THE BOOK OF WIRELESS

BEING A CLEAR DESCRIPTION OF WIRELESS TELEGRAPH SETS AND HOW TO MAKE AND OPERATE THEM; TOGETHER WITH A SIMPLE EXPLANATION OF HOW WIRELESS WORKS

BY

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FULLY ILLUSTRATED

D. APPLETON AND COMPANY
NEW YORK LONDON
1915

Printed in the United States of America

TO

OSCAR A. DE LONG, JR.

A MAKER OF GOOD WIRELESS THINGS

A WORD TO THE BOY

Wireless is a thrilling pastime.

Fancy a boy sitting in his room at home with his fingers on a telegraph key and a telephone receiver to his ear *listening-in* to the news of the world as it is flashed out from the great coast stations or by ships far out at sea! It's a great experience.

Yet thousands of boys are doing this wonderful thing every day and night of the year, and you, my young friend, can do it as easily as they, for any boy can own a real wireless station, if he really wants to.

If you have sharp eyes, you will see everywhere you go webs of wire spun from the housetops and barngables, or spanning backyards, and often frontyards, too. These wires are not clothes lines; no, indeed! They have a far higher and, I should say, as useful a purpose as clothes lines, for they are *wireless wires*.

These wires are called *aerials* by wireless operators. The word *aerial* may sound a little hard at first, and there are some other words used in wireless that are hard for the outsider, but they get to be very common words to the boy who puts up his own station, for there is no lesson so easily learned as the one taught by the thing itself, and no school like that of doing things yourself. Some of these aerials have a stretch of only twenty to thirty feet of wire, while others have upwards of 1,000 feet, the amount depending on the place, the pocket-book and the boy.

But you don't need to spend a lot of money to put up a good wireless station, for I have many boy friends who made all the apparatus they use, except the telephone receiver, and their stations work as well as those of some others I know who bought their outfits ready for use.

To be a wireless boy and make your own apparatus is to have the kind of stuff in you of which successful men are made—men who, if they were shipwrecked on a desert isle at daybreak, would have something to eat by noon, a spring bed to sleep on by night and a wireless station the next day sending out S O S to ships below the horizon, for help.

All you need to do to become a member of the great and growing army of wireless boys is the desire to own a station, and the rest is easy. A reading of this book will point the way, and, if my advice is followed, a successful station will result.

But if you should have any trouble and if any questions should come up which puzzle you, if you will write to me, I shall gladly do all I can to help you.

A. Frederick Collins,
"The Antlers," Congers, New York.

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THE BOOK OF WIRELESS

PART I

A SMALL WIRELESS OUTFIT

CHAPTER I

THE SENDER

Before trying to make a wireless telegraph outfit to send and receive messages over long distances, it is better for a beginner to put up a small set first and learn how to work it and how it works.

The very first thing to do is to get all of the parts of the *sender* and the *receiver;* connect them together, and put up an *aërial.* The next step is to learn the *wireless code,* that is how to use a telegraph key to make the dots and dashes which represent the letters of the alphabet and then—practice awhile.

When you can send and receive five or ten words a minute it is time to get a larger set and when you are ready for a larger set, a larger set will no doubt be ready for you.

All of the parts of the sets described in this book may be bought of dealers in electrical supplies, or they may be made at home. For the beginner it is, perhaps, better to buy certain parts ready made, especially the spark-coil, as the results will be surer.

If, on the other hand, you want to make the parts of either of the sets described, drawings will be found with the sizes marked on them and if you will but follow as well as you can the simple directions which I have given you cannot go wrong. So now get busy.

Every wireless *station* is made up of three distinct parts:

(1) A sender, also called a *transmitter,*

(2) A receiver, also called a *receptor,* and

(3) An aërial wire, also called an *antenna,* and a ground.

The sender will be described in this chapter.

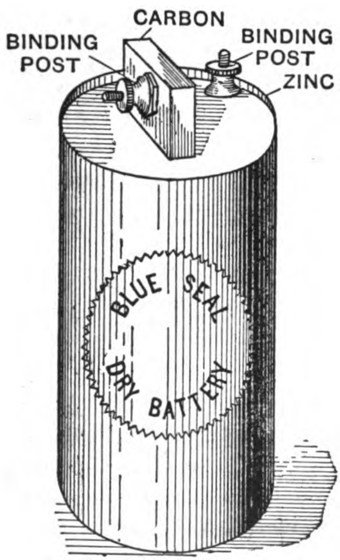


Fig. 1.—A Dry Cell.

There are four separate pieces of apparatus which go to make up this sender, and which with a suitable *aërial* and *ground,* will send messages over a distance of a quarter to half a mile.

These pieces of apparatus are:

(1) A *battery,* for producing a current of electricity,

(2) A *telegraph key,* for *making* and *breaking* up the battery current into *dots* and *dashes,*

(3) A *spark-coil,* also called an *induction coil,* which changes the current from the battery into *high pressure electricity,* and

(4) A *spark-gap,* in which sparks are set up by the high pressure electricity.

The Battery.—A battery for producing a current of electricity is made up of five or six *dry cells* connected together with pieces of copper wire.

A single *dry cell* is shown in Fig. 1. It is made up of a stick of *carbon* set in a tall cup formed of *sheet zinc,* the space in between being filled with a paste which acts upon the carbon and zinc and produces an electric current.

Look again at Fig. 1 and you will see that secured to the upper end of the carbon is a *binding post* and that to the upper edge of the zinc cup is fastened another binding post. Binding posts are used to make it easy to connect the ends of wires to the carbon and to the zinc. Fig. 2 shows the kind of binding post that is used on dry cells and is drawn full size.

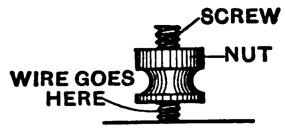


FIG. 2.—BINDING POST USED ON DRY CELLS.

Five or six dry cells when connected together will give enough current to work the *spark-coil.* These cells are connected with each other as shown in Fig. 3, that is the zinc of one cell is connected with the carbon of the next cell by a piece of copper wire about 3 or 4 inches long.

Any kind of copper wire will do for the connections but the kind known as *bell wire,* that is copper wire No. 18 Brown and Sharpe gauge covered with cotton thread and soaked in *paraffin,*

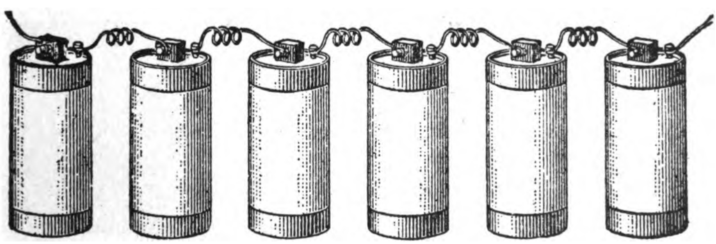


FIG. 3.—A BATTERY OF DRY CELLS.

such as is used for connecting up electric bells, may be bought for 10 or 15 cents a half-pound—about 75 feet—and a half-pound will be enough to connect up both the sender and the receiver.

The Telegraph Key.—This need not be a regular telegraph key, but instead it may be a simple *strap-key* as shown in Fig. 4. A strap-key can be easily made by cutting a piece of *spring sheet brass,* or even tin will do, 4 inches long and ½ inch wide, as shown in Fig. 5, and drilling a hole ⅛ inch in diameter through

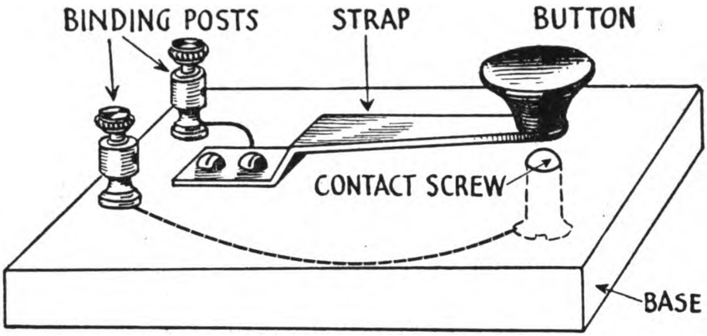


FIG. 4.—THE STRAP KEY COMPLETE.

each end; then bend it at one end as shown in Fig. 6. This piece of brass is called a *strap* and from this comes the name, *strap-key*.

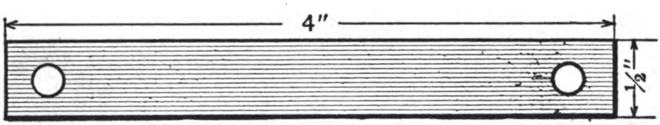


FIG. 5.—BRASS STRAP FOR KEY.

For a button, cut off the head of a clothes-pin and screw it to the long end of the strap with a round-headed screw. Make a wood base 4½ inches long by 2½ inches wide and ½ inch thick

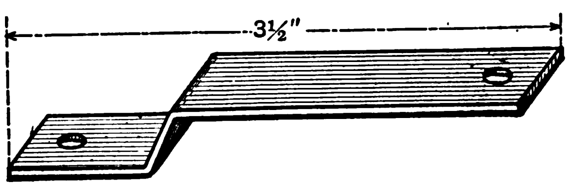


FIG. 6.—BRASS STRAP BENT.

and drill three holes, each ⅛ inch in diameter, through the base as shown in Fig. 7.

Screw the short end of the strap to the board at the place marked X so that the screw holding the button and the strap together will be directly over the hole at the other end of the base and which is marked *contact screw.* Put a machine screw having a nut on one end through this hole so that the head of the

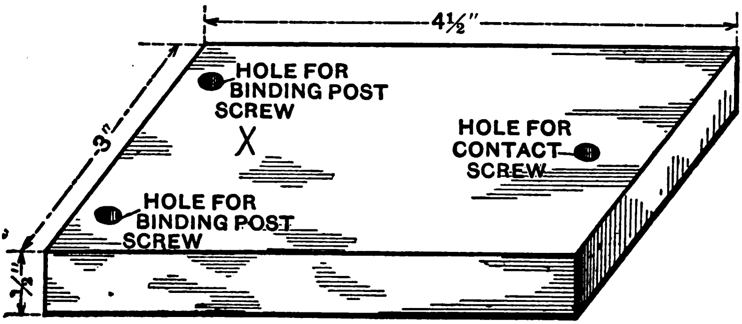


Fig. 7.—The Base as It Looks When Finished.

screw is on the bottom and the end sticks through the top of the board about $\frac{3}{16}$ of an inch and then screw on the nut.

Next screw on two binding posts to the back of the board and

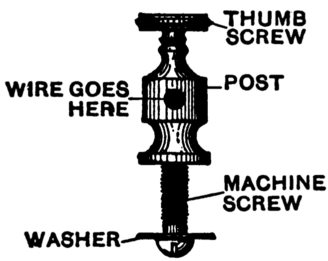


Fig. 8.—Binding Post Used on Key and Spark-Coil.

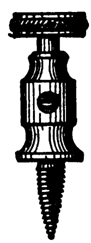


Fig. 9.—Wood Screw Binding Post.

the key is ready to be *wired up.* These binding posts are a little different from those used on dry cells (see Fig. 2) in that they have holes drilled through them so that the ends of the wire can be slipped into the holes and are held tight when screwed down, as shown in Fig. 8 and Fig. 9.

Take some bell wire and connect the strap of the key, by bending one end of a wire around the screw, which holds it to the board, to one of the binding posts; then loop the end of another piece of wire over the screw and under the nut in front and connect with the other binding post. The dotted lines in Fig. 4 show how the key is connected up.

The Spark-Coil.—The *spark-coil,* or *induction coil,* as it is often called, which is used to change the battery current into a

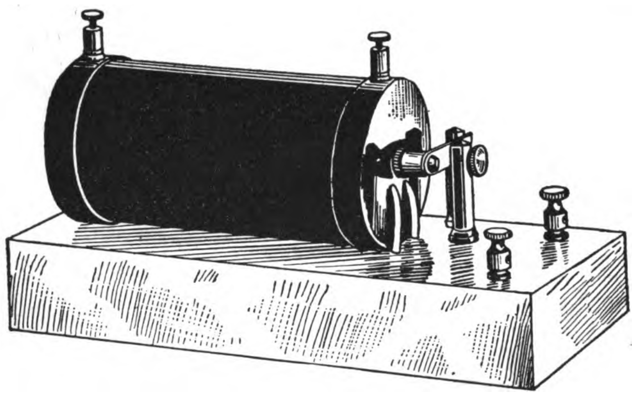


FIG. 10.—THE SPARK-COIL COMPLETE.

current of *high pressure* to make *jump sparks* is shown in Fig. 10.

The coil, it will be seen, is *mounted* on top of a polished wood base, and is covered with a thin sheet of hard rubber or bookbinder's cloth. On top of the base at one end of the coil is mounted an *interruptor*—a device which makes and breaks the battery current several hundred times a minute. A full-sized view of the *interruptor* is shown separately in Fig. 11.

Also at the right-hand end of the top of the base are two large binding posts, one for connecting in the wire from the battery and the other for connecting in the key.

Now every spark-coil, or induction coil, is formed of a little roll of soft iron wires, called a *core,* and around this core is wound two or three layers of rather thick, *insulated* copper wire, that is wire that is covered with cotton thread; this coil of wire is called the *primary coil* and the ends of this coil are connected to the large binding posts on the base through the *interruptor*.

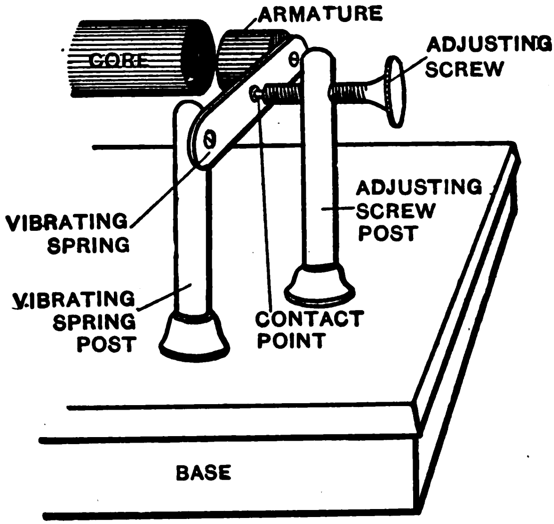


FIG. 11.—INTERRUPTOR OF SPARK-COIL.

Around the *primary* coil is wound another coil of very fine *insulated* copper wire called the *secondary coil.* A glance at Fig. 10 shows another pair of binding posts on top of the coil. The ends of the *secondary coil,* in which the *high pressure* currents are *set up* by the current from the battery, are connected with these binding posts.

The *spark-coil* shown in Fig. 10 is about 8 inches long, 4 inches wide and 5 inches high. When the coil is connected with a battery and two wires are screwed into the upper binding posts and the ends of these wires are drawn half an inch apart a bright, crackling spark will jump across the gap thus formed, and this is called a *spark-gap.*

The Spark-Gap.—The spark is a very important thing in wireless telegraphy, in fact the distance over which messages can be sent depends very largely upon the length and the kind of spark a coil gives. A thin, red spark has very little sending power, but a *fat,* snappy spark will send over long distances if the *aërial* and *ground* wires are right.

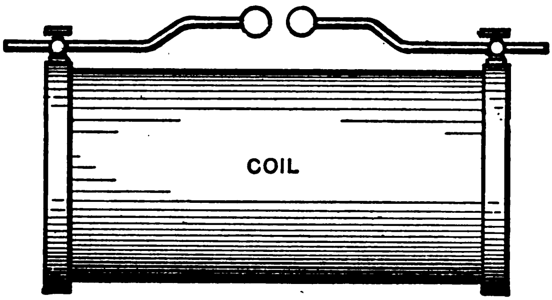


FIG. 12.—SPARK-GAP ON THE COIL.

For sending wireless messages a spark-gap formed of a pair of brass balls, or any other metal such as copper or zinc, and having a diameter of ⅜ inch or larger, is needed. Pieces of stiff brass wire 4 inches long and which will slip through the holes of the binding posts as shown in Fig. 12, must be screwed in,

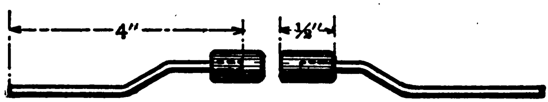


FIG. 13.—SPARK-GAP MADE OF ZINC ROD.

or soldered to the brass balls. The wires are bent up to keep the spark away from the coil.

I do not know of any maker of spark-coils who supply coils with spark-gap balls fitted to them. If brass balls are hard to get, or cost too much, another way to make a spark-gap is to cut off two pieces of brass or zinc rod having a diameter of at least ⅜ inch, and have each piece ½ inch long. Round the edges off with a file and screw in, or solder on, the brass wires as shown in Fig. 13.

This ends all the work to make the spark-coil complete, and all that remains to be done is to wire up the different parts and connect the spark-coil with the *aërial* and *ground* wire.

Connecting up the Parts.—Before connecting up the sender, the parts should be placed on the table or bench which is to be used for operating. The key should be placed on the right-hand corner nearest the operator; the battery near the right-hand corner away from the operator and the spark-coil a little to the left of the key and between the key and the battery.

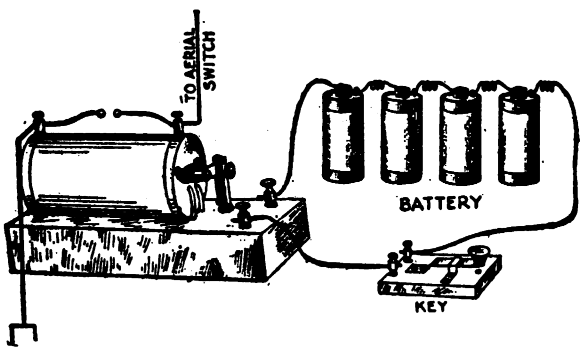


FIG. 14.—HOW THE SENDER IS CONNECTED UP

The purpose of this plan is to have the key in the handiest position for the operator, the battery out of the way and the spark-coil where the *adjusting screw* of the interruptor is within easy reach.

One of the wires of the battery is connected with one of the binding posts on the base of the spark-coil, and the other wire of the battery is connected with one of the binding posts of the key, while the other binding post of the key and remaining binding post of the spark-coil are connected together, all of which is clearly shown in the outline drawing, Fig. 14.

After the aërial wire is put up it is connected with one of the *spark-gap binding posts* while the other *spark-gap binding post* must be connected with a sheet of zinc, or of copper, buried in the earth, or if a water- or a gas-pipe is at hand the ground wire can be soldered to it as explained in Chapter III under the heading of *Aërial Wires and Grounds.*

Adjusting the Sender.—Two *adjustments* will have to be made before messages can be sent and both of these are on the spark-coil.

First set the spark-gap balls a half inch apart and then turn the *adjusting screw* of the *interruptor,* which is shown in Fig. 10 to the *right* until the *contact point* just touches the *vibrating spring* of the *interruptor.*

Now press down the button of the key and if the *interruptor* is in adjustment a stream of sparks will jump between the brass balls of the spark-gap. Turn the *adjusting screw* of the *interruptor* a little at a time until the sparks are white and crack clear and sharp. This done set the spark-gap balls so that they are only ⅛ inch apart. The sender is now in adjustment and ready for operation.

All through this chapter I have told you what to do but there is one thing I must caution you not to do, and that is not to hold down the strap of the sending key any longer than it takes to make a dot or a dash. If you do not heed this warning your battery of dry cells will soon *run down* and you will have to buy new ones or else close up shop.

Cost of Sender When Bought of Dealers

6 Dry cells at 20c.	$1.20
Nickel-plated strap-key	.50
Bell wire	.10
Spark-coil, ½-inch spark	6.00
Brass balls, per pair, ½-inch diameter	.50
Attaching brass rods to brass balls	.25
Total	$8.55

Cost of Materials to Make Sender

6 Dry cells at 20c	$1.20
Strap-key, brass, 10c; screws, 5c; 2 binding posts, 10c	.25
Bell wire, 50 to 75 feet	.10
Spark-coil, ½-inch spark	
Interruptor	1.00
Secondary wire No. 32, Brown & Sharpe gauge	1.50
Primary wire No. 16, Brown & Sharpe gauge	.25
Iron wire for coil	.10
Tin foil for condenser	.20
Brass rod for spark-gap	.10
Attaching brass rod to brass balls	.25
4 Binding posts	.25
Shellac varnish	.10
Total	$5.30

CHAPTER II

THE RECEIVER

A wireless telegraph receiver is a very simple affair and, with the exception of the *telephone receiver* which you will have to buy, the whole thing can be easily made and at a very small cost.

The receiver I shall describe in this chapter will receive messages over far longer distances than the sender you have just made will send. In fact, it is much easier to make a receiver which will receive messages over long distances than it is to make a sender which will send over equal distances. Usually, when you have made your receiver and connected it up with your aërial, you will find there is a *high power station* somewhere within your range.

There are four parts to this receiver, and with an aërial wire that is high enough and long enough, messages may be received from stations of from ten to fifty miles away, the distance, of course, depending largely upon the adjustment of your *detector,* and the power of the station that is sending.

The various pieces of apparatus are:

(1) A *dry cell,* for providing a current of electricity,

(2) A *switch,* for cutting off the current from the dry cell when the receiver is not in use,

(3) A *detector,* for changing the feeble *electric waves,* which strike the aërial wire from the sending station, into stronger electric currents produced by the dry cell, and

(4) A *telephone receiver* which changes the strong electric currents from the dry cell into *sound waves* so that the ear can hear them as dots and dashes.

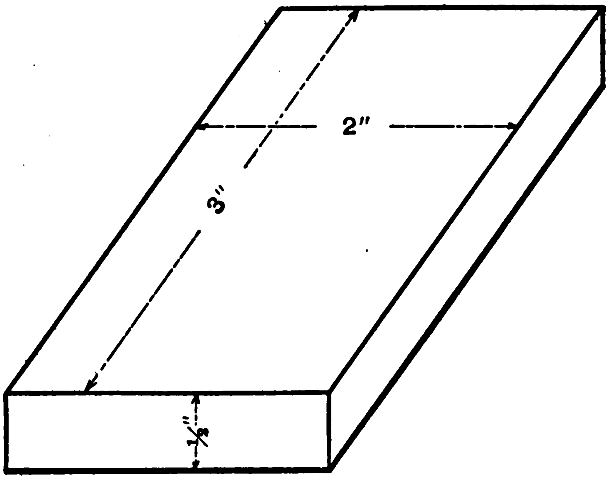


Fig. 15.—Base or Block for Switch.

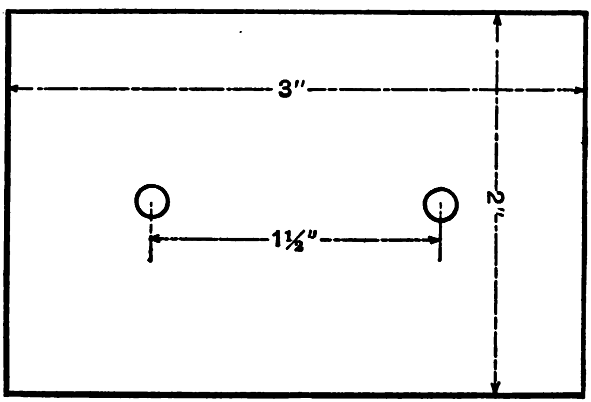


Fig 16.—Top of Base Showing Where Holes Are Drilled.

You don't need to bother just now about how the different parts of the receiver work, the main thing is to get the apparatus set up and in working order.

The Dry Cell.—The dry cell is exactly like the one shown in Fig. 1, on page 2; one dry cell will give all the current needed to work the detector and the telephone receiver.

The Switch.—To make a switch, saw out a block of wood 3 inches long, 2 inches wide and ½ inch thick, as shown in Fig. 15; the next drawing, Fig. 16, shows the top of the board, or base, as it is called. Now drill two holes ⅛ inch in diameter through the board 1½ inches apart at the places marked with the circles.

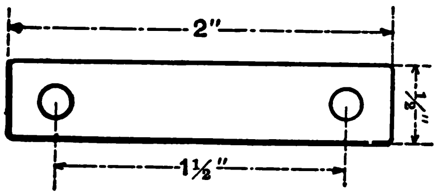


FIG. 17.—CONTACT LEVER SHOWING SIZE AND WHERE HOLES ARE DRILLED.

In making this base and others for different parts of your wireless apparatus the sharp edges of the wood should be smoothed off with sandpaper as this not only makes the blocks look better but prevents their edges from getting dented. A coat of *shellac varnish* will also give them a more finished appearance.

The next thing to do is to cut a strip of sheet brass ⅜ inch wide and 2 inches long. This strip is called a *contact lever* for the reason that it makes contact with another part of the switch.

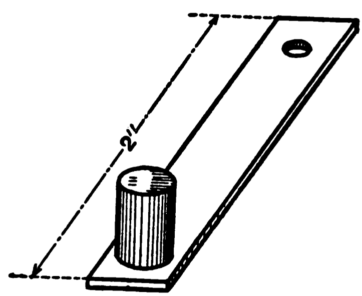


FIG. 18.—CONTACT LEVER WITH HANDLE.

Near the ends of the contact lever and at the places where the circles are drawn in Fig. 17, drill two holes 1½ inches apart; make a little wooden knob or handle about ⅜ inch in diameter and ½ inch long and screw one end of the contact lever to it

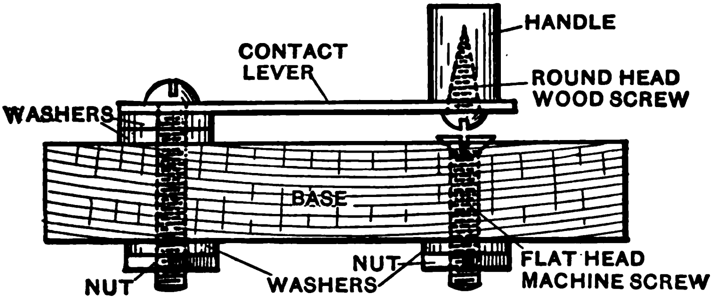


Fig. 19.—Cross Section View of Switch.

with a round-headed brass wood screw; this will leave the round head of the screw projecting from the bottom of the brass lever. The lever with the handle is shown in Fig. 18.

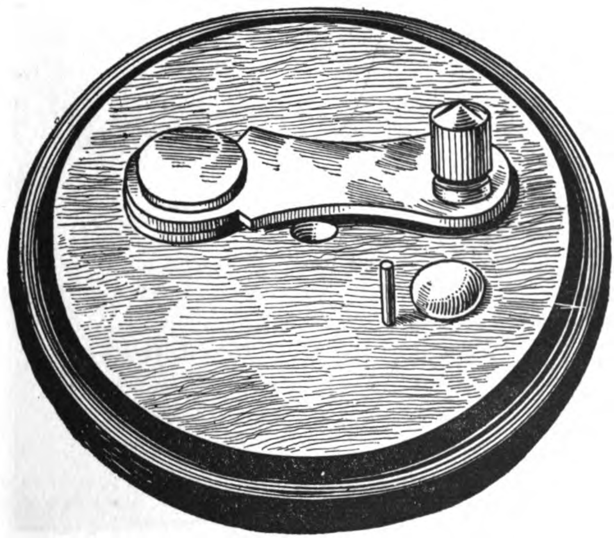


Fig. 20.—Switch Complete.

Through the other hole of the lever slip a machine screw 1 inch long, put on a couple of brass washers to raise the lever from the base a little; push the screw through one of the holes in the board; put on another washer, and last of all screw on a nut to keep the lever from working loose, but the lever must move smoothly back and forth.

Through the hole in the base under the handle of the lever put a flat-headed machine screw ¾ inch long and screw a nut on underneath the base. Now when the lever is brought to the middle of the base the round head of the screw which holds the lever and the handle together and the flat head of the screw on top of the base will meet exactly and so make contact with each other. A *sectional view* of the switch is shown in Fig. 19.

The switch when it is finished looks a little different from the one shown in Fig. 20, for this is a picture of a switch that was bought ready made; but they work just alike.

The Detector.—Though the detector is the chief part of a wireless telegraph receiver, this one is much easier to make than the switch just described. Make a base of wood 3 inches long, 2½

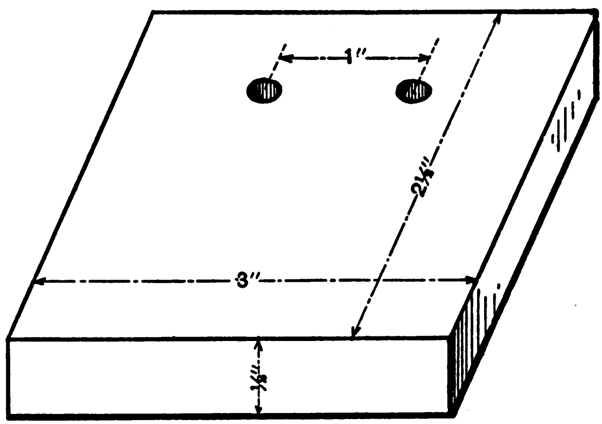


FIG. 21.—BASE OF DETECTOR.

inches wide and ½ inch thick, as shown in Fig. 21. Drill two holes ⅛ inch in diameter and about 1 inch apart at the places marked with circles, as in Fig. 21. Take two flat-headed machine screws $\frac{3}{4}$ inch long, and push them through the holes in the base; over the end of each screw slip a brass washer and screw on a binding post.

Before the binding posts are screwed down tight cut off two pieces of bell wire each about 6 inches long and scrape the ends bright; also scrape off the cotton covering of the wire, or *insulation* as it is called, for about an inch in the middle of the wire.

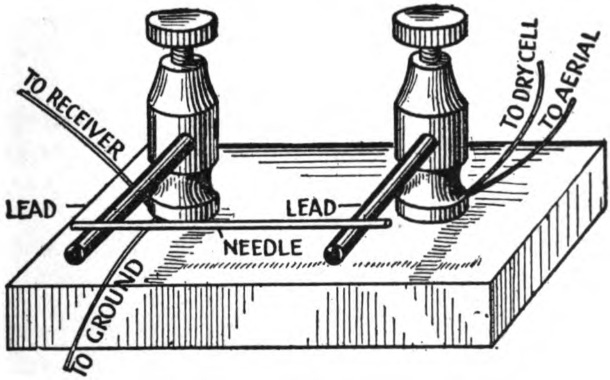


FIG. 22.—DETECTOR READY FOR USE.

Now around each screw and between the *washer* and the lower end of the binding post loop the middle of one of the wires and screw down the binding post tight.

This leaves the four ends of the wires free; one of the ends is connected with the dry cell and the other end from the same binding post is connected with the aërial wire; one end of the other wire is connected with the telephone receiver and the other end from the same binding post goes to the *ground*. These wires are shown and marked in Fig. 22.

To complete the detector slip into the hole of each binding post a piece of lead 1 inch long and $\frac{1}{16}$ inch in diameter. To obtain the right kind of lead simply split a lead pencil, take out the lead and cut or break off two pieces each 1 inch long.

The best kind of lead is fairly soft, and is used for drawing.

Care must be taken not to tighten the thumb screws of the binding posts too much or the leads will be broken.

Now take a common steel sewing-needle, about No. 9, and weight it by fastening a lead bullet to the middle of it with a drop of sealing wax and lay it across the leads. (See Appendix F.)

The Telephone Receiver.—While there is not very much to a telephone receiver, yet it is a piece of apparatus that is hard to make, and especially one good enough to use for wireless work. It requires a skilled workman and fine machine tools to make one *good enough* for even this small set. I shall not, therefore, encourage you, whether you are a beginner or an expert operator, to try to make your own telephone receiver, but it is well to know the names of the different parts which form it. How it works will be told in Chapter V.

A telephone receiver is formed of five chief parts, and these are:

(1) A thin, round piece of sheet iron called a *disk,* or *diaphragm,*

(2) A small *electromagnet,* made of a magnetized steel bar and wound with very fine silk-covered copper wire,

(3) A metal *case* which holds the electromagnet in place,

(4) A *cover,* having a small hole in it and which screws on to the case and holds the iron disk, or diaphragm, in place, and

(5) A *telephone cord,* that is a pair of very flexible insulated wires bound together.

Each part of the telephone receiver, except the *telephone cord,* is shown separately in Fig. 23, and the receiver is shown put together in Fig. 24. The *telephone cord* is shown in Fig. 25.

The *magnet* is screwed to the bottom of the case and the ends of the fine wires of the magnet are connected to two screws in the side of the case and to which the telephone cord is connected. The screws are insulated with little rings of hard rubber slipped over them and these keep them from touching the metal case. If the screws were not *insulated* in this way the elec-

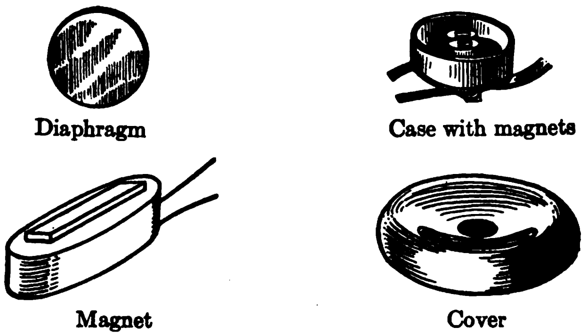


FIG. 23.—TELEPHONE RECEIVER TAKEN APART.

tricity from the dry cell would flow from one screw to the other across the case instead of flowing through the coil of fine wire around the magnet.

The edge of the disk of sheet iron just fits the outside edge of the case but does not touch the top of the magnet, a space

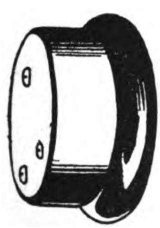


FIG. 24.—RECEIVER COMPLETE.

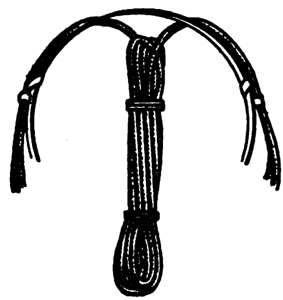


FIG. 25.—TELEPHONE CORD.

being left between them of about $\frac{1}{50}$ inch. The cover when screwed on the case holds the iron disk firmly by its edge, but does not touch it anywhere else, and this allows it to *vibrate* freely.

The receiver shown in Fig. 24 is called a *watch-case receiver,* because it is about the size of a watch. A watch-case receiver nickel-plated and with a hard rubber screw cap weighs about 6 ounces and can be bought for 75 cents or $1.00. An ordinary telephone cord 3 feet long can be bought for about a quarter. It is shown in Fig. 25.

Connecting up the Parts.—When all the parts of the receiver are at hand set them on the operating table to the left

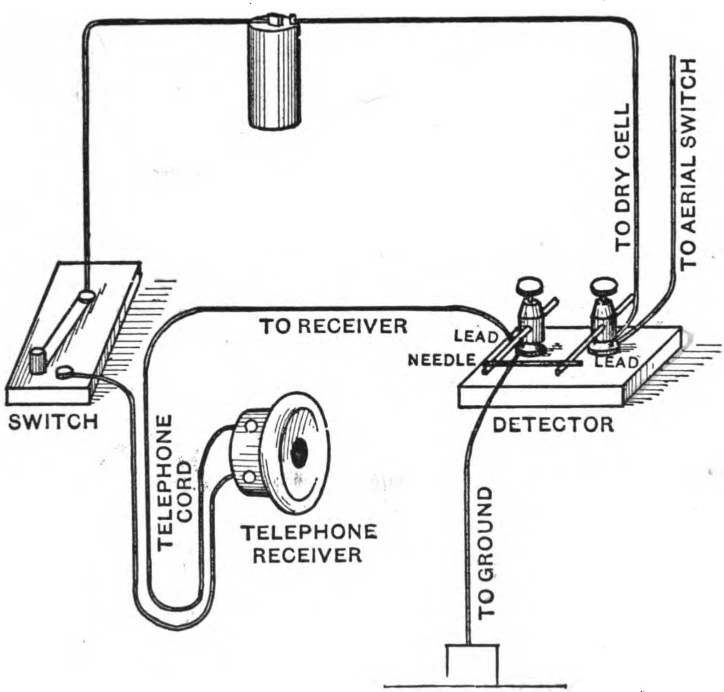


Fig. 26.—Receiver Connected Up.

of the sending apparatus. The detector should be placed on the side nearest the spark-coil and not closer than a foot from it. The switch should be placed to the left of the detector leaving plenty of room between them so that the telephone receiver can be laid on the table when you are not using it. The dry cell may be set back of the switch and the detector where it will be out of the way. The proper places for all these parts on the table are clearly shown in the outline drawing Fig. 26.

First connect the free end of the wire which is fastened to the binding post of the carbon of the dry cell to the back screw of the switch by looping it between the washers. Then connect the free end of the wire attached to the binding post of the zinc of the dry cell with one of the wires looped around the *right-hand* binding post of the detector. The other wire connected with this binding post of the detector is also connected, later on as we shall see, with the aërial switch which is described in Chapter III.

Next, one of the ends of the wire which is looped around the left-hand binding post of the detector is connected with one of the metal tips of a wire of the telephone cord while the other tip of the same wire is connected with one of the screws in the telephone receiver case. The other wire which is looped around the left-hand binding post of the detector connects with a wire which goes to the plates buried in the *ground* or to the water- or gas-pipe.

An end of the other wire of the telephone cord is connected with the remaining screw in the telephone case and the last connection is made by fastening the remaining tip of the telephone cord between the washer and the nut on the front screw of the switch, all of which is clearly shown in Fig. 26.

Adjusting the Receiver.—The only adjustment of the receiver needed is to move the needle of the detector now and then to a different place on the pencil leads. From the connections shown in Fig. 26, it will be plain that when the switch is closed, that is, when a contact is made by throwing over the lever to the right and when the sewing-needle is laid across the pencil leads of the detector, the *circuit* will be completed and the current from the dry cell will have a free path without a break in it to flow through and so must pass through the detector and the telephone receiver.

When the switch is closed and the telephone receiver is held to the ear a slight sound, something like bacon frying in a skillet, can be heard. If, now, the detector is connected to an *aërial wire* and a *ground* and some operator from a station that is not too far away is sending, you will be able to plainly hear the dots and dashes as he clicks them off with his key, and if you can read the *International Morse Code* you will have the pleasure of picking the messages right out of the air as they shoot by at the speed of light.

Cost of Receiver When Parts Are Bought

Switch	$ .30
Telephone receiver	.75 to 1.00
Telephone cord	.25
Detector[1]	.50
Dry cell	.20
Total	$2.25

Cost of Receiver When Parts Are Made

Switch	$ .10
Telephone receiver	.75 to 1.00
Telephone cord	.25
Detector (2 binding posts)	.10
Dry cell	.20
Total	$1.65

[1] It is doubtful if the detector I have described can be bought ready made, but any electrician will make it for you at a cost of not more than 50 cents.

CHAPTER III

A CHEAP AËRIAL WIRE

Although the *aërial wire* is merely two or three wires strung between two high places it is an important part of wireless and it must be put up right.

There are three things which go to make a good aërial and these are:

(1) To have the wires as *high* as possible,

(2) To have as long a *stretch* of wire as possible, and

(3) To have the wires well *insulated* at the ends.

The first thing to do is to choose two places as high and as far apart as you can find and one of which is near your operat-

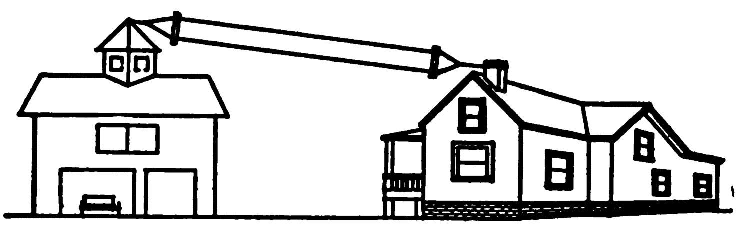


FIG. 27.—AËRIAL SUSPENDED BETWEEN HOUSE AND BARN.

ing room, and still have a clear sweep between them, that is, there should be no trees or anything else in the way to interfere.

One end of the aërial should be put up so that it will come close to the room where your wireless set is located. Suppose, for example, that your house and the barn are 100 feet apart. Then the aërial wires can run between the gable ends of the house and the barn as shown in Fig. 27. If there is no barn on your place, attach the end of the aërial to a chicken-coop or even to a near-by fence. Whatever you do though, get the aërial as high above the ground as you can.

There are five parts to an aërial and these are:

(1) The *wire,* of which the aërial is made,
(2) The *spreaders,* for keeping the wires apart,
(3) The *insulators,* for keeping the wires from touching the spreaders,
(4) The *rope,* for suspending the aërial, and
(5) The *leading-in* wire, which connects the aërial wires with the sending and receiving apparatus.

Kinds of Wire.—Any kind of wire will do for an aërial, but aluminum or copper wire about $\frac{1}{8}$ inch in diameter makes a very good one, that is if the aërial is a short one. Iron wire is much cheaper than copper wire, but it is not nearly as good for wireless work. If you want to use iron wire, try to get regular telegraph wire; this iron wire is *galvanized,* which means that it is plated with zinc. Galvanized iron wire is better for aërials than ordinary iron wire as it does not rust and conducts electricity better.

If neither copper wire nor galvanized iron wire can be had, use any kind of wire you can get and never mind the size as long as it is strong enough to hold together when strung up. Get as

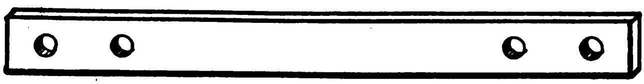


Fig. 28.—Spreader With Holes.

many feet of wire as you need for the distance between the places where you intend to suspend the aërial. When you have the wire, cut it in half and lay the two pieces side by side on the ground.

The Spreaders.—These are merely sticks of wood to keep the wires apart when they are in the air and to prevent them from getting twisted. For an aërial 100 feet long a stick, or spreader, at each end will be enough. For longer spans than 100 feet a spreader should be placed in the middle of the aërial.

For the spreaders get two sticks about 4 feet long, 1 inch thick and 3 inches wide, and bore a hole ¾ inch in diameter and 3 inches from each end; also bore two more holes of the same size at each end but 6 inches nearer the middle of the stick than the outside holes. Fig. 28 shows the spreader and the places where the holes are to be bored.

The Insulators.—Just as ordinary telegraph wires are looped around glass insulators to keep them from touching the

Fig. 29.—Porcelain Insulator.

telegraph poles, so the ends of the aërial wires are passed through *porcelain insulators* to keep them from touching the spreaders. These insulators are tubes made of porcelain and are about ¾ inch in diameter and 4 inches long. One end of the insulator is bulged out so that it cannot slip through the holes in the spreader. Fig. 29 is a picture of one of these insulators.

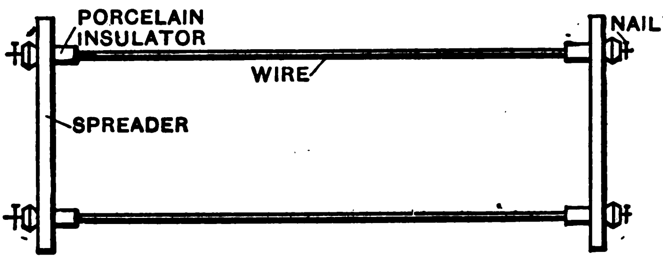


Fig. 30.—Spreaders With Insulators and Wires.

Four porcelain insulators will be needed for the aërial—two at each end. Push an insulator in the outside hole of each spreader. Now lay a spreader at each end of the wires on the ground with the heads, or bulged part of the insulators away from each other as shown in Fig. 30. Then slip the ends of the wires through the insulators and twist the end of each wire around a nail so that the wires cannot slip out after the aërial is hoisted into the air and drawn up tight.

The Rope.—The next step is to fasten a rope to each spreader. Each piece of rope should be about 15 feet long, more or less as may be needed; put an end of one piece of the rope through the holes in a spreader, loop it back and *splice,* or tie it to the other part of the rope so that it cannot work loose. Fasten

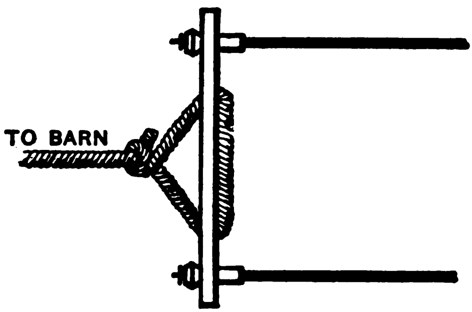


FIG. 31.—ROPE THROUGH SPREADER.

a piece of rope to the other spreader in the same way. Fig. 31 shows how it is done.

The Leading-in Wire.—The wires which connect the apparatus with the aërial are formed of:

(1) The *bridle,* or loop of wire whose ends connect with the wires of the aërial, and

(2) The *leading-in wire,* or wire connecting with the bridle and which is brought in the room through the window and connects with the *aërial switch.*

The Bridle.—To make the bridle, take about 8 feet of wire and twist one end to one of the aërial wires and twist the other end around the other aërial wire. These wires should be soldered to the aërial wires in order to make good connections. This is the part of the aërial wire which is called the *bridle.*

The Leading-in Wire.—To the middle of the loop, or *bridle,* so formed, twist and solder another piece of wire and be sure this is long enough to reach down and through the window and to your apparatus. This piece of wire is called the *leading-in wire.* It is shown in Fig. 32.

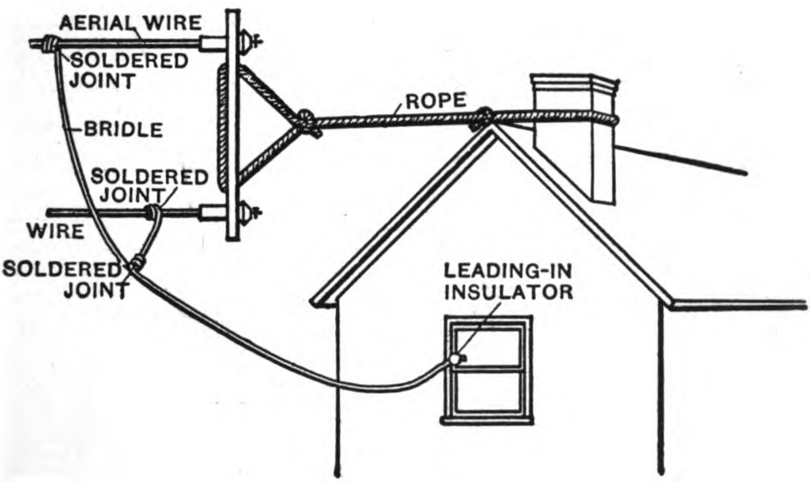


Fig. 32.—Aërial Completed and Put Up.

The Leading-in Insulator.—The aërial wire must not touch trees, buildings or other objects, but of course it must be supported in the air by something, so porcelain insulators are put in the spreaders to keep the wires from touching the wood. This is done to keep the electricity on the wires from running away and soaking into the wood.

Now this same thing will happen when the leading-in wire is brought from the outside of the house into the operating room unless it is well insulated. An easy way to insulate the leading-in wire is to bore a hole $\frac{3}{4}$ inch in diameter through the window sash and push a porcelain insulator as shown in Fig. 29 through it. The end of the leading-in wire of the aërial is pulled through the insulator in the window sash and brought down to the aërial switch in the operating room to which it is connected.

The Aërial Switch.—The purpose of the aërial switch is to connect the aërial wire first to the sender and then to the receiver, or the other way about, depending on whether you want to send or receive a message.

One thing is certain, the sender and the receiver must not be

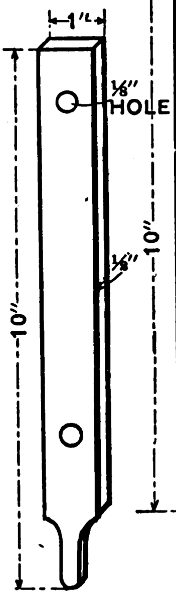


FIG. 34.—LEVER OF AËRIAL SWITCH.

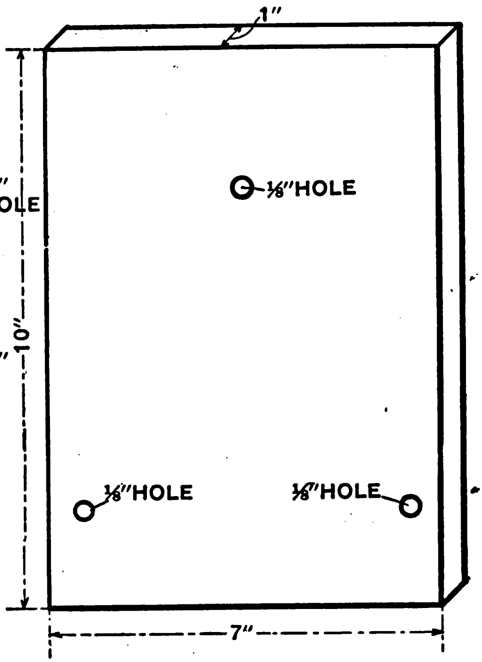


FIG. 33.—BASE OF AËRIAL SWITCH.

