CONSTRUCTION OF

RADIO PHONE AND TELEGRAPH RECEIVERS

FOR BEGINNERS

SOLID, USEFUL DATA, PHOTOS, AND DRAWINGS PREPARED SPECIALLY FOR THE RADIO NOVICE AND EXPERIMENTER ON THE ERECTION OF ANTENNAS, PLANNING A STATION, AND BUILDING ALL KINDS OF CRYSTAL, AUDION, AND REGENERATIVE RECEIVERS, WITH AMPLIFIERS AND LOUD SPEAKERS FOR RADIO TELEPHONE BROADCAST RECEPTION AND TELEGRAPH SIGNALS

BY

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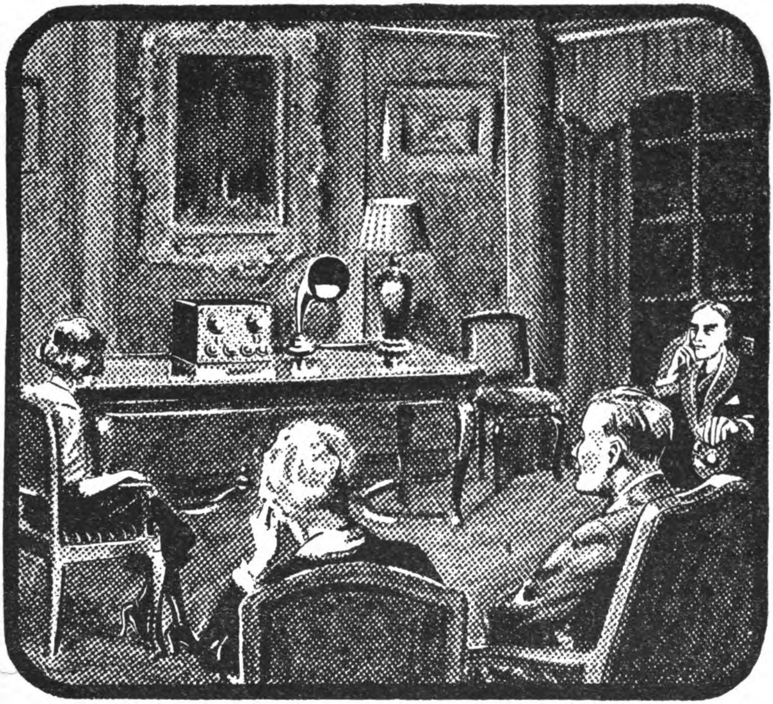
Author of "Design Data," "Radio Hook-Ups," etc.
Standardization Committee, I. R. E., 1921, 1922
Editor "Radio and Model Engineering"

NEW YORK
THE NORMAN W. HENLEY PUBLISHING CO.
2 West 45th Street
1922



A 1922 EVENING'S ENTERTAINMENT
Listening to One of the Radio Phone Broadcasting Stations

PRINTED IN U. S. A.

Composition, Electrotyping and Press Work
By Publishers Printing Company, New York

PREFACE

A radio book which attempts to teach is often less helpful than one which simply tells. In Radio Phone and Telegraph Receivers, explanations which are liable to puzzle rather than assist the experimenter have been carefully avoided, for education in radio generally works backward from practice to theory instead of following the academic order.

This volume, therefore, is a predecessor of Design Data, though it appears at a later date. From the understanding gained by following instructions in building apparatus the novice is better equipped to experiment and design instruments according to his own ideas.

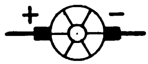
The interests of the novice who is desirous of receiving the radio broadcasting stations has been kept in mind, and equipment which can be installed in the parlor of one's home is described. It is hoped that this book will meet the needs of the novice and experimenter, and will be of benefit to both in the designing and building of receiving equipment.

M. B. Sleeper.

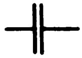
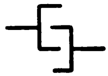
April, 1922,
New York City.

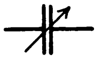
~ List of Symbols ~

Battery ---------------------------------- 

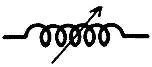
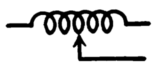
Direct Current Dynamo ---  or 

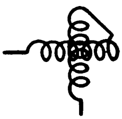
Alternating Current Generator } ---------------  or 

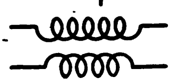
Fixed Capacitance (Condenser) ---------------  or 

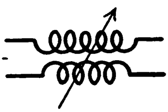
Variable Capacitance (Var. Condenser) ------------------- 

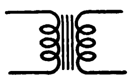
Fixed Inductance (Air Core Coil) ------------------- 

Variable Inductance (Air Core Coil) --------  or 

Variometer (Variable Inductance) --- 

Fixed Coupling of Coils (Fixed Inductive Coupling) ---------- 

Variable Coupling of Coils --------- 

Transformer -------------------------- 

Iron Core Inductance (or Reactance Coil) ---------- 

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CONSTRUCTION OF RADIO PHONE AND TELEGRAPH RECEIVERS FOR BEGINNERS

CHAPTER I

ERECTION OF SENDING AND RECEIVING ANTENNAS

In the construction of a radio station, naturally the first thing to consider is the antenna system for both the receiver and transmitter.

There are a number of types which are adaptable for transmitting—only two of which—the Umbrella and the T or inverted L will be described. The umbrella is suitable for a house of the general type shown in Fig. 1, for the ridge pole and two gables offer convenient means for fastening the wires. The height of the pole should not exceed 25 feet or the length of wires 35 feet so that it will be suitable to operate on the required transmitting wavelength of 200 meters.

The height of the roof and the material of the building will affect the capacity, so that definite dimensions cannot be given. In all events, this size is large enough, and, if too large, can be reduced, or a series condenser inserted in the ground lead of the transmitter. That latter method of reducing the wavelength is not advisable for a station which is to operate at maximum power.

Several methods can be employed to bring off the lead-in. The wires may be insulated at the top and bottom and connected together at the top for a lead at this point or from the foot of one of the wires. If an iron mast is employed, it can be held in

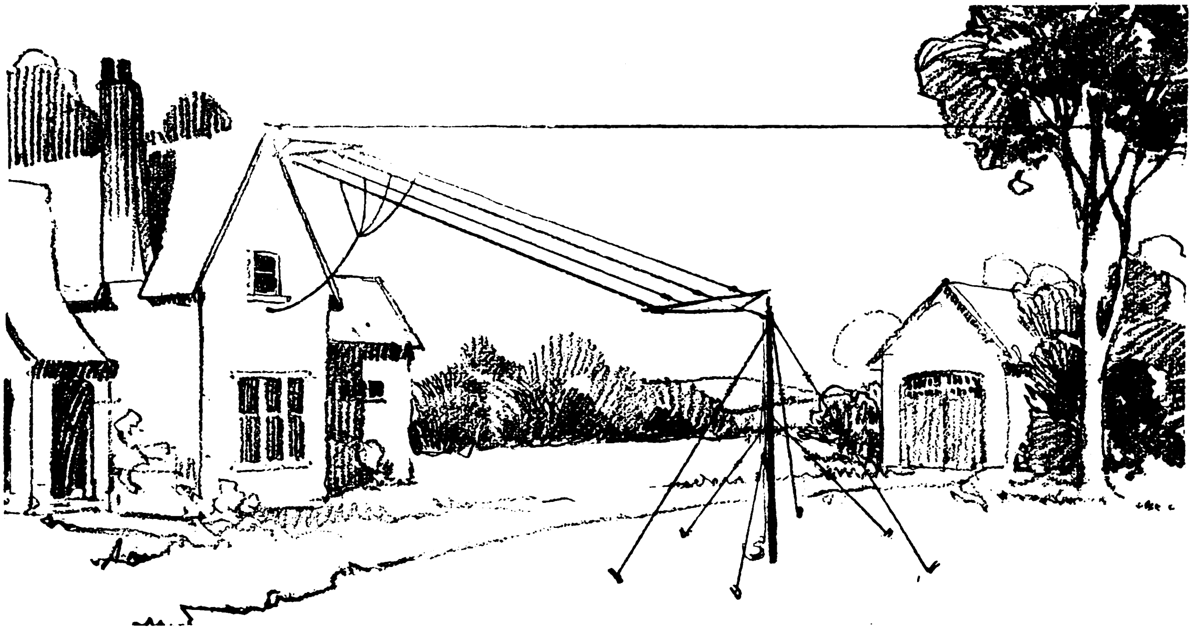

Fig. 2.—There is no advantage in high masts, for receiving, and the transmitting antenna is limited in size to a .200-meter wavelength. The inverted L and single wire types are shown here.

closer than five inches to the building and the antenna grounding switch and ground wire must be on the outside wall of the building.

Receiving antennas are considered in a different light. They are considered of no greater hazard than telephone lines and should be protected in the same way. A lightning arrester of the telephone variety or a one-eighth inch spark gap should be connected between the antenna lead-in and ground and the receiving instruments protected by a one ampere telephone type fuse in the lead between the lightning arrester or spark gap and the receiving set.

Fig. 3 illustrates the protection necessary for the two types of antennas.

The tube on which the coil is to be wound should receive the first consideration. Thin, spiral-wound mailing tubes are not satisfactory because they shrink after the wire has been wound on

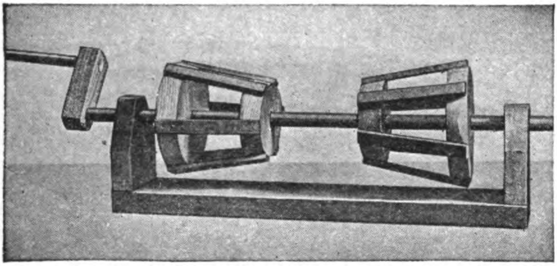

Fig. 5.—The winding rig

them. If cardboard tubes are used they should be of the straight wound type ⅛ or 3/16 in. thick. The tube used for the coil illustrated here was 4 ins. in diameter and 7 ins. long. This is a convenient size, and enough wire can be wound upon it to give

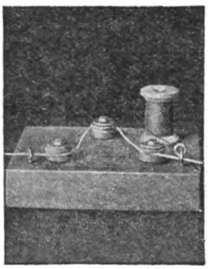

Fig. 6.—The wire straightener.

a considerable range in wavelength. Bakelite or formica tubing is much better, as it keeps its shape indefinitely. Fibre tubing should not be used, as it absorbs a very large amount of moisture.

the advantage that binding posts can be fitted directly to the ends of the rods at the outside of the end pieces.

The sliders can be made with a spring soldered to the tube, but this generally takes the spring out of the contact. It is better, therefore, to clamp the contact beneath the hard rubber handle.

Fig. 8 shows a completed tuner of the type described.

arranged so that a rather heavy pressure can be applied, is commonly used.

Sometimes two crystals in contact with each other are used. The two pairs most commonly used are zincite and chalco-pyrites or bornite and chalco-pyrites.

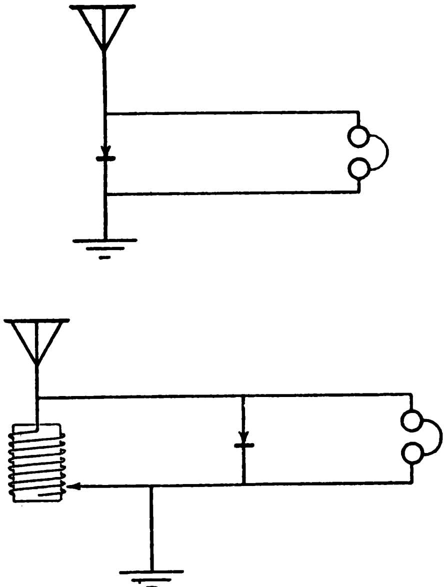

Fig. 9.

Diagram of connections of detector and phones.

Diagram of connections of one slide tuning coil, detector and phones.

To determine the point of sensitive adjustment of a detector, a buzzer test is needed. Any kind of buzzer will do, but a high-toned one which makes very little noise is best. It is advisable to keep the buzzer in a box filled with cloth or cotton to smother the noise. If this is done, the only sound heard comes from the telephones when a sensitive spot on the crystal has been found. The only connection to the radio set is a wire running from the fixed contact of the buzzer interrupter to the ground lead.

Some operators use a switch to stop or start the buzzer, while others have a telegraph key so that it can be used for code practice. To adjust the detector, the test is set in operation, and the contact

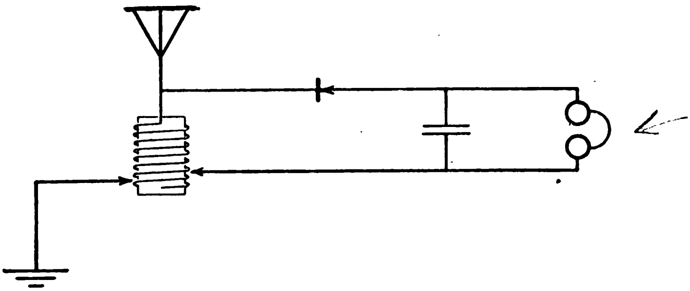

Diagram of connections of detector, two-slide tuning coil, phones and stopping condenser.

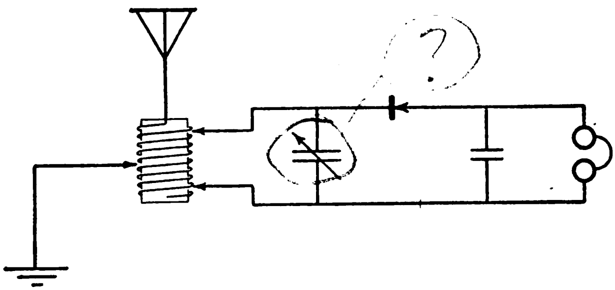

Fig. 10.

Diagram of connections of detector three-slide tuning coil, phones and fixed condenser.

moved over the crystal until a regular sound is heard in the telephones. This is not to be confused with other notes heard when parts of the set are touched with the hand.

When a clear and regular note is heard, the detector is ready to receive signals.

One of the first causes of no signals is the ground connection.

CHAPTER IV

A RECEIVER FOR NAVY CODE PRACTICE

The Naval radio station at 44 Whitehall Street, New York City, gives a nightly transmitting program, following the 9 P. M. press news, to give radio experimenters a chance to practice receiving at slow speed. The set described, used with a standard short or long range antenna, will copy the signals at a distance of several hundred miles. It is also a good set for general receiving work, and is simple enough for any beginner to operate.

The tuning coil, mounted at the right of the base, is made up of a tube 6 in. long and 5 in. in diameter, wound for 5 in. with No. 24 S. S. C. wire. Two methods can be used for mounting the tube—either holes can be drilled with an extension bit in the 6 x 6 in. end pieces, or wooden discs, fitted into the ends of the tube, may be fastened with brass screws to the end pieces.

Slider rods of 3/16 x 3/16 in. brass are secured to the end pieces by means of small brass wood screws. The sliders are square brass tubes, 1 in. long. A piece of spring brass, for a contact, is soldered to each one. On the top is soldered a flat head machine screw, to take the adjusting knob.

The wiring diagram, Fig. 11, shows that one end of the winding is brought out for connection to the ground, one slider rod to the antenna, and the other to the detector. Connections should be soldered if possible.

Under the small wooden block, beside the tuner, a fixed condenser is mounted. This consists of 15 sheets of tin foil, 2 x 1 in., separated by paraffined paper sheets. Alternate tin foil sheets are connected together, and leads brought out to shunt the phones. If care is used not to overheat the tin foil, it can be soldered. The comexperimental circuit, it is only necessary to unfasten the brass straps; later, it can be put back in place. Thus it is possible to use any instrument for temporary circuits without tearing up the receiver and it can be replaced in a minute. Additional apparatus can be put in, or the entire set rearranged.

Any type or kind of transmitting and receiving equipment can be made upon standardized panels, but to illustrate the method, a simple yet surprisingly efficient receiver is described here. It is

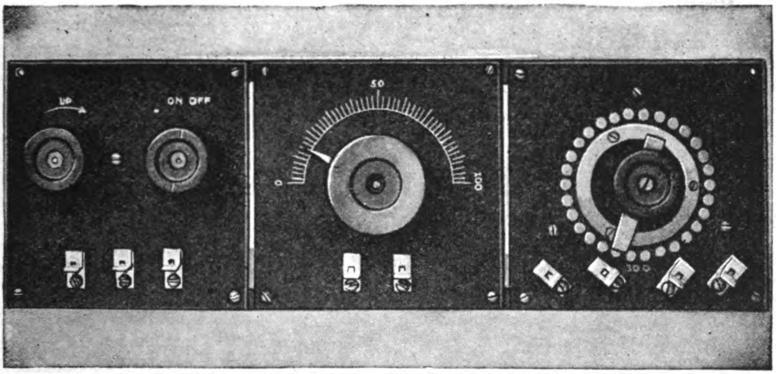

Fig. 13.—A receiver of which any experimenter may well be proud.

intended for use on experimental and the ordinary commercial wavelengths up to 1,000 meters.

The primary of the loose coupler has 30 taps, while all the secondary tuning is done in the variable condenser. The buzzer test indicates, when its signals are heard in the telephones, that the detector is adjusted.

This is an easy set to operate, for all the tuning can be done with two knobs. When the primary handle is turned, it moves the switch arm; pulled out or pushed in, it varies the coupling. Sharp tuning is accomplished with the secondary condenser.

Details of the loose coupler are given in Fig. 15. The primary coil is wound on a tube 3½ in. long and 3 in. in diameter. At the panel end, the tube is cut back so that there are three mounting legs ½ in. wide and ¾ in. long. This cutting must be done with a very fine saw, or, preferably, a sharp knife. Fig. 15 shows the brass angle brackets fastened to the legs by 8-32 machine screws and nuts.

The winding is composed of 100 turns of 3-16 No. 38 high frequency cable, wound in three banks, tapped every three turns, beginning with the thirteenth; 3-16 No. 38 means that three bunches

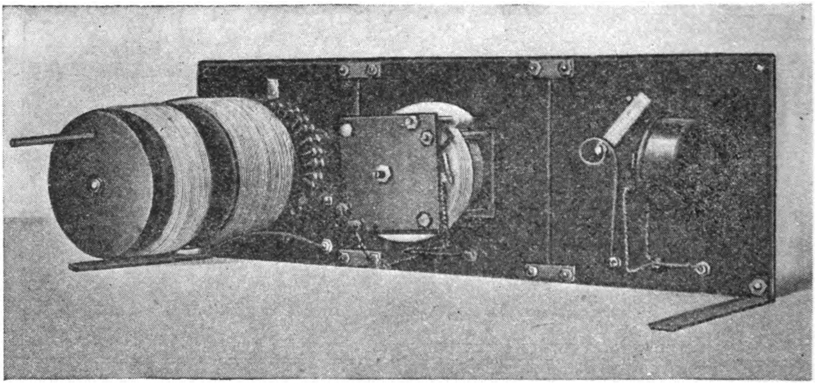

Fig. 14.—A near view of the Standardized Panel set.

of 16 strands of insulated No. 38 wire are twisted together and the bundle insulated again with silk. At the end of each bank, when the wire is brought from the top turn down to the tube, two holes are made, one for the end of the section, and the other to take out the start of the next.

