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CONSTRUCTION AND OPERATION OF A VERY SIMPLE RADIO RECEIVING EQUIPMENT.*

Prepared at the request of the States Relations Service of the U.S. Department of Agriculture for the use of boys and girls radio clubs.

Introduction

This pamphlet describes the construction and operation of a very simple and inexpensive radio-receiving outfit. The outfit will enable anyone to hear radio code messages or music and voice sent from medium power transmitting stations within an area about the size of a large city, and from high power stations within 50 miles, provided the weaves used by the sending stations have a wave frequency between 500 and 1500 kilocycles per second (i.e. wave lengths between 600 and 200 meters). This equipment will not receive undamped (continuous) waves. Occasionally much greater distances can be covered, especially at night. The total cost of the outfit can be kept below $10.00, or if an especially efficient outfit is desired, the cost may be about $15.00.

Essential Parts of Receiving Station.

The five essential parts of the station are the antenna, lightning switch, ground connections, receiving set and phones. The received signal comes into the receiving set through the antenna and ground connection. The signals are converted into an electrical current in the receiving set and the sound is produced in the phones. Either one telephone receiver or a pair, worn on the head of the listener is used.

The lightning switch protects the receiving set from damage by lightning. It connected the antenna directly to ground when the receiving station is not in use. When the antenna and the connection to ground are properly made and the lightning switch is closed, the antenna acts as a lightning rod and is a protection for the building.

The principal part of the station is the “receiving set”. In the set described herein it is subdivided into two parts, the “tuner” and the “detector”, and in more complicated sets still other elements are added.

The Antenna, Lightning Switch and Ground Connection

The antenna is simply a wire suspended between two elevated points. The antenna should be not less than 30 feet above the ground and its length should be about 75 feet. (See fig.1) This figure indicates a horizontal antenna; but it is not important that the antenna be strictly horizontal. It is in fact desirable to have the end where the pulley is used as high as possible. The “lead-in” wire or drop-wire from the antenna itself should run as directly as possible to the lightning switch. If the position of the adjoining building or trees is such that the distance between them is greater than about 65 feet; the antenna can still be held to a 75 foot distance between the insulators by increasing the length of the piece of rope (D) to which the far end of the antenna is attached. The rope (H) tying the antenna insulator to the house should not be lengthened to overcome this difficulty, because by doing so the antenna “lead-in” or drop-wire (J) would be lengthened.

Details of Parts – The parts will be mentioned here by reference to the letter appearing in Figures 1 and 2.

A and I are screw eyes sufficiently strong to anchor the antenna at the ends.

B and H are pieces of rope ¼ or 3/8 inch in diameter, just long enough to allow the antenna to swing clear of the two supports.

C is a single-block pulley that may be used if readily available. The pulley should not allow the rope to catch.

E and G are two insulators, which may be constructed of any dry hard wood of sufficient strength to withstand the strain of the antenna; blocks about ¾ x1x10 inches will serve. The holes should be drilled as shown in Fig. 1 sufficiently far from the ends to give proper strength. If wood is used the insulators should be boiled in paraffin. Precautions in regard to melting the paraffin are given on page 4 under “Accessories”. If porcelain wiring cleats are available they may be substituted for the wood insulators. Regular antenna insulators are available on the market but the two improvised types mentioned will be satisfactory for an amateur receiving antenna.

F is the antenna about 75 feet long between the insulators E and G. The wire may be N^{o} 14 or 16 copper wire either bare or insulated. The end of the antenna farther from the receiving set may be secured to the insulator (E) by any satisfactory method, but care should be taken not to kink the wire. Draw the other end of the wire through the insulator (G) to a point where the two insulators are separated by about 75 feet and twist the insulator (G) so as to form an anchor as shown in Figure 1. The remainder of the antenna wire (J) which now constitutes the “lead-in” or drop wire should be just long enough to reach the lightning switch.

K is the lightning switch. For the purpose of a small antenna this switch may be the ordinary porcelain base, 30 ampere, single pole double throw battery switch. These switches as ordinarily available have a porcelain base about 1 by 4 inches. The “lead-in” wire (J) is attached to this switch at the middle point. The switch blade should always be thrown to the lower clip when the receiving set is not actually being used, and to the upper clip when it is desired to receive signals.

