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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

Letter
Circular
LC 46

(September 6, 1922)

DESCRIPTION OF FIXED CONDENSERS USED WITH SIMPLE HOMEMADE RADIO RECEIVING SETS.*

Introduction

This Circular describes two "fixed" condensers which are used with either of the radio receiving sets described in the first or second Circulars* of this series. One of the fixed condensers, which is connected in series with the antenna, will be called in this Circular the "series-antenna" condenser. The other fixed condenser, which is connected across the terminals of the telephone receivers, will be called the "telephone-shunt" condenser.

The effect of the series-antenna condenser is to enable the receiving equipment to give signals of somewhat greater intensity when tuned to wave frequencies above 1000 kilocycles per second (that is, wave lengths of 300 meters or less). It will thus be seen that the effect of this condenser is just the opposite of the effect obtained by a greater number of turns of wire on a tuning coil, which, it will be remembered, permits the receiving equipment to respond to lower wave frequencies (longer wave lengths).

The effect of the telephone-shunt condenser is to increase the intensity of some radio signals to which the receiving set may be tuned. In most cases the use of this condenser has no effect upon the intensity of signals which are received from a radio telephone transmitting station, but will increase the intensity of radio signals which are received from most spark transmitting stations.

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*This is the fourth of a series of Circulars describing radio receiving equipment. The previous ones of the series are.

Bureau of Standards Circular No. 120 (formerly Letter Circular No. 43), "Construction and Operation of a Simple Homemade Radio Receiving Outfit."

Bureau of Standards Circular No. 121 (formerly Letter Circular No. 44), "Construction and Operation of a Two-Circuit Radio Receiving Equipment with Crystal Detector."

Bureau of Standards Letter Circular No. 45, "Construction and Operation of a Simple Radiotelegraphic Code Practice Set."

The first two Circulars of this series are now obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C. price 5 cents each.

Part. 1. Description of Series-antenna Condenser

The series-antenna condenser is shown in detail in Figs. 1A and 1 B. Two thin strips of metal (C and E) 1 inch wide and 3 inches long are used with three sheets of insulating material (B, D and F), 1-1/2 inches wide by 3 inches long. The metal strips may be thin copper, brass or aluminum. Each of the three sheets of insulating material is made up of two pieces of heavy white writing paper which are separately dipped in clean, melted paraffin. Each pair of sheets is then pressed together by means of a warm iron, and when cold the strip is cut out to the required size. A sheet of clear mica, having about the same thickness as the two sheets of writing paper mentioned above may also be used for the insulating material. Two blocks, (G =2-5/8"x 3" x 1/2", A =3" x 3-1/2" x 1/2") are cut out and preferably from hard wood. Two screws pass through holes H and J in the upper cap block G, which is placed over the base block A, so that the edges of the two blocks are even on three sides. (See Fig. 1A). The holes for the screws H and J are 3/8 inch from the sides of the cap block G and equally distant from the ends. Having located the correct position of the cap block G, the screws in holes H and J are loosened and the cap block is removed from A, leaving two small holes H' and J' to locate the proper position of the blocks when the condenser is finally assembled. The two screws L and M are located just far enough in from the front edge (See A, Figs. 1A and 1B) so that the block A may be screwed to the left end of the baseboard of the receiving set described in Circular No. 120 or to the primary coil support described in Circular No. 121. (See Figs. 2 and 3).

The wooden blocks are of dry wood smoothed up with sandpaper and given a coat or two of varnish which will not absorb moisture, or treated with paraffin as described in Circular No. 120.

A sheet of the paraffined paper or mica B is placed on the base block A between the holes H' and J' so that its ends are even with ends of the base block. A thin metal strip C is placed in position so that it lies in the center of B and has its right end 1/2 inch in from the edge of the base block and its left end projecting 1/2 inch over the opposite edge of the base block. (See fig. 1B).

Another sheet of paraffinned paper D is placed on C directly above B. The second piece of thin metal E is placed on D above C, except that one end of the metal strip E extends 1/2" over the right edge of block A instead of the left as did C. The third sheet of paraffined paper F is placed on E directly above D and B.

The alternate sheets of paraffined paper and thin metal are held carefully in position, and the cap block G is placed over them and screwed in position. The right end of the thin metal strip E is bent down, and a round-head brass screw N is passed through a hole K punched or drilled in the end of the metal strip. The projecting end of the strip C is not visible in Fig. 1A, but it is bent and fastened in the same manner as E. The completed condenser resembles the sketch shown in Fig. 1A.

