Building and Wiring a Crystal Radio Receiver

Maurice J. Grainger, 1922

Selected pages from Amateur Radio: How and Why of Wireless.

Bench diagrams walk through the tuning coil, crystal detector, headphones and connections for a simple receiving set.

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CHAPTER V

HOW TO MAKE A SIMPLE CRYSTAL SET

(Prepared by U. S. Bureau of Standards)

Essential Parts of a Receiving Station—Antenna, Lightning Switch and Ground Connections

THIS article tells how to construct the entire receiving station, including antenna as well as a crystal-detector receiving set. This station will enable one to hear the messages sent from medium-power transmitting stations within an area about the size of a large city, and to hear high-power stations within fifty miles, provided the waves used by those stations have wave frequencies between 500 and 1500 kilocycles per second (i. e., wave lengths between 600 and 200 meters). Much greater distances are often covered, especially at night. If the amateur constructs the coil and other parts as indicated, the total cost of this set can be kept down to about $6.00. If, however, a specially efficient outfit is desired, the cost may be about $15.00.

There are five essential parts to a receiving station: the antenna, lightning switch, ground connections, receiving set, and phone. The received signals come into the receiving set through the antenna and ground connection. In the receiving set they are converted into an electric current which produces the sound in the "phone." The phone is either one or a pair of telephone receivers worn on the head of the listener.

The purpose of the lightning switch is to protect the receiving set from damage by lightning. It is used to connect the antenna directly to ground when the receiving station is not being used. When the antenna and the connection to the ground are properly made and the lightning switch is closed, an antenna acts as a lightning rod and is a protection, rather than a source of danger to the building.

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

The antenna is simply a wire suspended between two elevated points. Wherever there are two buildings, or a house and a tree, or two trees with one of them very close to the

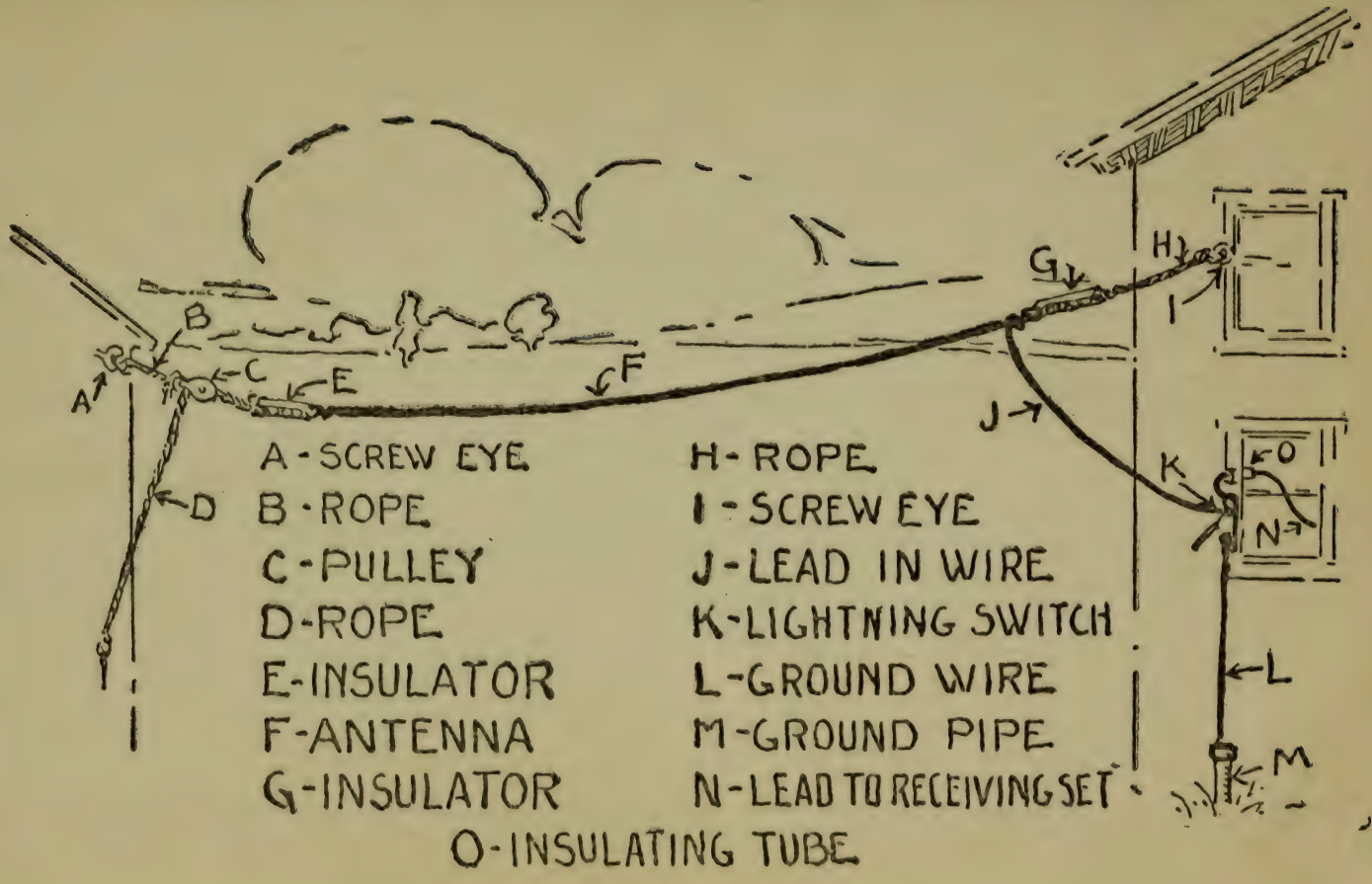
A - SCREW EYE
B - ROPE
C - PULLEY
D - ROPE
E - INSULATOR
F - ANTENNA
G - INSULATOR
H - ROPE
I - SCREW EYE
J - LEAD IN WIRE
K - LIGHTNING SWITCH
L - GROUND WIRE
M - GROUND PIPE
N - LEAD TO RECEIVING SET
O - INSULATING TUBE