L is the ground wire for the lightning switch. The ground wire may be a piece of wire the same size as used in the antenna, and should be of sufficient length to reach from the lower clip of the lightning switch (K) to the clamp on the ground rod (M).

M is a piece of iron pipe or rod driven 3 to 6 feet into the ground, preferably where the ground is moist, and extending a sufficient distance above the ground so that the ground clamp may be fastened to it. The pipe should be free from rust or paint. Special care should be taken to see that the pipe is clean and bright where the ground clamp is connected.

N is a wire leading from the upper clip of the lightning switch through the porcelain tube (O) to the receiving set binding post marked “Antenna”.

O is a porcelain tube of sufficient length to reach through the window casing or wall. This tube should be mounted in the casing or wall so that it slopes down toward the outside of the building. This is done to keep the rain from following the tube through the wall to the interior.

Figure 2 shows the radio receiving set installed in some part of the house.

P is the receiving set which is described in detail below.

N is the wire leading from the “Antenna” binding post of the receiving set through the porcelain tube to the upper clip of the lightning switch. This wire, as well as the wire shown at Q, should be insulated and preferably flexible. Un-braided lamp cord will serve for these two leads.

Q is the flexible wire leading from the receiving set binding post marked “Ground” to a water pipe, heating system or some other metallic conductor to ground. If there are no water pipes or radiators in the room in which the receiving set is located, the wire should be run out of doors and connected to a special “ground” below the window. The ground for the lightning switch should not be used for this purpose. It is essential that for the best operation of the receiving set this ground be of the very best type. If the soil near the house is dry, it will be necessary to drive one or more pipes or rods sufficiently deep to encounter moist earth. The distance between the pipes will ordinarily not exceed 6 feet. Where clay soil is encountered the distance may be three feet; in sandy soil it may be 10 feet. Some other metallic conductor, such as the casing of a drilled well, not far from the window, will be a satisfactory “ground”.

Tuner, Detector and Phone.

The “phone” and certain parts of the apparatus will have to be purchased. The other parts may be obtained at home.

Tuning Coil (R, Fig. 3) – This is a length of cardboard tubing with copper wire wound around it. The cardboard tubing may be an oatmeal box. Its construction is described in detail below. A cylinder of wood or other non-metallic substances may also be used.

Crystal Detector (S, Fig. 3) – The crystal detector may be of very simple construction. The crystal (1) as it is ordinarily purchased, may be unmounted or mounted in a small block of metal. It is very important that a very good tested crystal be used. A galena crystal will be satisfactory. Through binding post (4) is a nail with a wood knob or cork on its point and a 2½ inch piece of #24 bare wire attached below the head and bent so as to rest on the crystal.

The crystal detector is made up of a tested crystal, three wood screws, a short piece of copper wire, a nail a set screw type binding post, and a wood knob or cork. The crystal is held in position on the wood base by three brass wood screws as shown at 1, Fig. 3. A bare copper wire is wrapped tightly around the three brass screws for connection. The assembling of the rest of the detector is shown in Fig. 3.

Phone (T, Fig. 3.) – It is desirable to use a pair of telephone receivers connected by headband, usually called a double telephone headset. The telephone receivers may be of the standard commercial makes having a resistance of between 2000 and 3000 ohms. The double telephone receivers may cost more than all the other parts of the station combined but it is desirable to get them, especially if it is planned to improve the set later. A single 1000 ohm telephone receiver with a headband may be used but with less satisfactory results.

Accessories. – Under the heading of accessory equipment may be listed binding posts, switch arms, switch contacts, test-buzzer, dry battery, and boards on which to mount the complete apparatus. The binding posts, switch arms and switch contacts may be purchased from a dealer who handles such goods or the may be readily improvised at home. The pieces of wood on which the equipment is mounted, mat be obtained from a dry packing-box and covered with paraffin to keep out the moisture. Care should be taken in melting the paraffin not to get it too hot. For this reason it is a good plan to melt it in a pan set in boiling water. When the paraffin just begins to smoke it is at the proper temperature. When the wood parts have been drilled and cut to size, the paraffin should be applied quickly with a small brush. When cold, excess paraffin must be carefully scraped off with a straight piece of metal such as the brass strip in the edge of a ruler.

Details of Construction.