When the winding has been completed, the taps are cut to length, and each end heated red hot and dipped in alcohol twice. This removes the enamel insulation on the wires. An accident which occurred when this set was built will serve as a warning to others. In the first place, a small bowl of alcohol was used. During the work, a tap was put into the alcohol when the insulation was burning. This ignited the alcohol and, in some way, the bowl was tipped over. The result was a sheet of flame over the arms of the builder and on the floor and table of the shop. Then a small paint can cover was substituted for the bowl. If that had been tipped over, the small amount of alcohol would have done very little harm.

All the taps prepared, the two adjacent wires are twisted and soldered together, ready to be soldered to the switch points later.

The secondary coil is wound on a 3 in. tube 1¼ in. long. This winding has 58 turns of 3-16 No. 38 cable, in four banks, with no taps. Fitted at the outer end is a flanged wooden disc ¾ in. thick, in the center of which is a ¼ in. brass rod, 2 ins. long, drilled out with a No. 16 drill. This, as will be seen later, acts as a bearing for the square main shaft.

Another hole is made in the wooden end piece, 1 in. from the center, with a No. 20 drill. It will take the guide rod which prevents the coil from turning, as shown in Fig. 15.

The next step in constructing the loose coupler, is to assemble the switch parts. A 5 x 5 in. panel is used, preferably ¼ in. thick. This set was made with ⅛ in. bakelite, but it was not quite rigid enough for the weight of the parts.

Thirty ¼ in. diameter switch points are set in a circle 3 ins. in diameter. In the center of the panel a ¼ in. hole is drilled to take the switch shaft. The 3-ply switch arm has a No. 16 hole for the square shaft and two No. 36 holes to slip the 2-56 machine screws which hold it to the bearing. This bearing is of brass, ¾ in. long, turned down for ½ in. to ¼ in. diameter, while the remaining ¼ in. is ½ in. in diameter. It is to this head that the switch arm is secured by the 2-56 screws.

Through the center of the bearings a No. 16 hole is drilled from the back almost to the front end. The hole is completed by a No. 30 drill. Next, the smaller hole at the front is carefully filed square, to take the ⅛ x ⅛ in. shaft. Finally, a collar ¼ in. thick and ½ in. in diameter, with a ¼ in. hole, is made to fit over the end of the shaft. Two 6-32 machine screws act as set screws.

When the parts are assembled, the bearing is put into the panel from the front and the collar fitted on from the rear. Thus the shaft is free to turn, but cannot pull out, while the square shaft can move in and out, but, when rotated by the adjusting handle, it must turn the bearing and the switch arm attached.

The secondary coil must not turn with the main shaft. The shaft is threaded at the rear end with a 6-32 die, and two nuts are put on it at the outside and inside of the secondary end piece bearing. They are just loose enough to allow the shaft to turn in the brass insert, yet tight enough to prevent end play. Further provision against turning is made by a 1/8 in. brass rod which passes through the end piece. It is secured to a wooden strip glued inside the primary coil.

Fahnestock binding posts are provided at the front of the panel, though, in some cases, it is preferable to have only screws protruding at the rear, to which connections can be soldered.

The condenser shown in Fig. 16 is of the Clapp-Eastham make. The maximum capacity is 0.0006 mfd. The wavelength range is smaller, however, than with a 0.001 mfd. type, so that, for the full range, the larger condenser should be used.

Although it was not necessary, it was thought advisable to put solid bakelite end pieces on the condenser. The metal pieces, with bakelite inserts, offered a possible leakage path across the plates which would result in broad tuning and loss of efficiency with an audion.

The construction of new end pieces should be attempted only by a skilled mechanic, for it is an easy matter to put the plates all out of alignment. Moreover, it will be found necessary, in all probability, to make a new upper bearing for the shaft. In drilling the holes in the bakelite pieces, the metal plates were used as templates.

If the construction of the condenser is not changed, it is an easy matter to secure the upper plate to the panel with small machine screws. Because there is no way to secure the handle to the shaft except by means of set screws, two 6-32 screws were put into the smaller part of the knob. The heads were cut off and slotted, so that they hardly protrude.

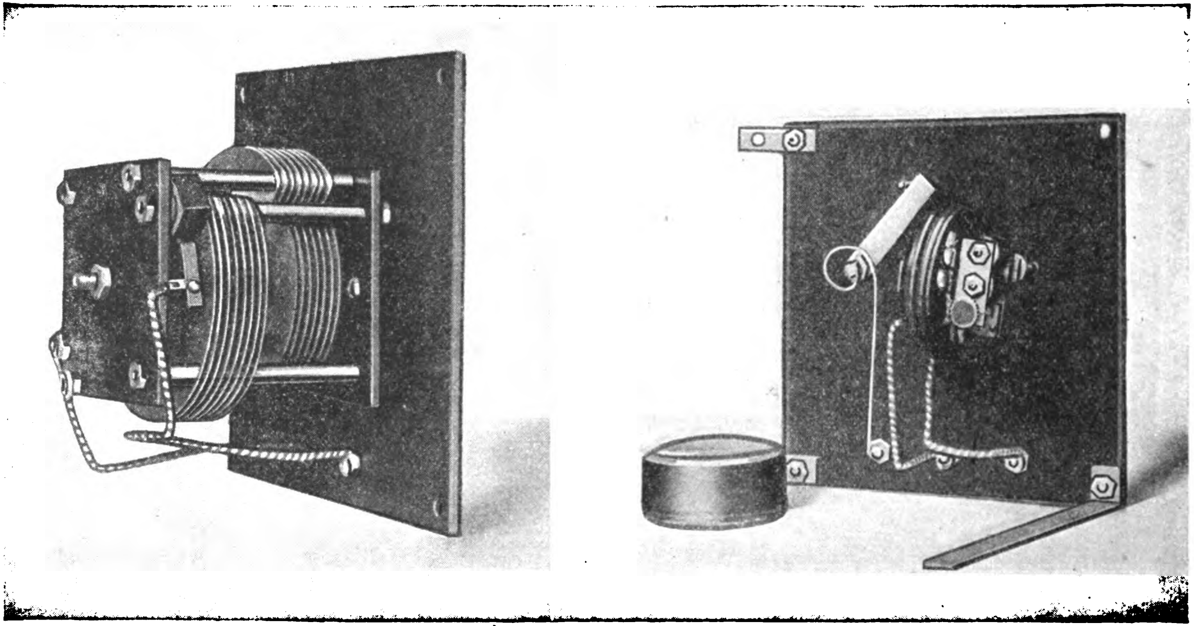

Fig. 16.—Details of the condenser and buzzer test panels.

When the coil was mounted, the zero end was put at the left, looking at the front of the panel, so that, to increase the inductance, the switch was turned clockwise. Three taps were brought out to the switch.

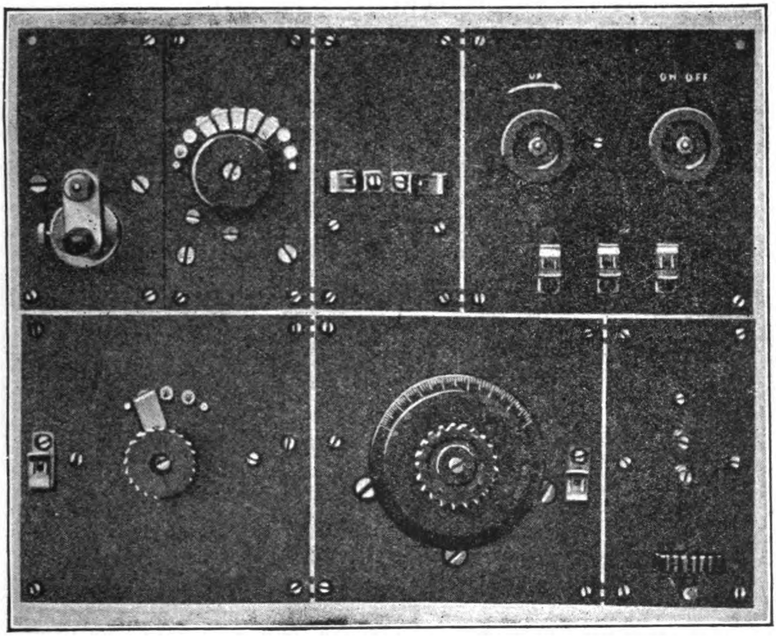

Fig. 17.—The instruments assembled, ready to wire.

Sufficient overlap is allowed, so that, with a Short Range antenna, the set will tune as follows:

Tap 1, 180 to 470 meters.
Tap 2, 380 to 990 meters.
Tap 3, 800 to 2,100 meters.

If a greater range of wavelength is required, a loading coil may be added to the set.

To increase the wavelength range of this set the panels must be changed around. The buzzer might be left out, or the key and telephone connection panel removed and replaced by a 5- by 5-in.

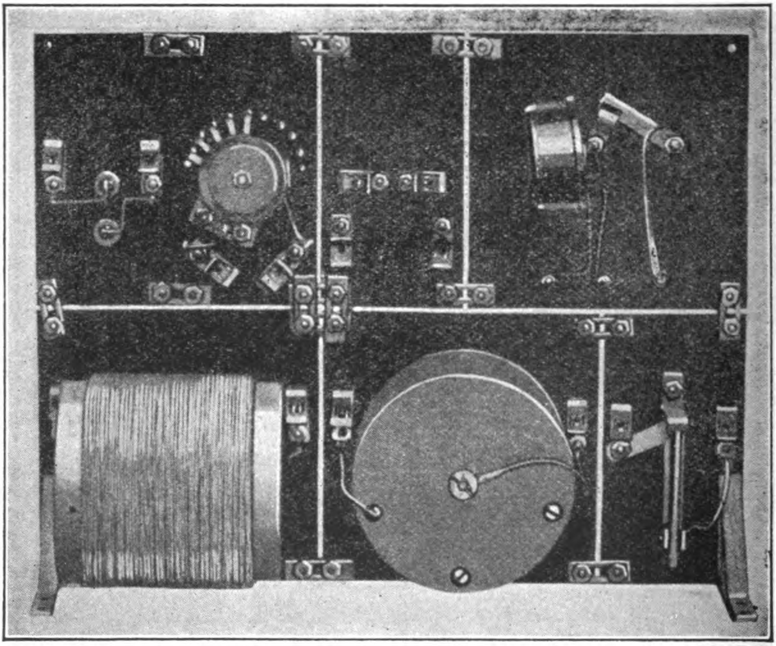

Fig. 18.—Rear view of the crystal receiver. Attention is called to the buzzer, mounted at right angles to the panel, so that the vibrator contact screw can be adjusted from the front.

panel to carry a loading coil. This is not shown, but the construction is simple. .

The coil to be described will include the D range, giving a latitude of 200 to 6,000 meters. A tube 3½ ins. in diameter and 6 ins. long is needed. The winding is of three banks of 10 No. 38 high frequency cable, a size which is more economical of space than the heavy cable, and gives much better results than solid wire. More-are adhered to closely, the inductance of the entire coil will be 18,200,000 cms.

Three points are neeeded on the switch that controls this coil. When connected in series with the other, the wavelength ranges are:

Tap 1, coil cut out.
Tap 2, 1,580 to 4,170 meters.
Tap 3, 2,665 to 7,050 meters.

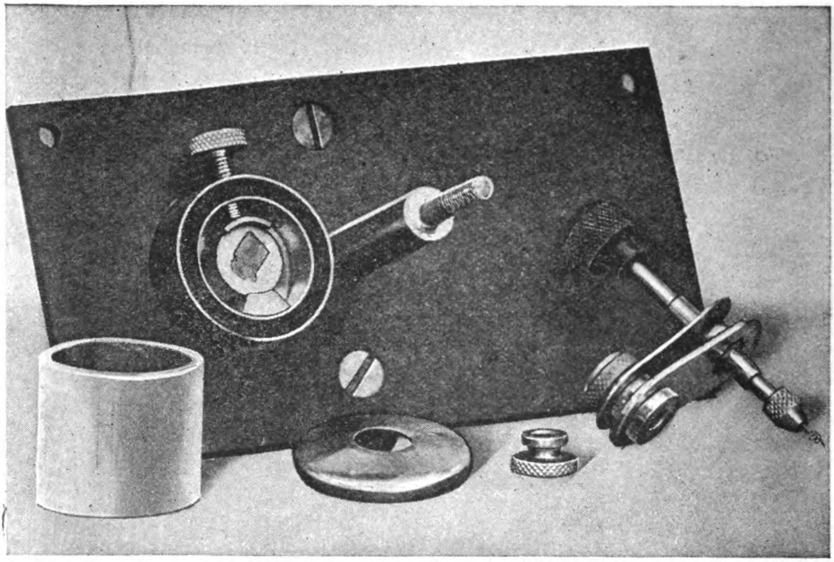

Fig. 20.—A disassembled view of the crystal detector, showing the cup construction and universal joint.

Sufficient space is allowed at the end of the tube so that it can be mounted on legs, with the axis of the coil perpendicular to the panel. This makes the coils at right angles, so that there is no mutual inductance between them.

The Tuning Condenser is made up of a G. A. Standardized lever strikes when the key knob is pressed. Movement in the other direction is stopped by a brass strip bent at the end.

Connections are taken from the U piece and from a brass strip into which the upper adjusting screw is threaded.

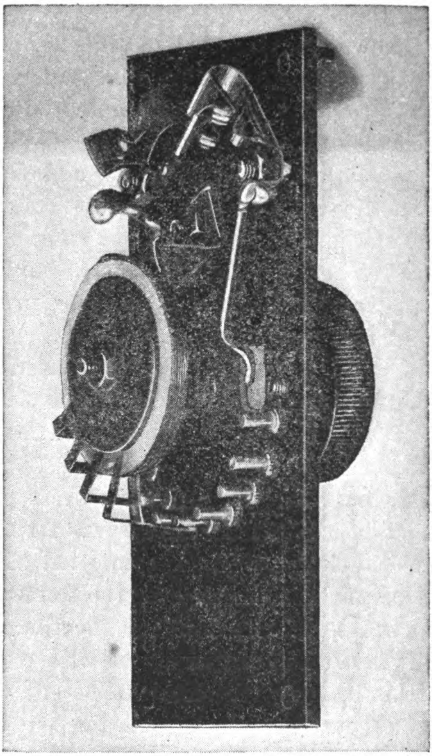

Fig. 21.—The condenser is made of discs of mica and copper foil

While this key cannot be used to break heavy currents, it is quite satisfactory to operate the buzzer test.

This panel has been illustrated before, in conjunction with a short wave set. An excellent feature of the instrument is that the shaft of the left hand knob is threaded into the regular contact adjusting screw. A drop of solder holds the rod in place. The cover is slotted at the side allowing it to be slipped on over the rod.

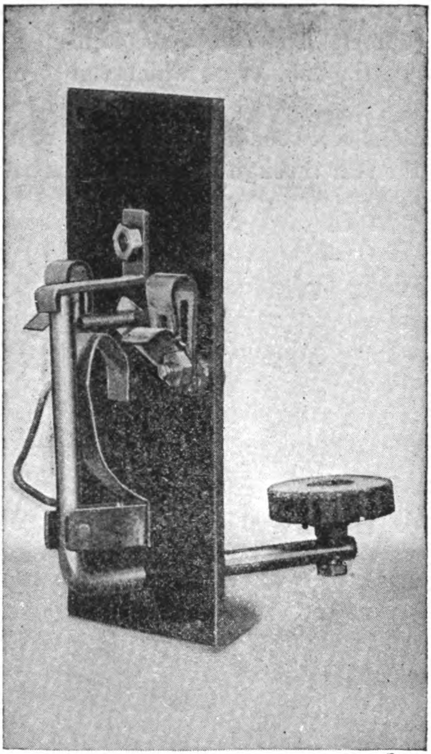

Fig. 22.—Both the tension and stopping screws can be seen in this view.

When the tone of the buzzer becomes irregular, it can be quickly adjusted from the panel, without the necessity of removing the cover.

The extreme simplicity of these instruments coupled with their excellent appearance, should appeal to the experimenters. All that is needed in the way of tools to build this apparatus are a set of drills, taps, files, a hacksaw, and a soldering iron.

Several methods can be employed to mount the panels. If another set of brackets is put on to support the top corners, the panels are sufficiently rigid for all purposes. Another way is to fit the set into a cabinet. This can be accomplished by putting small brass angles inside the cabinet, to which the corner screws can be secured.

Where connections were made at the front of the panels, wires can be run from the rear through the separations between the panels.

The grid connection goes to a grid condenser secured to the rear of the panel. It will be seen that one set of screws serves only to hold the bakelite clamping strips to the panel, while a separate set acts as terminals for the condenser. The bakelite plates are

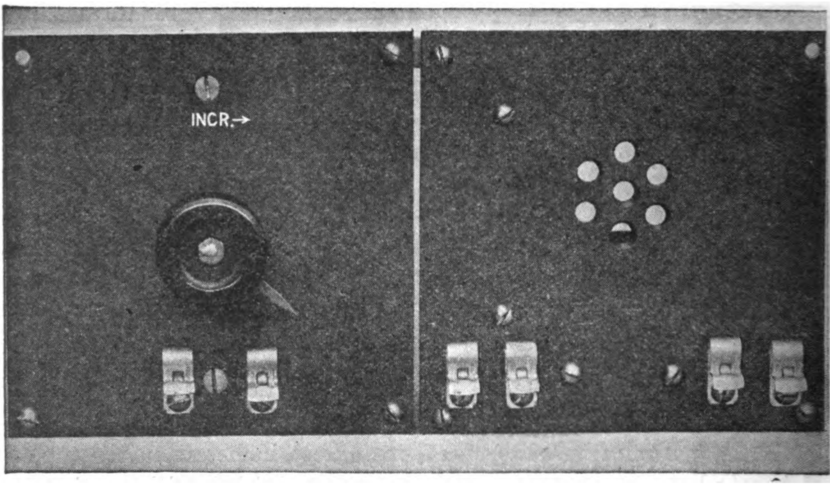

Fig. 23.—Always ready to fit into any kind of a set are these standardized audion control panels.

3 x 1½ ins. and 3/16-in. thick. Condenser plates were cut from No. 30 gauge brass, though tin foil will do, to a size 1½ x 1 in., with a No. 18 hole in the center line, ¼ in. from one end. Next, the two bakelite plates were drilled along the center line ¼ in. from each end. The top plate has two more holes ½ in. in from the others. These last holes are deeply countersunk. When the copper and paraffine paper strips were put in place, flat head screws were put through them and the inner holes of the upper plate. As the screws were tightened, the heads went down into the countersunk holes, leaving the top flush with the condenser plates.

