeng, Java
49.0+	PKIWK	6116	Java
49.0+	YV2RC	6112	Caracas, Ven.
49.0+	VE9HX	6110	Halifax, N. S.
49.0+	VUC	6109	Calcutta, India
49.1+	W3XAL	6100	Bound Brook, N. J.
49.1+	W9XF	6100	Chicago, Ill.
49.1+	VE9GW	6096	Bowmanville, Can.
49.2+	I2RO	6085	Rome, Italy
49.3+	CP5	6080	La Paz, Bolivia
49.3+	W9XAA	6080	Chicago, Ill.
49.3+	CQN	6073	Macao, Asia
49.3+	DER2	6072	Vienna, Austria
49.3+	VE9CS	6070	Vancouver, B. C.
49.4+	VQ7LD	6060	Nairobi, Kenya, Africa
49.4+	W8XAL	6060	Cincinnati, Ohio
49.4+	W3XAU	6060	Philadelphia, Pa.
49.4+	OXY	6060	Skamlebaek, Den.
49.5	GSA	6050	Daventry, England
49.6+	HJIABG	6042	Barranquilla, Col.
49.6+	WIXAL	6040	Boston, Mass.
49.7+	HP5B	6030	Panama City, Pan.
49.8	DJC	6020	Zeesen, Germany
49.8+	ZHI	6012	Singapore, Malaya
49.8+	COC	6010	Havana, Cuba
49.8+	XEBT	6010	Mexico City, Mex.
49.9+	VE9DN	6005	Montreal, Quebec
49.9+	HIX	6000	San Domingo, D. R.
49.9+	RW59	6000	Moscow, U.S.S.R.
49.9+	FIQA	6000	Tananarive, Madag.
50.1	TGX	5984	Guatemala City
50.2+	HVJ	5969	Vatican City
50.6+	HJ4ABE	5860	Medellin, Colombia
51.2+	YV5RMD	5850	Maracaibo, Venez.
51.4+	HJ2ABC	5824	Cucuta, Colombia
51.9	OAX4D	5820	Lima, Peru
51.9+	TIX	5795	San Jose, Costa Rica
52.0	TGTH		Almatices, San Jose, Costa Rica
52.9+	XQAJ	5660	Shanghai, China
64.5+	HC2EP	4650	Guayaquil, Ecuador
69.4	G6RX	4320	Rugby, England
69.5	YNLF	4316	Managua, Nicaragua
70.2	RWI5	4273	Khabarovsk, Siberia
73.0	HCJB	4107	Quito, Ecuador
80.0	CTICT	3750	Lisbon, Portugal
80.0+	Radio LL	3700	Paris, France
83.0	CT2AJ	3612	San Miguel, Azores
84.6+	CR7AA	3543	Lourenzo Marques, Mozambique