The following is a description of the method of winding the tuning coil and the construction of the wood panels.

Tuning coil. – See R, Fig. 3. – The cardboard tubing is 4 inches in diameter by 4½ inches long. One end of the tube should have the cardboard cover glued securely to it. About 2 ounces of N^{o} 24 (or N^{o} 26) double cotton-covered copper wire is used for winding the coil. Punch two holes in the tube about ½ inch from one end as shown at 2 in Fig. 3. Weave the wire through these holes in such a way that the end of the wire will be firmly anchored, leaving about 12 inches of the wire free for connecting. Start with the remainder of the wire to wind the turns in a single layer about the tube, tightly and closely together. After 10 complete turns have been wound on the tube hold these tight and take off a tap. This tap is made by twisting a 6-inch loop of wire together at such a place that it will be slightly staggered from the first connection. This method is clearly of taking off taps is shown clearly at U, Fig. 3. Proceed in this manner until 7 twisted taps have been taken off, - one at every 10 turns. After these first 70 turns have been wound on the tube, take off a six inch twisted tap for every succeeding single turn until 10 additional turns have been wound on the tube. After winding the last turn of wire anchor the end by weaving it through two holes punched in the tube as at the start, leaving about 12 inches of wire free for connecting. It is to be understood that each of the 18 taps is staggered from the one above, so that the taps will not bunch along one line on the cardboard tube. (See Fig. 3.) It might be advisable, after winging the tuning coil to dip the tuner in hot paraffin. This will help to exclude moisture. It is important to have the paraffin heated until it just begins to smoke, as previously explained, so that when the tuner is removed it will have only a very thin coat of paraffin.

Upright Panel and Base. – Having completed the tuning coil set it aside and construct the upright panel shown in Fig. 4. This panel may be a piece of wood approximately ½ inch thick, 4 ½ inches wide and 7 ½ inches long. This panel can be used with apparatus to be described in a later pamphlet. For this reason it is desirable to have the last contact an inch away from the right end of the panel (see Fig. 4). It is also desirable to have the contact points near the top of the panel. The position of the several holes for the binding posts, switch arms and switch contacts may first be laid out and drilled. The “antenna” and “ground” binding posts may be ordinary 8-32 brass bolts about 1 ½ inches long with three nuts and two washers. The first nut binds the bolt to the panel, the second nut hold one of the short pieces of stiff wire, while the third nut holds the antenna or ground wire as the case may be. The switch arm with knob shown at V, Fig. 3, may be purchased in the assembled form or it may be constructed from a 3/8 inch cut from a broom handle and a bolt of sufficient length equipped with four nuts and two washers together with a strip of thin brass somewhat as shown. The end of the switch arm should be wide enough so that it will not drop between the contact points, but not so wide that it cannot be set to touch only one contact. The switch contacts (W, Fig. 3) may be of the regular type furnished for this purpose or they may be 6/32 brass bolts with one nut and one washer each; they may even be nail driven through the panel with the individual tap fastened under the head or soldered to the projection of the nail through the panel. The base is of wood approximately ¾ inch thick, 5-1/2 inches wide and 10-1/2 inches long.

The telephone binding posts should preferably be of the set screw type shown at X, Fig. 3.

Instruction for Wiring

After the several parts mentioned have been constructed and (with the exception of the tuning coil) mounted on the wood base, the wires may be connected to the switch arms and binding posts and the taps may then be connected to the switch contacts. A wire is connected to the back of the left-hand switch-arm bolt (V, Fig. 3) twisted into a spiral of one or two turns, like a clock spring, and then led to the back of the binding post marked “ground”. Connection is made to the binding post by removing the insulation from the wire and clamping it between the nut and the washer. The same wire is now passed through a small hole and run underneath the base to the left-hand binding post marked “phone”. A wire is then run from underneath the right-hand binding post marked “phone” to underneath the binding post 4, Fig. 3, which is part of the crystal detector. The copper wire, which was wrapped tightly about the three brass wood screws that hold the crystal in place, is led underneath the base, up through a small hole, and is connected to the back of the binding post marked “antenna”. Another wire is connected to the back of the right-hand switch arm bolt (V) twisted into a spiral of one or two turns like a clock-spring and then connected to the back of the same binding post.