It is advisable to immerse the condenser, with the bottom plate clamped on, in paraffine. However, a mistake made when this instrument was built should be avoided. The paraffine was boiling hot, and bubbles rose profusely from the condenser. In fact, they did not stop at the end of ten or fifteen minutes. When the condenser was removed for inspection, it was found that the bubbles were coming from large blisters which had formed in the bakelite

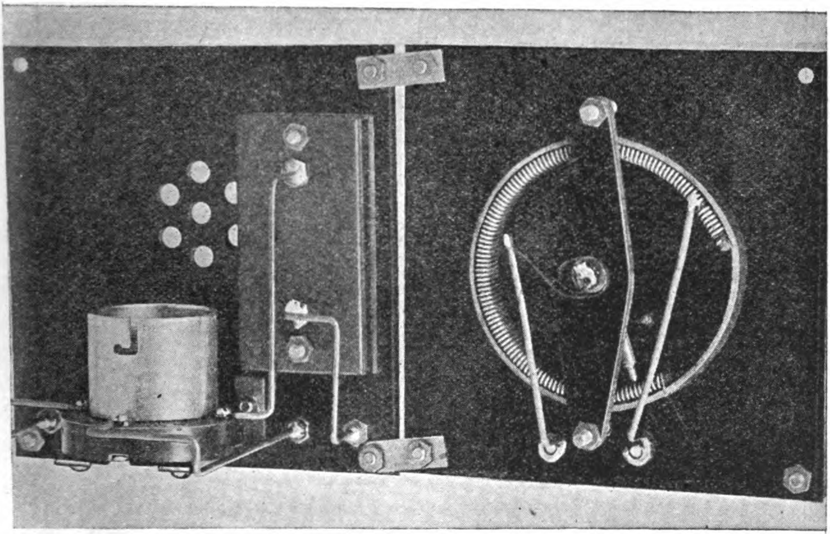

Fig. 24.—The neatness and simplicity, upon which efficiency depends, will commend this method of construction to radio men.

piece. Another condenser was made and left in the paraffine only one minute. This proved satisfactory in use, and did not injure the bakelite plates.

Numerous methods for building the rheostat were considered. The easiest way seemed to be to mount a regular 10-ohm Mesco rheostat on the back of the panel. However, it was very difficult to take out the screw which held the contact arm. In fact, during the course of operations the base was cracked. Another solution suggested itself. The remaining parts of the base were knocked away until only the resistance element was left. Then it was put inside a short length of cardboard tubing 3 ins. in diameter. Just the thing! It could be arranged with an internal contact.

The next step was to cut off a piece of brass tubing 1½ ins. long with a ⅛-in. hole, and to solder it to a length of 6-32 threaded

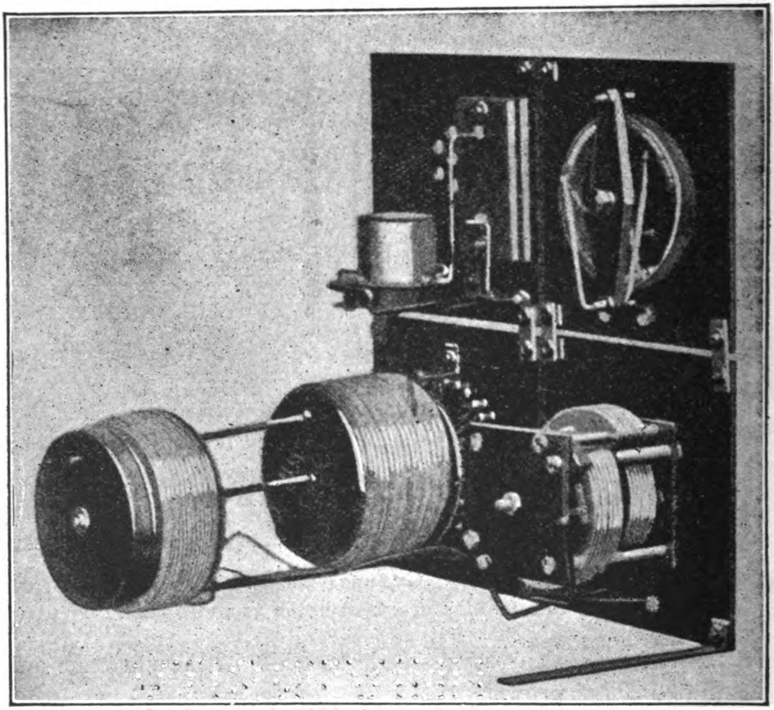

Fig. 25.—The audion panels in combination with a simple short wave receiver. Loading coil panels can be added for longer waves.

rod which served as a shaft for the handle. A small brass spring was inserted in the tube, and a ⅛-in. rod put in for a contact. Another difficulty came up. How could the rheostat circuit be opened at the point of minimum resistance? Finally, the wire was cut ¼ in. from the end, and a lead brought out as shown in Fig.

24. Without sticking over the wires, the contact can be run past the lead onto the disconnected end.

A clamping strip of 3/16-in. bakelite was put over the resistance

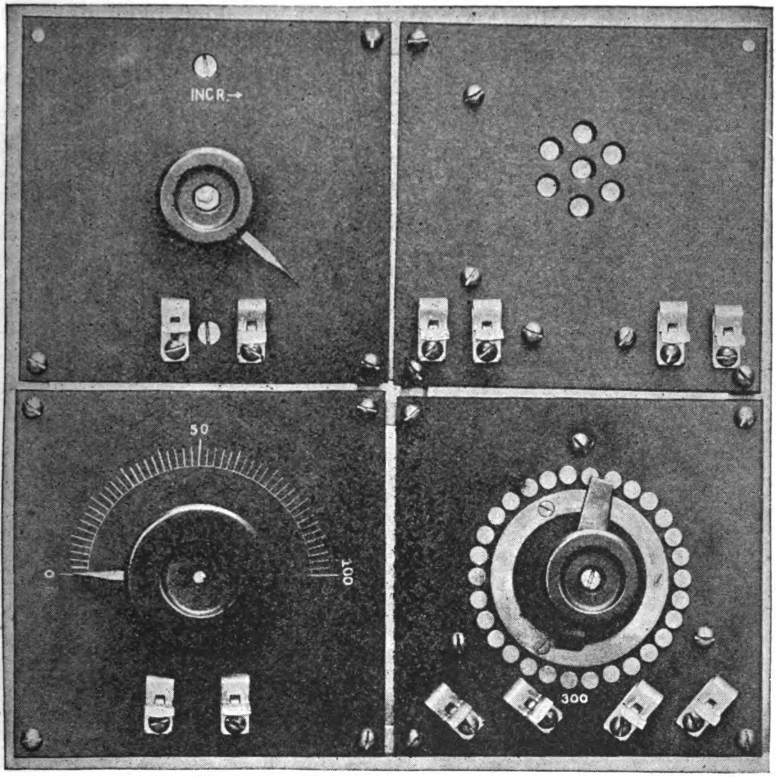

Fig. 26.—It is far easier to make good looking equipment by this method than when the instruments are all mounted on one panel.

unit and tube to hold them in place. Connection was made to the shaft with a thin strip of brass. Fig. 23 shows the handle and indicator.

These audion mounting and control panels represent a cost of

CHAPTER VIII

CONSTRUCTION OF A PORTABLE RECEIVER

A practical portable receiving set for field work or use in the country is not one that fits in the hip pocket, not one which requires a small cart to trundle it along. In the first place, the electrical circuits must be designed; then they must be worked out in instruments which will withstand use; these instruments must be grouped properly in a small space; and, of course, the arrangement must provide an easy method of control.

The Signal Corps of our Army used portable type apparatus almost exclusively during the war. One lesson that they must have learned is that one portable set cannot be designed for too broad a range of conditions if it is to operate at maximum efficiency under any one set of conditions. Some Signal Corps apparatus fell down alarmingly in the field because it was intended to do a little of everything and actually accomplished not much of anything.

In other words, the first thing to do as a preliminary to building a portable set, or any set, for that matter, is to decide exactly how few things it can do, yet meet the essential requirements. Ideas in this respect will vary widely. However, an average has been struck in the set described in this chapter.

Dependability is an important factor in any portable equipment, since in the field, laboratory facilities are lacking. Therefore, an audion detector was chosen for the foregoing reason and for its sensitivity.

Tuning circuits were the next consideration. Loose couplers meant extra coils, moving parts, additional space, and more difficult tuning than with a directly coupled circuit. These factors were

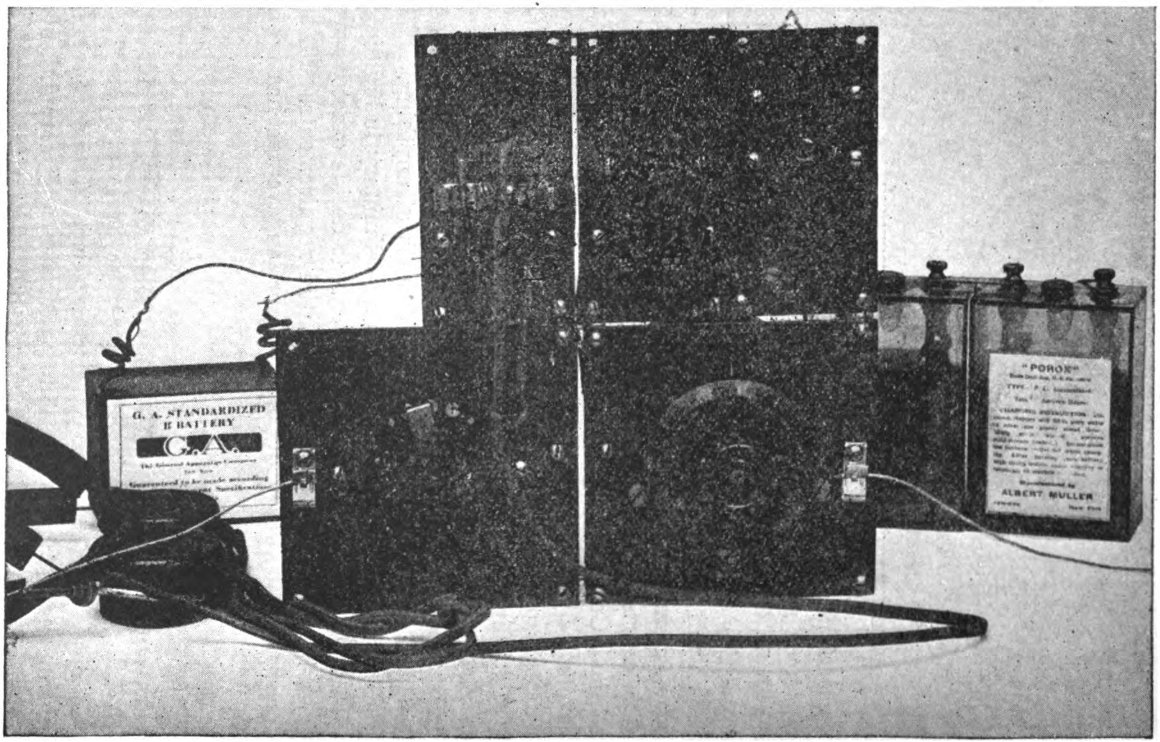

Fig. 27.—The complete receiver, ready for use at the laboratory. For portable work, it is fitted into a carrying case.

responsible for the decision to use the latter Moreover, sharp tuning was not of great importance.

The necessity for highest efficiency under the limitations called

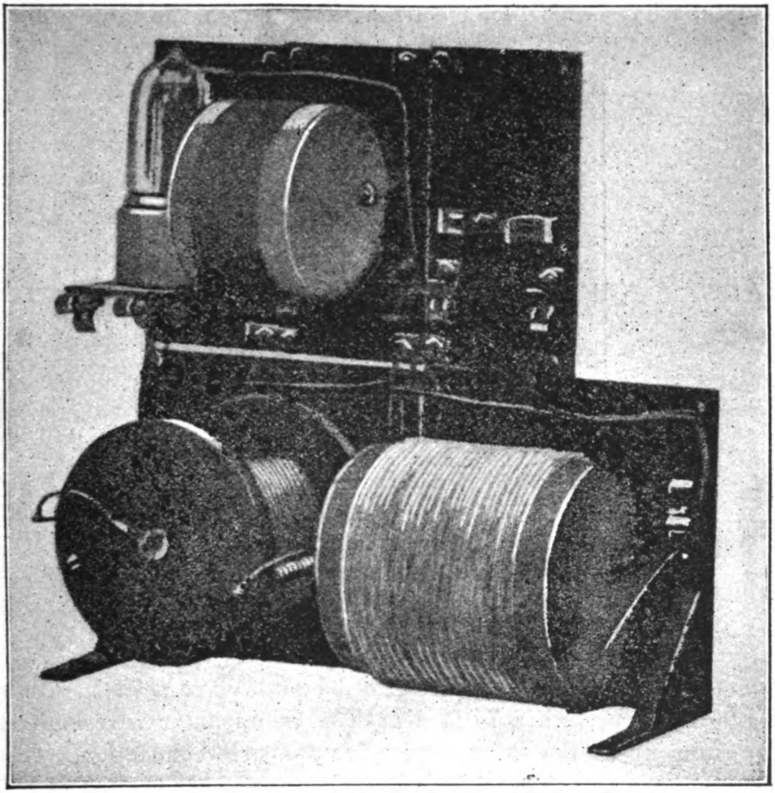

Fig. 28.—Showing some of the constructional details of the set, all wired except for the batteries.

for high frequency cable on the inductance, with a banked winding to conserve space. To get the sharpest tuning, it was decided to use a variable condenser with a small number of taps on the coil.

Experimenters who have used cable realize the difficulties of cleaning the separate wires to make soldered connections.

Before anything could be done on the coil or condenser, it was necessary to determine the size antenna to be used and its approximate capacity. This factor varies according to the situation in

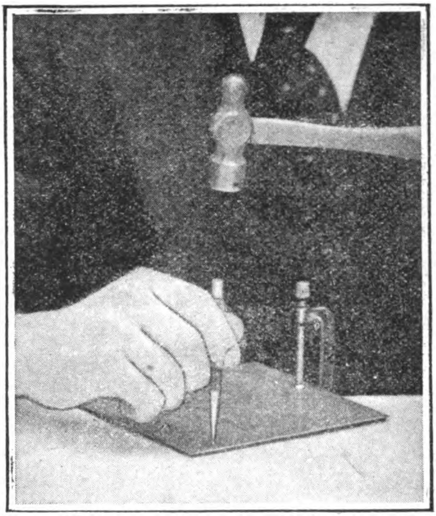

Fig. 29.—Using the jig for laying out a panel.

the field. For general work it seemed best to have a 75 ft. single wire 20 ft. high, with a 75 ft. length of annunciator wire laid on the ground under the antenna wire for the earth connection. This is better than metal rods driven into the ground, as the use of the latter means that a mallet must be included in the equipment, while the annunciator wire can be rolled off on a small spool.

The capacity of such an antenna was 0.0001 mfd.

While thinking of these points it was necessary to keep in mind the wavelength range. A B-C range, 200-600, 600-2,000 meters, covered experimental and the most important commercial stations.

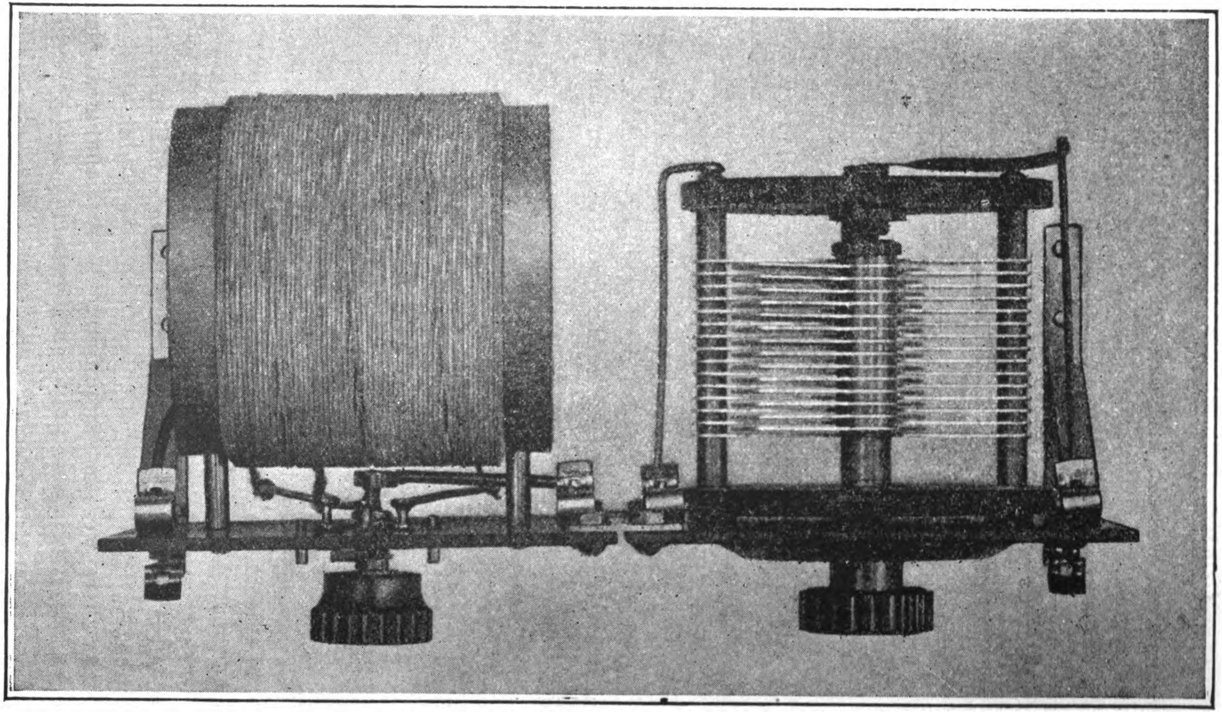

Fig. 30.—Looking down on the completed condenser and inductance panels.

To minimize space and weight, it was decided to have a 0.0005 mfd. condenser in shunt with the tuning inductance. The G.A. Standardized type was chosen because the minimum capacity was practically zero, and the maximum 0.0006 mfd.

This condenser, in shunt with the antenna of 0.0001 mfd., gives a capacity range from 0.0001 to 0.0007 mfd. Then the inductance steps, to cover 200 to 2,000 meters, were:

Capacity 0.0001 to 0.0007 mfd.
90,000 cms.—179 to 473 meters
400,000 cms.—377 to 997 meters
1,800,000 cms.—800 to 2,116 meters

A little figuring showed that with a three-bank winding of 3 x 16 No. 38 D.S.C. high frequency cable, 18 turns per inch, on a tube 3½ ins. in diameter, the tapping points were:

90,000 cms.,	22 turns
400,000 cms.,	57 turns
1,800,000 cms.,	157 turns

The length from the start of the winding to the taps were:

90,000 cms.,	0.40 in.
400,000 cms.,	1.05 in.
1,800,000 cms.,	2.90 in.

When the coil was mounted, the zero end was put at the left, looking at the front of the panel, so that, to increase the inductance, the switch was turned clockwise.

When the coil was wound, the panel was laid out and all holes drilled before anything was assembled. Fig. 29 shows a very useful fixture made to insure the accurate location of the holes at the corners. A sheet of No. 30 sheet brass was carefully marked with a 5 in. square, and punch marks made ¼ in. in from the sides at the corners. When the panels were laid out it was only necessary to clamp the brass sheet on a panel and punch the centers. This was important, for, otherwise, the panels would not have fitted together properly.