Fig. 7

house, it relieves one of the need of erecting one or both antenna supports. The antenna should not be less than 30 feet above the ground and its length should be between 75 and 100 feet. (See Fig. 7.) While this figure indicates a horizontal antenna, it is not important that it be strictly horizontal. It is in fact desirable to have the far end 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 buildings or trees is such that the distance between them is greater than about 125 feet, the antenna can still be held to a 100 feet 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 so doing the antenna "lead-in" or drop-wire (J) would be lengthened.

Details of Parts—The parts will be mentioned here by reference to the letters appearing in Figs. 7, 8, 9.

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

B and H are pieces of rope ⅜ or ½ inch in

diameter, just long enough to allow the antenna to swing clear of the two supports.

D is a piece of ⅜ or ½ inch rope sufficiently long to make the distance between E and G about 100 feet.

C is a single-block pulley which may be used if readily available.

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 1½ x 2 x 10 inches will serve. The holes should be drilled as shown in Fig. 7 sufficiently far from the ends to give proper strength. If wood is used the insulators should be boiled in paraffin for about 1 hour. If porcelain wiring cleats are available they may be substituted instead of the wood insulators. If any unglazed porcelain is used as insulators, it should be boiled in paraffin the same as the wood. Regular antenna insulators are advertised on the market, but the two improvised types just mentioned will be satisfactory for an amateur receiving antenna.

F is the antenna about 100 feet between the insulators E and G. The wire may be No. 14 or 16 copper wire either bare or insulated. The end of the antenna farthest from the re-

ceiving set may be secured to the insulator (E) by any satisfactory method, being careful not to kink the wire. Draw the other end of the antenna wire through the other insulator (G) to a point where the two insulators are separated by about 100 feet, twist the *insulator* (G) so as to form an anchor as shown in Fig. 7. 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 in. 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; it may be a piece of the same size wire as used in the antenna, 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 in order that the ground clamp may be fastened to it. Scrape the rust or paint from the pipe before driving in the ground.

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.