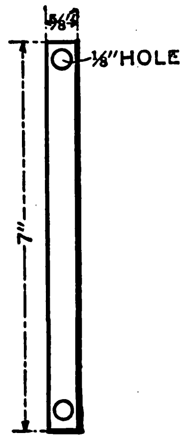


FIG. 35.—STRIP OF BRASS OF LEVER.

connected to the aërial wire at the same time for the reason that the spark from the spark-coil would *burn out* the detector when messages are being sent; nor should they be connected when receiving a message, for much of the current set up in the aërial wire by the incoming waves will flow through the sender and so weaken the message.

To make an aërial switch, get a board about 10 inches long, 7 inches wide and 1 inch thick. Drill three $\frac{1}{8}$-inch holes at the places marked with circles as shown in Fig. 33. Make a lever of a piece of wood 1 inch wide, $\frac{1}{2}$ inch thick and 10 inches long; drill a $\frac{1}{8}$-inch hole at the place marked with a circle, and round off the other end with a knife to make a handle as in Fig. 34.

Cut a strip of sheet brass 7 inches long, $\frac{1}{2}$ inch wide and $\frac{1}{32}$

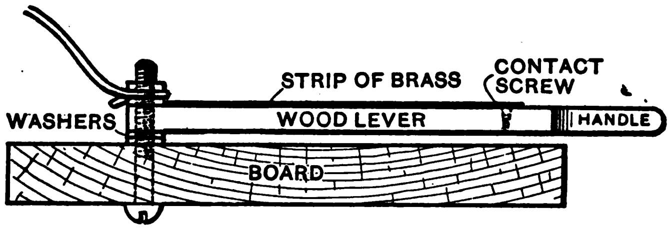


FIG. 36.—CROSS SECTION OF AËRIAL SWITCH.

inch thick and drill a hole in each end so that when the strip of brass is laid over the wooden lever the holes will come exactly together. This piece of brass is shown in Fig. 35.

The next thing to do is to put a wood screw through a hole in the strip of brass and screw it in the wood lever nearest the handle so that the head of the screw sets in *flush,* that is, even

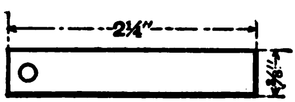


FIG. 37.—BRASS STRIP FOR CONTACT SPRING.

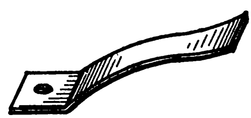


FIG. 38.—CONTACT SPRING.

with the surface of the strip of brass. The lever is attached to the board by putting a machine screw $1\frac{3}{4}$ inches long through the upper hole in the board (see Fig. 35) and the upper holes of the wood lever and the brass strip; before putting on the lever a couple of brass washers should be slipped on the screw so that the under part of the lever will be raised away from the board a little and can be moved freely from side to side.

A cross-sectional view, as if the switch was split right down the middle, is given in Fig. 36 and shows how the washers and screws should be placed through the lever and the board. One thing more, cut out two pieces of spring brass 2¼ inches long and ⅜ inch wide, and drill a ⅛-inch hole in one end as marked by the circle in Fig. 37; then bend the strips into the shape shown in Fig. 38 and screw one to the left-hand side of the board and the

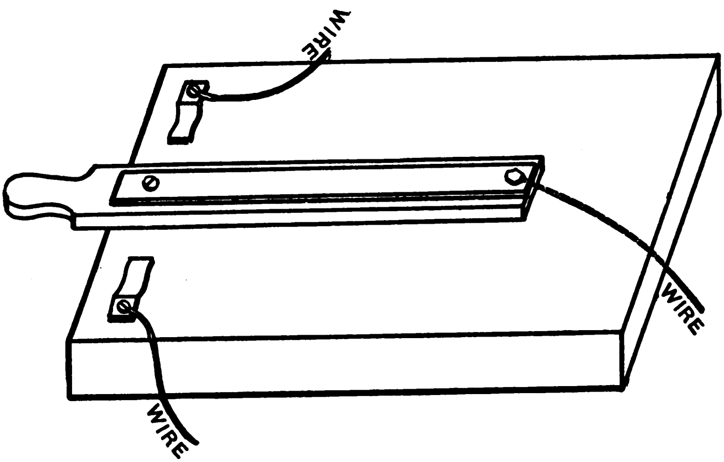


FIG. 39.—AËRIAL SWITCH COMPLETE.

other to the right-hand side of the board. Put the screws in from the back of the board and screw two nuts on each screw on top of the brass contact springs.

A wire is connected to each of these contact springs and another wire is connected to the top screw of the lever. These connections are easily made as the wire is bent round the screw between the nuts and the latter are then screwed down tight. Fig. 39 shows the aërial switch complete.

The Ground Connection.—There is one thing you must look after to put your station in working order and that is the *ground*. To *ground* an apparatus means to connect it with a sheet of metal that is buried in the ground, or some metal object such as a gas- or a water-pipe which leads to and runs into the ground.

A fairly good ground can be made by soldering a heavy wire to a sheet of zinc 3 feet by 4 feet and burying the zinc in the ground deeply enough so that it will always be moist. The ground wire need not be insulated from the building but it can be brought into the house and led to the operating room in any way that is easiest.

Connecting up the Sender and Receiver to the Aërial and Ground.—Connect the top wire of the aërial switch to the leading-in wire of the aërial. To the left-hand lower wire of the aërial switch connect the wire of the binding post of the detector marked *to aërial* as shown in Fig. 40, which is a complete wiring diagram of the whole station. Connect the right-hand lower wire of the aërial switch to the binding post of the spark-gap marked *to aërial switch.* Connect the wire of the binding post of the detector marked *ground* with the sheet of zinc buried in the ground; and finally connect the binding post of the spark-gap marked *to ground* to the same wire that the detector is connected with and which leads to the zinc plate in the ground. In other words, one sheet of zinc furnishes a ground for both the sender and the receiver. All of the connections are clearly shown in the outline drawing Fig. 40.

A *single pole, single throw* switch must be connected in between the top wire of the aërial switch and ground wire as shown in Fig. 40. This switch is to protect your apparatus from what is called *static electricity,* that is electricity which charges the air and the ground just before the coming of a storm. When sending and receiving this switch is *open,* but always *close* it when you are through working. A switch of this kind can be bought, or if you want to make one you will find the drawings, Figs. 147 and 148, and description needed on page 151. Before using your set read the Fire Underwriters' Rules given in Chapter III, Part III, page 199.

To send a message throw the lever of the aërial switch to the *right* and work the Morse key. To receive a message throw the

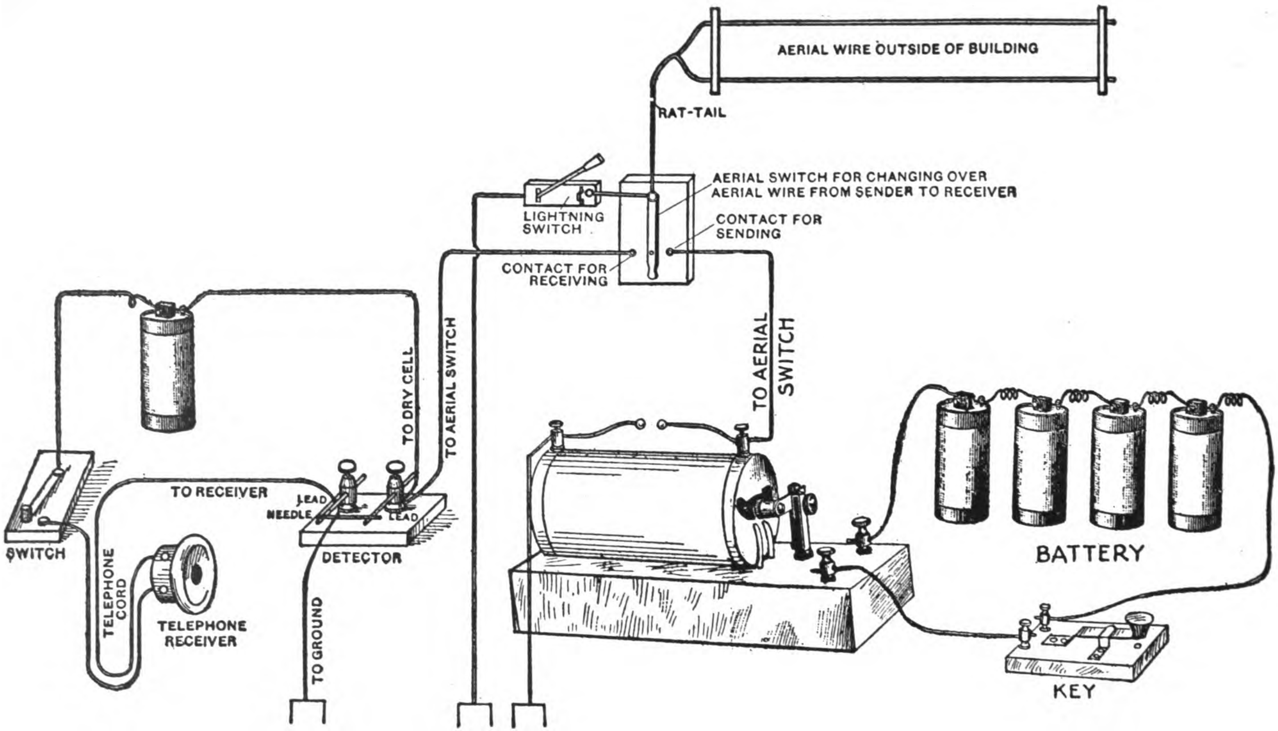


FIG. 40.—THE SENDER, RECEIVER AND AËRIAL WIRED UP AND READY FOR BUSINESS.

aërial switch to the left; close the receiver switch and hold the telephone receiver to your ear.

When you have finished throw the lever of the aërial switch to the *right* as for sending, and always leave it in that position except when you are *listening-in,* as this prevents *static electricity* from charging the aërial wire. When you have completed your set you can connect your receiver with the aërial and *listen-in,* but you must not connect your sender to the aërial and send until you have obtained a license from the Government as explained in Chapter III, Part III.

Cost of Materials to Make a 100-foot Aërial [1]

250 feet of No. 14 Brown & Sharpe gauge copper wire	$1.50
Or 250 feet of galvanized telegraph wire	.60
2 4-foot spreaders	.20
5 porcelain insulators (4 for aërial and 1 for leading in)	.50
30 feet of ¾-inch manilla rope	.60
Total cost for aërial with copper wire	$2.80
Total cost for aërial with telegraph wire	1.90

Aërial Switch

Board	$ .20
Screws, washers and nuts	.15
Strips of brass	.10
Total	.45

Ground

1 sheet of zinc 3 x 4 feet	.50
Total cost of aërial, aërial switch and ground	$3.30 or $4.20

[1] These are only approximate prices. Very often enough wire, rope, wood and zinc can be found in the cellar, attic or woodshed to make the aerial, switch and ground.

CHAPTER IV

LEARNING THE MORSE CODE

In the early days of North American history certain tribes of Indians had a crude way of sending signals without wires. When the Indians went on the warpath and they wanted to signal to others of their tribe some distance away that they were ready to scalp the pale-faces, which was usually at night, one of the braves would place a burning arrow in his bow and shoot the flaming signal high into the air. The distant watchers who were in on the secret would know at once what was meant when they saw its light. It was a way to signal without wires but it was not wireless telegraphy as it is done to-day. We have to remember though that the Indians were savages while we are highly civilized, or think we are.

The point I want to bring out, though, is that a burning arrow, the letters of the alphabet or the clicking of a telegraph instrument may mean whatever we have agreed beforehand that they shall mean. In other words they are merely *codes,* that is signs and signals which convey our ideas to others.

The Code.—In real wireless telegraphy, a *code* of dots and dashes is used by operators to send and receive messages. The word *code* in telegraphy means a set of electric impulses or signals, arranged in advance and which can be sent from one station to another station by the use of proper apparatus.

This *code* is formed of a number of *dots* and *dashes,* and each letter of the alphabet is represented by a dot, a dash, or by dots and dashes together. For example, suppose you are at one end of the table and I am at the other end and we each have a pencil. Now suppose I tap three times on the table with my pencil like this ● ● ● and that we have agreed before-

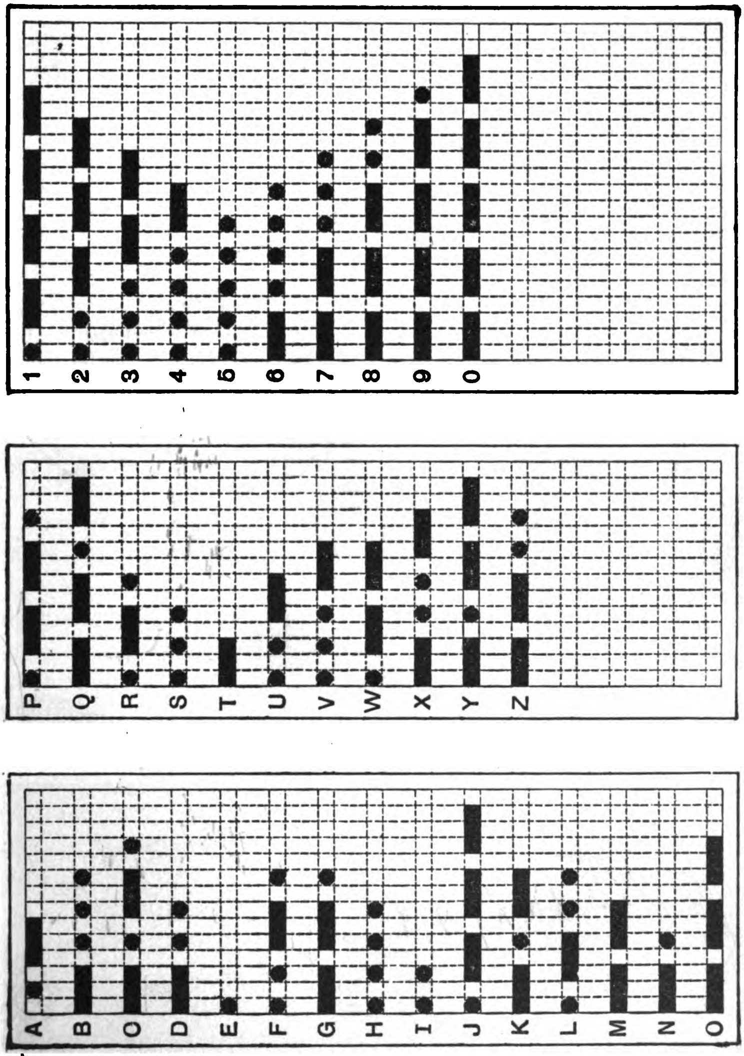


FIG. 41.—INTERNATIONAL MORSE CODE.

hand that when I make three taps, or dots, on the table you are to understand it to mean the letter S; suppose we have also agreed that when I tapped the end of the pencil on the table three times but held it down a second or so between the taps like this ▬ ▬ ▬ it will mean the letter O.

Now if I tapped out on the table three dots, ● ● ●, three dashes, ▬ ▬ ▬, and again three dots, ● ● ● you would read it as S O S, and this is the signal a ship sends out at sea when she is in distress.

Just so with all the other letters of the alphabet; thus A is a dot and a dash like this ● ▬; B is a dash and three dots, ▬ ● ● ●; C is a dash, dot, dash, dot, ▬ ● ▬ ● and so on.

The dot and dash code, originated by Samuel F. B. Morse, the inventor of the telegraph in 1844, is still used by operators of *land lines* in this country and this code is called the *American Morse code.* In this code there is one letter that has a longer dash than any of the others and there are several letters which have longer spaces, or *time intervals,* between the dots than others; and these things make the code a little harder than it would be if the spaces were all the same.

The International Morse Code.—In Europe someone, somewhere, sometime, thought he would make the code invented by Morse a little more simple and so he got up the code shown in Fig. 41. This code is now in use all over Europe and for this reason it is called the *Continental Morse code.*

Since the wireless telegraph was invented in Europe, when it came to be put on ships that sailed across the ocean, it was natural that the *Continental code* should be used; when the wireless telegraph finally reached America and it was installed on ships in the coastwise trade it was also natural that the *American Morse code* should be used.

When the wireless telegraph came into common use and there were hundreds of shore stations on both sides of the ocean, and every ship had a set, it became necessary for all operators to use the same code, so that ships in distress could communicate with any other ship or shore station.

For this reason all the countries sent representatives to the *International Radiotelegraphic Convention,* which met in London in 1912 (see Chapter III, Book III, page 196), and they all agreed that their countries would use the Continental Morse code for wireless telegraphy and so it is now known as the *International Morse code.*

How to Learn the Code.—It is much easier to learn to receive the Morse code for wireless work than for ordinary telegraphy since in wireless the dots and dashes are heard as buzzing sounds of different lengths in the telephone receiver, whereas, with the wire telegraph the difference between a dot and a dash is known by the length of the spaces between the clicks made by the *sounder.*

The first thing to do is to study the Morse code until you have learned the dots and dashes of all the letters by heart. If you have a good memory this will be an easy matter, but if you haven't a good memory you still have the satisfaction of knowing that once you have learned the code you will never forget it. The arrangement shown in Fig. 42 may help you to remember the code letters:

The idea is to make all of the dots and all of the dashes follow in a natural order. The figures of the Morse code are arranged exactly on this basis and you will be able to remember these with the slightest effort.

A good way to practice sending and receiving, if there is no other station near you, is to stretch a wire across your room and connect one of the balls of your spark-coil to it and connect the other ball to a wire fastened to a piece of zinc or copper about a foot square and which is laid on the floor. This makes a little sending station in your own room and you will not need a license to operate it.

By holding the telephone receiver to your ear with your left hand and working the sending key with your right hand you can send messages and hear them at the same time. This will give

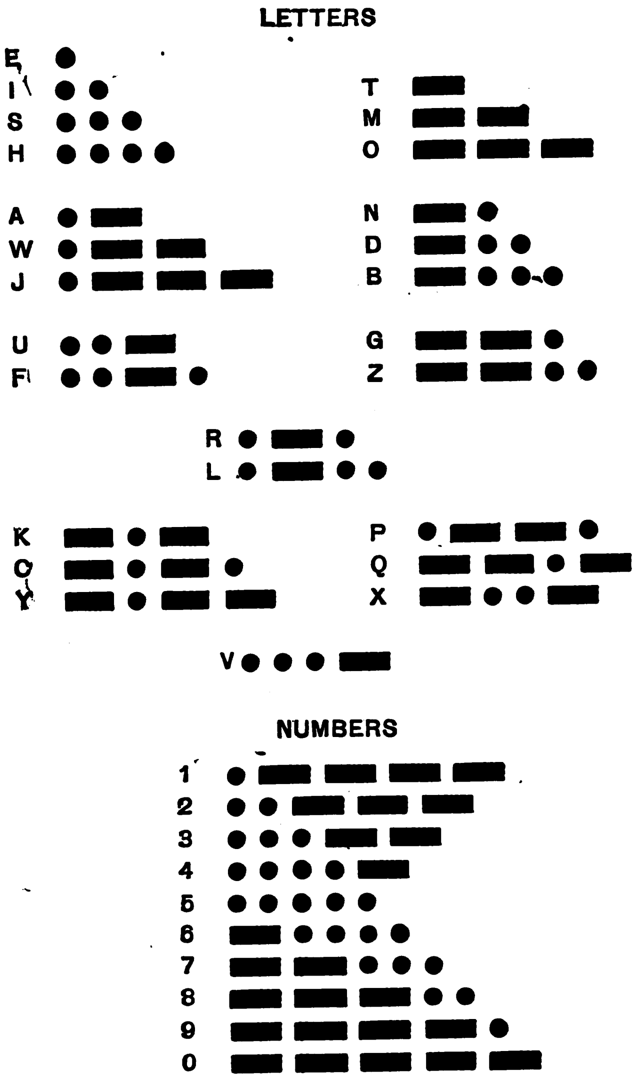


FIG. 42.—FIRST AID TO REMEMBERING THE CODE.

you the practice you need until you have mastered the code. When you can send five words per minute, each word to have at least five letters in it, without a mistake, you are well on your way to secure a license and become a real operator.

From five words per minute work up to ten or twelve words per minute; when you have reached this point wireless will be

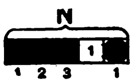


FIG. 43.—LENGTH OF DASH

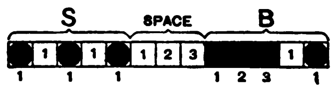


FIG. 44.—SPACE BETWEEN TWO LETTERS.

easy sailing for you and it will not be long before you can receive as fast as the best operators can send.

In learning to send remember that (1) a *dash* is equal to three dots; (2) the *space* between parts of the same letter is equal to one dot, as shown in Fig. 43; (3) the *space* between two letters is equal to three dots as shown in Fig. 44, and (4) the *space* between two words is equal to five dots as shown in Fig. 45.

In sending be careful to make your dots and dashes sharp

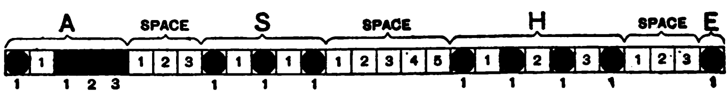


FIG. 45.—SPACE BETWEEN TWO WORDS.

and clear, which means that all the dots are of exactly the same length; all of the dashes the same length, that is, three times the length of the dots, and that the space intervals between them are equal.

Signals of Transmission.—The following signals are taken from the rules and regulations adopted by the International Radiotelegraph Convention of 1912.

(1) Ships in distress shall use the following signal:

• • • — — — • • •

The operator is to repeat this signal at brief intervals and then follow with the necessary particulars.

Whenever you hear a ship calling S O S you must stop sending and do not commence again until you are sure that the messages between the ship that called and the ones which answered have ended.

(2) When you want to call a station send this signal first:

— • — • —

Then send the call letter of the station you want and repeat this three times; next send the abbreviation for the word "from," which is

— • •   •

(3) When you and the station you have called are through sending messages send this signal:

• • • — • —

and end by sending your own call letters.

Abbreviations in Code.—The following abbreviations are used and understood by all operators and for this reason they are called *conventional signals.* After you have learned the Morse code well you should practice on these:

For instance, suppose you want to send the word "understand"; now instead of spelling this word out in full you simply send

• • • — •

and the operator who is receiving your message will know what you mean.

Period	· · · · · ·
Semicolon	— · — · — ·
Comma	· — · — · —
Colon	— — — · · ·
Interrogation	· · — — · ·
Exclamation point	— — · · — —
Apostrophe	· — — — — ·
Hyphen	— · · · · —
Bar indicating fraction	— · · — ·
Parenthesis	— · — — · —
Inverted Commas	· — · · — ·
Underline	· · — — · —
Double Dash	— · · · —
Distress Call	· · · — — — · · ·
Attention call to precede every transmission	— · — · —
General inquiry call	— · — · — — · —
From (de)	— · · ·
Invitation to transmit (go ahead)	— · —
Warning -- high power	— — · · — —
Question (please repeat after ...)--interrupting long messages	· · — — · ·
Wait	· — · · ·
Break (Bk.) (double dash)	— · · · —
Understand	· · · — ·
Error	· · · · · · · ·
Received (O. K.)	· — ·
Position report to precede all position messages)	— · — ·
End of each message (cross)	· — · — ·
Transmission finished (end of work) (conclusion of correspondence)	· · · — · —

FIG. 46.—ABBREVIATIONS IN CODE.

CHAPTER V

HOW WIRELESS WORKS

"How do you send wireless messages; and how do you receive them?"

These are the questions most often asked the boy who owns a wireless station, and he should be able to explain how these things are done as well as to understand them himself.

In sending and receiving wireless messages there are some things the eye can see and the ear can hear. For instance, when a message is being sent the eye can see the lever of the key move up and down under the fingers of the *operator;* and when the lever of the key is pressed down the eye can see a stream of sparks, or lightning on a small scale, jump between the brass balls of the spark-gap, and the ear can hear a lot of crisp, crackling sounds which is really thunder, caused by the miniature lightning.

When a message is received there is nothing for the eye to see and but little for the ear to hear, but that little may mean a great deal especially if it is an S O S signal from some ship in distress. The sounds heard are just faint buzzings of the diaphragm of the telephone receiver like a fly in an uncorked bottle.

But there are other things that take place, other forces that are at work, both at the sending end and the receiving end, and in the space between, which neither the eye can see nor the ear can hear, and to understand what is going on we must know a little about electricity and its twin brother *magnetism.*

What Takes Place When the Key Is Closed.—Now although neither electricity nor magnetism can themselves be seen, we can get a pretty clear idea of how they work by comparing them with things which we can see. Thus electricity behaves very much like water. We can think of a battery as being a pump, in fact it is an electricity pump; the coils of wire of the spark-coil and the wires that connect the key and the battery may be likened to a pipe in which the water flows, while the key is a valve for turning on and off the electricity.

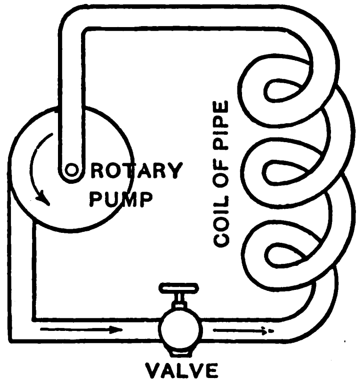


Fig. 47.—A Current of Water Flowing in a Coil of Pipe.

Let the *outlet* of a *rotary pump,* such as is used on an automobile engine, be connected with a coil of pipe at one end and the other side of the valve with the intake of the pump as shown in Fig. 47. Now when the pump is turned by a crank and the valve is set so that the water can get through it there will be a constant flow of water through the coil of pipe; but if the valve is turned so

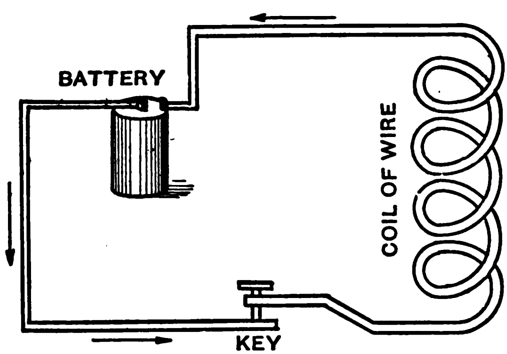


Fig. 48.—A Current of Electricity Flowing in a Coil of Wire.

that it is closed, of course no water can flow through the pipe or circuit.

The same thing happens when the lever of a telegraph key is pressed down for this closes the circuit, that is when the wire, or path, which includes the primary coil of the spark-coil is *made* by the key the electric current is forced through it by the battery. When the lever of the key is *up*, the circuit is broken and the current can no longer flow through the wire of the spark-coil. This arrangement is shown in Fig. 48.

The interruptor of the spark-coil is used to make and break the battery current a large number of times, while the key is *closed* so that the aërial wire and ground wire can be rapidly *charged* and *discharged* through the spark-gap to make the sparks follow each other quickly. The purpose of the interruptor of the spark coil is to make and break the primary current very rapidly and this changes the direction of the current in the secondary coil several hundred times a minute.

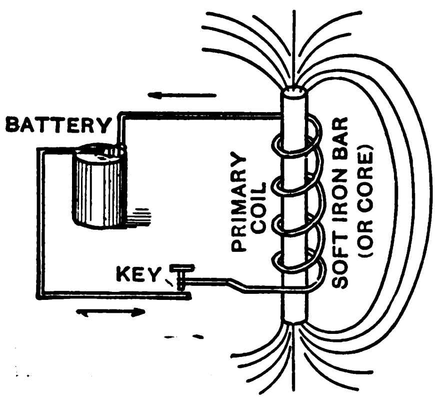


FIG. 49.—A BAR OF IRON MAGNETIZED BY CURRENT OF COIL.

If an insulated wire, called a primary coil, is wound round a bar of iron as shown in Fig. 49, and a current is sent through the coil of wire by a battery, the iron bar will be *magnetized,* that is the ends of the bar will attract needles, the blades of pocket-knives and other steel things to it. Such a bar of iron is called a *core.*

Again if a large number of turns of fine insulated wire is wound around a primary coil which has a core in it as shown in Fig. 50, and a current is sent through the primary coil, the iron bar will be magnetized as before and the magnetism will set up another, or a secondary electric current in the fine wire which forms the secondary coil.

In this way electric currents can produce magnetism and in turn magnetism can produce electric currents. Further, magnetism can pass right through glass or the cotton covering of insulated wires and for this reason the electricity in the primary coil can be changed over, or transferred to the secondary coil though they are insulated from each other. Each time the primary circuit is closed by the key a current will flow through

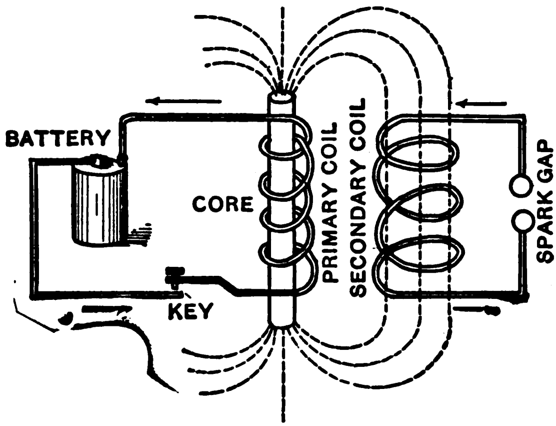


FIG. 50.—CURRENTS ARE SET UP IN THE SECONDARY BY MAGNETIC LINES.

the secondary coil in one direction and each time the primary circuit is broken by releasing the key another current will flow through the secondary coil in the opposite direction.

But the fine wire, or secondary coil, does more than to merely produce these *alternating currents,* as currents which flow first in one direction and then in the other are called, for it also raises the *pressure* of the currents.

To illustrate what it meant by saying that the *pressure* of the electric current is raised, let's see how water from a hydrant acts when it is forced through a nozzle. The *pressure* of the water from the hydrant though the hose may not be very great and without a nozzle a large amount of water would spout out a few feet only; but screw on a nozzle, that is a tube having a very small hole in the end, and though a smaller amount of water will squirt out of it, it will squirt much farther for *the pressure* of the water has been raised.

What the Spark Does.—The same thing takes place in a spark-coil. The amount of electricity in the fine wire of the secondary coil is very much less than that in the primary coil, but the secondary coil *raises the pressure* of the current so that by the time it reaches the spark-gap balls it jumps right through the air between them.

When the electricity jumps across the gap it burns up the air between the spark-gap balls and the burning air makes a flash which we call the spark. As fast as the air is burned up in the spark-gap the air around it rushes in to fill up the empty space and this inrushing air makes the crackling sound; the same thing happens when an electric light bulb is dropped on the floor; the bulb has had the air pumped out of it and when broken the air around it rushes in and makes a crack like a pistol shot.

What High-Frequency Currents Are.—Now that we have an idea as to how the spark-coil changes the low-pressure current of the battery into high-pressure currents which make the jump sparks, we will follow this up and find out what the spark has to do with the aërial and ground wires.

In some ways an electric current also acts very much like a rubber ball and this is the case with electricity in an aërial and ground wire. If you throw a rubber ball on a sidewalk it will bounce quite high the first time, not so high the next time and a little lower each time, until it no longer bounces at all, but lays at rest on the walk. If we make a line on paper to show how the ball bounced it would look about like that shown in Fig. 51.

When you raise a ball ready to throw it on the sidewalk *force* is stored up in it and all that is needed is to let it go. Just so with the electricity in or on the aërial and ground wires before the spark takes place.

There is power back of the ball and power back of the electricity in the aërial and ground wires; making the spark is just like throwing the ball, they both release their stored-up energy; the ball on striking the sidewalk bounces up into the air, while the electricity on reaching the end of the ground wire bounces up to the top of the aërial wire, and just as the ball bounces into the air every time it strikes the sidewalk, so the electric current bounces to the top of the aërial wire every time it strikes the ground.

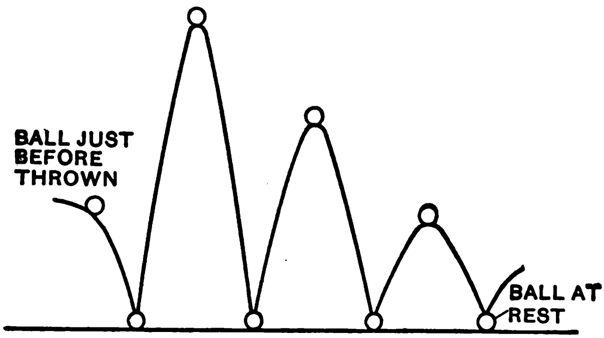


Fig. 51.—How A Rubber Ball Bounces.

You may wonder how the electric current in the aërial can pass between the spark-balls on its way to the ground and back again, since air is an insulator. It is because the spark has burned the air out of the gap and this hot space makes as good a path for the electricity as though the brass balls were connected at that instant with a copper wire.

Just as a ball can be started bouncing again after it is at rest by throwing it on the sidewalk so a current in the aërial and ground wires can be started by pressing down the key and making a spark.

Thus, we find that every time a spark jumps between the balls a current of electricity surges up and down the aërial and ground wires and if we could trace its motion on paper as we have the rubber ball we would have a wriggly line like that shown in Fig. 52.

While it has taken a long time to explain about the current in the aërial and ground wires, it travels up and down faster than the mind can think, that is to say a million times every second, more or less.

How Wireless Waves Are Made.—The purpose of the current surging up and down the aërial wire of the sending station is to send out waves to the receiving station. An easy way to

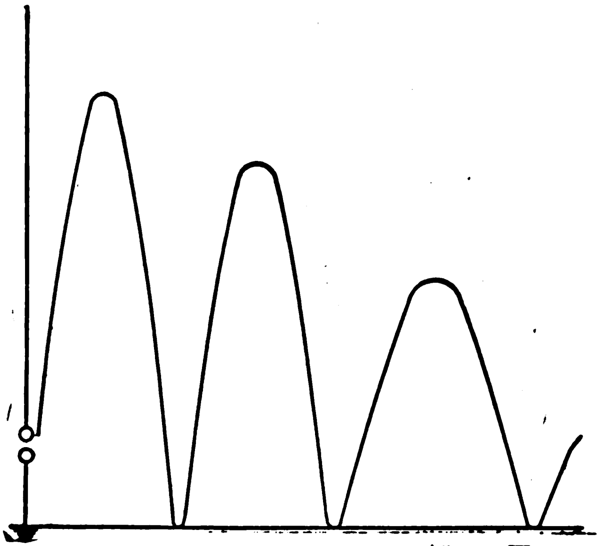


FIG. 52.—ELECTRIC CURRENT IN AN AËRIAL WIRE.

understand how this is done is to pick up a dozen stones and stand on the bank of a pool of still water.

Throw a stone into the center of the pool and you will see a ripple or small wave form in a ring around the place where the stone struck the water, and you will also see that the ring spreads out in every direction and as it grows larger it also grows weaker until it can no longer be seen.

After this experiment throw one stone in the pool after another quickly and a number of waves always traveling toward the edge of the pond will be set up and follow each other.

This is a fair picture of what happens when the electric currents run up and down the aërial and ground wires every time a spark jumps between the balls of the gap.

The running currents set up waves in space which travel away from the aërial in every direction, growing larger and weaker until they can no longer be detected.

How Wireless Waves Travel.—All around the aërial wire, everywhere as far as the eye can reach and beyond the space is filled with a substance of which electricity is made and which is perfectly still, just as the pool of water is still before the stones are thrown in, and, too, just as little waves are sent out by the stones striking the water, so the currents running up and down the aërial and ground wires strike this great pool called the *ether* and sets it into motion, and ripples or waves are sent out all around the aërial wire, somewhat after the manner shown in Fig. 53, but instead of being simple rings of elec-

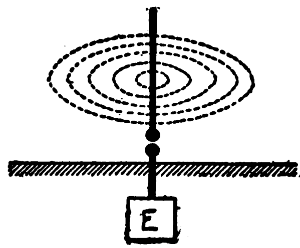


FIG. 53.—ELECTRIC WAVES AROUND AËRIAL.

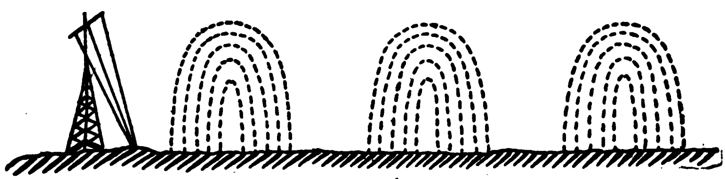


FIG. 54.—ELECTRIC WAVES THROWN OFF BY AËRIAL.

tricity they are shaped more like the half of an orange, as shown in Fig. 54.

How Wireless Waves Are Detected.—As you learned in building the wireless set, the detector of the receiver is connected with an aërial and ground wire when receiving just as the spark-gap is connected with the aërial and the ground when sending. The detector has been called a *wireless eye,* for it detects or makes known that which our eyes are unable to see, and that is feeble electric currents.

Going back again to the experiment of throwing stones into a pool of water, if you will put a cork on the still water near the edge of the pool, you will see the cork bob up and down every time a stone strikes the water, or rather as soon as the wave set up by the stone reaches the cork. The cork is then a kind of crude detector.

When the electric waves sent out by the aërial wire of a sending station strike the aërial wire of a receiving station, electric currents are set up in the aërial of the receiving station and run up and down the aërial wire through the detector and the ground wire exactly like the electric currents set up in the sending aërial, as shown in Fig. 52.

Where the water waves caused the cork to bob up and down, the electric waves set up electric currents in the aërial wire and these cause the pencil leads and the steel needle of the detector to draw together, or *cohere,* and then the current from the dry cell can flow through the detector more easily than when the needle lays loose on the leads—that is when they are not cohered—and a sound is heard in the telephone receiver.

Just the instant that the electric current stops running up and down the aërial wire and through the detector, the needle and the leads break apart and this prevents the current of the dry cell from flowing through the detector and the telephone receiver, and little or no sound is heard.

How Electric Currents Are Changed into Sound Waves. —We have seen how a current of electricity flowing through a coil of wire which is wound on a soft iron core makes a magnet of it.

The magnet of a watch-case telephone receiver is very small, as Fig. 55 shows, and is a thin flat piece of steel which is in itself a magnet; this magnet forms the core on which is wound a large number of turns of silk-covered copper wire which is almost as fine as a hair.

When the current from the dry cell is allowed to flow through the coils of the magnet by the detector, the steel core is magnetized still more and any change in the amount of current flowing through the coils will vary the strength of the magnet.

When a high-frequency current is set up in the aërial wire by an incoming wireless wave this current causes the steel needle

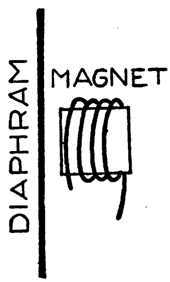


Fig. 55.—Magnet and Diaphragm of Telephone Receiver.

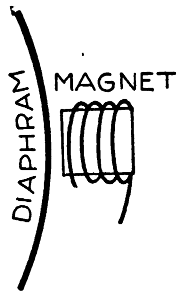


Fig. 56.—A Strong Current Pulls Diaphragm to Magnet.

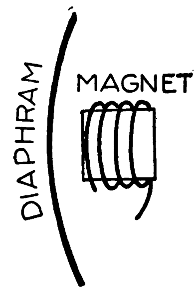


Fig. 57.—When Current Stops Diaphragm Springs Back.

to *cohere* as we have seen, and on this taking place the current from the dry cell can flow through the detector and the coils of the magnet of the telephone receiver.

When the current stops flowing in the aërial wire the needle and the leads break apart again of their own accord and this serves to break the circuit and so there is no current to affect the coils of the telephone magnet.

This is the way that high-frequency currents running up and down the aërial and ground wires and through the detector change the amount of current from the dry cell which flows through the coils of the telephone magnet, and this, of course, changes the strength of the magnet.

The soft iron disk or diaphragm of the telephone (see Fig. 55) is set over very close to the end of the magnet. The edge of the diaphragm is held fast between the case and the cap of the receiver, but the center of the diaphragm which is directly over the magnet is free to move, or vibrate.

Now since every change in the amount of current which flows through the coil of fine wire changes the strength of the magnet which forms the core, the diaphragm, since it is of soft iron, is pulled in toward the end of the magnet, as in Fig. 56, and when released it springs back as in Fig. 57. As the diaphragm moves to and fro very rapidly, or vibrates, under the action of the changing strength of the magnet it gives out a sound like a honey bee on a flower.

How the Message Is Heard.—We have just seen that the diaphragm of a telephone receiver vibrates and that this vibration is the cause of the buzzing sound we hear.

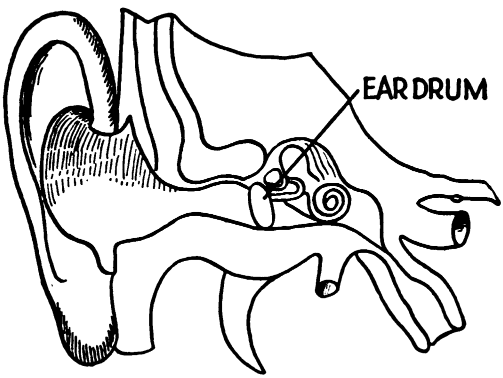


Fig. 58.—The Human Ear, Showing Ear-Drum and Auditory Nerve.

Now let's see just why a diaphragm when it vibrates sets up what we call a sound, and let's see just how our ears hear the air waves which we call sound.

When the diaphragm vibrates it causes the particles of air all around it to dance exactly in step with it and if the telephone receiver is held close to the ear the air which is set into motion cannot get away, but is held like a cushion between the diaphragm and the *drum* of the ear.

The human ear (see Fig. 58) is very much like a telephone receiver in that it also has a thin diaphragm, which we call the *drum,* but instead of being worked by an electromagnet it vibrates whenever the air outside the ear is set into motion; this being the case when the diaphragm of a telephone receiver sets the air into motion the drum of the ear vibrates exactly with it.

Connected with the ear-drum is an apparatus which ends in the *auditory* nerve and this nerve in turn leads to the brain. The ear-drum acts as a sender and the auditory nerve as a wire and when the ear-drum vibrates the brain is set a-tingling and this is what we call the sense of hearing.

This then is what happens when you hear the sounds a telephone receiver makes as it buzzes out the dots and dashes. The telephone receiver, then, makes a buzzing sound as long as the needle and the leads of the detector remain cohered, which is only as long as the electric waves last which strike the aërial.

It must be clear now that for whatever length of time the key at the sending station is pressed down the telephone receiver will buzz at the receiving end. This is how wireless works in about as few words as it can be told.

PART II

A LONG DISTANCE WIRELESS SET

CHAPTER I

THE TRANSMITTER

After you have put up and used the small wireless set, the making of a long distance set described in this chapter will not be a very hard thing to do and its operation will be a real pleasure.

The transmitter is made so that waves of a given length can be sent out and the receptor is made so that different lengths of waves can be received. The Government will not permit you to use a wave length that is more than 200 meters long, that is, 656 feet, but with the receptor waves of almost any length can be received and you can *listen-in* to almost any station that is sending.

All of the parts of this set are made of materials that are easily gotten and they are put together in as simple a fashion as possible.

There are two things, though, you should know something about before you try to make and use this larger set. The first is how to read *diagrams* and the second is the first principles of the electric current.

How to Read Diagrams.—In wiring together the different parts which go to make up the sender, but which we will from now on call the *transmitter,* and the receiver which is better called the *receptor,* to keep it from being confused with the telephone receiver, the following *symbols,* which are called *conventional symbols,* will be used. When an arrow is marked across

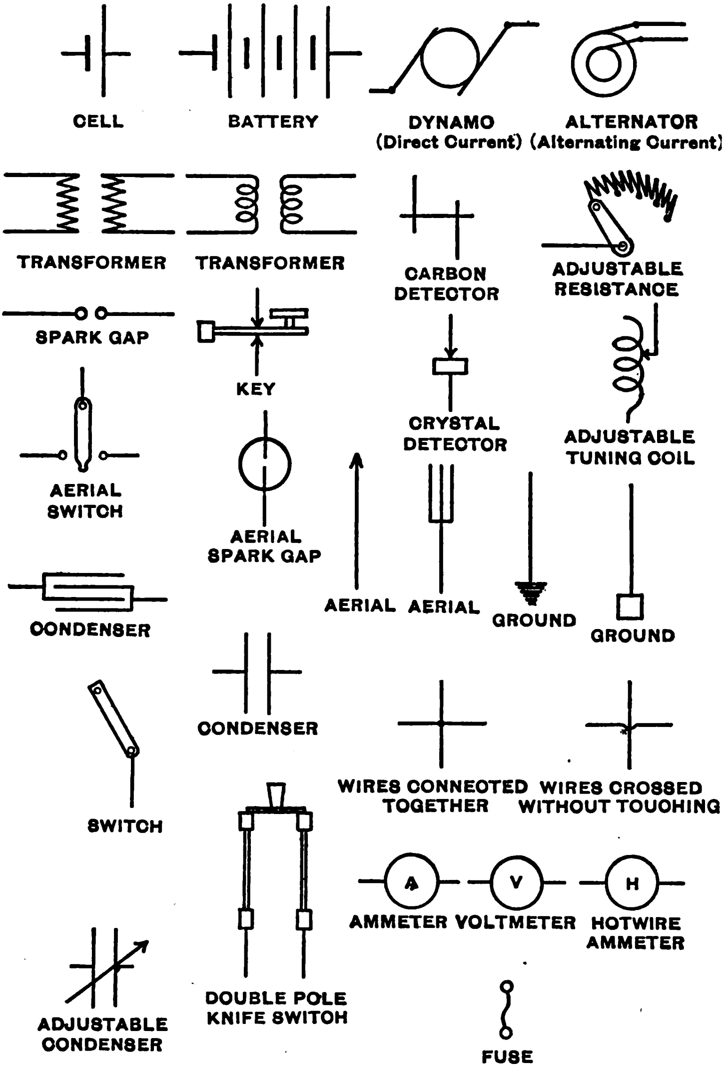


FIG. 59.—SYMBOLS USED IN WIRELESS TELEGRAPHY.

a symbol, it means that the apparatus represented is *adjustable.*

As an illustration, suppose we want to show a *condenser,* a *tuning coil* and a *spark-gap* connected together. It is not necessary to draw a complete picture but merely draw the symbols representing these parts as shown in Fig. 60.

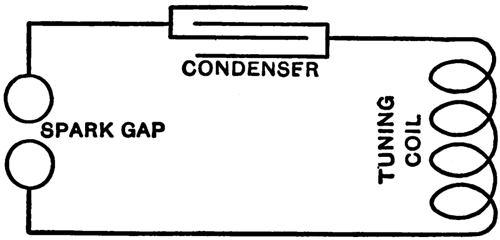


FIG. 60.—DIAGRAM OF CONDENSER, SPARK-GAP AND TUNING COIL.

Things to Know about a Current.—In the chapters describing the small wireless set the words *current* and *pressure* were used a great deal. A point has now been reached, though, where something more definite must be known about an electric current if a good station is to be built.

An electric current flowing in a wire, like water flowing in a pipe, has both *quantity* and *pressure.* When we speak of a *current* we usually mean both the quantity of electricity and the *pressure* which moves the *quantity* along the wire. But strictly speaking, *current* means *quantity.*

(1) A *current* or *quantity* of electricity is measured by a unit called the *ampere* just as water is measured by a unit called the gallon.

(2) The *pressure* of electricity is measured by the *volt* just as the pressure of steam is measured by the pound.

(3) The *watt* is the unit of work done, or the unit of work capable of being done by an electric current, just as horse-power is the unit of work done or capable of being done by steam or water flowing in a pipe.

To find the number of *watts* a current of electricity develops multiply the amperes (quantity) by the volts (pressure). Seven hundred forty-six watts are equal to one horse-power.

(4) When electricity is forced through a wire the wire opposes the passage of the current; this is called the *resistance* of the wire and resistance is measured in *ohms*. It is just the same with water forced through a pipe for the size of the pipe and the friction due to the water rubbing along the pipe offers a resistance to the flow of the water.

A Long Distance Transmitter.—In up-to-date wireless stations transformers have taken the place of induction coils which were formerly used and alternating current is employed to operate the transformers wherever it can be had.