The coil mounting was very simple. Two lengths of brass tubing 3/16 in. inside diameter and ¾ in. long were cut up and placed

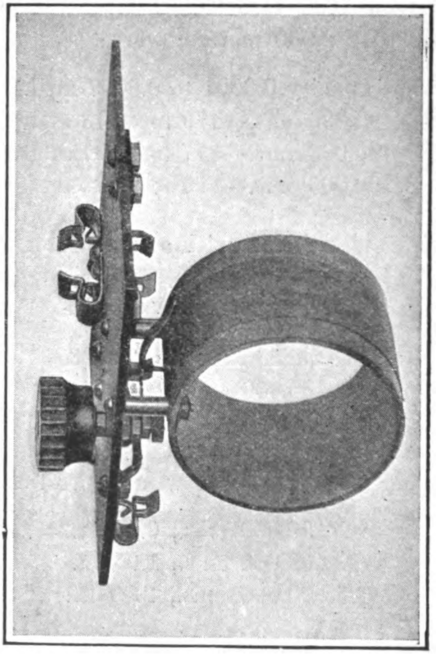

Fig. 31.—A side view of the rheostat with the connection panel linked on.

on 8-32 machine screws which go from the front of the panel to the coil. Washers were put on the screws inside and outside the tube so that the brass tubing and the nuts would not cut in.

Other details can be seen from the illustrations.

Fig. 30 shows the condenser mounting. To secure the condenser to the panel, the screws were removed which originally held the upper end plates to the fixed plates, and longer ones substituted, so a No. 26 drill, and countersunk at the front of the handle. The condenser is made with a hole in the end of the shaft threaded 6-32. When a 6-32 screw was put in the handle and turned into the shaft, it drew on the handle, clamping it securely. The depth of hole must be determined accurately so that the handle will not go on too far before it is stopped at the smaller hole.

The unusual strength and permanence of the design of this type makes it particularly well suited to portable work.

A departure from the usual rheostat was employed in this set, principally because the porcelain base type was too large for a panel 2½ ins. wide. The resistance element was simply No. 24 s.s.c. copper wire wound on a tube 3 ins. in diameter. The coil was 1¼ ins. long. To make it non-inductive, the direction of winding was reversed every ¼ in.

A spring washer was put on the shaft of the adjusting handle, with a nut soldered to the shaft to keep a tension on the handle. Two more nuts held a brass contact which, at the maximum resistance end of the coil, slipped off the winding and opened the circuit.

The audion mounting and grid condenser were put on a 5 x 2½ in. panel. Any type of socket could have been used, but the one shown was employed because it had been made up already. Two small angles of ⅜ x 1/16 in. brass strip held it to the panel.

Connections to the filament were made by Fahnestock clips put on the screws which held the tube contacts. The plate contact was wired to another clip, and the grid to one side of the condenser.

The condenser was made up of five sheets of No. 30 brass, 1½ ins. long and 1 in. wide, separated by paraffined paper. Two small bakelite plates secured the condenser in position.

Fahnestock clips were mounted at the front of the connection panel to take the telephone cord tips. Another pair at the rear were for the B battery.

This section is shown clearly in Figs. 27 and 28.

Obviously, it was not practical to use a 5-lb. Navy size B battery with this set. The small Signal Corps type gave results entirely satisfactory and saved 4 lbs. in weight.

Two 2-volt 10-ampere-hour Porox storage cells were decided upon, as their weight, filled, was only 2 lbs. each. The dimensions of the batteries shown in Fig. 27 were 3½ ins. long, 1½ ins. wide, and 4⅜ ins. high over the binding posts. These cells operated the audion for 9 hours at a charge, and have stood up so that they promise to last indefinitely.

The wiring of the audion plate and filament circuits were of the usual sort. With a Marconi or VT1, no adjustment of the plate voltage was needed, operating the tube on a 22.5 volt battery.

Looking at the rear of the set, the antenna was connected to the right-hand post wired to the coil, the ground to the condenser post at the left; then a wire was run from the left condenser post to the left of the coil, and the right condenser post to the right of the coil. Finally, a wire from the grid was run to the antenna connection, and one from the filament to the ground post.

CHAPTER IX

CRYSTAL RECEIVER FOR 200 TO 600 METERS

A novice or experimenter starting in wireless work should use simple circuits at the beginning until he is thoroughly acquainted with the various elementary phases of wireless work. There is also a demand among the more advanced radio men for a simple set which can be depended upon to work for a short range of wavelengths under all conditions. The set described in this chapter is intended to operate on an antenna of 0.0002 to 0.0005 mfd., giving wavelengths between 200 and 600 meters. This range is extended to 900 meters for the maximum antenna and reduced to a minimum value of 120 meters for the small antenna.

The points in designing which are brought out particularly are simplicity and rigidity of construction. It will be seen from the drawings that this is a single-tuned circuit comprising an inductance of 400,000 cms., with two sets of switches and a crystal detector. Binding posts are supplied for the phones and antenna and ground. A fixed condenser to shunt around the telephones should be mounted in the case.

The inductance switch is fitted with a handle and scale which revolves at a ratio of 1:8 of the handle. The necessity for this reduction is that there is considerable work required of the arm on the small-step switch in turning the disc on the large-step switch. This will be more completely described later on.

The detector is made up of a handle and plate which fits over an opening in the panel. A spring large enough to extend beyond the hole in all positions maintains the plate against the front of the panel. The outer tube fastened to the plate keeps the tension on

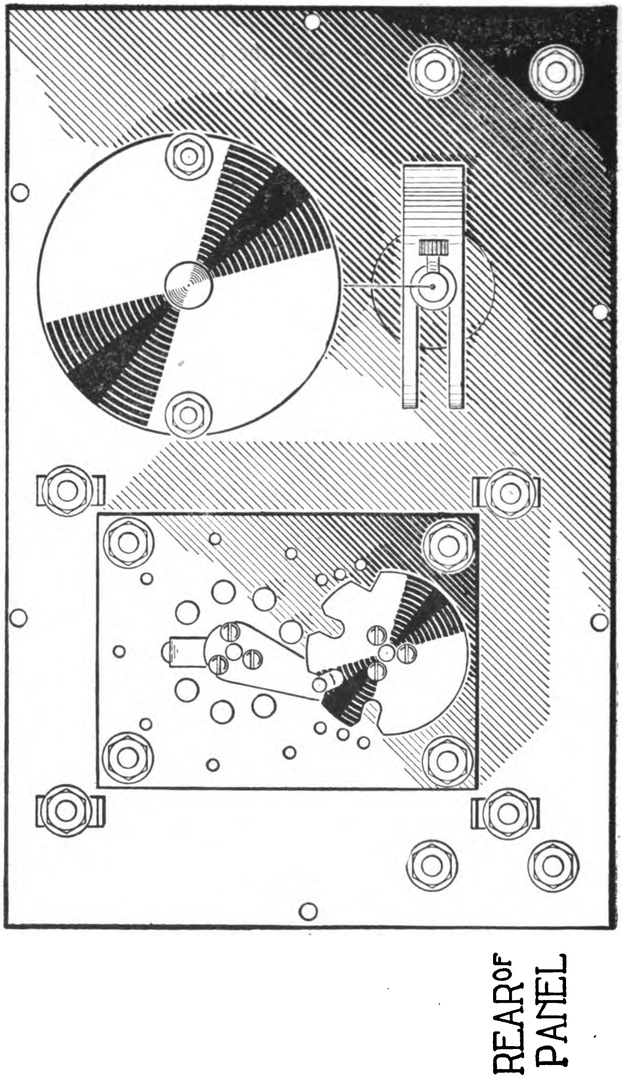

Fig. 33B.—Details of receiver for short wave traffic, specially designed for dependability and continuous use.

the shaft carrying the detector contacts so that the hardle will stay in place when pressed inwardly to put pressure on the crystal. By mounting the detector in this manner it is protected from dust and injury while the set is being moved about.

Fig. 33, a, b, c and d shows the front of the panel, the rear of

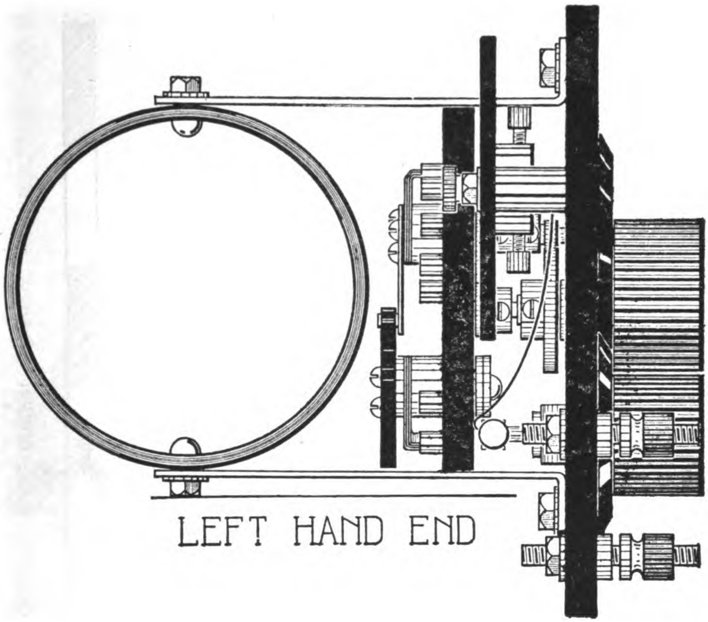

Fig. 33C.—Details of receiver for short wave traffic, specially designed for dependability and continuous use.

the panel with the coil removed, the left-hand end in which the tube is mounted in place, and the switch plate supports removed to give a better view of the interior, and sections through the detector and switch. The panel is 7½ in. x 5 in. x ¼ in. thick. Holes are provided to hold it to the case.

Detailed drawings have not been given of the detector since this is a comparatively simple mechanism. The handle bears a shaft

⅝ in. between the plate and the rear of the panel allows sufficient room for the adjustment of the detector wire. By using a plate of this size the appearance of the set is improved by hiding the interior except the space around the opening through which the movement of the wire can be observed.

The inductance switch may seem somewhat complicated, but it has the advantage over the simple geared types of causing the large-step switch to jump immediately when the small-step switch moves from maximum to minimum, instead of moving slowly and short-circuiting the large-steps during that part of the range.

Details of the inductance switch are given in Fig. 34. Numbers of Fig. 34 correspond to those in the cross-sectional view in Fig. 33d. The inductance is 3 in. in diameter, wound with 74 turns of No. 24 single silk covered wire. Taps are taken off as indicated at actual turns in Fig. 34. The designation numbers are those shown on the dimension drawing of the switch plate.

The handle is fastened in the standardized manner to the shaft 6 moving in the brass bearing 9. On the shaft is a gear 10 with a 3/16 in. shoulder secured by two 6-32 set screws. This gear has 20 teeth of 48 pitch giving a pitch diameter of 5/12 inch. The indicating plate is secured to the bearing 5 by four 2-56 machine screws. At the rear end of 5 is a gear 11, held by two 6-32 set screws. This gear has 48 teeth of 48 pitch, giving a pitch diameter of 1 in. There should be a running fit between 5 and 6.

Working against the two gears named are two other gears secured to 7. Gear 1 operating against 10 has a pitch diameter of 5/6 in. with 40 teeth of 48 pitch. Gear 2 is also made fast to 7. It has 12 teeth, 48 pitch, giving a pitch diameter of ¼ in. When the handle is turned gear 10 rotates gears 1 and 2. Gear 11 is turned by 2, rotating the indicating dial. Thus, 1 revolves once to every two revolutions of the handle. This gives the extra force necessary to operate the large-step switch. Since four revolutions of 1 are required for the entire range of inductance the ratio between 2 and 11 is 4:1.

The shaft 7 turning in the bushing 9 carries at the rear end a

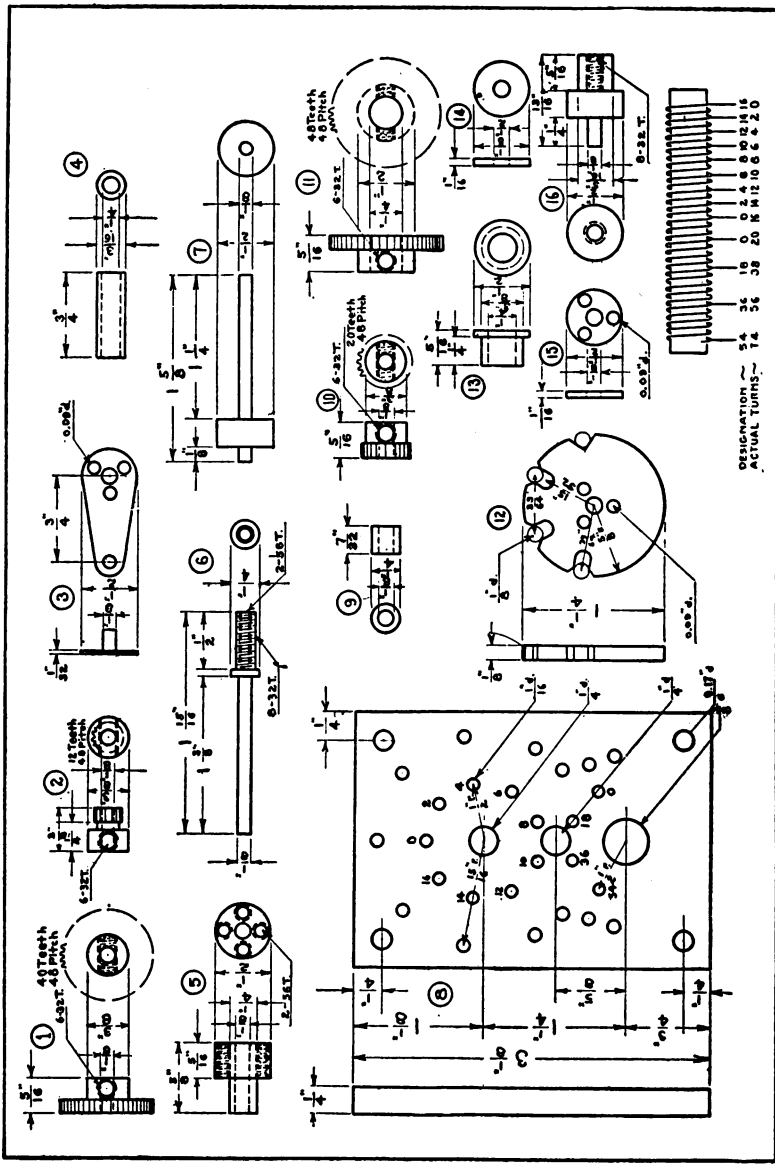

Fig. 34.—Inductance switch arranged that large-step switch jumps as small-step switch moves from max. to min.

4-ply contact and an arm with a pin which engages in the slots on 12. It is necessary to follow accurately the dimensions shown in the drawing to make the pin on 3 engage perfectly with the Bakelite disc.

In laying out 12, the holes indicated by the light-line circles should be drilled first and the corners filed at an angle of 45° to a radial line through the center of the hole. Then holes for the bottom of the slots should be drilled and the sides filed smooth. This disc is secured to 16 by three 2-56 machine screws. Beneath 12 is a washer sitting on the 4-ply switch. To take up the strain when the switch is rotating a brass bearing 13 is inserted in the plate. Then an 8-32 machine screw and washer 14 are put into the end of 16. This holds the switch securely. The entire panel is held by four pillars, 4, and 8-32 machine screws.

No diagram has been given because experimenters generally wish to change around their circuits to try out different methods.

Additional dimensions have been omitted because experimenters generally prefer to work out details according to their own ideas. However, the parts aside from the inductance switch are sufficiently simple that specific details are not required. A set of this type will give sharp tuning and operate quite satisfactorily for amateur communications or the reception of short-wave commercial stations. Since a large proportion of traffic is handled at wavelengths of 600 meters or below this set is well adapted for the regular work of receiving signals.

CHAPTER X

THE USE OF CONCENTRATED INDUCTANCE COILS

Although experimenters are nearly all familiar with the duo lateral or honeycomb type of inductance coil, so called because of the criss-cross appearance of the winding, there seems to be some misunderstanding as to the method of selecting the coils and of their use. This type of coil offers such advantages that this chapter has been prepared to clear up any difficulties connected with the honeycomb or duo lateral coils.

In the first place, these inductances, Fig. 35, are wound in a self-supporting manner, similar to a ball of string. They are of a standard width, 1 in., a standard inside diameter of 2 ins., and vary from 2¼ to 4½ ins., outside diameter. Each coil is fitted with a plug to connect with a corresponding one on the coil mounting. Sixteen different sizes are furnished in standard inductance values. There are no taps. This may appear to be a disadvantage, yet actually, this is the only way to obviate dead ends and unused turns in the field of an active coil. Moreover, with primary and secondary tuning condensers a large wavelength range can be covered without changing coils. The honeycomb inductance is also applicable to directly coupled receiving circuits, wavemeters, oscillators and low-powered vacuum tube transmitters.

Test on this type of winding show the high frequency resistance to be unusually low for the long wavelengths and the distributed capacity, negligible, making them particularly well adapted for use with wavemeters.

A tuner for damped or undamped waves, built up from these coils and a variation of the standard mounting is illustrated in Fig. 36. By the proper selection of condensers and inductances, however, it will tune to wavelengths from 150 to 30,000 meters. The coils shown, however, with condensers of 0.001 mfd. maximum, will tune to 6,500 to 15,000 meters. The method for determining the

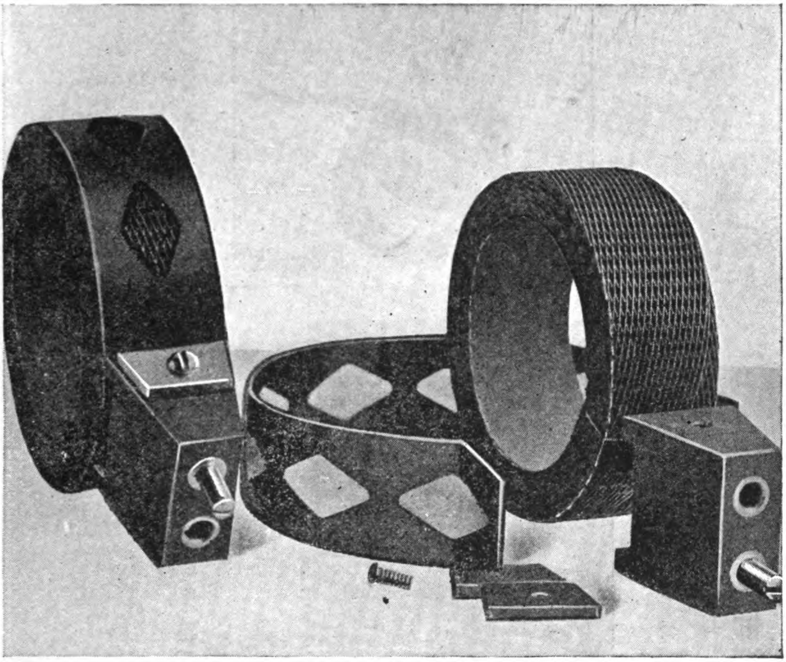

Fig. 35.—Showing how the honeycomb coils are made up on plugs for mounting.

sizes of the condensers and inductances for any wavelength range is discussed later in this chapter.