Fig. 8 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 by Q, should be insulated and preferably flexible. A piece of ordinary lamp cord

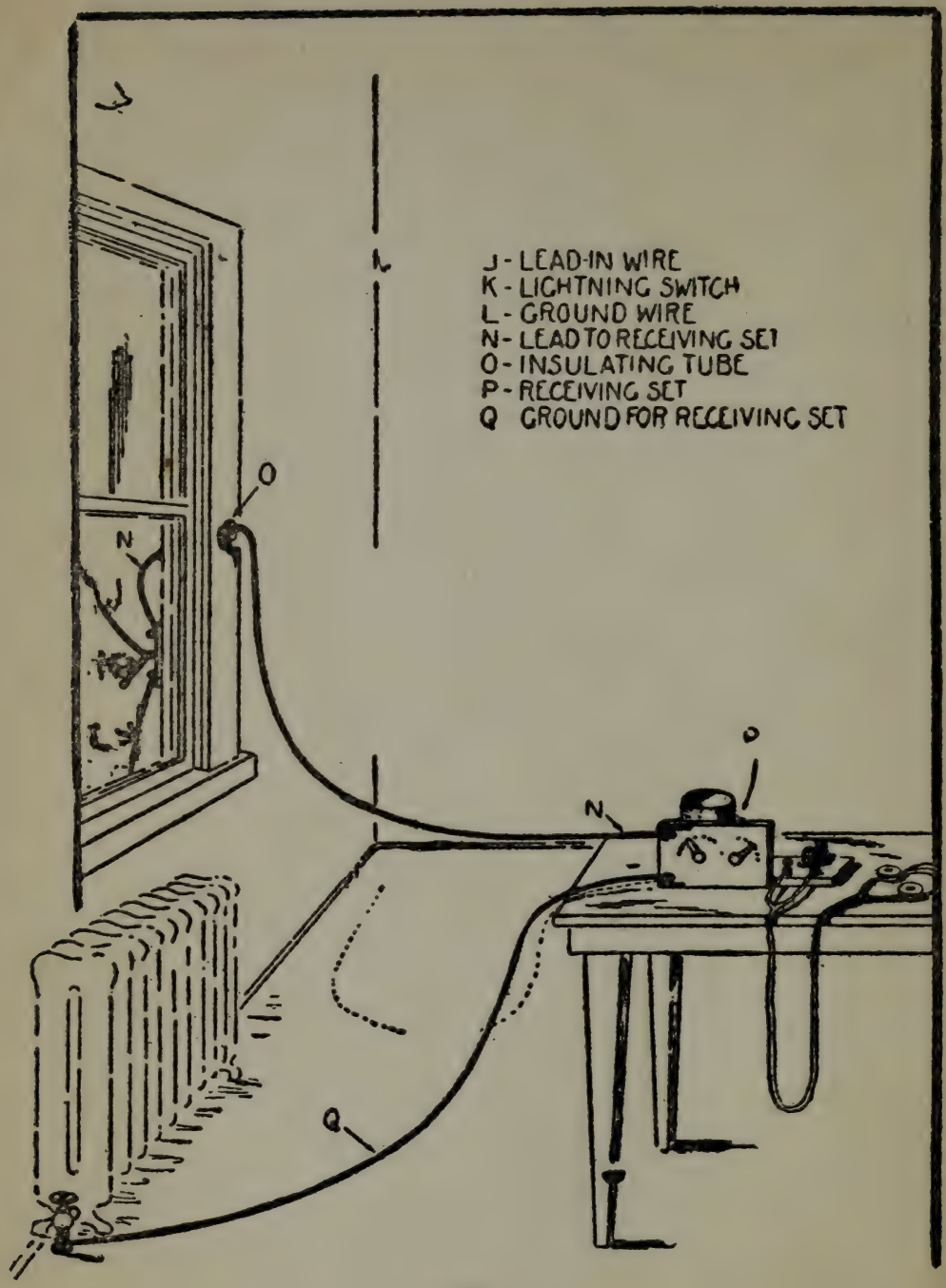
J - LEAD-IN WIRE
K - LIGHTNING SWITCH
L - GROUND WIRE
N - LEAD TO RECEIVING SET
O - INSULATING TUBE
P - RECEIVING SET
Q GROUND FOR RECEIVING SET
O
N
O
N
Q

Fig. 8

might be unbraided and serve for these two leads.

Q is a piece of flexible wire leading from the receiving set binding post marked "ground" to a water pipe, heating system or some other metallic conductor to ground, except M, Fig. 8. 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, which shall not be the same as the "ground" for the lightning switch. 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 is necessary to drive one or more pipes or rods sufficiently deep to encounter moist earth and connect the ground wire to the pipes or rods. This distance will ordinarily not exceed 6 feet. Where clay soil is encountered this distance may be reduced to 3 feet, while in sandy soil it may be increased to 10 feet. If some other metallic conductor, such as the casing of a drilled well, is not far away from the window, it will be a satisfactory "ground."