Mounting and Wiring

The condenser is mounted on either the single-circuit receiving set described in Circular No. 120 or the two-circuit receiving set described in Circular No. 121. Fig. 2 shows the method of mounting the condenser on the single-circuit receiving set. The condenser is fastened to the end of the baseboard by means of the screws L and M. A binding-post P is added to the panel of the receiving set about 1 inch from the binding-post marked "Antenna," as shown in Fig. 2. A wire is clamped under the condenser screw N which passes through the metal strip E, forming one terminal of the condenser. This wire is led to and connected to the back of the binding-post marked "Antenna" without disturbing any of the other wires which are already connected to this binding-post. Another wire is connected to the terminal of the metal sheet C and led to the back of the binding-post P.

In Circular No. 120 a short stiff wire is shown attached to the "Antenna" binding-post and extending toward a similar wire attached to the "Ground" binding-post. The wire on the "Antenna" binding-post is removed and a longer one substituted so as to form parts Q and S; fig. 2. A similar short piece of stiff copper wire T is attached between the first and second nuts of binding-post P. There is a very short gap between wires Q and T and between S' and S. These gaps are for protective purposes when one forgets to throw the lightning switch to the grounded side. Another method of protection would be to install a lightning arrester in the antenna system. The arrester may be installed just outside or just inside of the building, preferably the former. This serves as an extra precaution when one forgets to throw the lightning switch to the ground terminal when the receiving set is not being used.

If the condenser is mounted on the receiving set described in Circular No. 121, it may be placed as shown in Fig. 3. In other words, it is mounted upon the vertical board which supports the primary coil tube previously described. The connections from the condenser to the binding-post on the front panel of the two-circuit set are made as described above.

If the connections to the receiving set have been made as described in Circular No. 120 or No. 121, the antenna lead-in wire is removed from the binding-post marked "Antenna" and connected to the new binding-post which has been added to the front panel of the receiving set (See P, Figs. 2 and 3). The condenser is now included in the electrical circuit together with the tuning coil, between the antenna and ground. This connection to the binding-post is used when it is desired to receive wave frequencies of approximately 1000 kilocycles per second or above (wave lengths of 300 meters or below). To receive wave frequencies of 1000 kilocycles per second or below (wave lengths of 300 meters or more) the antenna lead-in will ordinarily be connected to the binding-post marked "Antenna" and the operation of the receiving set is then as described in Circular No. 120 or No. 121. In either case the set is tuned to the desired wave frequency in the same manner as described in Circulars No. 120 and No. 121. The switches are set so as to include more turns of wire on

the tuning coil (or the primary coil of the two-circuit receiving set) with the antenna lead-in connected to P than when it is connected to the binding-post marked "Antenna," when tuning to a given wave frequency.

Part II. Description of Telephone-Shunt Condenser

The parts used in the construction of the telephone-shunt condenser are: a cap piece of heavy pasteboard or wood (A) about 1-3/8 by 3 by 1/8 inches, a similar base of pasteboard or wood (B) 1-3/8 by 3-7/8 by 1/8 inches, 6 pieces of tin foil (C,D,E,F,G,H) 7/8 by 7 inches, 7 pieces paraffined paper or mica (J,K,L,M,N,O,P) 1-1/8 by 3 inches, 1 stiff paper clip or its equivalent (for temporary use), about 10 feet of No. 24 bare copper wire, and 2 round-head wood screws about 1/2 inch long. The several steps in the arrangement of these parts are shown in Figs. 4, 5 and 6. The layers of paraffined paper and tin-foil are alternated as shown, starting with a sheet of paraffined paper on the base B. The paper J is placed in the center of B so that there will be a 1/8 inch margin at the sides and 7/16 inch margin at the ends of B. A sheet of tin-foil C is then placed on the paper J so that there will be 1/8 inch of margin of paper uncovered on three sides. The tin-foil C will then extend 4-1/8 inches over the right-hand edge of the paper J, or 3-3/16 inches over the right-hand edge of the base B. The paraffined paper K is placed on C directly above J. The tin-foil D is placed on K. The overhanging end of D extends to the left instead of the right as did C. The other three sides of D are 1/8 inch in from the three edges of K. This arrangement of alternate layers is followed until the seven paraffined papers and the six sheets of tin-foil are placed in position. The cap piece A is then placed as shown in Fig. 4.