Wrap one end of a piece of No. 24 bare copper wire tightly around a nail, near the head, insert the nail into the binding post 4, Fig. 3, and adjust the wire until it rests on the crystal as shown. The detector is completed by pushing a cork or wood knob on the pointed end of the nail.

The taps leading from the tuner should now be connected to the switch contacts. Scrape the cotton insulation from the loop ends of the sixteen twisted taps as well as from the ends of the two single wire taps coming from the first and last turns. Fasten the bare ends of these wires to the proper switch contacts as shown by the corresponding numbers in Fig. 3. Be careful not to cut or break any of the looped taps. The connecting wires may be fastened to the switch contacts by binding them between the washer and nut as shown at 3, Fig. 3. After all the wires from the tuner have been connected, the tuner should be fastened to the base by two or three small screws passing through the cardboard end. The screws should be provided with washers.

Directions for Operating.

After all the parts of this crystal-detector radio receiving set have been constructed and assembled the first essential operation is to adjust the fine wire which rests on the crystal, to a sensitive point. This may be accomplished in several ways; one method is to use a buzzer transmitter. Assuming that the most sensitive point on the crystal has been found by the method described in paragraph below, "The Test Buzzer", the rest of the operation is to adjust the radio receiving set to resonance or in tune with the station from which the messages are sent. The tuning of the receiving set is accomplished by adjusting the inductance of the tuner. That is, one or both of the switch arms are rotated until the proper number of turns of wire of the tuner are made a part of the metallic circuit between the antenna and ground, so that together with the capacity of the antenna the receiving circuit is in resonance with the particular transmitting station. It will be remembered that there are 10 turns of wire between adjacent contacts of the 8-point switch and only 1 turn of wire between adjacent contacts of the 10-point switch. The tuning of the receiving set is best accomplished by setting the right hand switch arm on contact (1) and rotating the left-hand switch arm all over its contacts. If the desired signals are not heard, move the right-hand switch arm to contact (2) and again rotate the left-hand switch arm throughout its range. Proceed in this manner until the desired signals are heard.

It will be advantageous to know the wave frequencies (wave lengths) used by the radio transmitting stations in the immediate vicinity. A lower frequency (greater wave length) requires more turns of the coil.

The Test Buzzer. – (Z, Fig. 3) As stated, the more sensitive spots on the crystal can be found by using a test buzzer. The test buzzer is used as a miniature local transmitting set. This is shown at Z Fig. 3. The buzzer, dry battery and switch (5) may be mounted on the table or a separate board. The binding post marked "ground" may be one terminal of the dry cell connected to the binding post marked "ground" on the receiving set. The current produced by the buzzer will be converted to sound by the telephone receivers and the crystal, the loudness of the sound depending on what part of the crystal s in contact with the fine wire. To find the most sensitive spot connect the test buzzer to the receiving set (Z), close the switch (5, Fig. 3) and if necessary adjust the buzzer so that a clear not is emitted; set the right switch-arm on contact point No. 8 and connect the telephone receivers to the binding posts. Loosen the set screw of the binding post (4) slightly and change the position of the fine wire (6, Fig. 3) to several positions of contact with the crystal until the loudest sound is heard in the phones; then slightly tighten the binding post set screw (4).

Approximate cost of parts.

The following list shows the approximate cost of the parts used in the construction of the receiving station. The total cost will depend largely on the kind of apparatus purchased and on the number of parts constructed at home.

Antenna:

Wire – copper, bare or insulated, No 14 or 16 100 – 150 ft	$0.75
Rope – ¼ or 3/8 inch, 2c per foot	
2 Insulators – porcelain	0.20
1 Pulley	0.15
Lightning Switch – 30 ampere battery switch	0.30
1 Porcelain tube	0.10

Ground Connections:

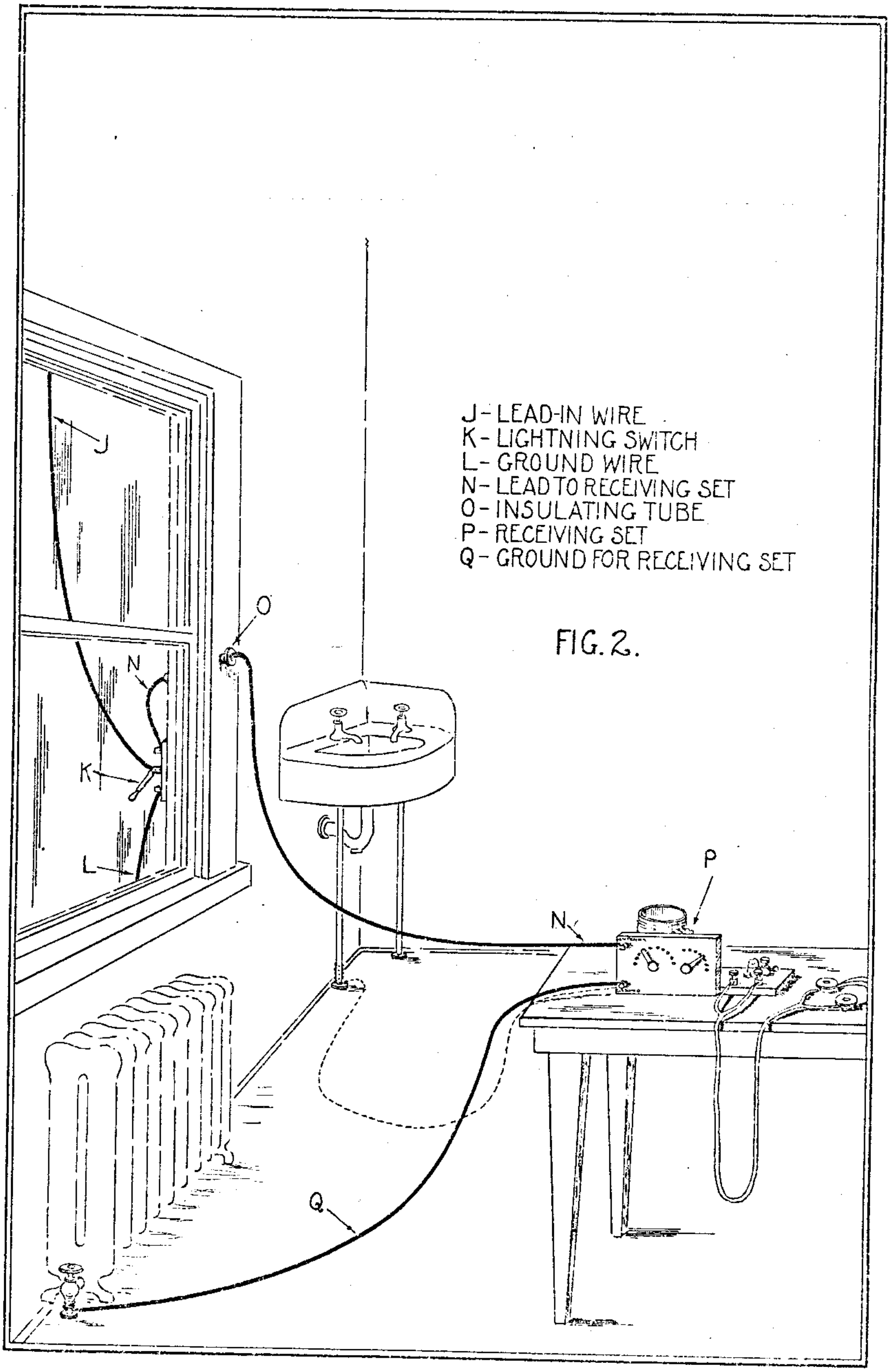
Wire (Same kind as antenna wire)	
2 Clamps	0.30
1 iron pipe or rod	0.25

Receiving Set:

3 ounces #24 copper wire, double cotton covered	0.75
1 round cardboard box	
2 Switch Knobs and blades complete	1.00
18 Switch contacts and nuts	0.75
3 Binding posts set screw type	0.45
2 Binding posts any type	0.30
1 Crystal – tested	0.25
3 Wood screws – brass, ¾ inch long	0.03
2 Wood screws – for fastening panel to base	0.02
Wood for panels (from packing box)	
2 pounds paraffin	0.30
Lamp cord – 2 to 3 cents per foot	
Test buzzer	0.50

	Dry battery	$0.30
	Telephone receivers	4.00 to 8.00
Total		$10.70 - $14.70

If the switches are constructed as directed and a single telephone receiver be used, the cost may be kept well below $10.00.