CHAPTER VI

HOME-MADE PARTS FOR CRYSTAL RECEIVER

A Simple Cardboard Tuner—How to Mount Crystals—Some Parts that Can be Improvised

THE detector and phone will have to be purchased. The tuner and certain accessories can be made at home.

Tuner (R, Fig. 9)—This is a piece of cardboard or other non-metallic tubing with turns of copper wire wound around it. The cardboard tubing may be an oatmeal box. Its construction is described in detail below.

Crystal Detector (S, Fig. 9)—The construction of a crystal detector may be of very simple design and quite satisfactory. The crystal, as it is ordinarily purchased, may be unmounted or mounted in a little block of metal. For mechanical reasons the mounted type may be more satisfactory, but that is of no great consequence. It is very important, however, that a very good tested crystal be used. It is probable also that a galena crystal will be more satisfactory to the beginner.

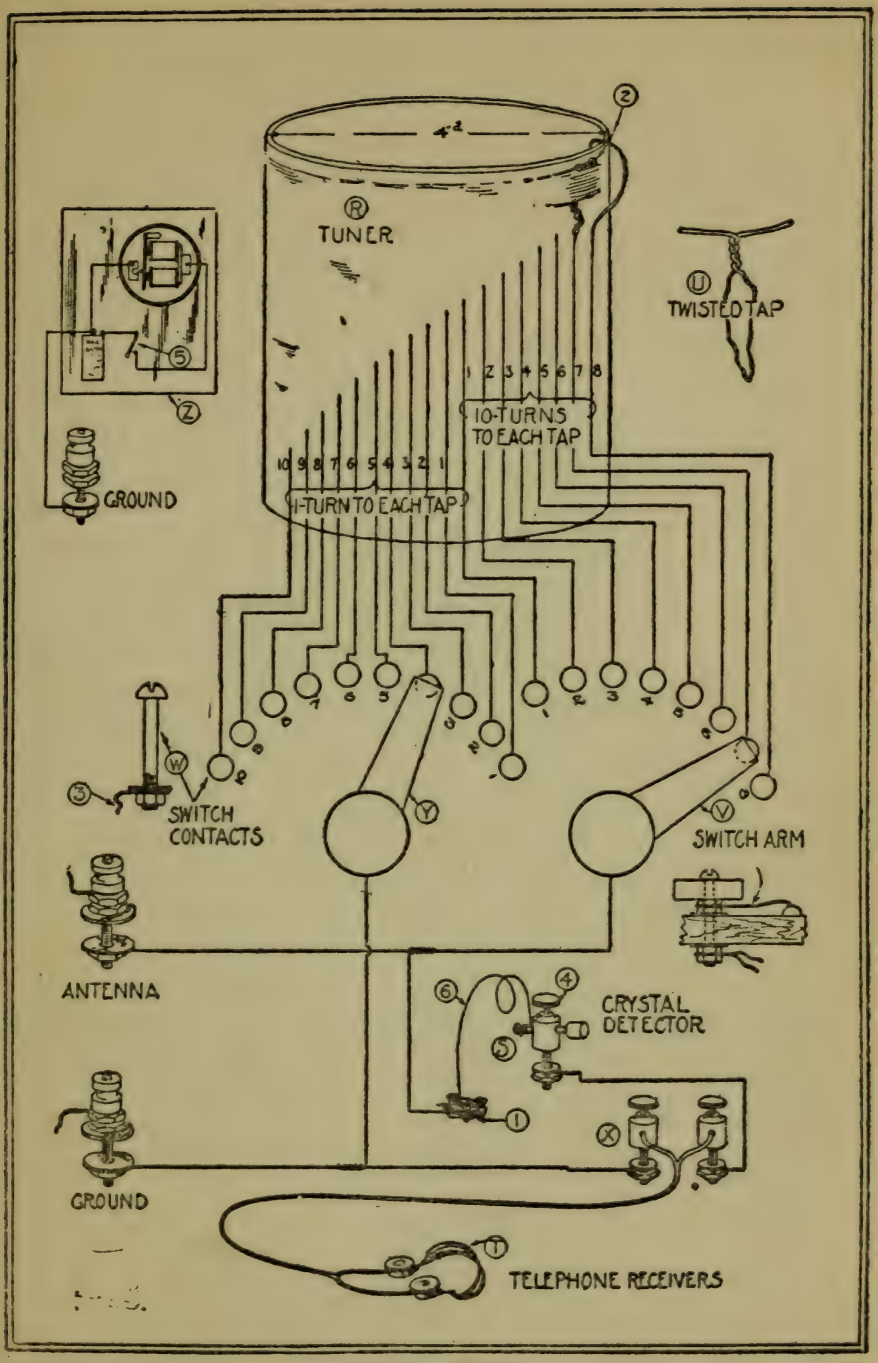
TUNER
TWISTED TAP
10-TURNS TO EACH TAP
1-TURN TO EACH TAP
GROUND
SWITCH CONTACTS
SWITCH ARM
ANTENNA
CRYSTAL DETECTOR
GROUND
TELEPHONE RECEIVERS