The condenser now appears as shown in Fig. 4, except that the thickness of the condenser is much exaggerated here in order to better show the parts. A paper clip or other form of temporary clamp may be used to hold the parts firmly together. The tin-foil strips D, F and H are now bent back over the end of the cap piece A and folded over at an angle of 45 (see line RS, Fig. 5) so that the tin-foil may be wrapped evenly around the pieces A and B and secured by several turns of No. 24 bare copper wire (see Fig. 6). The tin-foil strips C, E and G, Fig. 4, are wrapped in the same manner. The completed condenser appears about as shown in Fig. 6, except much thinner.

This telephone-shunt condenser just described may be added to the single-circuit receiving set described in Circular No. 120 or to the two-circuit receiving set described in Circular No. 121. The condenser is placed as shown in either Fig. 7 or Fig. 8. A somewhat simpler plan is to screw the condenser to the underside of the receiving set baseboard. This saves drilling more holes in the baseboard in order to keep the wiring on the underside. No matter with which receiving set this condenser is used, the two wires T and U (Figs. 7 and 8) are connected to the two telephone receiver binding-posts marked "Phones."

Fixed condensers may be purchased which will give about the same results as those described in this Circular. The series-antenna condenser has a rated capacity of about 0.0003 microfarad (300 micromicrofarads). The telephone-shunt condenser has a capacity of approximately 0.0015 microfarad (1500 micromicrofarads).

Approximate Cost of Parts

Series-Antenna Condenser

2 metal strips (copper, brass or aluminum)	$0.10
3 sheets of mica (if used)	.20
1 binding-post (any type)	.10
6 wood-screws	.10
2 small wooden blocks	
Paraffin	
Paper	
Total	$0.50

Telephone-Shunt Condenser

About 40 sq. inches of heavy tin-foil	$0.25
2 screws for mounting condenser	.05
2 small pieces of heavy cardboard or thin wood	
Paraffin	
Paper	
Total	$0.30

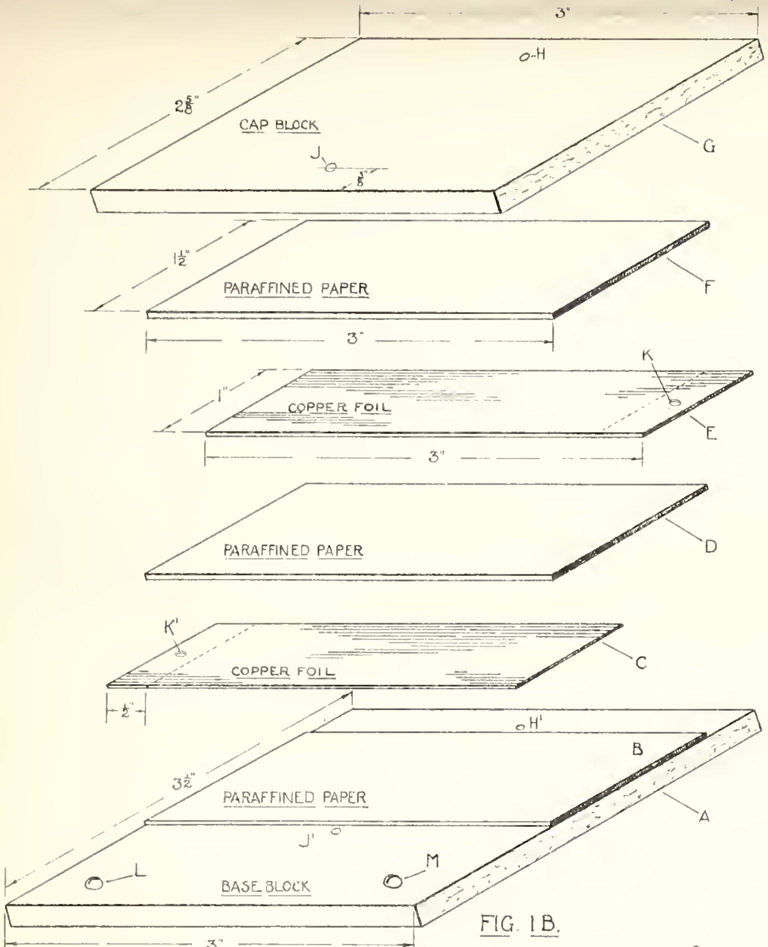

FIG. 1B.