Where only direct current is to be had the transformer can also be used, but an *interruptor,* which will also be described, is required. So whether you have alternating or direct current, the transmitting apparatus is just the same—except for the *interruptor.*

When I say that this is a *long* distance transmitter, I mean *long* as compared with the one previously described. The United States Government will not grant a license to any boy whose station is fitted with a larger transformer than one kilowatt.[1]

Unless you use a very large aërial, a ½ kilowatt transformer will give you all the power you need and this is the size I have taken for this set. A ½ kilowatt transformer will give you a sending radius of from 25 to 100 miles.

The different parts required for this transmitter are:

(1) A *source of current* to operate the transformer,

(2) A transformer for *stepping up* the low-pressure current of the lighting *mains,* which is about 110 volts, to a high-pressure alternating current of about 10,000 volts,

(3) A *resistance* for regulating the amount of current supplied by the alternating current mains to the transformer,

[1] One kilowatt is equal to about 1⅓ horse-power.

(4) A *telegraph key,* for making and breaking up the alternating current which supplies the transformer into the Morse code of dots and dashes,

(5) A *condenser of Leyden jars* which is charged by the high-pressure currents set up by the transformer and which discharges through

(6) A *spark-gap* and so sets up sparks, and

(7) A *tuning coil* through which the high-frequency currents set up by the spark-gap surges into the *aërial* and *ground.*

If a *direct current* is used then

(8) An interruptor will be needed to make and break the current in the primary coil.

The Source of Current.—To obtain an electric current sufficient to operate a transformer, the current should be taken from the *mains* of an electric light or power plant.

A battery powerful enough to work a transformer would be very costly to buy and to keep up. For this reason it is assumed that you have electric current for lighting purposes in your operating room.

In Fig. 47, page 43, a picture is shown of a pipe and a valve which resemble a battery connected with a coil of wire and a telegraph key. In these cases the current of water or of electricity always flows in the same direction.

An alternating current is different from a direct current in that it changes its direction 120 times a second, more or less.

In a piston pump every time the *piston* moves *up* the water will be forced through the coiled pipe in one direction, and every time the piston moves *down* the water will flow in the other direction, so that if the piston is moved up and down like a pump-handle when pumping water, the water in the pipe will move first in one direction and then in the other direction regularly. In other words the water in the pipe will *alternate* in direction.

This is also true of an alternating current of electricity and a machine for producing alternating currents, called a *generator,* is so built that the current changes its direction 120 times a second, or makes 60 complete *reversals,* or *cycles* as it is called, a second. A diagram including a generator, a primary coil of a transformer and a key is shown in Fig. 61.

The Transformer.—A transformer for using alternating current is even a simpler piece of apparatus than an induction coil, since it does not have an interruptor.

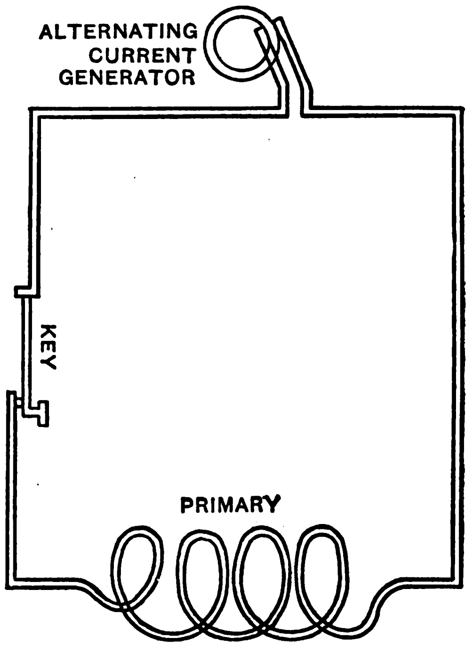


FIG. 61.—DIAGRAM OF ALTERNATING CURRENT CIRCUIT.

A transformer comprises three parts, and these are (a) a core, (b) a primary coil, and (c) a secondary coil.

The core is formed of pieces of thin sheet-iron. See Fig. 189, page 171.

A primary coil of heavy insulated wire is slipped over the *leg* of the core, the ends of the coil leading to a pair of binding posts mounted on the cheeks of the coil so that a connection can be made with the *regulating resistance* and one of the wires of the lighting mains. The secondary coil of fine wire is slipped over the other *leg* of the core and the ends of the coil are connected with the battery of Leyden jars. See Fig. 88, page 76.

The size of this transformer is about 6 inches high, $9\frac{3}{4}$ inches wide and $11\frac{3}{4}$ inches long. It weighs about 25 pounds and is *rated* at $\frac{1}{2}$ kilowatt, about $\frac{7}{10}$ of a horse-power.

A complete description of how to construct a ½ kilowatt transformer is given on page 171, Chapter I, Part III.

The Key.—A key having large contacts is required for breaking the current that *feeds* the primary coil of the transformer where upwards of 10 amperes are used.

A good substantial key can be made by following the drawings shown in Figs. 63, 64 and 65. The base is a block of wood 3 inches wide, 6 inches long and ¾ inch thick.

The *supports* which hold the lever up off the base are pieces of brass about ⅛ inch thick, ¾ inch wide and 1 inch high. The lower end is bent over ¼ inch while in the upper end of each support there is drilled a ⅛ inch hole and through the lower edge two ⅛ inch holes are drilled as shown in Fig. 62.

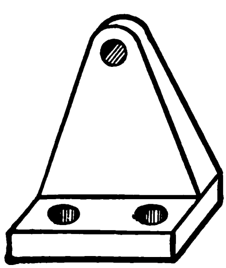


FIG. 62.—SUPPORT FOR KEY.

The lever, shown in Figs. 63 and 64, is a straight bar of brass ⅜ inch thick, ½ inch wide and 5 inches long. A ⅛ inch hole is drilled through each end of the lever, one for the adjusting screw (see Fig. 63) and the other for the screw holding a silver contact disk on one side and a hard rubber button on the other side. A ⅛ inch hole is also drilled through the thin side of the lever and at a distance of 1½ inches from the end in which the adjusting screw is placed. This hole is for the screw that holds the lever between the supports. All these holes are to be tapped with what is called 8-32 tap (see Appendix C); that is threads have to be cut in the brass where the holes are drilled.

The upper silver contact disk (see Fig. 63) is soldered to the head of a flat-headed machine screw which is screwed through the lever and into the hard rubber button. The lower silver contact disk is also soldered to a flat-headed machine screw, a washer is put on and the screw set in a hole in the wood base. In the bottom of the base a hole ⅜ inch in diameter is bored halfway through to meet the hole in which the contact screw is set and on the bottom of the screw is placed a nut. The silver disks, which are about $\frac{1}{32}$ inch thick and $\frac{1}{2}$ inch in diameter, may be bought of almost any jeweler for about a quarter, while the

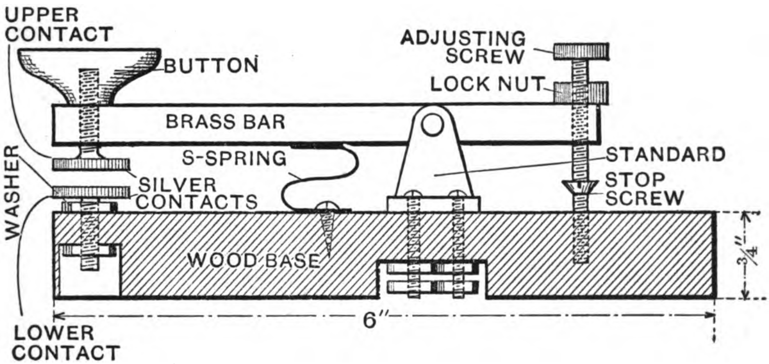


FIG. 63.—SIDE VIEW OF KEY.

hard rubber button may be bought from a dealer in electrical supplies for about 6 cents.

The brass supports are held to the base by machine screws

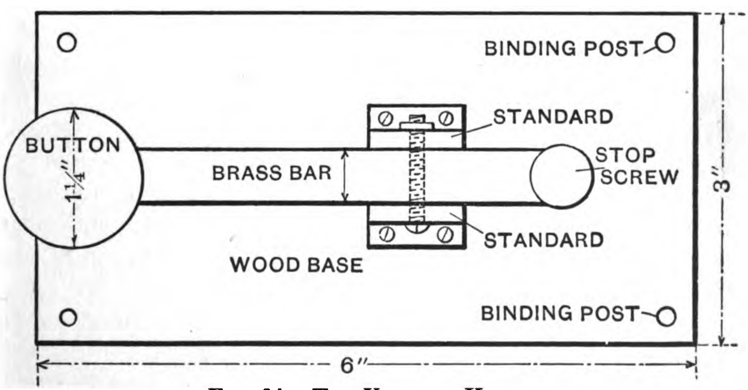


FIG. 64.—TOP VIEW OF KEY.

with nuts put on them, a hole being bored out of the bottom of the base for this purpose. The lever is held in place between the brass supports by a machine screw as shown in Fig. 64. The S spring is made of a strip of spring brass and is screwed to the base but not to the lever. A flat-headed machine screw is screwed through the back of the base under the adjusting screw and serves as a *stop* for the lever, that is it prevents the front end of the lever from flying up when released. Finally two binding posts are screwed on the back of the base.

The lever is connected with one of the binding posts by a piece of insulated wire hooked around one of the screws which

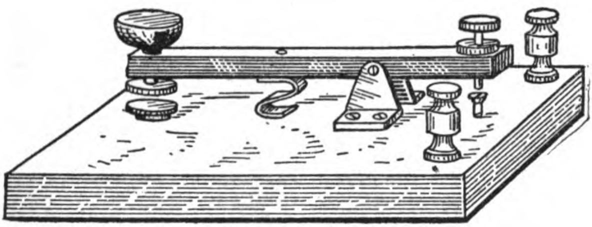


FIG. 65.—KEY COMPLETE.

holds the supports to the base, as shown in Fig. 63. The lower contact is connected to the other binding post, but this connection is not shown. Fig. 65 shows the key complete.

The Water Resistance.—Where an alternating current is used, some means must be provided to allow a certain amount of current, which must be neither too large nor too small, to flow into the primary coil of the transformer.

The amount of current depends upon the size, or *capacity,* as it is called, of the Leyden jars. If the primary current is larger than the jars can take, the spark will be thin and red; if the current is too small, the spark will be weak. Hence a variable resistance is needed to get the amount of current that is exactly right for the capacity of the Leyden jars.

There are many ways to regulate the current flowing into the primary coil, but a water resistance is the easiest and cheapest to make. Take a gallon jar, either of glass or of earthenware, and make a wood cover to fit it as shown in Fig. 66, which is a cross-sectional view of the resistance.

On the wood cover screw two binding posts near the edge

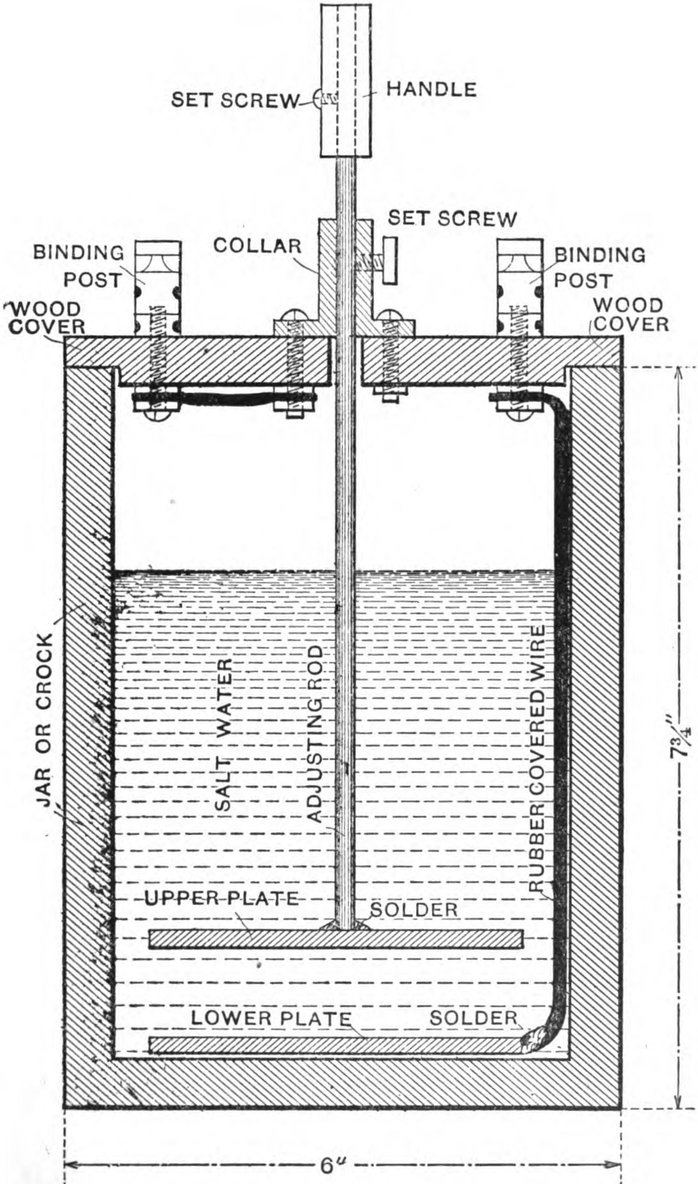


FIG. 66.—CROSS SECTION VIEW OF WATER RESISTANCE.

(see Figs. 66 and 67) and in the center screw on a brass *collar* having a *flange* and fitted with a *thumb screw*. This collar should have an inside diameter of ¼ inch, and be about 1¼ inches

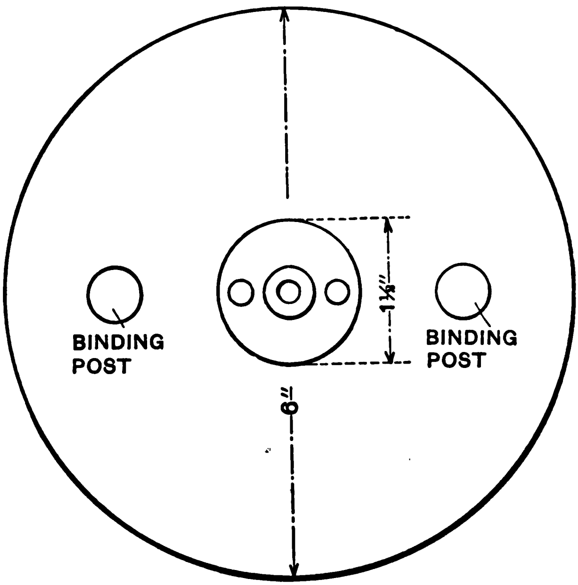


Fig. 67.—Top View of Water Resistance.

high. It is shown full size in Fig. 68. It is connected with one of the binding posts by a bit of heavy insulated wire.

Now solder a disk of copper, or galvanized sheet-iron, of such size that it can move freely up and down in the jar, to one end of a brass rod $\frac{3}{16}$ inch in diameter and 4 inches longer than the height of the jar.[1] To another disk of copper, or galvanized iron, of the same size as the first, solder a piece of rubber-covered wire and after placing this disk in the bottom of the jar bring the wire up the side of the jar and connect the end with the other binding post.

[1] As gallon jars vary in height and diameter, the length of this rod cannot be accurately given.

Pour ¾ gallon of water into the jar; throw in a handful of salt, and this piece of apparatus is ready for use.

The Condenser.—With an alternating current transformer the current at the ends of the secondary coil is so large that when the first spark passes, the current continues to flow across the gap in the form of a flaming arc.

To produce a succession of sparks a condenser is used and the Leyden jar condenser is one of the best known forms. When the current from the ends of the secondary coil charges the Leyden jars, these discharge across the spark-gap and this sets up high-frequency electricity.

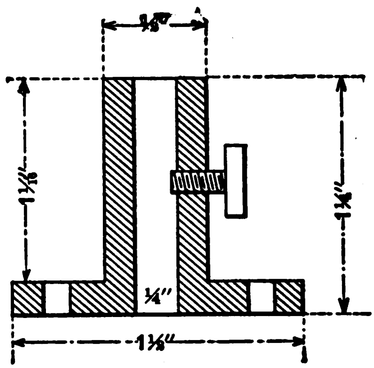


Fig. 68.—Cross Section of Collar.

To make a condenser get six half-gallon glass jars and a pound of *tin foil.* Clean and dry the jars thoroughly; next cut the tin foil into strips which will just cover the inside and the outside of the jars to within one-third of their tops. To fasten the sheets of tin foil to the jars get some shellac varnish and lay it on the inside of the jars first; take a sheet of tin foil and place it inside on the surface of one of the jars and rub out all the wrinkles and uneven places.

A circular sheet of tin foil must also be placed in the bottom so that it will overlap the sheet of tin foil around the inside. Next shellac the outside of the jar and cover it with tin foil the same way. When all the jars are done, shellac them all over, inside and out, glass and tin foil, several times, allowing enough time for them to dry after each coat is put on.

The covers for the jars should be made of wood and turned in a lathe to fit the necks closely. To each cover a binding post is screwed and to the screw of the binding post on the under side a thin brass spring is fastened as shown in the cross-section view of Fig. 69, while Fig. 70 is a view of the spring in *perspective.* This spring will pass through the neck of the jar and once inside will spring out and make a good contact with the inner coating of tin foil. Fig. 71 shows a Leyden jar complete.

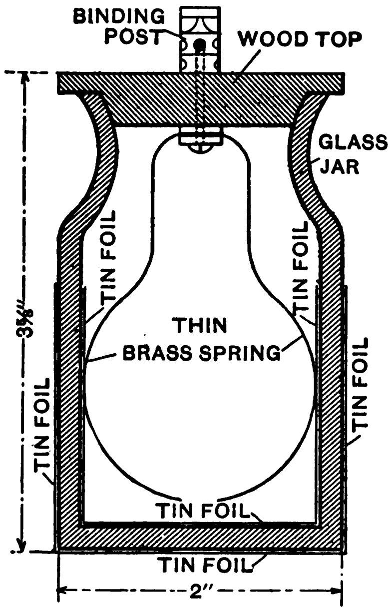


Fig. 69.—Cross Section View of Leyden Jar.

To hold the jars in position make a wood box 17 inches long, 12 inches wide and 6 inches high and screw on four porcelain insulators to the bottom. Solder a piece of wire to a sheet of zinc or brass, lay it in the bottom of the box and connect the wire to the screw holding a binding post to the outside of the box, as shown in Fig. 72.

The jars are set in the box on the sheet of zinc or brass and this connects all the outer surfaces of the jars together. The binding posts on top of the jars are connected up with pieces of heavy insulated wire as shown in Fig. 72. By this arrangement any one or any number of jars can be *cut in* or *out* and this makes the Leyden jar condenser adjustable. Fig. 73 is a picture of the condenser complete.

The Spark-Gap.—A spark-gap apparatus to carry half a horse-power or more of electricity must be of goodly size or there will be a great loss of energy, due to overheating.

A spark-gap for ½ kilowatt set should be mounted on a slate or marble base 4½ inches long, 3 inches wide and ½ inch thick as shown in Figs. 74, 75 and 76.

Make two supports of brass rod 1½ inches long, 1 inch wide and ½ inch thick, as in Fig. 77. Drill two holes in one end of each support and tap the holes to fit 8-32 machine screws which are to hold the supports to the slate base.

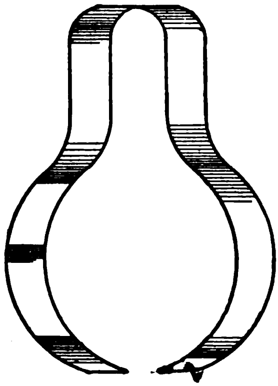


Fig. 70.—Spring of Leyden Jar.

Fig. 71.—Leyden Jar Complete.

In one of the supports drill a hole $\frac{5}{16}$ inch in diameter and thread it with a ⅜ inch tap cutting 18 threads to the inch to fit

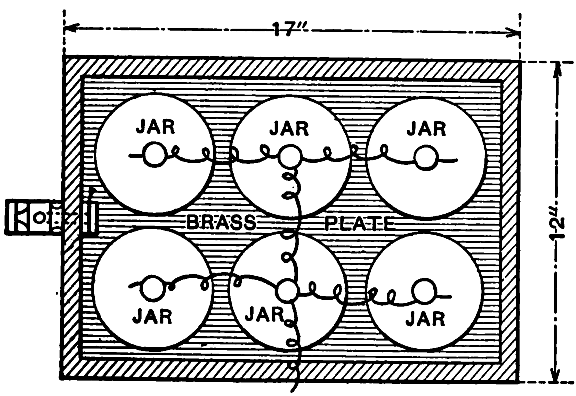


Fig. 72.—Top View of Leyden Jar Condenser.

the adjusting screw, see Figs. 74 and 75. Cut a *slot* with a *hack saw* in the top of the support, down through the hole and to $\frac{3}{8}$ inch below it. Through the upper end of the support, and at *right angles* to the big hole and the slot, drill a hole for a set

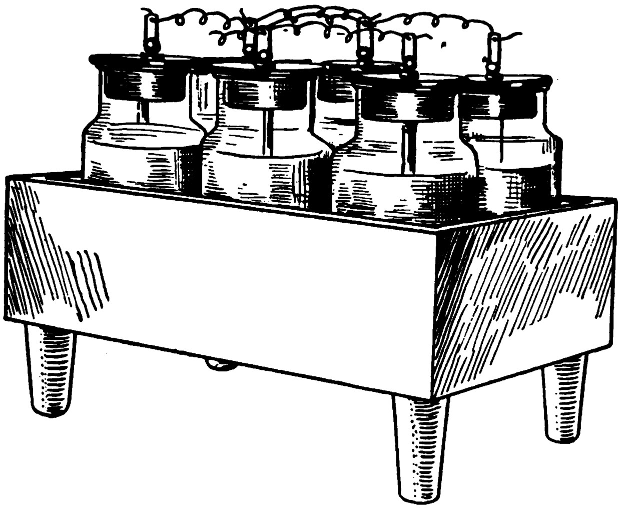


FIG. 73.—LEYDEN JAR CONDENSER COMPLETE.

screw. The purpose of the slot is to give plenty of freedom to the adjusting screw when needed and when the proper adjust-

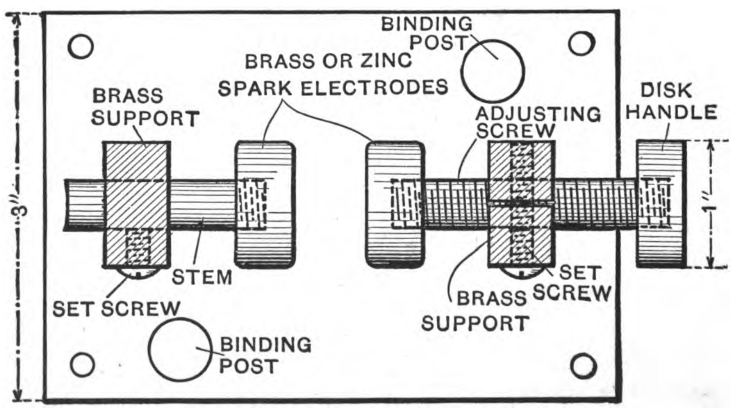


FIG. 74.—TOP VIEW OF SPARK-GAP.

ment has been made to permit the set screw to draw the ends of the support together and so hold the adjusting screw tight.

The other support is like the one just described except the

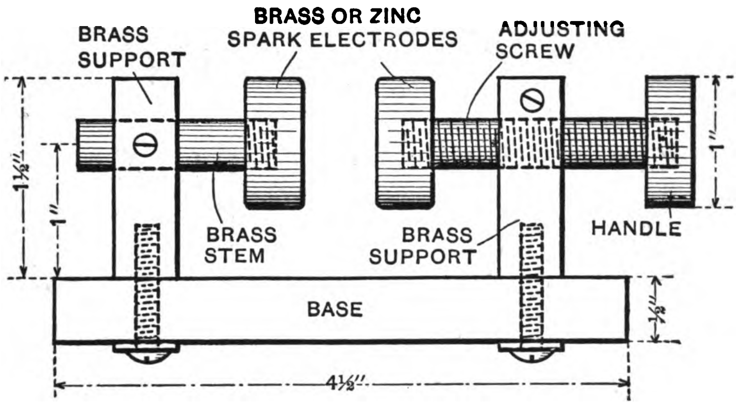


Fig. 75.—Side View of Spark-Gap.

large hole near the top is ⅜ inches in diameter and is *not threaded* and the set screw reaches through the support to the

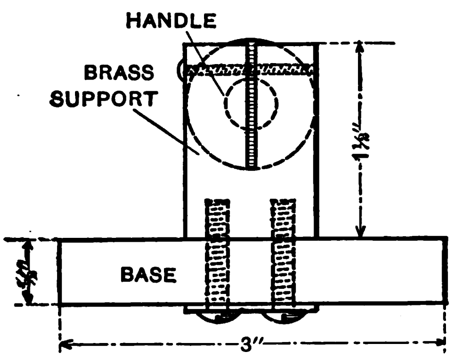


Fig. 76.—End View of Spark-Gap.

hole only, as shown in Fig. 74. The two supports are now screwed to the base as shown in Figs. 75 and 76.

To make the adjusting screw cut a piece of brass from a rod $\frac{7}{8}$ inch in diameter and $2\frac{1}{4}$ inches long, cut threads on this rod so that it will fit the threaded support. On one end of the adjusting screw, screw a disk of hard rubber or hard wood

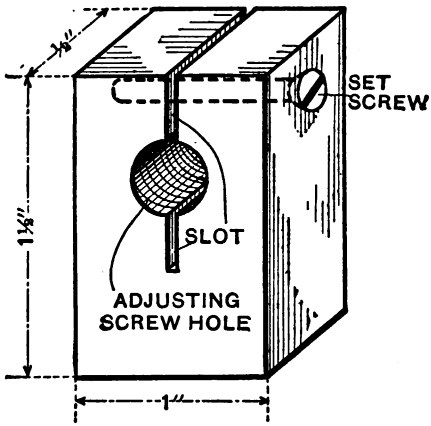


Fig. 77.—Adjusting Screw Support.

$\frac{3}{8}$ inch thick and 1 inch in diameter, as shown in Fig. 78. Now screw the adjusting screw in the support. For the *stem* cut a piece of brass $1\frac{1}{2}$ inches long and thread it at one end; slip it

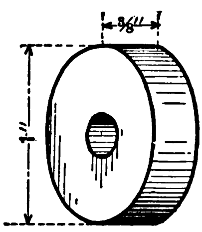


Fig. 78.—Adjusting Handle.

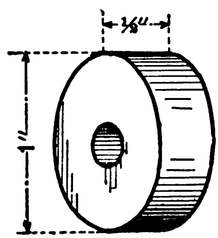


Fig. 79. — Brass Spark Electrode.

through the hole in the other support and screw up the set screw, as shown in Fig. 74.

Make, now, two spark *electrodes* of brass rod 1 inch in diameter and $\frac{1}{2}$ inch thick and drill and tap threads in these (see Fig. 79) and screw one to the end of the adjusting screw and the other to the end of the stem, and the spark-gap is completed as shown in Fig. 80.

The Tuning Coil.—This simple but important *device* is the chief means by which the transmitter is tuned and waves of the greatest force are sent out.

A tuning coil for sending is merely a large number of turns of heavy wire wound in a *spiral form* or *helix,* as it is called.

To make a tuning coil, cut out two disks of well-seasoned

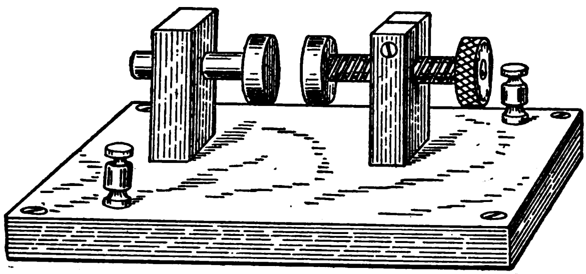
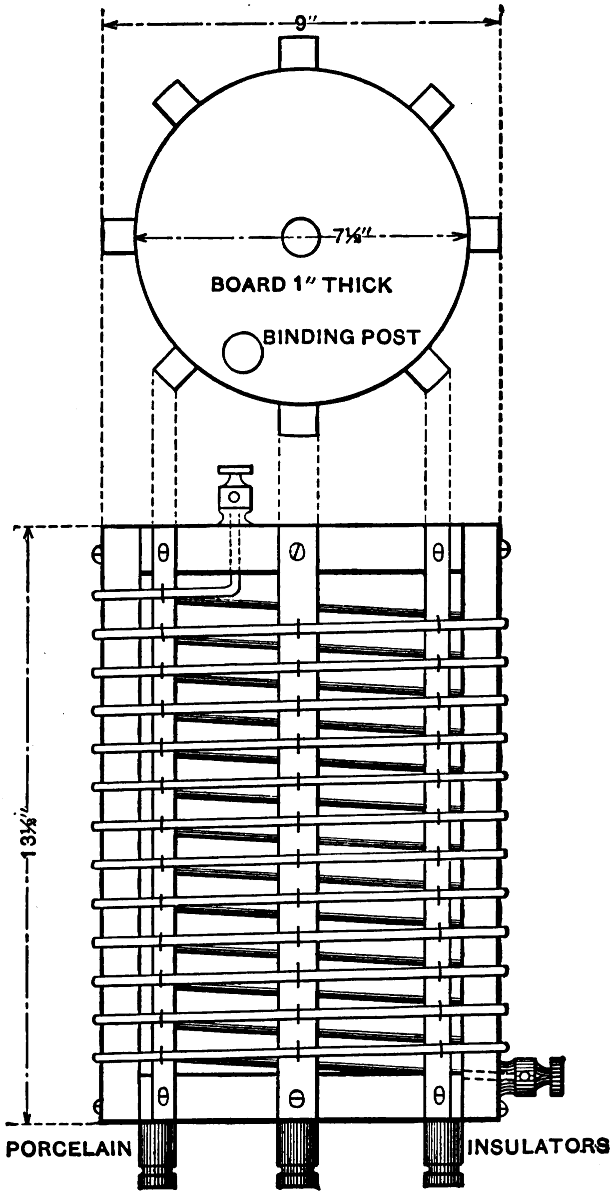


FIG. 80.—SPARK-GAP COMPLETE.

wood 1 inch thick and 7½ inches in diameter. Screw on with round-headed wood screws to these disks 8 sticks of hard wood ¾ inch square and 13½ inches long, as shown in Figs. 81 and 82 and so forming a sort of drum.

Next get 32 feet of brass wire ¼ inch in diameter and wind it on a form made of wood that is about 7 inches in diameter so that the turns of wire are close together. When the wire is taken off this form and placed over the drum it will be found to fit it snugly. Turn up one end of the wire and cut threads on the end so that a binding post can be screwed on to it. Thread the other end the same way. Pass the bent end through a hole in the top of the disk as shown in Fig. 82, screw on the binding post and slip the other end through a hole in one of the lower strips and screw on another binding post.

To hold the wire in place drive *insulated staples* over the turns of wire where they cross the strips. Finish the tuning coil by screwing on to the bottom three blocks of wood, or better,



Figs. 81 and 82.—Top and Side View of Tuning Coil.

porcelain knobs, for legs, all of which is shown clearly in Figs. 82 and 85.

To connect the coil with the other parts of the apparatus and with the aërial wire make three clips of brass as shown in Figs. 83 and 84. Cut six strips of spring brass $\frac{3}{8}$ inch wide and 2 inches long as shown in Fig. 83; bend the end of each piece to fit the wire of the coil and place the straight ends of a pair of these pieces on opposite sides of a thin piece of wood, *hard fiber* or brass and drill a hole through them for a small machine screw; push this screw through the pieces and screw a small

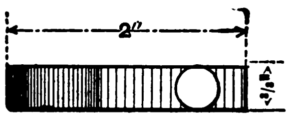


FIG. 83. — TOP VIEW OF SPRING CLIP.

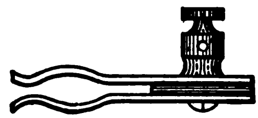


FIG. 84.—SIDE VIEW OF SPRING CLIP.

binding post on tight as shown in Fig. 84. The coil complete is shown in Fig. 85.

Connecting up the Apparatus for Alternating Current.— Having all of the parts of the transmitter at hand, lay them out on your operating table somewhat after the plan shown in Fig. 86. It really doesn't matter just how the different parts are placed on the table, though the key should be conveniently near the right-hand lower corner and the water resistance close to it on the right-hand side so that the current can be *varied* easily.

The transformer may set well back and the spark-gap can be screwed to the wall where its action can be easily seen and yet be well out of the way. This will be better than to have it screwed to the table in the position shown. The tuning coil should be set so that the clips can be changed from one turn of wire to another easily. The condenser will seldom have to be touched.

In bringing in the electric light *leads* see that they are properly put up in accordance with the Fire Underwriters' Rules which will be found in full in Book III, Chapter III, page 199.

While all of the connections are shown in the plan view

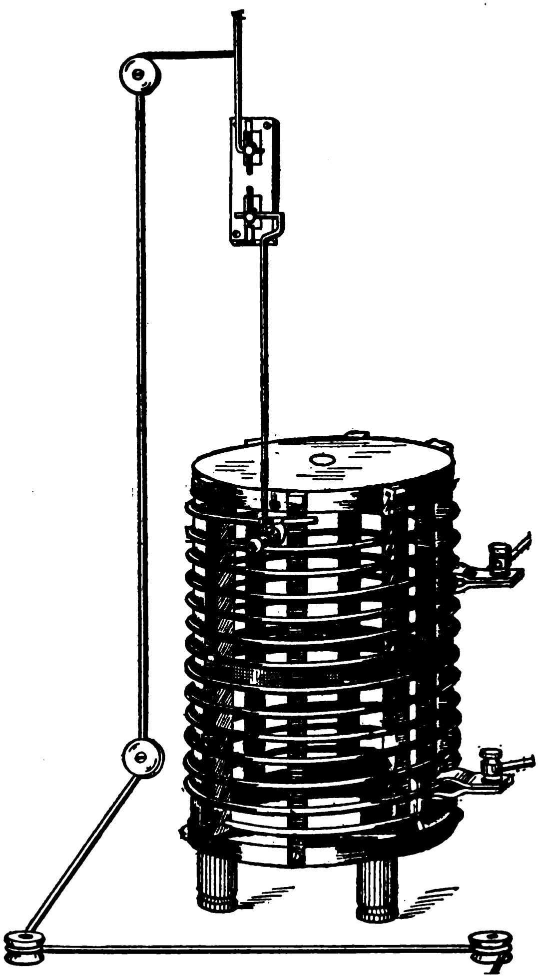


FIG. 85.—TUNING COIL COMPLETE.

Fig. 86, the *wiring* diagram, Fig. 87, gives a clearer idea of the connections. For wiring up the different parts, use No. 12

or 14 insulated electric light wire. The transmitter complete is shown in Fig. 88.

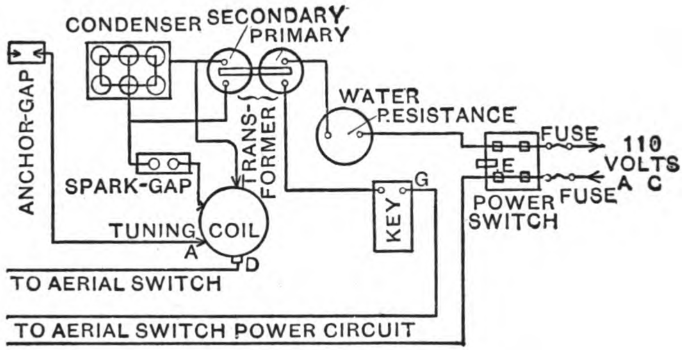


FIG. 86.—PLAN VIEW OF INSTRUMENTS ON TABLE.

Connecting up the Apparatus for Direct Current.—Where direct current only is to be had an *electrolytic interruptor* must

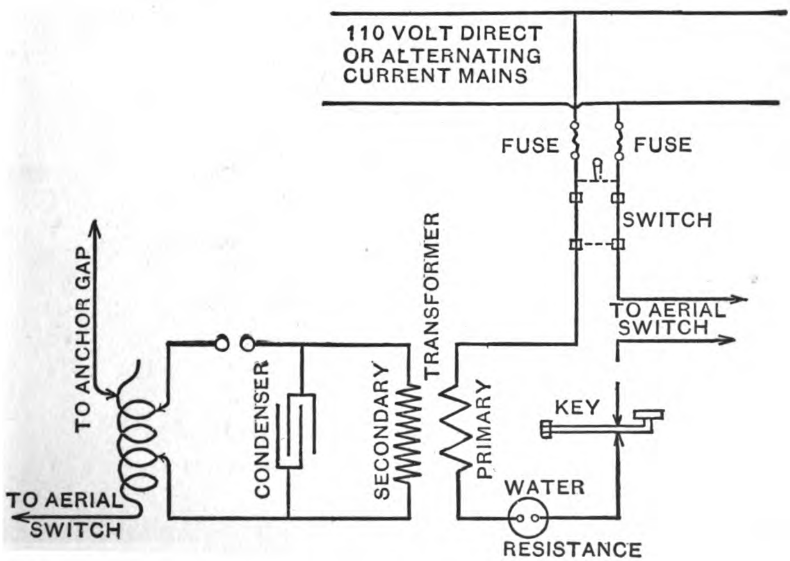


FIG. 87.—WIRING DIAGRAM OF CONNECTIONS.

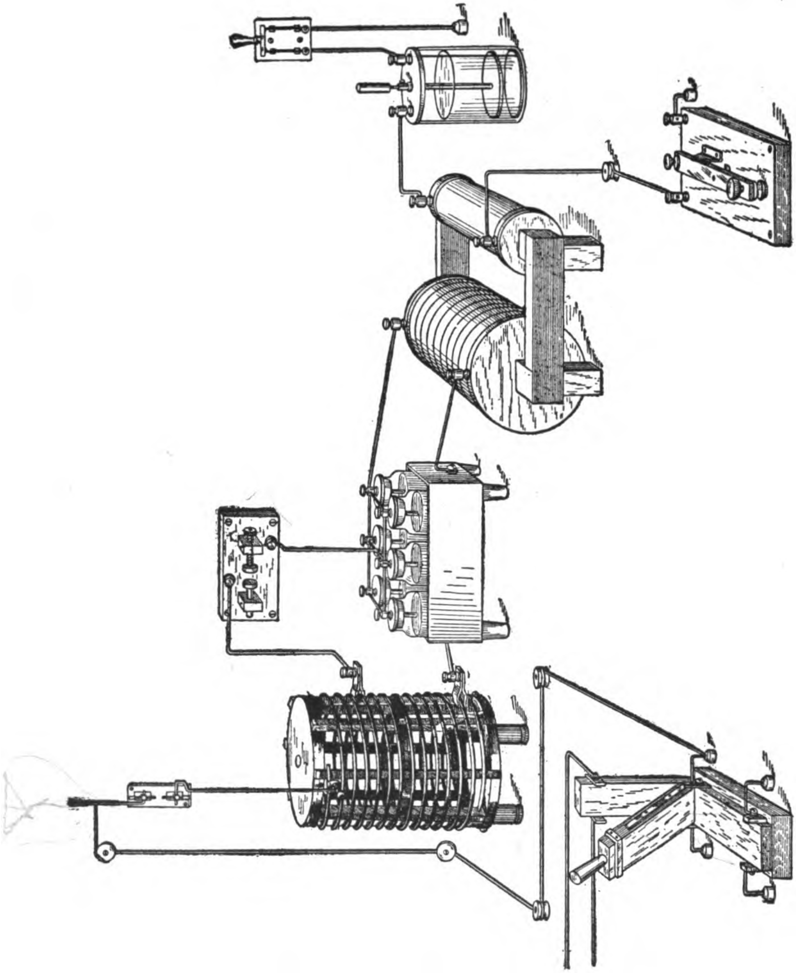


FIG. 88.—TRANSMITTER COMPLETE AND READY FOR SENDING.

be used to operate the transformer. When an electrolytic interruptor is used the water resistance is not needed, as the amount of current can be varied by adjusting the interruptor.

The interruptor is connected in the primary circuit exactly the same way as the water resistance so that no change in the wiring need be made. The construction of an electrolytic interruptor is given in Part III, Chapter II, page 191.

Adjusting the Transmitter.—After the apparatus is set up and connected with the aërial and ground raise the upper plate of the water resistance to nearly the top of the water so that the resistance will be high and hence keep too large a current from flowing through the primary of the transformer.

Have about four of the six Leyden jars connected together and set the spark-gap *electrodes* so that the gap is about $\frac{1}{8}$ inch long. Now close the switch in the main line circuit, close the key and watch the spark-gap. If no sparks pass, open the switch and let the plate down in the water a little farther. Repeat this operation until a good spark takes place in the gap.

When too much current flows in the primary of the transformer the spark will be red and stringy, and when this is the case use either less current or connect in more Leyden jars. The larger the number of Leyden jars the greater the amount of current which flows in the primary coil. When the current and the Leyden jars have been adjusted so that a good, white, snappy spark results, the switch is again opened and the spark-gap electrodes are *separated* until the gap is about $\frac{1}{2}$ inch wide.

Now change the position of the clips on the tuning coil, that is those clips which connect with the spark-gap and condenser until the longest sparks possible take place in the gap when the apparatus is roughly tuned.

A much better and easier way to adjust and tune the apparatus is to use a *hot-wire ammeter* and this piece of apparatus is described in Chapter IV, Part II, page 146.

COST OF TRANSMITTER WHEN BOUGHT OF DEALERS[1]

1 ½ kw. transformer	$20.00
1 regulating resistance	6.00
1 telegraph key	4.50
1 switch (double pole)	.50
1 tuning coil	10.00
1 condenser of 6-one-gallon or 12 half-gallon jars	15.00
1 spark-gap	5.00
1 fuse block	.25
1 roll of electric light wire	.50
1 dozen porcelain insulators	.25
Total	$62.00

COST OF TRANSMITTER WHEN HOME MADE

½ kw. transformer[2]

17 pounds sheet iron @ 6c	$ 1.02
3 pounds No. 13 double cotton-covered magnet wire @ 35c	1.05
5 pounds No. 34 double cotton-covered magnet wire @ $1.10	5.50
10 yards empire cloth	5.00
Base for coil	.25
2 binding posts	.20
Total	$13.02

Water Resistance

1 1-gallon jar or crock	$ .10
2 dishes of zinc or brass	.25
1 brass collar with set screw	.50
2 binding posts	.20
1 brass rod	.25
Total	$1.30

[1]The prices of the various parts of the apparatus as given below are only approximate and it is well to get prices from a number of dealers before buying.

[2]A full description with drawings for making a ½ kilowatt transformer is given in Chapter I, Part III, page 153.

Telegraph Key

Wood base	$ .10
Brass bar	.20
Adjusting screw	.10
2 supports	.30
Button	.10
2 silver contacts	.25
Screws	.05
2 binding posts	.20
Switch double pole	.50
Fuse block	.25
Total	$2.05

Leyden Jar Condenser

6 1-gallon glass jars	$ .50
1 pound tin foil	.60
6 turned wood covers	.30
7 binding posts	.70
1 pint of shellac varnish	.10
Sheet brass for springs	.25
Wood box	1.00
Total	$3.45

Tuning Coil

2 wood dishes (top and bottom)	$ .20
8 wood strips 13½ inches long	.25
32 feet of ¼-inch brass wire	1.50
Brass wood screws	.10
Insulated staples	.20
3 porcelain insulators	.06
4 binding posts	.40
Spring brass for clips	.15
Flexible lamp cord for clips	.50
Total	$3.36

Spark-Gap

1 slate base	$ .25
2 brass supports cut and threaded	.50
1 adjusting screw threaded	.25
1 stem (threaded)	.15
1 hard rubber handle	.25
2 iron electrodes drilled and tapped	.50
2 binding posts	.20
Total	$2.10
Roll of electric light wire	.50
1 dozen porcelain insulators	.30
Total cost of transmitter	$26.02

CHAPTER II

THE RECEPTOR

A good wireless receptor which will give you a lot of pleasure and service can be easily made—except the head telephone receiver—by following the drawings and descriptions given in this chapter.

While this *receptor* is not the best that can be made, still messages up to 500 miles or so can be received with it, the distance, of course, depending upon the length and height of your aërial, the power of the sending station and the adjustment of the apparatus.

There are a large number of wireless boys who have only a receiving apparatus connected with their aërials, and although they cannot send messages they can receive them from any station within their range.

The Government has a great wireless station at Arlington, Virginia, which has a sending range of over 3,000 miles and there are other Government stations scattered all over the United States, all of which send out the standard time daily and if you live within signaling range of one of these stations you can receive the correct time every day without cost. A Government license is not required where only a receiving set is used.

The various parts needed for a receiving set are:

(1) A *tuning coil,* for tuning the aërial wire so that waves of only a given length can be received. Thus any station can be *tuned in or out* as desired.

(2) A *crystal detector,* for changing the high-frequency currents which surge in the aërial wire and tuning coil into a direct current, capable of operating the telephone receiver.

(3) A *small condenser,* which with the tuning coil and the detector forms a closed circuit.

(4) A *telephone receiver,* for changing the direct current passing through the detector into sound waves so that the ear hears them as dots and dashes.

(5) An adjustable resistance, called a *potentiometer,* for

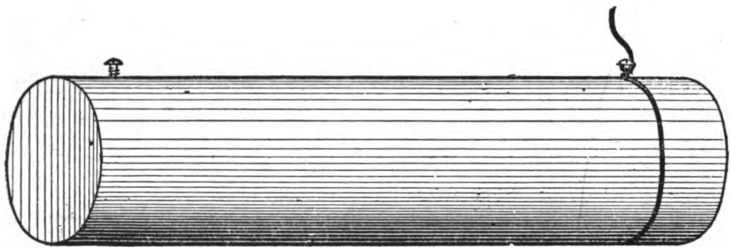


FIG. 89.—WOOD CORE OF TUNING COIL.

regulating the amount of current flowing through the detector from a dry cell.

(6) A *dry cell* for producing the current which flows through the detector, and

(7) A *small switch,* for opening and closing the dry cell circuit.

The Tuning Coil.—For this receptor the tuning coil should have three sliding contacts so that any station can be tuned in or out and the incoming signals made as strong as possible.

The tuning coil consists of a frame which holds:

(1) A core made of a cylinder of wood or a piece of glass tubing on which is wound (2) a single layer of insulated wire, the insulation being scraped off on three sides of the coil so that (3) the brass sliders whose springs make contact with the turns of wire can be moved freely back and forth over them.

To make the tuning coil get a wood worker to turn for you a cylinder of well-seasoned hard wood 8½ inches long and 2¾ inches in diameter and boil it in paraffin.

In this cylinder ½ inch from each end put a small wood screw as shown in Fig. 89, when it is ready for the wire. The best kind of wire for this purpose is known as *enameled wire* but if you cannot get this easily use double cotton-covered magnet wire. A ½ pound of No. 32 wire, Brown and Sharpe gauge, will be enough of either kind.

Before you begin to wind the wire on the cylinder twist an

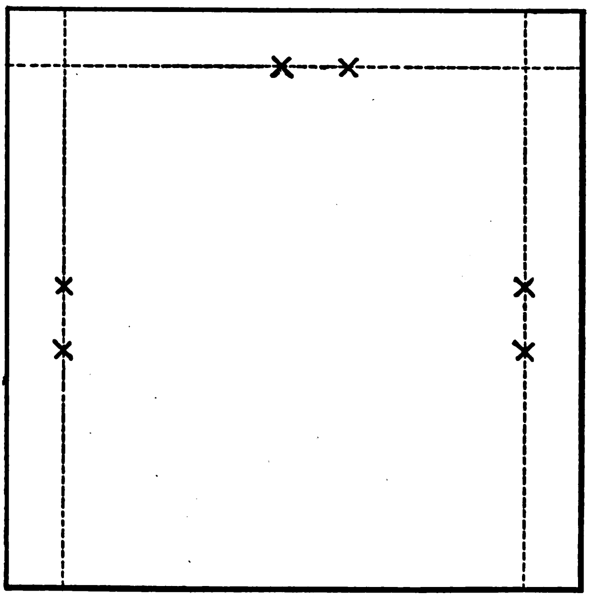


Fig. 90.—Cheeks of Coil.

end of the wire around one of the screws and put the screw in tight with a screw-driver as this end is not to be connected with anything. As you wind on each turn of wire draw it tight and press it up close to the last turn. When you have wound on enough wire so that the turns reach the screw at the other end, twist the wire around the screw and drive it down tight, but do not cut the wire off short, for this end is to be connected with a binding post.