In comparison to the large tubular inductances required for long wave reception, these coils are very convenient and easy to work into a small receiving set. In designing this panel, the intention was to use the tuner for long wave reception only, so that no special provisions were made for changing coils. However, if the panel is not set into a case, changes can be effected readily.

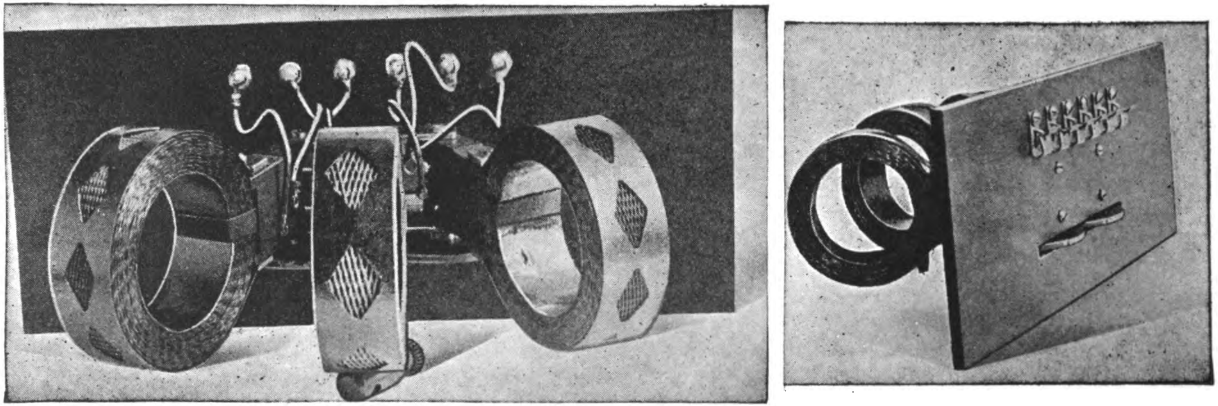

Fig. 36.—A loose coupler for damped or undamped waves. Coils of this size are made with inductance values up to 175 millihenries.

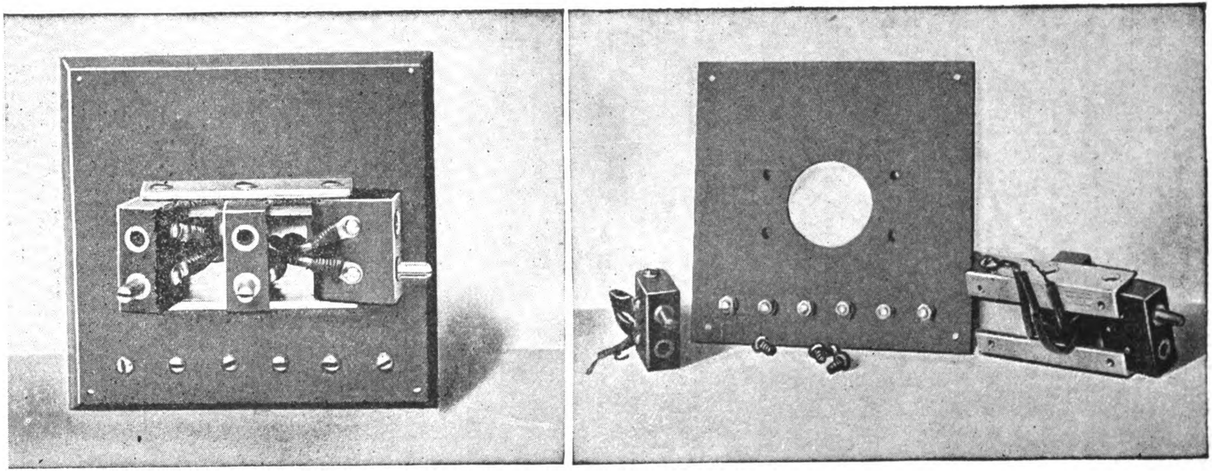

Fig. 37A.—The front of the original panel with the mounting in place.
Fig. 37B.—Rear view of panel and details of the plugs.

the value 0.0005 mfd. can be taken as an approximation, and substituted for the value of C_{ant} in the following equations.

For sharp tuning, the primary circuit should have a series condenser in the antenna lead. This decreases the effective capacity range, for the antenna acts as a second condenser in series with the tuning condenser, making the effective capacity at any adjustment of the tuning condenser.

$$C_{eff} = \frac{1}{\frac{1}{C_{ant}} + \frac{1}{C_{pri}}} \qquad (1)$$

where

C_{eff} = effective capacity of the circuit,
C_{ant} = capacity of the antenna.
and C_{pri} = capacity of the tuning condenser.

A primary condenser shunted around the inductance gives a larger wavelength variation, but broader tuning.

Then

$$C_{eff} = C_{ant} + C_{pri} \qquad (2)$$

The wavelength to which the antenna circuit will respond depends upon the effective capacity and the inductance of the tuning coil. Antenna inductance can be neglected. Hence the wavelength of the circuit will be

$$\lambda = 59.6\sqrt{LC} \qquad (3)$$

$$\text{or } L = \frac{\lambda^2}{3552\,C} \qquad (4)$$

$$\text{or } C = \frac{\lambda^2}{3552\,L} \qquad (5)$$

where λ = wavelength in meters,
L = inductance in cms.,
and C = effective capacity in mfds.

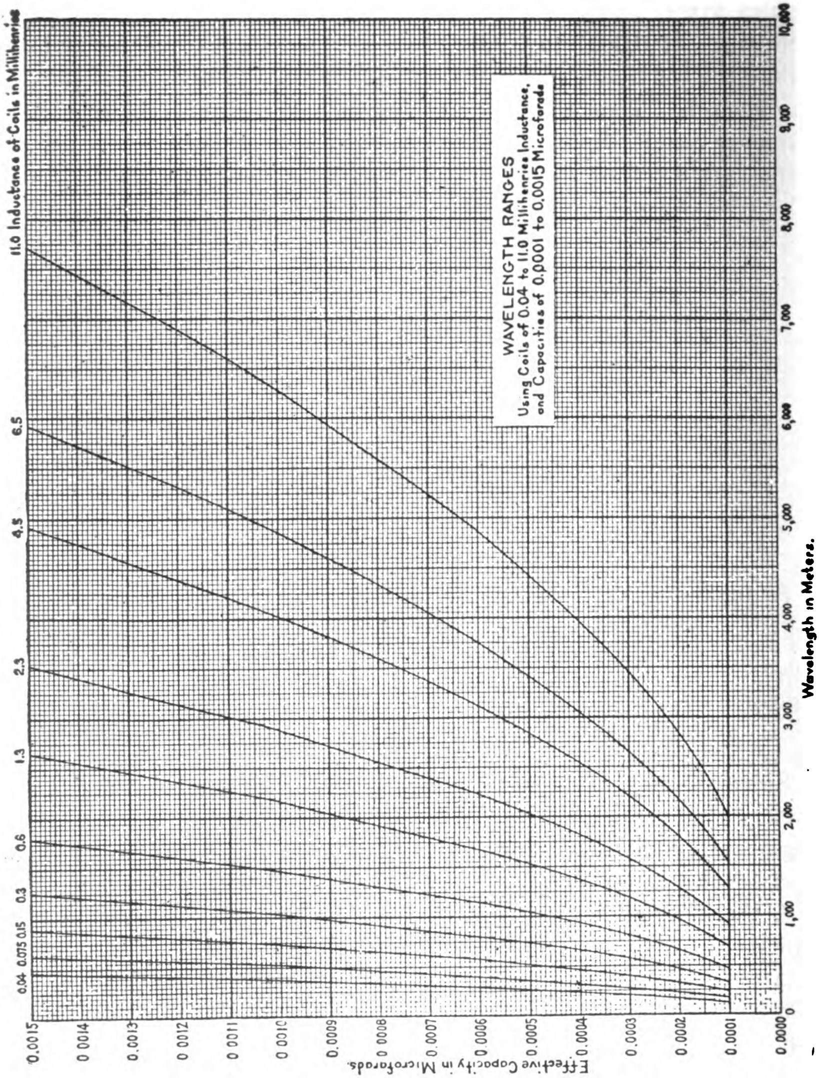

Fig. 39.—Curves showing the wavelength obtainable from the different coils with various capacities.

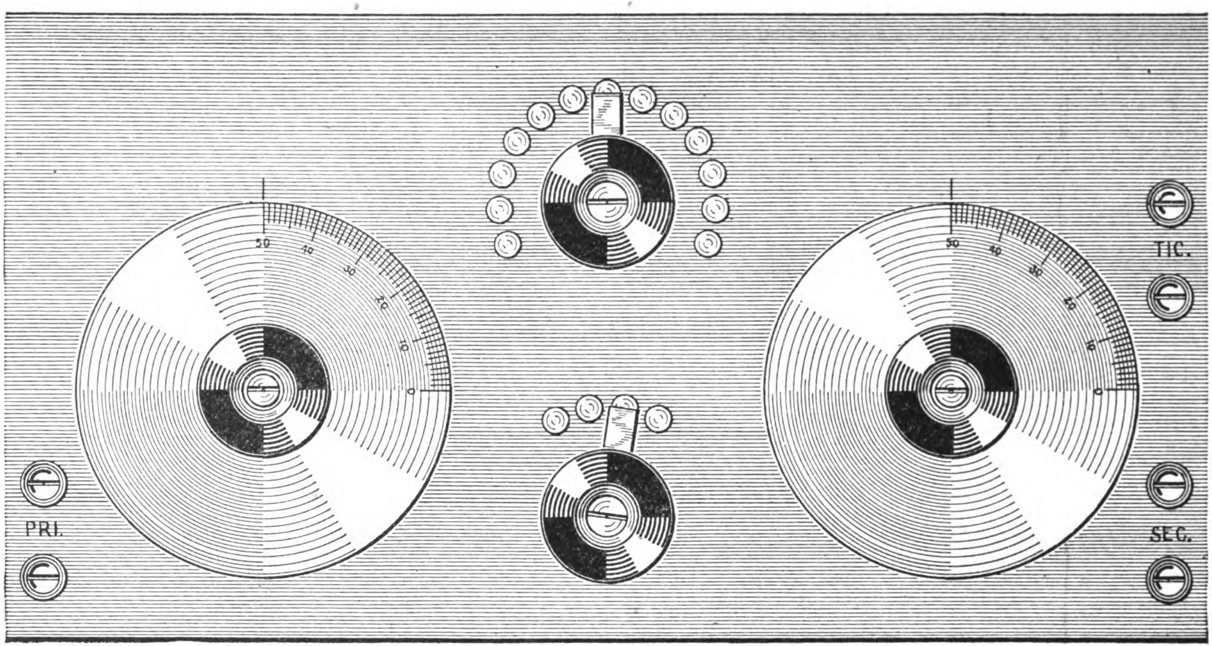

Fig. 41.—A regenerative receiver mounted on a 5- by 10-in. panel.

Short threaded brass pillars or angles of 3/8- by 1/16-in. brass strip can be used to mount the primary tube. This must be accurately and securely fixed. Otherwise, because of the small clearance, the secondary coil will touch the primary tube.

The construction of the secondary coupling coil and tickler are identical, both as to the method of mounting and the size of the coils. The tubes are 3 ins. in diameter, and 1¼ ins. long, wound with 20 No. 38 high frequency cable Each section is 3/8 in. long, with a separation of 3/8 in. between them.

If the bearing at the panel is carefully made, no rear support will be required for the shaft of either the coupling or tickler coil. For each coil, two brass washers, ¾ in. in diameter and 3/16 in. thick, are cut and threaded at the center with an 8-32 tap. The brass shaft, of 3/16 in. rod, is threaded at one end for a distance great enough to take one washer, the adjusting knob, and a nut to clamp the handle against the washer. Then, from the other end, the rod is threaded to within the thickness of the panel from the other threads. The washer under the handle bears against the front of the panel, while the other washer bears against the rear, leaving the unthreaded part of the rod to run in the hole in the panel. A lock nut holds the rear washer in place, and maintains a small amount of friction.

Two sets of nuts holds the coil in position on the shaft. Leads, run in Empire or soft tubing, can be wound around the shaft and brought off to the terminals.

The secondary leading coil, in series with the coupling coil, provided coupling to the tickler, independent of the primary-secondary coupling. The tube is 1¾ ins. in diameter, wound for 1 in. with 20 No. 38 cable. Starting at the rear end near the tickler, a tap is taken off at the tenth turn, and connected to the first point of the secondary switch, as can be seen in Fig. 43.

This coil should be mounted in a manner similar to that used for the primary. With this coil completed and in place, and the set carefully connected with No. 14 bare copper wire, all joints soldered, the set is ready for use. A condenser, mounted as shown

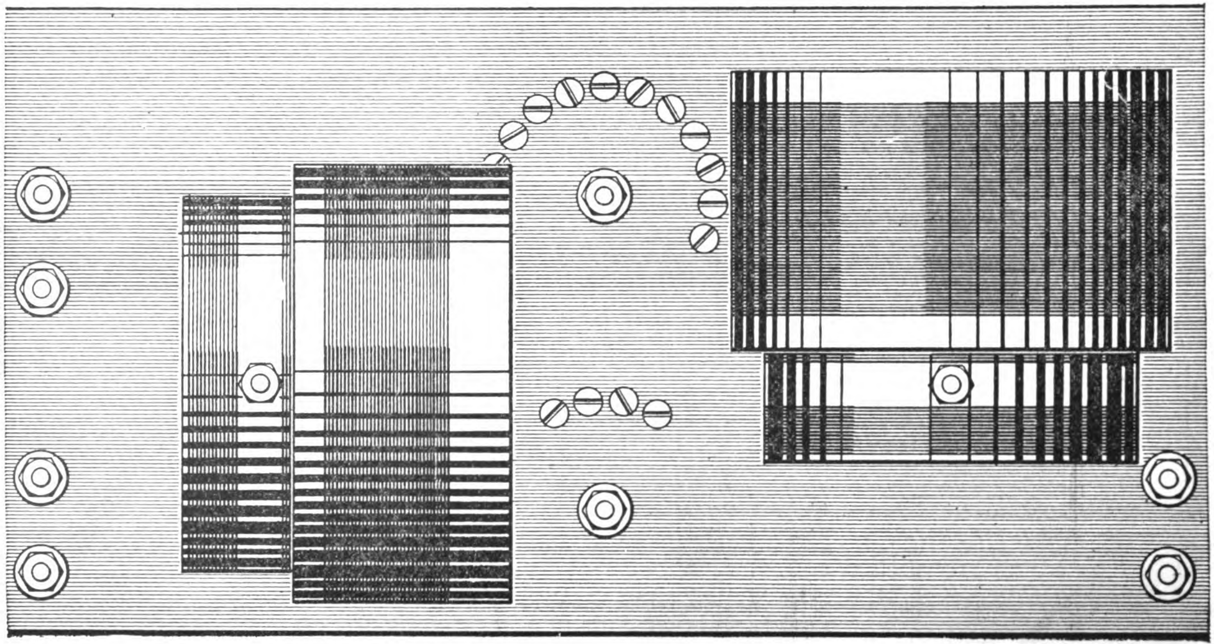

Fig. 42.—This shows the mounted coils on the rear of the panel.

in some of the preceding chapters, and a vacuum tube mounting, complete the set. If 5- by 5-in. panels are used for the audion and condenser, the set can be made up neatly with the 5- by 10-in. panels below, and the two smaller ones above.

Tuning in the primary circuit, accomplished by the 13-point switch, will be found quite sharp. The secondary condenser, giv-

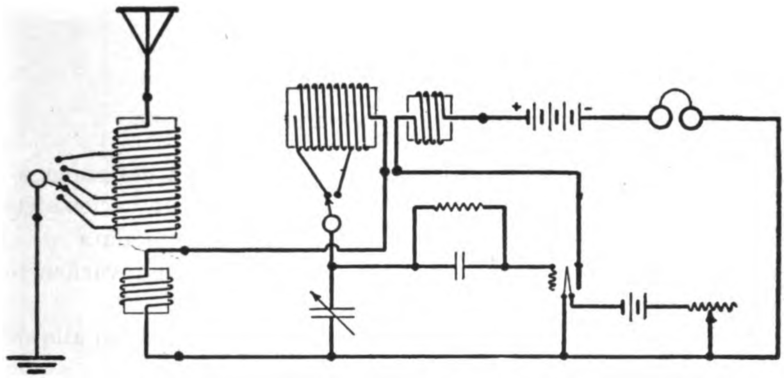

Fig. 43.—Connections for the regenerative receiver.

ing a facile control over a considerable range, saves just the amount of time which, with a receiver less easy to handle, causes the loss of a call. The coupling to the primary is usually made tight for listening-in, and loosened for sharp tuning.

If the tickler leads are of the correct polarity, regeneration can be readily adjusted, and will need practically no changing from 200 to 600 meters, another advantage over the tuned plate circuit which must be fixed for each signal.

Complaints about poor operation can often be traced to wornout B batteries. When anything goes wrong, the plate batteries should be examined first of all.

CHAPTER XII.

VARIOMETER TYPE REGENERATIVE RECEIVER

There is one mandate which must be observed in designing a regenerative set of the variometer type—"Know your variometers." In order to give the readers of this book accurate data on this kind of set, careful tests were made on the Radio Shop variometers, as these were of excellent and typical construction.

The values given are accurate within 3 to 5 per cent, an allowable variation for all practical use in design work.

First off, the mechanical dimensions were taken. The variometer stator was 4 15/16 ins. square, and each wooden half 1⅛ ins. thick, with a separation of ½ in. Each side was wound with 26 turns of No. 20 D. C. C. wire. The rotor measured 3⅞ ins. in diameter and 2¾ ins. thick, with 27 turns of No. 20 D. C. C. wire on each side. Terminals of the rotor were soldered to the shaft, which is open in the center. Connection to the shaft was made through large brass bearing blocks, fitted with springs which maintained a constant pressure against the shaft.

The true inductance, making the necessary allowance for distributed capacity, was calculated as 31,000 cms. at minimum, and 538,000 cms. at maximum, giving a ratio of 1 to 17.