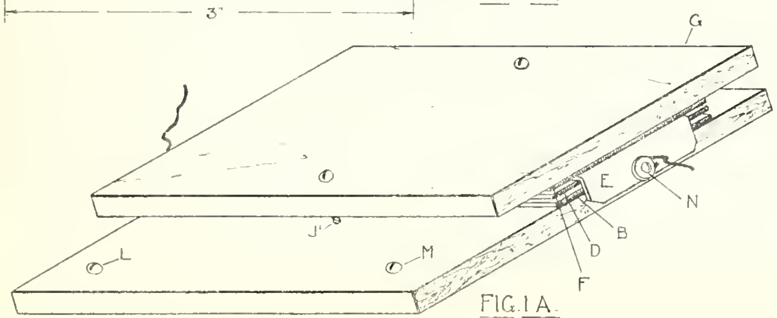

FIG. 1A.

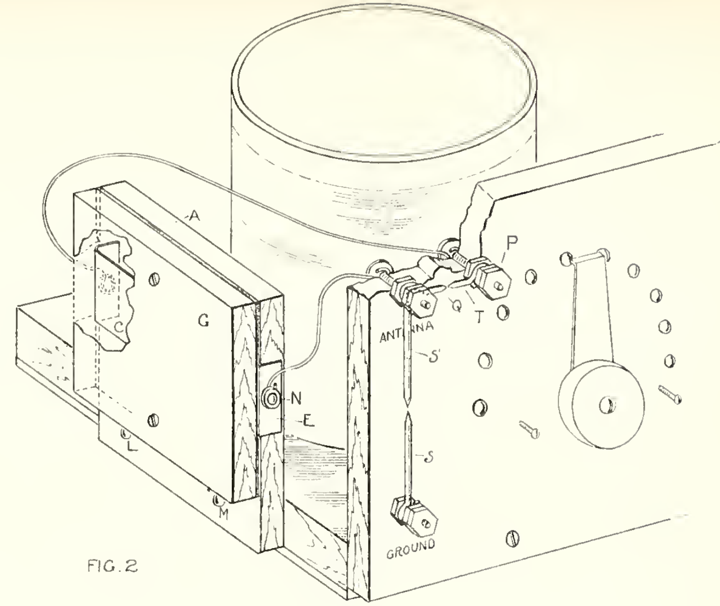

FIG. 2

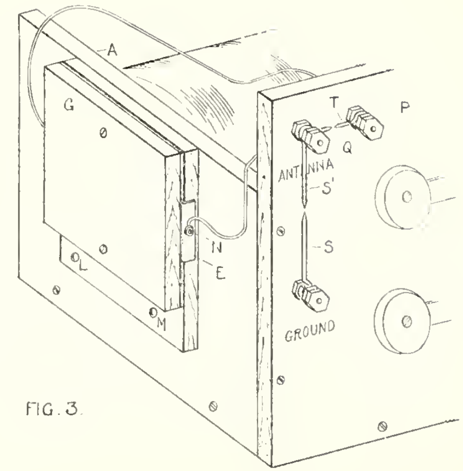

FIG. 3.