Fig. 9

The crystal detector may be made up of a tested crystal, three wood screws, short piece of copper wire, a nail, set-screw type of binding post, and a wood knob or cork. The tested crystal is held in position on the wood base by three brass wood-screws as shown at 1, Fig. 9. A bare copper wire may be wrapped tightly around the three brass screws for contact. The assembling of the rest of the crystal detector is quite clearly shown in Fig. 10.

Phone (T, Fig. 9)—It is desirable to use a pair of telephone receivers connected by a head band, usually called a double telephone headset. The telephone receivers may be any of the standard commercial makes having a resistance of between 2000 and 3000 ohms. The double telephone receivers will cost more than all the other parts of the station combined, but it is desirable to get them, especially if one plans to improve his receiving set later. If one does not care to invest in a set of double telephone receivers, a single telephone receiver with a head band may be used; it gives results somewhat less satisfactory.

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 all be purchased from dealers who handle such goods or they may be quite readily improvised at home. There is nothing peculiar about the pieces of wood on which the equipment is mounted. They may be obtained from a dry packing-box and covered with paraffin to keep out moisture.

The following is a detailed description of the method of winding the coil, construction of the wood panels, and mounting and wiring the apparatus:

Tuner—See R, Fig 9. Having supplied oneself with a piece of cardboard tubing 4 inches in diameter and about ½ pound of No. 24 (or No. 26) double cotton covered copper wire, one is ready to start the winding of the tuner. Punch two holes in the tube about ½ inch from one end as shown at 2 on Fig. 9. Weave the wire through these holes in such a way that the end of the wire will be quite firmly anchored, leaving about 12 inches of the wire free for connections. Start with the remainder of the wire to wrap the several turns in a single layer about the tube, tightly and closely together. After 10 com-

plete turns have been wound on the tube hold those turns snugly while a tap is being taken off. This tap is made by making a 6 inch loop of the wire and twisting it together at such a place that it will be slightly staggered from the first tap. This method of taking off taps is shown quite clearly at U, Fig. 9. Proceed in this manner until 7 twisted taps have been taken off at every 10 turns. After these first 70 turns have been wound on the tube then take off a 6 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 much as was done at the start, leaving about 12 inches of wire free for connecting. It is to be understood that each of the 18 taps is slightly staggered from the one just above, so that the several taps will not be bunched along one line on the cardboard tube. See Fig. 9. It would be advisable, after winding the tuner as just described, to dip the tuner in hot paraffin. This will help to exclude moisture.

Upright Panel and Base—Having completed the tuner to this point, set it aside and construct the upright panel shown in Fig. 10.