If cotton-covered wire is used it should be well shellacked

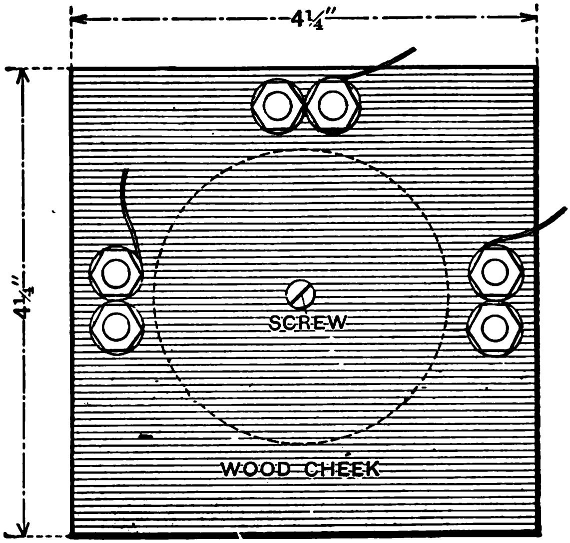


FIG. 91.—END VIEW OF TUNING COIL.

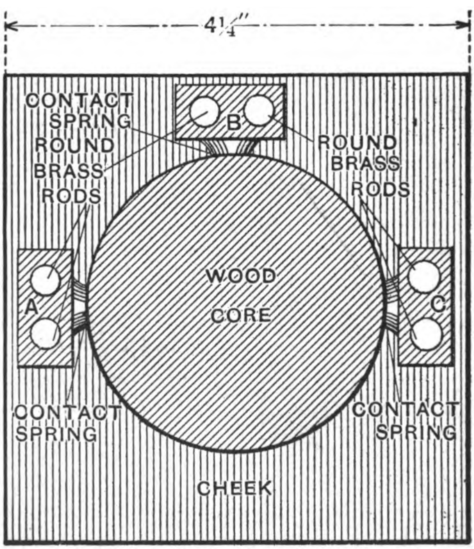


FIG. 92.—CROSS SECTION OF TUNING COIL.

and allowed to dry before assembling. But whether the wire is enameled or cotton-covered the insulation must be scraped off on a line ½ inch wide and the whole length of the coil on the three sides where the springs of the sliders are to make contact with the wire.

FIG. 93.—BINDING POST WITH WOOD SCREW.

With enameled wire this is an easy thing to do and a neat job will result, but with cotton-covered wire it is not so easy and a poor-looking job is likely to come of it. For this reason it is better to use enameled wire if it can be had.

The cheeks of the coil, as the wooden ends are called, are next in order. These should also be made of well-seasoned hard wood and should be 4½ inches square and ¾ inch thick. Now on each of the three sides draw a line ⅜ inch from the edge as shown on Fig. 90 by the dotted lines.

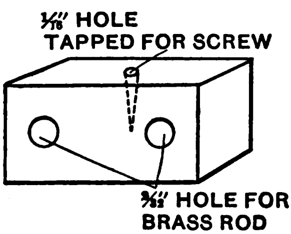


FIG. 94.—SLIDES FOR TUNING COIL.

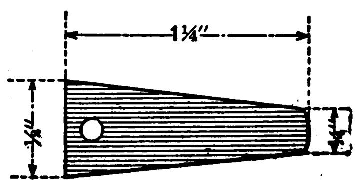


FIG. 95.—BRASS PLATE FOR CONTACT SPRING.

Measure from the middle of these lines ¼ inch each way, and make a point with a pencil and drill a hole 3/16 inch in diameter. This will make six holes, two on each side and the holes on each side will be ½ inch apart, from center to center, all of which is clearly shown in Figs. 91 and 92.

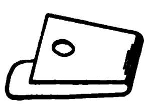


FIG. 96.—CONTACT SPRING FINISHED.

Smooth the cheeks up with sandpaper and give them a coat of shellac varnish, and when dry screw them to the ends of the wooden coil with a wood screw and see that the coil is exactly in the centers of the cheeks as shown in Figs. 91 and 92. On the edge of the cheek nearest the free end of the wire on the core put in a binding post having a wood screw on its base, as shown in Fig. 93.

Having made all of the easy parts of the coil you will now come to something a little harder—in metal. Get six pieces of round brass rods each of which is 10¾ inches long, and ¼ inch in diameter; cut threads on the ends of these rods about ¾ inch down and get 24 washers large enough to slip over the rods, and 12 brass nuts to fit the threads cut on the rods.

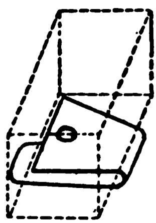


FIG. 97.—CONTACT SPRING ON SLIDER.

The next and last thing to do is to make the sliding contacts. These *sliders*, as they are called, are made of brass. Get three pieces of brass ½ inch square and 1 inch long, as shown in Fig. 94, and drill two holes in each one 9/32 inch in diameter and so that the centers of the holes are exactly ½ inch apart. These holes will have to be drilled very true or the sliders, when they are put on the rods, will not run smoothly.

Drill and tap a 1/16 inch hole in each slider between the larger holes but on a side at right angles to them as shown in Fig. 94. Spring brass will do for the springs which make contact with the wire of the core but springs made of phosphor-bronze are better. Make three springs of sheet brass or phosphor-bronze 1¼ inches long, ½ inch wide at one end and ¼ inch wide at the other end, as shown in Fig. 95; screw each spring to a slider and bend it over as shown in Fig. 96. Drill a 1/16 inch hole through the wide end of the spring and screw it to the brass slider block as shown in Fig. 97.

The next step is to put the tuning coil together. Slip a pair of the brass rods through the holes in each of the sliders and push the ends of the rods through the cheeks of the coil, when the contact springs should rest on the turns of wire where the insulation has been scraped off. Next slip a pair of washers over the ends of each rod and screw on the nuts.

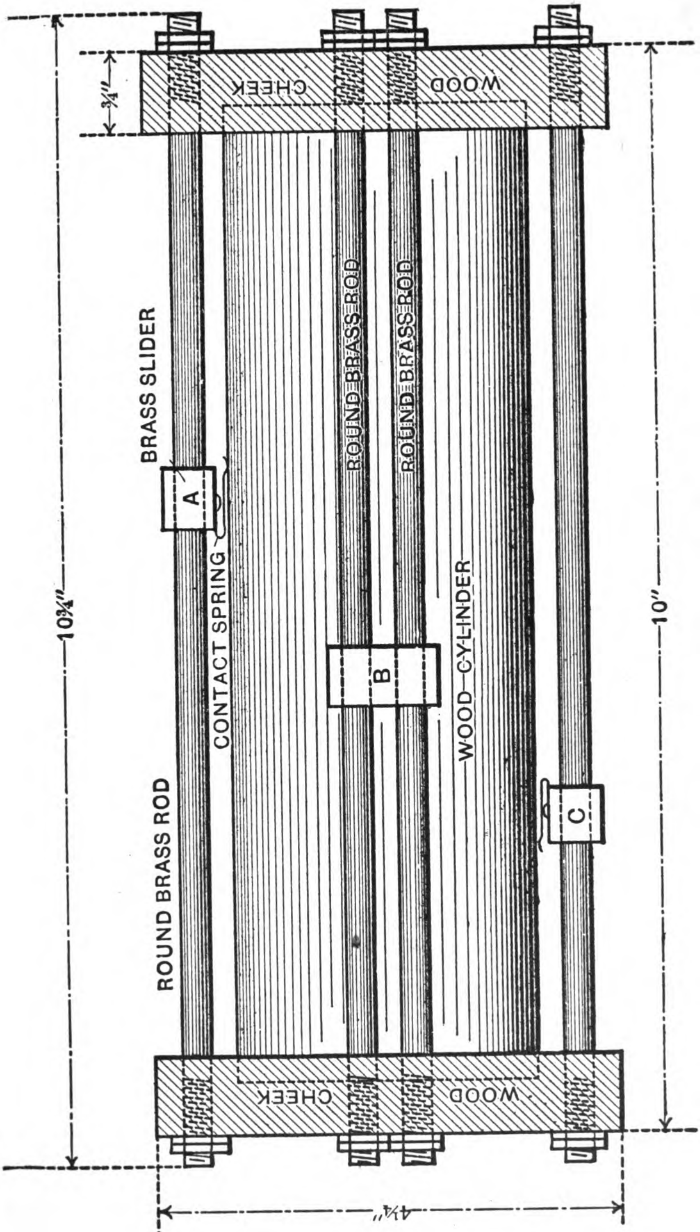


FIG. 98.—TOP VIEW OF TUNING COIL.

Before tightening up the nuts cut off three pieces of heavy insulated wire about 4 inches long and after scraping the ends bright loop them around the rods between the washers as shown in Figs. 91 and 99. These wires are to connect the sliders with the ground, the condenser, and the detector as shown in the plan

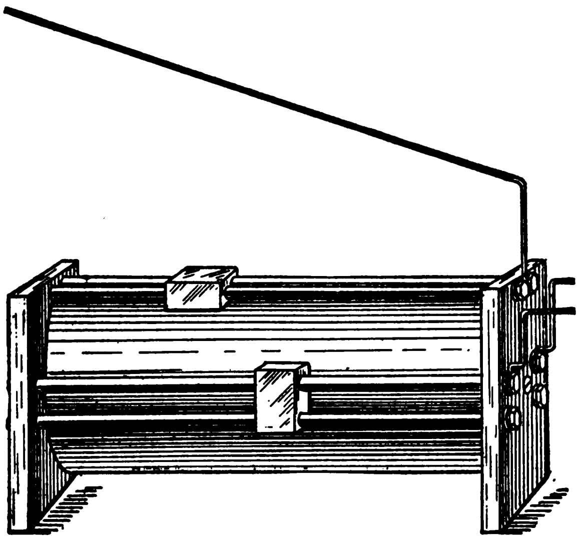


FIG. 99.—RECEIVING TUNING COIL COMPLETE.

and the wiring diagrams, Figs. 127 and 128. Fig. 98 shows a top view of the completed tuning coil, the cheeks being drawn in cross-section to show the rods a little better. The tuning coil complete is pictured in Fig. 99.

The Crystal Detector.—This detector is a good one in that it is simple in design, there is nothing to get out of order, its adjustment is fine enough for all ordinary working and it is almost as sensitive without using a dry cell as it is with one.

The base of the detector may be made of a good piece of seasoned wood but slate or marble is better as these last materials are better insulators. Whatever material you use get a piece 3

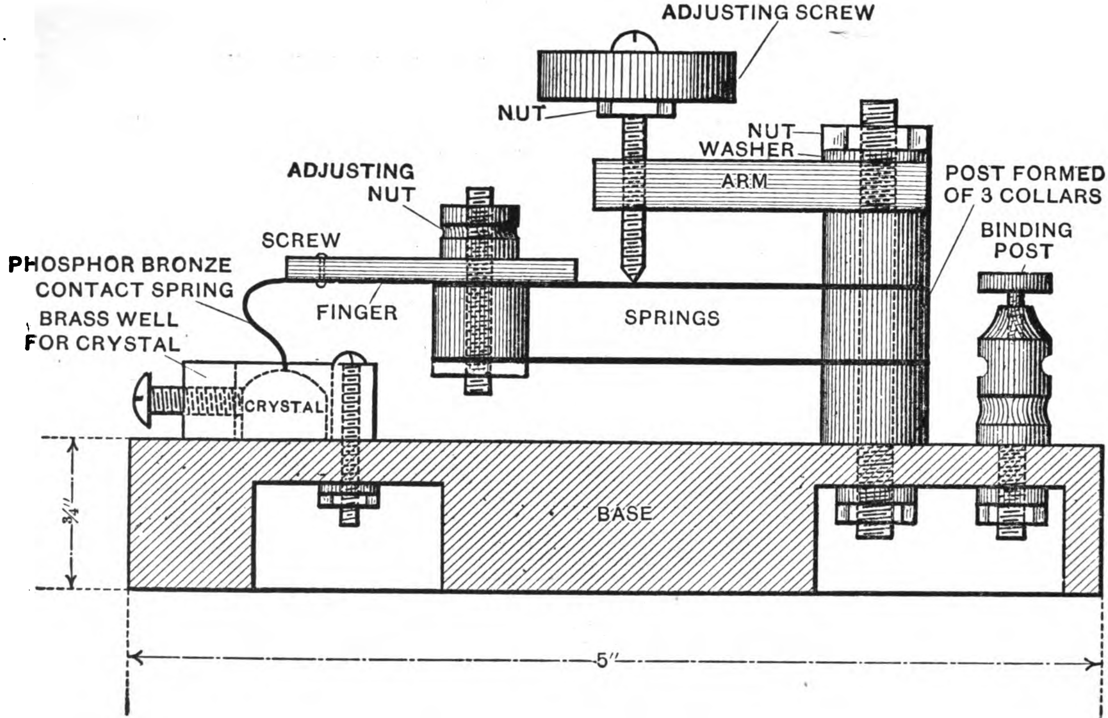


FIG. 100.—SIDE VIEW OF CRYSTAL DETECTOR.

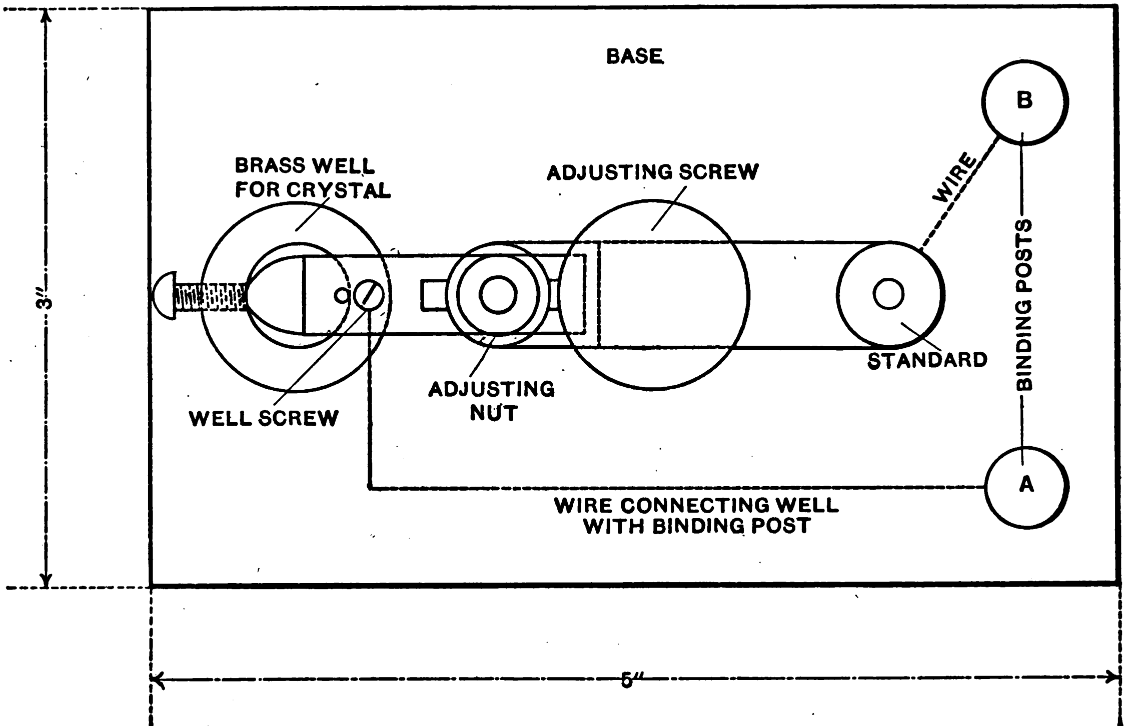


FIG. 101.—TCP VIEW OF CRYSTAL DETECTOR.

inches wide, 5 inches long, and ½ or ¾ inch thick. Drill three 3/32 inch holes in the base, two for the screws of the binding posts and one for the support; now at exactly 2¾ inches from the center of the hole for the support drill a 3/32 inch hole for the *well* screw as shown in Figs. 100 and 101.

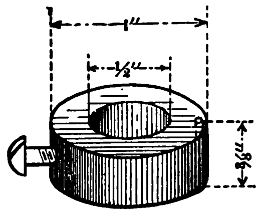


FIG. 102.—BRASS HOLDER OF CRYSTALS.

On the under side of the base *ream* out these holes until they are ⅝ inch in diameter and deep enough so that when the detector is put together the ends of the screws will not come below the bottom of the base. The top of the base should be perfectly smooth.

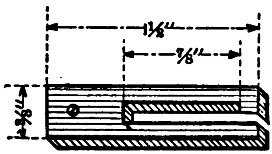


FIG. 103.—BRASS FINGER CONTACT.

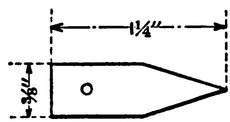


FIG. 104.—PHOSPHOR-BRONZE CONTACT SPRING (plate).

The purpose of the *well* is to hold any kind of a *crystal* tightly so that a good contact will be made. We will talk about the crystal presently. For the well cut a piece ½ inch long from a brass rod 1 inch in diameter and drill a hole ½ inch in diameter through it; also drill a 3/32 inch hole parallel with the large hole through the rim so that the well can be screwed to the base as shown in Fig. 100; now drill and tap a hole through the ring and put in a machine screw as shown in Fig. 102.

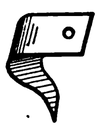


FIG. 105.—PHOSPHOR-BRONZE CONTACT SPRING (bent).

Next take a strip of brass 1½ inches long, ⅜ inch wide and ⅛ inch thick and saw out a slot in one end ⅞ inch long and 3/32 inch wide and drill a ⅛ inch hole through the other end as shown in Fig. 103. This piece is called a *contact finger*. A piece of sheet phosphor-bronze 1¼ inches long and ⅜ inch wide with one end cut to a point and a hole drilled in the other end, as in Fig. 104, is secured to the end of the finger with a screw. This permits the point which makes contact with the crystal to be taken off if needs be. The point is then bent as in Fig. 105.

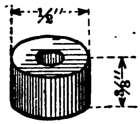


FIG. 106.—BRASS COLLAR.

The next step is to make four collars of round brass rod ½ inch in diameter, ⅜ inch long and drill holes through them 5/32 inch in diameter as shown in Fig. 106. Three of these collars are used to form the support which holds the springs and *adjusting screw arm* in position and the fourth collar is used to separate the free ends of the springs as shown in Fig. 100.

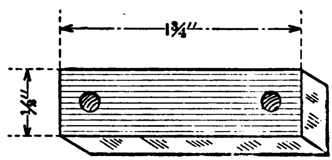


FIG. 107.—BRASS ARM FOR ADJUSTING SCREW.

The arm which holds the adjusting screw is made of a piece of brass 1¾ inches long, ½ inch wide and ¼ inch thick; drill a hole in each end, make one of them 3/32 inch in diameter and thread it and make the other 5/32 inch in diameter and leave this one smooth. The arm is shown in Fig. 107.

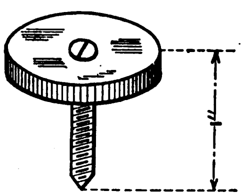


FIG. 108. — ADJUSTING SCREW.

The adjusting screw, Fig. 108, which fits into the threaded hole of the arm, is simply a machine screw 1¼ inches long with its end filed down to a point and having a disk of hard rubber, or of wood, 1 inch in diameter and 3/16 inch thick forced on up to the head of the screw; a nut on the under side will keep it from slipping.

Make two stiff springs of spring brass 2½ inches long, ½ an inch wide and about 1/64 inch thick (see Fig. 109). A 3/16 inch brass rod 2¼ inches long, and a 3/16 inch brass rod 1⅛ inches long and both of which have their ends threaded (Fig. 110), together with the adjusting nut (Fig. 111) and a pair of binding posts, complete the parts of the detector.

Now take the two large springs and place one of the brass collars between them at one end, slip the short threaded brass rod through them and screw on a nut. Slip the finger with the slot in it on the other end of the rod and screw on the adjusting nut. Put a collar between the springs at the other end and slip the longer threaded brass rod through the holes. Outside of each of the springs and over the rod slip a collar and on the collar next to the spring which carries the finger with the pointed contact set the adjusting screw arm, put on a washer and screw on a nut. Push the end of the rod through the hole in the base, put a couple of washers on the end of the rod on the bottom side of base and screw on a nut, all of which is clearly shown in the side view of the detector (Fig. 100).

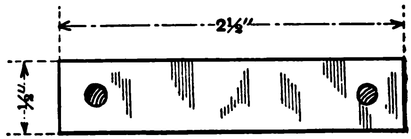


FIG. 109.—BRASS SPRING.

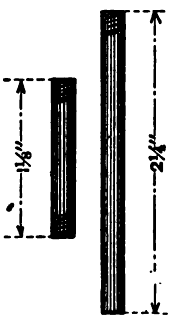


FIG. 110.—BRASS SUPPORT ROD.

Screw the binding posts to the base in their proper places and connect one of the binding posts with the brass well by means of a piece of insulated wire and the other binding post with the support as shown by the dotted lines in Fig. 101, and the frame of your detector is done. It is shown in its completed form in Fig. 112.


FIG. 111.—ADJUSTING NUT.

You will see that this detector has three means for adjustment, and these are: (1) The well can be moved from side to side; (2) the contact point can be moved forward and backward and from side to side, and (3) these two movements permit the phosphor-bronze point to be placed in any position on the surface of the crystal in the well, while the adjusting screw gives the needed pressure for bringing the phosphor-bronze point into contact with the crystal.

There are many kinds of crystals used in crystal detectors, but the kind known as *fool's gold,* or to call it by its right name, iron sulphid, works about as well as any, but silicon is largely used. But all kinds of iron sulphid will not work as a detector, so when you order be sure to say you want the bright crystalline kind.

The Condenser.—For this receiving set the condenser should be made of mica and tin foil. Mica is commonly called isin-

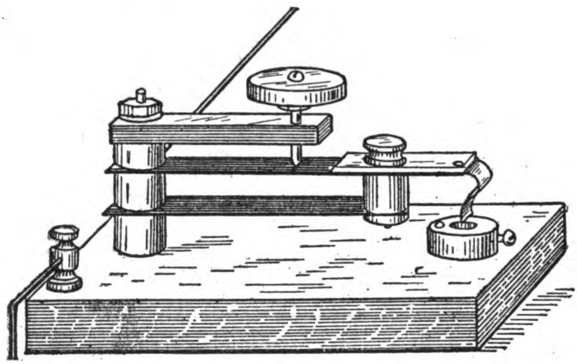


FIG. 112.—CRYSTAL DETECTOR COMPLETE.

glass and the kind used in parlor stoves will serve the purpose very well. Get 15 or 20 sheets of thin clear mica about 2 x 3 inches and be sure there are no holes in them. As this condenser cannot be varied the tuning must be done with the tuning coil.

Get enough tin foil to make 15 or 20 leaves 1½ x 3 inches; and lay these up alternately with the sheets of mica; that is lay a sheet of mica down first; then lay a sheet of tin foil on top of the mica as shown in Fig. 113, with the end of the tin foil lapping over the edge of the mica ¼ inch and on the right-hand side. This leaves a margin of mica ¼ inch all round on the other three sides.

Another sheet of mica is now laid on the tin foil, and another sheet of tin foil is laid on the mica, this time with the overlapping end on the left-hand side as shown in Fig. 114, and so on until all the sheets of mica have been used. The diagram (Fig. 114) shows the sheets of mica and leaves of

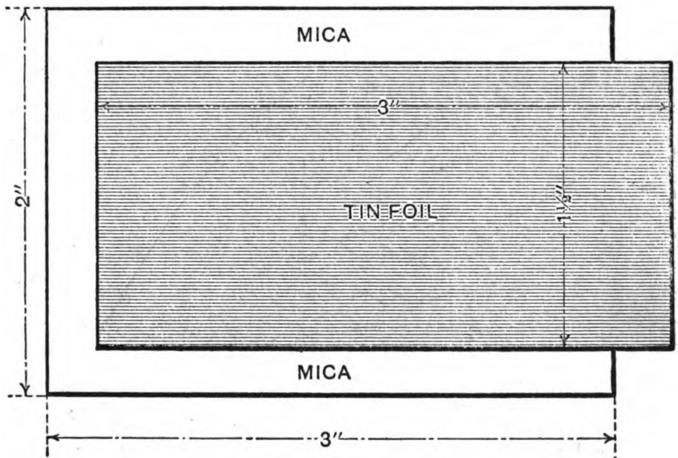


FIG. 113.—TIN FOIL LAID UP WITH MICA.

tin foil separated but, of course, when the condenser is actually laid up the sheets and leaves are close together.

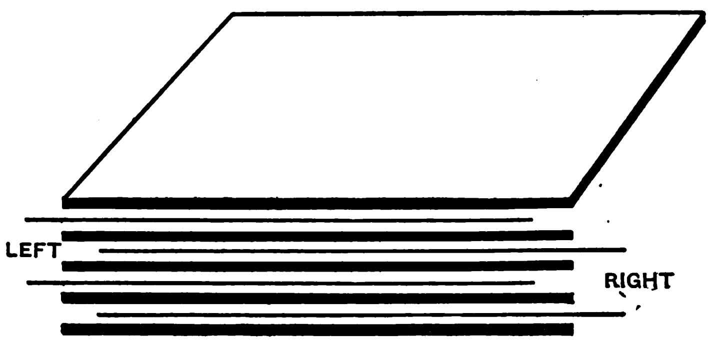


FIG. 114.—DIAGRAM SHOWING HOW MICA AND TIN FOIL ARE LAID UP.

After the condenser is laid up cut two pieces of stiff pasteboard the size of the mica, place one on each side of the condenser like the cover of a book, and put a rubber band round each end to hold the mica and tin foil in place.

The next thing is to solder a wire to each end of the con-

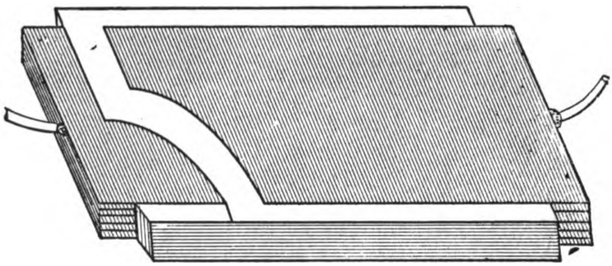


FIG. 115.—CONDENSER WITH SOLDERED ENDS.

denser. To do this place the condenser between a pair of smooth boards and screw it up in a vice with one end of the condenser up and above the boards. Sprinkle a little powdered rosin between the ends of the leaves of tin foil and then with a hot soldering iron melt some solder and let it fall a drop at a time on the tin foil. Do not touch the tin foil with the hot iron or it will melt away. Soon all the ends of the leaves will be melted in with the solder, and a firm metal edge will result as shown in Fig. 115.

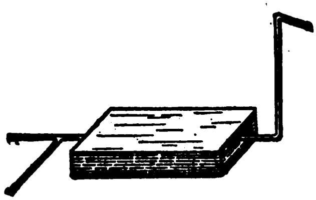


FIG. 116.—CONDENSER COMPLETE.

Now cut off two pieces of insulated wire about 4 inches long and scrape the ends clean. Lay an end of one of these wires on the soldered end of the condenser, sprinkle on a little rosin and hold your soldering iron on it until the solder runs just enough to hold the wire firmly.

Dip the whole condenser in melted paraffin several times until the paraffin has gotten into every crevice and then lay it on a table and put a flat-iron or other weight on it.

Make a little wooden box $2\frac{1}{2}$ inches wide, $3\frac{1}{2}$ inches long and

½ inch high on the inside. Drill two holes in the opposite ends of the box and draw the wires through the holes as shown in Fig. 116. Fill the box with melted paraffin and glue on the top. This makes a very good little condenser of what is called the *fixed* type, that is one whose capacity cannot be changed.

The Telephone Receiver.—A telephone receiver used for long distance wireless work is formed of two watch-case receivers connected with an adjustable head band so that it can be easily and quickly fitted to the head. The bands are made of strips of spring brass or steel and are either nickel-plated or covered with hard rubber or leather.

The ends of the head band are usually slotted and are attached to the cases of the receiver by means of a hinged joint, or, better, with a ball and socket joint; this latter kind of a joint gives a greater freedom of movement and allows the earpiece to be fitted closely to the ear and this helps the operator to hear the faintest sounds.

A telephone receiver to work properly with a crystal detector should have the coils of its magnets wound to a resistance of 1,000 ohms to 2,000 ohms. Usually the higher the resistance of the magnet coils of a telephone receiver the more sensitive it is, but there are other things which go to make a telephone receiver good, bad or indifferent.

With your pair of head telephone receivers you should buy a cord 6 feet long so that you can move freely about when you have them on, as this is a great convenience when you are sending and receiving.

Wireless telephone receivers cost anywhere from $3.00 to $12.00 a pair and so you must let your pocketbook be the judge of the price you pay. A pair of head telephone receivers is shown in Fig. 117.

The Potentiometer (Pronounced po-ten′-she-om′e-ter).—Potentiometer is a big word and means an apparatus for measuring electric pressures. It is a word which never should have been used for the *variable resistance* of a wireless receiving set since electric pressures, which are set up by the dry cell, are not measured but simply varied to meet the needs of the detector. But since the word is used by all wireless workers, right or wrong, we must accept it and use it too.

There are very few crystals used in wireless which need a battery current to make them work. The reason for this is because the high frequency currents set up in the aërial by the incoming electric waves are changed into direct current and this direct current is usually large enough to work a pair of telephone receivers without using a current from a dry cell.

Fig. 117.—Head Telephone Receivers.

A current from a dry cell will, though, sometimes make the signals in the telephone receiver louder than those produced by the current received by the aërial wire and changed into a *direct current* by the detector.

If now a dry cell is used to supply the extra direct current to the detector and telephone receiver a *potentiometer,* or *variable resistance,* should be used so that exactly the right amount of current can be had to make the loudest signals.

A simple and very good potentiometer can be made on exactly the same lines as the *water rheostat* which was described in Part II, Chapter I, on page 62, for the sending apparatus.

Make a piece of wood 5 inches long, 3½ inches wide and ¾ inch thick as shown in Fig. 118, and drill two holes ⅛ inch in diameter in the center of the circles which show the positions of the binding posts. On the under side of the base bore out these holes to ¾ inch in diameter and to within ¼ inch of the top as in Fig. 119. When these are done put on a couple of binding posts.

Saw out a support of the same kind of wood and make this 4½ inches long (or high), 3¼ inches wide at one end and 1 inch wide at the other end. Screw this support to the end of the base nearest the holes as in Fig. 120.

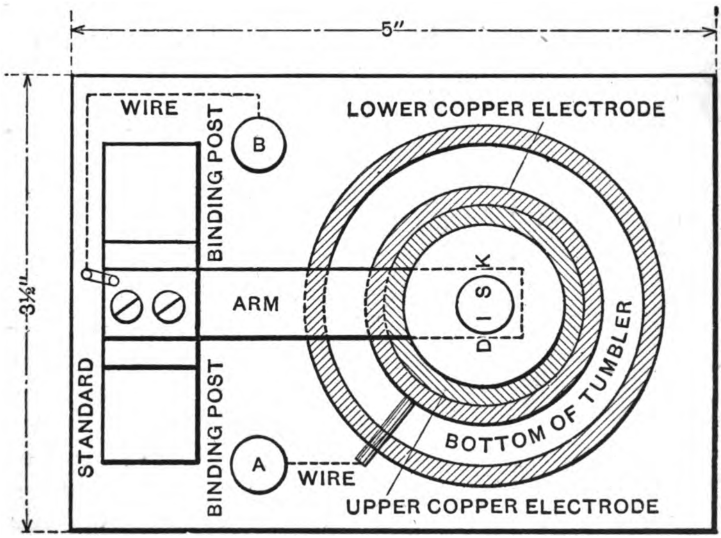


Fig. 118.—Top View of Water Potentiometer.

Now make a brass arm 3¼ inches long, ½ inch wide and ¼ inch thick and drill two ⅛ inch holes in one end and ream them out as in Fig. 121 so that the heads of the wood screws will set *in flush* when the arm is screwed down to the support as in Fig. 120. Drill a hole ⅛ inch in diameter and ⅜ inch from one end and tap it for the adjusting rod which screws into it.

The adjusting rod is formed of a piece of brass rod 3/16 inch in diameter and 5 inches long. Cut threads on the rod to about half its length to fit the threaded hole in the arm. On the plain end of the rod screw in or solder on a *disk* of copper or of zinc, 1½ inches in diameter and, say,   inch thick (see Fig. 122).

Next screw the rod through the arm and screw on a nut $\frac{5}{8}$ inch from the end, slip on a washer and put on a hard rubber,

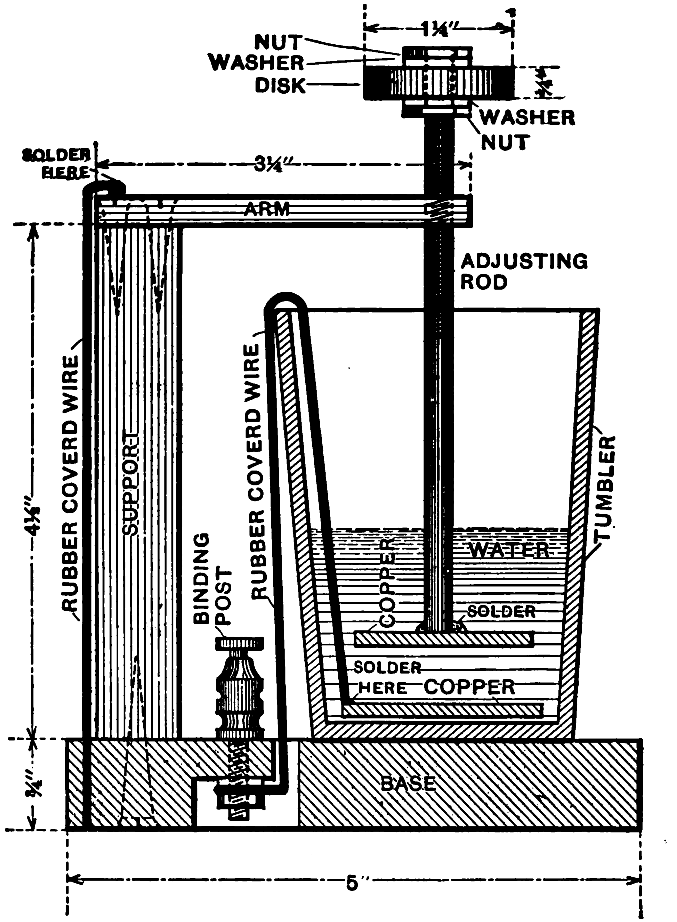


FIG. 119.—SIDE VIEW OF WATER POTENTIOMETER.

or a wood disk, 1¼ inches in diameter and ¼ inch thick, see Fig. 123, and slip on another washer and screw on another nut when the adjusting rod is complete as shown in Fig. 119.

Scrape clean the ends of a rubber-covered copper wire 8

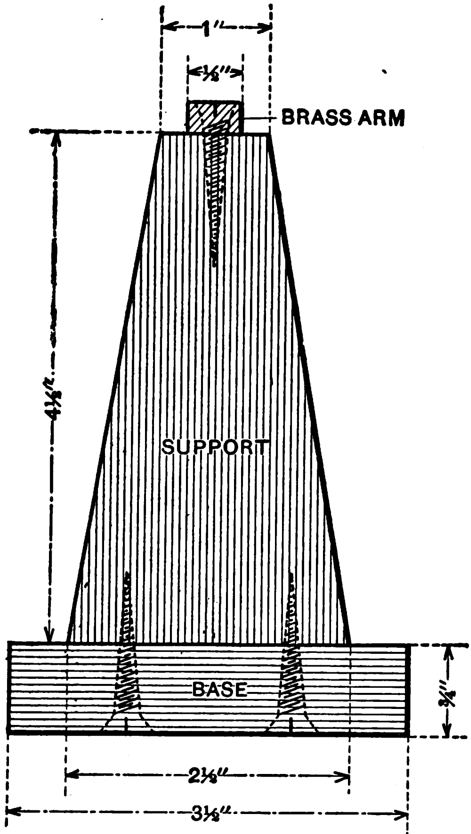


FIG. 120.—END VIEW OF WATER POTENTIOMETER.

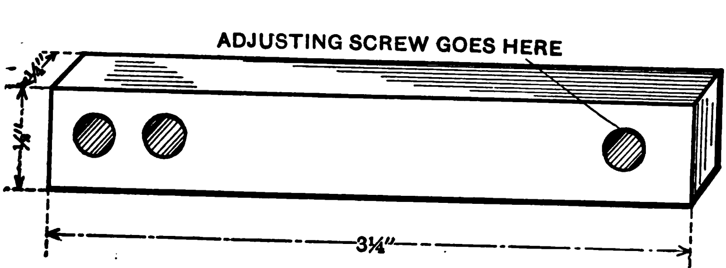


FIG. 121.—BRASS ARM FOR WATER POTENTIOMETER.

inches long and solder one end to the other copper or zinc electrode which should be about 1¾ inches in diameter (see Fig. 124) and place this electrode in the bottom of an ordinary glass tum-

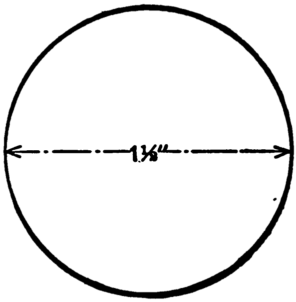


FIG. 122.—UPPER COPPER ELECTRODE.

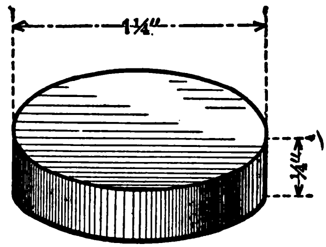


FIG. 123.—ADJUSTING DISK.

bler; bring the wire up the side of the glass, bend it over the top and set the tumbler on the base; now lead the wire through a hole in the base and connect the free end with one of the binding posts by looping it around the screw and between the washers.

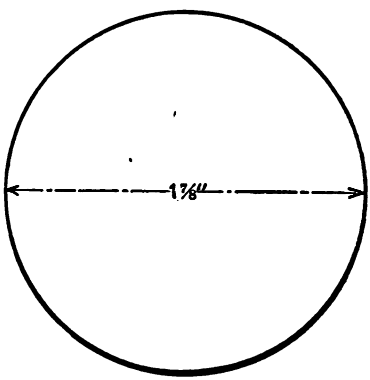


FIG. 124.—LOWER COPPER ELECTRODE.

To the end of the arm on the support solder an end of an insulated copper wire and bring this down back of the support through a hole in the base and over to the screw of the other binding post. Pour about half a glass of water into the tumbler and your potentiometer is ready for use. It is shown complete in Fig. 125.

The Dry Cell.—A dry cell of the ordinary kind, see Fig. 1, page 2, is used in connection with the potentiometer; or a battery of two or more dry cells can be used by joining them together, but one cell usually gives all the current needed.

The Switch.—The switch for breaking the dry cell circuit when the receiver is not in use is the same as that shown in Fig. 20, page 15, for the small receptor.

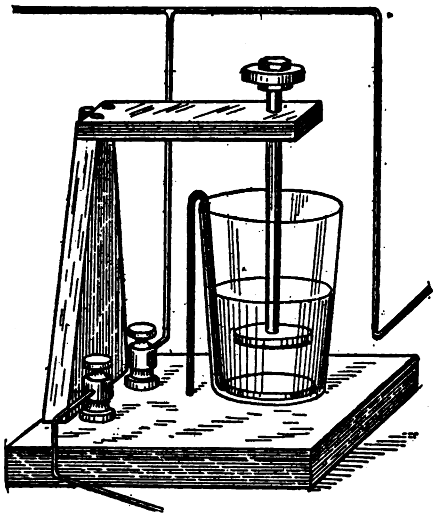


FIG. 125.—WATER POTENTIOMETER COMPLETE.

Connecting up the Apparatus.—When you have all of the pieces of apparatus for the receptor place them on the operating table on the left-hand side of your transmitter in about the position shown in the plan view, Fig. 126 and screw them down tight.

The exact position of each part is merely a matter of choice, though the tuning coil and the detector should be close to the key of the transmitter, as the tuning coil will have to be adjusted very often in order to get the incoming signals clear and loud in the receiver.

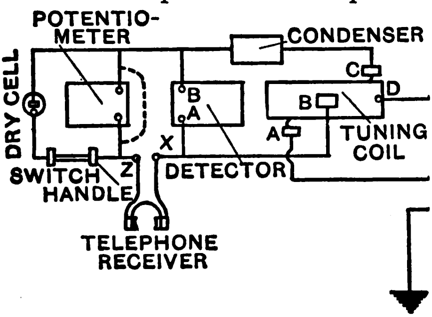


FIG. 126.—PLAN VIEW OF INSTRUMENTS ON TABLE.

The detector should be placed close to the tuning coil on the left or you may set it in front of the tuning coil, as this is also a device which will frequently need adjustment.

Screw into the table on the left of the detector a pair of *triple binding posts,* that is the kind of binding post which has three holes and three set screws for connecting in the wires. Three holes in each binding post are needed, as three wires lead to each post, as will be seen presently.

The potentiometer may be placed to the left of the detector with the dry cell to the back, or on the side of it with the switch in front. After all the parts are set on the operating table just where you want them screw them down tight.

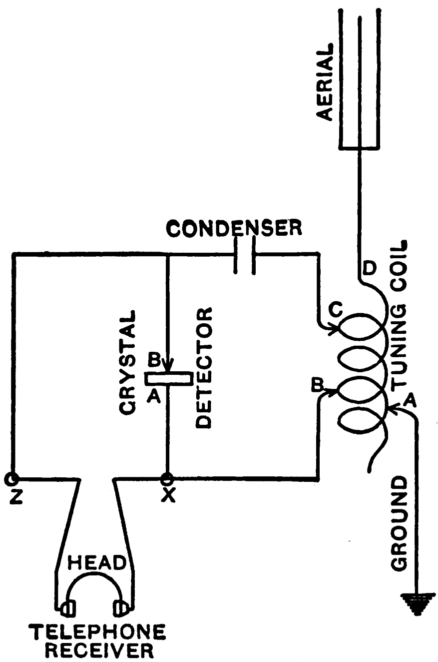


FIG. 127.—WIRING DIAGRAM OF RECEPTION WITH POTENTIOMETER.

Wiring up the Receptor.—To wire up the various parts follow the wiring diagrams, Figs. 127 and 128. These diagrams are alike except that one has the potentiometer and the other is without it.

In either case begin by connecting the slider A of the tuning coil, by means of the wire attached to one of the rods it slides on, to the ground. Connect the wire of the slider B with the triple binding post marked X and which is screwed to the table; connect the binding post A of the detector, which leads to the brass well, to the binding post marked X and also connect one end of the telephone receiver cord with the binding post marked X.

From the rod of the slider C run a wire to one end of the condenser and connect the other end of the condenser with the binding post of the detector marked B and which is connected with the phosphor-bronze point as shown in Fig. 100.

If the detector is to be used without the potentiometer all

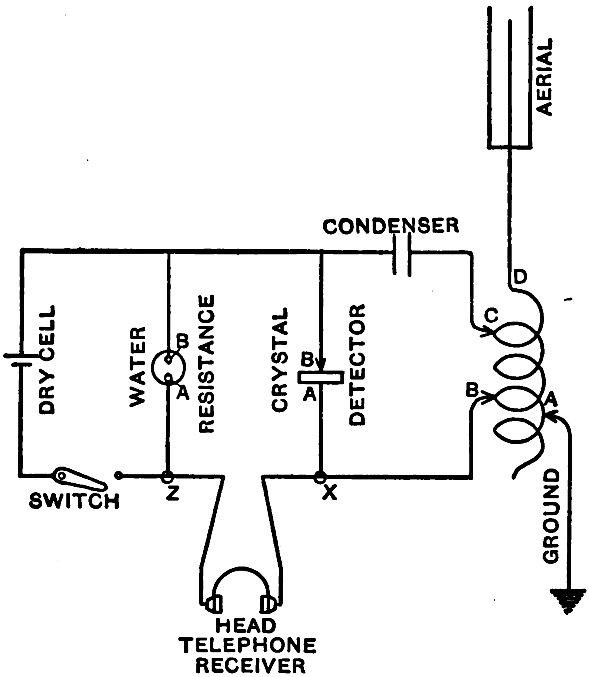


FIG. 128.—WIRING DIAGRAM OF RECEPTOR WITH POTENTIOMETER.

that remains to be done is to connect the binding post B of the detector and the other end of the cord of the telephone receiver with the binding post Z which is screwed to the table; these connections are shown in Fig. 127.

But if the potentiometer is to be used then connect the binding post B of this device with the binding post B of the crystal detector as shown in the wiring diagram, Fig. 128. Connect the binding post marked A of the potentiometer with the binding post Z and also with one end of the switch. Connect binding post B of the potentiometer to the carbon of the dry cell and connect the zinc of the dry cell to the switch. The receptor is now ready to be adjusted.

Adjusting the Receptor.—When you adjust the receptor for the first time after wiring it up it is better not to use the potentiometer and dry cell shunted around the detector as shown in Fig. 128, but to connect the telephone receiver directly to the binding posts of the detector as shown in Fig. 127. The receptor complete and ready for use is shown in Fig. 129.

To Adjust the Receptor Without the Potentiometer.—Put on the head telephone receivers and fit the cases closely to your ears. Adjust the detector by screwing the adjusting screw up and down and changing the position of the phosphor-bronze point on the crystal until you hear a slight crackling sound which means that you have found a sensitive point on the crystal.

There are certain parts or spots on crystals that are very sensitive and other places which give no results at all, so the only thing to do is to hunt around and find the best spot. Once you have found a sensitive spot do not move the phosphor-bronze point again, but simply vary the pressure of the phosphor-bronze point on the crystal by means of an adjusting screw, but be careful that you do not use too much pressure.

Now adjust your tuning coil. If there is a wireless station working near you, this will be a fine experience. Set the sliders B and C close together in the middle of the coil and the slider A near the end of the coil opposite the one to which the aërial wire is attached.

Begin to tune by slowly moving the sliders B and C apart and should you hear the faint buzzing of dots and dashes of some station sending messages move the sliders to and fro until you hear the signals the loudest; then move the slider A until you hear the signals still louder.

A very little practice will enable you to adjust the tuning coil so that the signals of any station will ring clear and loud in the receivers, since by moving any one of the sliders one way or

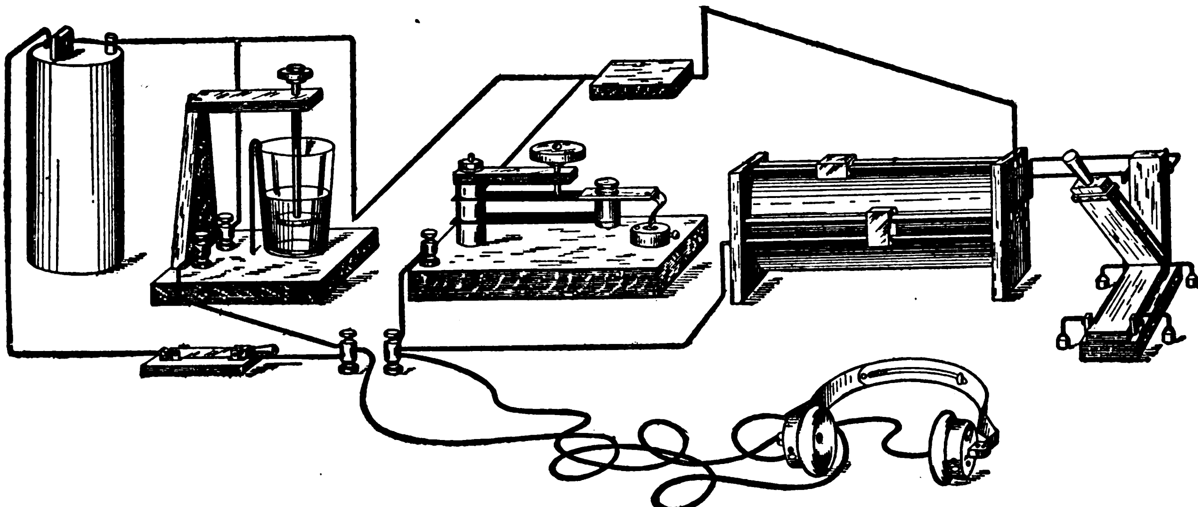


FIG. 129.—RECEPTOR COMPLETE AND READY FOR RECEIVING.

the other over the coil even a trifle, the signals will grow weaker or stronger and hence you know just which way you should move them.