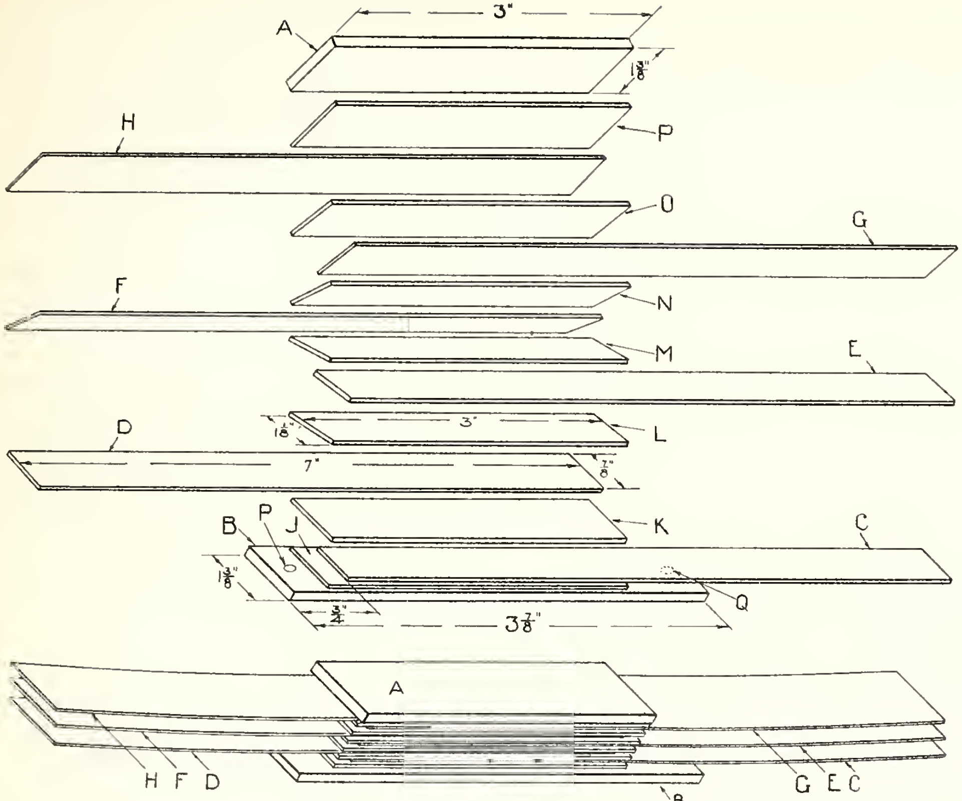

FIG. 4

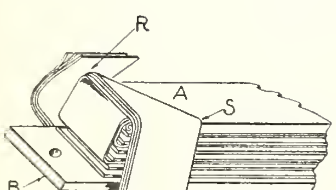

FIG. 5.

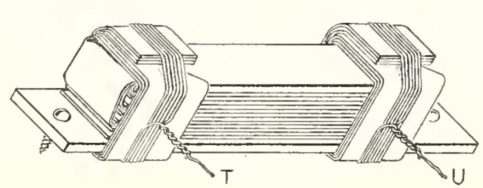

FIG. 6

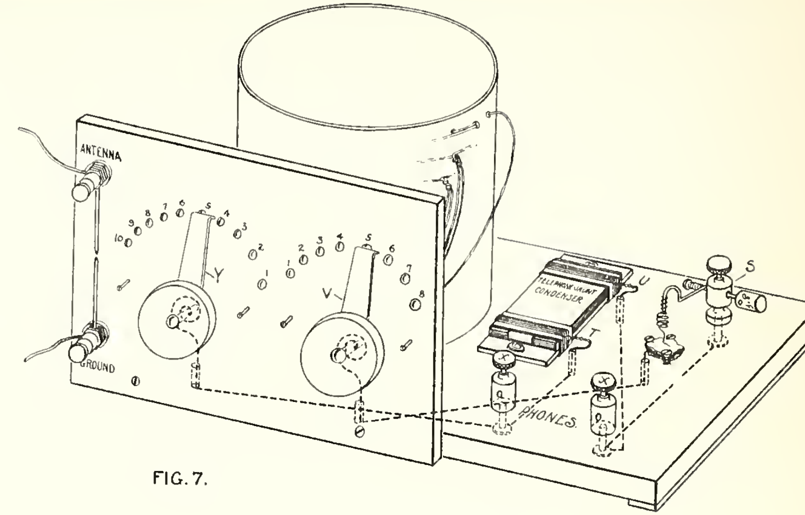

FIG. 7.

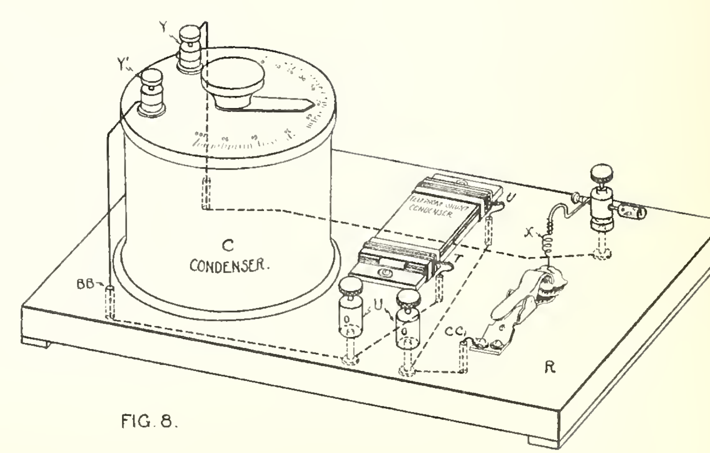

FIG. 8.

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

(August 7, 1922)

DESCRIPTION OF A LOADING COIL USED WITH SIMPLE RADIO RECEIVING SETS

Introduction

This Circular [1] describes a loading coil which is used in conjunction with the single-circuit radio receiving set described in Bureau of Standards Circular No. 120 [1]. The experimenter who is interested in using it in connection with the two-circuit set described in Circular No. 121 is referred to the section entitled, "Use with Two-Circuit Set," near end of this paper.