Although the variocoupler was not used in the set described in this chapter, its constants will be given. The base was 5 ins. square, on which was mounted a tube 4 ins. in diameter, wound with No. 20 D. C. C. wire. It was tapped at the 8th, 15th, 22nd, 30th, 37th and

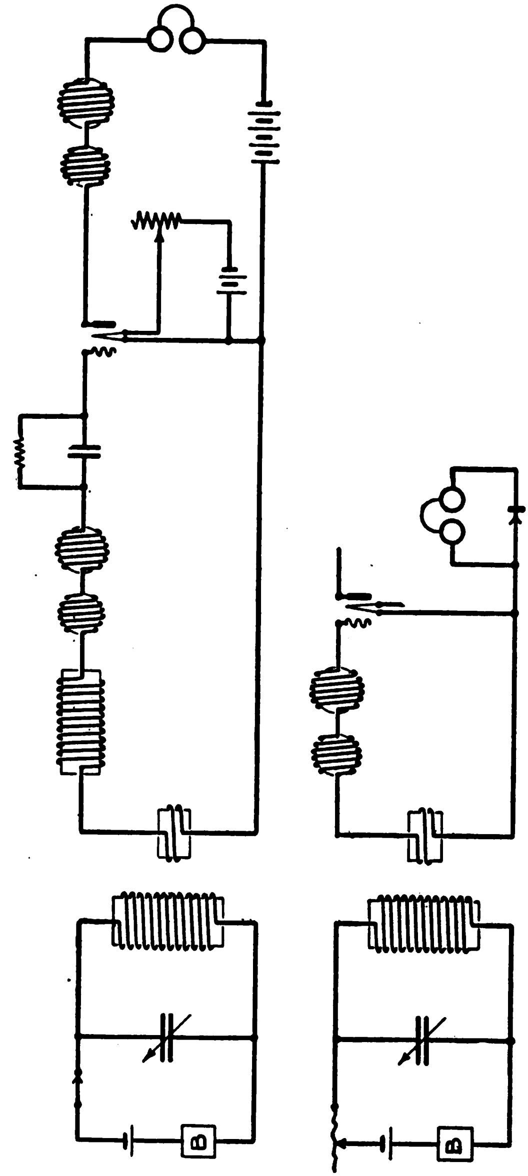

Fig. 44A.—Circuits used in the test and for the complete regenerative set.

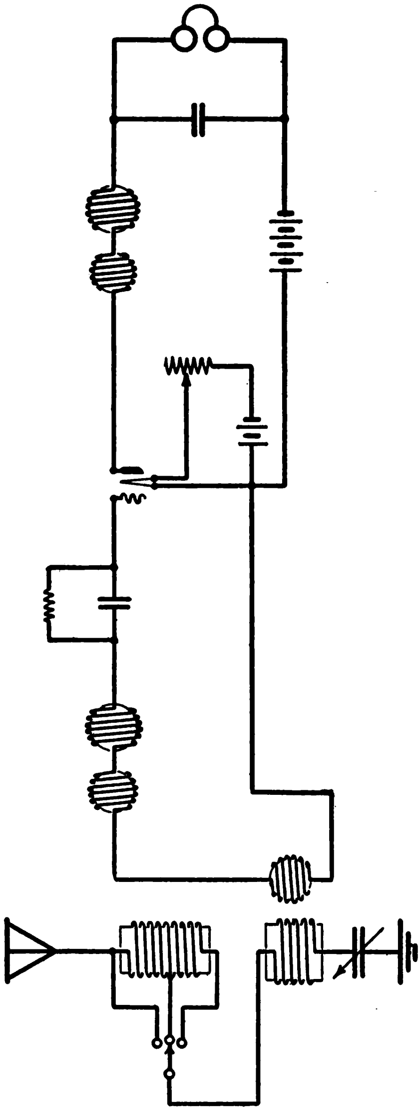

Fig. 44B.—Circuits used in the test and for the complete regenerative set.

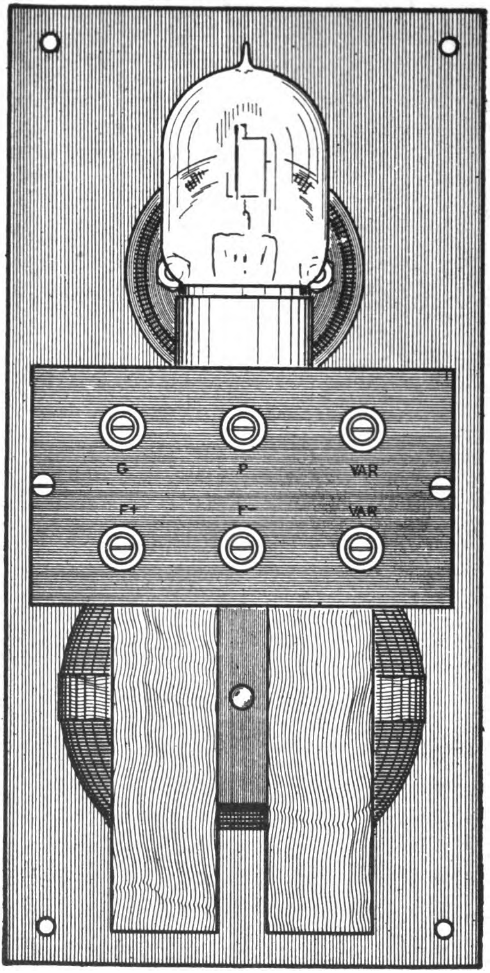

Fig. 45—Details of the audion and plate variometer mounting.

At first it was not possible to find a resonance point, for the sound in the telephones was the same over the range of the wavemeter. In fact, it seems as if there was no tuning in the circuit. Loosening the coupling only weakened the signals. Finally, a piece of Advance resistance wire, with an adjustable contact, was put in series with the buzzer. The resistance was increased until the buzzer barely vibrated. Under this condition a sharp resonance point was found without difficulty.

With a VT1 the wavelength range, at minimum and maximum on the variometer was less than 140 to 300 meters, and with a Marconi tube, less than 140 to 290 meters. This was expected, as the elements in the VT1 are much larger than in the other tube.

Another test was made to determine the relative settings of the grid and plate variometers, for maximum amplification, over the wavelength range. A large coupling coil to the wavemeter was used, with connections as in the diagram of Fig. 44A. The following readings were taken:

Wavelength	*GVMR*	*PVMR*
200m.	27°	0°
225	40	20
250	45	30
275	53	33
300	60	41
325	68	46
350	82	51
370	100	55

With the data given above, the design of a complete receiver was undertaken. The last table given showed that, in the secondary, no difficulty would be experienced in making the secondary circuit oscillate over a range of 200 to 350 meters. Since the set was designed especially for 200-meter reception, it seemed unnecessary to include a condenser for longer wavelengths. However, a condenser was used in the primary circuit, as an experimental set-up showed that tuning in this way was more easily accomplished. The switch once set, according to the antenna capacity, only the condenser was used for tuning.

Bakelite panels, 5 to 10 inches, were used, instead of the 5 by 5 inch ones, for the practical reason that the variometers were too

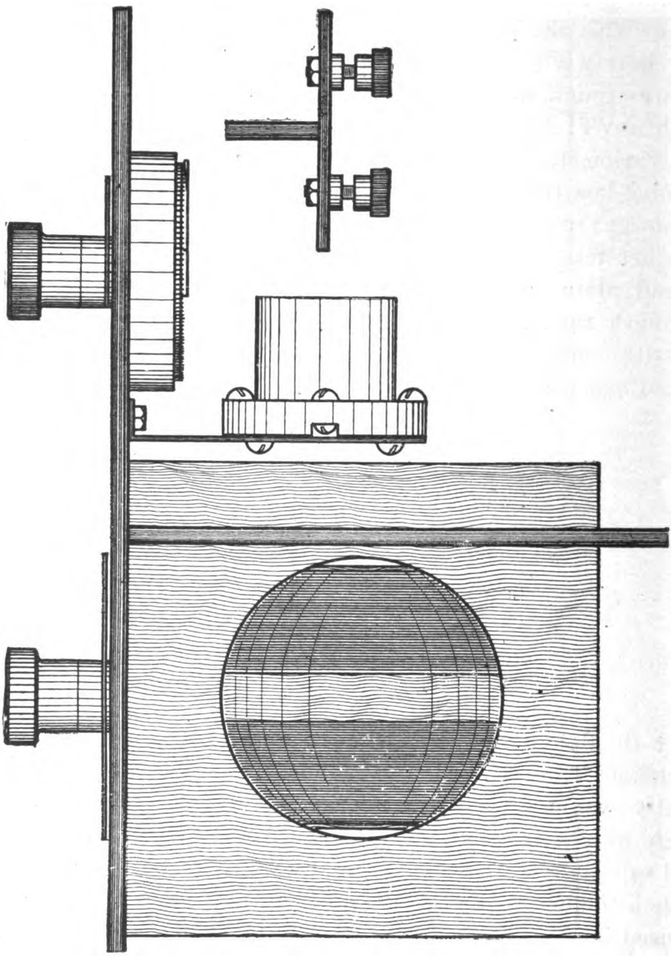

Fig. 46.—Details of the audion and plate variometer mounting.

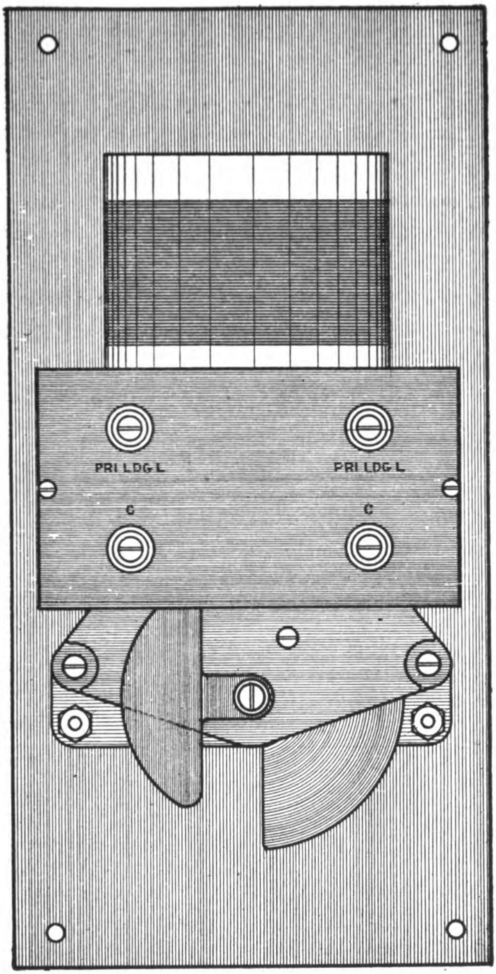

Fig. 48.—The antenna loading coil and 0.0006 mfd. condenser are carried on the primary panel. One-half scale.

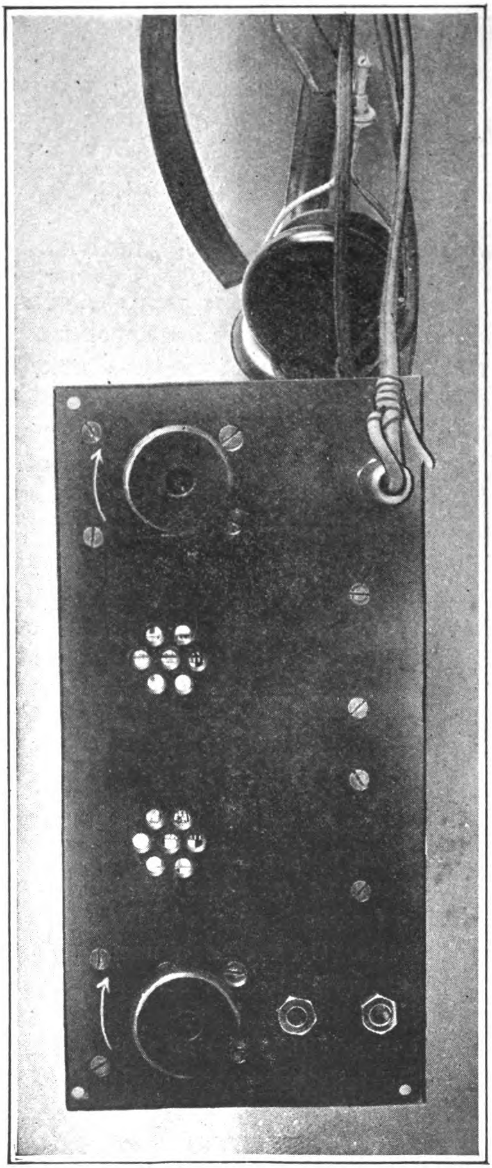

Fig. 49.—On the front of the panel are the rheostat controls, jacks for detector, first step and second step of amplification, and observation windows for the filaments.

which was equipped with those things, and cost more than six times as much as it did to make this one.

Fig. 49 shows the front of the panel, on which are the rheostats, jacks, and observation windows. The upper jack, of the double circuit type, allows the telephones to be inserted directly in the plate

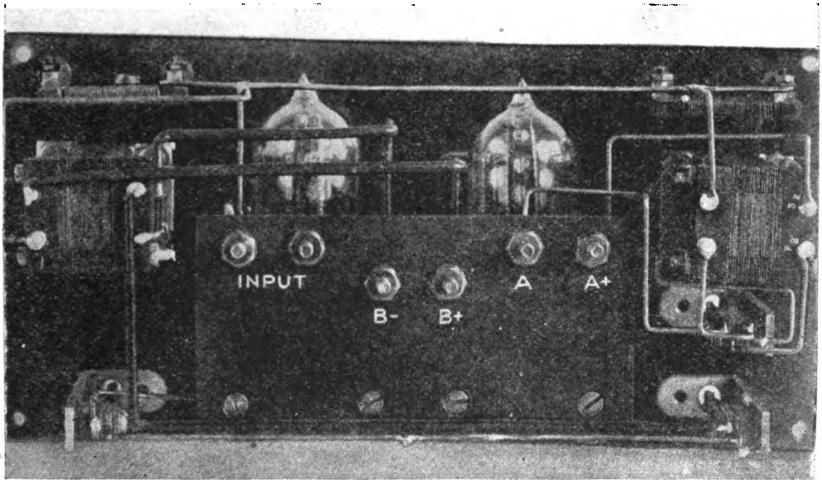

Fig. 50.—Rear view, showing the terminals for outside connections, carried on a separate bakelite panel.

circuit of the detector. The lower jack, at the left, is for the first step, and the third, at the right, is for the second step. A bakelite panel, 5 by 10 by 1/8 in., was used for the panel.

Arrows above the rheostat handles indicate the direction of turning for increased resistance. It should be noted that the clock-wise direction is used in standard practice, for increasing whatever is controlled. No pointers were used as, for this purpose, they are not essential and only add to the work.

On the rear, as can be seen from Figs. 50 and 51, are the instruments which make up the completed amplifier.

Practically all amplifiers are equipped with telephone jacks in-

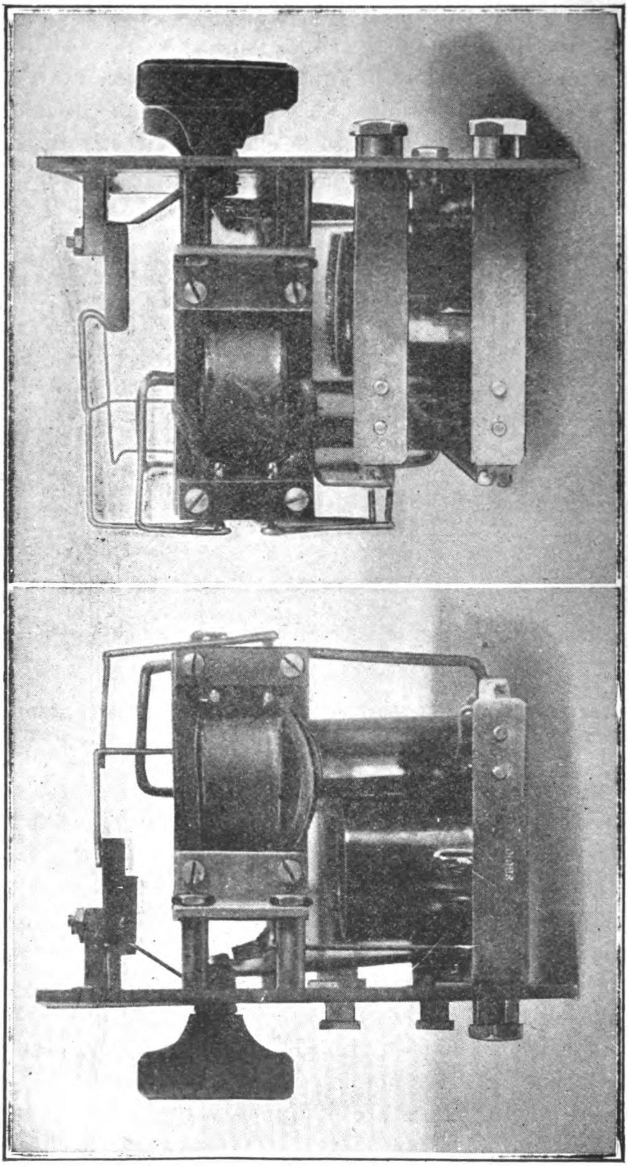

Fig. 51.—The methods of mounting the transformers and jacks are shown in these end views.

stead of binding posts. They permit a quick change from one step to another, and can be used to change circuits which would otherwise require elaborate switches.

The jacks used for this set are of the Federal type. The detector jack is of the double circuit construction, as shown in Fig. 54. Both the first and second steps are closed circuit types, although

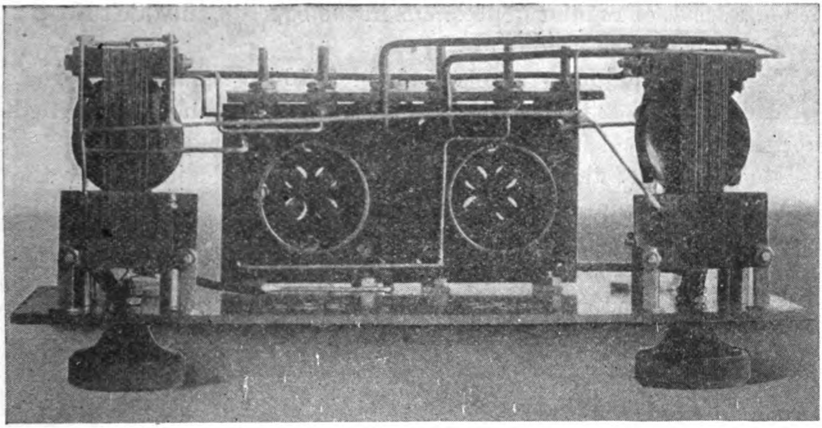

Fig. 52.—Notice the construction of the rheostats and the way in which they are supported. The posts which hold the transformers also act as stops for the rheostat contact arms.

it is better to use an open circuit jack for the second step. Then, though the filament of the second tube is lighted, no plate current will be consumed by that tube when only the first step is being used.

Because a 1/8-in. panel was used, a little trouble was experienced in mounting the jacks. This was overcome by making the holes in the panel only large enough to take the threaded portions of the front nuts, instead of the regular way with the hexagonal parts flush with the panels. This can be seen from the side views, Fig. 51.

Half a dozen different kinds of rheostats were tried and found unsatisfactory before the type finally adopted was worked out.

Rheostats are expensive and most of them take up considerable space on the panel. This design, shown in Figs. 51 and 52, is very simple and fitted in nicely with the other instruments.

First, two pieces of 1/8-in. bakelite were cut to a size of 1 3/4 by 1 in. Then the head of an 8-32 iron screw was cut off, leaving the threaded part 1 in. long. Next, the bakelite was put in a vise, and the screw hammered down on the four corners of the piece. This made a series of regular depressions in the bakelite, in which No. 24 Advance wire was wound.

The mounting posts were cut from 3/16-in. square brass rod, threaded with 6-32 tap for the screws through the panel, and drilled for the screws which hold the resistance units to the posts.