To Adjust the Receptor with the Potentiometer.—After you have learned to adjust the detector and tuning coil so that you can get good results, connect in the potentiometer and dry cell as shown in the wiring diagram, Fig. 128.

Before closing the battery switch have the copper electrode of the adjusting rod as high as it will go; now close the switch and begin to screw down the rod; this will be slow work the first time but once you have found the proper distance between the copper electrodes, and you will know this by the strength of the signals, you will not need to change the adjustment very much.

In connecting in the potentiometer you must be very careful to see that the current from the dry cell flows through the detector in the *same direction as the direct current* made by the detector from the high frequency currents which are set up in the aërial wire by the incoming waves. If the connections are made as shown and described these currents will flow in the same direction.

Cost of Receptor When Bought of Dealers[1]

1 tuning coil—3 slides	$3.50
1 crystal detector	5.00
1 pair of standard 1,000 ohms receivers	4.00
1 fixed condenser	1.00
1 potentiometer (carbon)	1.50
1 dry cell	.20
1 baby knife switch	.25
2 triple binding posts	.30
Total	$15.75

[1] The prices of the different parts of the above receptor are only approximate and you should get prices from a number of dealers before buying.

Cost of Receptor When Home-Made

Tuning Coil	
1 core of wood (turned)	$ .20
2 wood cheeks	.10
6 feet ¼-inch brass rod or tubing	.50
6 hexagon nuts	.10
1 piece of brass rod for sliders	.30
1 phosphor-bronze spring	.10
1 pound, enameled wire	1.50
4 binding posts	.40
	$3.20
The Crystal Detector	
1 wood base	$ .10
All brass needed except binding posts	.50
1 oz. silicon crystals	.25
Rubber handle for adj. screw	.15
2 binding posts	.20
Screws and nuts	.10
Total	$1.30
Telephone Receiver (1,000 ohms)	$4.00
The Condenser	
15 sheets of mica—2 x 3 inches	$ .35
Tin foil	.10
Box	.10
	$ .55
The Potentiometer	
Wood for base and standard	$ .20
Brass for adjusting rod and arm	.25
Copper or zinc electrodes	.10
Binding posts	.20
Tumbler (glass)	.05
	.80
Baby knife switch	.10
2 triple binding posts	.30
Total cost to make receptor	$10.25

CHAPTER III

A GOOD AËRIAL WIRE SYSTEM

With a well made transmitter and receptor you should by all means have a good *aërial wire system.* The term *aërial wire system* means the aërial wire, the ground and that part of the tuning coil which is connected with them.

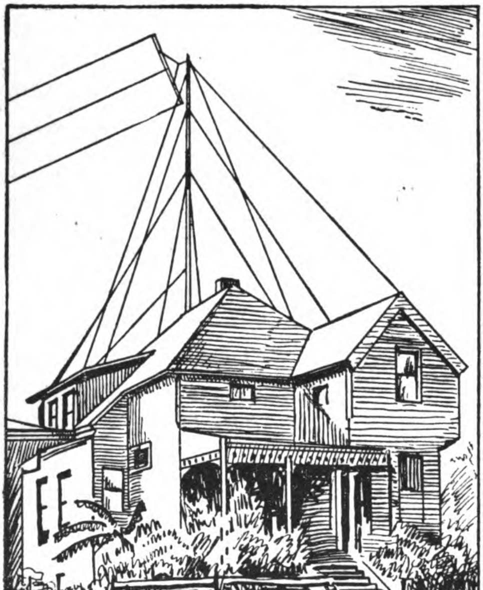


Fig. 130.—Pole —— on Top of House.

To be able to send and receive messages over the longest possible distance the aërial wire must be highly insulated to prevent the high-pressure currents used in sending and the feeble currents set up by the incoming electric waves in receiving from leaking away.

As all the material used in an aërial can be bought at a hardware store, to make and put up a good aërial is a simple matter. To get a place where the stretch is long enough and where there are two points high enough for your aërial is the hardest part and in this you will probably have a chance to show your ingenuity. No hard and fast rules can be given for this part of the work, as conditions everywhere are different.

The best way to get a suitable height is to put up a pole 30 or 40 feet high on top of your house as shown in Fig. 130, making the total height from the ground something like 60 or 70 feet. Of course a pole or mast need not be used and many boys are doing good work with low aërials, as the one described in Part I, Chapter III, but the higher the aërial the longer distance you will be able to send and receive over.

The Horizontal, or Flat-Top, Aërial.—There are many kinds of aërials (see Appendix E) but as all ships and nearly all shore stations have what is called the *horizontal,* or *flat-top* aërial—different names for the same kind of an aërial—this is the kind you should make and put up if conditions will permit.

This kind of an aërial, which is shown in Fig. 27, Part I, Chapter III, is made up of two or more parallel wires and is supported between two points of about equal height, like the masts of a ship.

While a high and a long aërial gives the best results so, too, a large number of wires adds to its sending and receiving power, that is if the wires are not too close together. The wires of an aërial should be at least 2 feet apart and so it will be seen that not more than three or four wires can be used to advantage as a 7-foot spreader is about as long as it is safe to put up in most places.

The aërial should have a stretch of at least 100 feet if a ½ kilowatt transformer is used for sending, and if you cannot get as long a stretch for your aërial as this then a smaller transformer, say ¼ kilowatt, will give just about as good service and will be much cheaper.

Making an Aërial.—The materials needed to make a good three-wire aërial, which let us suppose is to be 150 feet long, are:

550 feet of aluminum or bronze wire.
2 spruce spreaders 2½ inches in diameter and 5 feet long.
8 No. 6 electrose ball insulators.

1 spruce spreader 1½ inches in diameter and 5 feet long.
1 spruce spreader 1 inch in diameter and 2 feet long.
6 galvanized iron withes 2½ inches in diameter and having two eyes.
6 galvanized iron S hooks, 2½ inches long.
2 thimbles, for ¼ inch wire rope.
2 thimbles for ¾ inch manilla rope.
6 brass stops, ½ inch long and ½ inch in diameter.
6 porcelain insulator tubes, ½ inch in diameter and 3 inches long.
2 tackle blocks, of iron or wood, and
Enough manilla rope, ¾ inch in diameter.

Kinds of Wire.—There are four kinds of wire which may be used for the aërial and these are: (1) galvanized iron wire; (2) aluminum wire, (3) phosphor-bronze wire, and (4) silicon-bronze wire.

(1) Galvanized iron wire is not as good as the others for the reason that iron is not a good conductor of electricity; the good thing about galvanized iron wire though is that it is cheap.

(2) Aluminum wire is almost as good a conductor of electricity as copper; it is very light, quite strong and is a little cheaper than copper wire. If you use aluminum wire get No. 12 size Brown and Sharpe gauge, which is about ⅛ inch in diameter.

(3) Phosphor-bronze wire is an alloy made of copper and tin with a small amount of phosphorus in it. It is almost as good a conductor of electricity as copper; it is as tough as wrought iron and does not corrode easily. For this reason it is largely used for aërials. Get it soft drawn and made up of seven strands, each of which is No. 22 Brown and Sharpe gauge.

(4) Silicon-bronze wire is much cheaper than phosphor-bronze and is almost as strong.

Stranded wire is better for aërials than solid wire, as it has a larger surface, and this makes it a better conductor of high-frequency currents. Soft-drawn wire is much easier to handle than hard-drawn wire and this should not be overlooked when ordering.

The Spreaders.—Any kind of strong sticks will, of course, do for the *spreaders,* but it gives a fellow a lot of pleasure to have a good-looking aërial as well as a good working one.

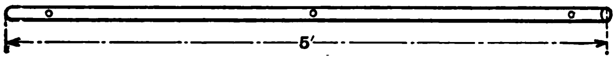


FIG. 131.—THE SPREADER FOR THE ENDS.

Four spreaders are needed, one at each end of the aërial, one in the middle to keep the wires apart, and a short one for the *leading-in* wires. Make these spreaders of *spruce* if you can get this kind of wood, for spruce is light, springy and strong. If you cannot get spruce use hickory, though hickory is heavier than spruce.

Make the two end spreaders 5 feet long and 2 inches scant in diameter, as shown in Fig. 131; make the middle spreader 5 feet long and 1½ inches in diameter, as in Fig. 132, and the leading-in spreader 2 feet long and 1 inch in diameter, as shown

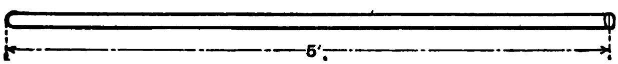


FIG. 132.—THE MIDDLE SPREADER.

in Fig. 133. Drill three ⅛ inch holes in the middle spreader (Fig. 132) and the leading-in spreader (Fig. 133)—a hole in the middle of each spreader and a hole at each end—so that the wires can be slipped through them.

The Spreader Withes.—Withes are simply galvanized iron rings with eyes attached to them. Six of these withes are needed —three for each of the end spreaders. Each withe should have two *eyes* as shown in Fig. 134 and have an inside diameter of 2½ inches.

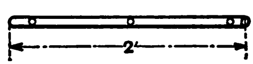


FIG. 133.—LEADING-IN SPREADER.

Slip three withes on each of the end spreaders—one for the middle and the other two for the ends. Drill a hole through each withe and drive in a screw to keep it from slipping on the spreader.

The Ball Insulators.—To properly insulate the wires from the masts is most important and you will never have a good station unless this is done.

The insulators generally used for high-grade aërials are made of a patented compound and are called *electrose insulators.* Electrose is almost as good an insulator as hard rubber, while it is very much stronger, is not affected by heat or cold, is waterproof, and, finally, it is cheaper than hard rubber.

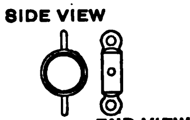


FIG. 134.—WITHE WITH TWO EYES.

The ball insulators made of electrose and which are used for holding the wires to the spreaders and the spreaders to the masts have eyes fastened to them as shown in Fig. 135. Eight No. 6 ball insulators will be needed—four at each end of the aërial.

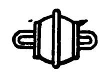


FIG. 135.—ELECTROSE BALL INSULATOR.

Other Hardware Needed.—To complete the list of materials for your aërial buy six galvanized iron S hooks, $2\frac{1}{2}$ inches long, as shown in Fig. 136, and connect the ball insulators with the rings of the withes on the end spreaders as shown in Fig. 137.

Next make, or have made, six brass stops, each of which is formed of a piece of brass rod $\frac{3}{8}$ inch in diameter, $\frac{1}{2}$ inch long and having a $\frac{1}{8}$ inch hole drilled through it so that it will slide on the wire; also drill a hole, tap it and fit in a short machine screw so that the stop can be screwed tight to the wire when it is put in position. One of these stops is shown in Fig. 138. A pair of the stops are put on the opposite sides of the middle spreader to prevent it from slipping out of place on the wires.

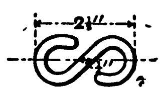


FIG. 136.—S HOOK.


FIG. 137.—S HOOK LINKING BALL INSULATOR WITH WITHE.

Steel Wire.—Get 20 feet of stranded steel wire $\frac{3}{8}$ inch in diameter—10 feet for each end of the aërial. Stranded steel wire is used at the ends of the aërials instead of manilla rope, as it does not stretch in wet weather. Cut the wire into four lengths and have two pieces 7 feet long and two pieces 3 feet long.

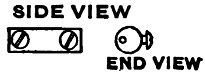


FIG. 138.—BRASS SPREADER STOP.

Thimbles.—Thimbles are galvanized iron ovals with grooves formed in them (see Fig. 139) and around which the steel wire or manilla rope is looped and fastened. Four thimbles will be needed, a large one and a small one at each end of the aërial. The small thimbles have $\frac{1}{4}$ inch grooves in them so that the stranded steel wire will lay in snugly, while the large ones have $\frac{3}{4}$ inch grooves to fit the manilla rope.

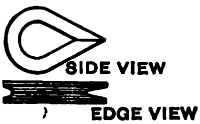


FIG. 139.—THIMBLE.

Shackle Bolts.—Shackle bolts are $\frac{3}{8}$ inch iron rods bent in the shape of the letter U and having eyes formed on the end of the rods so that bolts can be passed through them as shown in Fig. 140. These bolts are used to link the eyes of the insulators at the ends of the aërials with the thimbles holding the manilla rope.

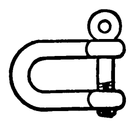


FIG. 140.—SHACKLE BOLT.

Tackle Blocks.—A tackle block consists of a grooved pulley on an axle and fitted in a case of iron, brass or wood having a ring at one end as shown in Fig. 141.

The block is secured to the masthead and by running a manilla rope, one end of which is fastened to the aërial, through the block and over the pulley, the aërial can be hoisted to the top of the mast and lowered if needs be.

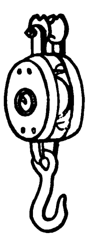


FIG. 141.—TACKLE BLOCK.

The Manilla Rope.—The amount of rope, which should be $\frac{3}{4}$ inch in diameter, is like the amount of aërial wire, subject to conditions, but you can easily figure out the amount after you have found the height and length of your aërial. Cut the rope into two pieces of the lengths needed and you are ready to assemble the aërial.

Assembling the Aërial.—Begin the work by linking a small thimble—it is open at the sharp end—through the eye of one of the insulators. Now loop the middle of one of the 7 foot lengths of steel wire around the thimble, twisting the end of one of the 3 foot lengths of steel wire around the other wires at the sharp end of the thimble, and wrap the three wires very tightly with some thin, strong steel wire as shown in Fig. 142.

Bring the free ends of the wires through the eyes in the withes on the end spreader and twist them around themselves so that there is no danger of their pulling apart. Fix the other steel wires on the thimble and fasten to the remaining end spreader in the same way.

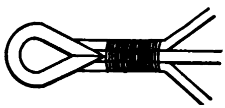


FIG. 142.—JOINING THE STEEL WIRE.

Next loop one end of a piece of manilla rope around one of the large thimbles and splice it to the body of the rope, if you know how to splice well. If not, lay the end close to the body of the rope and wrap it with two or three layers of fish line which must be put on very tightly. The thimble on the end of the manilla rope is linked into the eye of the ball insulator by means of a shackle bolt.

To each of the opposite eyes of the withes on the end spreaders secure a ball insulator with an S hook. This completes both supports of the aërial as in Fig. 143.

Now cut off three pieces of the aluminum or bronze wire each 150 feet long and lay them parallel on the ground. Slip the ends of the wires through the holes in the middle spreader and draw the wires through until the spreader is halfway between. On the wires at each end slip the brass stops and slide these along until they touch the middle spreader. By screwing them to the wires the spreader cannot slip from its position, as will be seen from the detailed drawing, Fig. 144.

Place the finished supports of the aërial close to the ends of the aërial wires, and loop the end of each wire through the eye of an insulator and twist it up tight.

This done, cut off a piece of the aluminum or bronze wire long enough to reach from the top of the mast to your apparatus on the operating table. Twist one end of the leading-in wire to the middle aërial wire and at a point far enough away from the end spreader so that when the aërial is hoisted to the masthead the leading-in wire will swing clear of the building.

To each of the two outside aërial wires twist an end of a 10 foot length of wire. Slip the free end of the leading-in wire through the middle hole in the leading-in spreader and slide it

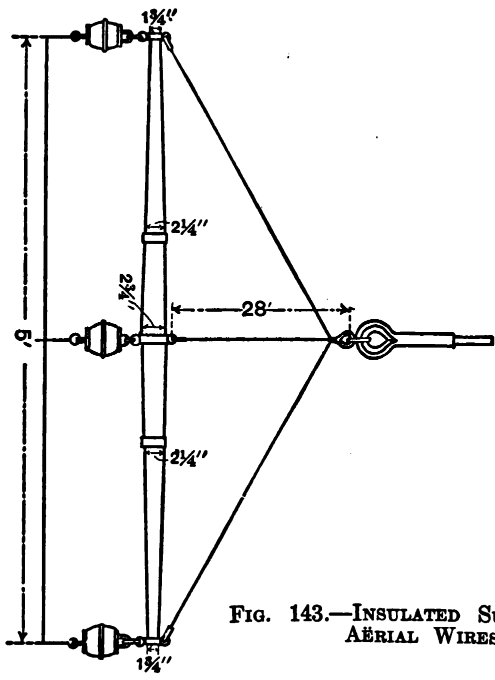


FIG. 143.—INSULATED SUPPORT FOR AËRIAL WIRES.

along until the ends of the shorter wires are reached. Thread these through the holes of the leading-in spreader and twist the free ends around the leading-in wire. The aërial is now ready to be hoisted to the mastheads.

Putting Up the Aërial.—The tackle blocks should be lashed to the mastheads with rope, and ropes long enough so that both ends will reach to the ground when the pole is up should be run through the blocks. All this, though, should be done before the poles are put up on top of the building.

After the poles are set up and guyed out bind one end of the small rope to the free end of the aërial rope and draw it up and through the pulley block. Keep on pulling the rope until the aërial swings high and taut between the mastheads.

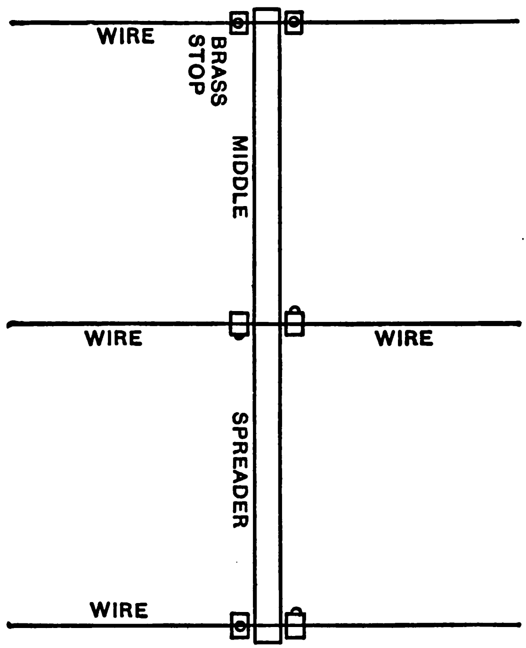


Fig. 144.—Brass Stops on Aërial Wire.

The Leading-in Insulator.—With an aërial as well made as the one just described you should keep up the good work and bring the leading-in wire of the aërial through the window-pane if possible.

The best way to do this is to get an electrose *leading-in insulator* which is largely used by the big wireless companies. This leading-in insulator is 5¼ inches long, 1¾ inches in diameter at its large end and 1 inch in diameter at its shank. The shank, which is ¾ inch long, is threaded and a brass ring 1¾ inches in diameter and ¼ inch thick is threaded on the inside so that it can be screwed on to the shank as shown in Fig. 145.

Cut a hole 1⅜ inches in diameter in a window-pane nearest your leading-in wire and put the insulator through the hole with the shoulder of the insulator up against the glass; now screw the threaded brass ring on to the shank on the other side of the pane of glass. Thread the end of your leading-in wire through the hole of the insulator, draw it inside the room and connect it with one side of the aërial switch. The way in which the end of the wire is led through the leading-in insulator is shown in Fig. 146.

FIG. 145. — LEADING-IN INSULATOR.

The Lightning Switch.—To protect the sending and receiving apparatus from lightning, a lightning switch should be used and in some places the Fire Underwriters require them.

The switch is simply a *double-throw, single-pole knife switch* as shown in Figs. 147 and 148. It is placed on the outside of the building close to the leading-in insulator.

A knife switch of this type mounted on a porcelain base can be bought about as cheaply as one can be made; however, if you want to make the switch yourself get a piece of slate or marble for the base about 3 inches wide, 10 inches long and ¾ inch thick. Drill twelve holes ⅛ inch in diameter in the base for the screws as shown in Figs. 147 and 148.

Now cut from a sheet of brass 1/16 inch thick six pieces 1 inch long and 1¼ inches wide and bend these over in a vise so that an angle plate is formed as shown in Fig. 149. Drill two ⅛ inch holes through the base of each of these angle plates so that they can be screwed to the slate, or marble base. In two of these angle plates drill ⅛ inch holes through the part marked contact to form a hinge for the contact blade. Screw all of these angle plates to the slate, or marble base.

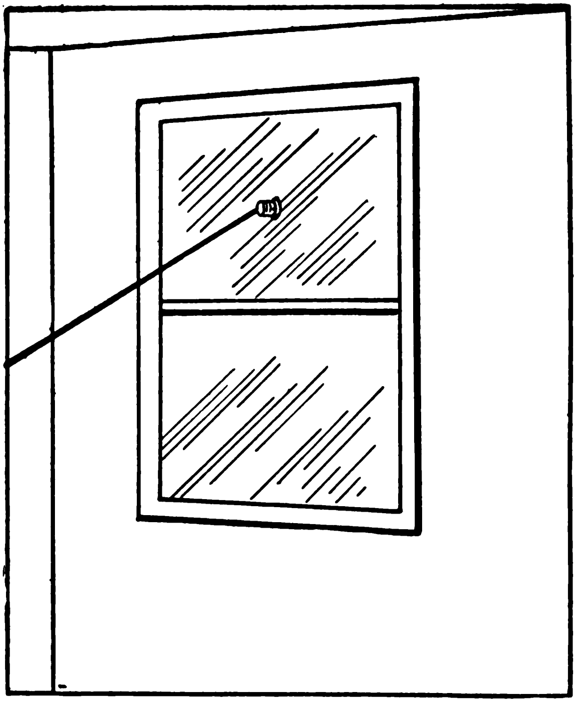
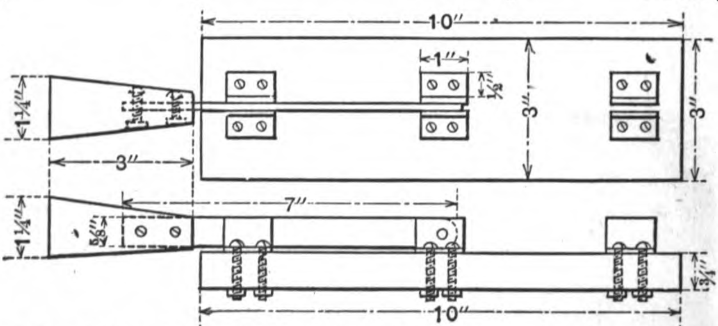


FIG. 146.—LEADING-IN INSULATOR THROUGH WINDOW.

Next make a contact blade of a strip of brass 7 inches long, ⅝ inch wide and ⅛ inch thick. Drill a hole ⅛ inch in diameter,



FIGS. 147 and 148.—TOP AND SIDE VIEWS OF LIGHTING SWITCH.

$\frac{3}{8}$ inch from each end and a third hole 1 inch from one of the ends.

Turn a handle of hard wood 3 inches long and make it 1 inch in diameter at one end and taper it down to $\frac{5}{8}$ inch at the other end and saw a slot in the small end $1\frac{1}{2}$ inches deep. Place the end of the contact blade with the two holes in it in the slotted handle and drill two holes through the wood exactly in a line with the holes in the blade. This done put in a couple of screws to hold it tight. This is clearly shown in Figs. 147 and 148.

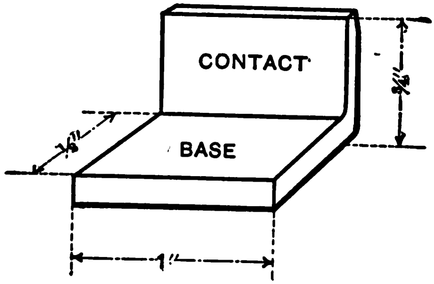


FIG. 149.—ANGLE CONTACT PLATE.

Put the other end of the blade between the middle angle plates, put a screw through the holes, slip on a washer and screw on a nut and your lightning switch is finished.

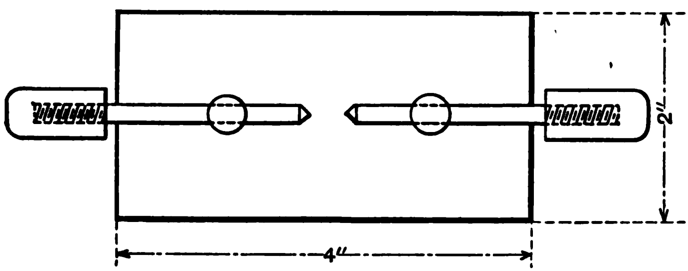


FIG. 150.—A TOP VIEW OF ANCHOR-GAP.

The lightning switch is fastened to the outside of the house with long screws passing through the base and porcelain insulators.

The Anchor-Gap.—An anchor-gap is merely a very small spark-gap and is used to connect one of the ends of the sending tuning coil with the aërial when messages are being sent and to cut off the sending tuning coil from the aërial when messages are being received.

The purpose of an anchor-gap is to prevent the high-frequency currents set up by the incoming electric waves from flowing into the transmitter and being wasted there in doing useless work.

To make a simple anchor-gap get a base of slate or marble, or of very dry, hard wood, 4 inches long, 2 inches wide, and $\frac{1}{2}$ or $\frac{3}{4}$ inch thick, as shown in Fig. 150. On inch from each end and in the middle of the base drill a $\frac{1}{8}$ inch hole. Drill

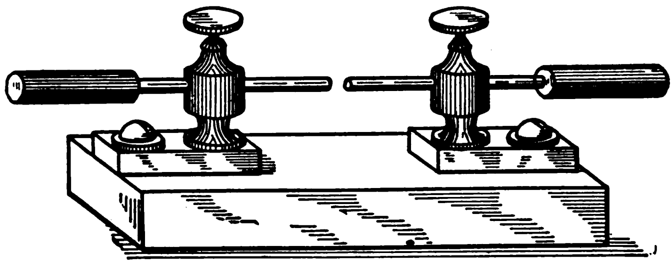


FIG. 151.—ANCHOR-GAP COMPLETE.

these holes out to $\frac{1}{2}$ inch in diameter on the bottom of the base and $\frac{1}{4}$ inch through. Mount two double binding posts on the base as shown in the cuts.

Take two brass rods $\frac{3}{32}$ inch in diameter and thread one end of each one and sharpen the other end. On the threaded ends of the rods screw two handles of wood, or hard rubber, $\frac{1}{2}$ inch in diameter and 1 inch long. It is shown complete in Fig. 151.

The anchor-gap is screwed to the wall and the leading-in wire of the aërial is connected with one of the binding posts. The other binding post of the anchor-gap leads to one of the clips of the tuning coil of the transmitter, all of which is clearly shown in Fig. 88.

The Aërial Switch.—An up-to-date aërial switch which is so arranged that the transmitter cannot be operated when the receptor is connected to the aërial, thus preventing burn-outs, is the next and last piece of apparatus needed for this set.

All of the woodwork of the aërial switch should be made of thoroughly seasoned hard wood, though the base may be made of pine or some other kind of soft wood. Make the base 9½ inches long, 5 inches wide and 1 inch thick. On top of the base screw a strip of wood 8½ inches long, 2 inches wide and ½ inch

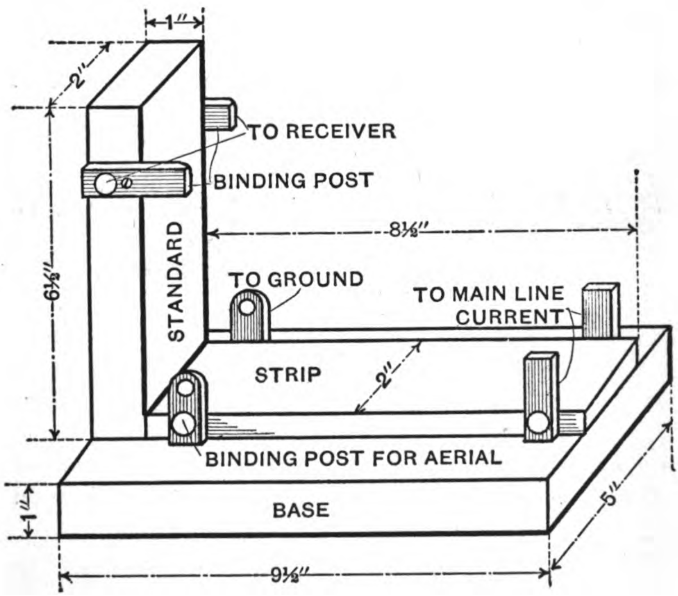


Fig. 152.—Base and Contact Supports for Aërial Switch.

thick and screw a standard of wood 6½ inches high, 2 inches wide and 1 inch thick at the end of the base as shown in Fig. 152.

Cut out two contact springs from a sheet of brass about $\frac{1}{32}$ inch thick and make these springs 2 inches long and ½ inch wide and bend out the ends a little, as shown in Fig. 152, to make a good contact. Screw these springs to the opposite sides of the wood standard, ½ inch from the upper end, with wood screw binding posts and to keep them from dropping down put a small wood screw in each side.

Now cut out two more contact springs ¾ inch long and ½ inch wide, bend out the ends of these as you did the others and screw them to the strip of wood ¾ inch from the front end with wood screw binding posts as shown in Fig. 152. Cut out two brass plates for hinging the lever and make these ¾ inch long and

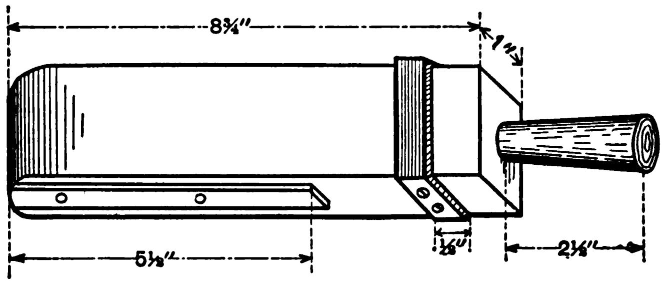


FIG. 153.—CONTACT LEVER FOR AËRIAL SWITCH.

⅝ inch wide, round off the edges at one end and drill a ⅛ inch hole through the ends that are rounded off. Drill holes in the other ends and screw these hinge plates to the strip of wood ¾ inch from the end which is nearest the standard with a pair of wood screw binding posts.

Make a lever of hard wood 8¾ inches long, 2 inches wide and 1 inch thick. Round off one of the ends as shown in Fig. 153 and have a ½ inch hole ¾ inch deep in the other end. Have a wood handle turned 3¼ inches long, 1 inch in diameter at one end and tapering down to ½ inch in diameter, ¾ inch from the other end, the rest of the way down being ½ inch in diameter. Smear the small end of the handle with glue and force it into the hole in the end of the lever.

Screw a strip of brass ½ inch wide to the lever one inch from the top and around it on three sides as in Fig. 153; this is to make contact with the front springs on the strip of wood. Cut two strips of brass 5½ inches long and ½ inch wide and drill three $\frac{1}{16}$ inch holes in each strip—two holes ¾ inch from the ends and one hole in the middle. Countersink these holes and then fasten the strips to the opposite side of the lever with $\frac{5}{16}$ inch flat-headed wood screws through the upper and middle

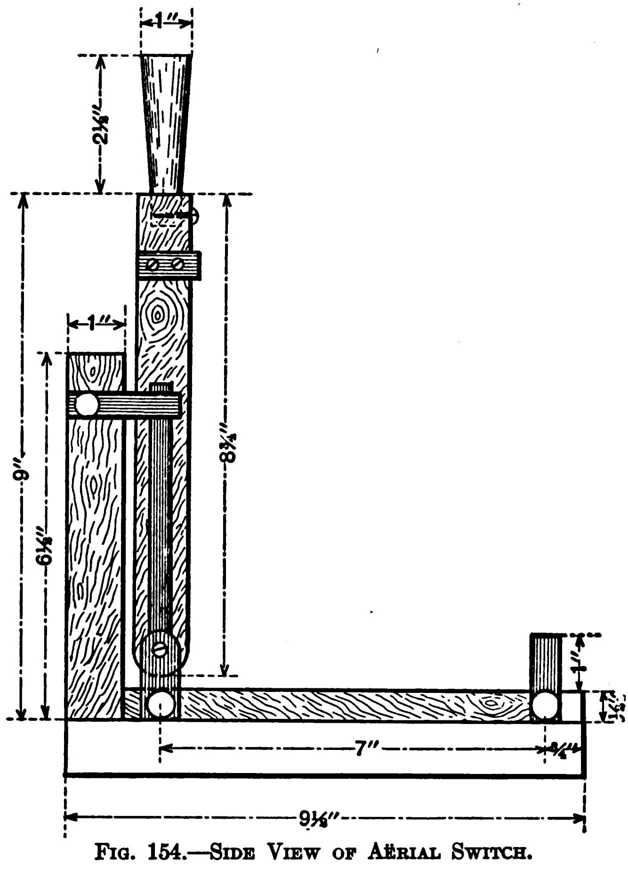


FIG. 154.—SIDE VIEW OF AËRIAL SWITCH.

holes, and drive the screws in flush with the strips. This completes the contact lever and all that remains to be done is to set it in between the brass hinge plates, as shown in Fig. 154, and then put in a round-headed brass wood screw $\frac{3}{8}$ inch long on each side.

Since one of the hinged plates is connected with the ground and the other one with the aërial when the lever is thrown to the vertical position—that is, up—and the brass strips make contact with the upper springs, the aërial and ground wires are connected with the receptor. On the other hand when the lever

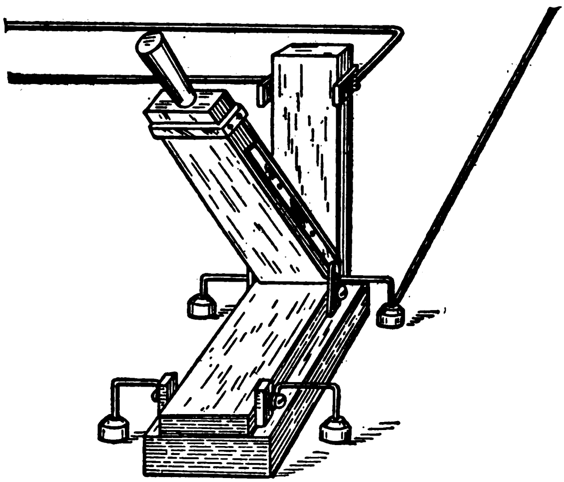


FIG. 155.—AËRIAL SWITCH COMPLETE.

is thrown to the horizontal position—that is, down—the strip of brass around the top of the lever will make contact with the springs on the wood strip and this will close the power circuit which supplies current to the transformer as the plan view, Fig. 86 and Fig. 87, shows. Fig. 155 shows the aërial switch complete.

A Good Ground.—A good ground is just as important a part of a wireless station as a good aërial.

When we speak of the *ground* in wireless we mean the place where the aërial wire system is connected with the earth. A good ground is one where there is little or no resistance between the earth and the wire which connects with it, and hence, the high-frequency currents can flow freely into and out of the earth.

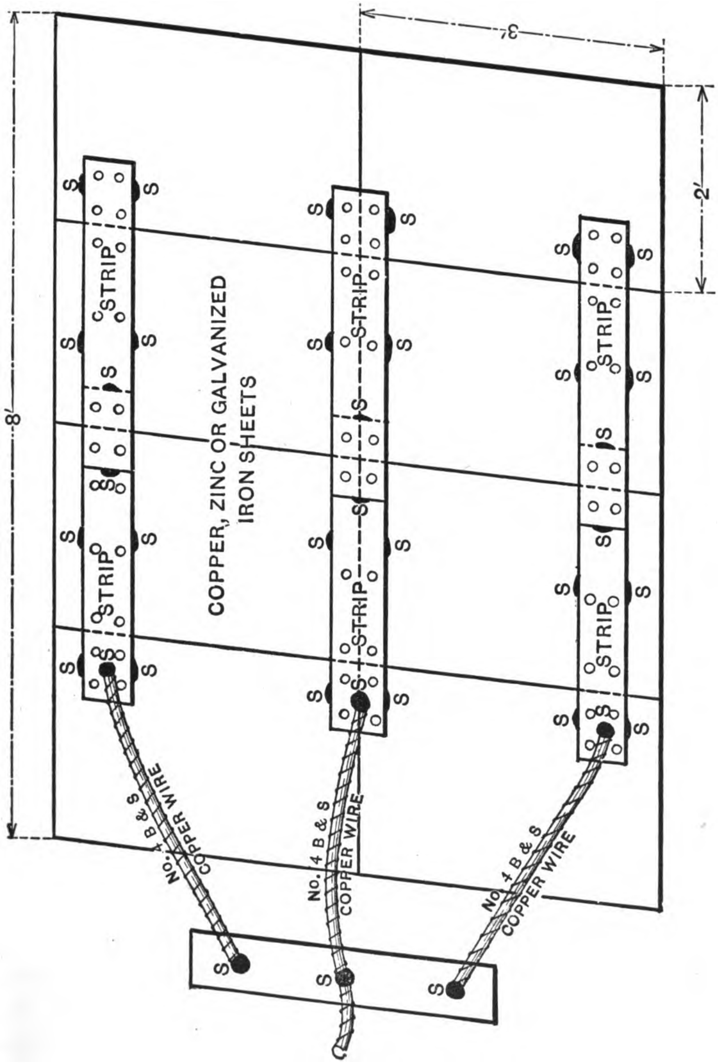


FIG. 156.—THE METAL GROUND.

To obtain a ground in the city the easiest and therefore the usual way is to connect the ground wire with the water or gas pipes, or both, but a better ground may be had by burying several large sheets of metal deep in the damp earth.

Any kind of metal in sheet form will do for a ground, as zinc, copper or galvanized iron. Zinc and copper make the best grounds because they are good conductors of electricity, but galvanized iron works very well and is very much cheaper. For the set I have described the ground should have at least 50 square feet of metal in it and if you can increase this to 100 feet so much the better.

To make a ground take ten sheets of zinc, copper or galvanized iron say 2 feet wide and 3 feet long. Cut two of these metal sheets lengthwise, into strips, 6 inches wide. Lay the remaining eight metal sheets flat on the floor with their edges together and lay six of the metal strips on top of them as shown in Fig. 156.

Now drill twelve holes through each of the pairs of metal strips and the metal sheets and rivet the strips to the metal sheets so that all the metal sheets are joined together. Next solder the metal strips to the metal sheets on the edges where the letter S is marked in Fig. 156 and then solder the ends of three pieces of bare copper wire No. 4 Brown and Sharpe gauge to the strips on the sheets and solder the other ends to a metal strip 3 feet long.

From this metal strip run a No. 4 copper wire, Brown and Sharpe gauge, to your operating table where it is connected with the aërial switch. This wire does not need to be insulated but can be fastened to the side of the house with double-pointed tacks, cleats or in any way that is the easiest.

Putting Down the Ground.—Dig a trench 3 feet wide, 9 feet long and 8 feet deep in soil that is as moist as possible. Fill the hole with water. Let the metal sheets down carefully until the lower edge rests on the bottom of the trench.

Fill in the hole with earth and see that the metal sheets are kept in the middle of the trench; this is done by throwing a shovelful of earth first on one side and then on the other of the metal sheets. Run water on top of the ground as often as you can and you will have what is called in wireless language a *good ground.*

Connecting the Transmitter and Receptor with the Aërial and Ground.—Having all the apparatus finished and set in place on your operating table and having the aërial wire put up and the ground plate put down, everything is ready for making the final connections.

Place the aërial switch between the transmitter and the receptor, as shown in the plan view, Fig. 157, and set it near the front of the table as it will be constantly in use changing the aërial from the transmitter over to the receptor and back again. Screw the base of the switch to the table so that it cannot move. The anchor-gap should be screwed to the wall where it can be seen and yet where it will be out of the way.

The plan view, Fig. 157, not only shows how the instruments are placed on the operating table but it shows how they are connected up by means of the binding posts. The wiring diagram, Fig. 158, shows the actual connections of all the wires so that you can follow the current from the time it is taken off the power circuit until it reaches the aërial wire system, and from the time it is received by the aërial wire system until it is changed into sound waves in the head telephone receiver. The heavy black lines show the power circuit and the light lines show the high-pressure and high-frequency circuits.

Now connect the end of the leading-in wire of the aërial with the hinged support of the aërial switch marked A. Connect the end of the ground wire with the other hinged support of the aërial switch marked B. To the hinge A, or at some part of the leading-in wire of the aërial before it reaches the leading-in insulator, solder on a piece of wire and lead it to one side of the anchor-gap, and connect the other side of the anchor-gap with the clip A of the sending tuning coil.

Connect the binding post D of the sending tuning coil with the hinge B of the aërial switch, or with some part of the ground

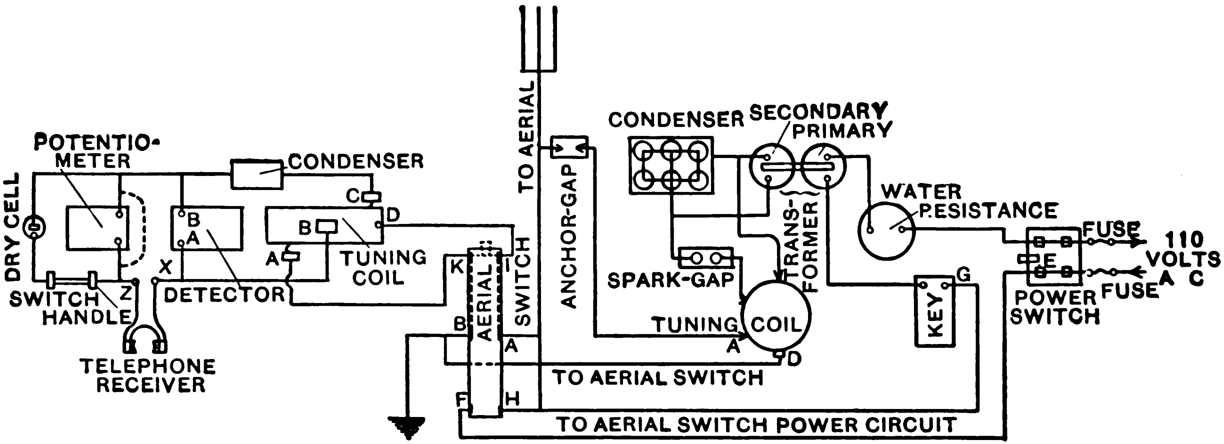


FIG. 157.—A PLAN VIEW OF TRANSMITTER, RECEPTOR AND AËRIAL SWITCH CONNECTED TOGETHER.

wire before it passes through the window-sill to the outside as shown in Figs. 157 and 158. Next connect the contact spring E of the power circuit switch with the contact spring F of the aërial switch and connect the binding post G of the key to the contact spring H of the aërial switch.

The binding post D of the receiving tuning coil is connected with the contact spring I of the aërial switch and the slider A of the receiving tuning coil is connected with the contact spring K of the aërial switch. When all these connections are made the apparatus is ready for sending and receiving messages.

Operation of the Sending and Receiving Apparatus.— We will begin by supposing you are going to send a message. First throw the lever of the aërial switch down when the brass band on top of the lever will make contact with the springs F and H of the power circuit, in which the primary of the transformer and the key are placed. Of course if the key is not closed the circuit will still be open, but the circuit is otherwise closed by the aërial switch and the power switch.

Now when the key is operated, the transformer changes the low-pressure current of the power circuit into high-pressure alternating currents which charge the Leyden jar condenser. When the condenser is charged it discharges through the spark-gap and this sets up high-frequency currents in the tuned closed circuit formed by the condenser, the tuning coil and the spark-gap. These high-frequency currents surge up the wire at A of the tuning coil, through the anchor-gap and to the aërial and back again through the anchor-gap and tuning coil to D and thence to the ground, which together forms a *tuned open circuit.*

Suppose, now, you have sent your message and you want to *listen-in.* Throw the lever of the aërial switch up into contact with the contact springs I and K. When this is done you will see from the plan view, Fig. 157, and the wiring diagram, Fig. 158, that the power circuit is broken at the contact springs F and H; hence even if you forget and try to send a message and begin working the key when *listening-in* no harm will come of it.

The purpose, then, of having the aërial switch break the

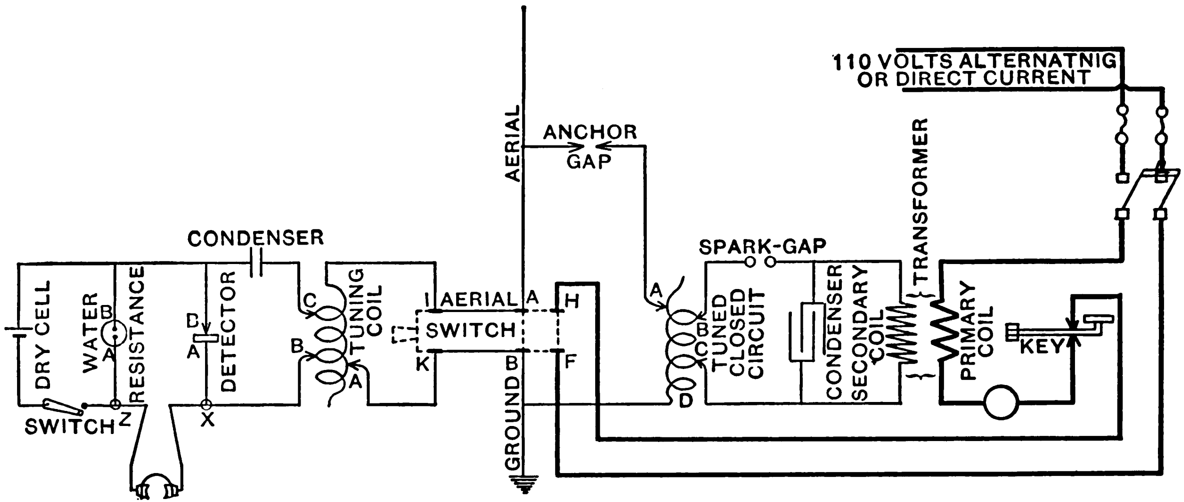


Fig. 158.—Wiring Diagram of Transmitter, Receptor and Aërial Switch.

power circuit is to prevent the sending apparatus from being operated while the receiving instruments are connected with the aërial and ground, and so preventing *burn-outs* and perhaps a lot of other damage.

But when the lever of the aërial switch is up the receiving tuning coil is connected directly with the aërial and ground wires, through the contact springs I and H. The high-frequency currents set up in the aërial wire by the incoming electric waves cannot flow into the transmitter, for the break in the circuit formed by the anchor-gap prevents the feeble current from jumping across and flowing this way, so that all of the current must flow through the receiving tuning coil.

It will be seen, then, that the sending tuning coil is connected with the ground wire both when sending and receiving. This does not matter in the least when receiving, for the currents which flow into the transmitter when you are receiving by way of the ground wire only add to the capacity of the ground, and this helps rather than hinders.

When the high-frequency currents from the aërial wire surge through the receiving tuning coil and to the ground, the current also flows through the closed circuit which includes the tuning coil, the condenser and the detector. The crystal detector changes the high-frequency currents into a direct current and this feeble direct current flowing through the magnet coils of the telephone receiver sets the diaphragm to buzzing and the ear reads off these sounds as dots and dashes.

If a dry cell and a potentiometer are used with a crystal detector to strengthen the signals, you must take care to have the current from the dry cell flow in the same direction as the direct current produced by the detector. Otherwise the signals will be weakened.

When you are through operating, throw the aërial switch halfway between the upper and lower contact springs, throw off the power switch and, if you are to be gone for any length of time, throw the lightning switch outside the window so that the aërial is connected direct to the ground.

CHAPTER IV

TUNING TRANSMITTERS AND RECEPTORS

Mechanical Tuning.—If you will tie two pendulums to a string stretched between two supports and set one of the pendulums swinging you will have a very good *demonstration* of tuning and what tuning means in wireless telegraphy.

The string which is stretched between the supports should be about two or three feet long and not too tight. Take two marbles of the same size, say *glassies,* and fasten a piece of string 12 inches long to each of them with sealing wax.

Tie the free ends of the strings about 12 inches apart to the stretched string as shown in Fig. 159. We will call the left-hand pendulum the transmitter and the right-hand pendulum the receptor, and mark them A and B.

If, now, you set the pendulum A to swinging, the other pendulum, B, will soon begin to swing also, the *energy* of pendulum A being *transmitted,* or carried, along the stretched string to the pendulum B.

Now make another pendulum using a marble of the same size as before, stick a piece of string 9 inches long to it and fasten the *free end* of the string to the stretched string between the pendulums A and B. Set the pendulum A to swinging again and you will see that while the pendulum B will swing as before, the short pendulum—which is not in tune with the other—will remain quiet.

Finally lengthen the string of the middle pendulum until it is 15 inches long and tie it to the stretched string. Set the pendulum A to swinging once more and again you will find that while the pendulum B swings in response to it the long pendulum will remain still just as the short one did.