The purpose of the loading coil is to enable the receiving equipment to respond to wave frequencies between 100 and 500 kilocycles per second (that is, wave lengths between 3000 and 600 meters). In other words, the loading coil increases the wave frequency (wave length) range of the receiving set. The receiving set described in Bureau of Standards Circular No. 120 has a wave frequency (wave length) range of between 500 and 1500 kilocycles per second (wave lengths between 600 and 200 meters).

The use of the loading coil will increase the receiving distance of the equipment, because many stations using the lower wave frequencies (longer wave lengths) use a high-power radio transmitting set. For example, the station NAA at Arlington, Va., uses a wave frequency of about 113 kilocycles per second (2650 meters wave length) and uses sufficient power to be heard a distance of about 200 miles when the loading coil described in this Circular is used with the receiving equipment previously described. At night this distance may be considerably increased.

The cost of the parts for the loading coil is approximately $3.00.

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[1] This is the fifth of a series of Circulars on radio receiving equipment, the previous ones are:

Bureau of Standards Circular No. 120, "Construction and Operation of a Simple Homemade Radio Receiving Outfit."

Bureau of Standards Circular No. 121, "Construction and Operation of a Two-Circuit Radio Receiving Equipment with Crystal Detector."

Bureau of Standards Letter Circular No. 45, "Construction and Operation of a Simple Radiotelegraphic Code Practice Set."

Bureau of Standards Letter Circular No. 46, "Description of Fixed Condensers used with Simple Radio Receiving Sets."

The first two Circulars of this series are now obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., price 5 cents each.

Description.- A loading coil is simply a coil of wire connected to the rest of the receiving equipment in such a manner that a variable number of its turns are included in the circuit between the antenna and the ground connection. When longer wave lengths (lower wave frequencies) are received, more turns are used on the coil.

The loading coil is shown at A in Figure 1A, and consists of 300 turns (about 5 ounces) of No. 28 double-cotton-covered copper wire wound on a round cardboard box 5-3/8 inches in diameter by about 8 inches long. An oatmeal box is used for the cardboard tube with the cardboard cover glued to one end. Certain of the turns are provided with taps which are connected to switch contacts so that the number of turns included in the circuit can be varied. One end of the wire is fastened at the closed end of the tube by weaving it through two holes 1/2 inch apart and 3/4 inch from the end. The free end of the wire projects about 10 inches. The wire is wound on the tube in a single layer so that the turns lie closely and evenly together. When 10 turns have been wound, a 10 inch tap is taken off. The method of winding and also one method of taking off the taps has been explained in Circular No. 120. Instead of using the simpler method of taking off taps as described in Circular No. 120 a somewhat more difficult and correspondingly more satisfactory method is used on this loading coil. After the given number of turns of wire have been wound on the tube, a hole is punched through the tube just underneath the last turn end, by using a small blunt tool or stick, a 10 inch loop of the wire is pushed through this hole. A second hole is punched through the tube about 1/2 inch farther along the circumference and the loop pushed through this hole to the outside of the tube again. The loop may or may not be twisted as it emerges from the second hole. See Fig. 1B. When 10 more turns have been wound, another tap is taken off in the same manner. The arrangement of these taps is shown in the left half of Fig. 1A. It will be noticed that there are 13 taps on the completed coil, counting the two ends of the wire at the start and finish. Each tap is slightly offset from the preceding one so that the line of completed taps progresses about half way around the coil, as indicated in Fig. 1A. After the wire is wound on the cardboard tube or oatmeal box it is placed in a warm oven to drive off the absorbed moisture. After the tube has dried for some time and while still warm, melted paraffin is brushed over the tube, inside and out. The paraffined tube is put back in the oven for a few minutes in order to more thoroughly impregnate the tube.

The switch panel B is made from a piece of dry wood about 7 inches long, 4-1/2 inches wide and 1/2 inch thick. Its general construction is similar to the switch panels described in Circulars Nos. 120 and 121. The two switch arms, C and D, which are used with this panel have also been described in Circular No. 120. Having drilled the holes for the two switch-arm bolts, the switch arms are placed in position and the knobs rotated in such a manner that the ends of the contact arms describe arcs upon which the contact points are to be placed. The holes for the switch contact bolts are then drilled; the spacing between contacts depending upon the width of the end of the switch arms, as well as upon the kind of contacts which are used. For the switch arm C there are 11 contacts and for the switch arm D, 3, as shown. The wood base E is a block of wood about 7 inches square and 3/4 inch thick.