J- LEAD-IN WIRE
K- LIGHTNING SWITCH
L- GROUND WIRE
N- LEAD TO RECEIVING SET
O- INSULATING TUBE
P- RECEIVING SET
Q- GROUND FOR RECEIVING SET
FIG. 2.
J
N
K
L
O
P
N
Q

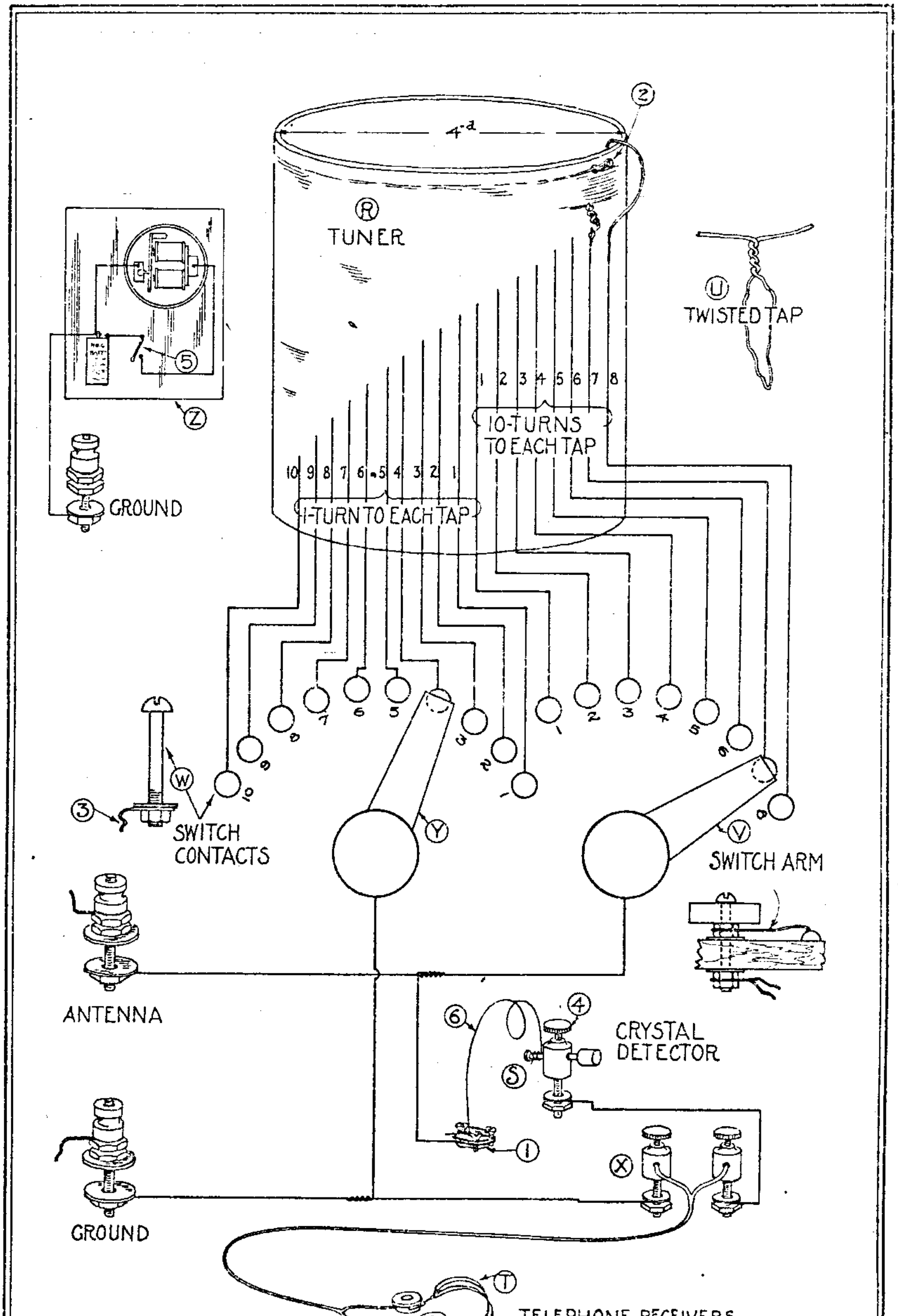

TUNER
TWISTED TAP
10-TURNS TO EACH TAP
1-TURN TO EACH TAP
GROUND
SWITCH CONTACTS
SWITCH ARM
ANTENNA
CRYSTAL DETECTOR
GROUND
TELEPHONE RECEIVERS

FIG. 3.