It must be clear, then, that the length of the strings and the size of the marbles are the things which control the swinging of the pendulums, or, as we would say in wireless, these are the *factors which determine their periods of oscillation.*

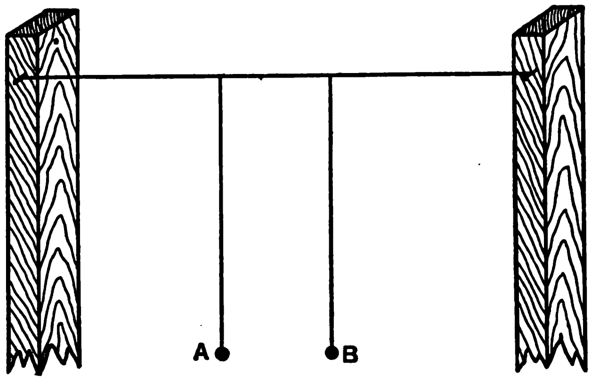


FIG. 159.—A PAIR OF TUNED PENDULUMS.

Electrical Tuning.—Another simple experiment which shows exactly how electric circuits are tuned can be easily made if you have a small induction coil and a pair of Leyden jars.

Take two Leyden jars of the same size, or *capacity,* as it is called, and set them a foot or two apart on a wooden base as shown in Fig. 160. Cut off two pieces of copper wire, No. 4 Brown and Sharpe gauge, each 18 inches long, bend these wires and fix them to a wood support (not shown in the cut) so that one end of one wire makes contact with the tin foil inside the Leyden jar A and one end of the other wire makes contact with the tin foil on the outside of the jar. Bend the wires over to form a spark-gap B, $\frac{1}{16}$ inch long and round off the ends of the wires with a file.

Cut off two more pieces of No. 4 Brown and Sharpe gauge copper wire 20 inches long and bend these as shown at C, Fig. 160. Fasten these to a wood support and have one end of one of the wires make contact with the tin foil inside the Leyden jar and the other end make contact with the tin foil outside the jar as before. Bend over the free ends of the wire so that they will be about 3 inches apart and parallel for about 10 or 12 inches.

Stick a strip of tin foil, one end of which is pointed, to the tin foil inside of the jar C and bend it over the top of the jar and down until the pointed end comes to within $\frac{1}{32}$ inch of the outside tin foil as shown at D. Bend the ends of a piece of

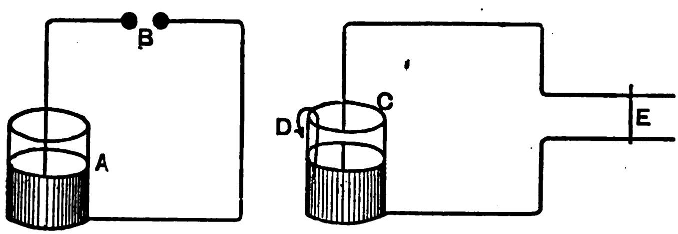


FIG. 160.—A PAIR OF TUNED LEYDEN JARS.

copper wire $3\frac{1}{2}$ inches long and slip it between the *parallel* wires.

If, now, you will charge the Leyden jar A with an induction coil it will discharge across the spark-gap B, and if the circuit which includes the Leyden jar C is in tune with the circuit A, that is if the electrical dimensions of the jars and the wires of both circuits are exactly the same, then the circuit C will respond to the high-frequency currents, or electric oscillations, as they are called, of the circuit A and sparks will jump across the little spark-gap at D of the circuit C.

If when the sparks jump across the spark-gap B of the transmitting circuit and sparks do not jump across the little gap D of the receiving circuit you will know that the circuit C is not in tune with the circuit A, but you can easily put them in tune by moving the wire slider E one way or the other on the parallel wires when you will find a place where the jar C will spark across the gap D. Then you will know that the circuits are in tune.

From this simple experiment you will learn many things about wireless in general and tuning in particular which will be of use to you in the operation of your station.

Electric Oscillations.—In making the experiment with the pendulums you will have noticed that a short pendulum swings, or oscillates, very fast while a long pendulum oscillates slowly, and this is also true of a circuit of small and large electrical dimensions in which electric oscillations surge.

Just as the length and size of a pendulum governs the time of its swings, or its period of oscillation as it is termed, so the electric oscillations surging in a circuit will be as fast or slow as we want them, that is if we make the circuit electrically small or large. This sounds like magic but it is really very simple.

It is done in this way. Just as a pendulum has length, breadth and thickness so every electric circuit has what we may call three electrical dimensions or properties, and these are called *resistance, capacity* and *inductance,* and by varying these three things we can make the electric oscillations as fast or as slow as we want them, nearly.

Resistance.—If you try to kindle a fire like a South Sea Islander, that is by rubbing a stick of hard wood on a block of soft wood you will notice that the stick will not slide over the block very easily and this is caused by *friction.* If you put soap on the block the stick slips over it with little effort, for soap lessens the *friction.*

When a current flows through a wire it is opposed by something that is very much like friction and this is called the *resistance* of the wire. Copper wire offers less resistance, or friction, to the passage of an electric current than any other metal except silver and this is the reason copper is used for conductors of electricity.

In wireless the resistance of the wires need not trouble you, for electric oscillations stick to the outside of the wires and if the wires are large and every joint and contact is well made there is very little resistance to overcome. In the sending circuit the spark-gap must not be too long or the electric oscillations will meet with a high resistance due to the air and the currents will not pass. As far as tuning is concerned you need not bother with the resistance of the circuits.

Capacity.—A gallon bucket will hold just four quarts and no more, but there are some contrivances which are never full until they burst. If you force gas into a rubber bag you cannot say it is full until it has reached the point where it explodes.

There are devices made for holding electricity but they are neither buckets nor gas bags. To hold electricity a condenser, with whose construction you are acquainted, is used, and a condenser is like a gas bag in that it is never full until the point is reached where the current which charges it breaks it down.

Different from fluids and gases, a charge of electricity always sticks to the outside of a sheet of metal and hence a sheet of tin foil $\frac{1}{100}$ inch thick will hold just as much electricity as a copper plate 1 inch thick of the same surface area, or size, that is if we neglect the edges.

All metals have a capacity for electricity but to get a large capacity into a small space leaves of tin foil separated by sheets of glass or mica or paper are used, and a device of this kind is called a *condenser*.

A condenser will slow down an electric oscillation flowing in a circuit, for the current has to charge the condenser each time before the condenser discharges itself.

The size of a condenser has the same effect on an electric oscillation that the length of a pendulum has on its swing; hence, if we want fast oscillations we must use a condenser of small capacity and if we want slow oscillations we must use a condenser of large capacity.

Inductance (Pronounced in-duk′tance).—It takes about $\frac{1}{2}$ second for a boy to throw a ball counting the time from the instant he begins to throw until the ball leaves his hand; and if we measured the time it takes him to catch the ball we would probably find it to be in the neighborhood of $\frac{1}{6}$ of a second.

It takes time for a street car to get up speed and when once going it takes time for it to stop. Everything we know of takes time to start and time to stop and electricity is no exception to the rule. Electricity travels 186.500 miles a second, which is just the speed of light—and yet it takes time for it to start and once started it takes time for it to stop.

This property of balls and cars and things to resist being moved when at rest and to keep on going when once in motion is called *inertia,* and the *inertia* of an electric current is called its *inductance.*

If the electric oscillations are flowing through a straight wire circuit, as in the tuned circuits shown in Fig. 160, it does not take as long for the oscillations to start and stop as it does if the wire is coiled up, for the inductance of a straight wire is not nearly as great as that of a coiled wire, but in either case the electric oscillations are slowed down according to the amount of inductance of each.

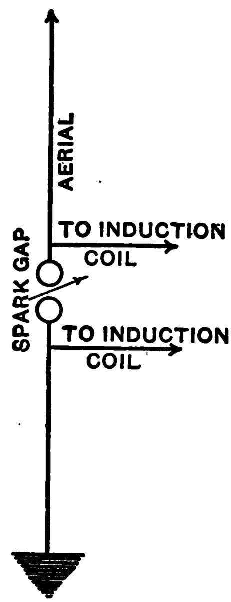


FIG. 161.—NON-TUNED OPEN OSCILLATION CIRCUIT.

Hence tuning coils are not only the most compact, but they are also the most effective forms of *inductances.*

Open Oscillation Circuits.—In wireless telegraphy the aërial wire system forms an *open oscillation circuit.* In a simple open oscillation circuit the spark-gap is formed between the ends of the aërial and ground wire as shown in Fig. 161. Since no tuning coil or condenser is used with this open oscillation circuit the *inductance* and *capacity* are laid evenly along the straight wires, and both the inductance and the capacity are, therefore, very small.

For this reason an electric charge produced by an induction coil on the aërial and ground wires in the small transmitter described in Chapter I, Part I, and which sets up the oscillating currents, is very small; as these currents are rapidly changed into electric waves the current only makes two or three swings, or oscillations, before it is entirely gone, or *damped out*, as it is termed, as shown in Fig. 162.

After these electric oscillations are damped out, or changed into electric waves, the aërial and ground wires are again charged by the induction coil, another spark takes place and two or three more oscillations surge in the aërial wire, and so on.

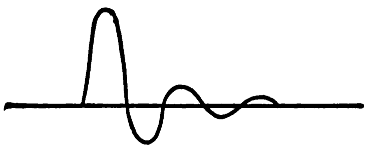


Fig. 162.—Strongly Damped Oscillations.

A straight aërial wire system sends out electric waves which are about four times the length of the aërial, and since there are neither tuning coils nor condensers connected with it the length of the electric wave which it sends out depends entirely upon the length of the aërial wire itself.

Closed Oscillation Circuits.—A pendulum which makes

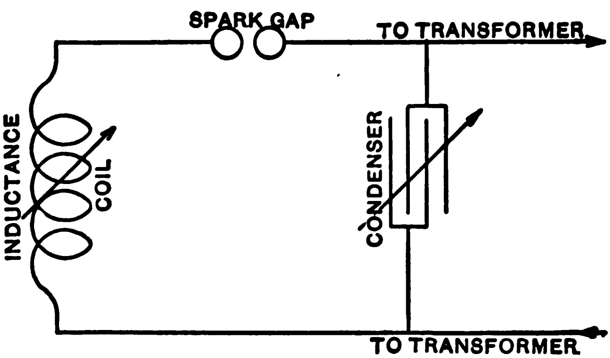


Fig. 163.—Tuned Closed Oscillation Circuit.

only two or three swings would cause another pendulum of unequal length to swing but very little if at all. In order to make another pendulum respond freely the first pendulum must swing a large number of times before it dies out.

And this, too, is what an electric current in a sending aërial wire must do in order to send out trains of waves to long distances and make a properly tuned receiving aërial respond to these waves.

Of course a simple open receiving aërial will respond to a sending aërial of the same kind but it does so by sheer force of the electric splash sent out and not because the receiving aërial is in any way tuned to the sending aërial.

Now to make a high-frequency current in a sending aërial oscillate a large number of times every time a spark jumps

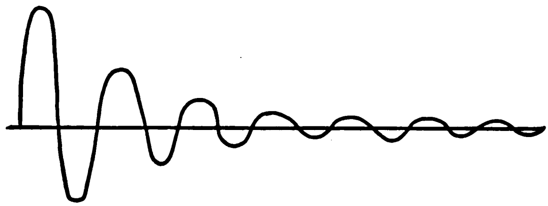


FIG. 164.—FEEBLY DAMPED OSCILLATIONS.

across the spark-gap the aërial and ground must be connected with a closed circuit, that is a circuit which has a spark-gap, a condenser and a tuning coil, as shown in Fig. 163, and all of which are adjustable.

This closed circuit is just the same as the circuits of the tuned Leyden jars except that a coil of wire and a number of Leyden jars have been put in the circuit to give it more inductance and capacity, and as these are made adjustable the circuit is easier to tune.

The electric current in a closed circuit swings to and fro, or oscillates, a large number of times before it dies out as a closed circuit does not change the oscillating current into electric waves very freely and so the oscillations are strung out to a dozen or twenty swings as shown in Fig. 164, and these *feebly damped oscillations*, as they are called, are just the kind which are needed for wireless tuning.

Coupled Oscillation Circuits.—Since an open oscillation circuit, such as is shown in Fig. 161, changes the electric oscillations surging in it into electric waves so quickly it is exactly the thing needed for a sending circuit, but for the very reason that the oscillations are damped out so quickly it is a very poor arrangement for tuning purposes.

On the other hand a closed oscillation circuit, as shown in

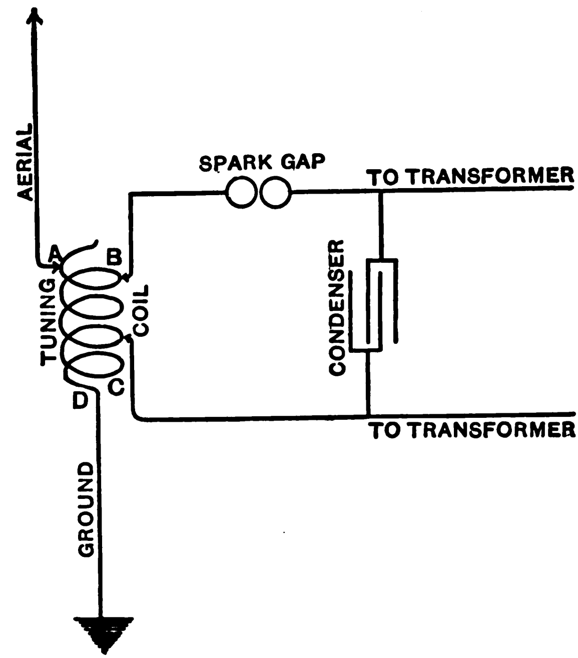


Fig. 165.—Coupled Open and Closed Oscillation Circuits for Transmitting.

Fig. 163, changes the electric oscillations surging in it into electric waves very slowly, but because the oscillations are so *feebly damped out* it is of no value as an aërial to send out waves.

To get in a measure the good effects both of the open and closed circuits so that long trains of strong electric waves will be sent out the two circuits are *coupled,* that is they are joined together.

There are different ways by which the aërial and ground wire can be coupled with a closed circuit, but the way we have chosen for the long distance set is that shown in Fig. 165 for the transmitter and Fig. 166 for the receptor. Joining the circuits together in this fashion is called a *direct*, or *conductive coupling.*

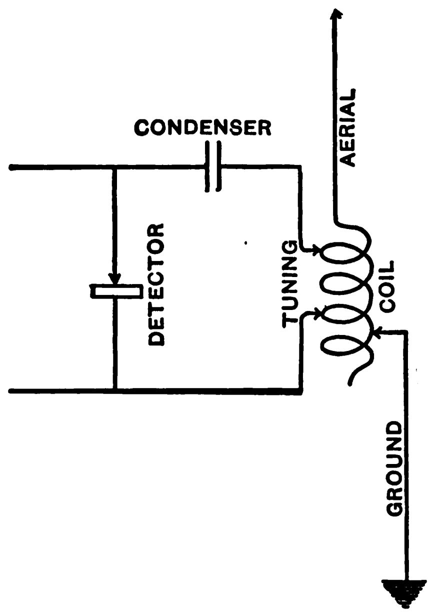


FIG. 166.—COUPLED OPEN AND CLOSED OSCILLATION CIRCUITS FOR RECEPTOR.

From what has been said it will be clear that when the open and closed circuits are coupled together they can be tuned to each other so that the electric oscillations in both circuits will surge together, or have the same *frequency*, as it is called. Likewise, the receiving station can be tuned to the sending station.

This is done by varying the capacity and inductance, which means, of course, that more or less of the condensers are used and cutting in and out turns, or parts of turns, of wire of the tuning coils. As a matter of fact, both the transmitter and the receptor can be tuned by simply changing the positions of the clips and sliders on the tuning coils and without touching the condensers, or they can be tuned by varying the capacity of the condensers without changing the values of the tuning coils.

Action of a Tuned Transmitter.—Starting with 110 volt, 60 cycle alternating current taken from the mains of a lighting or power circuit and supposing the key to be closed, the current flows through the regulating resistance—in this case a water resistance—and through the primary coil of the transformer.

Since the current changes its direction 120 times a second no interruptor is needed in the primary circuit to set up alternating currents, by *electromagnetic induction,* in the secondary coil of the transformer. The current at the ends of the secondary coil changes its direction exactly the same number of times per second as the current which flows into the primary coil.

While the frequency is the same for both the primary and the secondary coils the *pressure,* or *voltage,* is stepped up about 100 times, that is the primary coil is wound with, say, 300 turns of wire, and the secondary coil is wound with 30,000 turns of wire, the voltage is increased 100 times and 100 times 110 equals 11,000 volts at the ends of the secondary coil.

The ends of the secondary coil of the transformer are connected with the Leyden jar condenser and this condenser is charged (and discharged) every time the current changes its direction. Also every time the condenser is charged it discharges through the spark-gap and the turns of the tuning coil which are between the clips B and C, as in Fig. 165.

Now, the discharge of a condenser is always alternating, or *oscillating* as it is called, though both mean the same thing, and this oscillating current changes its direction anywhere from 100,000 to 1,000,000 or more times per second, depending upon the size of the condenser and the amount of inductance and resistance there is in the circuit.

These oscillating currents do not need a closed circuit to flow in, but they are so lively that they surge up to the end of the aërial wire and down through the tuning coil to the ground with amazing freedom. In order to get the best results a certain amount of inductance must be connected with the lower end of the aërial wire between the clips A and B of the tuning coil, and there must also be a certain amount of inductance between the ground wire D and the clip C of the tuning coil in order to tune the aërial wire to the closed oscillation circuit if strong electric waves are to be sent out.

The chief points to be remembered are (1) that the frequency of the electric oscillations in the aërial wire system depends entirely on the capacity, inductance and resistance of the aërial wire and the closed oscillation circuit, and (2) that the length of the electric waves sent out by the aërial wire depends solely on the frequency of electric oscillation in the aërial wire.

The best and easiest way to tell when the aërial wire and the closed circuit are in tune is to use a *hot-wire ammeter,* but if you want to know exactly what wave length your aërial is sending out you must use a *wave-meter.* Both of these handy instruments will be described presently.

Action of a Tuned Receptor.—When the electric waves which are radiated, that is sent out by the aërial of a transmitter, strike the aërial connected with a receptor (see Fig. 166), the electric waves are changed into electric oscillations, and if the circuits of the receptor are tuned to the circuits of the transmitter the oscillations will have exactly the same frequency as those in the aërial of the transmitter which sent them out.

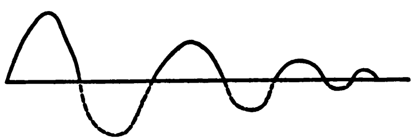


FIG. 167.—INTERMITTENT DIRECT CURRENT PRODUCED FROM ELECTRIC OSCILLATIONS.

As the oscillating currents run up and down the aërial and ground wires they flow through the closed circuit in which the condenser and the detector are connected.

When the oscillating currents flow through the contact made by the phosphor-bronze point and the crystal of the detector, they flow very freely in one direction, but they have hard work getting through the contact again in the other direction. In other words the lower half of the oscillating current is cut off as shown by the dotted lines in Fig. 167, and in this way the oscillating current is *rectified,* which means that it is changed into a direct current.

The direct current produced by the detector is large enough to energize the magnet of the telephone receiver, and which in turn causes the diaphragm of the telephone receiver to vibrate accordingly. The vibrations of the diaphragm set up sound waves which the ear hears as buzzing dots and dashes.

The reason that a detector must be used is that the received electric currents oscillate so very fast that the diaphragm of the telephone receiver cannot begin to keep up with it and so a direct current must be used.

The purpose of using a dry cell is to add current to the direct current produced by the detector. It will be readily seen that the current from the dry cell must flow in the same direction as the *rectified current* of the detector or the two currents will oppose instead of help each other.

It is important that exactly the right amount of current from the dry cell should be used with the crystal detector and the potentiometer permits this to be done.

How to Make and How to Use a Hot-Wire Ammeter.—When electric oscillations surge through a wire too small to carry the current easily the wire gets hot and it begins to stretch and this can be used to move a needle. This scheme is used in the hot-wire ammeter.

You can easily make a hot-water ammeter which will show when your sending circuits are in tune, but if you want a hot-wire ammeter with which to measure the amount of current in fractions of an ampere which is surging in your aërial you had better buy one.

Make a wood base ¾ inch thick, 5 inches wide and 6 inches long as shown in Fig. 168. Screw two small binding posts to the corners, and solder a piece of No. 30 copper wire, Brown and Sharpe gauge, about 3½ inches long to the posts and see that it is taut.

To the middle of the wire solder another copper wire of the same size, about 1 inch long, and make a loop at the free end. To this loop tie a stout silk thread and also tie the thread to the index needle. Tie the other end of the thread to one end of a spiral brass spring made of very thin wire and fastened to the base with a screw at its other end.

The index needle can be pivoted to the base by means of a pin but it must not wobble. The thread tied to the needle will keep it clear of the base. Make a cardboard scale and divide

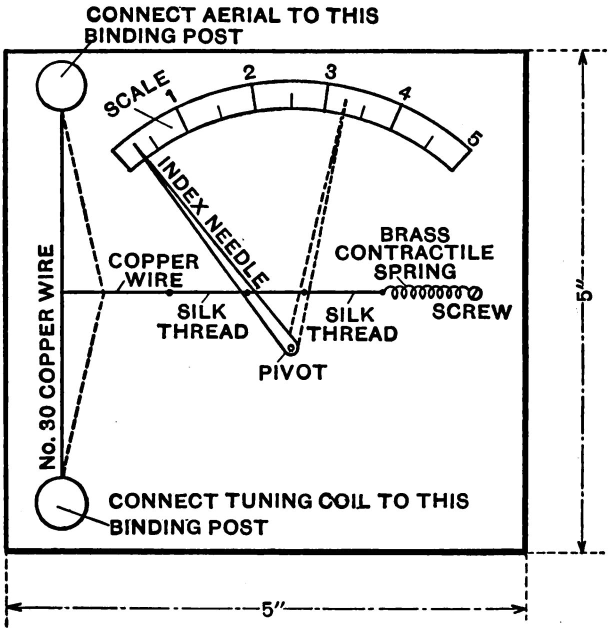


FIG. 168.—SIMPLE HOT-WIRE AMMETER—TOP VIEW.

it into say five divisions and tack it under the end of the needle. It can be marked with figures but unless the hot-wire ammeter is adjusted to read in amperes the figures will have no real value.

When the hot-wire ammeter is connected in between the aërial wire and ground and oscillations are surging through it the wire gets hot, owing to the resistance it offers to the flow of the oscillating currents and when it gets hot it begins to stretch. The brass spring which has been drawn out by the wire when cold now begins to draw in, or contract, and this takes up the sag of the hot wire and pulls the needle across the scale. Fig. 169 shows the hot-wire ammeter in perspective.

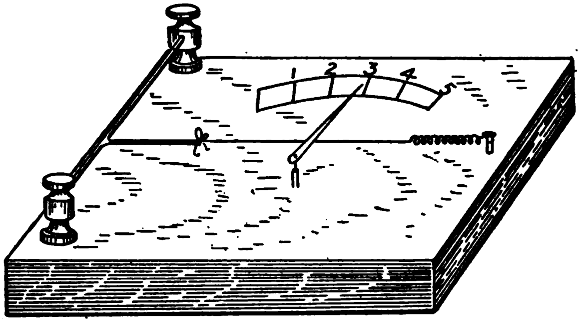


FIG. 169.—SIMPLE HOT-WIRE AMMETER COMPLETE.

By adjusting your condenser and tuning coil you will find that the needle of the hot-wire ammeter swings forth and back. When the amount of current which flows into the primary coil of your transformer has been regulated just right by the water resistance, and the capacity of your condenser, the inductance of your tuning coil and the length of your spark-gap have been adjusted just right, the needle of your hot-wire ammeter will swing farthest to the right of the scale and then you may be certain that your aërial wire and

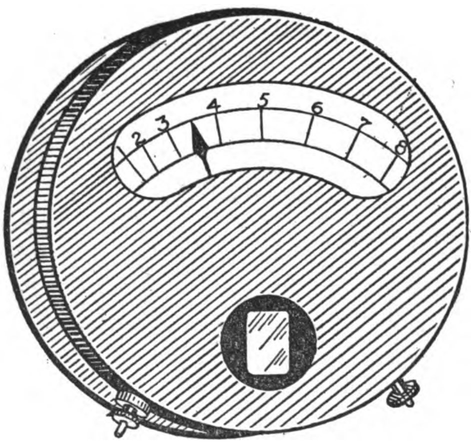


FIG. 170.—CHEAP HOT-WIRE AMMETER.

closed circuit are in tune. A cheap and fairly good hot-wire ammeter as shown in Fig. 170 can be bought for from $3.00 to $6.00 of dealers in wireless apparatus.

Construction and Use of a Wave Meter.—As the Government will not permit a boy to send out electric waves which have a length of more than 200 meters[1]—equal to 656 feet, the question naturally comes up as to how a fellow is to know

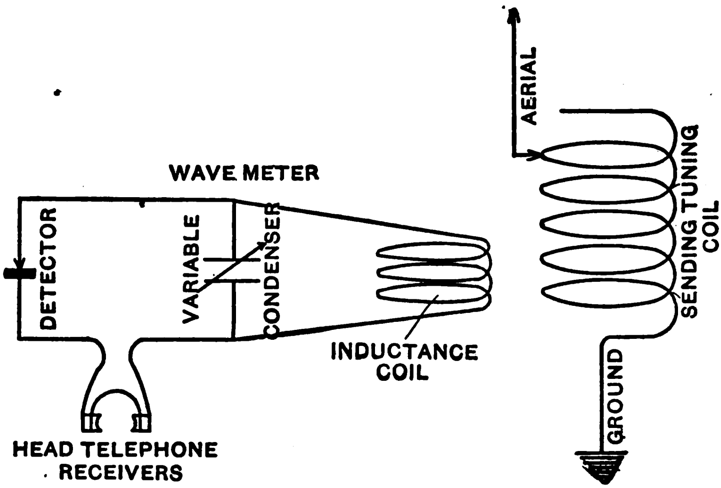


Fig. 171.—Diagram of Wave Meter and Sending Tuning Coil.

when his transmitter is sending out waves of the right length.

The answer is found in the use of a wave meter. If you have a wave meter you can do a lot of stunts with it, such as finding out if your transmitter is sending out one or two waves at the same time, the relative intensities of signals, the length of the waves sent out and the length of waves which are coming in.

A wave meter resembles a receptor without the aërial and ground wires, as it has a closed circuit formed of a crystal detector, a pair of head telephone receivers and a variable condenser; this closed circuit is connected with an inductance coil as shown in the diagram, Fig. 171.

[1] A meter is equal to 39.39 inches.

A wave meter is formed of a rotary condenser whose capacity is variable and an inductance coil whose inductance is fixed and you can use your own detector and head telephone receivers with them so that the cost of a wave meter is very small.

The rotary variable condenser is built up of a dozen or fifteen semicircular sheets of brass or aluminum rigidly fixed in a brass frame at a distance of $\frac{1}{16}$ inch from each other. Another dozen or fifteen semicircular sheets of metal are mounted on a spindle ending in a hard rubber disk handle on top of the condenser. These movable sheets of metal interleave, or slide between the fixed semicircles but do not touch them, as shown in Fig. 172.

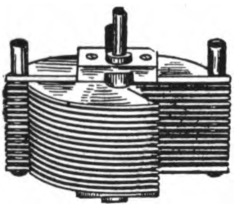


FIG. 172.—FIXED AND MOVABLE PLATES OF VARIABLE CONDENSER.

When all the sheets are interleaved the capacity is the greatest and when the fixed and movable sheets are turned away from each other the capacity is very little or nothing. The condenser is placed in a brass case which is fitted with a hard rubber cover through which projects the spindle when the handle is screwed on.

On the top of the condenser is engraved a scale—something like that described for the hot-wire ammeter. This scale is divided into 150 spaces, called degrees. On the spindle is fastened a pointer and by turning the handle the amount of capacity of the condenser can be seen from the position of the pointer on the scale. The whole arrangement is shown in Fig. 173. This condenser can be used to mighty good advantage in place of the fixed condenser, described on page 95, Chapter II, Part II, for sharper tuning can be done with it than with the tuning coil.

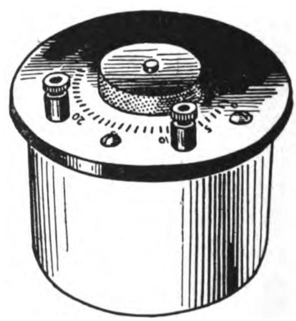


FIG. 173.—THE CONDENSER COMPLETE.

The inductance coil of the wave meter is made of about 25 feet of insulated wire wound in the groove of a disk or on a spool. The ends of the inductance coil are connected to a pair of binding posts, and which in turn are connected to the binding posts of the variable condenser as shown in Fig. 174.

With a wave meter of this type the length of electric waves from 150 meters up to 600 meters can be measured, and as a 600 meter wave length is the standard used by the Government

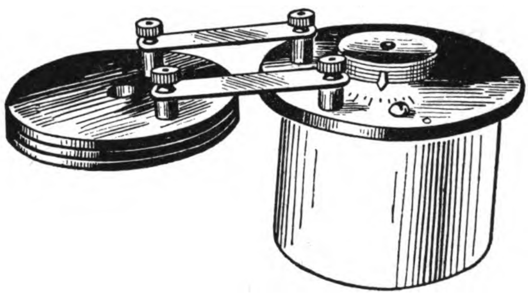


FIG. 174.—THE WAVE METER COMPLETE.

and commercial stations this is large enough for all your needs.

To use this wave meter disconnect your detector and head telephone receiver from your tuning coil and condenser and connect them to the binding posts of the variable condenser. Set the inductance coil of the wave meter close to and in parallel with the tuning coil of your transmitter as shown in Fig. 171.

The wave meter with the detector and head telephone receiver is entirely separate and distinct from the transmitter whose wave length is to be measured, but is acted upon by the currents flowing through the tuning coil of the transmitter just as the secondary coil of a transformer is acted upon by a current flowing through its primary coil.

When the key of the transmitter is closed, buzzing sounds are heard in the telephone receiver and as the capacity of the variable condenser is changed these sounds become fainter or stronger. When the sounds are loudest the circuits of the wave meter and the transmitter are in tune, that is the electric oscillations in both circuits have the same frequency.

Now by noting the number on the scale on which the pointer of the condenser rests and consulting a curve sheet which goes with the wave meter, the wave length your transmitter is sending out can be read directly in meters.

Cost of hot-wire ammeter when bought of dealers..	$3.00 to $10.00
Cost of hot-wire ammeter when home-made................	.50
Cost of variable rotary condenser when bought of dealers...	4.50
Cost of wave meter as shown in Fig. 174..................	6.00

PART III

INDUCTION COIL TRANSFORMER AND ELECTROLYTIC INTERRUPTOR

CHAPTER I

HOW TO MAKE A HALF-INCH INDUCTION COIL

One of the most pleasing pieces of apparatus a boy can own is a small induction coil. It cannot only be used to send wireless telegraph messages but a large number of other experiments of quite a startling nature can be made with it.

In itself an induction coil is a simple device, but to make one that will work well much care must be given each detail and so in making an induction coil you must start in with the idea of taking a lot of time and using a lot of patience.

If you will make up your mind to do the thing right and then work exactly as I say, you should have a good coil and one that will last longer than those which are usually sold by dealers.

There are four parts to an induction coil and these are:

(1) The *base* on and in which the other parts are mounted.

(2) The *induction coil,* which changes the low pressure battery current into high pressure alternating currents.

(3) The *interruptor,* which rapidly makes and breaks the current from the battery, and

(4) The *condenser,* which takes up the current when the interruptor breaks the circuit.

The base should be made of some kind of hard wood, as the interruptor is mounted on it, and this part of the coil must be very firm. Use ⅜ inch thick stuff for the base and saw out a top 5 inches wide and 9 inches long.

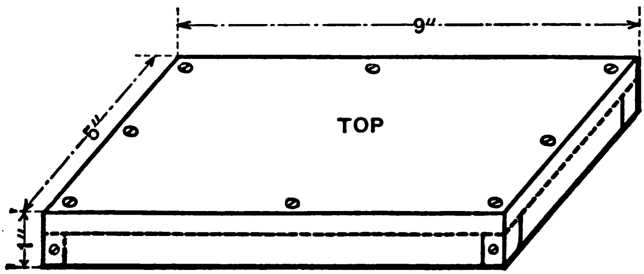


FIG. 175.—TOP VIEW OF BASE.

Saw two strips of wood ⅝ inch wide and 9 inches long for the sides and two more strips ⅝ inch wide and 4¼ inches long for the ends. Glue these strips together to form a frame 5 inches wide and 9 inches long and glue on the top. When the glue is dry either drive a brad in each corner to hold the frame

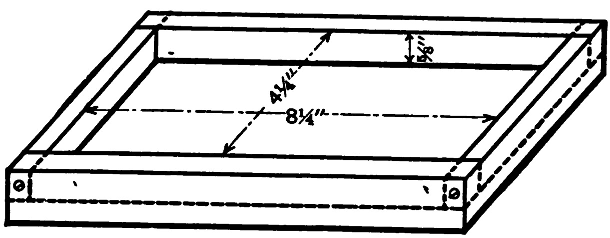


FIG. 176.—BASE TURNED UPSIDE DOWN SHOWING INSIDE.

and nail on the top or use small brass screws, which is better. A top view of the base is shown in Fig. 175.

Get a plain board of soft wood ¼ inch thick, 4½ inches wide and 8¼ inches long and smooth it down until it will just fit into the bottom of the base. The base is shown turned upside down in Fig. 176 and, of course, it is just the depth of the frame, that is ⅝ inch.

Make four base blocks ¼ inch thick, 1 inch wide and 1 inch long as shown in Fig. 177. These blocks are to be glued to the corners of the base when the coil is all done to hold in the condenser.

Having made the base your next move is to tackle the coil itself and you will find this part of the job very interesting and very particular. Buy ½ a pound of black soft iron wire about No. 18, 20 or 22 Brown and Sharpe gauge, at a hardware store and cut the wire up into pieces exactly 5¾ inches long. When you have enough to make a bundle ½ inch in diameter straighten out each piece so that there are no kinks in it. Next put all the wires together with their ends even and tie them with a string so that a round core ½ inch in diameter will result as shown in Fig. 178.

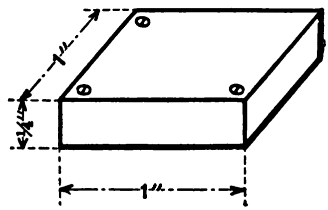


FIG. 177.—BASE BLOCK.

Take a sheet of heavy paper of any kind and cut it into strips 5½ inches wide; now roll a strip of paper tightly around

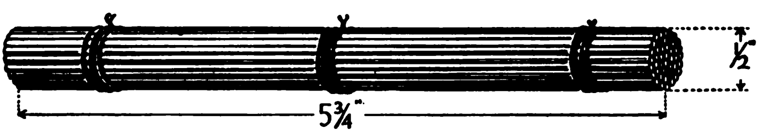


FIG. 178.—CORE OF COIL.

the soft iron core as shown in the cross-sectional drawing, Fig. 179, so that one edge of the paper is even with one end of the core and leaving the other end of the core projecting ¼ inch. Glue the paper as you roll it so that it can't slip and put enough paper on the core so that a tube 1/16 inch thick is formed around it.

This done make two wooden ends for the coil, called cheeks, ½ inch thick and 3 inches square. Bore a hole in the center of

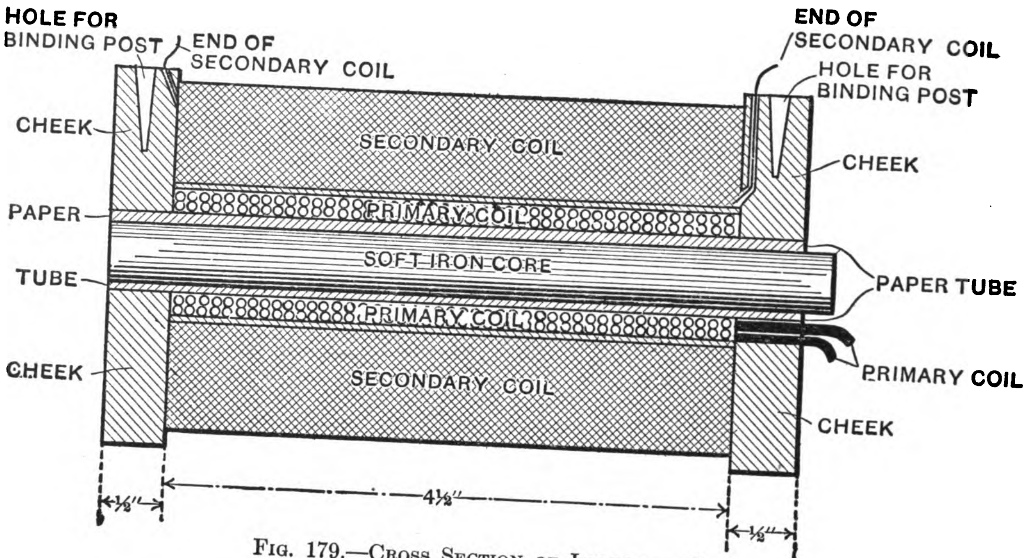


FIG. 179.—CROSS SECTION OF INDUCTION COIL.

each cheek $\frac{5}{8}$ inch in diameter. Drill a hole $\frac{1}{8}$ inch in diameter in one edge of each cheek for the screws of the binding post as shown in Fig. 180, and make each hole $\frac{5}{8}$ inch deep. Drill a hole $\frac{1}{16}$ inch in diameter close to the binding post screw hole and at a slant so that it will come through to the inside of the right-hand cheek $\frac{3}{4}$ inch from the edge as shown in Fig. 179. These holes are to bring the ends of the secondary wire through

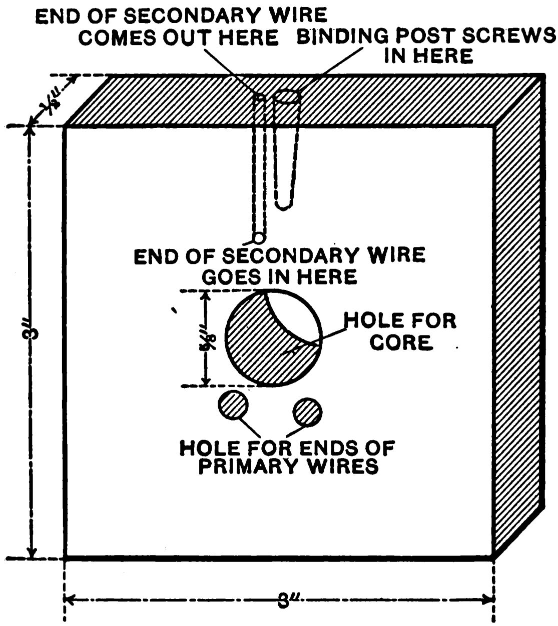


Fig. 180.—Cheeks of Induction Coil.

to the binding posts. In the right-hand cheek just below the hole for the core (see Fig. 180) drill two $\frac{1}{8}$ inch holes; the ends of the primary wires are to be brought out of these holes.

Now smear plenty of good glue on the ends of the paper tube around the core and slip the cheeks over the ends of the core and tube as shown in Fig. 179, and lay the spool away until it is thoroughly dry.

Next slip one end of a No. 16 Brown and Sharpe gauge, double cotton-covered magnet wire—ordinary bell wire will do—which is 25 feet or a little longer, through the hole in the cheek that is nearest the core and leave about four inches hanging out. Wind a layer of wire on the core and give it a good coat of shellac. Wrap on a layer of paper and then wind on the second layer of wire and be sure to put it on tight. This will bring both ends of the primary wire out of the same cheek as shown in Fig. 189, and this cheek should be the one through which the end of the core projects. Wrap a couple of more layers of paper round the primary coil and shellac it.

This coil of wire is called the primary coil for the current from the battery, or the *primary current* as it is termed, flows through this coil. The wire of the primary coil can be put on neatly enough by hand but when it comes to winding the secondary coil, that is the coil of fine wire, don't try to do it by hand, for the wire is so fine and there is so much of it and it must be put on so evenly that it is a very tiresome job unless you have a lathe or a winding machine.

Every locksmith and machinist has a lathe and you can get him to wind on the secondary wire for you or he will very likely let you wind it yourself. Almost all men are interested in boys since it is not so long ago that they were boys and were trying to do things themselves, and even now most of them are only overgrown boys who like to putter around. If you can get the use of a lathe the winding is easily and quickly done. If you can't get the use of a lathe make a winding machine as follows:

Make a base of wood ⅞ inch or 1 inch thick, 5 inches wide and 9½ inches long. One-half inch from each end and in the middle of the base, as shown in Figs. 181 and 182, secure a support of wood, each of which is 1 inch thick, 1½ inches wide and 4 inches high with long thin wood screws shown by the dotted lines.

Through the upper end of one support drill a ⅛ inch hole for the wood screw which is to serve as the *back center* of the

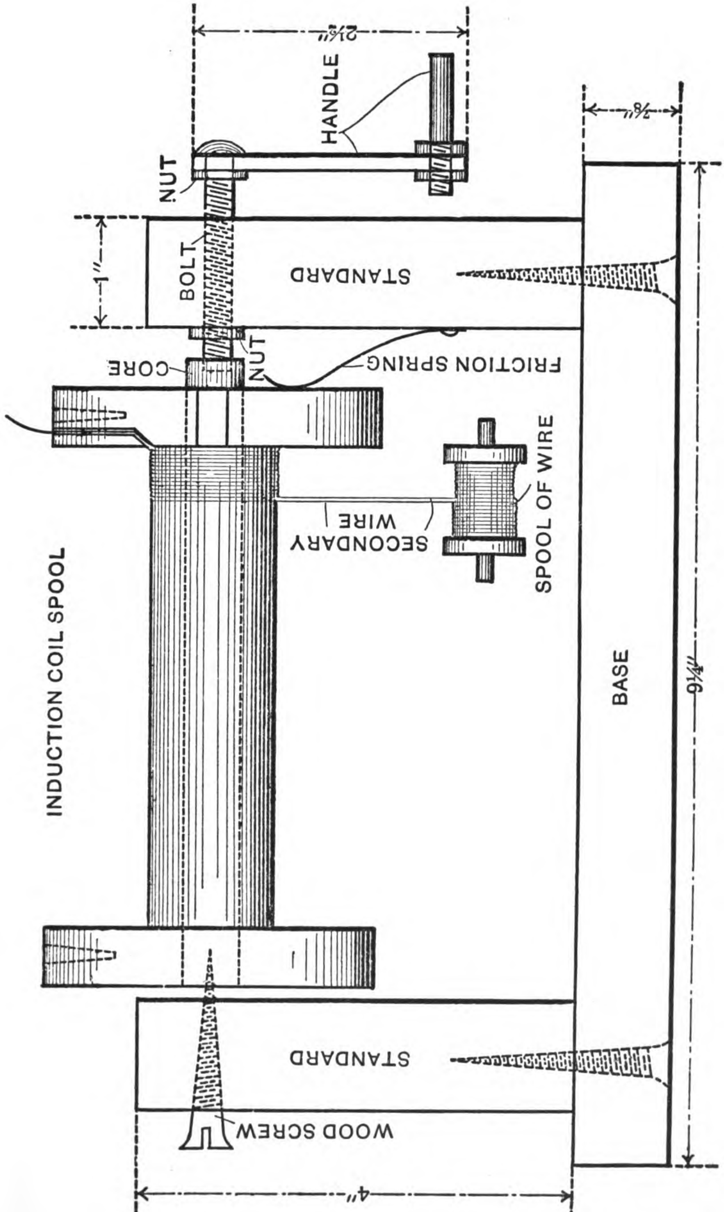


FIG. 181.—CROSS SECTION OF WINDING MACHINE.

winding machine and through the upper end of the other support drill a $\frac{1}{4}$ inch hole for a bolt, which is to be the *spindle* of the winding machine.

The bolt should be $\frac{1}{4}$ inch in diameter and 2 inches long and have it threaded clear up to the head and sharpen one end like

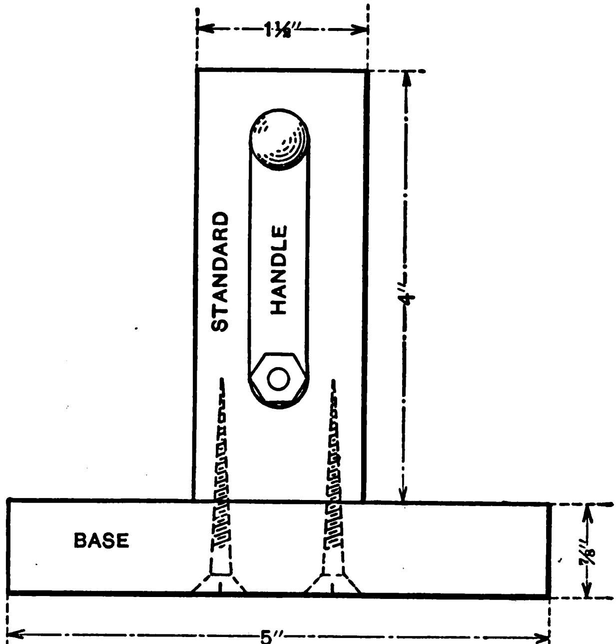


FIG. 182.—END VIEW OF WINDING MACHINE.

the end of a screw-driver. Make a handle bar $\frac{1}{2}$ inch wide and $2\frac{1}{2}$ inches long of a piece of brass $\frac{1}{16}$ or $\frac{1}{8}$ inch thick and drill a $\frac{1}{8}$ inch hole at one end and a $\frac{1}{4}$ inch hole at the other end.

Cut off a piece of brass rod $\frac{3}{16}$ inch thick and $1\frac{1}{4}$ inches long and cut threads on one end of it $\frac{1}{2}$ inch deep and screw on a nut as far as it will go. Slip the end through the smaller hole in the handle bar and screw on another nut and tighten both nuts up so that the handle will not work loose.

Slip the bolt through the hole in the other end of the handle bar, put on a tight-fitting nut and screw it up so that the handle bar will not turn on the bolt. Push the bolt through the hole in the wood support and screw on another nut.

Cut a friction spring out of a piece of sheet brass ½ inch wide and 2 inches long, bend it as shown in Fig. 181 and screw it to the inside of the right-hand support. This spring is to keep the induction coil spool from turning when you let go the handle; if it is not used the wire would loosen up.

This completes your winding machine when it should be screwed solidly to a table or a bench. Now set the induction coil spool between the supports and tighten up the wood screw and see that the point of the screw is exactly in the center of the core of soft iron wires as shown by the dotted lines in Fig. 181 so that a pivot is formed on which the spool can turn freely.

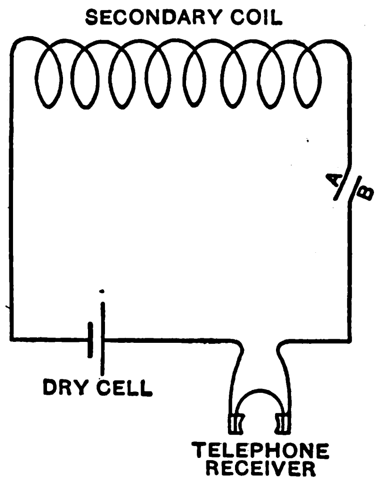


Fig. 183.—Testing Wire of Secondary Coil.

Push the screw-driver end of the bolt into the core to a depth of about ¼ inch in order that it may get a good purchase, or hold, in the core. Screw up the nut on the inside of the standard until the induction coil spool does not wobble. Everything is ready now to wind the secondary coil. A pound of double cotton-covered magnet wire No. 32 Brown and Sharpe gauge will be needed for the secondary coil. When ordering this wire state that you want it on a spool. You must test this wire carefully and know that there are no breaks in it. Sometimes the wire is broken and the cotton covering holds together when it will pass through the fingers unnoticed in winding.