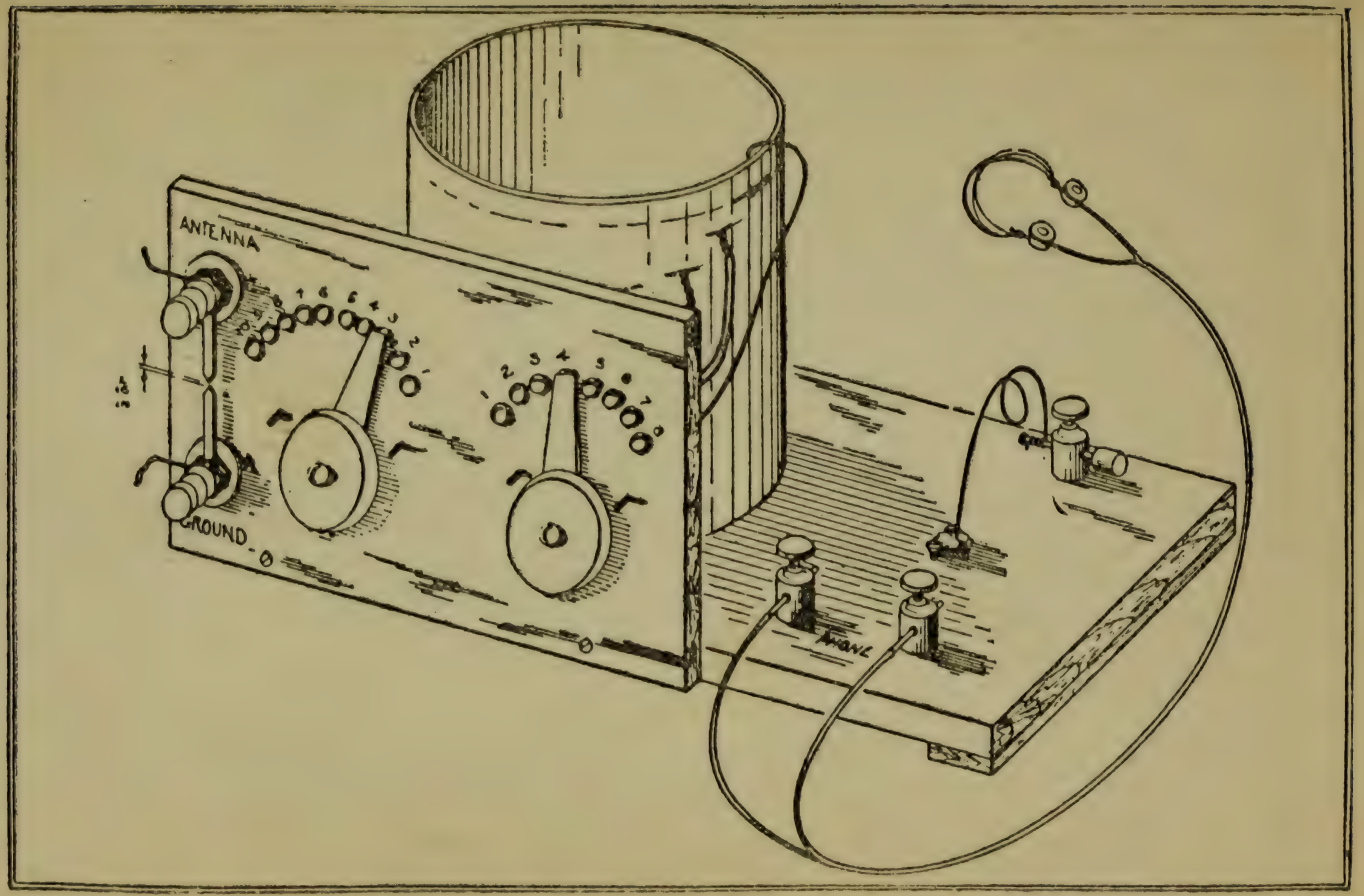

Fig. 10

This panel may be a piece of wood approximately ½ inch thick. 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 ⅛ inch brass bolts of sufficient length and supplied with three nuts and two washers. The first nut binds the bolt to the panel, the second nut holds 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. 9, may be purchased in the assembled form or it may be constructed from a thin slice cut from a broom handle and a bolt of sufficient length equipped with four nuts and two washers together with a narrow strip of thin brass somewhat as shown.

The switch contacts (W, Fig. 9) may be of the regular type furnished for this purpose or they may be brass bolts equipped with one nut and one washer each or they may even be nails driven through the panel with an individual tap fastened under the head or soldered to the projection of the nail through the panel. The switch contacts should be just close enough that the switch arm will not drop

between the contacts, but also far enough apart that the switch arm can be set so as to touch only one contact at a time.

The telephone binding post should preferably be of the set screw type as shown at X, Fig. 9.