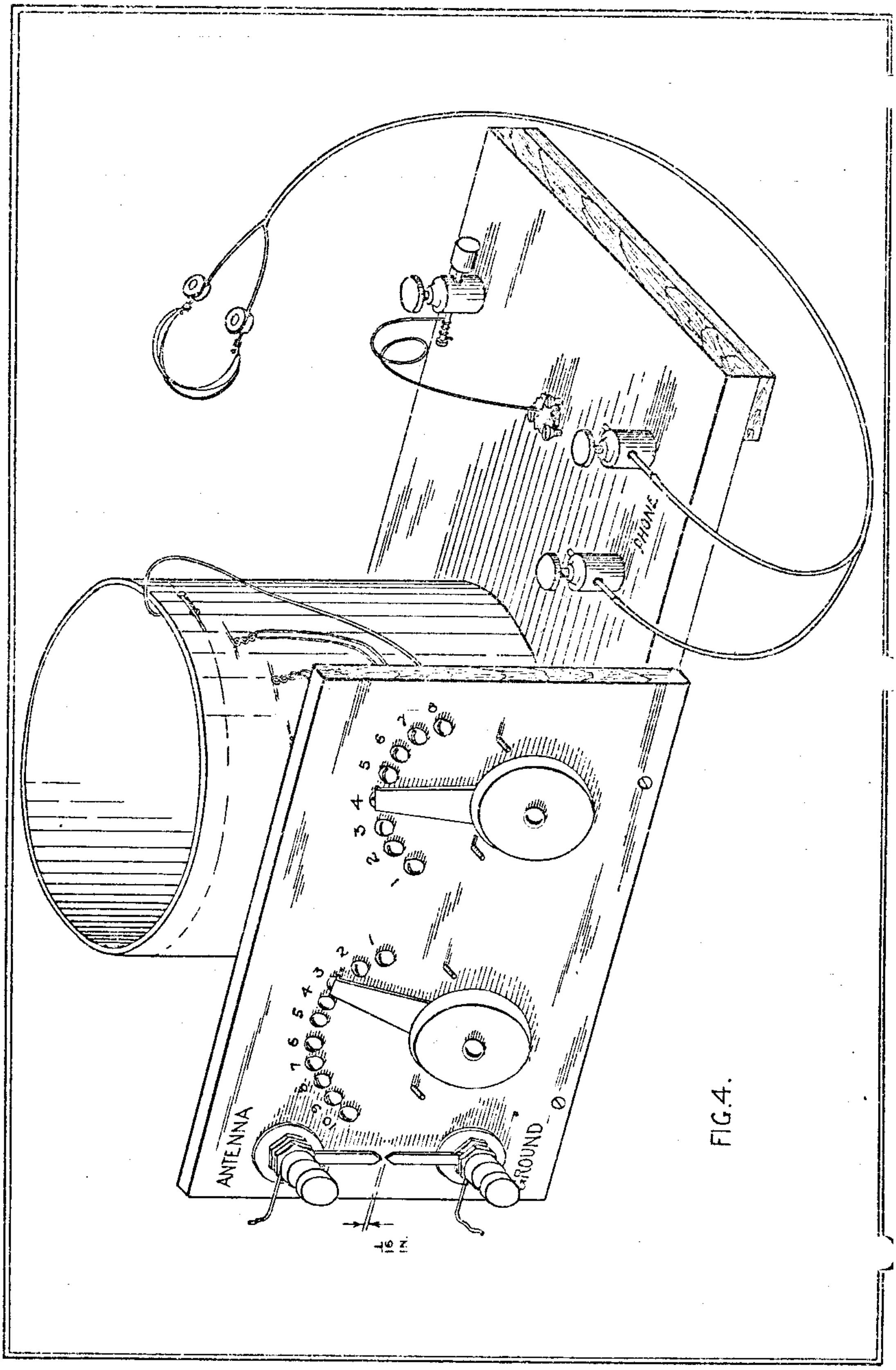


FIG. 4.