The centers of the rheostat handles are just 1 1/4 ins. below the centers of the supporting posts. This made it possible to use the upper transformer supports as stops for the rheostat contact arms. The contact arms are just short enough so that they clear the resistance element supporting posts, and pass on to the unwound portions of the small bakelite pieces, opening the filament circuits.

Flexible leads from the contact arms provide connections to those sides of the rheostats. Looking at them from the front, the resistance windings are open at the right, and connected to the filament circuits at the left.

Federal transformers were selected for this set, because of their small size and high efficiency. Still, they were too large to mount directly on the panel without too much crowding. Accordingly, eight pieces, 3/4 in. long, were cut of 1/4- by 3/16-in. brass tubing. These pieces, put on 8-32 machine screws, act as spacers to hold the transformers back from the panel. This gives the necessary room, under the transformers, for the shafts of the rheostat controls.

Also, the binding posts of the transformers are made even with the terminals of the jacks, an advantage in wiring. The four posts hold the transformer as rigidly as if it were directly on the panel.

In Fig. 51, the audion sockets can be seen, and Figs. 52 and 53 show the mounting panel. The sockets themselves were made of 15/16-in. lengths of brass tubing 1 3/8 ins. inside diameter. Short lengths of threaded rod, soldered to the tubes, were used to hold them down on the mounting panel.

A bakelite panel ⅛-in. thick, 5 ins. long and 2½ ins. wide, was cut out for the socket mounting. In this piece were drilled the holes for the audion contact pins, socket mounting rods, and contact spring screws. Experimenters who use manufactured audion sock-

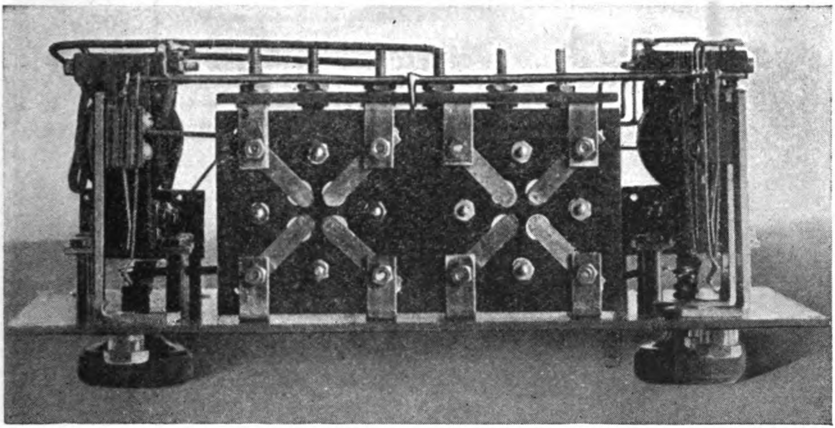

Fig. 53.—This view shows the brass angles which carry the tube panel and rear connection panel.

ets can readily change the arrangement of the panel without departing from the general idea.

To hold the socket panel to the main panel, four brass angles were made from ⅜- by 1/16-in. strip. Four more were made at the same time to hold the rear connection panel. When holes must be drilled in parts of this sort, it is always advisable to drill them before bending, to make the work easier. These angles are held by the same crews which hold the contact springs, as illustrated in Fig. 53.

Connections to the contact springs were soldered to the heads of the screws on the upper side of the panel. This made the wiring easier than it would have been to connect at the bottom, though it called for clever manipulation of the soldering iron.

Another ⅛-in. bakelite panel, 5 by 2½ ins., was used for the connections. As explained before, it is held by brass angles to the socket mounting panel. Three sets of terminals are provided for

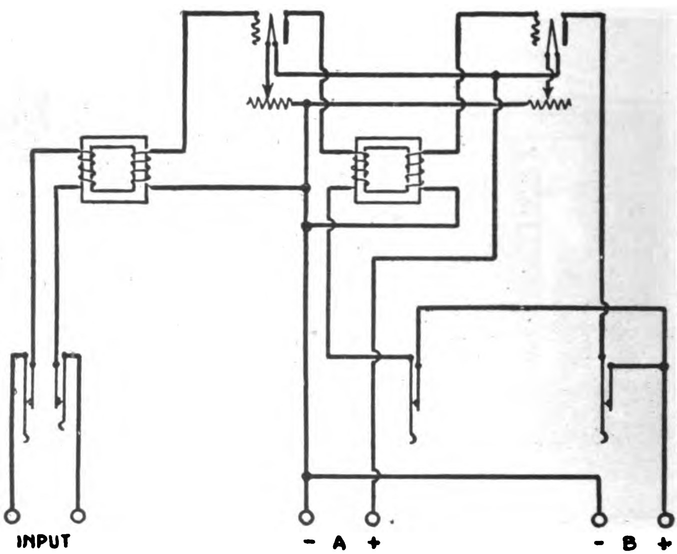

Fig. 54.—Diagram of connections for the two-step amplifier.

connections to the input, or plate circuit of the detector, and the A and B batteries.

The terminal screws are slightly staggered so that the wires will not interfere with each other. Lacking an engraving machine, the letters were simply scratched deeply and filled with white lead. Paraffine and zinc oxide are easier to handle, but are apt to melt out if the bakelite is heated while the connections are being soldered.

One of the easiest ways to spoil the appearance of an instrument is to wire it in a slipshod manner. Good wiring adds greatly to the looks of any apparatus. For this amplifier, No. 14 bare copper wire

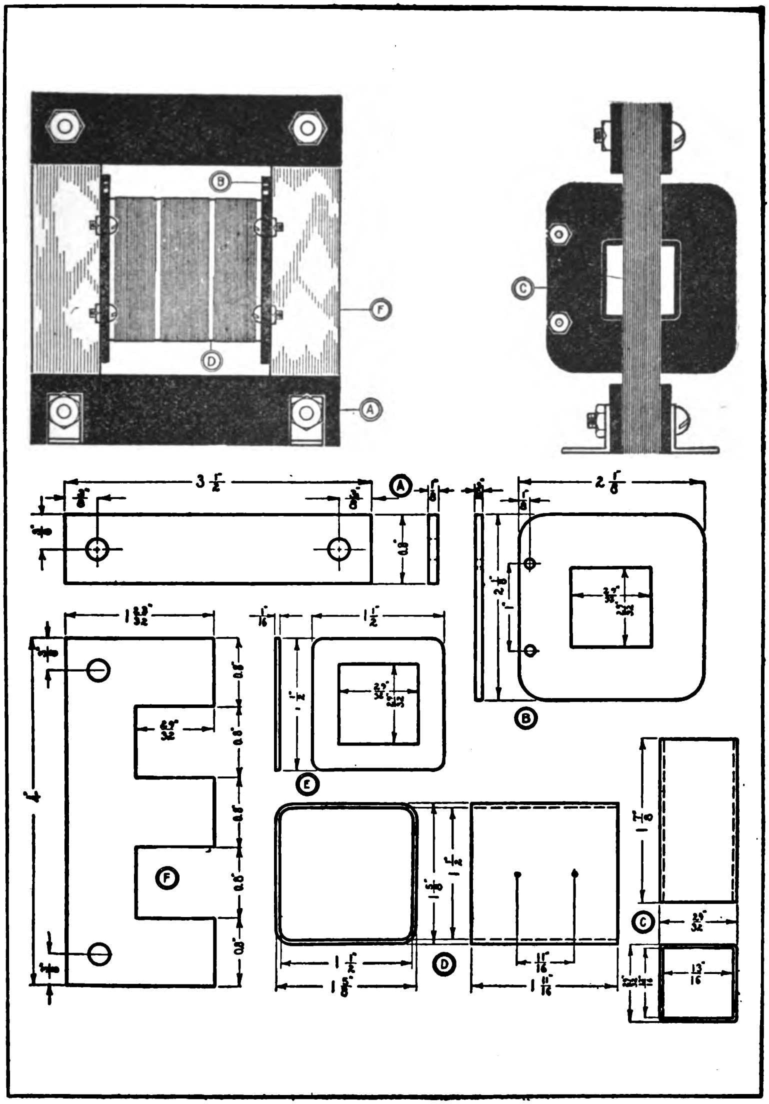

Fig. 56.—The letters on the assembly refer to the details. This instrument calls for no difficult construction or expensive parts.

snips to the approximate size, they should be clamped to the template and filed accurately. The dimensions of the two halves of the core are identical. There is an air gap between the parts when they are put together.

Four bakelite strips, marked A, are used to hold the laminations together. Before they are assembled on these strips, one-half of the laminations must be dipped in japan or varnish and hung on wires to dry. Then the plain and japanned laminations are put together alternately. This should make a total thickness, when the core is completed, of 7/16 in.

At this point mounting legs should be cut from a brass strip 3/8 in. wide by 1/16 in. thick.

A cardboard form (Fig. 57), C, is first made to go over the center part of the core. This supports two washers, E, over which a larger paper tube, D, is placed. The progressive assembly in Fig. 57 shows that another set of washers, B, are put over the outer tube. These washers carry the binding posts of the primary and secondary windings.

The tube C is made on a wooden mandrel 13/16 in. square. Bond paper about 8 in. wide is wrapped around it and varnished at the center part with Valspar. Enough sheets are used to make the tube about 3/64 in. thick. When completed the paper should be wrapped with string and the whole outfit put in a warm oven to dry.

Wide paper is called for here because, if the Valspar leaks out at the edges, it will cause the paper to stick to the mandrel, making its removal impossible. After the drying process the tube should be cut to length before it is taken from the mandrel.

Then end washers may be cut with a sharp knife from heavy cardboard to the dimensions given in Fig. 56. If cardboard of sufficient thickness cannot be obtained, several layers can be glued together and dried under pressure.

A larger mandrel must be made for the tube D, which carries the winding. This should be treated as explained in the first part of this section.

The assembled view in Fig. 56 shows the primary and secondary

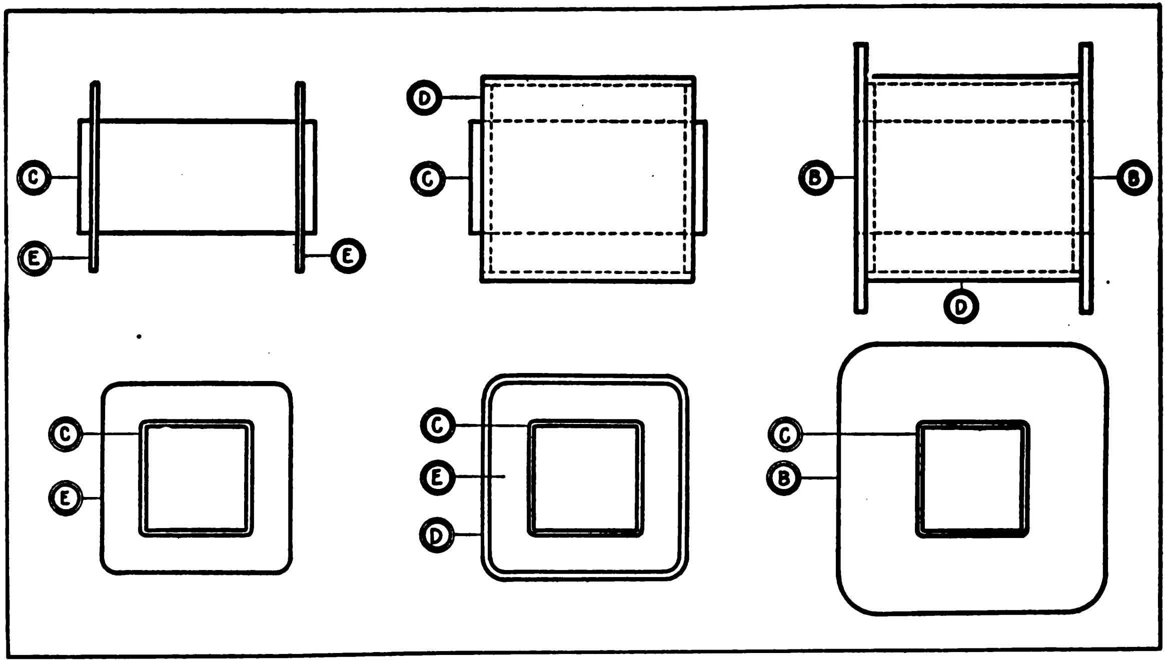

Fig. 57.—Progressive steps in assembling the cores and end pieces which support the primary and secondary winding.

winding on the tube D. Two sections are used for the secondary, with the primary at the center. In the matter of winding the radio frequency transformer is much simpler than the audio frequency type.

First, the secondary coils are wound, each section having 90 turns of No. 40 single silk covered wire. The winding is of the ordinary sort secured with Valspar. Connections between the sections should be made inside the tube, and the wires soldered to make a perfect connection. Be sure that both parts of the coil are wound in the same directions, so that they will be equivalent to a continuous winding.

The primary requires 105 turns, also of No. 40 single silk covered wire. When the coils are completed, they should be covered with Valspar and baked dry in a warm—not hot—oven.

Leads can be brought from the coils directly to the binding posts, or pigtails, secured to the tube, can be used instead. The latter method insures their permanence.

The beginning of the secondary should be brought to a terminal marked Sg, and the corresponding end of the primary to a terminal marked Pp. Thus, the Pp end will go to the plate of the first radio frequency audion, and the Sg end of the secondary will be connected to the grid of the next tube.

When the parts are ready, the tubes and end pieces should be assembled as shown in Fig. 57. An application of Valspar will keep the parts in place. Then the coil system is put on the core, and the end plates tightened until the laminations are clamped closely. If the coil mounting is not tight on the core, put a little Valspar on it and put it away to dry out. This varnish is better than glue for holding light parts, for once dry, it does not soften.

CHAPTER XV

RADIO AND AUDIO FREQUENCY AMPLIFIER

This chapter describes a very interesting combination of a radio and audio frequency amplifier. This unit was built and it proved so successful, that it is felt it will be of service to those who desire to obtain strong signals from stations from which it is now impossible to get good signals. This amplifier is also very well adapted for use with loop antennas.

A tuned impedance coupled amplifier employs an inductance and shunt condenser between the output circuit of one tube and the input circuit of the next. The inductance and condenser must be tuned to the wavelength of the incoming signals, to give maximum amplification. In a receiving set using concentrated inductances, the coil and condenser may be identical in size with those in the secondary tuning circuit. If possible, the coupling circuit condenser should not exceed 0.0005 mfd. at maximum, for the larger the coil, and the smaller the capacity, the greater is the amplification. Moreover, this type of circuit operates at somewhat greater efficiency on long waves than short ones.

The combination of radio and audio frequency amplification is of decided advantage for the reception of weak signals over the two-step audio frequency amplifier, and equal to the other for strong signals.

A new method of construction is shown in the illustrations. Instead of crowding the binding posts on the front or back of the main panel, a bakelite plate 4 7/16 by 2½ ins. is supported at the rear by two square brass rods, and all connections located upon it. If wooden cabinets are not used, several panels made up in this way will present uniform connecting plates at the rear. On the other

other ways, were provided. Instead of putting the screws into the wooden case itself, 1-in. lengths of 1/4-in. square brass rod were secured in the corners of the cabinet, and the holding screws put into threaded holes in the ends of the brass pieces. However, if the method of fitting the panels together, previously shown is used,

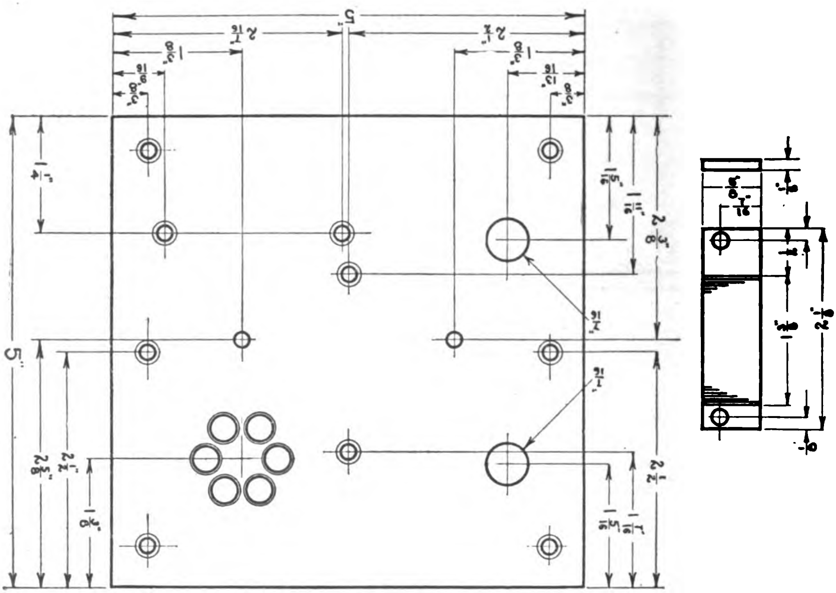

Fig. 60.—Layout of panel and resistance units.

the holes should be 1/4 in. in from the sides, and for 8-32 screws, should be made with a No. 18 drill.

Federal jacks, Fig. 61, a No. 1422-W for the detector stage, and a No. 1421-W for the amplifier, were mounted at the left. This method of connecting the telephones is generally preferred because connections can be made quickly, and the plate circuit is closed automatically, at the detector stage, when the plug is removed.

Two 6 13/16-in. lengths, and six 1 25/32-in. lengths of 3/16-in. square brass rod, one 1/8-in. bakelite panel 4 7/16 by 2 1/2 in., and mounting plate. Other makes can be used, but this is particularly desirable because of its small size.

Small strips of fibre or bakelite, wound with No. 26 Advance wire, comprised the resistance elements. Exact dimensions are given in Fig. 60. Notches, made by hammering an 8-32 screw against the corners of the strips, held the wires in place. The resistance supports were fastened to the rear of the panel by ¾-in., 6-32 flat head

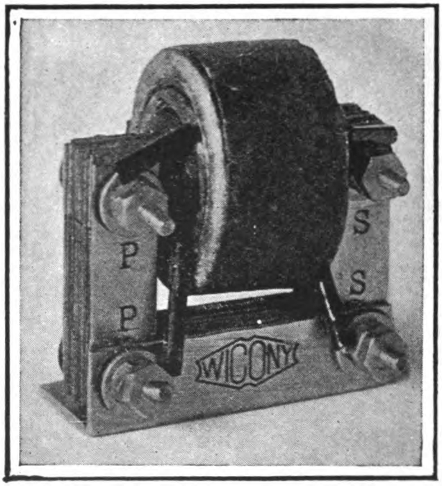

Fig. 62.—The amplifying transformer.

screws. Holes in the strips were threaded so that no nuts were required. The extending ends of the screws served as stops for the contact brushes.

Arrows on the panel show the direction of rotation for the OFF position, although it might be better to have them point in the opposite direction in which case they would show the direction for increasing the filament brilliancy.

A diagram of connections for the complete receiving circuit is given in the upper part of Fig. 63. Binding posts on the rear panel are indicated by circles. Great care was taken in connecting

Using only one step, this set is better than the resistance coupled type, which requires an extra potential battery, or the straight impedance and transformer coupled amplifiers which have such resonance effects that they must be designed for a limited range of wavelengths, and cannot be made readily by experimenters.