CHAPTER VII

THE WIRING OF A CRYSTAL SET

Directions for Operating—Uses of Test Buzzer—Approximate Cost of Parts of Home-made Crystal Set

HAVING constructed the several parts mentioned in previous chapter and mounted them on the wood base, one is ready to connect the several taps to the switch contacts and attach the other necessary wires. Scrape the cotton insulation from the loop ends of the sixteen twisted taps as well as from the ends of the two single 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. 9.

One should be careful not to cut or break any of the looped taps. It would be preferable to fasten the connecting wires to the switch contacts by binding them between the washer and the nut as shown at 3, Fig. 9. A wire is run from the back of the binding post marked "ground" (Fig. 9) to the back of the left-hand switch-arm bolt (Y), thence

to underneath the left-hand binding post marked "phones."

A wire is then run from underneath the right-hand binding post marked "phones" to underneath the binding post (4, Fig. 9), which forms a part of the crystal detector. A piece of No. 24 bare copper wire about 2½ inches long, one end of which is twisted tightly around the nail (the nail passing through binding post 4), the other end of which rests gently by its own weight on the crystal (1).

The bare copper wire which was wrapped tightly around the three brass wood-screws holding the crystal in place is lead to and fastened at the rear of the right-hand switch arm bolt (v), thence to the upper left-hand binding post marked "antenna." As much as possible of this wiring is shown in Fig. 9.

After all the parts of this crystal-detector radio receiving set have been constructed and assembled the first essential operation is to adjust the little piece of wire, which rests lightly on the crystal, to a sensitive point. This may be accomplished in several different ways; the use of a miniature buzzer transmitter is very satisfactory. Assuming that the most sensitive point on the crystal has been found by

method described in paragraph below, "The Test Buzzer," the rest of the operation is to get the radio receiving set in resonance or in tune with the station from which one wishes to hear messages.

The tuning of the receiving set is attained 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 each of the first 8 switch contacts and only one turn of wire between each 2 of the other contacts.

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 over all 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 for the one using

this radio receiving equipment to find out the wave frequencies (wave-length) used by the several radio transmitting stations in his immediate vicinity.

The Test Buzzer (Z, Fig. 9)—As mentioned previously, it is easy to find the more sensitive spots on the crystal by using a test buzzer. The test buzzer is used as a miniature local transmitting set. When connected to the receiving set as shown at Z, Fig. 9, the current produced by the buzzer will be converted into sound by the telephone receivers and the crystal, the loudness of the sound depending on what part of the crystal is in contact with the fine wire.

To find the most sensitive spot connect the test buzzer to the receiving set as directed, close the switch (5, Fig. 9) (and if necessary adjust the buzzer armature so that a clear note is emitted by the buzzer), set the right-hand switch arm on contact point No. 8, fasten the telephone receivers to the binding posts marked "phones," loosen the set screw of the binding post slightly and change the position of the fine wire (6, Fig. 9) to several positions of contact with the crystal unit until the loudest sound is heard in the phones, then tighten the binding post set screw (4) slightly.

Approximate Cost of Parts

The following list shows the approximate cost of the parts used in the construction of this radio 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, 100 to 150 ft., about	$ .75
Rope—3/8 or 1/2 inch. 2c per foot.	
2 insulators, porcelain	.20
1 pulley	.15
Lightning switch—30 ampere battery switch	.30
1 porcelain tube	.10
Ground connections—	
Wire (same kind as antenna wire.)	
1 clamp	.15
1 iron pipe or rod	.25
Receiving set—	
1/2 pound No. 24 copper wire double cotton covered	.75
1 cardboard box.	
2 switch knobs and blades complete	1.00
18 switch contacts and nuts	.75
3 binding posts—set screw type	.45
2 binding posts—any type	.30
1 crystal—tested	.25
3 wood screws, brass, 3/4 in. long	.03

Wood for panels (from packing box.)		
2 pounds paraffin	.30	
Lamp cord, 2 to 3c per ft.		
Test buzzer	.50	
Dry battery	.30	
Telephone receivers	4.00 to	$8.00
Total	$11.00	$15.00

If nothing but the antenna wire, lightning switch, porcelain tube, crystal, telephone receiver, bolts and buzzer are purchased this total can be reduced to about $6.00.