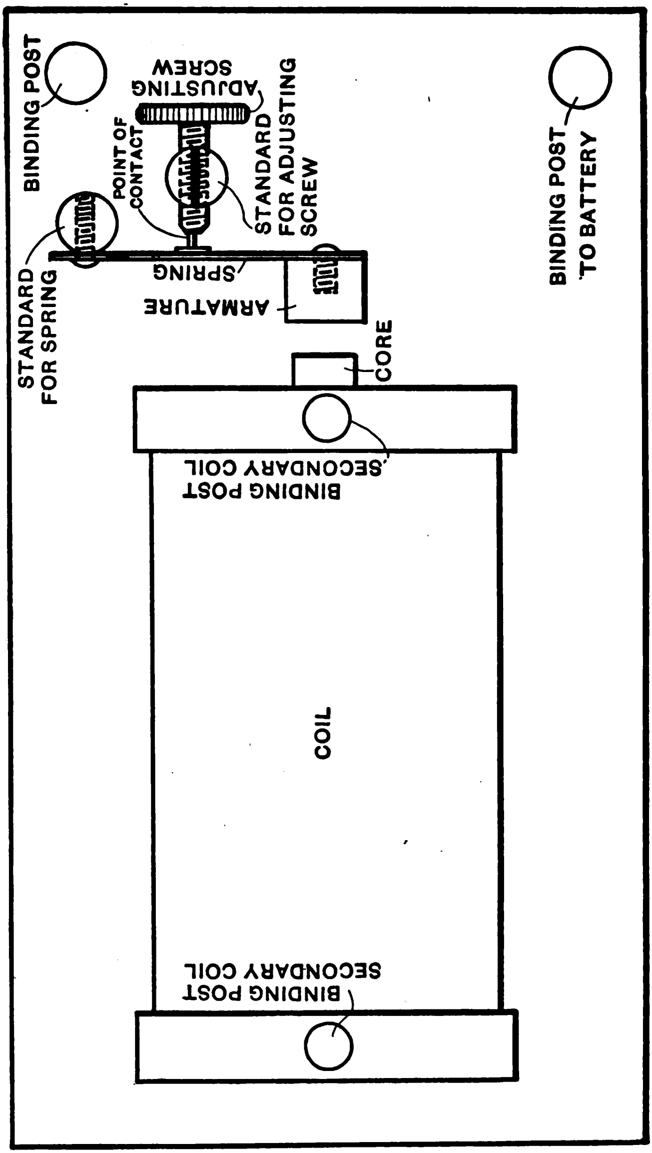


Fig. 184.—Top View of Induction Coil.

To prevent this, connect the ends of the wire with a telephone receiver and a dry cell as shown in the diagram, Fig. 183. By touching the ends of wires A and B together if the secondary wire is unbroken you will hear the telephone receiver click, but if the wire is broken there will be no sound in the telephone receiver.

Before starting to wind the secondary coil cut a large number of strips of thin paper, a shade less than 4½ inches wide and long enough to go around the primary coil and lap over ½ inch. Have a bottle of shellac varnish and a brush handy to put it on with.

Take an end of the secondary wire and thread it through the hole in the right-hand cheek from the inside and draw it through the edge an inch or so as shown in Fig. 181. Turn the handle of the winder with your right hand and guide the wire with your left hand, keeping the turns close to each other and applying enough tension to the wire as it slips through your fingers to make it tight.

When you have wound on one layer of wire, give it a coat of shellac and put on another strip of paper. Put on another layer of wire and shellac it; then another strip of paper and so on until the spool is nearly full of wire; bring the end out of the hole in the other cheek and take the coil out of the winding machine.

The coil can be given a neat finish by gluing a strip of bookbinders' cloth around the secondary coil and have the lap come on the under side. Now screw the coil to the base in the position shown in Fig. 184. This is done by screwing four thin round-headed brass wood screws 1 inch long through the base from the bottom and into the cheeks of the coil—that is two screws for each cheek.

Into each hole on top of the cheeks screw two small wood screw binding posts (see Fig. 93). Loop the ends of the wires around the screws of the binding posts and screw them tightly down to the cheeks.

The coil itself is done and the next thing to do is to make

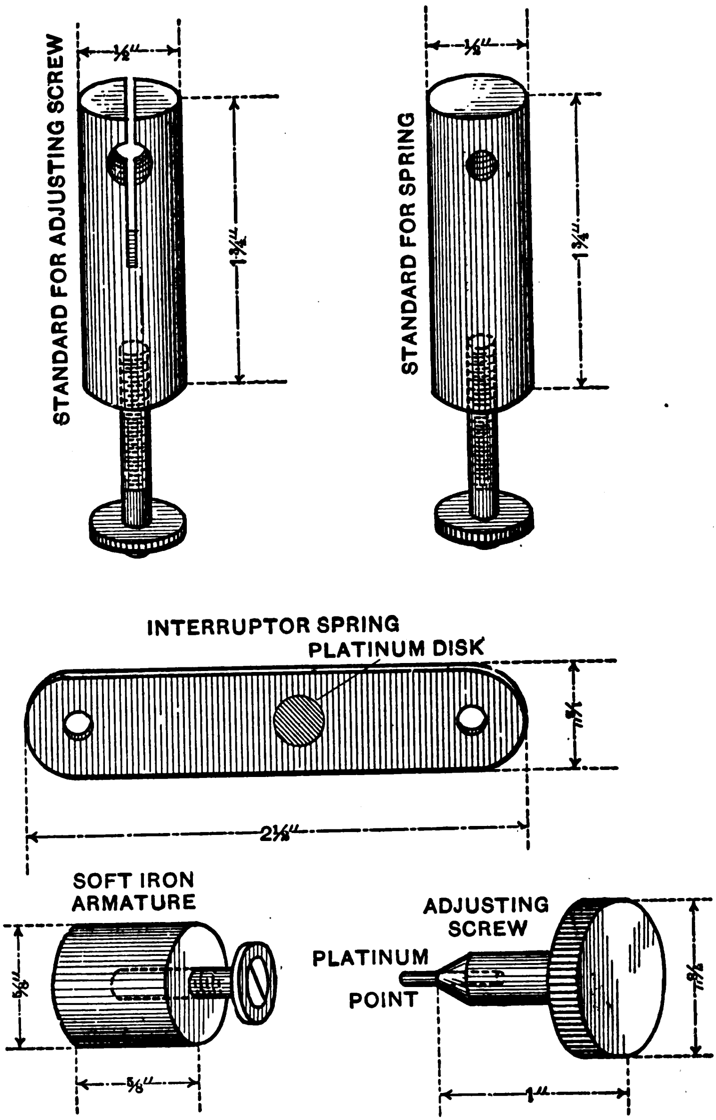


Fig. 185.—Parts of Interruptor.

the interruptor. This is formed of five parts as shown in Fig. 185. Cut off two pieces of brass rod $\frac{1}{2}$ inch in diameter and $1\frac{3}{4}$ inches long for the standards. In one piece drill a hole $\frac{1}{8}$ inch in diameter and $\frac{1}{4}$ inch from the end. Cut or slot the end down $\frac{3}{4}$ inch with a hack-saw. This standard is for the adjusting screw and the slot will make the end of the standard springy, which will prevent the adjusting screw from slipping without the use of nuts. In the end of the standard drill and tap a hole for a machine screw.

The adjusting screw is made of a piece of brass rod $\frac{3}{16}$ inch in diameter and threaded to fit the hole in the standard. The head of the screw can be of any size, though it is marked $\frac{7}{8}$ inch in the drawing. A $\frac{1}{16}$ inch hole is drilled into the end of the adjusting screw and a platinum wire $\frac{1}{2}$ inch long is forced halfway into the hole as shown in Fig. 185.

In the other brass standard which is to support the spring drill a $\frac{3}{32}$ inch hole $\frac{1}{4}$ inch from the top and in the end drill a $\frac{1}{8}$ inch hole and tap it for a machine screw. The spring can be made of a piece of stiff sheet spring sheet brass, though phosphor-bronze is better. Cut a strip $\frac{1}{2}$ inch wide and $2\frac{1}{2}$ inches long and drill a $\frac{3}{32}$ inch hole near each end.

Now comes the hardest part of the job. Get a piece of platinum $\frac{1}{32}$ inch thick and $\frac{3}{16}$ inch in diameter and solder this disk to the spring as shown in Fig. 185. Sometimes the contact disk gets very hot and the solder melts. A better way is to have a jeweler hard solder the disk to the spring and it will never melt off.

Fasten one end of the spring to the end of the standard with a machine screw $\frac{3}{4}$ inch long and put a nut on the end. To the other end of the spring and on the opposite side of the platinum contact disk, screw on the soft iron armature. This completes the interruptor and the standards can now be screwed to the hardwood base at the places shown in Fig. 184.

This brings the standard carrying the armature spring to one side of the base and leaves a space $\frac{1}{4}$ inch between the end of the armature and the end of the core of the coil as may be seen in Fig. 184. The standard carrying the adjusting screw must come exactly in a line with the platinum disk on the spring which is also shown in Fig. 184. Drill two holes in the corners of the base and put on two binding posts with machine screws.

There is still another and a very important part of the induction coil to make and this is the condenser. In all small coils the condenser is concealed in the bottom of the base.

The condenser is made up of sheets of paper and leaves of tin foil. What you want to do now is to get your coil done

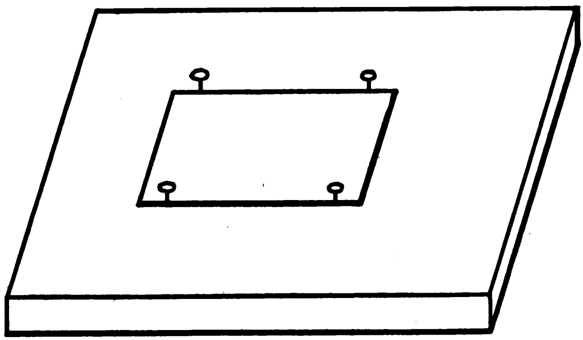


Fig. 186.—Guide for Laying Up Condenser.

and in working order and we shall find out presently what part the condenser plays in the working of the coil.

Get enough good bond paper, such as is used for typewriting, to make 170 sheets, 4 inches wide and 7 inches long and test each sheet by holding it between your eyes and a strong light to see that there are no pin holes in them. Cut out two sheets of heavy cardboard 4 inches wide and 7 inches long.

Lay one of the sheets of cardboard on a smooth piece of pine wood and drive four thin wire nails around it as shown in Fig. 186. This scheme will make it easy to get all of the sheets of paper even.

Three-fourths of a pound of tin foil will be needed and this can be of any quality and thickness. *Composition foil* is just as good as pure tin foil and the thinnest is just as good as the thickest foil.

Cut the tin foil into leaves 3 inches wide and 6½ inches long. Begin to build up the condenser by laying a couple of sheets of paper on the cardboard, then lay a leaf of tin foil on the paper so that it will project over the edge of the paper ⅜ inch. This will leave a margin of ⅞ inch at the opposite end and ½ inch margin on each side—exactly in the same fashion as that de-

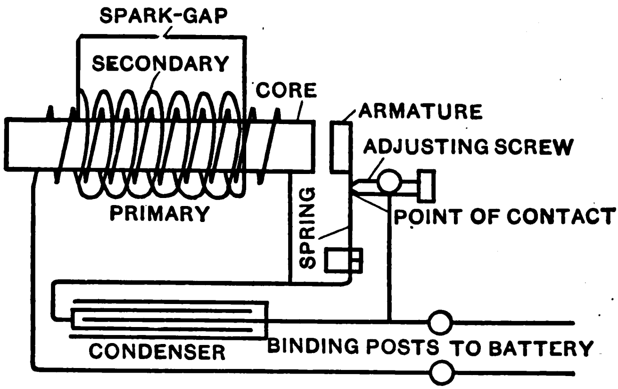


FIG. 187.—WIRING DIAGRAM FOR INDUCTION COIL.

scribed in Chapter II, Part II, on page 95, for the mica condenser.

Lay two more sheets of paper on the tin foil and then another leaf of tin foil on the paper with the other end sticking out and so on until you have used up all your paper. This brings the end of every other sheet of tin foil out from the opposite end.

When the condenser has been laid up, lay a couple of more sheets of paper and the other sheet of cardboard on top of it and slip a rubber band around each end to hold the condenser together. Place the condenser between two boards in a vise with the end sticking out and solder a wire to each end as explained on page 96.

The last thing on the list is to connect up the different parts. Fig. 187 shows how the induction coil is wired up. In this drawing the primary and secondary coils are shown as single layers with the turns far apart but this is done to make the drawing clear.

Drill two holes in the base under the end of the core next to the interruptor and draw the ends of the primary wire through the base underneath. Use heavy insulated wires for the connections. Connect one end of the primary coil directly to the screw holding the standard which carries the armature spring.

From the screw of this standard lead a wire to one side of the condenser. Connect the other end of the primary coil to the screw of one of the binding posts on the base. From the other binding post lead a wire to the screw of the standard carrying the adjusting screw. Connect a wire to the screw of this standard and join it to the other side of the condenser.

Having wired up all the parts, place the condenser in the base and be very careful that none of the wires lay on the ends of the condenser. Put it in the bottom of the base and screw on the corner blocks to keep it in.

Now, if you will connect a battery of five or six dry cells to the binding posts on the base, connect a pair of wires to the binding posts of the secondary coil, leaving a gap ½ inch long between the free ends and adjust the screw of the interruptor, you should get a good ½ inch spark. If you have made a very good coil you should get a ¾ inch spark from it. The completed coil is shown in Fig. 10, page 6.

A word now as to the action of an induction coil as it is always good to know how a thing works as well as to know that it works well.

When there is no contact between the point of the adjusting screw and the platinum disk on the spring, it will be clear that no current can flow through the primary coil, since the circuit is broken.

Screw up the adjusting screw until it just makes contact with the platinum disk on the spring when the current will flow through the primary coil and this will make a magnet of the core of soft iron wires.

The end of the core attracts the soft iron armature on the end of the spring and pulls it to it. When the spring is pulled over a trifle, the platinum disk on the spring and the platinum point of the adjusting screw are separated and the circuit is broken.

The instant the circuit is broken the current stops flowing through the coil, the iron loses its magnetism and releases the armature when the spring flies back and contact is again made between the platinum disk and point; and this is repeated several hundred times a minute.

The reason a condenser is connected across the contact points of the interruptor is to take up the battery current when the platinum contact points break apart; otherwise the heavy current would *arc* across or flow through the gap made by the contact points when they break apart and this would prevent a *quick break* from being made. A quick break at the contact points is needed to set up strong alternating currents in the secondary coil.

Every time the current flows through the primary coil currents of magnetism, called *magnetic lines of force,* flow from the end S of the core to the end N through the core and these lines of magnetic force flow back from the N end of the core to the S end through the air as shown in Fig. 188. Of course when there is no current flowing in the primary coil there are no magnetic lines of force flowing through and around the core.

This rise and fall of magnetic lines cut across the turns of wire of the secondary coil and set up currents of electricity in them, a current flowing in one direction when the primary circuit is made and the magnetic lines of force expand, and a current flowing in the other direction when the primary circuit is broken and the magnetic lines of force contract. These secondary currents are not continuous but each one lasts for only a moment.

The pressure of these secondary currents is increased since there are a large number of turns of fine wire in the secondary coil as explained on page 45.

If you start off with a battery of five or six cells, each cell will give a pressure of about 1½ volts, but the current is very

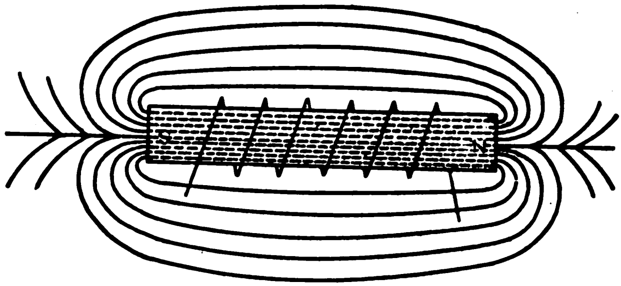


FIG. 188.—MAGNETIC LINES OF FORCE IN COIL.

large. If the ends of the secondary coil are separated ½ inch and a spark jumps across the gap you will know that the pressure has been increased from 7 or 8 *volts* which the battery gives, to about 30,000 volts at the spark-gap, for it takes a pressure of about 30,000 volts to break down ½ an inch of air.

COST OF MATERIALS TO MAKE AN INDUCTION COIL

Interruptor	$1.00
Wire for secondary coil	1.50
Iron wire for core	.10
Wire for primary coil	.25
Tin foil for condenser	.20
Four binding posts	.24
Shellac varnish	.10
Total	$3.39

CHAPTER II

HOW TO MAKE A ONE-HALF KILOWATT TRANSFORMER

A transformer is really a kind of induction coil but it is more simple and more powerful than an ordinary coil which uses the same amount of current.

Like an induction coil a transformer has a core of soft iron, a primary coil and a secondary coil, though nearly all induction coils have *straight* soft iron cores like that shown in Figs. 178 and 179, Chapter II, Part III, while nearly all transformers have *rectangular* soft iron cores, as that shown in Fig. 189.

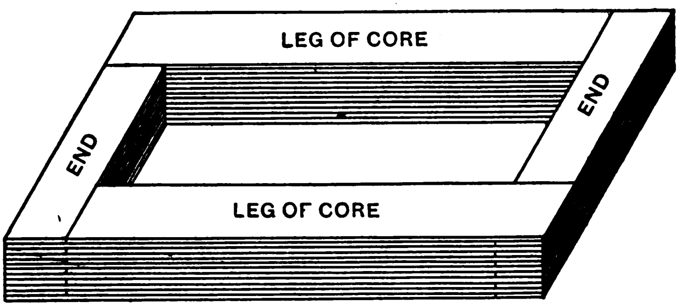


Fig. 189.—Core of Transformer.

Again a transformer works like an induction coil in that when a current flows through the primary coil it magnetizes the iron core and the magnetic force of the coil sets up electric currents in the secondary coil.

When an alternating current is used to work a transformer an interruptor is not needed to make and break the primary circuit and this also does away with the paper and tin foil condenser.

With a transformer, though, a Leyden jar condenser must be used to produce sparks, otherwise only a *flaming arc* will take place between the ends of the secondary coil. A Leyden jar condenser of the kind needed to produce sparks has been described on page 65.

If a direct current is used to work the primary coil then an *electrolytic interruptor,* described on page 191, should be used to make and break the primary circuit. This kind of an interruptor does not need a condenser, for it has a certain *capacity* of its own which is enough for it to get by with.

The Soft Iron Core.—The core of the transformer is made up of very thin strips of soft sheet-iron laid up in the form of a rectangle as shown in Fig. 189. Sheet-iron such as is used for making stove-pipes will do for the core and this can be bought at a tinsmith's. Have him cut it for you to the exact width and length needed with his foot-power shears so that when the core is formed it will be nice and even.

These strips of sheet-iron should not be thicker than $\frac{1}{32}$ inch and if you can get them thinner than that so much the better. If they are $\frac{1}{32}$ inch thick have the tinner cut 176 strips in all—74 for each side of the core. If these strips are thinner than $\frac{1}{32}$ inch get enough to make the core $1\frac{3}{8}$ inches thick.

Have all the strips cut $1\frac{3}{8}$ inches wide, and have half of them cut $5\frac{1}{2}$ inches long for the ends of the core and the other half cut $10\frac{3}{8}$ inches long for the sides, or *legs* as they are called, of the core. The weight of the iron for the core will be in the neighborhood of 17 pounds.

While the strips do not have to be varnished, it makes the transformer work better to give them a coat of shellac. This will prevent *electric whirls,* called *eddy currents,* from being set up in the iron which wastes the current in heat.

To build up the core begin by laying one of the long strips of iron on a table or bench, and lay a short strip with one of its ends up to the end of the long strip. Then lay another long strip on the other side and another short strip on the other end as shown at A in Fig. 190. The ends of these strips are not lapped over each other but they are laid up against, or about, each other.

On top of these four strips, marked A in Fig. 190, lay four more strips, B, in the same fashion except that this time the strips are laid so that one end of each of the long pieces of the B rectangle laps over one end of each of the short pieces of the A rectangle, as shown in Fig. 190, and this forms what is called a *staggered joint.*

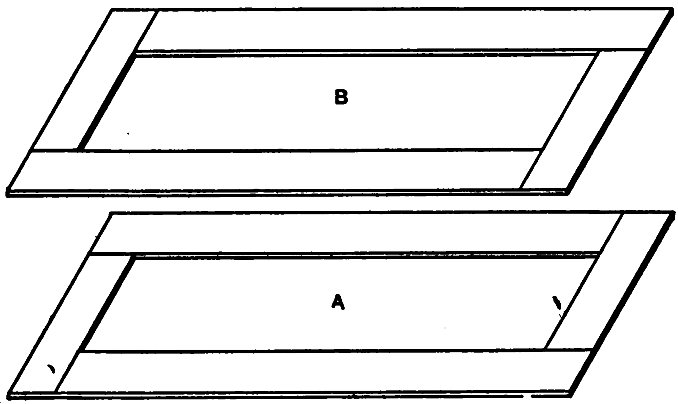


FIG. 190.—HOW STAGGERED JOINTS ARE MADE.

After the core is laid up as shown in Fig. 189, wrap the two sides, or *legs* and one of the ends with *friction tape.* Friction tape is the kind of tape electricians use for taping wire joints. This kind of tape comes in rolls about ½ inch wide. Wrap this tape on the core tightly lapping the edges of the tape, as shown on one of the ends in Fig. 191.

Now cut some *empire cloth* into strips 8 inches wide and wind enough of the strips on each *leg* of the core to make the cloth insulation about ¼ of an inch thick. *Empire cloth* is merely a linen cloth covered with an insulating varnish. Around the legs covered with the empire cloth wrap another layer of friction tape to hold it tightly together. The legs of the core are shown in Fig. 191 covered with the empire cloth strips.

One of the ends of the core must now be taken out so that the primary coil and secondary coil, when these are wound, can each be slipped on over a leg of the core, but in taking the strips

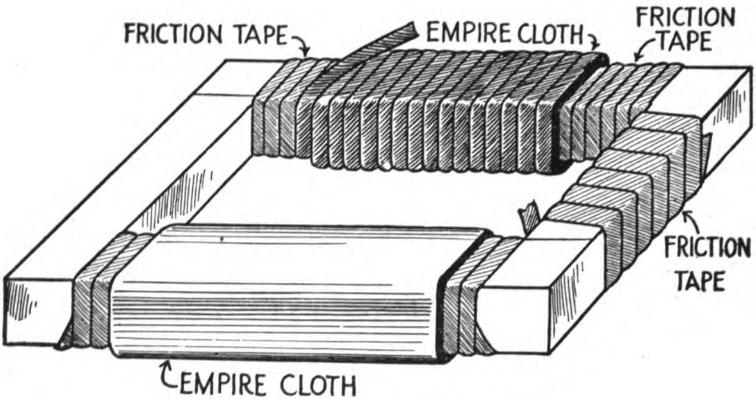


FIG. 191.—HOW TRANSFORMER CORE IS INSULATED.

of iron out of the core you must be careful not to disturb the *legs* and the other end. This, then, leaves only three sides of the core together.

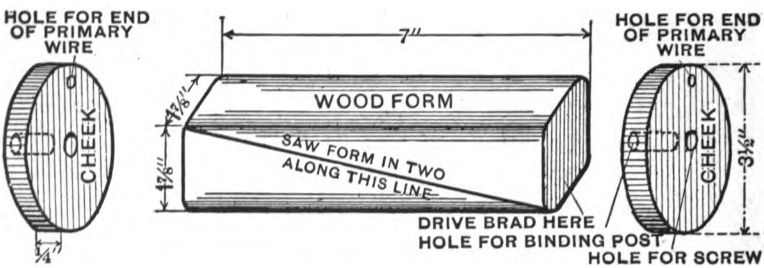


FIG. 192.—WOOD CORE FOR WINDING PRIMARY COIL.

The Primary Coil.—The primary coil cannot be wound directly on the leg of the core but it must be wound on a wooden form first and then put on one of the legs. This form can be made of a stick of soft wood 2 inches square and 7 inches long, see Fig. 192, as this will allow the inside of the primary coil to fit over the leg of the core which with its insulation of empire cloth and friction tape is 1⅞ inches square.

The edges of the wood form must be rounded off with a plane until it is exactly the same shape as the leg of the core. Saw the stick lengthwise and at a slant as shown in Fig. 192 and drive a brad in each end to hold the pieces together. The purpose of this is to make it easy to draw the form out of the coil after it is wound.

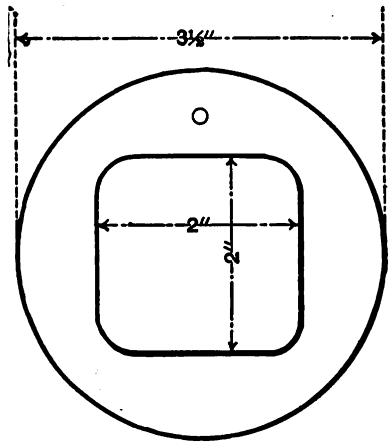


Fig. 193.—Cheek With Hole for Leg of Core.

Make two cheeks of wood ½ inch thick and 3½ inches in diameter, as shown in Fig. 193. Drill a ⅛ inch hole in the center of each cheek, so that they can be secured to the ends of the wood form. Drill a hole in one cheek ⅜ inch from the edge, and in the other cheek drill a hole ⅝ inch from the edge; these holes are for the ends of the primary coil. Finally drill a ⅛ inch hole in the edge of each cheek toward the center, so that binding posts can be screwed into the cheeks later on. Now screw the cheeks to the ends of the wood form and wrap on a couple of layers of paper.

Put this spool in a lathe if you have one, but if not you can wind the wire forming the primary coil on by hand without trouble.

For the primary coil, get 3 pounds of double cotton-covered magnet wire No. 13 Brown and Sharpe gauge. Slip one end of the wire through the hole in the cheek nearest the core. Now begin winding the wire on the form, drawing each turn up tight and forcing the turns up close together.

After you have wound on a layer of wire, put on a coat of melted compound formed of 1 pound of beeswax and 3 pounds of rosin, with a flat brush. The purpose of this compound is to keep the coil in shape after it is taken off the form, but it

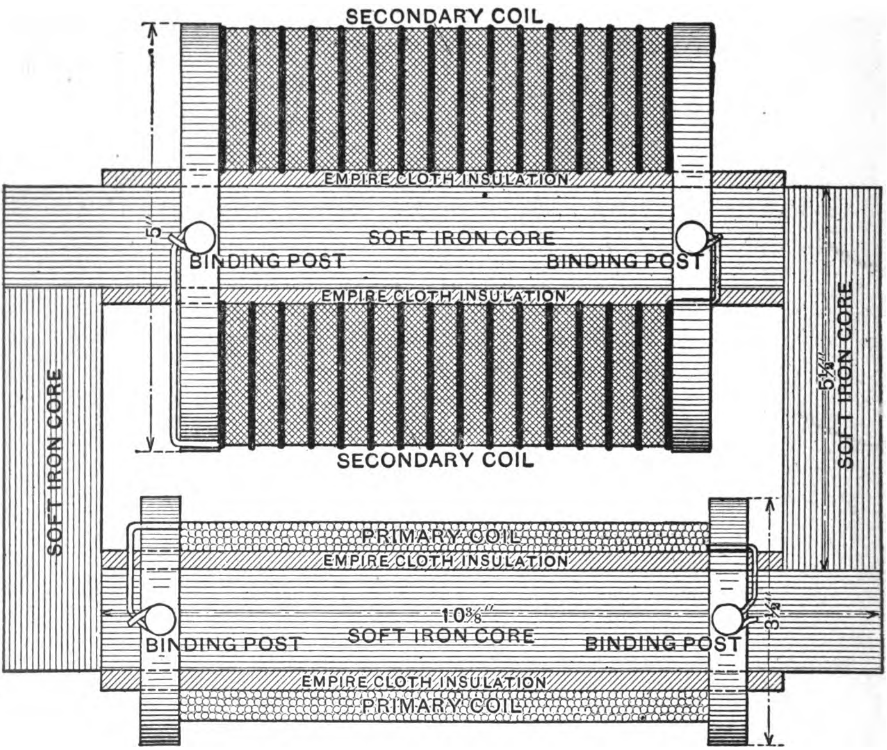


FIG. 194.—TOP VIEW OF TRANSFORMER IN CROSS SECTION.

will also help to insulate it. Wrap on a layer of empire cloth, then wind on another layer of wire and give it a coat of the rosin and beeswax compound and so on until you have put on four layers of wire which will make 336 turns altogether, or 84 turns to each layer.

When the compound is cold and hard, take off the cheeks, draw out the brads in the ends of the form and gently pull the pieces apart when they will easily slip from your coil. Now cut a hole in each cheek the shape and size of the legs as shown in Fig. 193, and push one of the cheeks over one of the legs down to the end of the insulation as shown in the top view of the transformer, Fig. 194.

Run some melted rosin and beeswax compound around the end of the empire cloth and cheek to hold the cheek in place. Next slip the primary coil over the leg, put on the other cheek and run some more melted compound around the end to hold this cheek in place.

Wrap a layer or two of empire cloth around the primary coil and tape it with friction tape. This completes the primary coil except for the binding posts and these can be screwed in later.

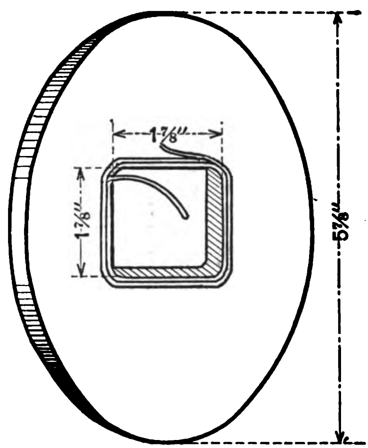


Fig. 195.—One of Disks or pies for Secondary.

The Secondary Coil.—The secondary coil should be wound in thin disks called *pies,* as shown in Fig. 195.

For the secondary coil of a ½ kilowatt transformer you should buy 5 pounds of No. 34 Brown and Sharpe gauge double cotton-covered magnet wire.

Five pounds of this sized wire will make about 31,500 turns of wire altogether, but it must be divided up into 15 disks or *pies,* each of which is ¼ inch thick and has an opening 1⅞ inches square and an outside diameter of 5⅞ inches as shown in Fig. 195; thus the number of turns of wire in each pie is 2,100.

A lathe or a winding machine will be needed to wind this wire into *pies.* A winding machine can easily be made but the work must be well done so that the pies may be evenly wound.

Make a base of wood 1 inch thick, 6 inches wide and 7 inches long. Saw off two strips of wood 1 inch thick, ½ inch wide, and 5⅝ inches long; through one of the strips ⅝ inch from the end,

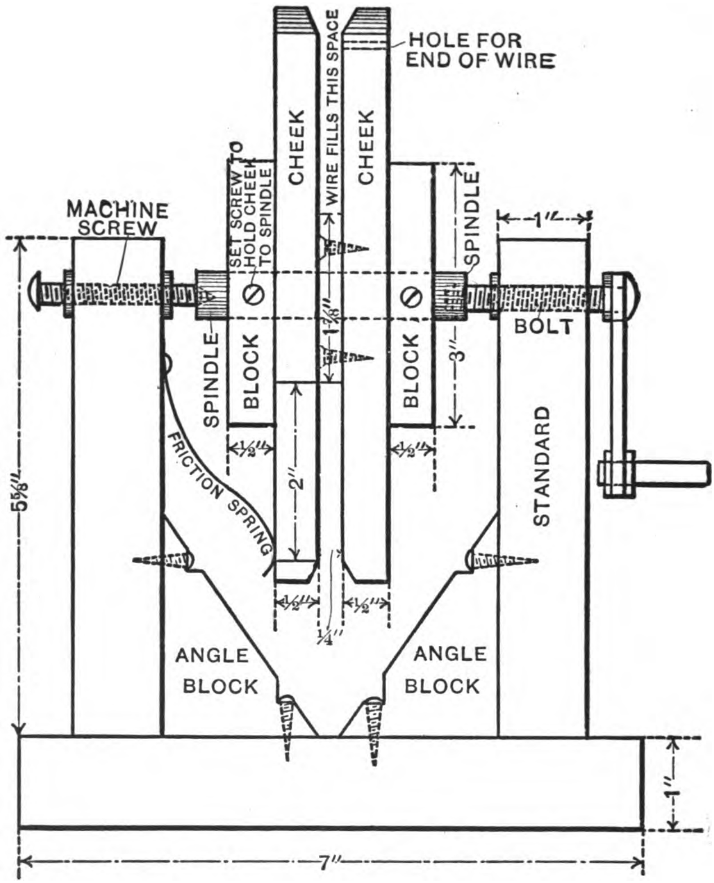


FIG. 196.—SIDE VIEW OF WINDING MACHINE.

drill a ⅛ inch hole for a screw which will serve as a *back center.* Through the end of the other strip drill a ¼ inch hole for a bolt which is to screw into the spindle, and secure these to the base with thin wood screws 2 inches long as shown in Figs. 196 and 197.

These strips of wood form the uprights which are to sup-

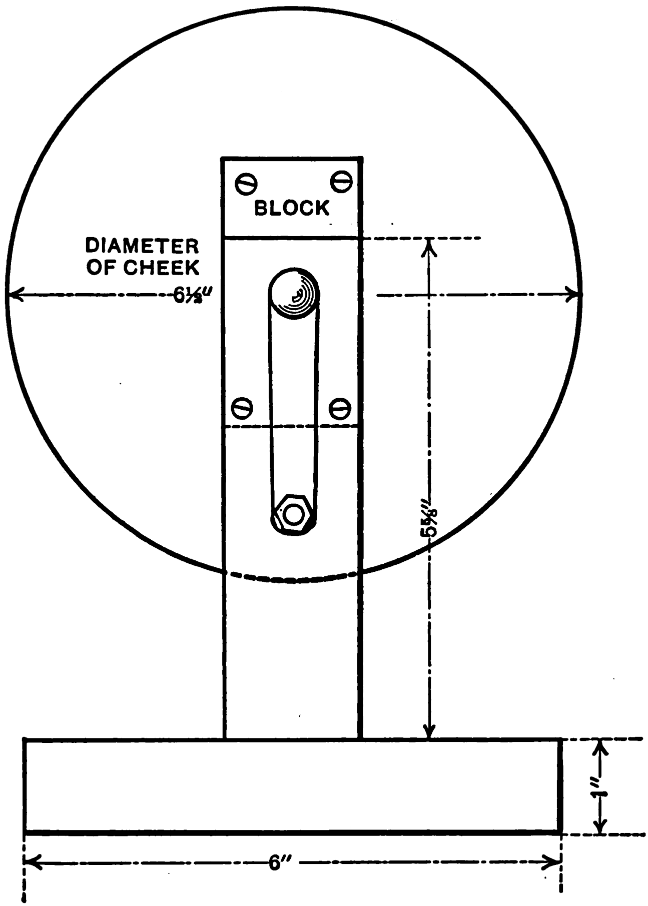


FIG. 197.—END VIEW OF WINDING MACHINE.

port the winding form and they must be screwed very rigidly to the base. To make them rigid screw an angle block 1 inch thick, 1¾ inches at the base and 2½ inches on the side to the middle of each upright and to the base as shown in Fig. 196.

Make a spring of stiff sheet brass ½ inch wide and 3 inches long, bend it as shown in Fig. 196 and screw one end to the left-

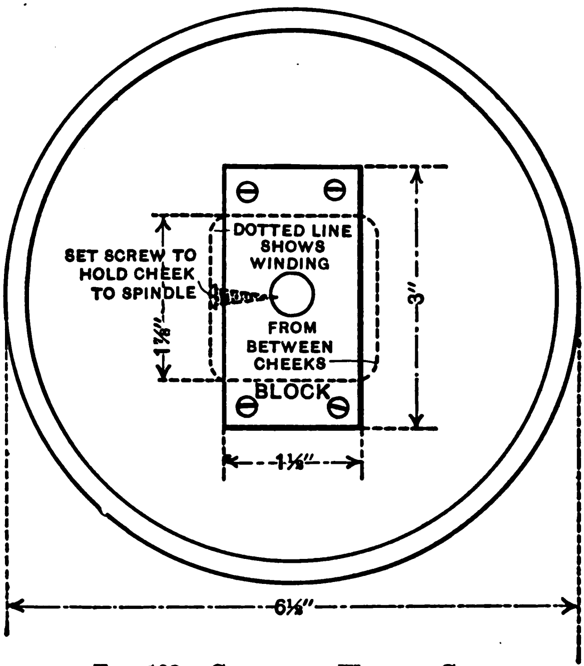


Fig. 198.—Cheek for Winding Coil.

hand upright. This spring is to press against the side of one of the cheeks, to keep the wire from unwinding when the handle is released.

Saw out of a good smooth board ½ inch thick two cheeks 6½ inches in diameter; bore a ½ inch hole through the centers of both cheeks and round off the inner edges as shown in Figs. 196 and 198. Make a wood block ¼ inch thick and 1⅞ inches square; round off the corners until it is exactly the same shape as the leg of the core and bore a hole ½ inch in diameter in the middle of the block as shown in Fig. 199; when done screw this block to the right-hand cheek as shown in Fig. 196.

Saw out two more blocks, each of which is ½ inch thick, 1½ inches in diameter and 3 inches long and bore a hole ½ inch in diameter in the middle as shown in Figs. 196 and 197. Through one side of each block put in a thin wood screw to hold the cheeks to the spindle, as is also shown in Figs. 196 and 197, and screw these blocks to the outside of the cheeks.

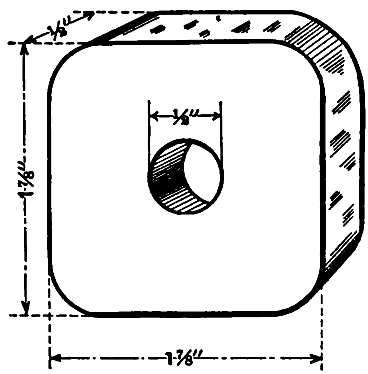


FIG. 199.—WOOD CORE ON WHICH PIES ARE WOUND.

The spindle, or shaft, is made of a piece of a straight iron bar ½ an inch in diameter and 3 inches long as shown in Fig. 200. Drill a hole ⅛ inch in diameter in one end ¼ inch deep, and drill a $\frac{3}{16}$ inch hole ⅝ inches deep in the other end and cut threads in this end with a tap, so that the bolt can be screwed into it. Drill two holes each ⅛ inch deep in the spindle and ⅝ inch from the ends for the set screws in the sides of the blocks as shown in Fig. 200.

Put a ring of paper on the inside of the cheeks and slip the cheeks over the spindle until the small block separating the cheeks is in the middle. Then screw down the set screws in the edges of the blocks on the cheeks until the points of the screws sink into the holes in the spindle when the cheeks will be held firmly in place.

Get a bolt ¼ inch in diameter and 2 inches long and cut threads on it clear up to the head. Cut out a handle bar of sheet brass ⅛ inch thick, ½ inch wide and 2½ inches long, and drill a $\frac{3}{16}$ inch hole in one end and a ¼ inch hole in the other end. Slip the bolt through the larger hole in the handle bar;

screw on a nut and tighten it up until the handle bar cannot turn on the bolt.

Cut off a piece of brass rod for the handle $\frac{3}{16}$ inch in diameter and $1\frac{1}{4}$ inches long and thread it $\frac{1}{2}$ inch down from the end. Screw on a nut as far as it will go, slip the handle bar over the end of the handle and screw on another nut. This completes the crank, and is shown in the side view of the winding machine, Fig. 196, and the end view, Fig. 197.

Push the bolt through the hole in the standard and put on another nut. Screw a nut on a thin 2-inch machine screw, put

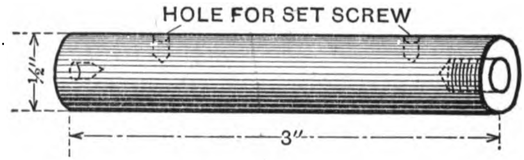


Fig. 200.—Iron Spindle for Winding Machine.

the screw through the hole in the other standard and screw on another nut. File the end of the screw to a point.

Next and last, set the spindle with the cheeks on it between the ends of the pointed screw and the bolt; then screw the bolt into the end of the spindle by turning the handle forward, and your winding machine is ready for use.

Loop the end of the wire over the wooden core between the cheeks and begin to wind. The wire does not have to be wound on evenly, but just guide it into the groove between the cheeks and it will find its own level. Hold the wire taut enough so that the turns are wound on rather tight, but on the other hand the wire must not be pulled tight enough to stretch it. After the disk, or pie, is wound up to within $\frac{1}{4}$ inch of the edge of the cheeks cut off the wire and slip the end through the hole in the cheek at this point as shown in Fig. 196.

Now hold the cheeks firmly with the left hand and turn the handle backward to unscrew the bolt from the spindle when the *revolving part,* as the spindle and cheeks are called, will drop out.

Have a pan half-full of very hot melted paraffin ready—the pan should be about 3 inches deep and 7 inches square or larger—and lay the whole revolving part flat in the pan when the paraffin will flow over, through and into every crevice of the *pie.* Let the revolving part lay in the pan for a few minutes, then take it out and drain off the paraffin into the pan.

Lay the revolving part by for half an hour or until the paraffin is cold and hard. You can then loosen the screw in the block that holds the left-hand cheek to the spindle. Slip the blade of a table knife between the rings of paper and the cheeks all round when the upper cheek can be lifted off and the wire pie can be taken off as smoothly as you please. Strip off the rings of paper when the pie will look like the drawing, Fig. 195.

Carefully lay the pie away and place another pair of paper rings on the cheeks, put the cheeks together again in the spindle and secure the revolving part in its place between the supports. Wind another coil in the same fashion as you did the first one, put the revolving part in the melted paraffin as before and set it aside to cool.

While the second pie is cooling wrap the first pie with strips of muslin ½ inch wide and with the edges lapping over each other, but be sure to have both ends of the wire out; the pie now will look like Fig. 201.

Test each pie to know that the wire is not broken. This can be done by connecting one end to a telephone receiver and the other end to the zinc of a dry cell and make and break the circuit by striking the end of the other wire of the telephone receiver to the carbon of the dry cell. If the wire is not broken you will hear a click in the telephone receiver, but if the wire is broken there will be no sound. Now mark an arrow on the muslin tape of the pie, making it point in the direction in which the wire is wound, as shown in Fig. 200. When the pie is completely taped, tested and marked, lay it on a sheet of tin whose ends are bent up, and place it in a pan of melted rosin and beeswax compound kept hot by a flame, or a stove and let it stay there for 30 minutes or until no more bubbles rise to the sur-

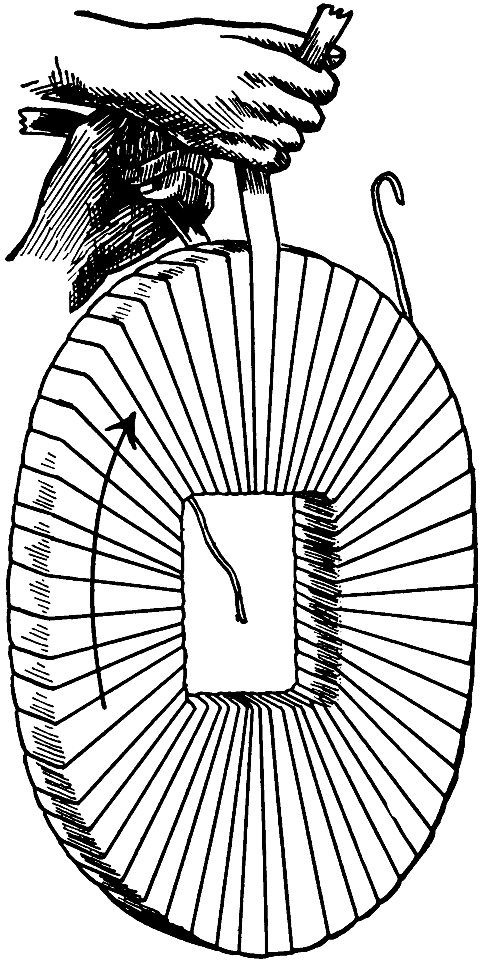


FIG. 201.—TAPING UP "PIE."

face. Take it out and let it cool and harden on the tin. To remove the pie from the tin, heat the bottom of the tin just a little.

By this time your second pie is ready to take out of the

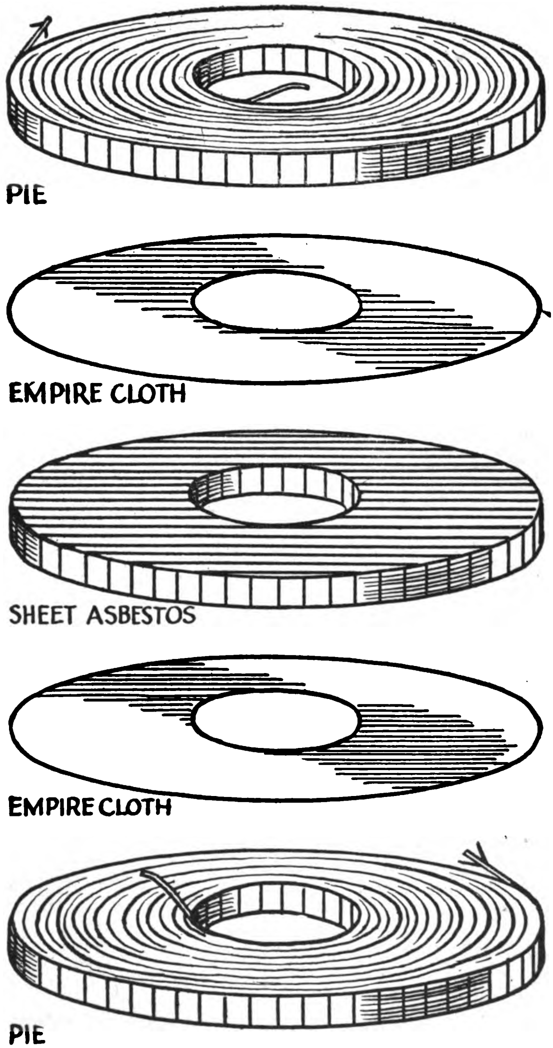


FIG. 202.—INSULATION AND PIES OF SECONDARY.

revolving part and after doing this you may wind another pie; tape, test and mark the second pie and keep these processes going until you have 15 pies wound up.

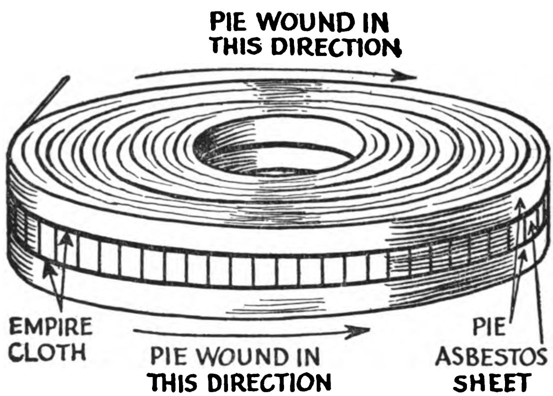


Fig. 203.—Laying Up Secondary Coil.

When all the pies are done cut out 30 rings of empire cloth and make these rings 6½ inches in diameter and cut holes in the centers that will fit snugly over the leg of the core; also cut out

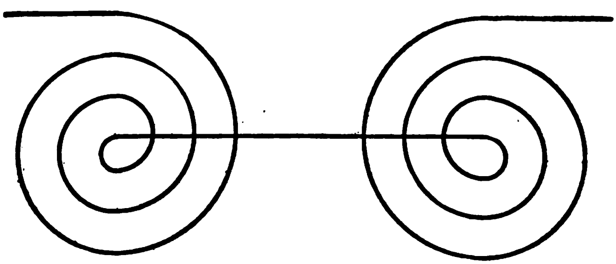


Fig. 204.—How Pies are Connected Together.

of *asbestos paper* $\frac{1}{16}$ inch thick 15 rings the same size as those of the pies and empire cloth.

Lay a pie on the table so that the arrow and hence the wire runs toward the *right* as at A in Fig. 202; lay a ring of *empire* *cloth* B on the pie and a ring of asbestos paper C on the ring of empire cloth; lay another ring of empire cloth D on top of the asbestos ring and finally lay on the second pie E, but this time have the arrow pointing to the *left* and *hence* the wire running in the *opposite* direction, all of which is clearly shown in Fig. 202. This method, of course, reverses the directions of

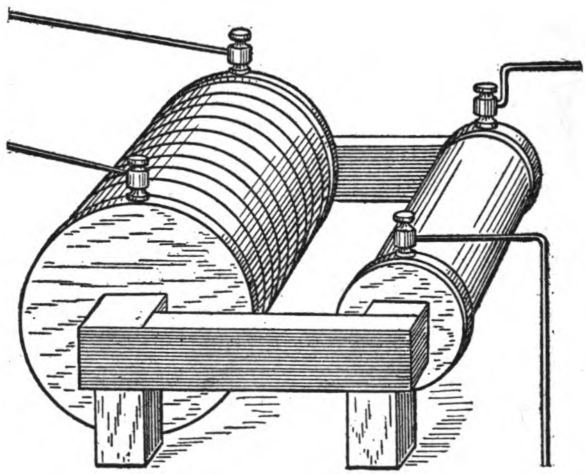


FIG. 205.—ONE-HALF KILOWATT TRANSFORMER COMPLETE.

the turns of wire in the pies but when the *inner ends* of the first two pies and the *outer ends* of the second and third pies are connected together the current flows through the coils in the *same* direction.