The set described in this chapter is for the B-C wavelength range, that is, from 200 to 2,000 meters. Fig. 66 shows the front of panel, with the inductance and condenser controls, and Figs. 67 and 68 the side and rear views.

Any condenser of 0.0005 mfd. maximum capacity can be used, although one of the General Apparatus type is indicated here. A

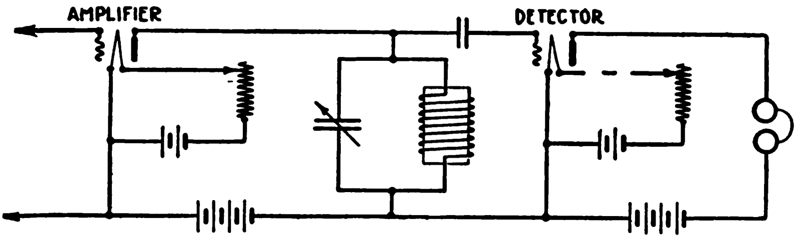

Fig. 64.—A simplified circuit of the amplifier.

Corwin dial, fastened to the panel by means of two small machine screws is well suited as an indicator.

The pointer is simply a ⅛ in. brass rod, slotted at one end and threaded at the other. In the slot, a piece of No. 30 brass sheet is soldered and filed down at an angle corresponding to the bevelled edge of the dial.

For this particular condenser, the knob is made with a hole drilled part way through it of a diameter to take the shaft. Then a smaller hole is made the rest of the way to take a 6-32 screw which is threaded into the end of the shaft. In this way, the handle is held securely in place.

The inductance is clearly shown in the accompanying illustrations. It is made up of a two-bank winding of 10 No. 38 high frequency

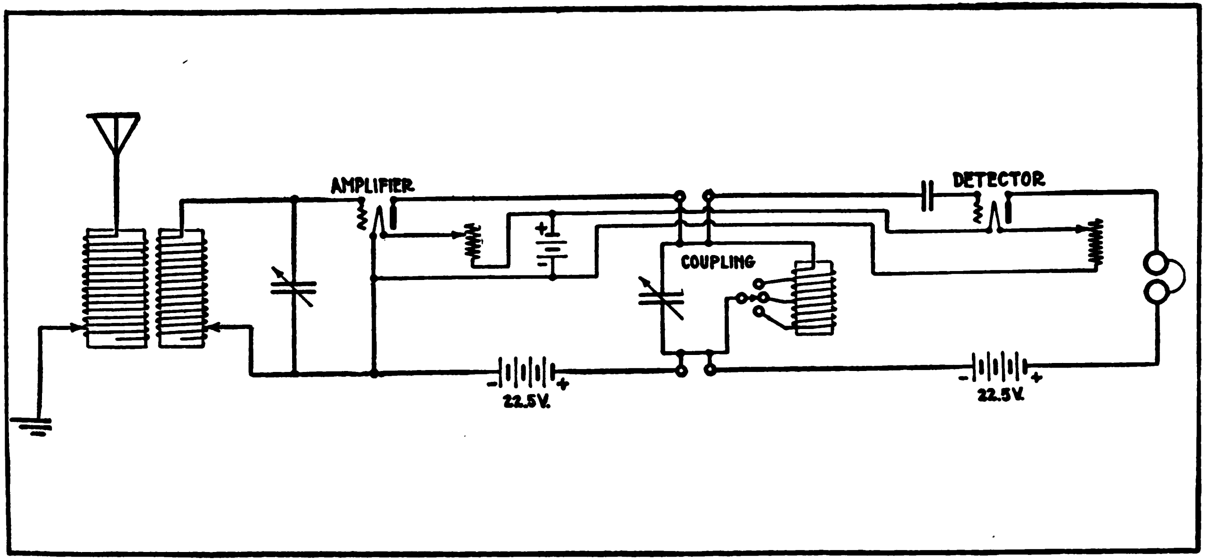

Fig. 65.—Complete connections for the radio frequency amplifier.

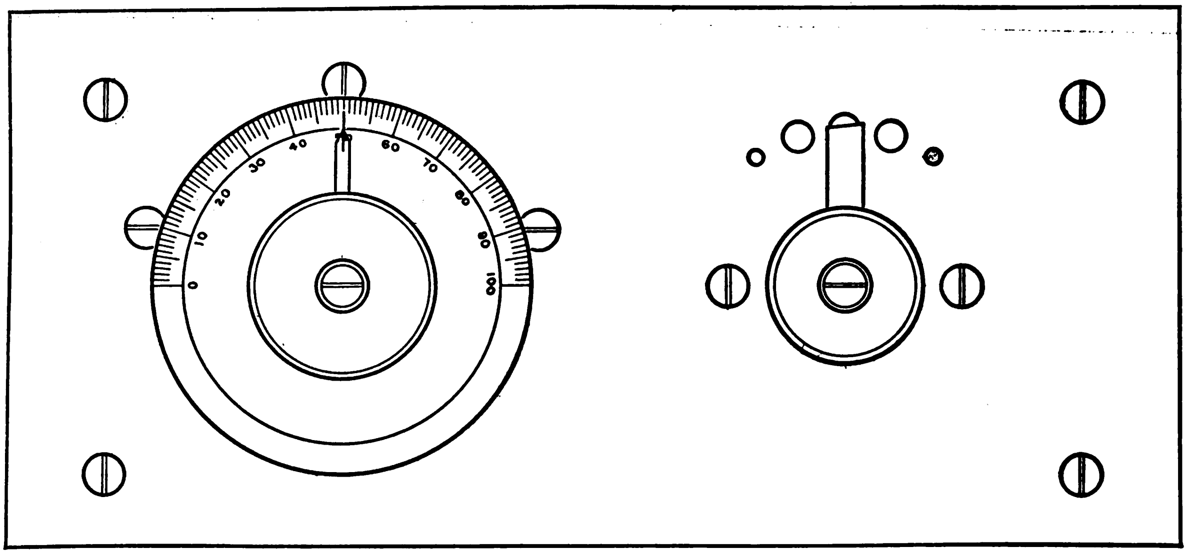

Fig. 66.—There is nothing difficult about the construction of this set.

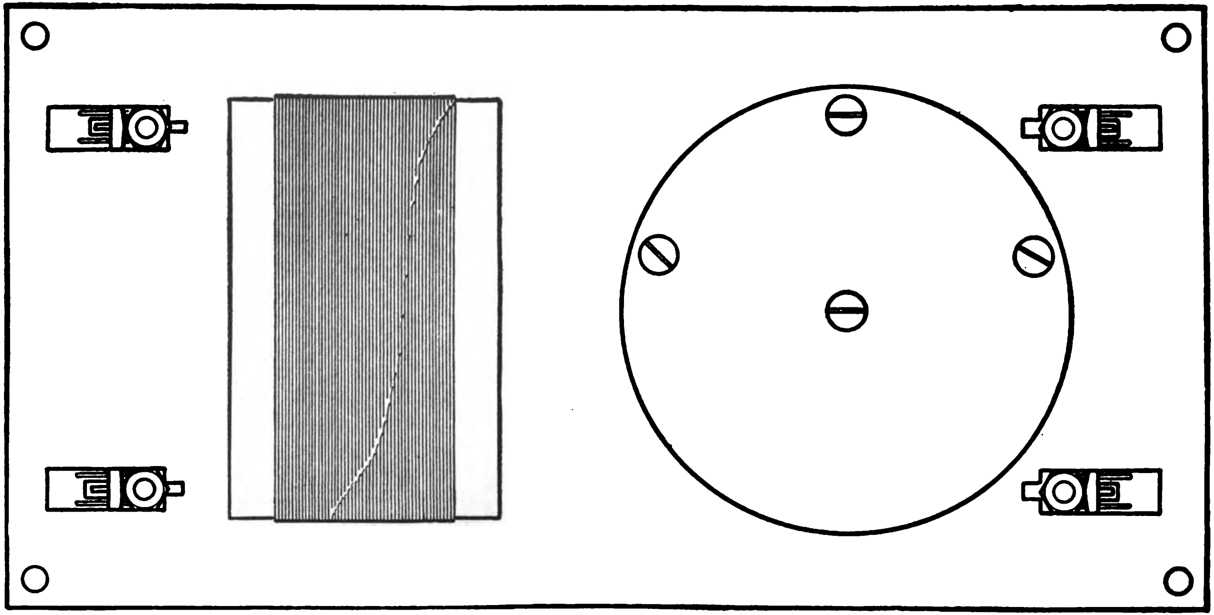

Fig. 68.—A condenser and inductance are the only instruments needed.

wound, is 120,000, 500,000, and 2,000,000 cms. This gives a wavelength range, with a condenser of 0.0001 to 0.0005 mfd. of

Tap 1. 200 to 460 meters
Tap 2. 420 to 940 meters
Tap 3. 840 to 1,885 meters

As a matter of fact, the G. A. Standardized condenser has a maximum capacity of 0.0006 mfd., bringing the maximum wavelength up to 2,000 meters. By adding another section on the coil, the wavelength with 0.0005 mfd. could have been brought up to 2,000 meters, but this shortcoming did not seem to warrant the additional wire required.

Four Fahnestock clips are provided for connection to the other circuits. As shown in Fig. 65 the condenser and coil are joined in parallel, and wires run from each side to two of the terminals. One set of binding posts go to the plate and filament of the amplifier tube, and the other set to the grid and filament of the detector tube.

There are two ways to use this amplifier. The first requires at least an approximate idea of the wavelength adjustments of the primary and secondary tuning circuits. Then, at various settings of these circuits, the amplifier can be quickly tuned to the same wavelength.

This probably sounds worse than it really is, for, with only three taps on the inductance, the amplifier is easy to tune. If the amplifier is to be used for 200-meter traffic only, the inductance can be reduced to only 27 turns. In that case, only the variable condenser will need adjusting.

The other method, used only when signals with the detector alone can be heard but are too faint to read, is to have a switch by which the secondary circuit can be connected directly to the detector for standby work, or to the amplifier for copying. This simplifies the amplifier tuning, for with the primary and secondary already adjusted, it is an easy matter to tune the amplifier to the other circuits.

This is more efficient than a one-step audio frequency amplifier.

The mechanical form of the amplifier will not be described as no doubt the experimenter will wish to build it along the same lines as the amplifier equipment he already has.

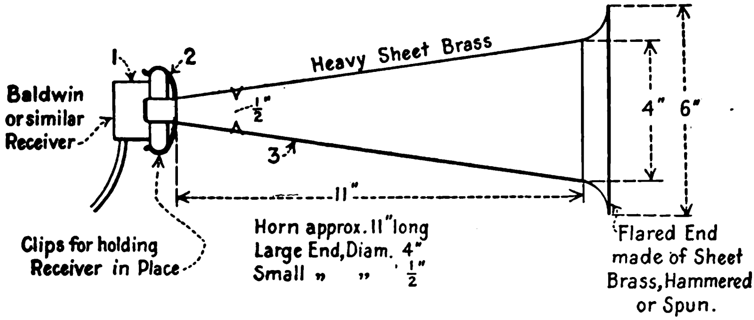

Fig. 70.—Loud speaking telephone unit complete.

Fig. 69 is the circuit diagram of the amplifier. The primary of the amplifying transformer is connected in place of the telephone receiver and the loud speaking receiver to the terminals so marked.

It should be noted that the UV-202 power tube is used as considerable energy is required to give a satisfactory signal. The

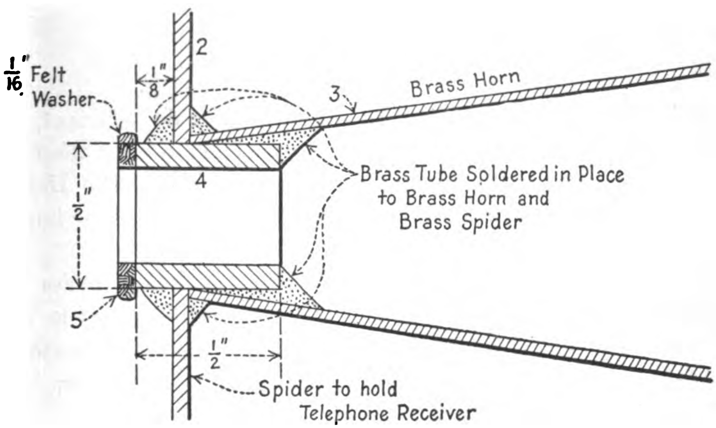

Fig. 71.—Details of receiver end of horn.

same filament battery is used and is connected to the points marked — and + 6 Volts. It is necessary to employ a grid biasing battery of 6 Volts and a plate battery of 100 Volts; the latter is connected between the points marked — and + 100 Volts. The rheostat is provided so that the filament current can be adjusted to the proper value. Almost any of the amplifying transformers on the market today, such as the Federal, G. A. Std., Acme, General Radio or the Radio Corporation UP 712 can be used.

Most of the loud speaking telephone receivers are quite expensive

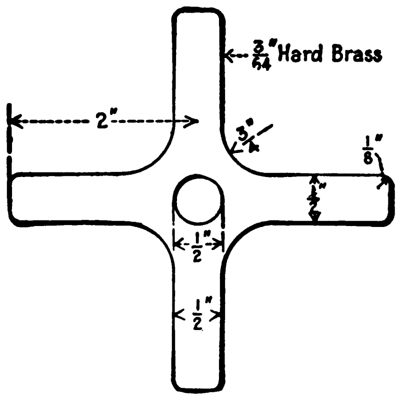

Fig. 72.—Details of the spider.

so nothing will be said about them but a simple, efficient, loud speaker made from a Baldwin or similar receiver will be described.

Fig. 70 illustrates the completed unit comprising the Baldwin Receiver, 1; the brass spider to hold the receiver against the horn, 2; and the horn, 3.

The horn is made by rolling up a sheet of heavy brass on a wooden mandrel of the dimensions shown and solder the seam. The flared end can be made by spinning a thin sheet of brass over a wooden form and soldering a large brass wire on the larger diameter end of the flared piece.

Fig. 71 shows in detail how the spider is secured to the horn and how the joint between the face of the receiver and horn is made.

A half-inch piece of ½-inch outside diameter brass tube (4) about 3/32 in. thick is soldered to the ½-in. end of the horn (3). The brass spider (2) is slipped over the tube and flush against the brass horn (3) where it is soldered in place. In order to make a soundproof joint between the horn (3) and the receiver (1), a 1/16-in. felt washer is cemented to the end of the brass tube; ⅛-in. of the brass tube must protrude beyond the inner face of the spider so it will make a tight joint between the horn and receiver.

Fig. 72 is the details of the spider (2). When the unit is completed and assembled the receiver cap is unscrewed from the receiver and placed on the spider in position; thus the four ends are bent over the receiver cap as shown in Fig. 70. The cap can then be removed and the ends given a further bend so that the receiver will be held snugly against the horn. This receiver will be found very satisfactory for the reproduction of the music, speech, etc., broadcasted from the radio broadcasting stations.

CHAPTER XVIII

THE RADIO SET FOR THE PARLOR

Up to little less than eight months ago, radio receiving sets were used only by "dyed in the wool" amateur experimenters. This was due, principally, to the fact that the radio telephone was

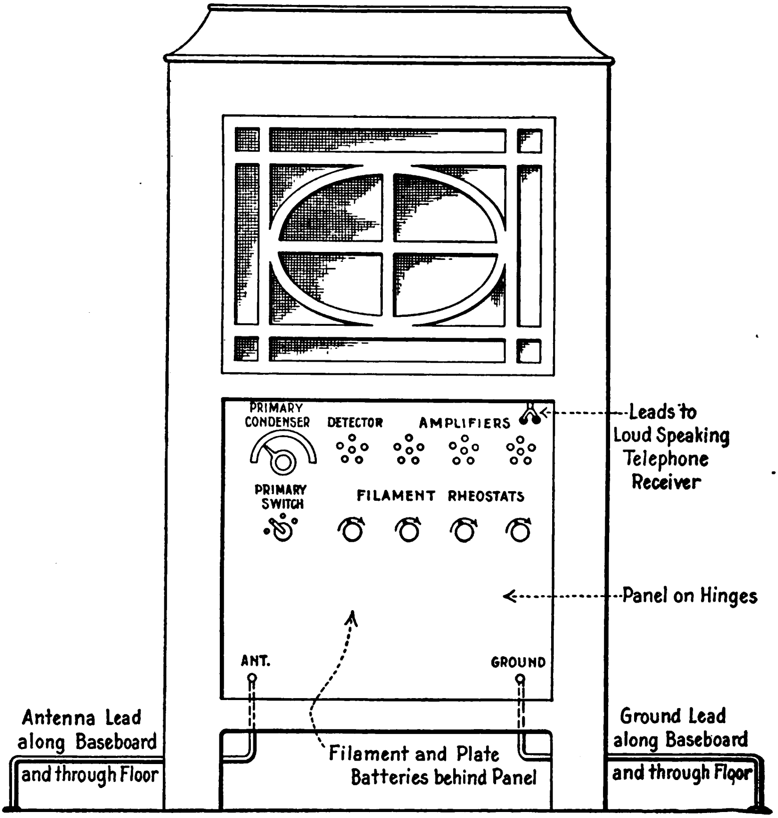

Fig. 73.—Phonograph receiver.

not used to such a large extent as it is today. Now, with radio phone broadcasting stations maintaining regular and interesting programs, the radio telephone has become or is becoming nearly as much of a necessity as the phonograph. The ordinary type of equipment is not a thing of beauty and most people, not radio enthusiasts, would hesitate to put such a set in their parlor. In this chapter a type of set will be described, in general terms, which will meet the parlor requirements and still function as a satisfactory radio set. A simple adapter will be illustrated which will make

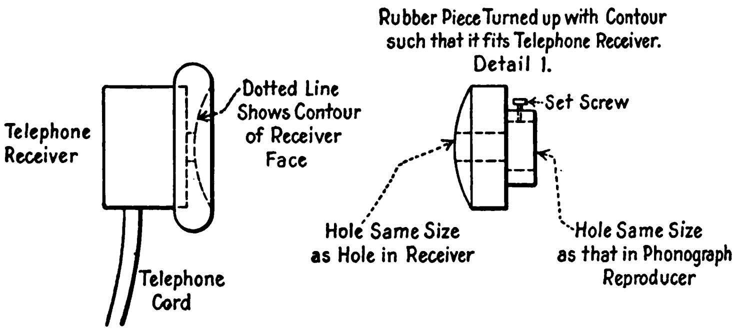

Fig. 74.—Details to adapt telephone receiver to phonograph.

it possible to use one of your telephone receivers in connection with the phonograph horn for a loud speaking telephone receiver.

In order that the loud speaking receiver be satisfactory it will be necessary to use the amplifier described in Chapter XVII.

Fig. 73 shows an ordinary phonograph with the compartment for records converted into a radio receiver. All of the equipment, consisting of tuning circuits, detector, two stage amplifier and loud speaker amplifier, can be mounted on a hinged panel. The necessary batteries can be placed behind the panel in the record compartment. The antenna and ground leads can enter through the base of the compartment and can be led to the antenna and ground respectively along the baseboard in the room.