Assembly and Wiring.- Before any of the parts are assembled the base and panel are treated with paraffin as described in Circular No. 120 or they may be thoroughly dried and coated with a good grade of varnish which will not absorb moisture. Shellac is not used. The panel B is fastened to the base E and the coil A is placed in position so that the row of taps faces the rear of the panel. The coil is fastened in this position by small wood screws passing through the cardboard end, each screw being provided with a washer. The two switch arms with the necessary contact bolts are placed in position on the panel. A wire connection is made between switch arm D and binding post H and between switch arm C and binding post I as explained in Circular No. 120, or a spring washer is slipped over each switch-arm bolt at the rear of the panel and the wires soldered to these. See Fig. 1C. The several taps from the coil are cut off to a length sufficient to reach from the coil to the contacts. The insulation is scraped from the ends of the wires and the ends of the double taps twisted together below the point G, Fig. 1A. The taps are fastened between the nuts and washers of the proper contact bolts as shown in the left half of Fig. 1A.

This loading coil is used in connection with the receiving set described in Circular No. 120. The method of making the connections is shown in Fig. 1A. A 10 inch copper wire with a battery clip at one end is fastened to the binding post H with the clip attached to the receiving set binding post marked "antenna". The wire originally leading from the back of the "antenna" binding post was connected to the back of the switch arm bolt V. This wire is removed from the back of the "antenna" binding post and attached to a new bolt or binding post fastened to the baseboard of the simple receiving set. This bolt or binding post is located just at the rear of the receiving set binding post marked "ground". A 10 inch piece of copper wire is attached to this new bolt or binding post with a battery clip attached at the end toward the loading coil binding post I. The wire leading from the crystal to the rear of the "antenna" binding post, as described in Circular No. 120, remains as it was. If this wire was originally connected as described in Letter Circular No. 43, or directly to the switch-arm bolt V it is removed and connected to the rear of the "antenna" binding post. All other wiring is as described in Circular No. 120.

Method of Operating.--The wire leading to the antenna is connected to the binding post marked "antenna" and the wire leading to the ground is connected to the binding post marked "ground" as before. In order to receive messages transmitted at wave frequencies between 500 and 1500 kilocycles per second (wave lengths between 600 and 200 meters) the switch arms C and D on the loading coil panel are both set on the contacts marked O. When receiving at the shorter waves (200 to 600 meters), it is better to remove the battery clip from the "antenna" binding post and put the clip previously attached to I in its place, that is, attach the wire from the new binding post to the "antenna" binding post. The loading coil is thus entirely disconnected from the receiving set and should be removed some distance from it. The operation of the receiving set is then exactly the same as described in Circular No. 120. In order to receive messages transmitted at wave frequencies less than 500 kilocycles per second (wave lengths over 600 meters) the loading coil is again connected as shown in Fig. 1A and the switches on the loading coil panel are adjusted so that the proper number of turns is included in the circuit. The switches on the panel of the original receiving set are set so that they include all of the wire on the coil, (i.e., set switch arm Y on contact point 10 and switch arm V on

contact point 8, Fig. 1A - See also Fig. 3, p. 10, Circular No. 120). The switch D on the loading coil panel is set to the extreme left on contact O, and the switch arm C is rotated slowly over its entire range. If signals are not heard, the switch arm D is set on the next contact to the right and the switch arm C is again rotated over all of its contacts. If the signals are still not heard, the switch arm D is placed on the contact to the extreme right and the switch C again rotated over its contacts. When the transmitting station is heard, the signals may be improved by adjusting the right-hand switch arm V of the original receiving set, and the same time changing slightly the setting of the switch arm C.

Use with Two-Circuit Set.--The loading coil is described herein has been found quite satisfactory in extending the wave length range of the single-circuit receiving set described in Bureau of Standards Circular No.120. The experimenter may be interested to try various ways in which to extend the wave length range of the two-circuit set such as is described in Bureau of Standards Circular No. 121. For the general guidance of the experimenter, the following methods will give results, with varying degrees of satisfaction: use of the loading coil in one of the two circuits and no loading in the other (this means that one of the circuits will not be tuned to the wave); use of loading coil in the primary, together with a fixed condenser (See Bureau of Standards Letter Circular No. 46) in parallel with the variable condenser; use of loading coil in one of the two circuits and winding more wire on the coil in the other circuit.

Approximate Cost of Parts.--The parts listed below are those used in the loading coil. The receiving set parts are listed in Circular No. 120. The two sets of parts constitute a complete receiving equipment which has a rather wide range of wave frequencies as explained in the first part of this Circular. The approximate cost of the complete equipment is therefore the sum of the amount given below and the amount given in Circular No. 120.