Having laid up the first two coils, as shown in Fig. 203, solder the *inner ends* of the pies together—do this with rosin and a soldering iron—and tape the joint with a narrow strip of empire cloth.

After this is done lay on another ring of empire cloth, another ring of asbestos paper, another ring of empire cloth and then another pie with the arrow pointing in the *right*-hand direction, and this time solder the *outer ends* of the second and third pies and tape the joint. Keep laying up the secondary coil until all the pies are in the pile and all the ends of the wires are soldered together; Fig. 204 shows in diagram just how the pies are connected together.

As each pie is added to the pile and the ends are soldered together test the coil to make sure that no wires are broken. When all the pies are laid up and tested, tear off strips of muslin ½ inch wide and tape them all together, being *mighty* careful not to break any of the connections. When the secondary coil is all done there will be about 30,000 turns of wire in it, and it will be about 5 inches in diameter. Dip the coil into melted rosin and beeswax again, take it out and let it cool when it will be a hard mass.

Saw two cheeks out of wood ½ inch thick and make them 6 inches in diameter, and cut holes in the centers of each cheek so that they will fit snugly over the empire cloth insulation on the leg of the core. Drill a ⅛ inch hole for a binding post in the edge of each cheek.

Push one of the cheeks over the leg until it is within 2 inches of the end of core and have the hole for the binding post on top as shown in Fig. 205. Now slip the secondary coil over the leg and close up to the cheek, and pour some very hot melted rosin and beeswax compound around and between the empire cloth insulation on the leg of the core and the inside of the secondary coil.

Put on the other cheek with the binding post hole on top and pour some compound around this one to hold it on tight, for the time being. This done you can now set in the strips of soft iron forming the end of the core and which makes the core complete.

The finishing touches are put on the transformer by screwing a binding post into each of the cheeks of the primary coil and into the cheeks of the secondary coil; loop the ends of the primary coil and the ends of the secondary coil around their *respective* binding posts and then screw the binding posts down tight.

This transformer will develop a pressure of 10,000 volts at

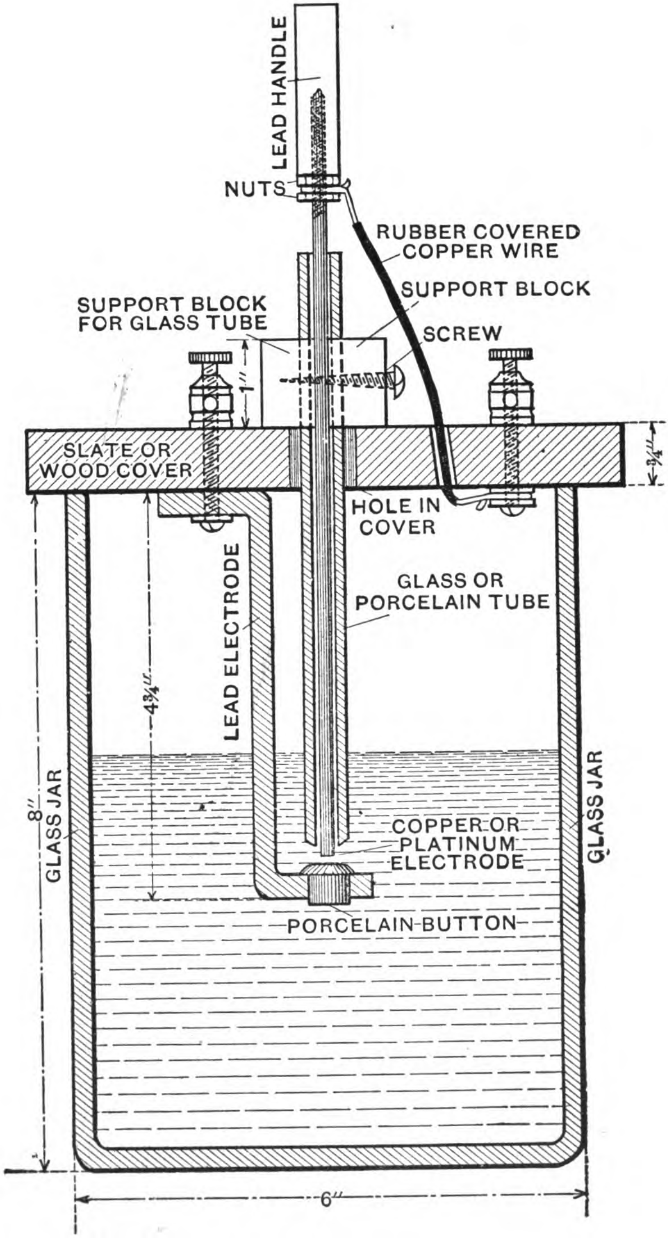


FIG. 206.—SIDE VIEW OF ELECTROLYTIC INTERRUPTOR.

the ends of the secondary coil when a current of 110 volts is flowing through the primary coil.

The transformer can be used just as it is by placing a block of wood 3 inches high under each corner of the core, but it is

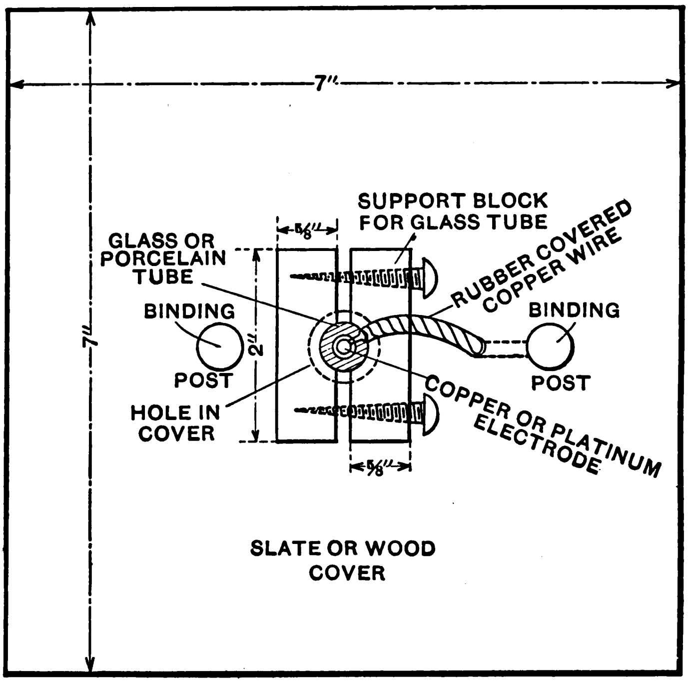


FIG. 207.—TOP VIEW OF ELECTROLYTIC INTERRUPTOR.

safer to put the transformer in a box made of wood, or sheet iron, and which is 7 inches deep, 11 inches wide and 13 inches long on the inside.

The connections should be made with pieces of rubber-covered copper wire. Fig. 205 shows the transformer complete.

Cost of ½ kilowatt transformer when bought.........about $20.00
COST OF ½ KILOWATT TRANSFORMER WHEN HOME MADE..about $13.00

How to Make an Electrolytic Interruptor.—A transformer works better with an alternating current than with a direct current, but if an alternating current is not at hand you can work the transformer with a direct current by using an *electrolytic interruptor.*

Get a glass jar of any size and kind. The one shown in Fig. 206 is known as a *crowfoot* or *gravity* battery jar. Make a cover of slate or wood ¾ inch thick and 7 inches square for the jar as shown in Figs. 206 and 207.

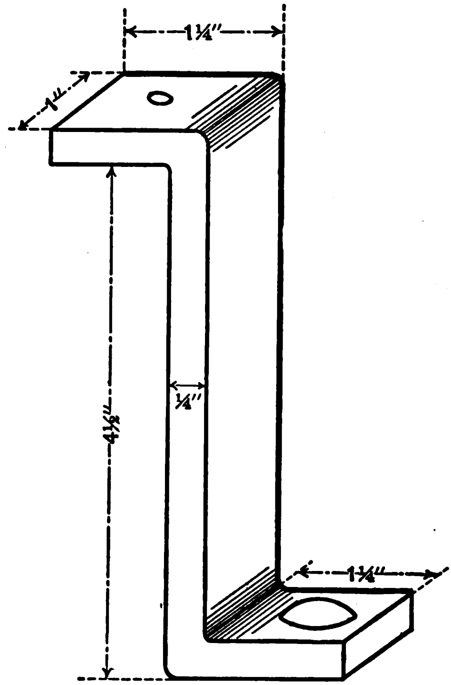


FIG. 208.—LEAD ELECTRODE.

Drill or bore a hole in the center of the cover ¾ inch in diameter and to one side of this hole, 1¼ inches from its center, drill a hole ⅛ inch in diameter—this is for a binding post—and on the other side and in a line with the other holes and at a distance of 1⅜ inches from the center of the large hole drill a ⅛ inch hole for the rubber-covered connecting wire to pass through; and, finally, at a distance of ⅞ inch from this hole drill a ⅛ inch hole for the other binding post.

Take a strip of sheet lead ⅛ or ¼ inch thick, 1 inch wide and 7 inches long; in one end of this strip drill a ½ inch hole for a porcelain button and in the other end drill a ⅛ inch hole. Bend

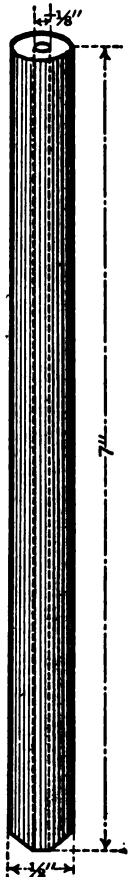


FIG. 209.—GLASS OR PORCELAIN TUBE.

each end of the lead strip over 1¼ inches as shown in Fig. 208.

Put a porcelain button through the hole, or fasten a piece of glass to the lead strip instead of the porcelain button. Push a machine screw, 1½ inches long, through the hole in the other end of the lead strip and through the cover and screw on a binding post as shown in Fig. 206. Through the outside hole in the cover screw on another binding post.

Next get a piece of glass or porcelain tubing 7 inches long, and having an outside diameter of about ½ inch and an inside diameter of ⅛ inch and round off one end a little with a file as shown in Fig. 209. Now get a piece of smooth copper rod ⅛ inch in diameter or a trifle smaller so that it will just slide through the glass or porcelain tube.

Thread one end of this rod down to about an inch and screw on two nuts. Make a lead handle ½ inch in diameter and 2 inches long and drill a 3/32 inch hole in it to a depth of 1 inch and thread it so that the end of the rod can be screwed into it, as shown in Fig. 210. Loop an end of a piece of rubber-covered wire about 5 inches long around the rod and between the nuts. This forms the other *electrode* of your interruptor.[1]

Saw out two hardwood blocks ⅝ inch thick, 1 inch wide and 2 inches long. Lay these blocks together with a piece of wood ⅛ inch between them, put them in a vise and bore a hole ½ inch in diameter through them as shown in Fig. 211.

[1] The scheme of weighting the copper rod so that it would fall to the bottom of the jar and keep the same amount of copper surface always exposed was invented by Mr. Oscar A. De Long, who made it, worked it and wrote it up for the *Collins Wireless Bulletin* when he was only 14 years old.

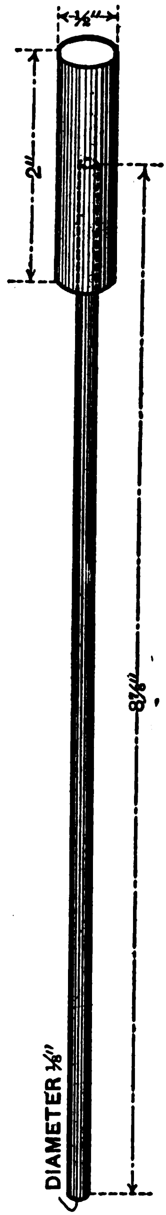


Fig. 210.—Copper Rod Electrode and Lead Handle.

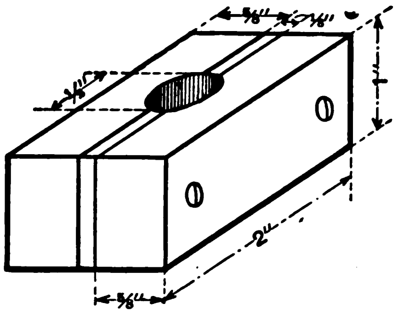


Fig. 211.—Adjusting Blocks.

Take them out of the vise, throw away the piece of strip and drill a $\frac{1}{8}$ inch hole through each end of *one* of the blocks. Place a block on each side of the glass or porcelain tube and screw the blocks together, leaving one end of the tube sticking out about 1 inch on one side and 5 inches on the other side as shown in Figs. 206 and 207. This allows the tube to be adjusted.

Grease the copper rod with lard to within $\frac{1}{8}$ inch of the lower end where it comes in contact with the *porcelain button;* slide the rod through the glass tube and put the tube through the hole in the cover. Slip the free end of the rubber-covered copper wire through the hole in the cover and loop it around the screw of the binding post between the washers.

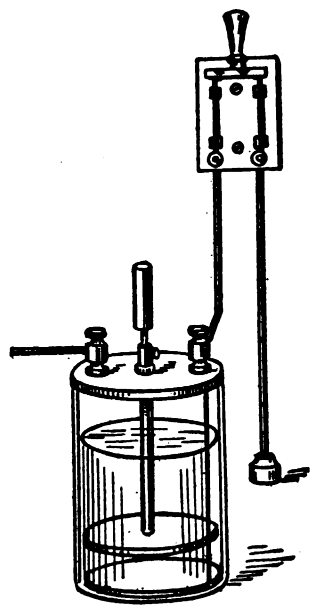


Fig. 212.—Electrolytic Interruptor in Perspective.

Fill the jar about two-thirds full of a solution made of 9 parts of water and 1 part of sulphuric acid. Put the cover on the jar, when the interruptor is ready for use. Keep on adding sulphuric acid until the interruptor works well.

When the interruptor is connected with the primary of a transformer in which an alternating current is flowing, bubbles of insulating gas are formed on the end of the copper rod and this interrupts or breaks the current; when the bubble explodes the current is then free to flow again.

These bubbles are made and broken very rapidly by the current when the interruptor is working good and as many as 10,000 breaks a minute can be had.

The number of breaks a minute depends on the pressure of the alternating current and the amount of copper rod which is exposed below the end of the glass tube. The reason the glass tube is placed between the two wooden blocks is so that the tube can be raised or lowered and more or less of the copper rod is exposed. In this way the interruptor can be regulated. A piece of platinum wire set in a lead rod and both fitting in the glass tube will give better results than the copper which is eaten rapidly away. Fig. 212 shows the electrolytic interruptor in perspective.

Cost of electrolytic interruptor when bought...............$2.25

Cost of Electrolytic Interruptor When Home Made

1 glass jar, 6 x 8 inches	$ .25
1 slate cover, ¾ x 7 x 7 inches	.40
1 lead electrode, ¼ x 1 x 7 inches	.25
Porcelain button	.10
Glass tube, ½ x 9 inches	.20
Copper rod, ½ x 9 inches	.20
2 binding posts	.20
1 pound sulphuric acid	.10
	$1.70

CHAPTER III

USEFUL INFORMATION

Government Rules and Regulations.—The time was, and not so very long ago, when a boy could own any kind of a wireless set, use any length of wave he wanted to and send messages wherever he pleased and no one could say him nay.

But things have changed in the last couple of years and while anyone can still receive wireless messages without having a license no one can send wireless messages without having first passed an examination and received a license from the Government.

There are two grades of licenses issued to boys by the Government. The first grade and second grade licenses are exactly the same as far as the ability of the operator goes, the only difference in the two grades is that the first grade boy is personally examined by a wireless or *radio* inspector, while the second grade boy is not personally examined. If you live in the vicinity of one of the places where the examinations are held you will be examined personally; if not, your examination will go in in writing.

The following paragraphs are taken from a pamphlet called "Radio Communication Laws of the United States," which contains the radio Act of Congress of August 13, 1912; the articles of the International Radiotelegraphic Convention, London, 1912; and the Government Regulations for radio operators and the use of radio apparatus on ships and on land. (The word *radio* is the official word for *wireless*.)

This pamphlet is issued by the Department of Commerce, Bureau of Navigation, Radio Service, Washington, D. C., and if you will send 15 cents to the Superintendent of Documents, Government Printing Office, Washington, D. C., you will receive a copy by mail.

Paragraph 121, Part III, Regulations Governing Radio Operators, says:

Amateurs before applying for licenses should read and understand the essential parts of the International Radio-telegraphic Convention in force and Sections 3, 4, 5 and 7 of the Act of Congress of August 13, 1912. [The word *amateur* means boys and others who own and operate stations for pleasure.]

The Department recognizes that radio communication offers a wholesome form of instructive recreation for amateurs. At the same time its use for this purpose must observe strictly the rights of others to the uninterrupted use of apparatus for important public and commercial purposes.

The Department will not knowingly issue a license to any amateur who does not recognize and will not obey this principle. To this end the intelligent reading of the International Convention and the Act of Congress is prescribed as the first step to be taken by amateurs.

Paragraph 122. *Amateur First Grade.* The applicant must have a sufficient knowledge of the adjustment and operation of the apparatus which he wishes to operate and of the regulations of the International Convention and Acts of Congress in so far as they relate to interference with other radio communication and impose certain duties on all grades of operators.

The applicant must be able to transmit and receive in Continental Morse at a speed sufficient to enable him to recognize distress calls or the official *keep-out* signals.

A speed of at least five words per minute (five letters to the word) must be attained.

Paragraph 123. *Amateur Second Grade.*—The requirements for the second grade will be the same as for the first grade. The second grade license will be issued only where an applicant cannot be personally examined or until he can be examined.

General Restriction of Amateur Stations, fifteenth regulation, Section 4, of the Act of Congress, August 13, 1912, says in substance: that amateur stations shall not use a wave length when transmitting which shall exceed 200 meters (a meter is

39.39 ~~feet~~ inches); or a transformer having an input exceeding 1 kilowatt. (Input is the amount of current flowing through the primary of the transformer.)

Special Restriction of Amateur Stations, sixteenth regulation, Section 4, of the Act of Congress, August 13, 1912, says in substance: that no amateur station which is situated within five nautical miles[1] of a naval or military station shall use a transmitting wave length which shall exceed 200 meters or a transformer input exceeding ½ kilowatt.

Secrecy of Messages, nineteenth regulation, Section 4, of the Act of Congress, August 12, 1912, says in substance: that no person engaged in or having knowledge of the operation of any station or stations shall divulge or publish the contents of any messages transmitted or received by such station, except to the person to whom the message may be directed.

Any person guilty of divulging or publishing any message except as this regulation provides shall be fined not more than $250.00 or imprisoned not longer than three months or both.

Summary.—Boiled down, then, the Government will permit you to (1) receive messages without a license, but (a) you must keep secret all messages you receive, and (2) send messages after you have obtained a license, providing that (a) your wave length does not exceed 200 meters, and that (b) the input of your transformer is not more than 1 kilowatt.

Examinations for License.—An examination for a license consists of, first, a test as to your ability to *receive* messages.

The test is made up of call letters, signals of various kinds, abbreviations, etc., but in no case is the message made up of simple connected reading matter. In order to pass, you must be able to receive at least 5 words per minute.

The written examination consists of seven questions and to answer these you should know:

(1) How to make a diagram of the transmitting and receiving apparatus.

[1] A nautical mile is 2,029 or $\frac{1}{60}$th of a degree of the earth's equator. A statute or ordinary mile in the U. S. is 5,280 feet.

(2) How the transmitting apparatus is made and how it works.

(3) How the receiving apparatus is made and how it works.

(4) The International regulations for wireless communication and the United States wireless laws and regulations.

If you have made the apparatus described in this book, can send five words per minute, and will read the pamphlet, "Radio Laws and Regulations," issued by the Government you should have no trouble in getting your wireless license.

Places Where Examinations Are Held.—Applicants for wireless licenses will be examined at the following places:

(1) United States Navy Yards: Boston, Mass.; New York City; Philadelphia, Pa.; Norfolk, Va.; Charleston, S. C.; New Orleans, La.; Mare Island, Cal.; Puget Sound, Wash.

(2) Naval Wireless Stations: San Juan, Colon, R. P.; Honolulu, H. I.; Key West, Fla.

(3) United States Army Stations: Fort Omaha, Neb.; Fort Wood, N. Y.; Fortress Monroe, Va.; Fort St. Michael, Alaska; Fort Valdez, Alaska.

(4) Bureau of Navigation, Department of Commerce, Washington, D. C.

Special dates and places where examinations will be held may be ascertained of the Commissioner of Navigation, Washington, D. C.

Licenses when awarded will be delivered through the officer who conducted the examination.

Fees.—The government makes no charge for any operator or station license.

Rules and Requirements of the National Board of Fire Underwriters for Wireless Telegraph Apparatus.—The following paragraphs are taken from the *National Electrical Code,* a copy of which may be had for the asking by addressing the National Board of Fire Underwriters, 135 William Street, New York City:

Section 86. Wireless Telegraph Apparatus. Note.—These

rules do not apply to wireless telegraph apparatus installed on shipboard.

In setting up wireless telegraph apparatus, all wiring within the building must conform to the general requirements of this Code for the class of work installed and the following additional specifications:

(a) Aërial conductors (wires) to be permanently and effectively grounded at all times when station is not in operation by a conductor not smaller than No. 4 Brown and Sharpe gauge copper wire, run in as direct line as possible to the water pipe at a point on the street side of all connections to said water pipe within the premises, or to some other equally satisfactory earth connection.

(b) Aërial conductors (wires) when grounded as above specified must be effectually cut off from all apparatus within the building.

(c) Or the aërial to (can) be permanently connected at all times to earth through a *short-gap lightning arrester;* said arrester to have a gap of not over .15 inch between brass or copper plates not less than 2½ inches in length parallel to the gap and 1½ inches the other way with a thickness of not less than ⅛ inch mounted on non-combustible, non-absorptive insulating material of such dimensions as to give ample strength. Other approved arresters of equally low resistance and substantial construction may be used.

(d) In cases where the aërial is grounded as specified in paragraph (a) the switch employed to join the aërial to the ground connection shall not be smaller than a standard 100-ampere knife switch.

(e) Where current is obtained direct from the street service the circuit must be installed in approved metal conduits or armored cable. In order to protect the supply system from high potential surges, there must be inserted in the circuit either a transformer having a ratio which will have a potential on the secondary leads not to exceed 550 volts, or two condensers in series across the line, the connection between the said condensers to be permanently and effectually grounded. These condensers should have a capacity of not less than one-half *microfarad.*

List of Land and Ship Stations.—A list of land and ship stations of the United States, including amateurs, and giving call letters, wave lengths, nature of service, etc., can be had by sending 15 cents to the Superintendent of Documents, Government Printing Office, Washington, D. C.

APPENDICES

APPENDIX A

Brown and Sharpe Wire Gauge.—A wire gauge is not only used to find the sizes of wires, but to measure them as well. A wire gauge is a flat piece of steel cut in a circular form about $\frac{1}{10}$ inch thick and $2\frac{1}{4}$ inches in diameter. It has 36 slots cut in

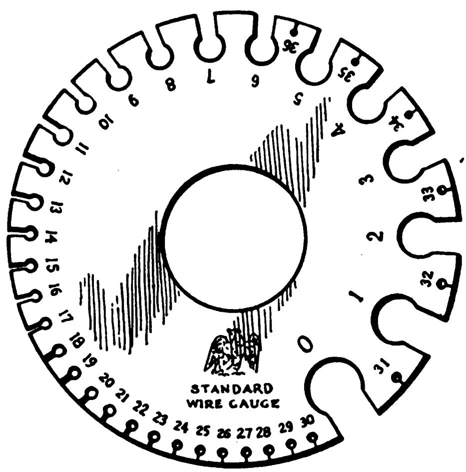


FIG. 213.—BROWN AND SHARPE WIRE GAUGE.

its edge and each slot is stamped with a number beginning with 5 and ending with 36; and each number is the size of the wire which fits into its respective slot. The holes at the end of the slot have nothing to do with the size of the wire. A cut of the *Brown and Sharpe gauge,* which is also called the *Standard*

Wire Gauge, is shown full size, so that you can roughly judge the number of any of the larger sized wires. Brown and Sharpe wire gauge is abbreviated B and S gauge; a B and S wire gauge costs about $2.10.

APPENDIX B

Drills.—Drills for drilling holes in wood and metal are used with a drill stock. The drills are called twist drills, and the sizes of drills needed for doing the work set down in this book are:

No. of Drill	For Taps or Screws
38 For	4—36
32 For	6—32
28 For	8—32
22 For	10—24
13 For	12—24

The smaller drills cost about 5 or 6 cents each, and the larger drills cost about 10 or 12 cents each.

APPENDIX C

Taps and Dies.—*Taps* are for cutting inside threads, as in nuts, while *dies* are for cutting outside threads, as on screws. Taps are used in a wrench and dies are used in a stock. A set including the following sizes with wrench and stock in a box costs $4.25.

No.	Threads to Inch
4	36
6	32
8	32
10	24
12	24

APPENDIX D

Screws and Nuts.—Machine screws and nuts run in the same sizes as taps and dies. The size is found with a Brown and Sharpe standard screw gauge. When you ask for a 4—36 screw or a 4—36 tap you mean that you want a screw or a tap size No. 4 Brown and Sharpe screw gauge and which has 36 threads to the inch.

No.	Threads to Inch
4	36
6	32
8	32
10	24
12	24

APPENDIX E

Types of Aërials.—There are a number of types of aërials and the kind of an aërial you will put up will probably depend very largely on conditions. The very simplest type is the *vertical aërial.* The vertical aërial has very little capacity and is

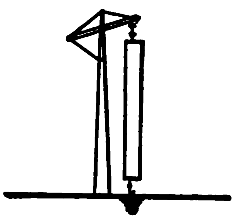


Fig. 214.—Vertical Aërial.

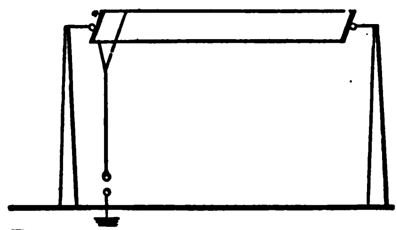


Fig. 215.—Horizontal ⅂ (Inverted L) Aërial.

now seldom used. The type described in Chapter III, Part II, is called a *horizontal* or *flat-top,* the first being called a *T aërial* for the reason that the leading-in wire is connected in the middle of the aërial and this makes it look somewhat like the capital letter T. The second form is the inverted L (⅂) aërial, the leading-in wire in this case being connected with the aërial at one end or the other. The horizontal aërial of either form is a much better radiator of electric waves than the vertical aërial, and is widely used. The horizontal aërial is the type used at the great Arlington Station. Another type is the *fan aërial,* of which there are, likewise, two forms. In the first form the aërial is put up with all the wires insulated from the top of the pole

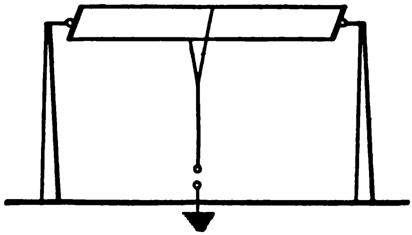


FIG. 216.—HORIZONTAL T AËRIAL.

and spreading out and down toward the ground. In the second form the wires are fastened to a wire or rope stretched between

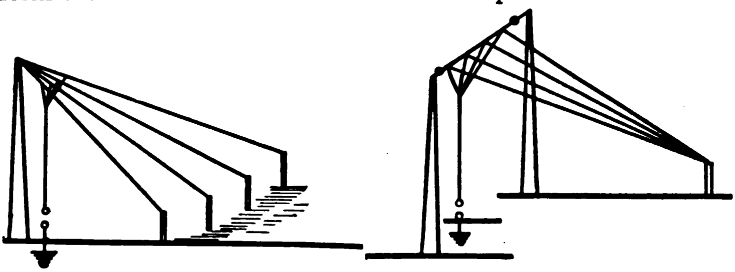


FIG. 217.—FAN AËRIAL.

two poles and are brought down to the ground in a single wire. A fan aërial is almost as good as a horizontal aërial, especially if

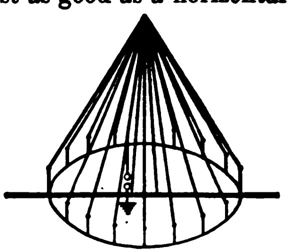


FIG. 218.—UMBRELLA AËRIAL.

a large number of wires are used. The fan aërial is the type used at the great Eiffel Tower Station in Paris. A modification of the fan aërial is to spread out the wires all around the pole when it becomes an *umbrella aërial.* This makes a better aërial than any of the other types.

APPENDIX F

A Simple Crystal Detector.—A detector which is very much more sensitive than the one described in Chapter II, Part I, and which can be used instead of it, can be easily made. Make a hardwood base $\frac{1}{2}$ inch thick, 2 inches wide and 3 inches long. Near one end bore a $\frac{1}{2}$ inch hole and near the other end drill a $\frac{1}{8}$ inch hole and screw on a binding post. Around the screw loop a wire which is to connect with the ground. Cut off a piece of brass rod $\frac{1}{2}$ inch in diameter and 1 inch long and drill

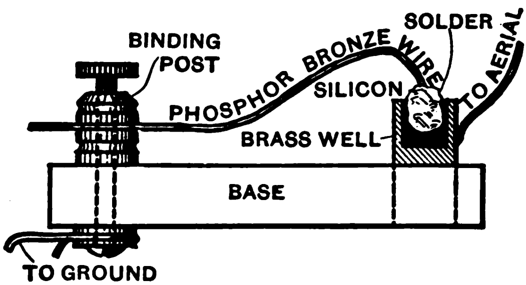


FIG. 219.—A SIMPLE CRYSTAL DETECTOR.

a hole in one end $\frac{3}{8}$ inch in diameter and to a depth of $\frac{3}{8}$ inch. Heat the end of the rod in an alcohol, or a gas flame, and run it full of melted solder. Force a bit of silicon or any other sensitive crystal into the solder so that when the solder is cold the silicon will be firmly imbedded in it. Solder a wire to the rod so that it can be connected with the aërial and force the rod down into the hole in the base. Sharpen one end of a piece of phosphor-bronze wire, No. 18 or 20 Brown and Sharpe gauge, about $3\frac{1}{2}$ inches long and bend the wire as shown in the cut; slip the blunt end of the wire through the hole in the binding post. Now adjust the wire until the pointed end presses on the crystal and you will have what is called a *cat-whisker detector.*

DEFINITIONS OF SOME WORDS AND TERMS USED IN THIS BOOK

Abbreviations. The shortening of words or sentences for wireless messages. For instance, instead of spelling out the whole message, "How do you receive me?" you simply send the letters Q R K, which also means "I am receiving well."

Act of Congress of August 13, 1912. Laws passed by Congress to regular wireless communication. See Part III, Chapter III, page 196.

Acts. Laws passed by Congress.

Adjustable. (1) to Change by steps. (2) A word interchangeably used with *varied,* as an *adjustable* resistance.

Adjustable resistance. A resistance which can be changed so that exactly the amount of current needed will flow through the circuit.

Aërial. See Appendix E.

Aërial conductors. Aërial wires.

Aërial rope. A rope fastened to the end of an aërial and brought down through a pulley block.

Aërial wire system. An aërial and ground wire and that part of an inductance coil which connects them.

Affected. To act upon or to be moved by.

Alternate. To change in direction.

Amateur. One who practices wireless for the fun and interest and not for the money there is in it.

Ampere. (1) The unit of current strength. (2) A fresh dry cell will develop from 15 to 20 amperes.

Antenna. An aërial.

Arc across. A continuous flame between the ends of the secondary coil of a transformer. An *arc* differs from a *spark,* which is a periodic luminous discharge.

Arm. A projecting piece of metal.

Back center. One of the two fixed points of a winding machine or lathe between which a spool or form is held and turned. The back center is the left-hand center; it is also called a *dead center.* The right-hand center is called a live center.

Ball and socket joint. A joint connecting the head band and ear-pieces of a telephone receiver so that they can be turned in almost any position.

Bell wire. No. 18 Brown and Sharpe gauge copper wire, double cotton-covered, paraffined and colored so that when a number of wires are run together they can be told from each other without sorting them over.

Bookbinder's cloth. A kind of glazed cloth used for covering books, also for covering small induction coils.

Broken. When a circuit is not completed it is said to be *broken.*

Call letters. Letters by which ship and shore stations are known. Three letters are used for all Navy, Army and Commercial stations. The call letters of the Government Station at Arlington, Va., are N A A.

Call signal. The figures and letters by which your station is known. The call signal of your station is given you by the Government when you receive your license.

Cell. (1) A single element for producing a current, as a dry cell. (2) Two or more cells coupled together form a battery.

Chalcopyrite. Copper pyrites, a brass-colored mineral used as the sensitive element in crystal detectors. (See Zincite.)

Closed. When a circuit is completed, or made, by means of a key, interruptor, etc., the circuit is said to be *closed.*

Cohere. To draw together. When electric oscillations surge through a loose contact such as is formed by a steel needle resting on a pair of leads, the molecules of the steel and lead are drawn together, or *cohere.*

Collar. A ring or band of metal.

Composition foil. A low grade of tin foil made so by the addition of lead to the tin.

Conductive coupling. An aërial and a ground wire, forming an open circuit, and a closed circuit, which are connected together by a single inductance coil. Also termed a *direct coupling.*

Contact point. The spot where contact is made between two substances. The spot where a metal or a crystal touches another piece of metal or a crystal.

Contact points. Any two wires or electrodes which are used to make and break a current, as the *contact points* of an interruptor or the *contact points* of a key.

Continuous. Without a break.

Contractile spring. A spiral spring which draws together, or contracts, when the tension is removed.

Conventional symbols. A number of different marks, figures and signs which wireless workers have agreed to use to represent certain pieces of apparatus.

Counter-sink. An enlargement of a hole for a screw so that the head of a screw will set in flush with the surface.

Crystal detector. A detector in which crystals such as silicon, zincite, etc., are used as the sensitive element.

Crystalline. Pertaining to or like crystal.

Cut-in. To put more resistance, inductance or capacity in a circuit, as to *cut-in* a turn of wire.

Cut-out. To take some resistance, inductance or capacity out of a circuit, as to *cut-out* a Leyden jar.

Cycle. (1) A series of changes which when completed are again at the starting point. (2) A period of time at the end of which an alternating or an oscillating current repeats its original direction of flow.

Damped out. (1) The rate at which electric oscillations decrease or die out. (2) Electric oscillations are *damped out* by the resistance and the inductance of a circuit and the change of energy into electric waves.

Determine. To fix or to make, as the inductance of a circuit *determines* its *period* of oscillation.

Device. (1) An apparatus or instrument or part thereof. (2) Any arrangement for producing a required result.

Die. A steel block with teeth on its inner surface. It is used for cutting threads on rods, etc.

Direct coupling. An aërial and ground, forming an open circuit, and a closed circuit, which are connected together by a single inductance coil. Also termed a *conductive coupling.*

Disk. A thin, circular piece of metal or wood. A telephone diaphragm is a disk of sheet iron. The cheek of a coil is a disk of wood. A pie is a disk formed of wound-up wire.

Eddy currents. Electric currents set up in the core of a transformer by the currents flowing in the primary coil. These eddy currents waste the primary current by developing heat in the core. The way to prevent eddy currents is to make the coil of very thin strips of soft iron and then varnish the strips.

Electric oscillations. The same as high-frequency currents.

Electric pressure. The force that moves a current along a wire. It is called *electromotive force.* The *unit of electromotive force* is called a *volt.*

Electric waves. Waves in the *ether* sent out by electric oscillations in an aërial wire.

Electrodes. Usually the parts of an apparatus which dip into a liquid and carry a current. The *electrodes* of a battery are the zinc and carbon elements; the *electrodes* of an electrolytic interruptor are the copper rod, or platinum point and the lead plate; the *electrodes* of a spark-gap are the metal points or balls between which the sparks pass.

Electrose insulator. Insulators for aërial wires made of a patented compound having a high resistance and great strength.

Energy. The power of an electric current.

Ether. A substance filling all space and in, by and through which light, electricity and magnetism travels.

Examination. Testing the skill and knowledge of an operator by a wireless inspector to ascertain if he should be granted a license.

Eye. A hole in the ring of an insulator or a *withe.*

Factor. One or more causes that produce an effect, as the capacity of an aërial wire is a factor in determining its wave length.

Feebly damped oscillations. High-frequency electric currents which swing, or oscillate, a large number of times before they die out.

Feed. To supply to; to furnish with.

Finger. A small strip of metal.

Fixed condenser. A condenser whose capacity cannot be changed.

Flaming arc. The continuous luminous discharge which takes place between the ends of the secondary coil of a transformer.

Flat-top aërial. See Appendix E.

Flexible cord. A number of very thin copper wires twisted together and having a silk or cotton covering woven about them so that it will bend easily. It is used for connecting a detector with a telephone receiver.

Fools' gold. Iron pyrites, a yellow mineral which glitters like gold. It is used in crystal detectors for the sensitive element.

Free end. All through this book you will find the term *free end* used. After a wire, or spring, or other piece of metal, is fastened at one end the other end is called the *free end,* at least until it is fastened to something else or something else is fastened to it.

Full load. Using as much current as the apparatus is designed to use. Said of a transformer when it is taking its full amount of current.

Generator. (1) A dynamo. (2) Any machine or apparatus which produces a current of electricity.

Government rules and regulations. See Part III, Chapter III, page 196.

Ground clamp. A clamp for making a good connection between the ground wire and a pipe.

Guy out. To fasten a pole or mast in position with ropes, called guy ropes.

Hack saw. A small saw used for sawing metals.

Hard fiber. An insulating material made of the pulp of paper which has been toughened and waterproofed by chemicals and hardened by pressure.

Hard solder. An alloy used by jewelers for soldering gold, silver and other metals; it only melts at red heat. It is melted by means of a blowpipe.

Head telephone receiver. One or two *watch-case receivers* joined together with a metal or hard rubber band which fits over the head and holds the receivers closely to the ears.

Helix. (1) A tuning coil for sending. (2) A spiral of wire.

High-frequency currents. The same as electric oscillations.

High potential surges. Currents of high pressure which sometimes back up into the primary of the transformer and into the feed wires. Such surging currents will burn out the generator and do other damage unless devices are installed to prevent them.

High-power station. Stations using large amounts of power. The Government station at Arlington, Va., has a sending range of about 3,000 miles.

High-pressure circuit. The circuit of the secondary coil of an induction coil, or of a transformer. The pressure in these circuits may range from 5,000 to 300,000 volts.

High-pressure current. A current such as is usually produced by the secondary coil of an induction coil or a transformer or the discharge of a Leyden jar or glass plate condenser. A high-voltage current.

High-pressure electricity. Same as high-pressure current. A current such as is usually produced by the secondary of an induction coil or a transformer or a Leyden jar.

Horizontal aërial. See Appendix E.

Horse-power. One horse-power equals 33,000 pounds, raised 1 foot in 1 minute.

Incoming waves. Electric waves which impinge or strike the aërial of a station.

Jump sparks. Electric discharges produced by an induction coil or a condenser.

Lead. (1) To carry a wire to. (2) A wire carrying a current.

Lever. A bar of metal which moves freely on a fixed point.

License. Permission given by the Government to a person to operate a wireless station.

Licensed operator. A wireless operator who is licensed to operate a station.

Lines of Magnetic Force. Curved lines of force extending from one pole of a magnet to the other. If a magnet is placed under a sheet of glass or a heavy sheet of paper and fine soft iron filings are sprinkled over the glass or paper the filings will move about and form themselves into curved lines which show the lines of magnetic force.

Linking. Joining together.

List of land and shore stations. Published by the U. S. Government. A list of wireless telegraph stations of the U. S. The edition of 1915 gives the names of all the ship and shore stations, their call signals and the wave lengths which they use. It also gives the names of all the boys and amateurs who own licensed stations, the location of their stations, their call signals and the power in *watts* which they use. Send 15 cents to the Superintendent of Documents, Washington, D. C., and he will send you a copy.

Listening-in. Listening to wireless messages.

Loose contact. Contact between conductors without pressure. When a steel needle is laid across the leads of a detector a *loose contact* is formed which is sensitive to electric oscillations.

Low-pressure circuit. The circuits of the generator and primary coil of an induction coil or a transformer. The pressure in these circuits may range from 110 to 220 volts.

Low resistance. Having little resistance.

Made. When a circuit is completed by means of a key, interruptor, contact of wires, or spark-gap the circuit is said to be *made*.

Magnetic force. The magnetizing power of a current in the magnet coils.

Mains. The wires which carry the current from the street service into the house.

Masthead. The top or highest point of a wireless pole or mast.

Meter. A meter is 39.39 inches long.

Mica. A transparent mineral, sometimes called isinglass, which can be split into very thin sheets. It is a very good insulator and is largely used in making condensers.

Microfarad. The $\frac{1}{1000}$ of a *farad.*

National Board of Fire Underwriters. A Board organized to enforce such rules and regulations as the Electrical Committee of the National Fire Protective Association may recommend. See Book III, Chapter III, page 199.

National Electrical code. The rules and requirements laid down by the *National Board of Fire Underwriters*.

Nautical mile. A nautical, or sea, mile is 6,087 feet. A statute, that is a legal, or ordinary mile in the United States, is 5,280 feet.

Non-absorptive. A substance which will not absorb water.

Non-combustible. A substance which will not burn.

Ohm. The unit of resistance. The resistance of 400 feet of common telegraph wire is about *one ohm*.

Open. When a circuit is not completed or is broken, it is said to be *open*.

Open key. When a circuit is broken by means of a key, the key is said to be *open*.

Oppose. To offer resistance.

Oscillating currents. Currents which surge with high frequency in open or closed circuits.

Oscillation. (1) The swing of a pendulum. (2) The swing of a high-frequency current. (3) A train of electric *oscillations* set up by a single spark.

Out-going waves. Electric waves which are emitted or sent out by the aërial of a station.

Parallel. When all the zincs of a battery are connected together and all of the carbons are connected together, the battery is said to be connected in parallel.

Period. The length of time it takes a pendulum or an electric oscillation to make a complete swing.

Power switch. A switch placed in the circuit formed by the generator and the primary of the transformer.

Principles. The first causes that produce results.

Process. The way of working, the course of procedure.

Quick break. A quick separation of the contact points of an interruptor. A quick separation of an electric circuit. A *quick break* and the number of breaks per minute which an interruptor makes are entirely different things, but both are needed for the proper working of an induction coil.

Radiated. Sent out, as electric waves are *radiated* from an aërial wire.

Radio. Wireless. The word *radio* was adopted by the International Radio Telegraphic Convention to take the place of the word wireless. Wireless and *radio* mean exactly the same thing.

Radio Communication Laws of the United States. See Part III, Chapter III, page 196.

Ream. To enlarge a hole.

Reamer. A tool for enlarging holes.

Rectified. To change an oscillating current into a direct current. Oscillating currents are *rectified* or changed into direct currents by crystal detectors.

Resistance. The friction offered by a wire or other conductor to the passage of a current.

Respond. To act when a force is applied, as a detector responds to the action of electric oscillations.

Reversal. Change of the direction of the flow of a current.

Revolving element. The spool, or form, including the spindle on which it is fixed in a winding machine.

Roughly tuned. To be tuned nearly enough for practical purposes.

Satisfy. To fulfill all the required conditions.

Scale. Spaces or divisions marked off for the purpose of measurement, or comparison, as the scale of a hot-wire ammeter.

Sending helix. A tuning coil for sending.

Sensitive. Affected by a very small current. A detector is sensitive when it will respond to oscillations of one $\frac{1}{5000}$ of an *erg*.

Series. When the zinc of one cell is connected to the carbon of another cell the battery thus formed is said to be connected in series.

Shank. (1) The part of a bolt between the threaded end and the head. (2) The part of a leading-in insulator next to the shoulder.

Shoulder. (1) The bulging part of a leading-in insulator which sets up against the window pane. (2) An offset for keeping a thing in place.

Silicon. A chemical element used in crystal detectors for the sensitive element. It is one of the most sensitive of the rectifying crystals.

Slider. A piece of metal which slides along rods or other guides and which carries a contact spring.

Slot. A slit or narrow cut in a piece of metal, as a slot in a screw head.

Soft-drawn wire. Wire which is not made springy during the process of making. This kind of wire is easily handled when making aërials.

Source of current. A battery or any kind of a generator of electric currents.

Specifications. The definite statement of requirements of the *National Board of Fire Underwriters* for installing wireless stations. These are included in the *National Electrical code.*

Static. Atmospheric electricity which charges the aërial and discharges through the detector. When the *static* is strong close your lightning switch.

Stem. A slender cylindrical piece of metal.

Stepping-up. Increasing the pressure of a current, as an induction coil, or a transformer *steps-up* the pressure of a current.

Stranded wire. Aërial wire made up of a number of small wires twisted together.

Strongly damped oscillations. High-frequency electric currents which make only a few swings, or oscillations before they die out.

Succession. Following each other at regular intervals.

Support. A piece of wood or metal which holds something in place.

Surging. Moving to and fro; oscillating. Said of high-frequency currents in a circuit.

T aërial. See Appendix E.

Tap. A tool for cutting inside threads.

Taper. Smaller at one end than at the other.

Taut. To stretch tight, as a taut aërial.

Telephone cord. See *Flexible cord.*

Thread. (1) The tooth of a screw. (2) To cut threads on a rod with a die. (3) To thread a nut.

Thumb screw. A screw or nut having wings on it so that it can be tightened or loosened with the thumb and fingers.

Trains of waves. Electric waves which follow each other at regular intervals. Each electric oscillation sends out an electric wave and, hence, as several oscillations take place before all the energy is damped out, an equal number of electric waves will be sent out. This forms a *train of waves.*

Transferred. The energy of a current flowing in a primary circuit or coil which is changed over to current which is set up in the secondary coil or circuit. This *transfer* of energy takes place by induction.

Tune in. To *tune* a receptor so that the signals from the station wanted are the loudest.

Tune out. To *tune* a receptor so that the signals of all stations not wanted are weakest.

Tuned closed circuit. (1) A circuit formed of a condenser, inductance coil and a spark-gap for a transmitter. (2) A circuit formed of a condenser, inductance coil and a detector for a receptor.

Tuned open circuit. A tuned aërial wire system.

Variable. To change gradually, as a variable condenser.

Variable condenser. A condenser whose capacity can be changed.

Variable resistance. A device for regulating a current flowing in a circuit, as a water resistance in the primary circuit, or a potentiometer in the receiving circuit.

Vibrate. To move to and fro rapidly, as the diaphragm of a telephone receiver; to swing; to oscillate.

Volt. The unit of electric pressure, or electromotive force as it is called. A dry cell will develop from 1½ to 2 volts.

Washer. A small flat metal ring placed on a screw between the head or below a nut to serve as a cushion. Where a connection is to be made with a screw two washers are slipped on the screw, and the wire is looped around the screw between them.

Watt. (1) The unit of work done by a current. (2) One ampere × one volt = one watt. (3) 746 watts = one horse-power. (4) a dry cell giving 20 amperes at 1½ volts will develop $24\frac{7}{8}$ of a horse-power.

Wire up. (1) To connect all the parts of an apparatus with wire. (2) To complete all necessary circuits.

Wireless code. (1) The International Morse code. (2) The alphabet arranged in dots and dashes. (3) A modification of the regular Morse code.

Wireless eye. A fanciful name given to detectors, since detectors sense electric waves which are too long for the eye to see through the electric oscillations which are set up.

Wireless key. A device for making and breaking up a current into dots and dashes. A key for wireless work usually has larger contacts than an ordinary telegraph key.

Wireless waves. (1) Electric waves. (2) The waves sent out through space by oscillating currents in an aërial wire.

Work. To energize, to operate, as to work a transformer.

Zincite. A deep red mineral crystal. It is used in crystal detectors as a sensitive element. Zincite is very sensitive to electric oscillations when in contact with *chalcopyrite.*

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