5 Ounces No. 28 copper wire, double cotton covered	$0.80
2 battery clips	.20
2 switch knobs and blades, complete	1.00
14 switch contacts, nuts and washers	0.60
1 cardboard box (5-3/8" dia.x 8" long)	
3 binding posts	0.45
Wood for panel and base	
Paraffin	
Total	$3.05

Department of Commerce,
Washington, D. C.

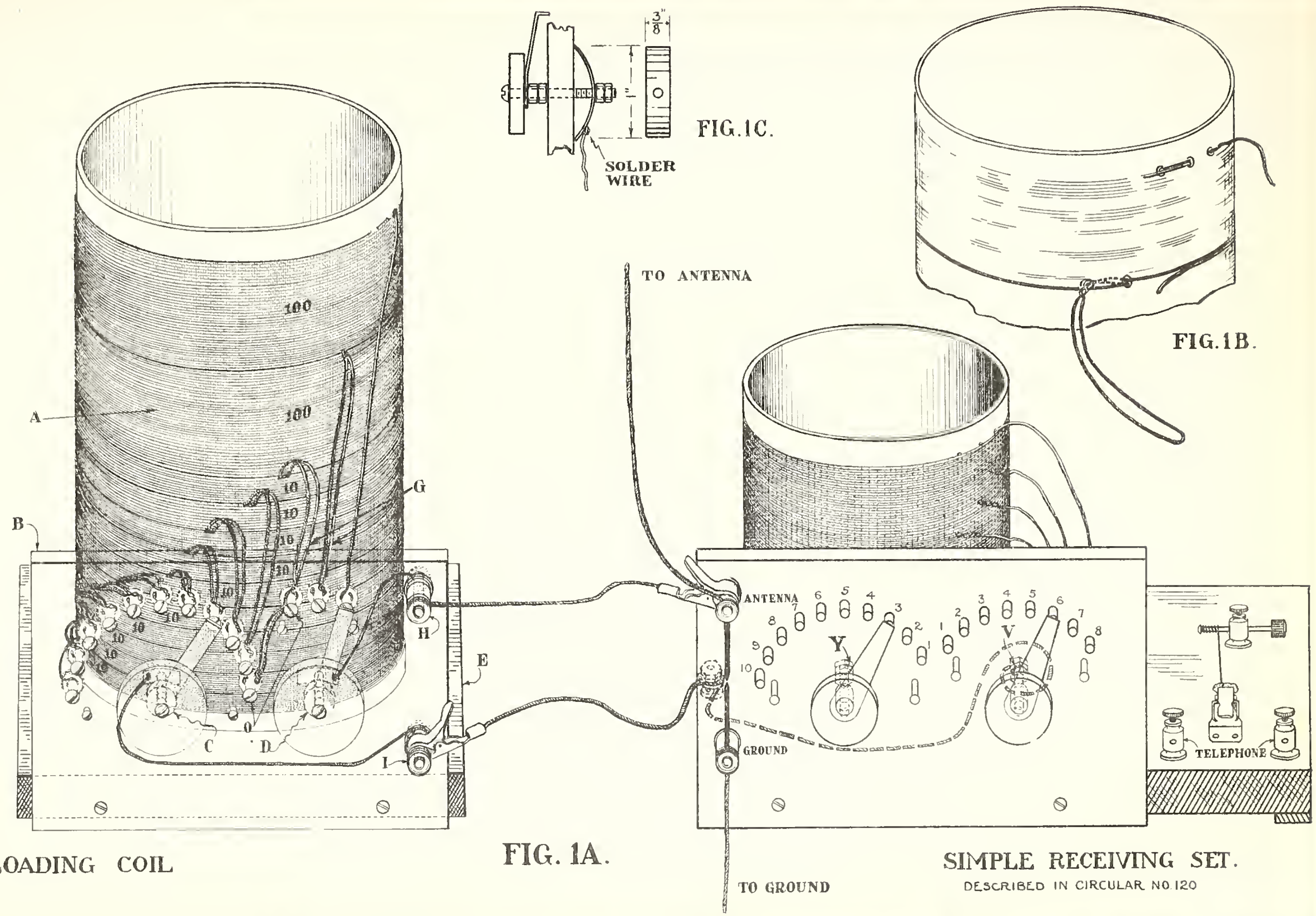

FIG. 1C.

FIG. 1B.

LOADING COIL

FIG. 1A.

SIMPLE RECEIVING SET.

DESCRIBED IN CIRCULAR NO. 120